A PENTON PUBLICATION JULY 2000

FOR DESIGNERS AT HIGHER FREQUENCIES

Microwaves & RF

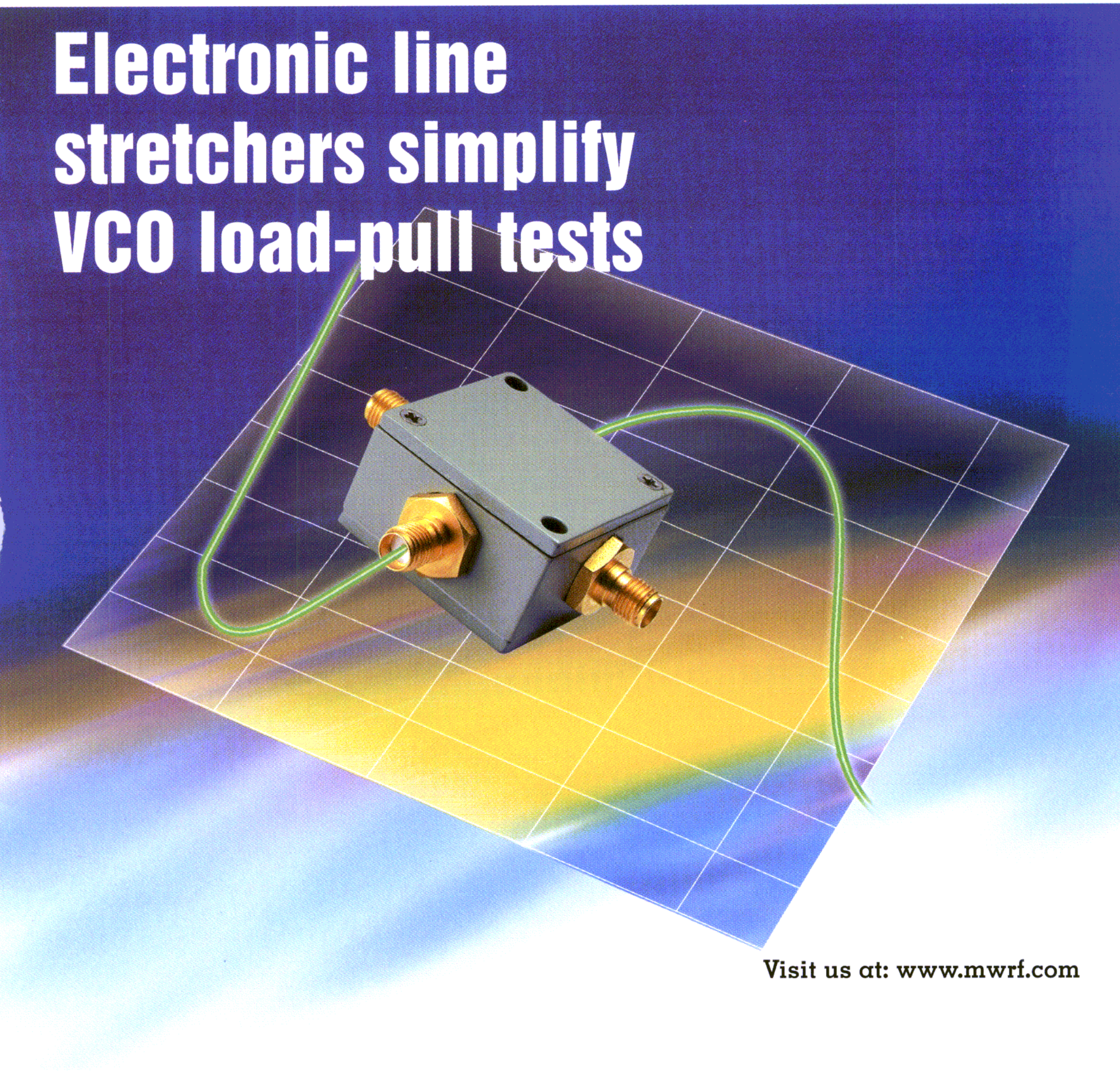
Fiber-Optics Technology Issue

NEWS
Spotlight on 10-Gb/s optical communications

DESIGN FEATURE
Accurately predict NPR performance

PRODUCT TECHNOLOGY
Microwave analyzer tests group delay

Electronic line stretchers simplify VCO load-pull tests

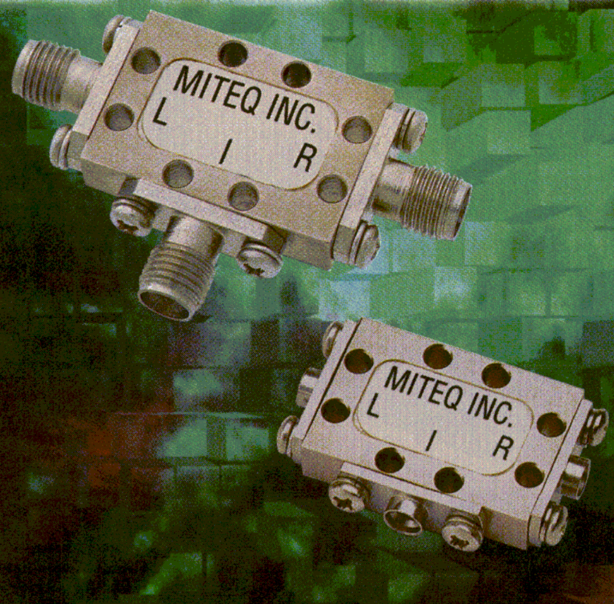


Visit us at: www.mwrf.com

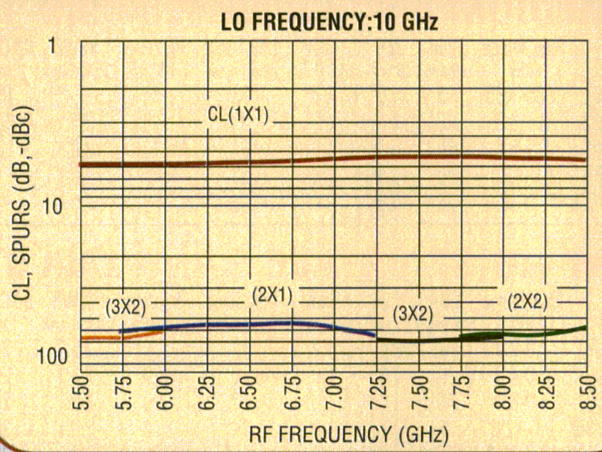
LOW SPURIOUS
SPACEBORNE MIXERS

FEATURES:

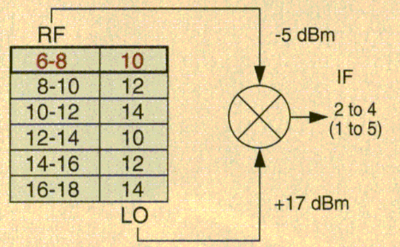
- Broadband operation
- Minimal variation in conversion loss
- High IP3 and 1 dB compression versus LO power



CONVERSION LOSS/SPURIOUS



TYPICAL OPERATING BANDS



SPECIFICATIONS - Model TBR0618HA1/TBR0618HA1-S

RF/LO Input Frequency Range	6 to 18 GHz
IF Output Frequency Range	0.05 to 5 GHz
Conversion Loss	6 dB Typical
Spurious	-55 dBc
Third Order Intercept Point	+23 dBm Typical
1 dB Compression Point	+13 dBm Typical

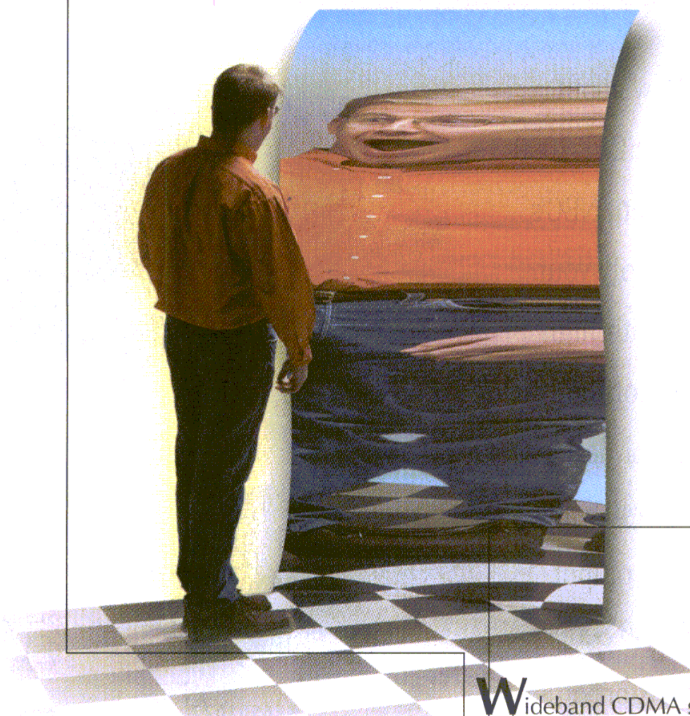
NQA ISO 9001 REGISTERED COMPANY

For further information, please contact Mary Becker at (631) 439-9423 or e-mail mbecker@miteq.com

MITEQ

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

CIRCLE NO. 246



A Penton Publication

JULY 2000 VOL. 39, NO. 7

Microwaves & RF

Visit us at
www.mwrf.com

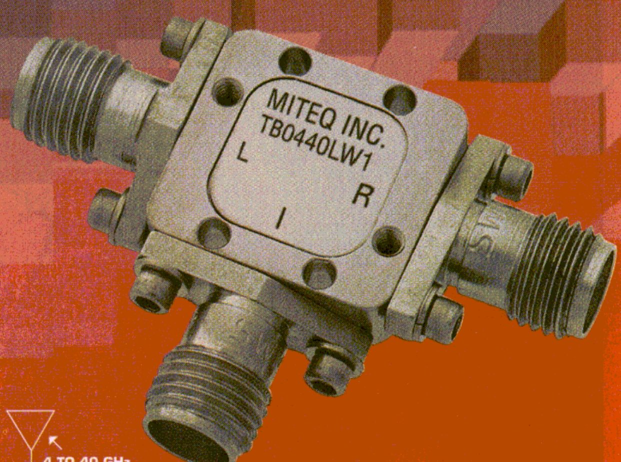
Penton

SUBSCRIPTION ASSISTANCE AND INFORMATION POSTMASTER: Please send change of address to *Microwaves & RF*, Penton Media, Inc., 1100 Superior Ave., Cleveland, OH 44114-2543. For other subscription information or assistance, please call (216) 696-7000 and have a copy of your mailing label handy.
Microwaves & RF (ISSN 0745-2993) is published monthly, except semi-monthly in December. Subscription rates for US are $80 for 1 year ($105 in Canada, $140 for International). Published by Penton Media, Inc., 1100 Superior Ave., Cleveland, OH 44114-2543. Periodicals Postage Paid at Cleveland, OH and at additional mailing offices.
Canada Post International Publications Mail (Canadian Distribution Sales Agreement Number 344311). CAN. GST #R126431964.

#1 Web Site*
www.
Digi-Key
.com
1-800-DIGI-KEY
Digi-Key
.com
QUALITY ELECTRONIC COMPONENTS
SUPERIOR SERVICE
PARTS SEARCH
ONLINE ORDERING
CATALOG
ORDER STATUS
NEW PRODUCTS
INDUSTRY LINKS
ABOUT DIGI-KEY
CONTACT US
Rated #1 by...
Purchasing
Design Engineering
Design Engineering Management
Corporate Management
Best Web Site by all four categories!
* Distribution Trends 2000, Cahners Electronics Group
CIRCLE NO. 206
© 2000 Digi-Key Corporation

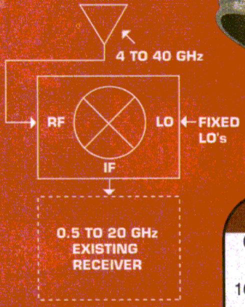
4 - 40 GHz BLOCK DOWNCONVERTER

MITEQ's Model TB0440LW1 allows the use of existing wide bandwidth receivers over millimeter frequency bands!

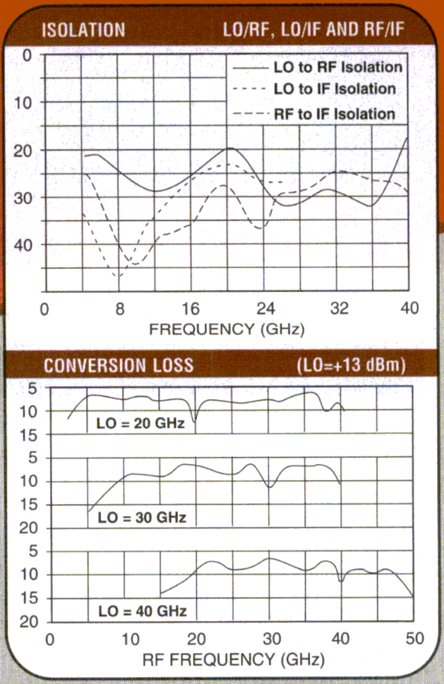


FEATURES:

- RF/LO Coverage....... 4 to 40/4 to 42 GHz
- IF Operation.............. 0.5 to 20 GHz
- LO Power Range ...... +10 to +15 dBm (usable at +7 dBm)
- RF to IF Isolation...... 25 dB
- Removable K Connectors
- From Stock



INPUT PARAMETERS	MIN.	TYP.	MAX.
RF frequency range (GHz)	4		40
RF VSWR (RF = -10 dBm, LO = +13 dBm)		2.5:1	
LO frequency range (GHz)	4		42
LO power range (dBm)	+10	+13	+15
LO VSWR (RF = -10 dBm, LO = +13 dBm)		2.0:1	
TRANSFER CHARACTERISTICS	**MIN.**	**TYP.**	**MAX.**
Conversion loss (dB)		10	12
Single sideband noise figure (dB, at +25° C)		10.5	
Isolation - LO to RF (dB)	18	20	
Isolation - LO to IF (dB)	20	25	
Isolation - RF to IF (dB)	20	30	
Input power at 1 dB compression (dBm)		+5	
Input two-tone 3rd order intercept point (dBm)		+15	
OUTPUT PARAMETERS	**MIN.**	**TYP.**	**MAX.**
IF frequency range (GHz)	0.5		20
IF VSWR (RF = -10 dBm, LO = +13 dBm)		2.5:1	



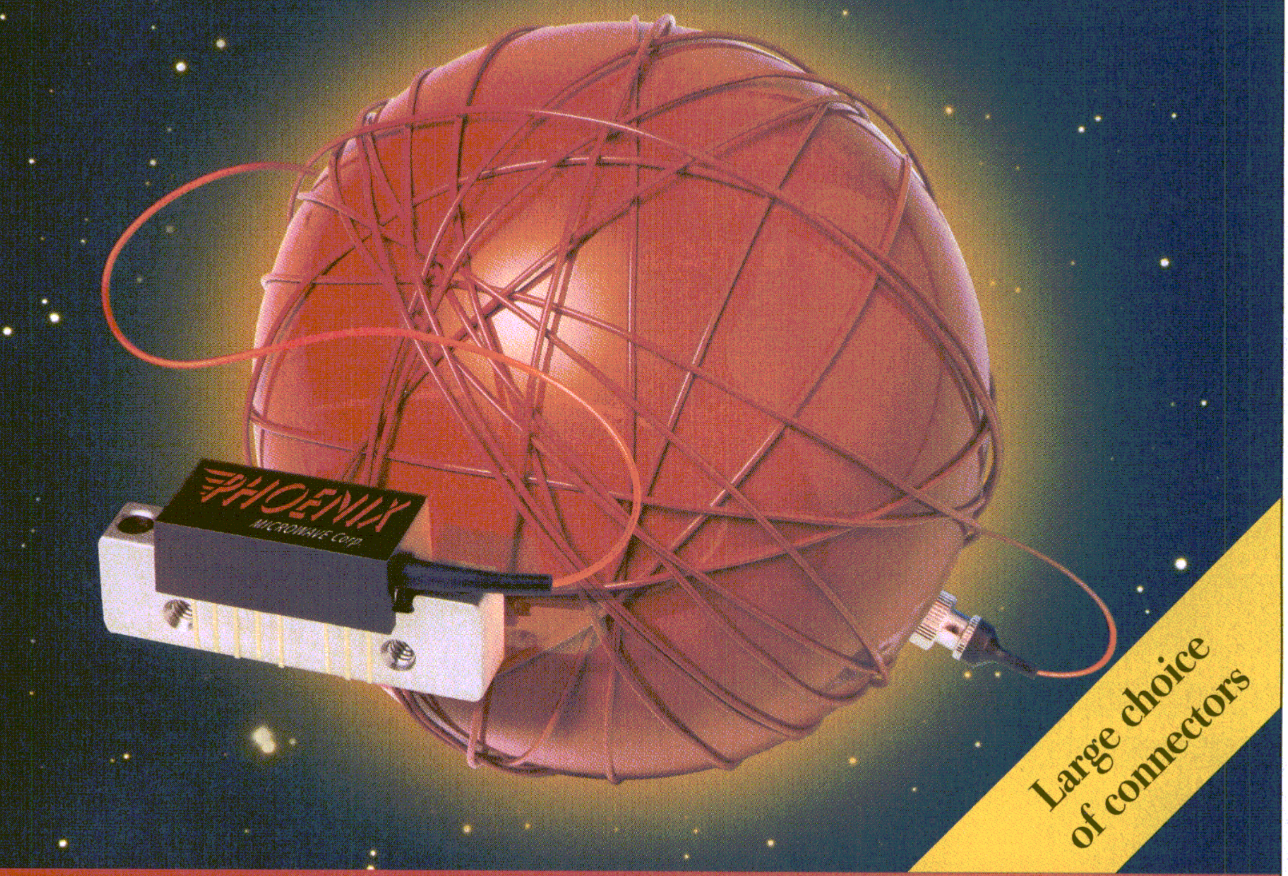
For additional information, please contact Mary Becker at (631) 439-9423
or e-mail mbecker@miteq.com

MITEQ

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

CIRCLE NO. 263

A New World Of Optical Receiver Hybrid Modules



From the Leader in Broadband Linear Components

Model # PFO3 and PFO4 (FC/APC connector)	
Typical Performance @ +25° C (λ=1310 nm @ +24volt/220 ma)	
Frequency Range	40 to 860 MHz
Responsivity	1100 V/W
Spectral Density	0.95 A/W
Gain Flatness (p/p)	0.5 dB
Optical Input Return Loss	50 dB (connector dependent)
Output Return Loss (Referenced to 75Ω)	20 dB
3rd Order(IMD_3) Two Laser Test, 3 tones Test Freq 324.25 MHz @ 0.33 mw/tone	>85 dBc
2nd Order (IMD_2) Two Laser Test, 2 tones Test Freq 324.25 MHz @ 0.5 mw/tone	>80 dBc
Ein Equivalent Input Noise	<7 pA/√Hz
Note for PFO4 model only.	**Pin #4 provides independent DC input to optical diode detector.**

ISO 9001 Registered Company

For those CATV system designer's who have wrestled with the tough problems of matching a Photodiode and a RF linear amplifier up to 860 MHz, Phoenix Microwave offers a unique solution.

Our new product line of Broadband Lightwave Receiver modules offers flat frequency response from 40 to 860 MHz, excellent linearity and low noise, high optical operating power and above all *excellent return loss*. And for those of you who prefer their own customized optical receiver solution, we are prepared to design a cost effective module around your specification. So, from your initial design concept to high volume production make Phoenix Microwave your Optical/RF module partner.

Call today: 215-723-6011.

Stellex

PHOENIX MICROWAVE

Phoenix Microwave 100 Emlen Way, Telford, PA 18969 • Fax: 215-723-6015 • e-mail: info@phnixmw.com • Website:www.stellexms.com

CIRCLE NO. 202

SIDEBAR CALIBRATION

To the editor:

In the noise-figure sidebar story "Necessity's Grandchild (The Roots Of Noise Figure)" that appeared on page 202 of the May issue, I thought I might clarify some points since I happened to be there (during those times as mentioned in the sidebar).

The first point is that Harold Friis, "the father of noise figure," was, of course, a career engineer and manager at Bell Labs (specifically Holmdel, NJ) during the post-World War II years of microwave-radio development for AT&T communications technology. It was there that he defined the concept of noise figure. In his later years of retirement, he became a consultant at Hewlett-Packard microwave-development labs in Palo Alto, CA.

The second point is that the HP 340A was not the first noise-figure instrument. The first was a noise-figure meter from the Airborne Instrument Laboratories of Long Island, NY, an aerospace contractor who had a small commercial instrument business. The other instrument was from Magnetic AB, a company in Sweden. In the 1950s, Bill Hewlett was working to increase Hewlett-Packard's presence in Europe and he spent a lot of time there. On one visit, he purchased the patent rights to the Magnetic noise-figure meter circuitry.

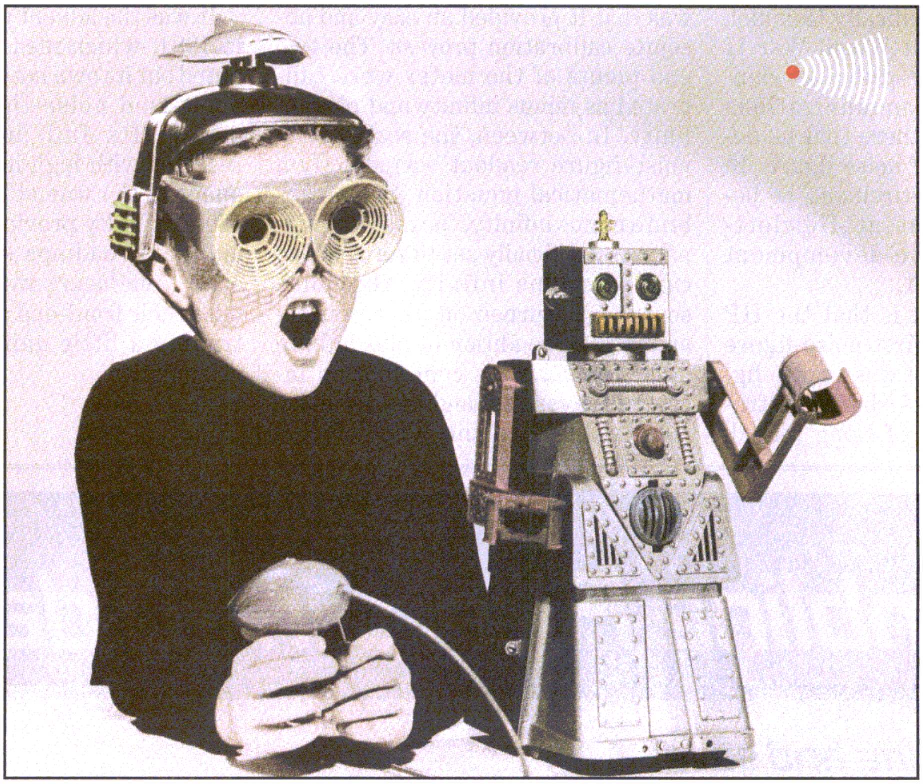
The novel circuitry in the HP 340A, based on the Magnetic patent, was that it provided an easy and absolute calibration process. The two end points of the meter were calibrated as minus infinity and plus infinity. In between, the scale of the noise-figure readout was strictly a mathematical equation. So to calibrate minus infinity, the metered signal was artificially set to zero, and to calibrate plus infinity, the noise source was turned on, representing an artificial condition of plus infinite noise figure. HP's contribution included waveguide and coaxial noise sources, before the years of microwave diodes configured to act as calibrated noise sources.

But, alas, the noise-figure market was mostly limited to radar and electronic-warfare (EW) applications. Communications applications were more interested in linearity of amplification and not noise performance. Noise-figure measurements for component developments helped some. But the commercial success of noise-figure instruments was modest.

It was the advent of the HP 8970A in 1981, which measured and computed out its own noise figure, that re-energized noise-figure measurements. Its full downconversion receiver with high intermediate frequency (IF) was able to tune 10 to 1600 MHz. By providing noise figure and gain readings simultaneously, circuit engineers were able to optimize their front-end amplifiers, often trading a little gain for improved noise figure.

John Minck
Palo Alto, CA

TECHNOLOGY



CAPABILITIES

PLACING A SPOTLIGHT ON FIBER OPTICS

Fiber-optic technology has often been considered a rogue science within the traditional high-frequency design community. After all, it is a technology based on photons rather than electrons, and subject to laws other than those formulated by Kirchoff, Ohm, and Thevenin. In the 1980s, when commercial optical laser sources and photodetectors became available at gigahertz rates, many RF and microwave designers of electromagnetic (EM) circuits and systems felt threatened by a technology based on glass fibers and light waves.

But time can change the way that things are viewed. Fiber-optic technology now runs at microwave rates; laser diodes and photodetectors are available for analog bandwidths in excess of 10 GHz, such as the 1-to-11-GHz links (see *Microwaves & RF*, April 2000, p. 133) developed by MITEQ, Inc. (Hauppauge, NY), or the host of integrated circuits (ICs) for 10-Gb/s digital applications from a variety of semiconductor suppliers.

The cellular market is often viewed as an opportunity for suppliers of wireless equipment, but many fiber-optic manufacturers have also found this to be a market for their technology. Anacom Systems Corp. (New Brunswick, NJ) has enjoyed several years of steady growth in their sales of fiber-optic transceiver modules for remote connections in cellular systems. And Ortel Corp. (Alhambra, CA) expanded its business well beyond cable-television (CATV) systems by marketing wide-bandwidth, high-speed optical communications systems to cellular service and equipment providers. The firm's success in cellular markets was a large reason for its acquisition earlier this year by Lucent Technologies, one of the leading suppliers of wavelength-division-multiplex (WDM) fiber-optic hardware.

For much of its history, fiber-optics technology has relied on simple, direct-amplitude-modulation techniques to transfer information through a glass fiber. But time has also taught communications engineers to borrow from other technologies. The results are wideband WDM (WWDM) and dense WDM (DWDM) formats with enhanced information-carrying capabilities.

If some of the presentations from the recent first WDMcon conference and exhibition are an indication (see p. 29), there will be a great deal more crossover of modulation techniques occurring from the EM world to the optical world. Presenters such as Eric Schmidt, director of business development at Centerpoint Broadband Technologies (San Jose, CA), pointed to such techniques as optical subcarrier multiplexing (SCM), essentially a form of frequency-division multiplexing (FDM), as a means of dramatically increasing a given slice of bandwidth in an optical system through channelizing. While this has been a long-time practice in microwave receivers, many such modulation techniques are first being explored in fiber-optic systems.

With the push for Internet access, video on demand, and other bandwidth-intensive services, there is little doubt that even more bandwidth-conserving modulation methods will be needed in next-generation optical systems, and that EM and optical systems will continue to move closer together. ••

Jack Browne

Publisher/Editor

Microwaves & RF

A Penton Publication

Group Publisher Craig Roth—(201) 393-6225
Publisher/Editor Jack Browne—(201) 393-6293
Managing Editor Peter Stavenick—(201) 393-6028
Senior Editor Gene Heftman—(201) 393-6251
Senior Editor Don Keller—(201) 393-6295
Special Projects Editor Alan ("Pete") Conrad
Copy Editor John Curley ▪ Mitchell Gang
Editorial Assistant Dawn Prior
Contributing Editors Andrew Laundrie ▪ Allen Podell

MANUFACTURING GROUP
Director Of Manufacturing Ilene Weiner
Group Production Director Mike McCabe
Customer Service Representative
Dorothy Sowa—(201) 393-6083 or FAX: (201) 393-0410
Production Coordinators Lu Hlavaty, Judy Osborn, Eileen Slavinsky
Digital Production Coordinators Mike Turro, Leilani Locket, Pat Boselli

ART DEPARTMENT
Group Art Director Peter K. Jeziorski
Associate Group Art Director Anthony Vitolo
Staff Artists Linda Gravell ▪ James Miller ▪ Michael Descul
Art Coordinator Wayne M. Morris

Reprints Reprint Services (651) 582-3800
Circulation Manager Nancy Graham—(216) 696-7000
Vice President/Group Director John G. French

Penton
Penton Media, Inc.

Chief Executive Officer Thomas L. Kemp
President/Chief Operating Officer Daniel J. Ramella
Chief Financial Officer Joseph G. NeCastro
Chief Technology Officer Gary W. Hargreaves
Executive Vice President/Group President David B. Nussbaum
Executive Vice President/Group President James W. Zaremba
Senior Vice President/Human Resources Katherine P. Torgerson
Vice President/Investor Relations Mary E. Abood

Editorial Office
Penton Media, Inc.
611 Route #46 West, Hasbrouck Heights, NJ 07604
Phone: (201) 393-6286, FAX: (201) 393-6297

International editions are shipped via several entry points, including: Editeur Responsable (Belgique), Vuurgatstraat 92, 3090 Overijse, Belgique.

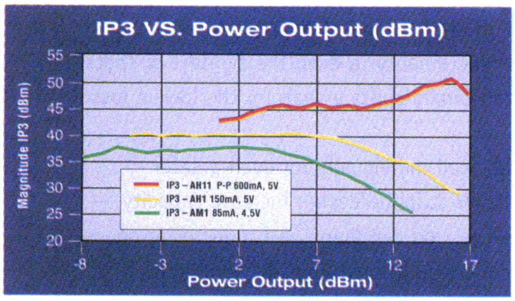
Microwaves & RF is sent free to individuals actively engaged in high-frequency electronics engineering. In addition, paid subscriptions are available by writing to: Penton Media, *Microwaves & RF*, c/o Bank of America, Subscription Lockbox, P.O. Box 96732, Chicago, IL 60693; Tel.: (216) 931-9188, FAX: (216) 696-6413. Prices for non-qualified subscribers are:

			Single Copies	
	1 Yr. (Surface)	1 Yr. (Air Mail)	Regular Issues	PDD Only
U.S.	$ 75.00	—	$10.00	$100.00
Canada	$100.00	$135.00	$12.00	$125.00
Mexico	$120.00	$174.00	$14.00	$125.00
All other countries	$135.00	$243.00	$16.00	$125.00

Reprints can be ordered from Reprints Services at (651) 582-3800.

Back issues of *MicroWaves* and *Microwaves & RF* are available on microfilm, microfiche, 16-mm, or 35-mm roll film. They can be ordered from Xerox University Microfilms, 300 North Zeeb Rd., Ann Arbor, MI 48106. For immediate information, call (313) 761-4700.

Need Higher Power? You need Watkins-Johnson's new AH11 amplifier.



WJ High Dynamic Range Amplifiers

Product	Frequency (MHz)	IP3 (dBm, typ.)	P1dB (dBm, typ.)	NF (dB, typ.)	Bias current (mA, typ.)
AH11	250-3000	47	27	3.7	600
AH1	250-3000	41	21	2.9	150
AM1	250-3000	36	18	2.6	75

Ultra high IP3 is what our new AH11 is all about. Combined with a very low noise figure, it's the perfect choice for today's multichannel wireless systems. Drawing only 600mA, the AH11 delivers 17dBm of linear output power with an IP3 of 50dBm. A great price combined with the outstanding linear efficiency makes this versatile amplifier perfect for multiple sockets, reducing overall part count.

Need Lower Power? Both the AH1 and AM1 offer low noise figures which, together with their inherent high IP3, deliver superior performance at the best price in the industry.

For more details, call our toll free number or fax us at 650-813-2447. Email us at wireless.info@wj.com to request data sheets and a complete catalog.

The Communications Edge™

ISO 9001 WATKINS-JOHNSON WIRELESS PRODUCTS GROUP

Visit us on the web at www.wj.com

1-800-WJ1-4401

WATKINS-JOHNSON

Distributed In U.S.A. by Nu Horizons Electronics: 888-747-6846; **Richardson Electronics:** 800-348-5580

In Europe call WJ: +44-1252-661761 or your local Richardson Electronics Office: **France:** (01) 55 66 00 30; **Germany:** (089) 890 214 0; **Italy:** (055) 420 10 30 **UK:** (01753) 733010

CIRCLE NO. 308

Breakthrough Occurs In Contact Printing Technology

MUNICH, GERMANY—KARL SUSS announced recently that it has finalized an agreement with Motorola Labs to offer proprietary new Mask Protection Technology (MPT) to its worldwide client base. The immediate customer benefit of this new technology includes significantly increased device yields through extreme reduction of particle contamination in hard- and vacuum-contact lithography. This patent-pending technology supports a large number of contacts between mask and wafer without the normal mask wear or damage. The results of this new process allow SUSS to immediately provide its customers with a dramatically increased yield compared to conventional contact printing. This is accomplished with a resolution capability that is similar to projection-lithography techniques.

Vacuum-contact prints manufactured with the new process at the 0.75-mm resolution level show no significant degradation after 200 wafers are processed. There is no remarkable particle contamination of the mask, so that an excellent contact can be maintained between mask and wafer, even after a large number of subsequent prints.

SUSS considers the main markets for this novel technology to be communication-market [gallium-arsenide (GaAs) devices, surface-acoustic-wave (SAW) filters, optoelectronics] as well as MEMS/MST applications where contact printing is already widely used. The new technology will make the transition from laboratory devices to production easier, since the same printing method can be used for both.

Enhancement/ Depletion Semiconductor Process Is Announced

LOWELL, MA—M/A-COM, a provider of wireless RF, microwave, and millimeter-wave integrated circuits (ICs), recently announced a gallium-arsenide (GaAs)-based Enhancement/Depletion (E/D)-mode semiconductor IC process. M/A-COM has installed the process at its Colorado Springs, CO fabrication facility as well as its newly acquired Roanoke, VA operation (formerly ITT GaAsTEK), placing M/A-COM among the few companies in the world manufacturing E/D ICs.

M/A-COM developed the E/D process to meet the increasingly stringent linearity and single-supply-voltage requirements of second-generation (2G) and third-generation (3G) wireless handsets, infrastructure, and wireless local-area-network (WLAN) products. In addition, this process will also support the integration of high-frequency analog and high-speed digital circuitry on the same semiconductor chip.

The E/D process features two field-effect-transistor (FET) device types (one enhancement-mode FET and one depletion-mode FET). The enhancement device supports on-chip gain-mode switching without requiring a negative supply voltage. The depletion-mode device is ideal for RF switching, mixing, and amplification. Cellular-phone transceivers developed using this process offer more than 50-percent lower current consumption for equivalent RF performance compared to the latest silicon-germanium (SiGe) bipolar-complementary-metal-oxide-semiconductor (BiCMOS) products.

Mobile Internet Services Are Introduced

ATLANTA, GA—GTE recently introduced three mobile Internet services that provide users with information pertinent to them in a more timely fashion than previously available.

"We saw that the existing wireless Internet services were not meeting the needs of customers," says Marc Lefar, vice president of marketing for GTE Wireless. "So we set out to solve the two biggest problems—there's too much information on the Internet to be easily accessed on a wireless phone and it's too difficult to navigate through multiple websites to get all the information you need while on the go."

GTE Wireless has introduced a new personal web page (http://www.mygtew.com) that provides customers with the ability to use their desktop personal computers (PCs) to tailor the exact information that they want to see on their phone screens. Additionally, a user can instruct the web page to contact them when certain events occur, such as a stock hitting a certain price. This provides users with direct, immediate access to customized information.

To get started, customers simply log onto their personal My GTEW web page using their desktop PC. They then begin selecting the specific information they want to see when using their wireless phones. Customers can easily set up their web page to alert them on their wireless phones when selected events occur.

Interactive Website Features 3D Animation Technology

INDIANAPOLIS, IN—Telstreet.com, Inc. (http://www.telstreet.com), an electronic retailer of wireless phones, services, and accessories, recently announced the introduction of several interactive features on its website including three-dimensional (3D) animated phones, live chat, and text messaging.

Telstreet.com is the first wireless aggregator website to feature cutting-edge 3D animation technology that allows customers to view wireless phones from all angles with a simple mouse click. Additionally, narrated phone features and a helpful programming guide provide customers with concise user information without having to search through a cumbersome user's manual.

Telstreet.com also offers consumers a click-to-chat feature, which supports real-time question-and-answer sessions without having to disconnect from the Internet to call a customer-service representative. In addition, the site's free text-messaging service makes it possible to send a personal note to anyone with a text-enabled wireless phone.

"Telstreet.com's enhanced website gives the customer an opportunity to virtually 'touch and feel' the product," says Terry Dwyer, president and CEO of Telstreet.com. "This greatly improves the online shopping experience for wireless products and helps customers and small-to-medium-size businesses purchase the phone and service package that best fits their needs."

Encryption Technology Secures Wireless Data Services For Law Enforcement

FAIRFIELD, NJ—Paradigm4, a provider of wireless data services and solutions, announced that it is safeguarding criminal data-base queries that are conducted on its recently launched SmartPartner Pager using technology from BellSouth Wireless Data, a provider of wireless data-communications solutions, and Certicom, a mobile e-business security firm. Paradigm4's SmartPartner Pager is a wireless data service that provides law-enforcement officers with the ability to access information from local, state, and federal criminal data bases through the RIM 950 wireless handheld device.

The SmartPartner Pager wireless data service operates in a manner similar to mobile computers found in police cars and enables law-enforcement officers to conduct a range of activities, from validating driver's license and vehicle-registration integrity, to conducting stolen-vehicle and wanted-person searches. Due to its small size and weight, SmallPartner Pager allows officers walking the beat, on bike or equestrian patrol, conducting undercover investigations, or in other situations, to directly retrieve information in an environment where they typically lack that capability.

The SmartPartner Pager operates on the RIM 950 wireless handheld, a device that fits inside the palm of an officer's hand. Paradigm4 developed the SmartPartner Pager application with the assistance of the BellSouth Powertool™ software. Data transmitted and received by the SmartPartner Pager over the BellSouth Intelligent Wireless Network℠ are encrypted with Certicom's elliptic-curve-cryptography (ECC) technology.

CTIA Chief Calls For Wireless Simplified Taxation

WASHINGTON, DC—Tom Wheeler, president and CEO of the Cellular Telecommunications Industry Association (CTIA), recently testified before the House Judiciary Committee's Commercial and Administrative Law Subcommittee in support of H.R. 3489—the Wireless Telecommunications Sourcing & Privacy Act. CTIA worked with the National Governors' Association, the National League of Cities, the Federation of Tax Administrators, the Multistate Tax Commission, and the National Conference of State Legislatures to develop a nationwide, uniform method of sourcing and taxing wireless revenues.

Wheeler says that states and localities have adopted a variety of ways to tax wireless subscribers for the calls that they make, including siting the taxes to the location of the originating cell site, the origination switch, or the billing address of the customer. As a result, wireless customers may be taxed several times for one call.

Wheeler states, "A new method of sourcing wireless revenues for state and local tax purposes is needed to provide carriers, taxing jurisdictions, and consumers with an environment of certainty and consistency in the application of tax law; and to do so in a way which does not change the ability of states and localities to tax these revenues."

Multimedia Application Delivers High-Quality Video

DALLAS, TX and SAN DIEGO, CA—The ability to preview movies or catch the day's sports highlights on wireless phones will soon be a reality as Texas Instruments, Inc. and PacketVideo Corp. announced that PacketVideo's PVPlayer™ decoding software and PVAuthor™ encoding software will provide streaming media support for TI's next-generation Open Multimedia Application Platform (OMAP™). This software, enabled by TI's programmable digital-signal-processor (DSP)-based technology, will support the delivery of full-motion video and audio over wireless networks on mobile-information devices, including smart phones, handheld devices, wireless personal digital assistants (PDAs), and laptop computers, bringing movie previews, news briefs, traffic reports, and product-purchasing information to consumers.

PacketVideo's PVPlatform™, which includes PVPlayer and PVAuthor, provides MPEG-4-compliant software-based encoding, decoding, and transmission-management capabilities designed to deliver a variety of content and rich media to mobile devices.

"TI's OMAP offers an outstanding platform for distributing a wide range of multimedia applications and content wirelessly to a consumer's hip pocket," says Dr. James Brailean, co-founder, president, and chief technology officer for PacketVideo. "By leveraging OMAP's performance and power capabilities, PacketVideo's MPEG-4-compliant multimedia software will deliver superior picture and audio quality to mobile-information devices, at significantly reduced power-consumption levels. This will enhance a consumer's experience with wireless-rich digital media."

PacketVideo's error-resilient technology recognizes and conceals errors that are inherent in wireless networks, enabling mobile-information devices to receive enhanced video-image quality on wireless networks with bit rates as low as 14.4 kb/s. PacketVideo's solution has been designed to support all major digital wireless telephony standards in use today, as well as next-generation wireless networks currently being developed.

Kudos

Stealth Microwave recently received an award from Raytheon Microsystems in Buena Park, CA for recognition and appreciation of superior value, service, and innovative power-amplifier (PA) design...Teradyne, Inc. has shipped its 500th Catalyst, the first test system to introduce system-on-a-chip (SOC) testing capabilities and the leading SOC system to date. The 500th system was shipped to STMicroelectronics in Agrane, Italy...Joseph P. Walker, chairman, president, and chief executive officer of CTS Corp., received the Marco Polo Award at the Hong Kong Macau Centre in Beijing, China on March 30. The prestigious Marco Polo Award is given to individuals or corporations in recognition of their support for the "China Project," which sends foreign volunteer experts to China to contribute their knowledge and expertise to improve China's economic and social development...Stanford Microdevices, Inc. (SMDI) announced recently that it has received ISO 9002 certification from QMI, an accredited registrar. In order to meet the ISO 9002 standards, the company underwent rigorous inspections of procedures and policies before being thoroughly audited...Agilent Technologies announced that it has shipped more than one million industry-standard, small-form-factor (SFF) MT-RJ fiber-optic transceivers. Agilent is the first company to reach this milestone. MT-RJ has risen as the de-facto standard connection for backbone and campus fiber-optic networks...Dr. Zoltan Cendes, founder and chief technology officer of Ansoft Corp., was honored with the "Scientist" award on April 4 at the 2000 Science & Technology Awards for Excellence. The 2000 Science & Technology Awards for Excellence recognize and celebrate the most outstanding recent achievements in science and technology in Southwestern Pennsylvania...STMicroelectronics has announced that Joseph Borel was awarded one of the IEEE's prestigious Third Millennium Medals at the International Solid-State Circuits Conference (ISSCC) held in San Francisco from February 7 to 9. The Solid-State Circuit Society of the IEEE awarded medals to 45 leading academic and industrial figures worldwide who were deemed to have made outstanding contributions to the Solid-State Circuits Society and Council. Borel was director of design automation and integrated systems for ST's Central research-and-development (R&D) group until his recent retirement. He played a key role in ST's work in the field of system-on-a-chip (SOC) technology.

National's New Multi-Carrier 14-Bit, 135 MSPS D/A Converter Simplifies Wireless Basestation Design

DAC14135 Combines Multiple Carriers, Reducing Basestation Cost and Size

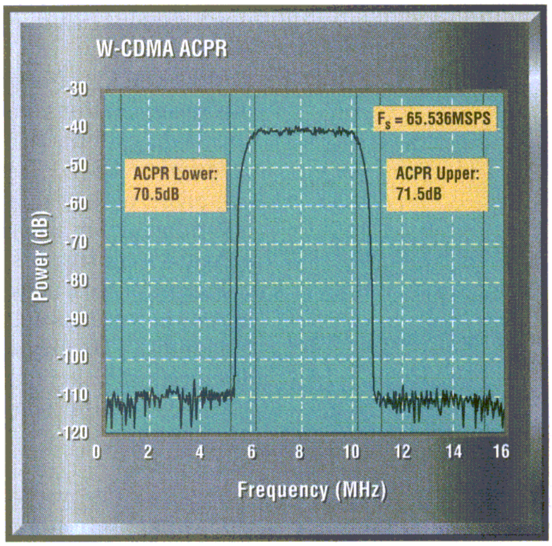
- Wide dynamic range with:
  85dBc SFDR @ 1MHz
  70dBc SFDR @ 20MHz
- TTL/CMOS (+3.3V or +5V) Inputs
- 48-pin TSSOP provides small footprint
- Low 185mW power dissipation
- Costs less than $10

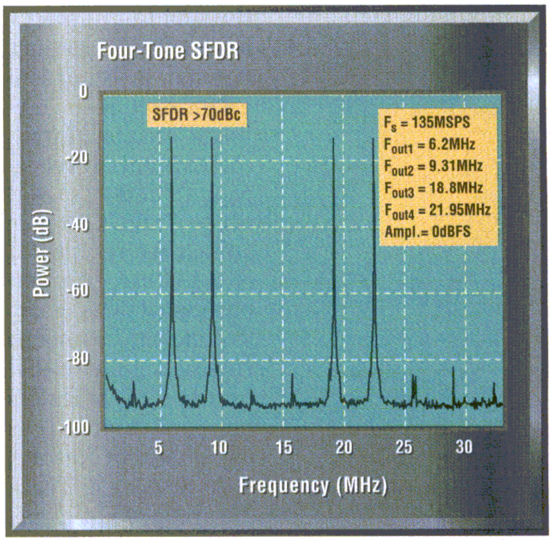
Ideal for Multi-Carrier and Multi-Standard Cellular Basestations, Wireless Local Loop Basestations, Direct Digital Synthesis (DDS), ADSL and HFC Modems, and Instrumentation

For More Information on DAC14135:
www.national.com/appinfo/wbp/
1-800-272-9959

Evaluation Board Available at:
www.national.com

Free CD-ROM Data Catalog Available at freecd.national.com





National Semiconductor®

Fiber-Optic Report

Demands for broadband services and high-speed data have pushed the production of devices and test equipment that are ready for the installation of 10-Gb/s optical networks.

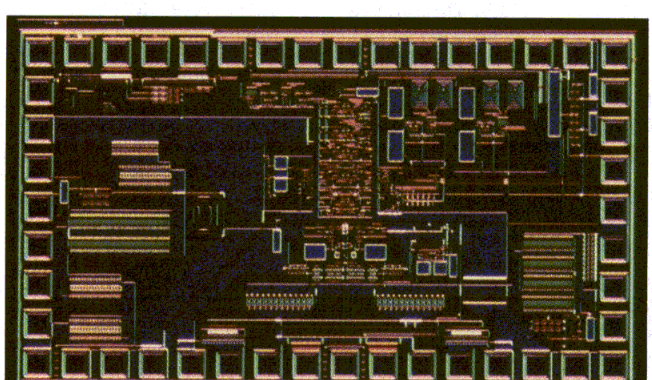
Optical Systems Look To 10 Gb/s And Beyond

JACK BROWNE
Publisher/Editor

FIBER-OPTIC technology has made tremendous strides in recent years in terms of bandwidth and data capacity. With the increasing use of electronic mail (e-mail) and the Internet, communications service providers must now anticipate that the bandwidth of present wired and wireless networks will erode quickly. For that reason, fiber-optic links are attractive since they can be readily upgraded through new transmitters (Tx) and receivers (Rx) to achieve higher data rates. The current target for speed in new systems is 10 Gb/s, with 40 Gb/s just around the corner.

The optical landscape has been one of change during the past year. Carriers now seriously recognize the need for diversification in transport technologies and are willing to create networks that combine wire, wireless, and optical-fiber approaches. Lucent Technologies (Murray Hill, NJ), for example, completed its acquisition of Ortel Corp. (Alhambra, CA) this past April. Ortel, a leader in high-speed optical device technology, was one of the first firms to offer laser diodes capable of operating past 10 GHz. In addition to a strong market in cable television (CATV), Ortel is also a leading supplier of fiber-optic subsystems for in-building distribution of wireless communications networks.

By most accounts, the market for fiber-optic components and systems should continue to grow rapidly during the next few years. Much of the motivation for this growth lies in the desire of the business and private sectors for increased broadband services, for such things as Internet access and video on demand. And, according to market-research firm Forrester Research, the broadband data market is one of the fastest-growing segments of the communications networking market. The company projects the market for broadband Internet access in the US alone to top $33 billion by 2003.

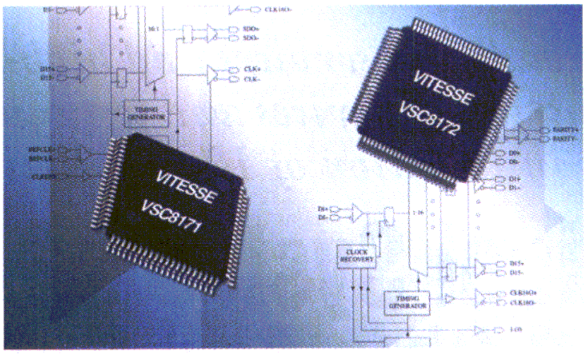


1. The model VSC7990 laser driver operates to 10.7 Gb/s. (Photograph courtesy of Vitesse Semiconductor Corp., Camarillo, CA.)

Optical fiber, of course, can channel wide information bandwidths. A fiber network is generally limited only by the speeds of the optical switches, sources, and photodetectors, and these components are getting faster. For years, semiconductor suppliers have offered components capable of supporting optical-carrier (OC) rates to OC-48 (approximately 2.5 Gb/s). And now, many of these same firms, including Fujitsu Compound Semiconductor, Oki Semiconductor (Sunnyvale, CA), and Vitesse Semiconductor (Camarillo, CA), are sampling photodetectors, laser diodes, and other components ready for OC-192 applications at 10 Gb/s.

Fiber-optic digital design has always been about compressing as many data streams as possible onto an optical cable. Multiple channels are placed on a single cable by some form of multiplexing. For example, Synchronous Optical Network (SONET) systems are based on time-division-multiplex (TDM) techniques. SONET TDM systems send data for each channel during short time slots, assigning one time slot per channel. Due to this approach, TDM components must operate at the combined data rate for all channels.

An alternative method is the use of wavelength-division multiplexing (WDM), where a different wavelength is used for each multiple data streams (see sidebar). In these systems, multiple laser sources and detectors are used at different wavelengths, with signals passed through narrowband optical filters to avoid the equivalent of optical signal crosstalk which can result in reduced bit-error-rate (BER) performance in digital systems. A dense-wavelength-division-multiplexing (DWDM) system is a WDM variant used primarily in backbone networks where the highest information-carrying capacity is needed.



2. The VSC8171 multiplexer and the VSC8172 demultiplexer are shown. (Photograph courtesy of Vitesse Semiconductor Corp., Camarillo, CA.)

Another form of optical multiplexing, optical subcarrier multiplexing (SCM), is actually a form of optical frequency-division multiplexing (FDM). The available optical spectrum is divided into channels, with a different frequency band for each channel. Each SCM circuit operates only at the individual channel-data rate, creating a flexible system with high data capacity. The multiplexing approach has been used in the past in CATV distribution systems and in satellite-communications systems.

In all of these multiplexing approaches, the bandwidth of the optical fiber is essentially the bandwidth of the components at either

CONFERENCE FOCUSES ON WDM

ALAN "PETE" CONRAD
Special Projects Editor

Wavelength-division multiplexing (WDM) provides a method of increasing the data capacity of high-speed optical networks. Interest in the technology recently drew several hundred attendees to the first WDMcon conference and exhibition, which was held May 23-25, 2000 at the Wyndham Hotel (San Jose, CA). The conference covered core WDM technology, future metropolitan and long-haul markets, strategies for deployment, and methods of managing bandwidth.

The keynote address was made by Harry Carr, chairman and CEO of Tellium, Inc. (Sunnyvale, CA). Carr noted that growth in data traffic continues to outpace the ability of carriers to deliver services. He volunteered that the use of optical components enables carriers to "gracefully" upscale network performance.

Presenters at the conference represented a range of firms involved in WDM development, including Centerpoint Broadband Technologies (San Jose, CA), Chromatis Networks (Chevy Chase, MD), Lucent Technologies (Murray Hill, NJ), The Kevryn Corp., and Tellium, Inc. For example, David Andreasen from The Kevryn Corp. presented a one-day introductory session on WDM, covering optical terminology, key fiber-optic parameters, critical optical components (such as couplers, isolators, and filters), and incorporation of WDM, wide WDM (WWDM), and dense WDM (DWDM) for such functions as asynchronous-transfer-mode (ATM) communications over Synchronous Optical Network (SONET) systems and packet communications over ATM and SONET systems.

Rob Newman, CEO and co-founder of Atmosphere Networks (Campbell, CA), reviewed optical-access architectures and the decisions for choosing different physical topologies and protocols. He reviewed different aspects of access-network support and services using time-division-multiplex (TDM) SONET rings and cross-connects, Internet-protocol (IP) switches and routers, and multiservice aggregators. He also covered how to build optical networks, how to provide broadband services, and applications based on digital-subscriber-line (DSL) technology.

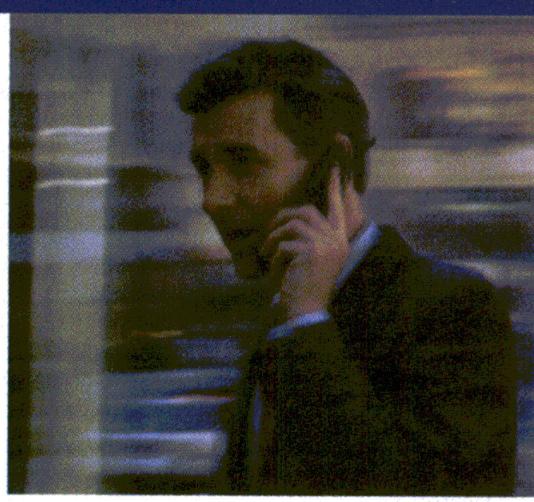
Jeff Kunst, director of product development, and Doug Green, vice president of Marketing, both of Chromatis Networks, Inc., detailed an all-optical network where information would be carried without electrical components. The presenters compared the benefits of an all-optical network and optical-to-electrical network configurations, describing performance trade-offs for each approach. In a related talk, Hal Calhoun, vice president of product marketing for ONI Systems, reviewed the challenges associated with the existing metropolitan-network infrastructure plus solutions offered by an all-optical approach.

Eric Schmidt, director of business development for Centerpoint Broadband Technologies (San Jose, CA), reviewed high-capacity optical multiplexers and modems for metropolitan-fiber networks. The company's bandwidth-efficient single-board gigabit modems support rates through OC-12 (622 Mb/s), with ready interconnectivity to SONET and SDH services through fiber or wireless connections between nodes.

Stefan Hunsche of Lucent Technologies reviewed the segmentation of global networks. His report covered the evolution of single-mode fiber, attenuation and chromatic dispersion by fiber type, and network trends. He also discussed DWDM long-haul transmission networks, the impact of fiber amplifiers, and terabit networks. Other topics included the effects of dis-

Things are moving fast. Can you keep up with the demands of tomorrow's CDMA handset designs?

Now you can. Design faster and with more confidence with Agilent Technologies' flexible **CDMAdvantage** RF chipsets for your handset designs.



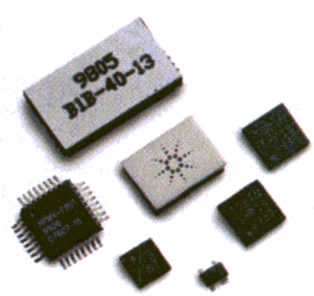
The **CDMAdvantage** complete product family of RF solutions is designed to work together in DBTM, DBDM and SBSM handsets. We supply extensive characterization data as well as complete receive and transmit chain demonstration boards. All to enable you to make better decisions faster– this is the **CDMAdvantage**.

Our transmit chain maximizes efficiency, from the adaptive current control on the upconverters to medium power optimization on the power module. The receive side has a switched LNA and an adjustable linearity downconverter to ensure compliance to even the most rigorous system specs.

Agilent RF semiconductors are already in millions of CDMA phones. And we are continuously adding more capacity, so you can move with the speed that the market demands.

At Agilent we listen to your needs to help you reach the right solution– fast.

World's smallest PCS duplexer,
Integrated DBTM Power Amplifier,
High output-level Upconverters,
Variable linearity Downconverters,
Miniature LNA with Bypass Switch



See how fast you can move with the flexiblility of the CDMAdvantage RF chipset. Visit our website to see product specifications and our latest technologies.

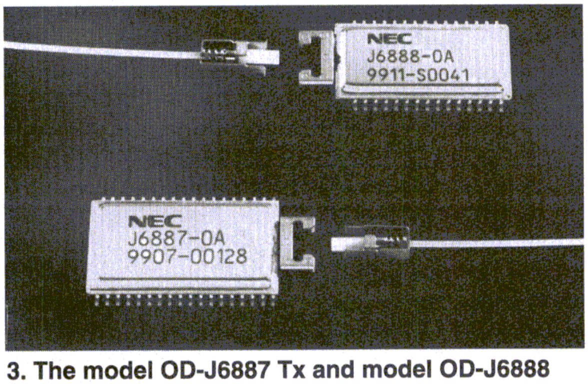
www.agilent.com/view/cdmadvantage

Agilent Technologies
Innovating the HP Way

CIRCLE NO. 221

Agilent Technologies is a subsidiary of Hewlett-Packard Company CDMA 4/00 ends of the fiber: the laser diodes, the photodetectors, and the multiplexers/demultplexers. Within the past year, semiconductor manufacturers have begun to produce 10-Gb/s devices in production quantities for the buildup of OC-192 optical networks.

For example, Vitesse Semiconductor Corp., a long-time supplier of gallium-arsenide (GaAs) components for high-speed telecommunications systems, recently announced a complete line-card solution for 10-Gb/s optical systems. The line of integrated circuits (ICs) includes the model VSC7990 laser driver, the model VSC8171 16:1 multiplexer with clock-multiplication unit (CMU), the model VSC8172 1:16 demultiplexer with CDR, and the VSC9116 transport-terminating transceiver.



3. The model OD-J6887 Tx and model OD-J6888 Rx are designed for use at data rates to 2.44832 Gb/s. (Photograph courtesy of California Eastern Laboratories, Santa Clara, CA.)

The VSC7990 laser driver (Fig. 1) is suitable for OC-192 and STM-64 SONET and synchronous-digital-hierarchy (SDH) systems of all distances. The laser driver features rise and fall times of less than 35 ps with low jitter at temperatures from –40 to +125°C. In support of DWDM systems requiring extra headroom for forward-error-correction (FEC) algorithms, the laser driver operates to 10.7 Gb/s. Laser bias and modulation currents (to 100 mA) are set by external components. Clock and data inputs are differentially terminated in 50-Ω impedances for simple circuit-board layouts.

The VSC8171 is a 16:1 multiplexer that integrates a high-speed clock output which can be used to verify jitter performance (for compliance, for example, to the SONET standard) or to reclock data. The clock output can be disabled to reduce power requirements. The VSC8172 1:16 demultiplexer, which features 50-mV peak-to-peak sensitivity, incorporates the necessary clock- and data-recovery functions at 10 Gb/s. The multiplexer and demultiplexer (Fig. 2) suit standard OC-192 and STM-64 systems at 9.953 Gb/s and for use through 10.66 Gb/s in systems with FEC.

CONFERENCE FOCUSES ON WDM *(continued from page 30)*

persion on optical crosstalk and how WDM enables a cost-effective evolution to high-capacity networks.

In other presentations, Peter Meade, managing partner of TeleResearch, Inc. (Medford, NJ), chaired a discussion with service providers about the roadmap set out by the optical-domain-services-interconnect (ODSI) system for a smooth connection between electrical and optical elements in networks. Demetri Elias, director of product management for Sorrento Networks (Channahon, IL) reviewed how metropolitan-area networks originally designed for voice can achieve a migration path to an end-to-end optical solution. Scott White, director of technology for Atmosphere Networks (Campbell, CA), addressed the technology and architecture of DWDM and how to retain the service-creation capability of higher-layer switching of multilayer networks and the impact of these changes on carriers and subscribers. Bill Mitchell vice president of marketing for Astral Point Communications (Chelmsford, MA), covered the topics of the "last 10-mile problem" reviewing the constraints of DSLs, cable Internet, local-area-network (LAN) services, passive optical networks (PONs), and the evolution of the SONET ring-based environment.

Tom Alexander, CEO and president of LuxN, Inc., covered the benefits of optical access and how optics unblocks the bandwidth bottleneck between customer-premesis equipment (CPE) and central office or population (POP) using dark-fiber solutions. Jeff Kunst, director of product management of Chromatis Networks reviewed WDM technology as applied to long-distance cross-connects and metro-area connects. Scott T. Wilkson, senior manager of applications engineering for Kestrel Solutions, covered problem solving with DWDM, including a review of the metropolitan-network challenge, the advantages and disadvantages of DWDM and SONET, optical frequency-division multiplexing (FDM) advantages and disadvantages, and optimal metropolitan-network solutions. The session reviewed the topics of a rapidly changing metropolitan market, the variety of traffic types and demands, metropolitan-transport-layer requirements, and the importance of timely responses to consumer demand. The session reviewed the rapidly changing metropolitan market.

Numerous exhibitors displayed their wares at WDMcon, including Canoga Perkins Corp. (Chatsworth, CA), a leading manufacturer of fiber-optic data-communications equipment; Oplink Communications, Inc., (San Jose, CA), a manufacturer of components to expand optical bandwidth and enhance network performance; and Kaifa Technology, (Sunnyvale, CA), a large-volume manufacturer of WDM- and DWDM-integrated components, such as circulators and isolators. Additional exhibitors included ADC Telecommunications, Inc. (Richardson, TX), a supplier of high-bandwidth systems, services, and solutions for the last mile of communication networks; and Veeco Instruments, Inc. (Plainview, NY), a supplier of metrology, etching, and deposition tools.

The VSC9116 performs the section- and line-termination functions, monitors OC-192 (STS-192) system performance, and enhances the byte interleaving/deinterleaving of an STS-48 datastream. Overhead-access ports support insertion and extraction of each overhead byte from the incoming data stream for flexible performance monitoring. The VSC9116 incorporates a 4 × 4 STS-48 granular crosspoint matrix for cross-connect and testing.

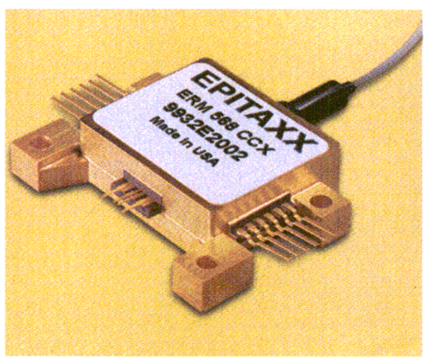
Another veteran supplier of GaAs components for optical communications, Oki Semiconductor has announced a 16:1 multiplexer (model KGL4221) , a 1:16 demultiplexer (model KGL4222), and a limiting amplifier (model KGL4217) for use in OC-192 systems. Based on a low-power 0.2-μm gate-length GaAs metal-semiconductor-field-effect-transistor (MESFET) process, the devices are compatible with lower-speed optical systems. The multiplexer and demultiplexer make use of the firm's memory-cell flip flops (MCFFs) and direct-coupled FET-logic (DCFL) technology to operate at maximum speeds to 12.5 Gb/s with low power consumption.

The KGL4217 limiting amplifier also makes use of the DCFL technology to achieve power dissipation of 0.25 W for a +2-VDC supply. Capable of operating at rates in excess of 10 Gb/s, the limiting amplifier offers sensitivity of 50 mV peak-to-peak.

A line of optical components from Fujitsu Compound Semiconductor, Inc. supports data rates through 10 Gb/s. The firm's model FRM5N1 42DS avalanche photodiode detector features a gain-bandwidth product of 80 GHz and can be used as an optical Rx in 1310- and 1550-nm SONET and SDH systems operating through 10 Gb/s. It incorporates a heterojunction-bipolar-transistor (HBT) preamplifier to achieve typical sensivity of –24 dBm and optical return loss of 27 dB. The device is also available with less sensitivity, as model FRM5J142DS, with typical sensitivity of –17 dBm while maintaining the operating bandwidth to 10 Gb/s.

The company offers extensive lines of semiconductor lasers for high-speed fiber-optic networks, including the model FLD5F10NP. The multi-quantum-well (MQW)-distributed feedback (DFB) laser integrates an electro-absorption modulator to achieve long transmission spans in 10-Gb/s systems. Capable of 5-mW typical optical power, the modulator/laser achieves extinction ratios in excess of 10 dB with +2.6-VDC peak-to-peak modulation.

Optical semiconductor suppliers have even paid attention to the need for high-volume manufacturing practices when building high-speed fiber-optic equipment. California Eastern Laboratories (Santa Clara, CA), for example, on behalf of Japanese partner Nippon Electric Corp. (Tokyo, Japan), announced the industry's first fiber-optic Tx and Rx modules developed for pick-and-place assembly. The model OD-J6887 Tx and model OD-J6888 Rx (Fig. 3) are designed for use with a single +3.3-VDC supply and can be used for data rates to 2.44832 Gb/s (OC-48 and STM-16).



4. The ERM 568CCX PIN/TIA high-gain optical Rx module features typical sensitivity of –17 dBm when operating at 10 Gb/s. (Photograph courtesy of JDS Uniphase Corp., EPITAXX Div., West Trenton, NJ.)

EPITAXX, Inc. (West Trenton, NJ), which was acquired by JDS Uniphase late last year, offers a comprehensive lineup of 10-Gb/s APD and positive-intrinsic-negative (PIN) optical Rx for OC-192 and SDH-64 applications. The firm is actively pursuing research and development (R&D) on Rx and detectors for OC-768 and SDH-256 (40 Gb/s).

The company offers the model ERM 568CCX PIN/TIA high-gain optical Rx module (Fig. 4). The typical responsivity of 0.90 A/W at 1550 nm. The sensitivity is −17 dBm when operating at 10 Gb/s, while the output return loss is typically 12 dB. The Rx module dissipates 0.8-W maximum power, and can be supplied in a choice of packages with an optical pigtail connector.

New manufacturing technologies have been developed to meet demands for DWDM components. Fused-fiber technology is a method where wavelength-filtering and power-splitting functions can be achieved through appropriate splicing, stretching, and fusing of optical fibers. The approach supports the cost-effective manufacture of DWDM multiplexers and demultiplexers, couplers, and spectral filters. Wavesplitter Technology (Fremont, CA) is combining fused-fiber technology with traditional technology to create components and subsystems for large-channel-count installations. Other firms adopting the technology include Arroyo Optics (Santa Monica, CA) and ITF Optical Technologies (Montreal, Quebec, Canada) for laser-pump combiners and multiplexers/demultiplexers using the technology.

Not all advances in fiber-optic technology rely on fiber. TeraBeam Corp. (Seattle, WA) has developed a unique laser-based line-of-sight link that takes advantage of the enormous information (modulation) bandwidth available in focused optical beams. The firm's fiberless optical technology aims at the "last-mile" connections to businesses as part of a larger hybrid (wired, wireless, and optical) communications network. The firm entered into an agreement with Lucent this past April to provide high-speed data networking between local-area-network (LAN) and wide-area-network (WAN) systems. As part of the agreement, the two companies will team on the launch of TeraBeam Internet Systems.

TeraBeam's system uses a diffuse laser beam to broadcast signals and employs special software to compensate for interference caused by building motion and weather.●●

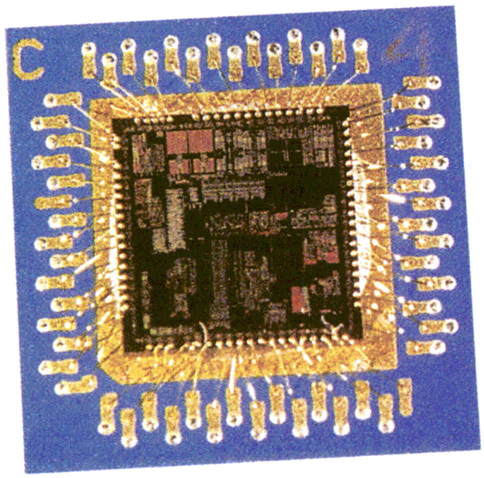
Application Profile

How Do I Make Bluetooth Wireless Products Small and Inexpensive??

Use the Integrated ASIC LTCC Modules from National Semiconductor Using DuPont Green Tape™ and Fine-Line Technology.

An integrated ASIC? Inexpensive?? Tell me more!!!

National Semiconductor leads the way in Bluetooth, Cell Phone and other wireless applications in applying LTCC to integrated wireless modules. National's latest advances in LTCC manufacturing technology, combined with DuPont's advances in Green Tape™, Fodel® Compositions and thick film conductor materials, have established a new low-cost standard for wireless modules.



LOW-COST LTCC

LTCC is the least expensive alternative for your RF wireless design. Consider that the LTCC raw material is inorganic (earth oxides) versus the alternatives — organic (oil). Also, the process is scalable in panel size as the manufacturing volume increases, thereby drastically reducing cost per square inch.

LTCC has the highest passive integration capability of any active/passive component board-level system. More passive components in the LTCC and not on top of the module, resulting in less space utilized and the lowest system cost solution.

THE INTEGRATED ASIC

With the capability of DuPont's Fodel® fine-line technology, active components can be flip-chip mounted to the LTCC module. The high frequency characteristics of the entire vertical structure can be modeled, and performance optimized. Also, results have shown higher-yielding DC interconnects, improved Q on edge-coupled, edge-sensitive structures, and more consistent electromagnetic results in RF structures. The resultant module performance is optimized, space minimized, and the resultant cost 25% to 50% below competing technologies.

LTCC has come to lead the wireless revolution, and offers the lowest-cost, smallest-size, and highest-performance solution to your wireless design. National's LTCC foundry technology offers you the fastest design-to-volume format. Proto cycle times in less than seven days, flexible manufacturing lines accommodating design and capacity changes without delivery interruption, 30-day ramp to volume — all this plus complete assembly and test services that support the full line of DuPont Green Tape™ products.

National: Doing what we do best — prototype turns in 7 days; state-of-the-art technology; and low-cost/high-volume QS9000 manufacturing.

For more information, call National at (949) 380-2054 or visit the National LTCC website at http://www.national.com/ltcc.

National Semiconductor®

DUPONT®

GREEN TAPE™ FODEL® BIROX® DIFFUSION PATTERNING™ LUXPRINT®

CIRCLE NO. 227

EUGENE R. BRANNOCK is the Executive Vice President of Marketing and Engineering for Fujitsu Compound Semiconductor, Inc. (FCSI). He comes to Fujitsu with more than 23 years of experience in the microwave and lightwave industries, specializing in wireless and millimeter-wave technology. As a member of Fujitsu's Board of Directors, Brannock leads FCSI's Marketing Team and Engineering Design Centers.

An Interview With EUGENE R. BRANNOCK

MRF: *What semiconductor technologies for the wireless industry up to 2.5 GHz does Fujitsu specialize in, and what other wireless markets at frequencies beyond 2.5 GHz do you consider important to the company?*

Brannock: Below 2.5 GHz, Fujitsu primarily uses GaAs pseudomorphic HEMT, and will be using InGaP HBT for terminal applications. For the base-station side, we are looking at what we call GaAs power HFET (heterojunction FET). As far as the other wireless markets, we are looking at very broad markets and they utilize the same basic process technologies, which is we think is critical. Those are in the millimeter-wave area (LMDS and SATCOM) in the unlicensed millimeter-wave bands of 50 and 60 GHz, and AICC (Autonomous Intelligence Cruise Controller) sometimes called collision avoidance at 76 GHz. We are not forgetting our traditional applications—wireless local loop; L-, S-, and C-band point to point; and the 5-GHz unlicensed bands. That is an idea of the applications that we are looking at.

MRF: *In the base-station market, what power semiconductor technology do you see as having the best chance for success, assuming that most third-generation (3G) wireless technologies will use some type of wideband-CDMA. And by the way, do you agree that wideband-CDMA is going to be the core of third generation?*

Brannock: Yes we do. And, of course, we have a heavy presence in the Japanese arena, which is already far along on wideband-CDMA system implementation and development. For the base station, as I said, we are looking at the power HFET and actually it is a quasi-enhancement mode version that has excellent performance. We trade-off linearity for power and still maintain excellent efficiency, which we think is very important in the wideband-CDMA application.

MWRF: *Does it have the power capability? How high in power can it go?*

Brannock: Right now, we have readily available 150-W devices and a 240-W device will be discussed at MTT-S (Boston, MA) in June. By the end of the year, we will have a 200-W device on the market. So the power is quite good and we are pretty excited about the power and linearity simultaneously keeping our efficiencies in line.

MRF: *Why do you think the technology (technologies) that you picked will emerge as the power-amplifier (PA) frontrunners? Are there any economic reasons?*

Brannock: The economic reasons on the customers' side are very important. We see power management as very critical to them, and the efficiency of our devices is going to be a significant advantage to them. We have compared silicon LDMOS; and we have also looked at our older GaAs FET MESFET technologies. When we weighed all of the parameters, we came up with our belief that the HFET will be the dominant technical choice. It also has good yield within the factory. We can use relatively larger geometries—LDMOS, for example, is pushing its crit-

EUGENE R. BRANNOCK

ical dimensions; so the yields, I think, will play more of a major role as they continue to shrink the device geometries to maintain the frequency performance. We, on the other hand, are capitalizing on the speed of the material and within the GaAs technology, and we do not have to rely as heavily on the critical dimensions at this point for the 2-GHz application.

MRF: *Some of the manufacturers of GaAs MESFETs believe that they have a declining market share in the wireless infrastructure PA applications. Do you disagree?*

Brannock: We do not disagree with that.

MRF: *You see that the same way as they do, and the HFET is your response to that?*

Brannock: Yes it is.

MRF: *Now maybe we can go into the handset market, and the handset PA market, where a number of semiconductor technologies are available: PHEMTs, HBT, BICMOS, SiGe all aiming at similar applications, so why are there so many different types. What are people trying to do?*

Brannock: Our belief is that the handset market (the entire cellular market) has evolved quite rapidly. And when we were in the 800- and 900-MHz applications and analog configurations, the silicon and the BiCMOS bipolar were readily available, and excellent devices for those applications. But as systems evolved like the HandyPhone at 1.5 GHz and then PCS/DCS at 1800 to 1900 MHz, the silicon structures began to run out of steam and the evolution to GaAs devices, both PHEMT and HBT, became more compatible with the application. When the volumes began to increase, the price competition became fairer between the two technologies, because a fab is a fab. The major cost is the fab facility, not necessarily the material, so if you can properly utilize a GaAs fab in the same way as a big silicon fab, you are very competitive.

MRF: *You are basically saying that that is possible, because a lot of people are always worried about the cost of GaAs compared to silicon.*

Brannock: Yes. In the past, when a GaAs fab was in a niche market, utilizing only 20 percent of its capacity, they could not compete with a silicon fab at full capacity. But when you take a look at the overall costs (assembly, packaging, and testing) and GaAs fabs are at full capacity, you see a more cost-competitive situation.

MRF: *Integration of functions is pretty vital, and a lot of people are trying to do it, in order to reduce cost, size, and power consumption. How are the integration efforts coming along, and what do you foresee for integration in the next year or two?*

Brannock: Fujitsu originally was very successful with its discrete devices and merging them into an MIC. In other words, taking a discrete device and putting it into a module. Then we evolved like the rest of the industry into the MMIC technology, and we think that in itself will be very strong over the next few years. Also evolving in the coming years are multichip modules as the next step in taking the MMIC and integrating it into a module concept, facilitating more functionality within the component. Basically a subsystem is where you might be able to mix semiconductor technologies within a module—where you have conversion, switching, PA, and driver amplifiers. These cannot all be put on the same semiconductor, but could be put in the same module using different materials. We are very proactive on the MCM strategy.

THE MAJOR COST IS THE FAB FACILITY, NOT NECESSARILY THE MATERIAL, SO IF YOU CAN PROPERLY UTILIZE A GaAs FAB IN THE SAME WAY AS A BIG SILICON FAB, YOU ARE VERY COMPETITIVE.

MRF: *Do you see any problem in getting passive components into these modules? How would that be done?*

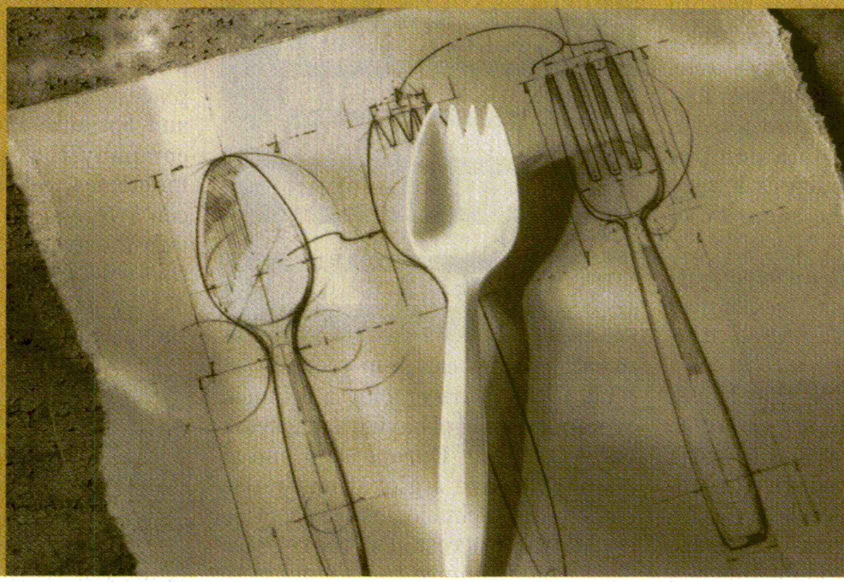
Brannock: There are a lot of passive components that can be integrated on the IC itself, there is no doubt about that. Some of the recent packaging technologies are not traditional ceramic—they are non-ceramic and they are processed in a fashion that allows you to put the passive components and tighter dimensions into the package, unlike the semiconductor. This is just an example.

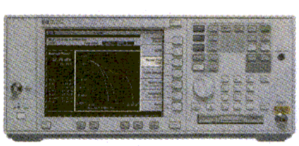
MRF: *In terms of packaging, you know that is a big cost item in a handset and do you have any feeling where they are going in the next couple of years to reduce cost, improve reliability, put more inside that package?*

Brannock: One of the items we have capitalized on within Fujitsu is our effort in the AICC area, the 76-GHz technologies. Those are very high volumes for the automotive industry, and emerging quite rapidly (in domestic Japan). We have learned a great deal in recent years about very-low parasitic packages and very cost-effective packages as well as manufacturing techniques like flip-chip bonding, the non-ceramic materials, and robotics. We are taking these to lower frequency applications and applying the appropriate pieces of it to HandyPhone, as we call it, or cellular markets and also many markets in between.

MRF: *What are the main challenges in the future for the wireless industry semiconductor manufacturers? What do you see looming on the horizon?*

Brannock: We believe that a major challenge is having multiple sources for security of supply. Traditionally, RF and microwave manufacturers have used techniques that really didn't bode well for second- or multiple-source opportunities. The major suppliers, ourselves, and others need to work closer together to enable these overall markets to fully capitalize on their potential so that there is supply in appropriate volumes when necessary. Another major factor for the markets is that we see the mobile communications segment maturing now. There are less planned system changes—remember we went from generation one, to two, to two and a half, to three, and not a lot of activity or dis-





Agilent Technologies' E4406A Vector Signal Analyzer cussion on four, five, or six. We see 3G having relatively longer lifetime and reliability is going to be a key factor. System integrators do not want to go out and repair these systems, and there is going to be less need to replace them with new system architectures. 3G seems to be very stable. Data traffic is very important, and our customers are heavily involved in that aspect. From a data point of view, we think reliability is a very major factor as is the security of supply.

MRF: *Lastly, what impact will 3G wireless standards have on the way devices are manufactured and marketed?*

Brannock: We think that third-generation standards are going to motivate the manufactures to work closer together. We believe the supply, as mentioned earlier, is critical to the rapid and stable growth of these markets. There is no doubt this is a global market, and although the majority of users will be regional, the manufacturers can gain economy of scale if the users employ a common system. Instead of having a market in the US, one in Europe, and one in Asia, you have a global market in component technologies that can be standardized across all of the regions. This would require the suppliers to understand and to work together to make sure we capitalize on this growth.

INSTEAD OF HAVING A MARKET IN THE US, ONE IN EUROPE, AND ONE IN ASIA, YOU HAVE A GLOBAL MARKET IN COMPONENT TECHNOLOGIES THAT CAN BE STANDARDIZED ACROSS ALL OF THE REGIONS.

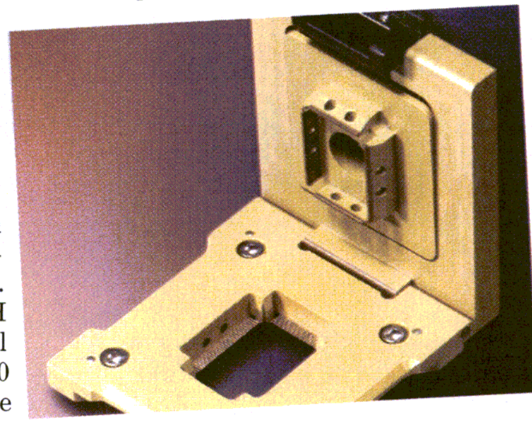
MRF: *Do you have any final comments, or do you have any feelings that you would like people out there to know?*

Brannock: One thing that is important at our level of manufacturing is for the suppliers in the marketplace to have multiple technologies and optimize those. For example, a company that manufactures flash memories, SAW devices, and PAs can leverage all of their components into the system itself, and we think that will be efficient from a cost point of view and a service point of view to the marketplace. ••

For more information on this topic, visit us at **www.mwrf.com**

Test sockets boast smallest lead pitch

A family of test sockets boasts the smallest lead pitch available—0.4 mm—for testing high-frequency devices. The sockets hold devices that are housed in quad-flat-pack (QFP) and other packages, and can be furnished for any peripheral leaded package with as many as 208 leads. Each contact exhibits 0.01-nH self inductance, and the signal loss of the socket is 1 dB at 10 GHz. The contact block is made

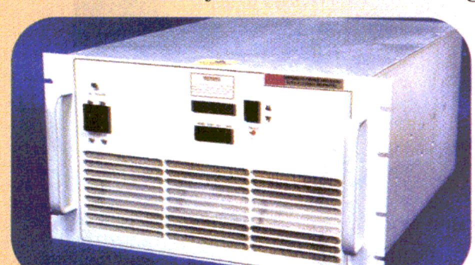


of UL 94 V-O thermoplastic, and the microstrip contacts are 0.008 in. (0.020 cm) wide and plated with hard gold. The sockets can typically withstand more than 500,000 insertion/withdrawal cycles with no loss in performance. Operating temperature spans the range of –55 to +170°C. **Aries Electronics, Inc., P.O. Box 130, Frenchtown, NJ 08825; (908) 996-3891, FAX: (908) 996-3891, Internet: http://www.arieselec.com.**

CIRCLE NO. 57 or visit www.mwrf.com

Class A amplifier boosts RF signals

Model 5080 Class A, multioctave amplifier operates from 800 MHz to 4.2 GHz to boost cellular, personal-communications-services (PCS), and wireless-local-loop (WLL) signals. A 0-dBm RF signal will drive the amplifier to its saturated output power of 100 W with the linearity expected from a Class A amplifier. Applications include electromagnetic-interference (EMI)/RF-interference (RFI) susceptibility, high-power driver, antenna range amplifier, as well as laboratory use. The auto-switching

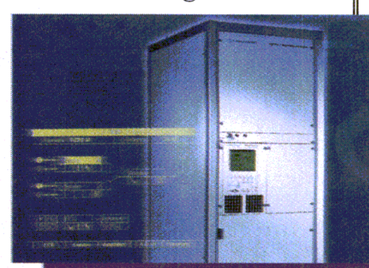


AC input allows the amplifier to be used transparently in 120- and 240-VAC environments. Available options include a microprocessor-based controller with liquid-crystal display (LCD) and various communication-port options. The amplifier supports IEEE-488, RS-232, and RS-422 communication standards, which allow the user to control the amplifier remotely with a personal computer (PC) or custom controller. Controller functions include automatic level control and VSWR protection. **Ophir RF, Inc., 5300 Beethoven St., Los Angeles, CA 90066; (310) 306-5556, FAX: (310) 577-9779, Internet: http://www.ophirrf.com.**

CIRCLE NO. 59 or visit www.mwrf.com.

TV transmitters serve medium-power applications

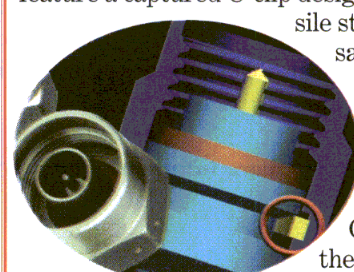
The NH/NV700 family of TV transmitters is available with integrated coders for analog TV or for orthogonal-frequency-division-multiplexing (OFDM)/eight-channel-vestigial-sideband (8VSB) digital television (DTV). The analog TV transmitters are available at power levels from 250 W to 2 kW, while the DTV transmitters are available from 100 to 800 W. These compact, air-cooled modular transmitters can be retrofitted from analog to DTV simply by exchanging the encoder module. The transmitters employ laterally-diffused-metal-oxide-semiconductor (LDMOS) technology and offer a high degree of redundancy, allowing the modules to be exchanged during operation. **Rohde & Schwarz GmbH & Co., Muhldorfstr. 15, D-81671 Munich, Germany; +49 89 4129-3779, FAX: +49 89 4129-3777, Internet: http://www.rohde-schwarz.com.**



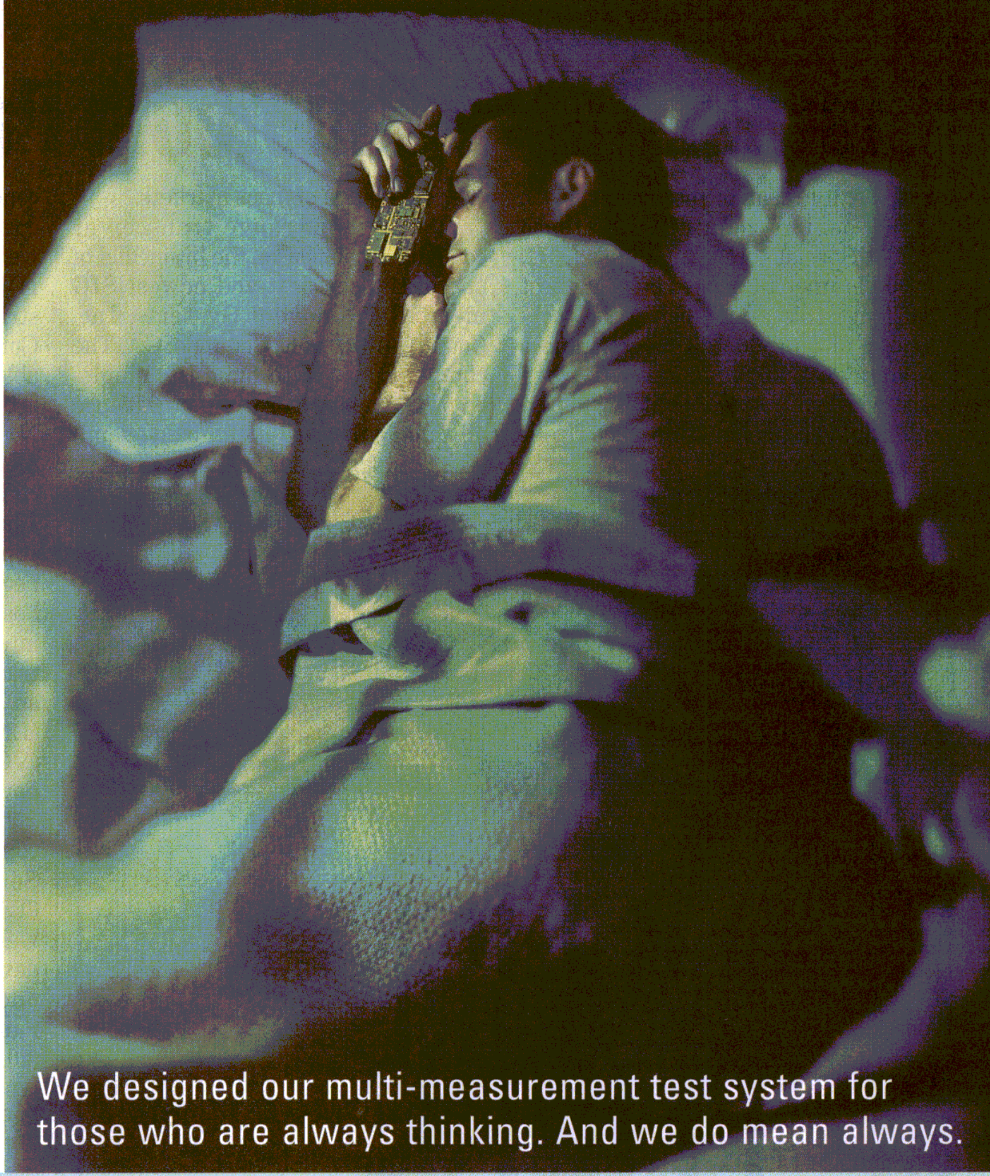
CIRCLE NO. 58 or visit www.mwrf.com.

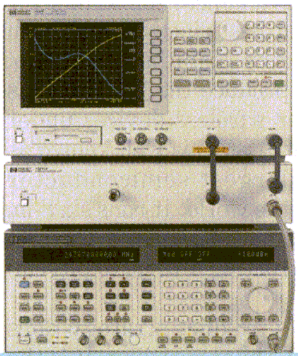
C-clip connectors offer high tensile strength

The Keystone series of C-clip connectors for microwave cable assemblies now offers a tensile strength in excess of 250 lb., depending on the connector and cable size. The connectors feature a captured C-clip design that substantially increases the tensile strength of the connectors by using the same principle as a keystone in an arch. The more tensile stress that is applied to the body of the connector, the more firmly the C-clip holds the connector together by squeezing tighter into its holding groove. The Keystone C-clip is now standard equipment with the company's flexible microwave coaxial cable and with its silicon-dioxide (SiO_2) cable assemblies. **Kaman Instrumentation, 3450 N. Nevada Ave., Colorado Springs, CO 80907; (719) 635-6916, FAX: (719) 634-8159, Internet: http://www.stablecable.com.**



CIRCLE NO. 60 or visit www.mwrf.com.





The 4352S VCO/PLL Signal Test System

Startup Seeks Bluetooth Paydirt

With a year of meteoric growth behind them, the Bluetooth Special Interest Group's (SIG) 1800-plus members face their toughest challenge this year: turning the technology into products that consumers will crave. A key is to develop a low-cost wireless transceiver that will permit Bluetooth-enabled products to fit the price range of mass markets.

Such a short-range transceiver could be in the works, the brainchild of one of the smallest and newest SIG members, Innovent Systems, Inc. (founded 1999) of El Segundo, CA. The company's claim to fame is a single-chip RF transceiver using an 0.35-μm all-complementary-metal-oxide-semiconductor (CMOS) process, a solution currently unavailable from the heavyweight SIG members. Known as the NVT1003, the transceiver was demonstrated recently at the Bluetooth 2000 Congress in Monte Carlo, and is available to customers for sampling. Since it is built on a generic CMOS process, the NVT1003 has the economic advantage meeting the frugal cost demands of consumer products that aspire to be Bluetooth capable. The process also supports the high level of integration necessary to reduce parts counts and board space. The transceiver is said to integrate virtually all the components traditionally located off-chip, including an RF-input filter, low-noise amplifier (LNA), voltage-controlled oscillator (VCO), phase-locked loop (PLL), and power amplifier (PA).

Innovent is a fabless semiconductor company that has joined with Taiwan Semiconductor Manufacturing Co. (TSMC), to produce the NVT1003 as well as other wireless devices under development. TSMC is well known as one of the largest semiconductor foundries in the world. It runs six 8-in. (20.32-cm) wafer fabs and is in the process of constructing a 12-in. (30.48-cm) facility.

Innovent's product strategy does not stop with the transceiver. It is the first member of a family of Bluetooth integrated circuits (ICs) the company calls the Blutonium™ family. Other members of the family include the NVT5001, a stand-alone digital baseband processor, and the NVT7001, an IC that incorporates RF and baseband functionality. The latter integrates the functionality of the NVT1003 and NVT7001, and can accommodate custom intellectual property when a user wants to specify their own processor, interface, or special baseband configuration. This allows a user to take a modular plug-and-play approach to defining how a device can deliver the most benefit for an application.

Behind Innovent are the brother/sister team of Dr. Ahmadreza Rofougaran and Maryam Rofougaran, who spent many years in CMOS RF design while conducting research at UCLA. The company has 60 employees and is backed by a number of venture capital firms. ●●

Contracts

Gabriel Electronics, Inc.—Has been chosen to manufacture and provide microwave antennas for the longest continuous wireless network in the world. This reallocation system project clears the 1.9-GHz band for the new personal-communications-services (PCS) licensees in Chile. Originating from the city of Arica, on Chile's northern coast, this telecommunications network stretches 1863 miles (3000 km) to Puerto Montt in southern Chile.

Harris Corp.—Was awarded an additional $13 million contract for high-frequency radio-communications systems by the US Navy Space and Naval Warfare Systems Command. The contract, the fourth in a series of orders from the US Navy for shipboard systems, adds on to previous contracts totaling $37.8 million. The original $91 million, five-year radio-systems contract was announced in August 1998.

Superconductor Technologies, Inc.—Has received a new contract from the Defense Advanced Research Projects Agency (DARPA) to develop Totally Agile RF-Sensor Systems (TASS). The initial 18-month contract is for $7.3 million, and DARPA has authorized an initial funding increment of $3.4 million.

EMS Technologies, Inc.—Announced a contract valued at up to $1.7 million to supply its packet-data SATCOM terminals to Seimac Ltd., a mobile-satellite service provider and engineering firm based in Nova Scotia, Canada.

Aethercomm, Inc.—Was awarded a contract by Metric Systems Corp. of Fort Walton Beach, FL for the manufacture of 70 S-band, 100-W solid-state power amplifiers (PAs) for use on the URITS system. The URITS system is used by fighter aircraft in training missions and allows pilots to simulate air-to-air combat missions and record them for playback after the mission is complete.

Signal Technology Corp.—Announced that funding has been released for initial production of Patriot Advanced Capability (PAC-3) MISSILE power supplies from Lockheed Martin. This award comes after successful flight testing at White Sands Missile Range in New Mexico. Signal Technology's Keltec Division in Fort Walton Beach, FL will be responsible for the low-rate initial production (LRIP-1) of these power supplies. Long-term follow-on will be funded on an annual basis.

Andrew Corp.—Signed a global agreement with Crown Castle International to supply antennas, coaxial cable, connectors, accessories, and pressurization equipment for use on Crown Castle wireless communication sites worldwide. Under the terms of the agreement, Andrew will be the preferred supplier to Crown Castle in the UK and the US.

Spectrum Signal Processing, Inc.—Announced its first contract win resulting from a recently announced joint technology-development agreement with Northrop Grumman Corp. Spectrum and Northrop Grumman have developed a new multiprocessor digital-signal-processor (DSP) system for next-generation radar programs within Northrop Grumman's Baltimore, MD-based Electronic Sensors and Systems Sector (ES^3). ES^3 will use the new platform in its TPS-70 radar, a ground-based tactical air-surveillance system, which is one of the first in its class that can provide simultaneous detection and tracking of aircraft and missile targets within its surveillance range.

Fresh Starts

Philsar Semiconductor—Has opened a sales office in Irvine, CA to support its expanding customer and technology-partner activity in the US.

Askey Computer Corp.—Announced that it has joined the Wireless Ethernet Compatibility Alliance (WECA). By joining WECA, an organization devoted to the testing of wireless local-area-network (WLAN) products, Askey will be able to submit its WLAN product, the WLC010, for WECA certification.

Hittite Microwave Corp.—Has achieved re-certification to the requirements of the ISO 9001 Quality System standard. Hittite was originally certified to ISO 9001 in 1997 and has maintained this certification for the full three-year certification cycle.

Teradyne's Connection Systems Division—Announced the appointment of Hackmeister Advertising & Public Relations Co. of Fort Lauderdale, FL for ongoing press-relations services.

Nitres, Inc.—Has agreed to be acquired by Cree, Inc., a firm involved in the development and manufacture of semiconductor materials and electronic devices made from silicon carbide (SiC). Cree has signed a definitive agreement to acquire the company.

Boldt Metronics International, Inc. (BMI)—Announced the opening of the company's first international headquarters and manufacturing cell in Europe to better serve and expedite delivery of metal-electronic components to its global customers. BMI expects its presence overseas to strengthen customer relationships and drive new business initiatives.

Xcelerate—Recently completed a project for Kosherfinder.com, a virtual start-up company vying to become the nation's leading information provider for kosher products and services.

Xemod, Inc.—Announced its completed expansion into Tempe, AZ as well as the relocation of its headquarters to Santa Clara, CA. This expansion more than doubles Xemod's square footage, enabling the company to house increased manufacturing and engineering personnel.

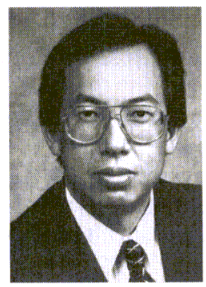
Renaissance Electronics Corp.—Announced an affiliation with Microwave Components Marketing (MCM) of Melbourne, FL. MCM will represent Renaissance for the entire state of Florida.

Motorola, Inc.'s Network Solutions Sector (NSS)—In conjunction with Beijing Mobile Communication Corp., China's first general-packet-radio-service (GPRS) end-to-end demonstration was held during the First International GPRS China 2000 Conference. The April conference took place in Beijing.

Endwave Corp.—Bruce Margetson to chief financial officer; formerly controller of the Enterprise WAN and Voice Business units for Cisco Systems. Also, Don Dodson to chief operating officer; formerly vice president and general manager of TRW MilliWave.

DB Products—Julie Williams to marketing manager of the Microwave Switch Division; formerly held a management position with the Dow Key division of K&L Microwave Corp.

WILLIAMS



CHEUNG

Trompeter Electronics, Inc.—Adolf Cheung to vice president of engineering; formerly director of engineering for Dow Key Microwave. Also, Garry Heverly to regional sales manager for the Eastern US; formerly district sales manager for the Northeast at Robinson Nugent.

Decibel Products—Robert "Ken" Sowards to senior vice president of operations; formerly executive vice president of operations for a division of Trinity Industries, Inc.

Littelfuse—William S. Baron to vice president and general manager of the electronics worldwide business unit; formerly responsible for overall sales and marketing. Also, Michael P. Sammons to general manager of the automotive business unit; formerly marketing and sales division manager for automotive products. In addition, Dal Ferbert to general manager of the power-fuse unit; formerly marketing and sales division manager for power-fuse products.

Cidera, Inc.—Edward D. Postal to executive vice president and chief financial officer; formerly executive vice president and chief financial officer at PSINet.

Ensemble Communications, Inc.—Steve Schlumberg to vice president of sales; formerly vice president of sales and marketing at Wireless Systems Technology.

IPC—Sandra Martocchia to director of communications; formerly managing editor at *SMT Magazine*.

ANADIGICS—Dennis F. Strigl to the Board of Directors; remains as president and CEO of Bell Atlantic Mobile and Bell Atlantic Global Wireless.

CTS Corp.—Otis E. Hayes to director of quality; formerly director of quality assurance at Coto.

Means Engineering, Inc.—Derwin Fritts to engineering manager; formerly engineering and project manager for TRICAD Engineering.

Andrew Corp.—Guy Campbell to president; formerly group president of the Wireless and In-Building Products Group.

SCC Communications Corp.—Jack Howe to director of program and product management; formerly a managing partner at Howe and Associates. Also, Brian Davenport to director of business development and marketing; formerly served in an executive capacity with CommNet Cellular.

Electronic Connections, Inc.—Charles Cannata to vice president; formerly served as vice president for corporate programs at Sager Electronics.

CANNATA

BESONG

Rockwell Collins—John-Paul Besong to vice president, electronic business; formerly executive, enterprise resource planning.

Leitch Technology Corp.—Steven E. Muni to channel manager for the US sales operation; formerly employed in management positions in the areas of engineering and market development with Sony Corp. of America.

Short Courses

Die and Packaging-Level Microelectronics Assembly: Base and Advanced Technology
August 21-23 (Catamaran Resort Hotel, San Diego, CA)
The University of Arizona College of Engineering and Mines
Engineering Professional Development
Tucson, AZ 85719-4552
(520) 621-3054, FAX: (520) 621-1443
e-mail: epd@engr.arizona.edu
Internet: http://intermix.engr.arizona.edu/~epd

Near-Field Antenna Measurements and Microwave Holography
August 28-September 1 (Boulder, CO)
Georgia Institute of Technology
Continuing Education
Atlanta, GA 30332-0385
(404) 385-3502, FAX: (404) 894-7398
e-mail: conted@gatech.edu
Internet: http://www.conted.gatech.edu

Asynchronous Transfer Mode Overview—Understanding ATM's Potential and Value
August 29-30 (Seattle, WA)
Telcordia Technologies (formerly Bellcore)
Learning Services
Registrar's Office, Room F212
6200 Route 53
Lisle, IL 60532-3198
(800) 832-2463, FAX: (630) 960-6300
e-mail: teachme@telcordia.com

Software Radio
September 4-5 (Oxford, England)
University of Oxford
Department of Continuing Education
Oxford OX1 1PT, England
Dee Broquard
0-1865-286959, FAX: 0-1865-286956
e-mail: dee.broquard@conted.ox.ac.uk

Fundamentals of Data Communication
October 2-4 (Madison, WI)
University of Wisconsin-Madison
Department of Engineering Professional Development
Madison, WI 53706
Katie Peterson
(800) 462-0876, FAX: (608) 263-3160
e-mail: custserv@epd.engr.wisc.edu.

Meetings

NIWeek2000—The Worldwide Conference on Measurement and Automation
August 16-18 (Austin Convention Center, Austin, TX)
National Instruments
Austin, TX 78759-3504
(800) 258-7022, FAX: (512) 683-9300
e-mail: niweek@ni.com
Internet: http://www.ni.com/niweek

2000 IEEE International Symposium on Electromagnetic Compatibility
August 21-25 (Washington, DC)
IEEE Electromagnetic Compatibility Society
William Duff, Chairman
Computer Sciences Corp.
(703) 914-8450, FAX: (703) 914-8499
e-mail: wduff@csc.com

ISSSTA 2000 IEEE Sixth International Symposium on Spread Spectrum Techniques & Applications
September 6-8 (Parsippany, NJ)
IEEE Communications Society and Center for Communications and Signal Processing Research
New Jersey Institute of Technology (NJIT)
Newark, NJ 07102
Clare Naporano
(973) 596-8474, FAX: (973) 596-8473
e-mail: Clare@megahertz.njit.edu.

EMC Europe 2000-4th European Symposium on Electromagnetic Compatibility
September 11-15 (Brugge, Belgium)
TI-KVIV
Mrs. Peys
Desguinlei 214
B 2018 Antwerpen Belgium
32/(0)3 216 09 96, FAX: 32/(0)3 216 06 89
e-mail: emc2000@conferences.ti.kviv.be
Internet: http://www.ti.kviv.be/conf/emc2000.htm

DCI's Summit on Wireless Computing
September 12-14 (Hyatt Regency Orlando Airport, Orlando, FL)
DCI, Inc.
(978) 470-3880, FAX: (978) 470-0526
e-mail: ConfReg@dci.com
Internet: http://www.dci.com/brochure/wireol

Seventh European Conference on Fixed Radio Systems and Networks (ECRR 2000)
September 12-15 (Dresden, Germany)
Verband der Elektrotechnik (VDE)
Elektronik Informationstechnik e.V.
D-60596 Frankfurt/Main, Germany
FAX: 49-69-9631-5213
Internet: http://www.vde.com/ECRR2000

2000 IEEE Bipolar/BiCMOS Circuits and Technology Meeting
September 24-26 (Marriott City Center Hotel, Minneapolis, MN)
IEEE Electron Devices Society, the IEEE Solid State Circuits Society and the IEEE Twin Cities Section
Janis Jopke, Conference Manager
CCS Associates
Eden Prairie, MN
(612) 934-5082, FAX: (612) 934-6741
e-mail: jjopke@aol.com

Wireless/Portable Engineering Technology Conference & Showcase at PCIA GlobalXChange
September 26-29 (McCormick Place, Chicago, IL)
Penton Media, Inc.
611 Route 46 West
Hasbrouck Heights, NJ 07604
(888) 947-3734, FAX: (201) 393-6297
e-mail: wirelessreg@penton.com
Internet: http://www.WirelessPortable.com

IEEE Broadcast Technology Society 50th Annual Broadcast Symposium (Broadcasting for the New Millennium)
September 27-29 (Sheraton Premiere at Tyson's Corner, Vienna, VA)
IEEE Broadcast Technology Society
445 Hoes Lane
Piscataway, NJ 08855-1331
Mrs. Mary Clemente
(732) 562-5350, FAX: (732) 981-1203
e-mail: m.e.clemente@ieee.org.

Model predicts noise in RF CMOS mixers

Flicker (1/f) noise at the output of an RF complementary-metal-oxide-semiconductor (CMOS) mixer can grow large enough to prevent the device from being used in certain applications such as in direct-conversion receivers. To predict mixer-noise effects, Hooman Darabi and Asad A. Abidi of the Department of Electrical Engineering, University of California, Los Angeles (Los Angeles, CA) developed a qualitative physical model that explains flicker and white noise, and allows the flicker noise to be optimized in a downconversion mixer intended for use at or near zero intermediate frequency (IF). The authors use simple analytical expressions to capture mixer noise, which was analyzed with more complex equations or specially developed simulation tools. Although the model uses several simplifying assumptions, good agreement is obtained with actual measurements performed on a mixer fabricated in a 0.25-μm CMOS process. However, the model is largely independent of transistor type and can be applied to bipolar active mixers. See "Noise in RF-CMOS Mixers: A Simple Physical Model," *IEEE Journal of Solid-State Circuits*, January 2000, Vol. 38, No. 1, p. 15.

What makes an EMI receiver suitable for compliance testing?

An electromagnetic-interference (EMI) receiver for making measurements that meet the specifications of CISPR Publication 16, part 1 (the International Special Committee on Radio Interference) must satisfy a number of requirements in order to qualify. These specifications are spelled out by Werner Schaefer of then Hewlett-Packard Co. (now Agilent Technologies, Santa Rosa, CA) with an eye toward avoiding over specification. For example, a receiver can use either a stepped or swept technique and readout the test results in either numerical or graphical form. The CISPR 16 specifications are divided into two frequency ranges: 9 kHz to 1 GHz, and greater than 1 GHz. Specifications such as resolution bandwidth, rejection of intermediate frequency (IF), image frequency, and screening effectiveness are examined in both of the frequency ranges to explain what qualities an instrument must have to be suitable for CISPR 16 compliance testing. Spectrum Analyzers are the preferred receiver for EMI measurements above 1 GHz, but frequently fall short of the CISPR requirements below 1 GHz. See "Interpreting EMI receiver specifications," *Interference Technology Engineer's Master (ITEM)*, 1999 edition, p. 164.

Wideband OFDM enables high-speed wireless data

By combining wideband orthogonal frequency-division multiplexing (WOFDM) with the enhanced data rates for Global System for Mobile Communications (GSM) evolution (EDGE) data-access system, the authors of this report show how EDGE can deliver high-speed wireless data rates (2 Mb/s and better), wide-area coverage, and good quality for packet-data services. Justin Chuang *et al.* of AT&T Labs—Research, Hong Zhao of AT&T Wireless Services, Lang Lin of WINLAB, Rutgers University, and Mitsuhiro Suzuki of Sony Corp. explain that a future high-speed wireless data system with a wideband 5-MHz channel using WOFDM modulation to mitigate multipath fading could provide peak data rates of approximately 5 Mb/s. While new to the EDGE application, OFDM has been used in digital-audio broadcasting (DAB) and asymmetric digital subscriber line (ADSL). It is known for robust performance over heavily impaired channels, and has the spectrum efficiency and flexibility to accommodate narrowband and wideband services. See "High-Speed Wireless Data Access Based on Combining EDGE with Wideband OFDM," *IEEE Communications Magazine*, November 1999, Vol. 37, No. 11, p. 92.

Microwave system charges spacecraft batteries

Sitting on a launch pad ready to blast off, a spacecraft's batteries are kept charged through an umbilical cable. But when the cable is disconnected, the batteries begin to discharge, and their power output could become dangerously low if the spacecraft is forced to spend long hours on the pad. A neat solution based on a wireless microwave system has been proposed by Richard Rolnicki of the Goddard Space Fight Center, (Greenbelt, MD). Just before the umbilical is disconnected, a microwave source on the launch pad aims its beam at a microwave-transparent window on the craft. An antenna inside the vehicle picks up the signal and sends it to a rectifier/converter system, which converts the microwave energy to DC power to charge the batteries. The concept can be applied to other battery-based system that must be kept in a high state of readiness, and where cable connections are inconvenient. See "Microwave Battery Charger," *NASA Tech Briefs*, April 2000, Vol. 24, No. 4, p. 43.

Predict NPR For RF Modules Using System Simulation

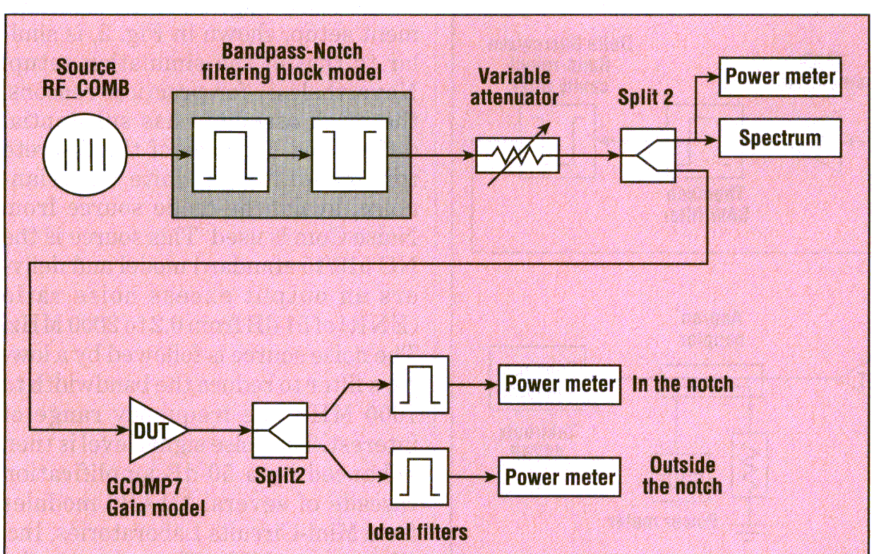
This new method allows designers to measure noise-power ratio using accessible equipment.

Pascal Delemotte and Yves Crosnier
Institut d'Electronique et de MicroÈlectronique du Nord, IEMN, UMR CNRS 8520, Av. Poincarè, BP 69, 59652 Villeneuve d'Ascq, France; +33-03-20-43-65-09, FAX: +33-03-20-43-65-23, e-mail: delemotte@univ-lille1.fr

INCREASING demand for mobile and satellite communications and the related need for multiple-channel equipment require system designers to know the intermodulation distortion (IMD) of devices and subsystems that they intend to use. IMD occurs when mixing two or more carriers and is caused by the nonlinearities of the active devices used in the circuits. Evaluating IMD involves the measurement of noise-power ratio (NPR), which is defined as the ratio of the averaged power of the multiple carriers to the averaged IM power falling into a narrow frequency notch.[1-3] The first NPR measurement was performed more than 30 years ago through an analog method using a diode-based noise generator as the stimulus and a spectrum analyzer for analysis. Recently, a digital method was proposed using digital synthesis and digital filtering to generate the noise stimulus, together with digital signal analysis.[4,5] But these two measurement methods require very specific equipment that is rarely at the disposal of every system designer.

The purpose of this article is to propose an alternative to these NPR measurement methods. It consists of a software simulation available to everyone with access to a commercial system simulator and a vector network analyzer (VNA). The article presents simulations of commercial modules using the OMNISYS software from Hewlett-Packard Co. (Santa Clara, CA). Validation is achieved by using a measurement setup built around a Noise Com, Inc. (Paramus, NJ) source, a bandpass surface-acoustic-wave (SAW) filter, and a cavity notch filter. The NPR range covered here is approximately 50 dB. Detailed descriptions of the simulation procedure and measurement configuration are provided, along with application examples.

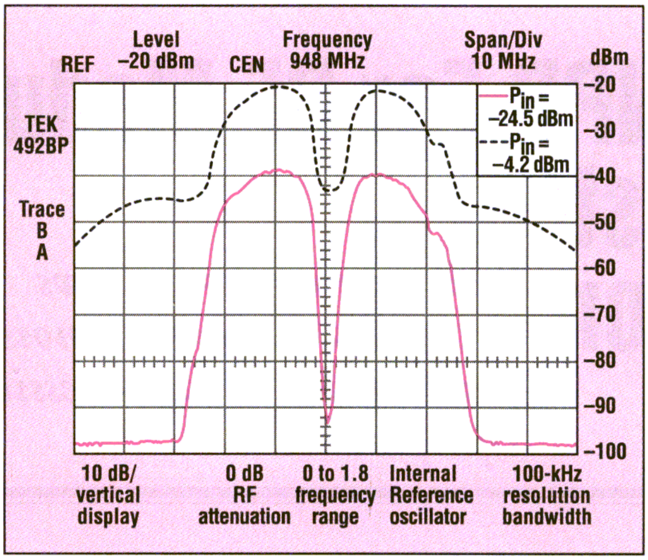
Most current system simulators offer multiple random-carrier excitation, together with filtering operations and nonlinear-device modeling based on amplitude-modulation/amplitude-modulation (AM/AM) and amplitude-modulation/phase-modulation (AM/PM) distortions.



1. This block diagram shows the OMNISYS-based NPR simulation.

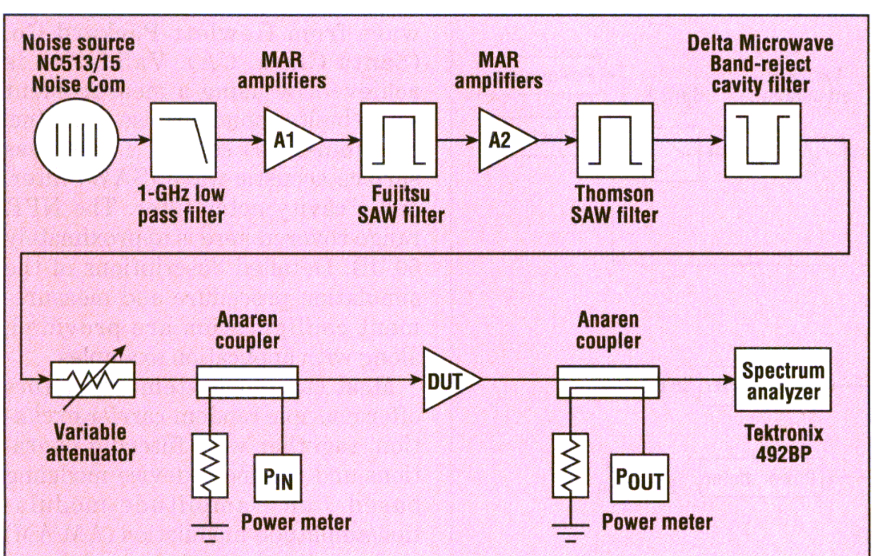
Therefore, they can simulate NPR measurement as long as the amplitude and phase distortions of the devices under investigation are precharacterized using a VNA.

Basically, the NPR measurement of a device or system needs to apply to its input a Gaussian random signal with a uniform spectral density containing a narrow spectral notch. Due to the nonlinearities of the device under test (DUT), a signal passing through the device results at the output in the spreading of the power spectral density, which partially fills the notch. NPR is defined as the ratio, at the DUT output, of the power of the spectral components outside the notch to the power of those inside the notch.



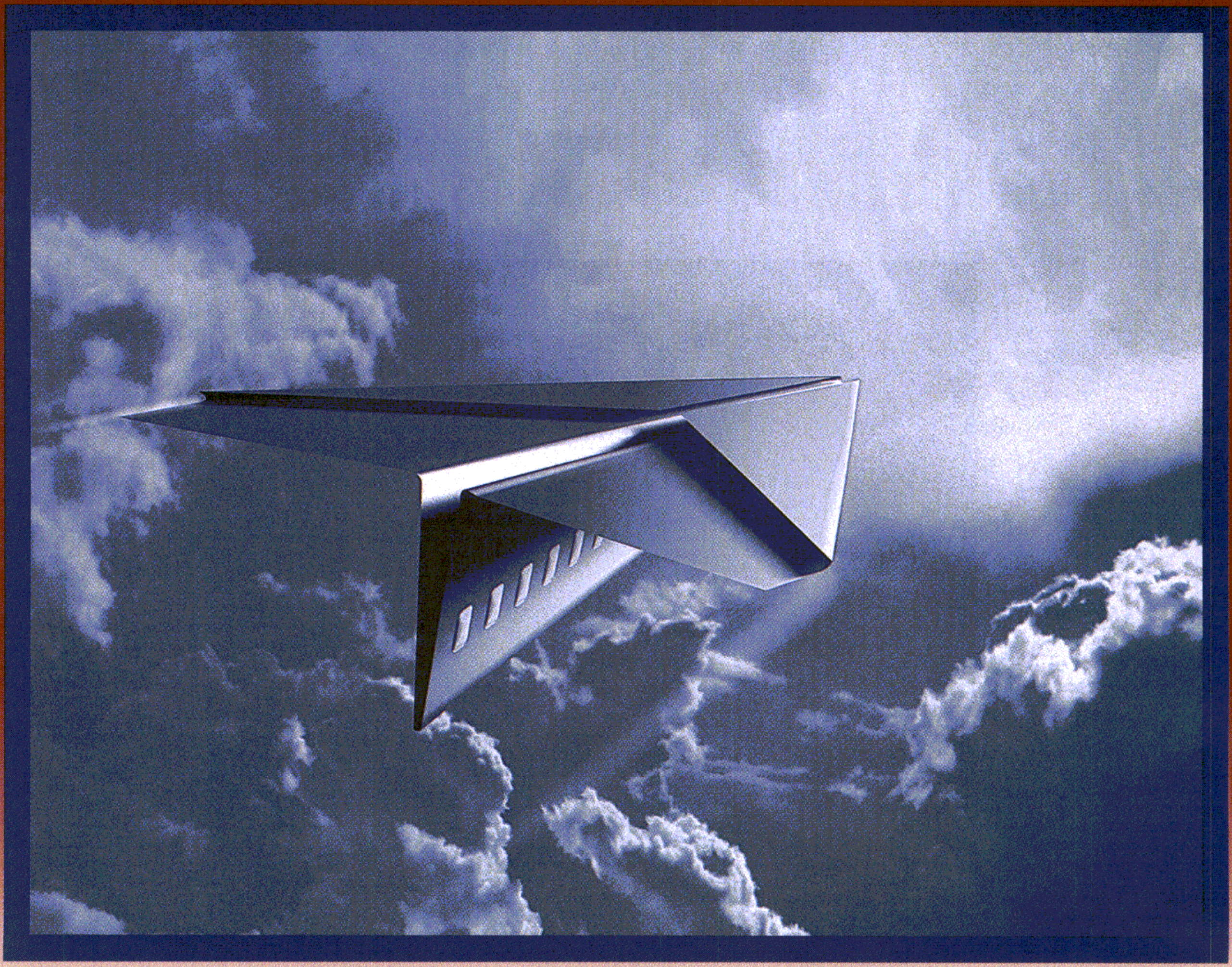
3. These are typical examples of an experimental NPR spectrum obtained for a Mini-Circuits MAR 3 amplifier at two input-power levels: P_{in} = –24.5 dBm and –4.2 dBm.

The noise stimulus spectrum is centered on 947.5 MHz, with a passband of 35 MHz and a notch band of 2 MHz. Figure 1 shows a block diagram of the simulation setup implemented in the OMNISYS software for generating the stimulus and taking the required NPR power measurements. The "RFCOMB" source is used as a basic generator. The spectrum generated by this kind of source consists of a large number of equal-amplitude carriers that have random uniformly distributed phases, which approximates a random Gaussian process. The chosen number of tones—7000—is the maximum value allowed by the memory capacity of the computer (HP 9000 C200). The tone spacing is 13 kHz, and the total bandwidth is 91 MHz. This bandwidth is purposely made wider than that to be applied to the DUT (35 MHz) to allow the simulation to cover the IM process. The effective working-noise profile is fashioned from the "RFCOMB" source by a two-port black box, the data set which consists of the S-parameters provided by measurements of the practical bandpass-notch filtering block. The notch depth is more than 50 dB and its width is approximately 2 MHz at 40-dB attenuation. The filtering block is followed by a variable attenuator to ensure automation of the DUT input-power sweep. The next block is the DUT itself with ideal splitters at its input and output to ensure power and spectrum controls. The DUT description makes use of the model "GAIN" with the compression item "GCOMP 7" to account for its AM/AM and AM/PM distortions. The data set introduced in "GCOMP 7" is directly provided by the VNA measurements of the DUT S_{21} amplitude and phase as a function of input power. At the DUT output, the NPR measurement is performed using two ideal 1-MHz bandpass filters terminated with power meters and centered on 947.5 MHz—the notch center, and 957.5 MHz—10 MHz outside the notch. Power densities inside and outside the notch at the DUT output, the total DUT input power, and the resulting NPR response are computed using the Fast Fourier transform (FFT) procedure. Time consumption is typically five minutes for 40 steps of input-power level.



2. This is a block diagram of the analog NPR measurement setup.

The block diagram of the measurement setup, shown in Fig. 2, is similar to that of the simulation setup. Nevertheless, for practical reasons, the block assembly has substantial differences. In place of the discrete tone generator, a white Gaussian-noise, avalanche-diode source from Noise Com is used. This source is the NC 513/15 standard model and delivers an output excess noise ratio (ENR) of 51 dB from 0.2 to 2000 MHz. The noise source is followed by a low-pass filter to reduce the bandwidth to 1000 MHz, the frequency range of interest. The noise signal level is then enhanced by a 50-dB amplification cascade of several "MAR" modules from Mini-Circuits Laboratories, Inc. (Brooklyn, NY). Then comes the NPR filtering block, which consists



Imagine the possibilities.

Introducing our newest NGA InGaP HBT amplifier family with low thermal resistance for higher reliability and improved linearity with broader bandwidth.

Stanford Microdevices introduces the NGA-100 through 600 Series InGaP HBT amplifiers designed for today's and tomorrow's advanced communication infrastructure equipment. Design and fabricated with state-of-the-art InGaP/GaAsHBT technology for higher reliability, these devices are ideal for use as driver stages for higher power applications. Available in small-form factor plastic packages, the NGA series are biased with a single voltage and provide wide bandwidth, high gain and exceptional linearity.

For more information on these new InGaP amplifiers, visit our website today. Imagine the possibilities with RF innovation from Stanford Microdevices.

NGA - InGaP MMIC 50 Ohm Gain Block Amplifiers

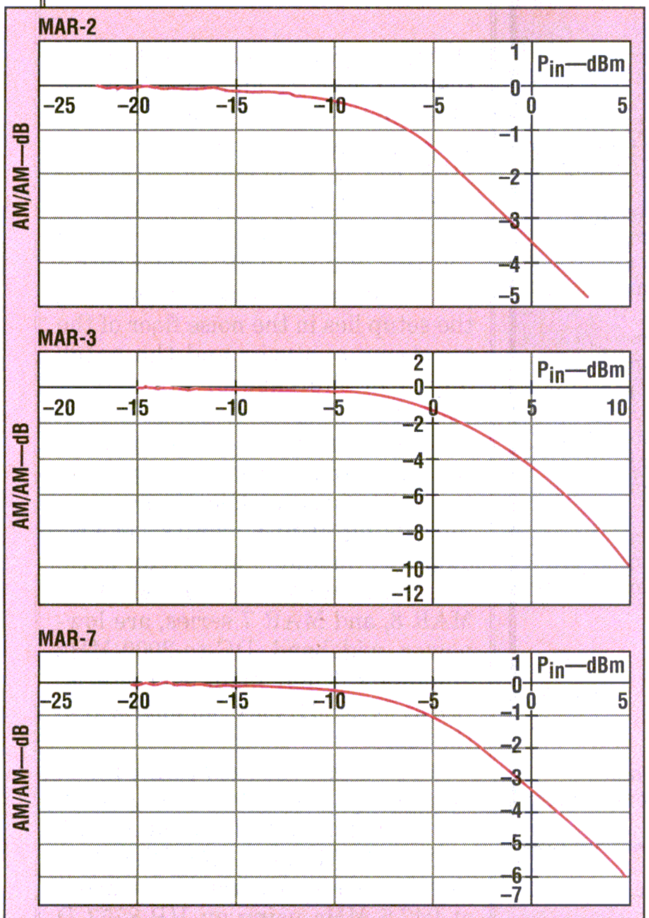
Model	Freq Range (GHz)	Vd (V)	Id (mA)	Gain (dB)	PldB (dBm)	IP_3 (dBm)	Thermal Resistance (°C/W)
NGA-186	0.1-6.0	4.1	50.0	12.5	14.6	32.9	120
NGA-286	0.1-6.0	4.0	50.0	15.5	15.2	32.0	120
NGA-386	0.1-5.0	4.0	35.0	20.8	14.5	25.8	144
NGA-486	0.1-6.0	5.0	80.0	14.8	18.3	39.5	118
NGA-586	0.1-6.0	5.0	80.0	19.9	18.9	39.6	121
NGA-686	0.1-6.0	5.9	80.0	11.8	19.5	37.5	121

Data at 1 GHz and is typical of device performance.

STANFORD MICRODEVICES

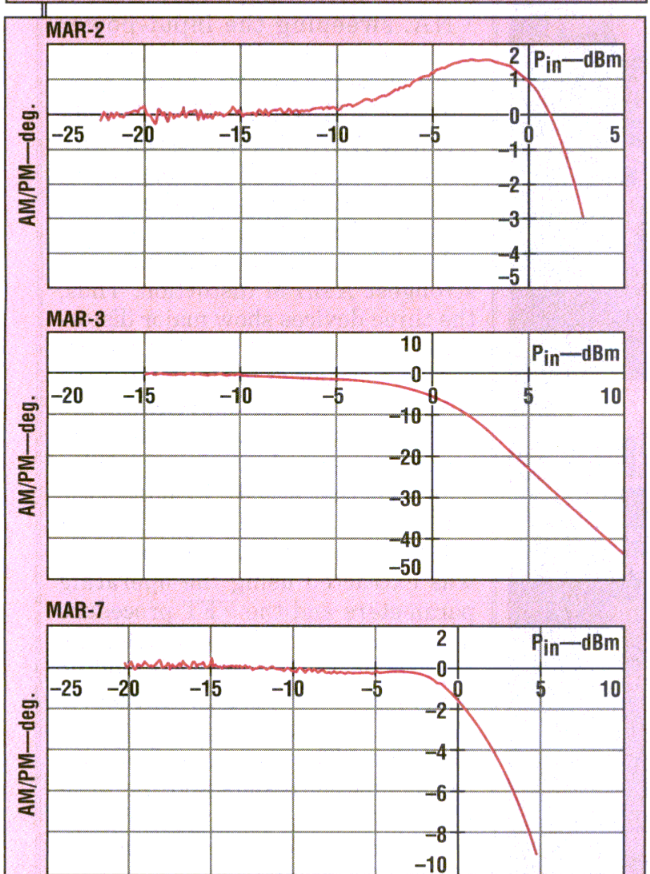
www.stanfordmicro.com • 800-764-6642

CIRCLE NO. 204



4. These are the AM/AM-measured characteristics (HP 8753D VNA) of the modules MAR 2, MAR 3, and MAR 7 from Mini-Circuits.

of two bandpass SAW filters separated by a 16-dB buffer amplifier (MAR module) and a cavity notch filter. At the output of this filtering block, the NPR noise stimulus is readily available. It has a center frequency of 947.5 MHz, a 40-MHz passband (at –3 dB), an approximate reject band of 2 MHz (at –40 dB), and –5-dBm total power. Variation and control of the input noise level is achieved through a variable step-by-step attenuator and a directional coupler inserted between the filtering block and the DUT. At the DUT output, the NPR is measured using a 492BP spectrum analyzer from Tektronix, Inc. (Portland, OR). To ensure good repeatability and accuracy of the NPR estimate, power averaging within and outside the notch is performed around markers placed at 947.5 and 957.5 MHz using a sweep time of 10 s, a total span of 100 MHz, a resolution bandwidth of 100 kHz, and a video bandwidth of 300 Hz. Figure 3



5. These are the AM/PM-measured characteristics (HP 8753D VNA) of the modules MAR 2, MAR 3, and MAR 7 from Mini-Circuits.

shows a typical measurement where the DUT is an RF amplifier from the Mini Circuits' "MAR" series. Finally, with this measurement setup, the NPR can be reasonably extracted from 50 dB down to 15 dB over an input-power range between –5 and –40 dBm using a 10-dB coupler with a power meter. The main limitation of the setup lies in the noise floor of the spectrum analyzer and the notch depth in the case of low-power excitation.

As an illustration of the ability of this approach to accurately predict the NPR of any module, three examples using Mini-Circuits "MAR" amplifier modules are given here. These modules, from the MAR 2, MAR 3, and MAR 7 series, are low-power, wideband, DC-to-2000-MHz amplifiers. Their main characteristics at 947.5 MHz are summarized in the table.

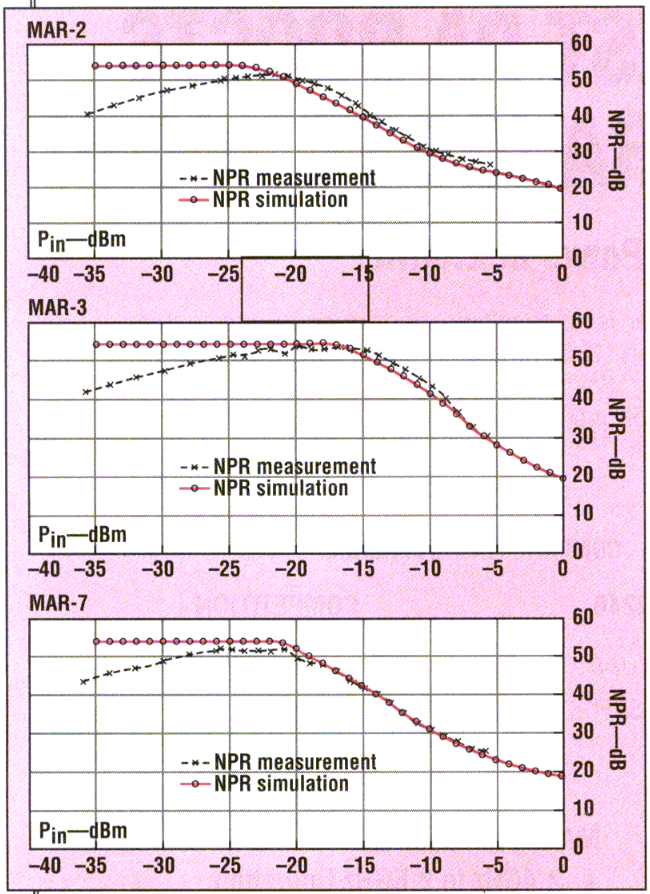
It is evident from the table that MAR 2 and MAR 7 have less power-generating capabilities than MAR3. Their AM/AM and AM/PM distortions have been accurately extracted at 947.5 MHz using an HP 8753 D VNA, sweeping the input-power level from –20 to +10 dBm. Figures 4 and 5 show the results of these measurements. MAR 2 and MAR 7 exhibit similar AM/AM responses but with very different AM/PM responses. Curiously, MAR 3 is less affected by AM/AM distortion than the two other devices, but exhibits the strongest AM/PM distortion. Thus, the three devices show major distortion differences and, for that reason, can be considered useful for testing the validity of the approach. Data sets of these AM/AM and AM/PM measurements have been implemented in the GCOMP 7 model of the simulation setup. This model was activated and the theoretical NPR was extracted using the operating parameters and the FFT procedure described previously. In parallel, the experimental NPR of each module was measured using the measurement setup described in the preceding section. The comparison between the simulation results and the measurement results is shown in Fig. 6.

At first glance, this comparison shows a substantial discrepancy for

the low-input-power region. Indeed, for each DUT below a threshold input power, the simulated NPR becomes constant, while the measured NPR exhibits a positive slope variation of approximately 1 dB/+1 dBm. In reality, this discrepancy is purely artificial and results from the inherent limitations in both cases. In the simulation, the constant value of NPR is due to the finite depth of the notch (approximately –54 dB). The result is that as soon as the IM level becomes lower than the notch bottom, the noise stimulus is no longer affected when passing through the DUT. In the measurement, the slope of one is simply related to the natural noise floor of the spectrum analyzer. The result is that, at low input power, the noise-power density becomes constant within the notch. As a consequence, the NPR variation mirrors the input noise-power variation.

Apart from this extreme situation, as soon as the noise input-power level becomes sufficient to make the NPR pass below the threshold of approximately 50 dB, the simulated curve tracks closely to noise input-power levels that are measured within a 2-dB margin in the worst case. Note that curves plotted in Fig. 6 result from an averaging among several runs for simulation as well as for measurement. The standard fluctuation has been found to be less than ±0.5 dB, so that the present agreement can be judged as being fully significant. Also note the physical coherence of the results shown in Fig. 6. The values of the input power where the NPR starts to decrease correlate well with the relative sensitivities to single-tone and two-tone distortion of the three devices. Indeed, MAR 2 and MAR 7, which in the table appear to be more sensitive than MAR 3, have their NPR starting point between –20 and –25 dBm, while that of MAR 3 is between –15 and –20 dBm. This coherence can again be confirmed by comparing the respective values of the two-tone IMR given at P_{in} = –13 dBm in the table and the corresponding NPR values at the same total input power as shown in Fig. 6. Hence, the two-tone IMR is 40 dB for MAR 2 and MAR 7, and 54 dB for MAR 3, while NPR is 36 dB, 38 dB, and 49 dB, respectively. As expected, these results are placed in the same order and NPR is always lower than the two-tone IMR by a few decibels.

The examples previously mentioned demonstrate the ability of commercial system simulators to provide fast and accurate prediction of NPR for common RF amplification modules. The only requirements for succeeding in this prediction are an accurate extraction using a VNA of AM/AM and AM/PM characteristics and the availability in the simulator of gain models taking these characteristics into account. This article does not address the problem of distortion with memory effect.[6-8] This problem can be caused by long-time



constants linked to thermal phenomena, biasing, or feedback circuits. In this case, the amount of amplitude and phase distortions does not depend solely on the instantaneous input signal level, and the relation between NPR and AM/AM and AM/PM characteristics can be somewhat complicated. This question requires a special approach on which the authors are working. ●●

6. This is a comparison of the measured and simulated NPR responses versus the total input power corresponding to the modules MAR 2, MAR 3, and MAR 7 from Mini-Circuits.

References

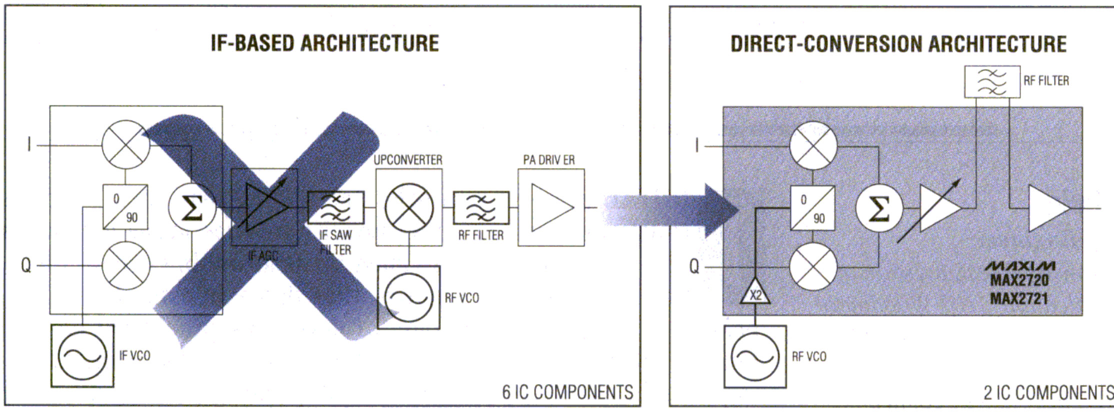
1. R.J. Westcott, "Investigation of Multiple F.M./F.D.M. Carriers Through a Satellite T.W.T. Operating Near Saturation," *Proceedings of IEE*, Vol. 114, No. 6, pp. 726-740, June 1967.
2. R.W. Koch, "Random Signal Method of Nonlinear Amplitude Distortion Measurement," *IEEE Transactions Instrument Measurements*, Vol. 20, No. 2, pp. 95-99, May 1971.
3. G.L. Heiter, "Characterization of Nonlinearities in Microwave Devices and Systems," *IEEE Transactions MTT*, Vol. 21, No. 12, pp. 797-805, December 1973.
4. R. Hassun, "Comparing Analog and Digital Techniques For Measuring Noise Power Ratio," *Microwave Journal*, pp. 88-98, March 1997.
5. "Noise Power Ratio (NPR) Measurements Using the HP E2507B/E2508A Multi-Format Communications Signal Simulator," Hewlett-Packard Product Note No. E2508-1, May 1997.
6. W. Bosch and G. Gatti, "Measurement and Simulation of Memory Effects in Predistortion Linearizers," *IEEE Transactions MTT*, Vol. 37, No. 12, pp. 1885-1890, December 1989.
7. J. Lajoinie, E. Ngoya, D. Barataud, J.M. Nebus, J. Sombrin, and B. Rivierre, "Efficient Simulation of NPR for the Optimum Design of Satellite Transponders SSPAs," *IEEE MTT-S Digest*, pp. 741-744, 1998.
8. V. Meghdadi, J.P. Cances, F. Chevallier, B. Rojat, and J.M. Dumas, "Modeling of Solid State Power Amplifiers (SSPA) and Validation by Means of a System Simulator," *Annual Telecommunications*, Vol. 53, No. 1-2, pp. 4-13, 1998.

For more information on this topic, visit us at **www.mwrf.com**

WORLD'S ONLY FULLY INTEGRATED 2.5GHz DIRECT I/Q TRANSMITTER

Ideal for Wideband CDMA Wireless Local Loop Systems

Reduce cost, component count, and board space and increase manufacturing yield with the MAX2720/MAX2721 direct I/Q transmitters. By utilizing a direct conversion architecture and expert RF integration, these transmitters reduce the number of RFIC components from 6 to 2, saving 35% cost, 50% board space, and reducing costly production alignment time.



MAX2720/MAX2721 Features:

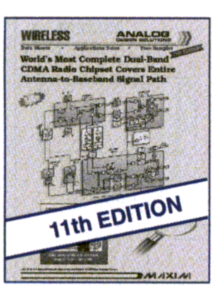
- 1.7GHz to 2.1GHz RF Output (MAX2720)
- 2.1GHz to 2.5GHz RF Output (MAX2721)
- 35dB Gain Control Range
- Integrated PA Driver with +13dBm Output P_{1dB}
- Full LO or 1/2 LO Frequency Input
- 33dB Carrier Suppression
- 40dB Sideband Suppression
- +2.7V to +3.3V Single Supply
- 1µA Shutdown Mode

Why Direct Conversion?

- Eliminate IF SAW Filter, Upconverter, and VCO
- Reduce Number of ICs from 6 to 2
- Save 35% in IC Cost
- Save 50% in Board Space
- Reduce Production Alignment Time
- Increase Manufacturing Yield

Other Applications:

- PCS/DCS Base-Stations
- MMDS, LMDS
- 2.4GHz ISM Band Radios



Subscribe to Maxim's EE-Mail™ today to receive automatic new product updates via e-mail. Go to www.maxim-ic.com for easy signup.

CALL TOLL-FREE 1-800-998-8800 for a Design Guide or Free Sample
6:00 a.m. – 6:00 p.m. Pacific Standard Time

1999 EDITION!
FREE FULL-LINE DATA CATALOG
ON CD-ROM

ISO 9001

MAXIM
www.maxim-ic.com

NEW! Get Price, Delivery, and Place Orders Online at www.maxim-ic.com

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.
Distributed by Maxim Distribution, Arrow, Avnet Electronics Marketing, CAM RPC, Digi-Key, Elmo, Nu Horizons, and Zeus.
Distributed in Canada by Arrow and Avnet Electronics Marketing.

CIRCLE NO. 238

DESIGN FEATURE

Transmit Power Combiner

Increase CDMA Network Capacity With A Transmit Combiner

A filter-based transmit combiner can increase channel density in each antenna sector of a PCS system with minimal cost and complexity.

Siva Chebolu

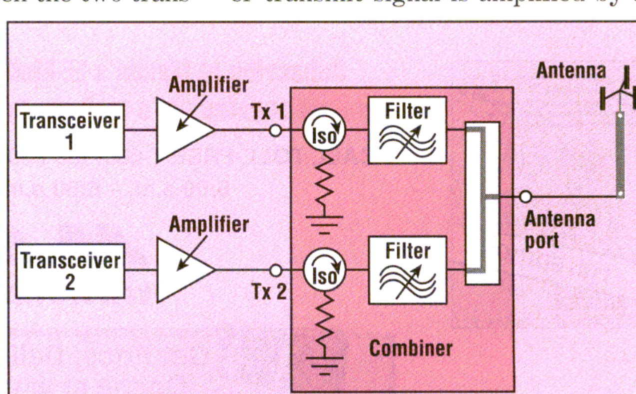
Senior Staff Engineer

Narda Microwave-West, division of L-3 Communications, 107 Woodmere Rd., Folsom, CA 95630; (916) 351-4500, FAX: (916) 351-4550, e-mail: siva.chebolu@l-3com.com.

DIGITAL wireless networks are adding new subscribers at such a rapid rate that network capacity in some areas is near saturation and additional carriers must transmitted in each sector. Of course, fierce competition requires that this expansion be realized for the least cost with the least amount of new and replacement equipment, and minimal disruption of service. The most obvious alternative—adding antennas in each sector for each additional channel—involves considerable additional hardware, licenses, and sufficient spacing between antennas in each sector to ensure adequate channel-to-channel isolation. In addition to its cost and complexity, spatial-isolation requirements make this approach impractical when more than two channels are required in each sector. Another alternative employs high-power linear multicarrier (rather than single-carrier) amplifiers, but can be quite expensive. A more straightforward approach employs a transmit combiner, which provides a simple way to increase the channel density in each sector, without resorting to massive hardware changes and their accompanying drawbacks.

There are two types of transmit combiners—hybrid and filter. A two-way hybrid combiner provides multiplexing without restrictions on frequency spacing of individual channels. However, due to the lack of coherence between the two transmitted signals, half of the power is dissipated in the terminating resistance of the hybrid. Similarly, an N-channel hybrid has a minimum loss of 10log10(N) dB. This high loss relegates hybrid combiners to applications in which only a few channels are used and where "frequency agility" is critical.

Combiners using narrowband filters provide the desired characteristics—without the high losses of hybrid-based combiners. In a typical configuration (Fig. 1), each low-power transmit signal is amplified by a



1. In this two-channel transmit combiner, the low-power transmit signals are amplified by a dedicated single-carrier PA, and then combined in a high-power transmit multiplexer.

SV MICROWAVE™

RF Connectors • Cable Assemblies • Resistive Products

As a leader in the microwave industry, our RF Connector, Cable Assembly and Resistive Products Division has over 40 years of proven high-quality performance. We design and manufacture RF coaxial connectors, cable assemblies, attenuators and terminations. From custom designs to standard off-the-shelf products, we can meet the most demanding requirements of the aerospace, defense electronics, satellite and wireless communication markets. Call us at 561-840-1800.

SV MICROWAVE™

Commercial Products Group

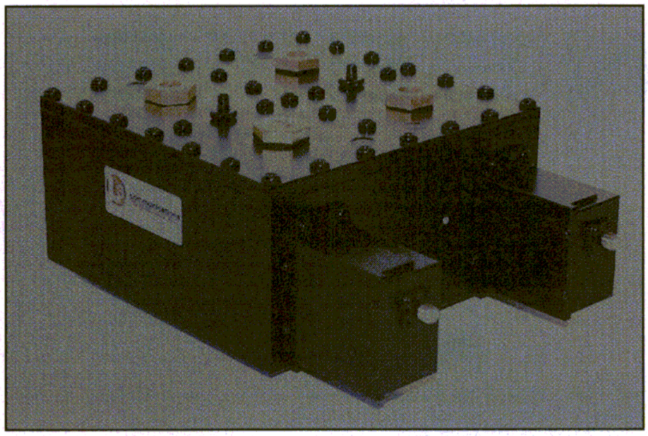
Our Commercial Products Group specializes in "high-volume, custom-designed" passive microwave components for the wireless and broadband markets. Our competitively priced products include mixers, IQ modulators and demodulators, directional couplers, power splitters, phase shifters, attenuators, hybrids and transformers. Let our experienced team of engineers fulfill all your component design requirements. Call us at 727-541-5800.

www.svmicrowave.com

CIRCLE NO. 236

dedicated single-carrier power amplifier (PA). These amplified signals are combined in a high-power transmit multiplexer consisting of bandpass filters, isolators, and a combining network. The combined output is fed to the antenna. The selectivity of the filters requires minimum spacing to be maintained between adjacent channels to ensure adequate isolation. For example, in a code-division-multiple-access (CDMA) system, alternate channels of 1.23-MHz passband are transmitted through the same combiner, resulting in a minimum channel separation of 2.46 MHz between the center frequencies of each channel.

In certain high-traffic areas, it is possible to achieve an increase in capacity by transmitting contiguous channels using a combination of these schemes. For example, all of the even and odd channels in a CDMA system can be fed to two separate combiners, and their combined outputs can be transmitted through two separate, spatially isolated antennas. These multiplexed outputs can be directed to a single antenna through a hybrid combiner (with an additional 3-dB loss). Several parameters must be considered when designing a combiner for a specific application. For this discussion, the typical combiner characteristics are assumed to be for the two-channel personal-communications-services (PCS) CDMA combiner shown in Fig. 2.

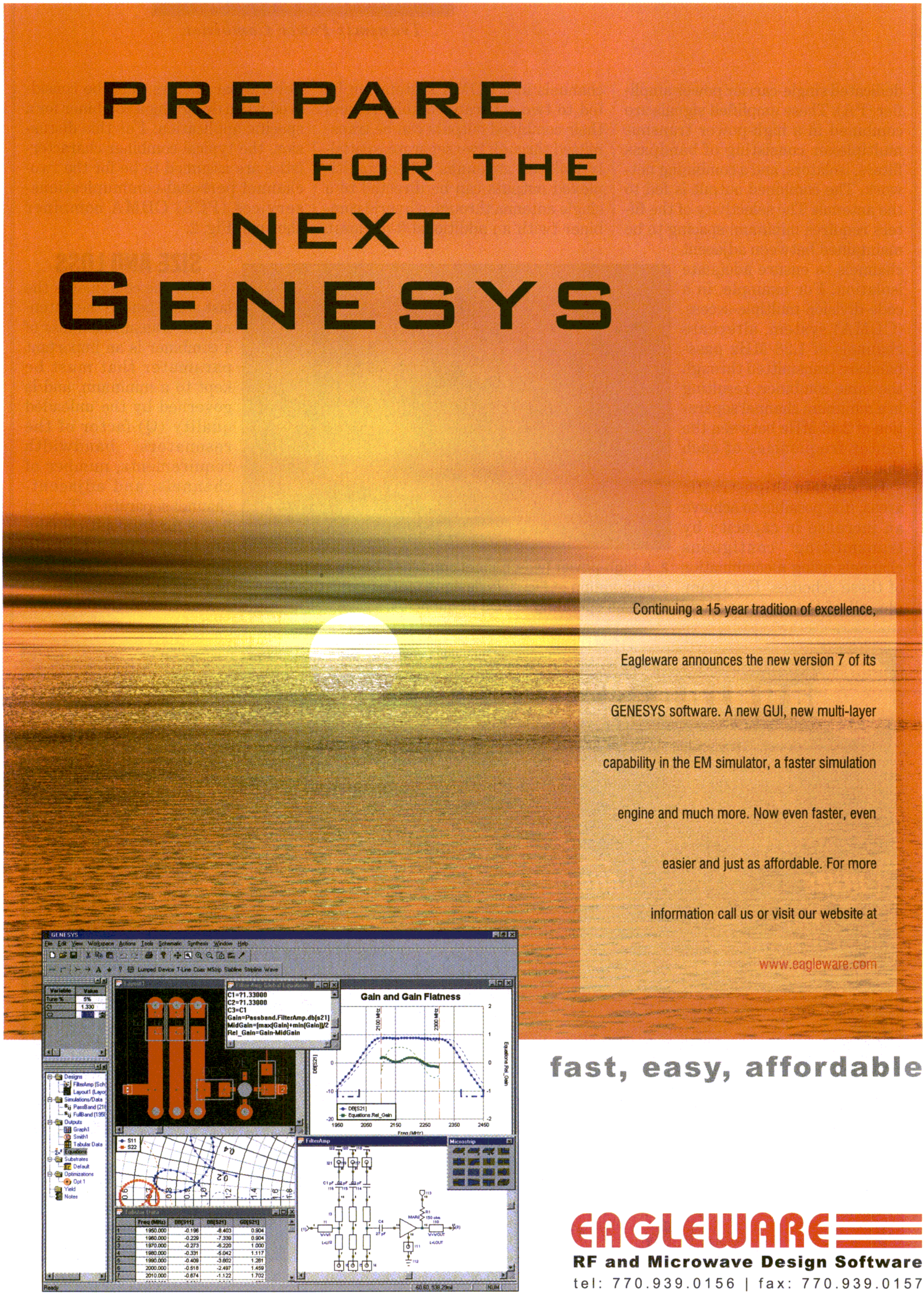


2. A high-power two-channel combiner, based on the configuration of Fig. 1, is designed for use with CDMA systems operating at PCS frequencies.

SIZE AND LOSS

Since the combiner is the last stage before the antenna, the transmission loss of a combiner is an important parameter that must be kept to a minimum, and is governed by the unloaded quality (Q) factor of the resonators, bandwidth requirements, number of channels, and adjacent-channel separation. Typical losses for transmit combiners range from 1 to 4 dB, depending on the application and design.

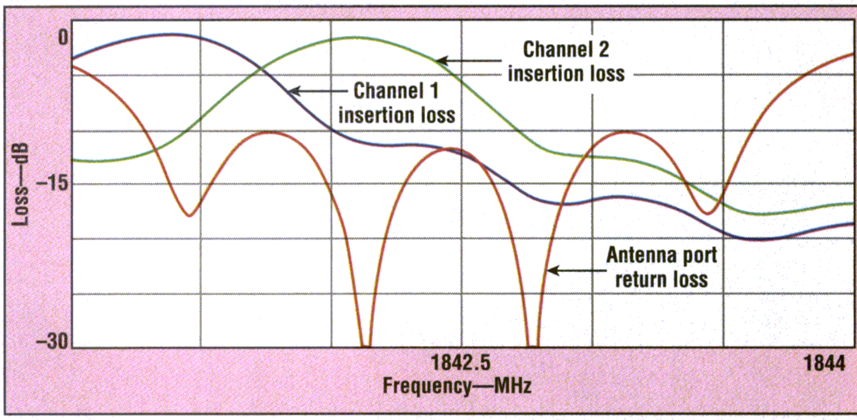
For filters, the insertion



CIRCLE NO. 273

loss is inversely proportional to the Q factor of the resonator, and this loss is a major portion of the combiner loss. At PCS frequencies, for example, unloaded Q factor of a silver-plated coaxial cavity of 4 × 4 × 3 in. (10.16 × 10.16 × 7.62 cm) is approximately 12,000, while a rectangular resonant cavity of similar dimensions can provide a Q factor of about 17,000. With the development of low-loss, temperature-stable ceramics such as barium titanate ($BaTi_3$) and other composites over the past decade, dielectrics offer many benefits because their high Q factors can be achieved in relatively compact resonators. At PCS frequencies, a ceramic resonator with a dielectric constant of 39 housed in an aluminum cavity of 2.4 ×2.4 × 2.4 in. (6.10 × 6.10 × 6.10 cm) can provide an unloaded Q factor of 24,000. Q factors greater than 30,000 can be achieved using a more-expensive ceramic resonator that has a dielectric constant of 29.

The order of a filter is determined by bandwidth and rejection requirements. Time-division-multiple-access (TDMA) and Global System for Mobile Communications (GSM) standards require passbands of 30 and 200 kHz, respectively. These narrowband combiners can be realized using single-pole filters. For example, Fig. 3 shows numerical simulations of the insertion loss and the antenna-port return loss for a four-channel combiner for GSM-1800 communications with 200-kHz passband and 700-kHz spacing between the center frequencies of adjacent channels. This combiner can be designed to operate from 925 to 960 MHz or 1805 to 1880 MHz. Typical four-channel combiner loss, including single-stage isolators, is approximately 2.5 dB.

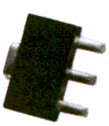


3. This insertion loss and antenna-port return loss is typical of what can be achieved with a four-channel combiner for GSM applications.

More power equals more freedom.

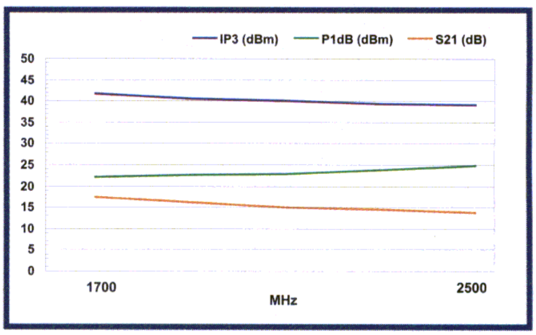
Introducing the SXT-289. A new wideband GaAsHBT power amplifier.

Stanford Microdevices introduces the SXT-289 — the perfect driver amplifier for today's and tomorrow's advanced communication infrastructure equipment.



With power to spare, giving you freedom from design constraints, this amplifier was designed and manufactured using state-of-the-art Gallium Arsenide heterojunction bipolar transistor (GaAs HBT) process technology. These devices are ideal for use as a driver stage for power amplifiers installed in cellular PCS infrastructure equipment and conform to TDMA, CDMA and PCS 1900 modulation standards. The SXT-289 operates from a single 5VDC supply and offers exceptional linearity performance in a small form-factor plastic SOT-89 with backside ground.

For more information on the SXT-289 or any of our other products, visit our website today and experience RF Innovation from Stanford Microdevices.



Typical device performance. Bias =5V @ 110mA typ.

STANFORD MICRODEVICES

www.stanfordmicro.com • 800-764-6642

CIRCLE NO. 207

Combiners for CDMA signals, which have 1.23-MHz bandwidth, require a two-pole filter. A four-channel combiner implemented with high-Q ceramic resonators has only 1.3-dB loss. Wideband CDMA (WCDMA), with 5-MHz passbands, requires higher-order filters. Minimum channel spacing is also a major contributor to combining loss. For example, in the case of the four-channel GSM combiner whose response is shown in Fig. 3, the overall loss increases from 2.5 dB to more than 4 dB as channel separation is reduced from 700 to 350 kHz. In addition, closer separation between channels requires greater filter selectivity to ensure adequate isolation.

TUNABILITY

Cavity combiners are tunable over the transmit band of interest. For example, a PCS combiner covers the 1930-to-1990-MHz transmit band while an Advanced Mobile Phone Service (AMPS) combiner tunes from 869 to 894 MHz. The frequency allocation of a particular channel is often determined by traffic configuration, demand, adjacent-cell frequencies, and other factors. For example, during peak service periods, some cell sites might be busy while others have little traffic. In these instances, the service provider can make better use of available resources by reallocating some of the frequencies being used in the less-loaded sites to the more heavily trafficked sites.

This frequency allocation transfers service loading to unused neighboring channels and requires field-tunable combiners. At Narda Microwave-West (Folsom, CA), novel design techniques for the tuning mechanism and the use of broadband combining networks make the combiners field tunable with minimal effort. For example, the PCS CDMA combiner shown in Fig. 2 can be tuned over the entire transmit band without adjusting the input and output coupling parameters. Self-locking tuning screws are used to further simplify the tuning process.

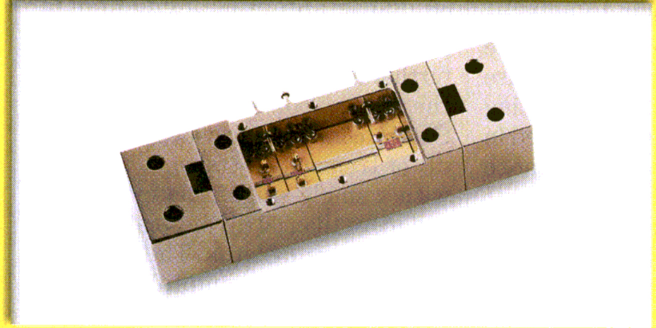
Isolation between the antenna and transmitting ports is achieved through single-stage or dual-stage isolators that provide approximately 22- and 45-dB isolation, respectively. The isolation between transmitters is further enhanced by the selectivity of the filter. For example, the PCS CDMA combiner provides at least 35 dB of transmit-to-transmit isolation with a single-stage isolator (Fig. 4) and more than 60 dB of isolation with a dual-stage isolator. The isolators also protect the amplifiers from receiving any reflected power in the event of an antenna failure by dissipating this energy in a high-power termination mounted on an efficient heat sink.

TEMPERATURE STABILITY

Transmit combiners are designed to withstand a wide variety of environmental conditions such as humidity, temperature variations of –40 to

Specialty Products for LMDS and Point-To-Point Radio Applications

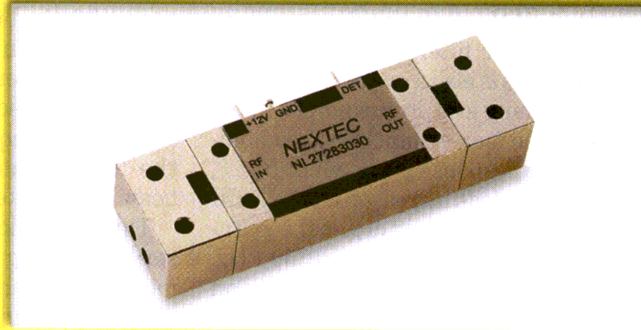
Ka-Band Driver and Power Amplifiers



From 24 GHz to 30 GHz for LMDS and B-WLL

- P1dB up to 2 Watts
- Small size/low cost
- +12 V single bias
- IP3 up to 40 dBm
- K-connector option
- VSWR In/Out < 2:1

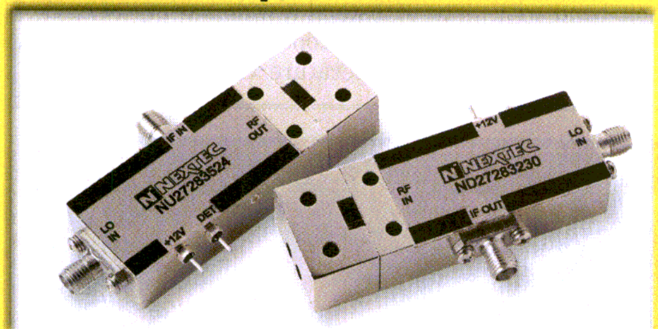
Ka-Band Low Noise Amplifiers



From 24 GHz to 30 GHz for LMDS and B-WLL

- NF less than 2.5 dB
- Rugged thin film construction
- Gain flatness ±1.0 dB
- Gain control option
- Unconditionally stable
- Fast delivery

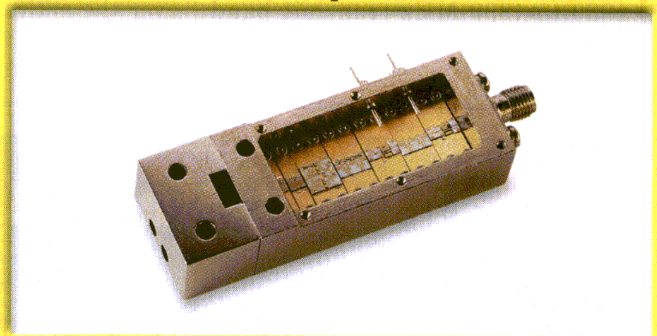
Ka-Band Up/Down Converters



From 24 GHz to 30 GHz for LMDS and B-WLL

- P1dB up to 2 Watts
- Gain/power control option
- Highly efficient
- Less than 3.0 dB NF
- VSWR In/Out < 2:1
- Small size/low cost

Multipliers



From 2 GHz to 40 GHz

- Power out up to 1 Watt
- Rugged thin film construction
- Power control option
- Small size
- Low cost
- Power detector option

Nextec Microwave & RF, Inc. is committed to providing the global wireless community with on time delivery of specification compliant, high quality products, ensuring our customers receive the optimum value for their investment.

In addition to the products shown above, Nextec designs, manufactures and markets components and subsystems for RF, microwave and millimeter wave applications.

Our line of products also includes:

- Communication Band Amplifiers
- Broad Band Amplifiers
- PLL Oscillators
- Voltage Controlled Attenuators
- Other custom designed products including Transceivers, Ku-Band VSAT Up Converters, MMIC Modules, Millimeter Wave Packaging

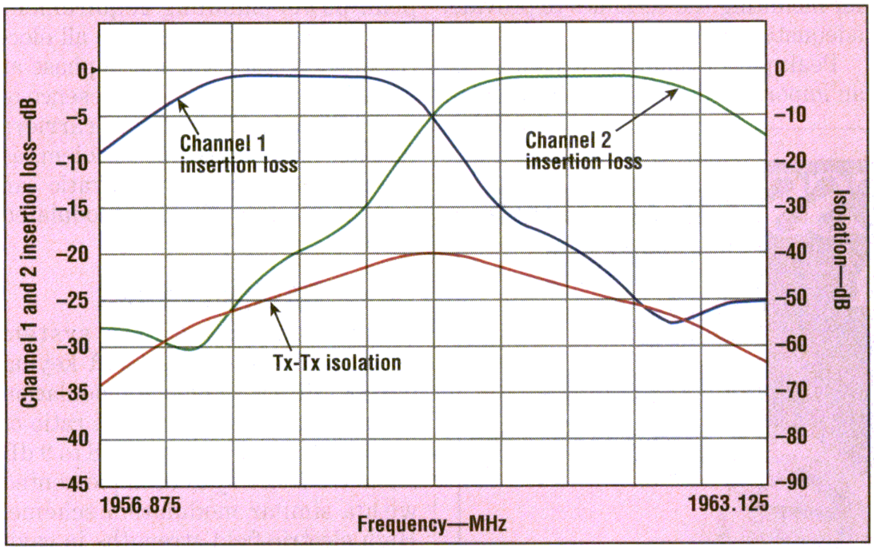
NEXTEC MICROWAVE & RF INCORPORATED

2255-E, Martin Avenue
Santa Clara, CA 95050 USA
PHONE 408.727.1189
FAX 408.727.5915
info@nextec-rf.com
www.nextec-rf.com

CIRCLE NO. 233

+60°C, and altitudes up to 10,000 ft. Their electrical characteristics are compensated for these severe conditions. For example, as temperature increases, the whole filter structure expands, while individual components expand according to their respective coefficients of thermal expansion. This expansion causes resonant frequencies and coupling coefficients to change, resulting in a changed filter response. Fortunately, this differential expansion of various materials can be used effectively to minimize frequency drift over the operating temperature range. The employed compensation techniques are unique to each type of resonator. For example, coaxial filters often use center conductors that are manufactured of different materials, and waveguide cavities employ bimetallic strips. For dielectric resonators, an appropriate temperature coefficient of the ceramic is chosen to achieve the same effect.

In high-power transmit multiplexers, the phenomenon of power compensation must be addressed. For example, in an eight-way PCS TDMA resonant-cavity combiner, insertion loss is approximately 3 dB for a channel separation of 630 kHz. When each channel carries 60 W of power, more than 240 W of power is continuously dissipated in the combiner. As the dominant transverse electromagnetic (TE) TE_{101} modal energy is concentrated in a small region in the res-



4. The two-channel PCS CDMA combiner described throughout the article achieves low insertion loss and high transmit-to-transmit isolation.

onator, the temperature gradient is not uniform throughout the structure. This behavior causes a different frequency drift under power loading compared to the drift produced due to ambient temperature variations. Similar phenomena occur in other types of resonators. In ceramic resonators, the poor thermal conductivity of most dielectric materials, coupled with the additional complexity of conducting heat away from the ceramic to the metallic housing, makes power compensation a challenging task. In these instances, thermally conductive structures are used for mounting the ceramics to provide adequate heat dissipation.

Peak power-handling capability is an important design issue in combiners as all of the high-power signals are multiplexed into one common output port. If "n" carriers at separate frequencies within the transmit passband are applied simultaneously with a peak power level "P," the overall peak power-handling requirement becomes n × n × p because all electric-field vectors will add in phase at some instant in time. The presence of multiple spread-spectrum carriers further compounds this problem, as the peak-to-average signal ratio can be quite high in digitally modulated systems.

RAISING PEAKS

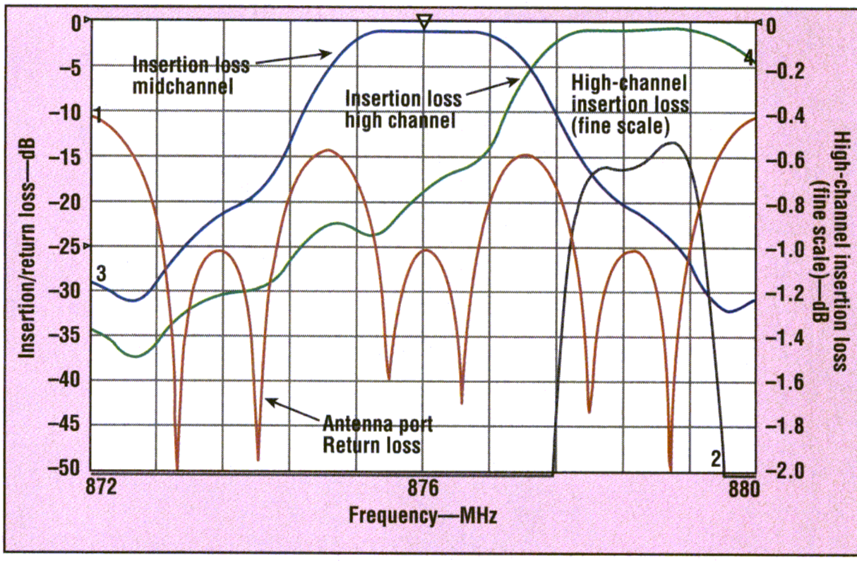
For example, a CDMA system using quadrature-phase-shift-keying (QPSK) direct-sequence modulation has a peak-to-average signal ratio of 10 to 12 dB, and this ratio is 8 to 9 dB for a WCDMA system implemented with a similar modulation scheme. High electric-field strengths in cavities can cause arcing due to voltage breakdown. In ceramic resonators, other mechanisms, such as dielectric heating or enhanced microwave absorption caused by the presence of foreign particles, can control the breakdown threshold. These destructive phenomena can be avoided with proper electrical design, reducing sharp corners or protrusions, pressurizing the cavity with an inert gas, and using proper surface treatment of the metals to minimize the introduction of foreign particles.

Rigorous temperature and power testing must be performed to ensure that the combiners function effectively over extreme operating conditions. For example, a typical Narda PCS CDMA combiner can handle 75 W in each channel, and has a peak power rating of 750 W, even when terminated by an antenna with a VSWR of 2:1. It also maintains all of its electrical characteristics over a wide temperature range of –40 to +60°C, and exhibits frequency drift of less than 75 kHz under these conditions.

Systems that employ digitally modulated signals require that strict attention be paid to passband loss variation and group-delay spread introduced by the combiner. Unlike analog signals that use frequency-modulated carriers to transmit infor-

mation, digital schemes modulate the amplitude and phase of the RF carrier. Significant loss variation and group-delay spread increase the bit-error rate (BER) considerably, and prevent proper resolution of these signals at the receiver (Rx).

The passband of a combiner is always tilted due to the varying levels of isolation provided by adjacent channels, and this effect is more pronounced at the outer channels. Figure 5 shows the measured loss response of a three-channel AMPS/CDMA combiner implemented using two-pole filters without cross-coupling. In addition, Fig. 5 shows passband loss of the high channel on an expanded scale to view the tilt. This loss variation can be reduced through increased isolation between the channels by using cross-coupling between non-adjacent resonators to introduce finite transmission zeros on either side of the passband. This technique produces steeper selectivity for the filter response and decreases the passband loss variation. However, the additional cross-coupling makes the unit difficult to tune in the field, and it is rarely used. However, the use of appropriate combining networks ensures minimal passband loss variation, typically less than 0.4 dB in the unit of Fig. 5, and a maximum group-delay spread of 80 ns from –40 to +60°C.



5. In this three-channel AMPS CDMA combiner, minimal passband loss variation (typically less than 0.4 dB) is achieved, along with a maximum group-delay spread of 80 ns from –40 to +60°C.

IM ISSUES

Since transmit multiplexers and duplexers often have a low-loss leakage path to the low-noise receiver, it is important to reduce the passive intermodulation (IM) products generated in a combiner. IM products can be caused by the formation of thin oxide layers on metal surfaces, mechanical imperfections in joints, microcracks or voids in materials, and dirt or metal particles on the surface.

The isolators, which precede the filters, are a significant source of IM due to the inherent nonlinearity of the ferrites and magnets. However, the IM products generated in an isolator are additionally attenuated by the selectivity provided by the filter before reaching the receiver or other transmitters. For example, PCS CDMA combiners using drop-in isolators provide a maximum third-order IM of –70 dBc in the transmit band with two +44-dBm input tones. By using connectorized, low-IM isolators, such as those produced at Narda Microwave through careful design procedures and controlled manufacturing processes, third-order IM products can be reduced to less than –100 dBc in the transmit band and less than –120 dBc in the receive band.

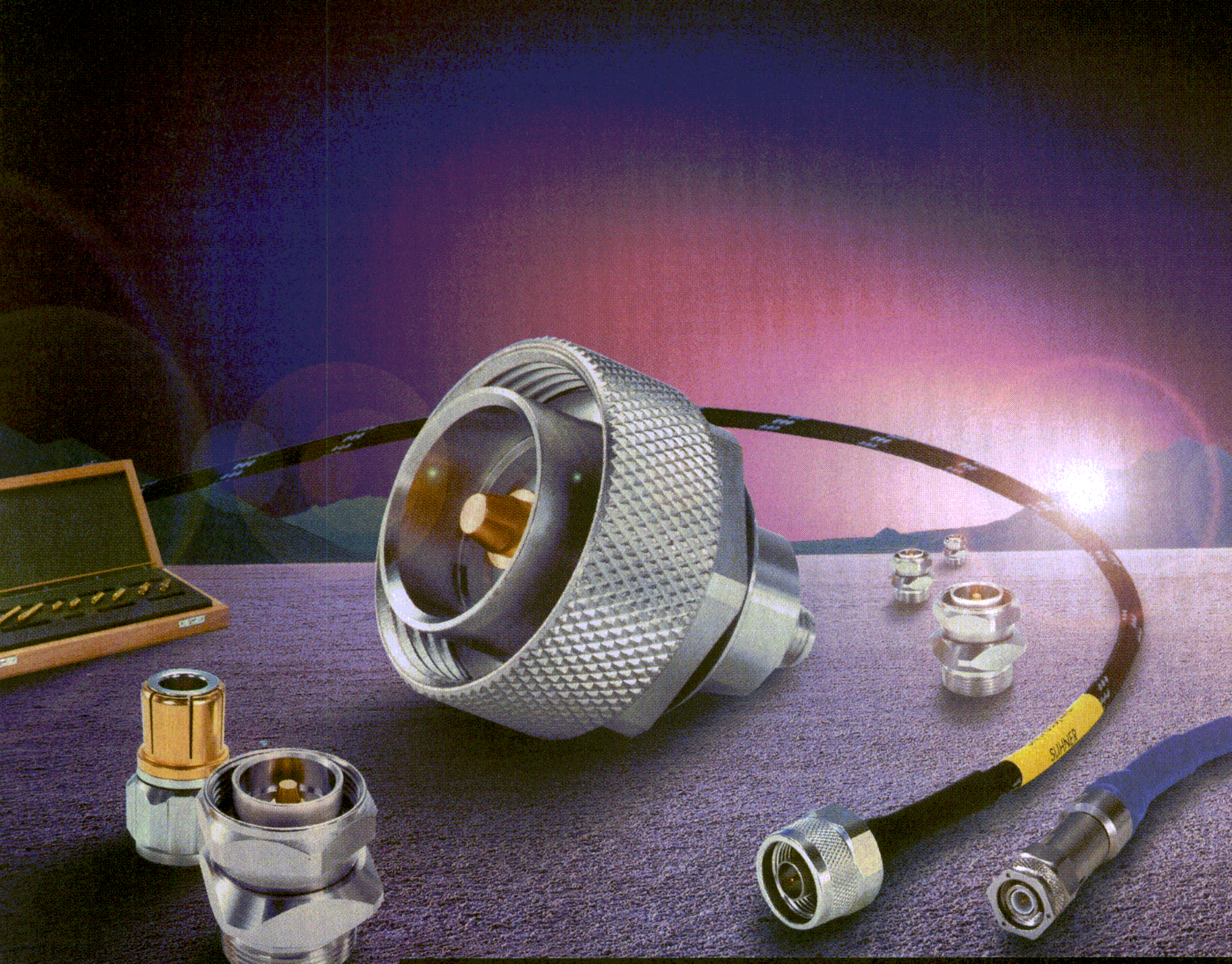
CIRCUIT SIMULATIONS

With accurate equivalent circuit models, which are valid representations of these narrowband filters, the electrical response of a combiner can be synthesized in a few minutes to achieve the desired characteristics. Once the equivalent circuit has been realized, full-wave three-dimensional (3D) electromagnetic (EM) field solvers are used at Narda Microwave to simulate various types of resonators, optimizing their dimensions to yield the highest Q-factors for a particular size. These field solvers also provide useful information to ensure that higher-order modes are sufficiently far from the principal resonant mode of operation. In addition, mechanical design tools such as Mechanica are employed to perform thermal and structural stress analysis and obtain information about the impact of shock and other vibrations on the device without resorting to destructive tests on prototypes. With these sophisticated computer-aided-design (CAD) tools, experimental prototyping is minimized, leading to a reduction in the overall design-cycle time. In addition, novel design methodologies significantly reduce the assembly and tuning time of these combiners.

PRACTICAL SOLUTION

Although the future holds promise for alternative technologies such as high-temperature superconductors, and wideband software-definable architectures using feedforward and multicarrier PAs, the high-power transmit combiner is still the most cost-effective method to expand the capacity of existing base stations.

High-Q ceramic resonators and low IM isolators, coupled with advanced design techniques, provide compact, high-power combiners that are easy to tune and feature low loss and good temperature stability. A multichannel combiner also accommodates future expansion by simply terminating the unused channels with 50-Ω loads. With all of these features, combiners provide a convenient way to upgrade existing systems to increase network capacity. ••




bring your
design team
together with
SystemView®
BY ELANIX
The program manager gets a complete view of the project at hand, including the immediate effects of changes.
The DSP designer gets bit-true simulation and a direct path to TI C5x/C6x DSP implementation.
The systems architect can build his working simulation with easy to use functional blocks—then hand off to DSP and RF designers.
The RF designer can design with distortion-true system blocks, then move directly to Xpedion simulation tools.

Use Transmitting Power FETs For Antenna Switching

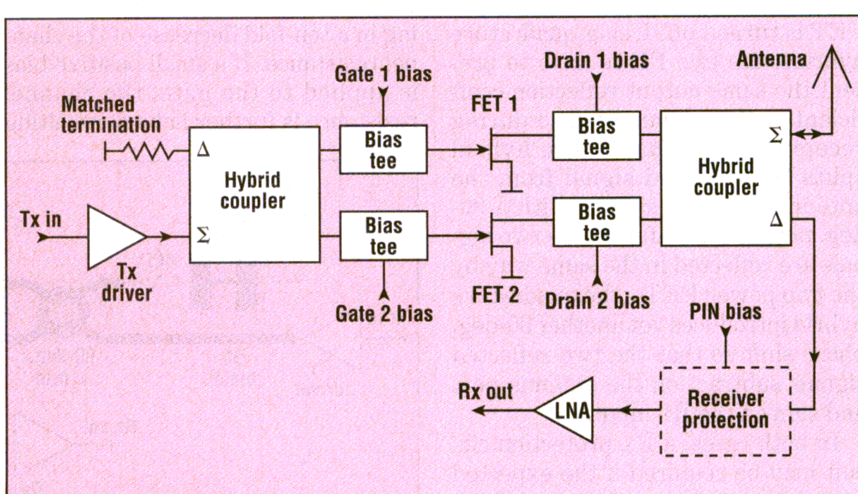
This novel design uses a transceiver's power-amplifier devices for antenna switching, reducing parts count, mismatch, and insertion loss.

Matjaz Vidmar,
Sergeja Masere 21, 5000 Nova Gorica, Slovenia; FAX: (386) 61 176-8424, e-mail: s53mv@uni-mb.si.

IN transceivers that do not use a non-reciprocal device (i.e., a circulator), the antenna switch requires at least two switching devices—one for transmit mode and one for receive mode—regardless of the technology used to build the switch. For example, a mechanical antenna relay requires at least two contacts, a positive-intrinsic-negative (PIN)-diode antenna switch requires at least two diodes, and a gallium-arsenide field-effect-transistor (GaAs FET) antenna switch requires at least two FETs. Even more switching devices may be required for higher power handling or improved switch isolation. But every switching device contributes some impedance mismatch and increases the insertion loss of the antenna switch. Therefore, it makes sense to look for solutions with a reduced number of switching devices to improve the electrical performance of the transceiver.

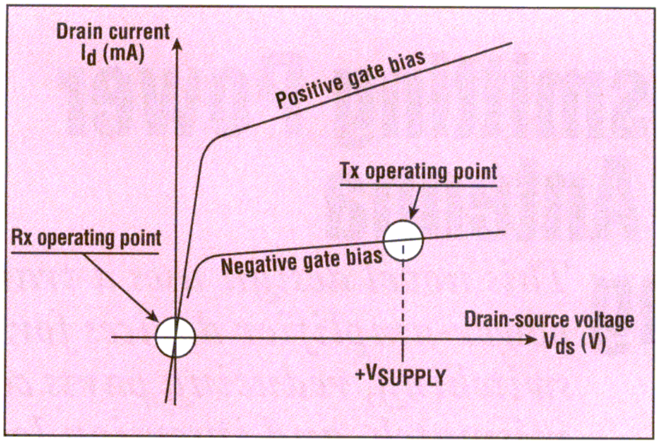
This article presents a K-band receive/transmit module design that does not require any additional components for antenna switching. In this design, the same transmitter power devices are biased in a different way during reception to route the RF signal from the antenna to the Rx input. In addition to reducing the number of switching components, this design can reduce the insertion loss in receive and transmit modes.

In most simplex radio transmitters, it is possible to control the out-



1. This schematic demonstrates antenna switching with transmitting power devices.

put impedance or reflection coefficient by properly adjusting the bias point of the output-power device(s) in the power-off state during Rx operation. This technique has often been used at low frequencies (below 30 MHz) to save one switching component in the antenna switch. The same technique can be used at microwave frequencies[1] by making the Tx output fully reflective when powered off.



2. This graph shows the power FET operating points.

In radio transmitters with more than one power device in the output stage, the designer has more degrees of freedom to adjust the bias points of the single power devices independently in the power-off state, as shown in Fig. 1. During transmission, the two power FETs are combined with two hybrid couplers. During reception, the bias points of the two power FETs are adjusted so that the signal coming from the antenna is reflected into the Rx.

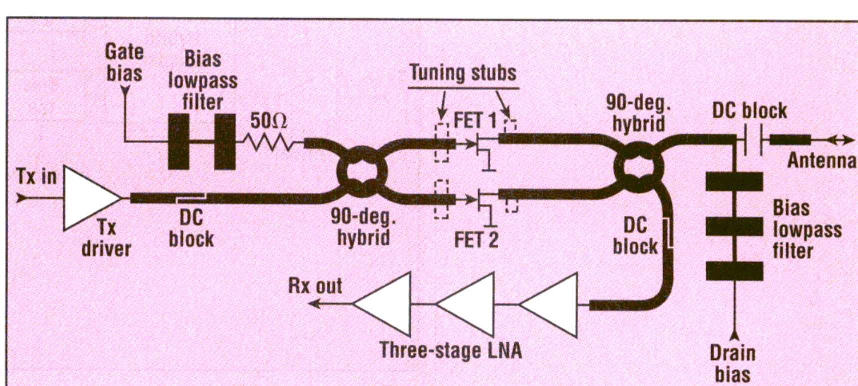
Reflecting the incoming signal from the antenna into the Rx during reception can be achieved by using in-phase power dividers and combiners, or by using quadrature hybrids. Using in-phase power dividers and combiners (like rat-race hybrids), the two FETs have to be biased in a different way to provide a 180-deg. difference in the phases of their output refection coefficients. For example, one FET is turned on while the other FET is turned off. Using quadrature hybrids, the two FETs have to present the same output reflection coefficient with the same phase during reception. The quadrature hybrid splits the received signal from the antenna into two signals with a 90-deg. phase shift. After these two signals are reflected in the same way by the two power FETs, the quadrature hybrid introduces yet another 90-deg. phase shift so that the two reflected signals subtract on the antenna port and sum on the Rx input.

In both cases, a Rx-protection circuit may be required if the expected transmitter unbalance power is high enough to damage the receiver's front end. Of course, worst-case conditions have to be considered. These conditions can include maximum device mismatch and load conditions, such as a disconnected or obstructed antenna. The receiver protection may include a limiter and/or a shunt PIN-diode switch. In low-power transceivers with less than 200-mW transmitter power, the maximum unbalance power is usually too low to damage the receiver, so no special receiver-protection circuit is required.

Although the geometry of popular transmitting-power FETs is probably not optimized for operation as RF switches, most GaAs FETs provide useful switch performance, as shown in Fig. 2. During transmission, the dynamic-channel resistance is closely matched to the system's characteristic impedance (usually 50 Ω). With the drain bias removed, the I_d-versus-V_{ds} curve becomes much steeper, resulting in a ten-fold decrease of the channel resistance. If a small positive bias is applied to the gate, the channel resistance is further halved, resulting in an output reflection coefficient close to –1. On the other hand, if a highly negative bias is applied to the gate, the FET channel resistance will increase to very high values, resulting in a reflection coefficient close to +1 at low frequencies. In either case (FETs on or off), not much additional noise is generated with the drain bias removed, resulting in very little reduction in the sensitivity of the receiver.

To demonstrate the feasibility of the proposed antenna-switching design, the author built and tested a practical low-power transceiver front end for the 24-GHz industrial-scientific-medical (ISM) band. It includes a Tx driver stage, an output stage with two FETs, and a three-stage low-noise amplifier (LNA). While easy-to-use and inexpensive packaged pseudomorphic high-electron mobility transistors (PHEMTs) originally designed for 12-GHz TVRO downconverters still provide useful performance at 24 GHz, finding cheap and easy-to-use RF switching components for 24-GHz applications is more difficult. An efficient alternative was finally found by performing the Rx/Tx antenna switching with the same Tx power devices.

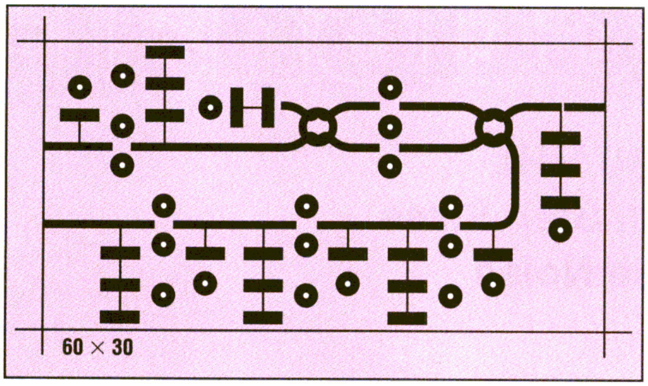
The simplified circuit diagram of the 24-GHz transceiver front end is shown in Fig. 3. Due to circuit parasitics, the phases of the reflection coefficients are difficult to control at 24 GHz. At high frequencies, it is simpler to obtain two reflections with the same phase rather than two reflections exactly 180 deg. out of



3. This is the simplified circuit diagram for a 24-GHz transceiver front end.

phase. Thus, the author decided to use quadrature hybrids and apply the same bias to both transmitter output FETs.

The practical circuit uses ATF35076 packaged PHEMTs in all stages. According to the manufacturer's data sheet,[2] these devices are not specified above 18 GHz, so tuning stubs are required to obtain 7 to 8 dB of small-signal gain at 24 GHz. With an input of +10 dBm (at 24 GHz) to the driver and +4-VDC output-stage drain bias, a saturated power of 95 mW could be measured with an HP8485A thermocouple and an HP435A power meter on the antenna connector.



4. The 24-GHz front-end microstrip board layout measures 60 × 30 mm on soft laminate.

The unbalance power on the LNA input can be made arbitrarily low with circuit tuning. Even without specific tuning, the unbalance power remained well below the +10-dBm input damage level[2] of the ATF35076 PHEMT. Therefore, no special receiver-protection circuit was required in this application. The three-stage LNA gain is approximately 22 dB, including the antenna-switch insertion loss.

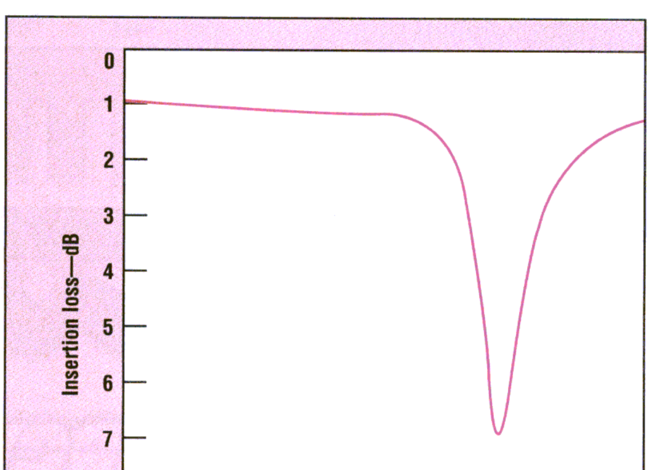
The 24-GHz transceiver front end is built as a microstrip circuit on 0.25-mm (10-mil)-thick, fiberglass-Teflon laminate with 35-µm copper on both sides (ARLON DiClad 870, which has a dielectric constant of 2.33). The microstrip-board pattern shown in Fig. 4 measures 60 × 30 mm. Since the Teflon board is quite soft, the bottom side is soldered to a 0.3-mm-thick brass plate for mechanical support.

The 1/8-in. (3.2-mm)-diameter holes in the microstrip board are used either for grounding the source leads of the PHEMTs to the brass-plate groundplane or for accommodating feedthrough capacitors required for the various supply voltages. Most DC blocks are built as quarter-wavelength coupled lines. Since it is difficult to etch very narrow slots in 35-µm-thick copper, the actual slots are too wide and the resulting mismatch has to be compensated with the tuning stubs.

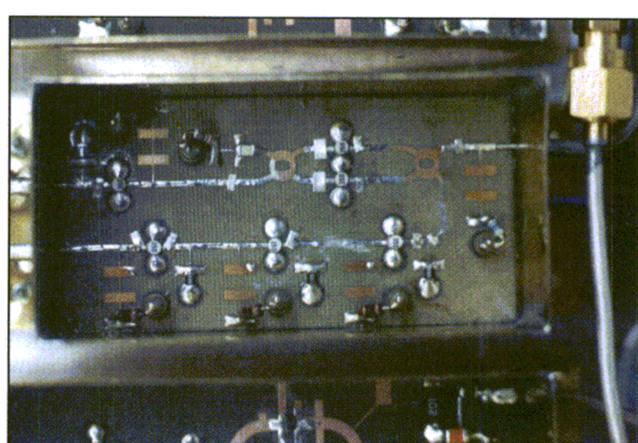
The only exception is the antenna's DC block, which is a discrete capacitor made from a small rectangular piece of double-clad, 0.13-mm (5-mil)-thick Teflon laminate soldered on top of the output microstrip line. The width of this capacitor matches the microstrip width, while the length is one-quarter wavelength. The top electrode is connected to a microstrip by a small piece of tinned-copper foil.

The microstrip circuit board includes a few additional components, including bias networks for all amplifier stages. All three stages of the receiving LNA and the transmitter driver operate at zero gate bias for maximum gain. Although the PHEMTs provide some useful gain at 24 GHz, their insertion gain increases quickly at lower frequencies. If no special countermeasures are taken, a 24-GHz amplifier design will most likely self-oscillate at or below 15 GHz. One must carefully design the bias networks to prevent these unwanted oscillations at low frequencies. Therefore, all bias networks include a lowpass structure terminated into a resistor toward ground or the bias feedthrough capacitor. The lowpass structure is designed to reflect K-band signals while terminating lower frequencies into the following resistor. The unwanted low-frequency gain is further reduced by the resonant quarter-wavelength, coupled-line DC blocks.

Unfortunately, the described countermeasures are not enough to ensure the stability of the transmitter output stage. Its two quadrature hybrids represent a near-perfect short circuit at frequencies below 5 GHz. Push-pull oscillations of the output stage are therefore possible below 5 GHz. These oscillations are



5. This graph shows the measured Rx insertion loss.



6. This photo shows the 24-GHz front end with cover and absorber removed.

suppressed by carefully selecting the lengths of the lines connecting both gates and drains to the corresponding hybrids. In particular, the drain lines must be longer than the gate lines.

The same drain- and gate-bias voltages are applied to both output PHEMTs through the quadrature hybrids. The drain-bias network includes a simple lowpass structure, while the gate bias is applied through the 50-Ω termination on the difference port of the hybrid. The 50-Ω termination is a 0805-size SMD resistor, installed "upside-down" with the resistive layer facing the printed-circuit board (PCB).

Figure 5 shows the measured receiver insertion loss as a function of the gate-bias voltage, with an estimated absolute accuracy of ±0.5 dB. As expected, the insertion loss is low (approximately 1 dB) for both a positive gate bias (approximately +0.65 VDC) as well as a large negative gate bias –2.5 VDC). The drain supply of the transmitter output stage is, of course, switched off during reception. The gate current is limited by a resistor when a positive bias is applied.

Figure 6 shows the entire 24-GHz front end with the cover and absorber removed. Since the whole microstrip board is rather large in terms of the operating wavelength, microwave-absorbing foam is required to kill high-Q cavity resonances when the microstrip board is installed in a shielded case. The best place to install the microwave-absorbing foam is on the entire underside surface of the cover.

THE DESCRIBED FRONT END REQUIRES NO ADDITIONAL COMPONENTS FOR ANTENNA SWITCHING

The positions of the tuning stubs were found to be reproducible when using the same transistors on the same circuit-board material. Of course, the construction tolerances have to be kept tight during the assembly of the circuit—especially the spacing of the coupled lines and the positioning of the PHEMTs on the board.

The described 24-GHz, ISM-band transceiver front end requires no additional components for antenna switching. There is no additional insertion loss for the transmitter, since all components used for antenna switching are already part of the transmitter. The receiver insertion loss is reasonably low and is comparable to conventional PIN-diode or GaAs-FET switches.••

Acknowledgement

The author would like to acknowledge Mr. Michel Leclercq, Director of Marketing & Technical Service, ARLON Europe, for supplying the laminate used in this project.

References

1. M. Vidmar, "Use Single Diode To Design Antenna Tx/Rx Switch," *Microwaves & RF*, Vol. 38, No. 6, pp. 99-105, June 1999.
2. Hewlett Packard, "Communications Components Designer's Catalog, GaAs and Silicon Products," pp. 7.73-7.75, 1993.

Digital Modulation Forces New Testing Techniques

RF components slated for digitally modulated communications systems must be characterized in a new way, using complex stimulus measurements.

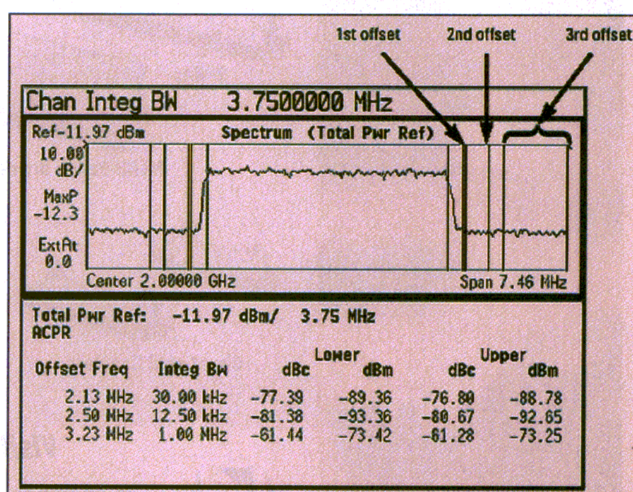
Mike Wimsatt

Agilent Technologies, Component Test Market Solutions Unit, Santa Rosa, CA 95403; (707) 577-2418, Internet: http://www.agilent.com/find/component_test.

DIGITAL modulation has created a revolution in RF and microwave communications. In the past, RF and microwave components destined for analog systems were tested using single or multiple continuous-wave (CW) signals to characterize their performance and evaluate distortion. The proliferation of digital-modulation techniques in wireless communications demands new types of measurements requiring a digitally modulated stimulus and the ability to analyze the device's response. Cellular systems have moved from the old analog Advanced Mobile Phone Service (AMPS) and Total Access Communication Service (TACS) systems to second-generation (2G) North American Digital Communications (NADC), code-division-multiple-access (CDMA), and Global System for Mobile Communications (GSM) standards. Today, the wireless industry is moving to next-generation digital systems such as wideband CDMA (WCDMA), cdma2000, and EDGE. As third-generation (3G) systems such as WCDMA and cdma2000 evolve, and performance requirements become tighter, these measurements have become more important.

Outside of cellular communications, the broadcast industry is also moving into the era of digital modulation. High-definition-television (HDTV) systems will use 8-level vestigial-side-band (8VSB) and coded-

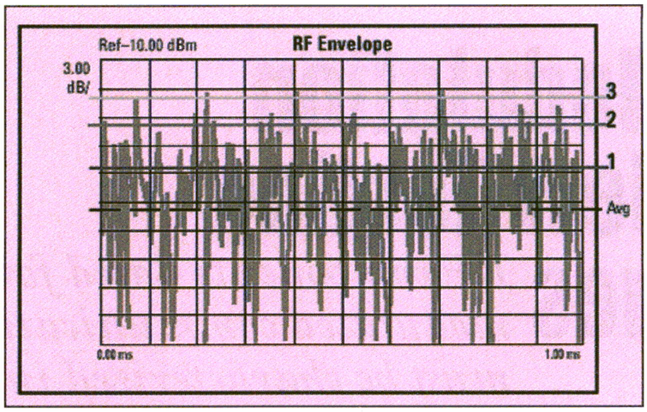
1. This type of test setup is required for generating and measuring signals on components to be used in digitally modulated communications systems.



2. An accurate ACPR measurement as shown here is necessary to characterize a component for operation in a cdma2000, spread-rate 3 (SR3), multicarrier system.

orthogonal-frequency-division-multiplexing (COFDM) digital-modulation formats in various parts of the world. Microwave multipoint distribution system (MMDS) and local multipoint distribution service (LMDS) will use versions of OFDM and quadrature amplitude modulation (QAM).

The design and test of modern wireless components requires RF-power and modulation-quality measurements on components that are excited by a complex-modulated stimulus. RF-power measurements include adjacent-channel power ratio (ACPR) and the complementary cumulative distribution function of a signal's power. Two modulation-quality measurements are error-vector magnitude (EVM) and code-domain power.



3. A power versus time graph of a nine-channel cdma2000 signal shows the instantaneous power envelope produced by the in-phase (I) and quadrature (Q) components.

For each measurement described in this article, a common test configuration is shown in Fig. 1. The signal generator should be capable of generating complex modulated signals according to the desired digital-modulation formats. Signal analysis can be performed by a spectrum analyzer or vector signal analyzer, depending on the measurements. A measurement of the adjacent-channel interference caused by a component is ACPR or spectral regrowth. ACPR is the ratio of adjacent-channel power to the average power level of the channel. A high-power CDMA (cdmaOne, cdma2000 or WCDMA) base-station amplifier serves as an example.

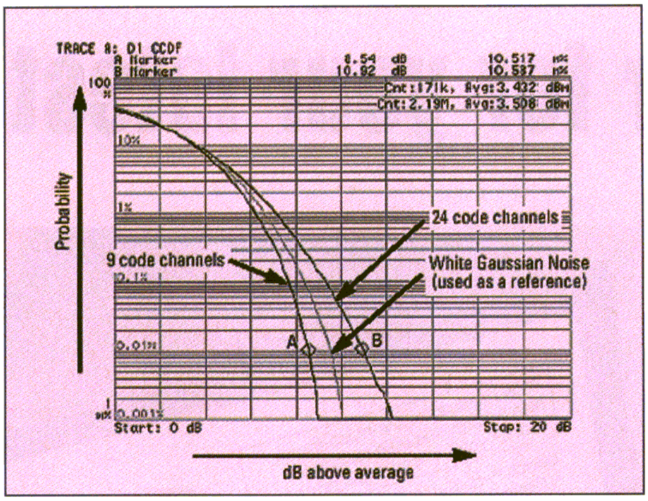
Traditionally, two-tone intermodulation (IM) measurements were used to assess an amplifier's distortion performance. For narrowband signals, the IM products caused by nonlinearities create spectral components at frequencies given by:

$$F_I = Nf_1 \pm Mf_2$$

where:
N and M = the integers
f_1 and f_2 = the two frequencies pre-

sent at the input of the nonlinear device, and

f_i = the frequency of the IM products. CDMA signals can be thought of as many closely spaced spectral components. IM products form a shelf or "shoulders" around the expected CDMA spectrum.

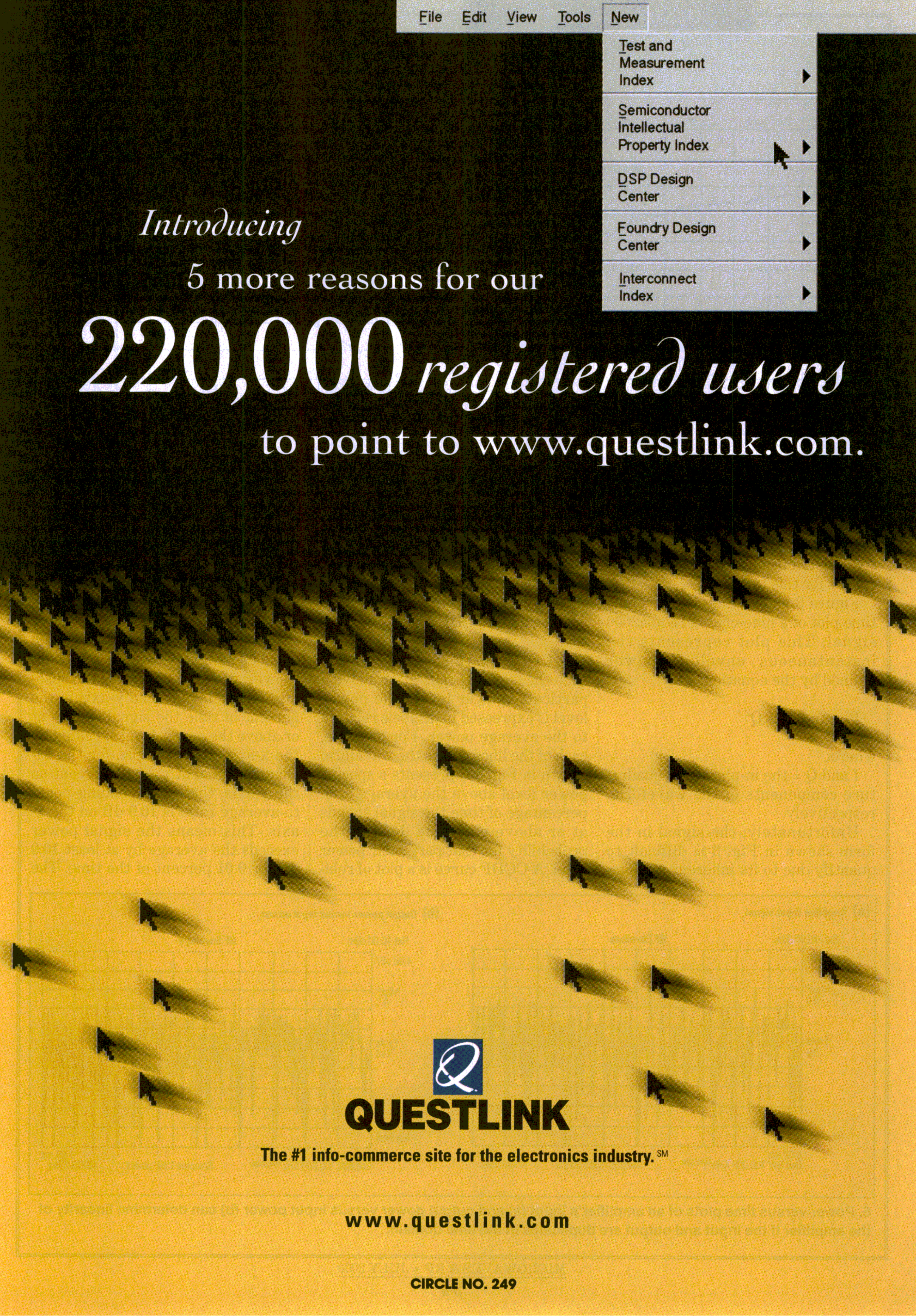


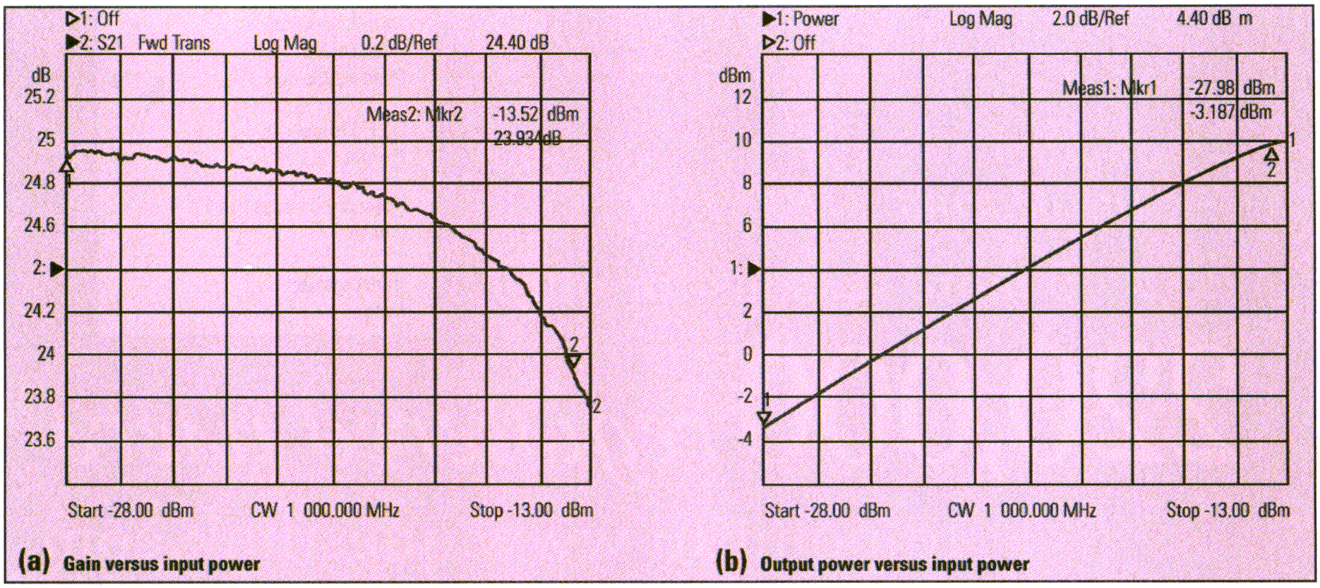
4. The statistical distribution of the graph of Fig. 3 is given by this complementary-cumulative-distribution-function (CCDF) curve which shows how much time a signal stays at or above a given power level.

The measurement of IM products is complicated by the fact that CDMA signals have high-stress characteristics. Therefore, the traditional two-tone signal is not an appropriate stimulus. Tests made with a two-tone stimulus do not provide a useful measure of the operational performance of CDMA base-station amplifiers. Network-equipment manufacturers instead require component manufacturers to provide ACPR results as the figure of merit for distortion performance. A sample ACPR measurement for a cdma2000 spread rate 3 (SR3) multicarrier signal is shown in Fig. 2.

In component testing, the stimulus signal must provide the appropriate channel configuration (number of channels and individual channel settings—data rate, power level, and so forth—for each channel). It must also provide the correct modulation, filtering, and chip rate for the system. This is important when performing modulation quality and RF power measurements.

When designing components and testing ACPR, it is important to take into account the power statistics of the signal. Different peak-to-average ratio values have a different impact on nonlinear components. In CDMA systems, the statistics of the signal depend on its channel configuration, modulation, filtering, and clipping level. The safest approach is to select at least one high-stress stimulus signal and test with various combinations of chan-


File
Edit
View
Tools
New
Test and Measurement Index
Semiconductor Intellectual Property Index
DSP Design Center
Foundry Design Center
Interconnect Index
Introducing
5 more reasons for our
220,000 *registered users*
to point to www.questlink.com.
QUESTLINK
The #1 info-commerce site for the electronics industry.SM
www.questlink.com
CIRCLE NO. 249



5. An amplifier can be characterized by its gain versus input power (a) or as its output power versus input power (b). If the input and output signals are within the amplifier's power specs, there will be no distortion (called compression).

nels. Use Complementary Cumulative Distribution Function (CCDF) curves for this task.

Figure 3 shows the power versus time plot of a nine-channel cdma2000 signal. This plot represents the instantaneous envelope power defined by the equation:

$$\text{Power} = I^2 + Q^2$$

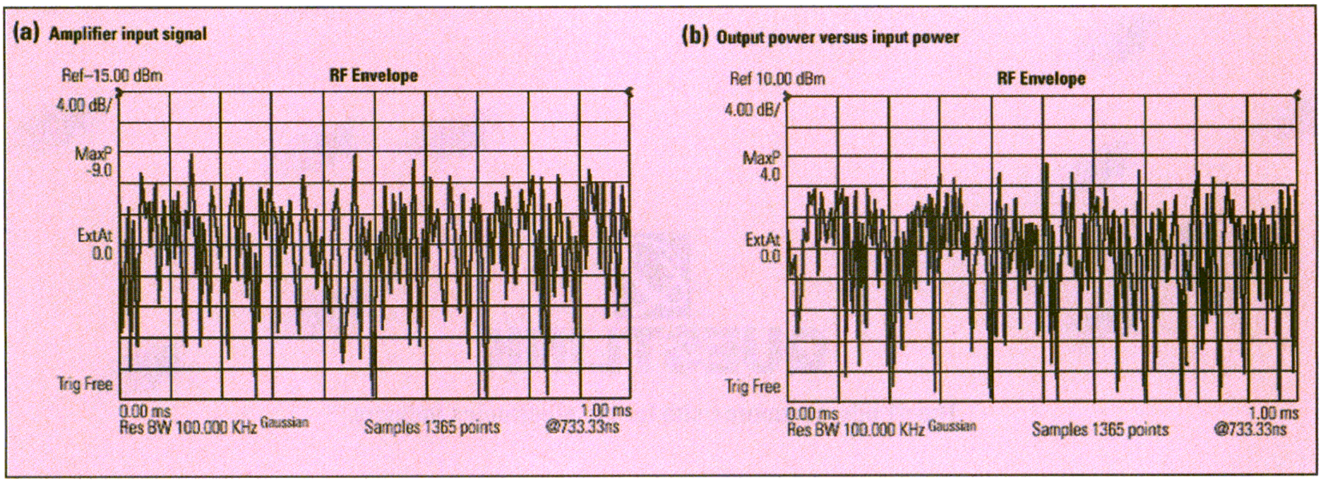
where:

I and Q = the in-phase and quadrature components of the waveform, respectively.

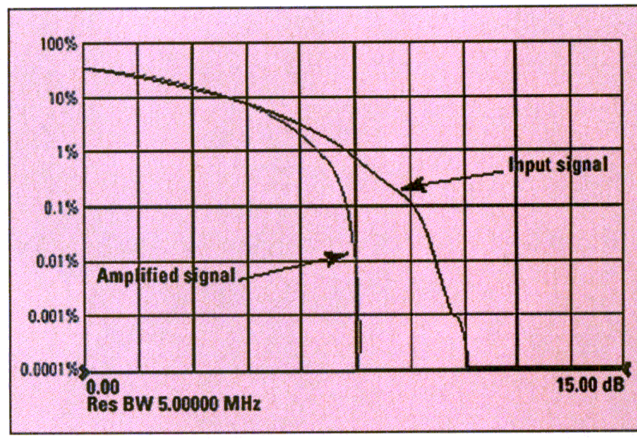
Unfortunately, the signal in the form shown in Fig. 3 is difficult to quantify due to its inherent randomness and inconsistencies. To extract useful information from this noise-like signal, a statistical description of the power levels in this signal is needed, and a CCDF curve gives just that.

A CCDF curve shows how much time the signal spends at or above a particular power level. The power level is expressed in decibels relative to the average power. For example, each of the lines across the waveform shown in Fig. 3 represents a specific power level above the average. The percentage of time the signal spends at or above each line defines the probability for that particular power level. A CCDF curve is a plot of relative power levels versus probability.

Figure 4 is the CCDF curve of the same nine-channel cdma2000 signal, along with a 24-channel signal. Here, the x-axis is scaled to decibels above the average signal power, which means actually measuring the peak-to-average ratios as opposed to absolute power levels. The y-axis is the percent of time the signal spends at or above the power level specified by the x-axis. For example, for the 24-channel signal at t = 0.01 percent on the y-axis, the corresponding peak-to-average ratio is 10.9 dB on the x-axis. This means the signal power exceeds the average by at least 10.9 dB for 0.01 percent of the time. The



6. Power versus time plots of an amplifier's input (a) and output power versus input power (b) can determine linearity of the amplifier if the input and output are duplicates in the time domain.



7. The CCDF is a good indicator of compression because the input and output signals would be the same if the output were an exact amplified version of the input.

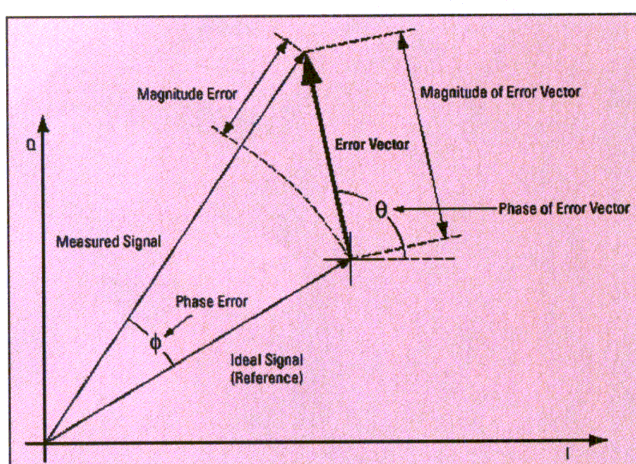
position of the CCDF curve indicates the degree of peak-to-average deviation, with more stressful signals (higher peak-to-average power ratios) further to the right.

CCDF curves can help:

1. Determine the headroom required when designing a component. For example, in Fig. 4, 10 dB of headroom would result in clipping 0.04 percent of the time for a 24-channel signal.

2. Confirm that the component design is adequate. For example, it is possible to compare the CCDF curves of a signal at the input and output of the RF amplifier. If the design is correct, the curves coincide. If the amplifier compresses the signal, the peak-to-average ratio of the signal is lower at the output of the amplifier.

The measurement methodology for peak-to-average power ratio and CCDF curves is the same regardless of the signal's format. For accurate measurements, the instrument must have flat amplitude and phase response across the bandwidth of the signal. It cannot distort the waveform in any way.



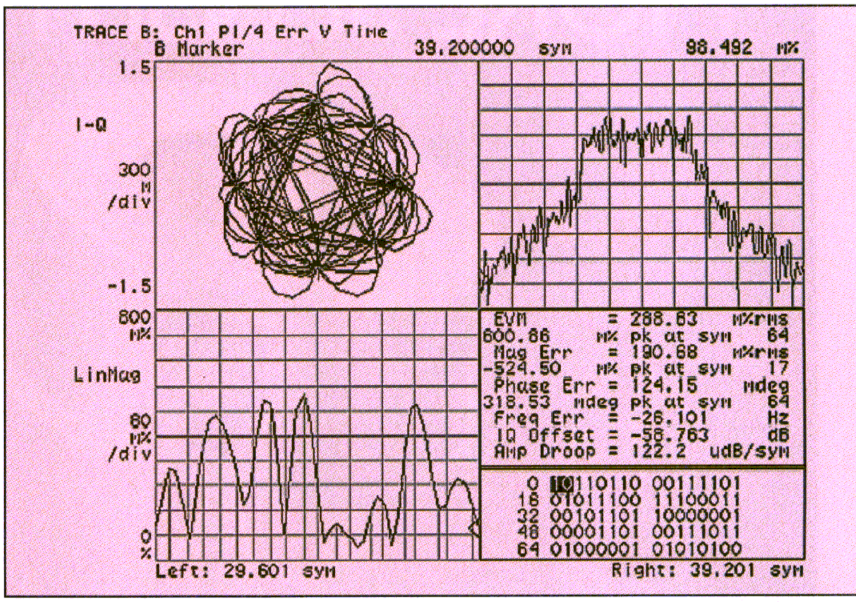
8. An important metric in digital communications is the error vector magnitude (EVM) which is the RMS value of the error vector over time at the instants of symbol clock transitions.

In nonlinear components, compression of signals may occur. For instance, an amplifier compresses a signal when the signal exceeds the amplifier power limitations. To avoid compression, an engineer needs to know the optimum input power level for the amplifier.

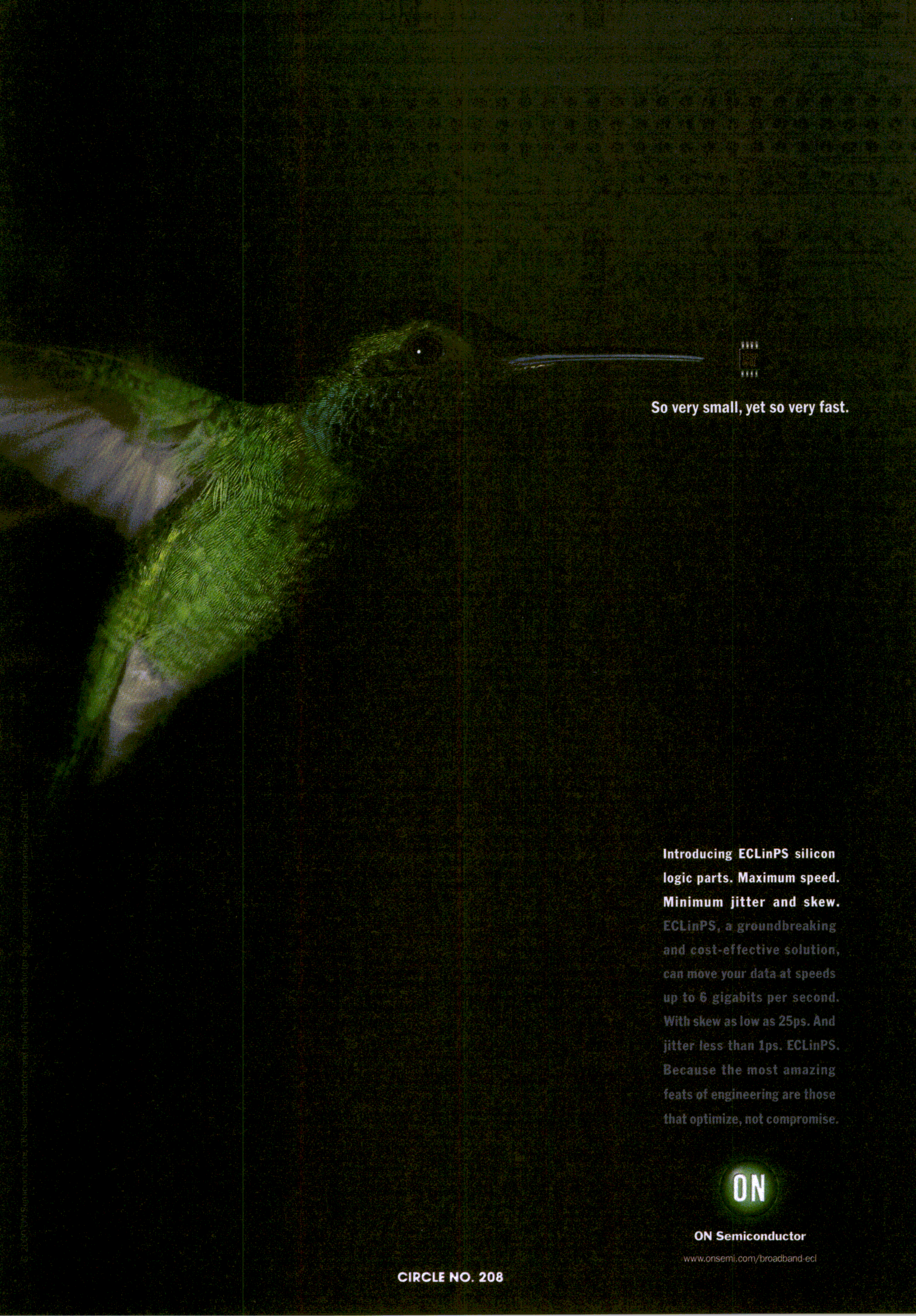
CCDF curves can be used to determine input power levels and serve as a guide for RF power-amplifier (PA) designers and systems engineers.

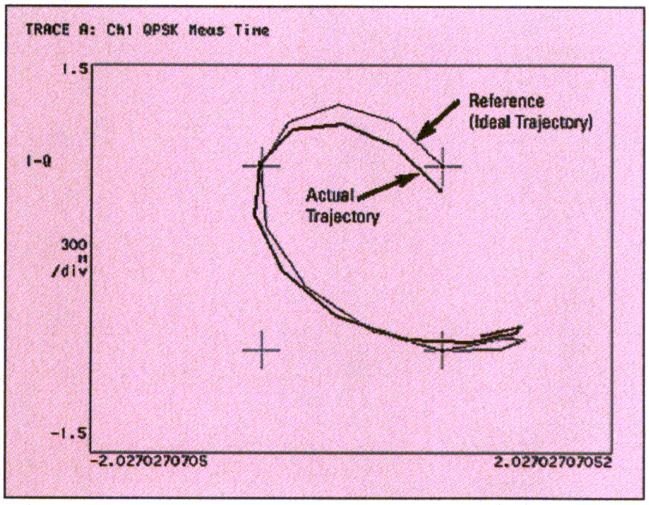
Figure 5 shows two characterizations of the same amplifier. The left display shows the amplifier gain versus input power. The right display shows the same information portrayed as a plot of output power versus input power. Consider a noise-like signal passing through this amplifier. If the input and output signals remain within the power constraints of the amplifier, then the output would be a linear amplification of the input signal. If the signal exceeds the power limitations of the amplifier, the signal undergoes compression.

Unfortunately, it is difficult to see compression effects in the time domain (Fig. 6), because appreciable amounts of clipping cannot be seen. Even if it were possible to perceive

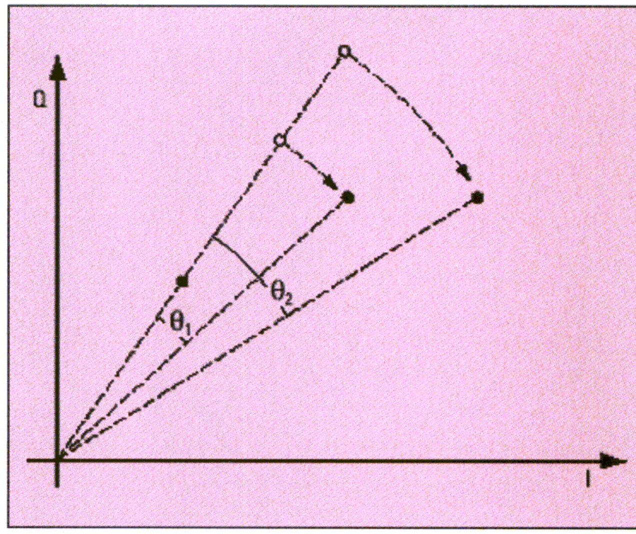


9. A polar diagram can show if compression exists in an amplifier by comparing the compressed signal to an ideal version. Since they are not identical, compression is occurring.


So very small, yet so very fast.
Introducing ECLinPS silicon logic parts. Maximum speed. Minimum jitter and skew.
ECLinPS, a groundbreaking and cost-effective solution, can move your data at speeds up to 6 gigabits per second. With skew as low as 25ps. And jitter less than 1ps. ECLinPS. Because the most amazing feats of engineering are those that optimize, not compromise.
ON
ON Semiconductor
www.onsemi.com/broadband-ecl
CIRCLE NO. 208



10. AM-to-PM conversion is another non-linearity that affects amplifiers and indicates the phase distortion between the input and output power.



11. AM-to-PM conversion is verified with a polar plot in a manner similar to the verification of compression.

some clipping, there is no convenient way of describing the compression quantitatively in the time domain. However, compression of a signal can be easily detected by comparing the power CCDF of the input signal and the amplified output signal.

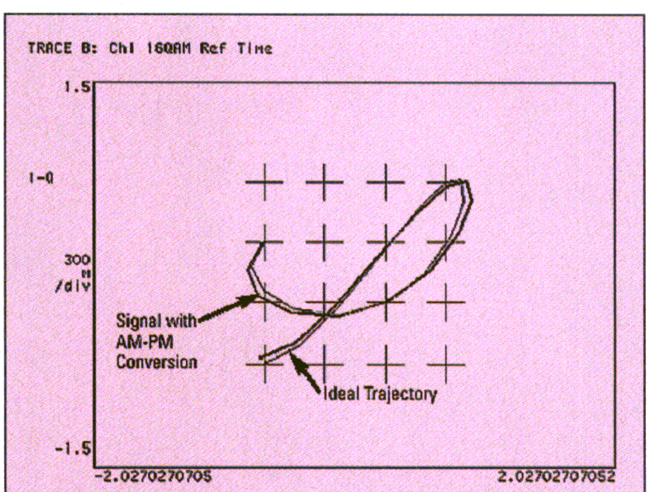
As shown in Fig. 6, CCDF curves are an excellent tool for displaying compression effects. By definition, CCDF curves measure how far and how often a signal exceeds the average power. If a signal passing through an amplifier were perfectly (linearly) amplified, the output waveform of the signal in the time domain would perfectly resemble the input waveform, with a gain in power. Both the average and envelope power of the amplified signal would increase by a common factor. Therefore, the peak-to-average power ratio would not change, and the two CCDF curves would appear identical. However, when the output signal exceeds the power limitations of the amplifier, clipping occurs; the output waveform no longer resembles an amplified version of the input waveform, and the peak-to-average ratios change. The CCDF curve of the clipped signal contracts and no longer matches that of the original input signal. This effect makes the CCDF a good indicator of compression (Fig. 7).

The most widely used modulation quality metric in digital communications systems (DCS) is EVM. When performing EVM measurements, the analyzer samples the transmitter output to capture the actual signal trajectory. The signal is usually demodulated and a reference signal is mathematically derived. The error vector is the vector difference at a particular time between the ideal reference signal and the measured signal. The error vector is a complex quantity that contains a magnitude and a phase component. It is important not to confuse the magnitude of the error vector with the magnitude error, or the phase of the error vector with the phase error. A graphical depiction of these differences can be seen in Fig. 8.

EVM is the root-mean-square (RMS) value of the error vector over time at the instants of the symbol clock transitions. By convention, EVM is usually normalized to either the amplitude of the outermost symbol or the square root of the average symbol power.

Apart from the constellation and polar diagrams, other important displays associated with EVM are magnitude of the error vector versus time, the spectrum of the error vector (error-vector spectrum), phase error versus time, and magnitude error versus time.

Measurements of EVM and related quantities can, when properly applied, provide much insight into the quality of a digitally modulated signal. They can also pinpoint the causes for any problems uncovered by identifying exactly the type of degradation present in a signal and even help identify their sources. Two sources



12. Measuring code-domain power is a key for ensuring that an amplifier transmits the correct power in each channel in a cdmaOne system. The code-domain power in noncompressed signal (a) does not get into other channels but a compressed signal (b) generates sufficient mixing products to spill power into other channels.

of degradation in a wireless component that can be detected using EVM measurements are compression and AM-to-PM conversion.

If the high peak levels of the transmitted signal are clipped, the signal has a lower overshoot. This effect can be seen by comparing the trajectory of the compressed signal to the ideal trajectory in the polar diagram, as shown in Fig. 9. Since filtering at the receiver causes dispersion in time, compression often causes an error in the symbol(s) after a peak excursion of the signal. Therefore, EVM may be affected.

Apart from compression (AM-to-AM conversion), PAs may cause phase distortion for high levels of signal amplitude. This effect is known as AM-to-PM conversion (Fig. 10).

AM-to-PM conversion typically occurs at the linear range of the amplifier; that is, for amplitude levels below compression. It is particularly relevant for signals with high peak-to-average power ratios, where different amplitude levels suffer different phase shifts.

One can verify AM-to-PM conversion by looking at the polar diagram. Comparing the actual trajectory of the signal with its ideal trajectory for a few symbols shows higher errors for higher amplitude levels (Fig. 11). Since small errors at lower amplitudes may cause relatively large phase errors, the correlation between higher amplitudes and large phase errors may not be obvious. Filtering at the receiver causes dispersion in time. Therefore, AM-to-PM conversion may cause an error in the symbol(s) after a peak excursion of the signal.

Code-domain power is another in-channel measurement. To analyze a composite CDMA waveform, each channel is decoded using a code-correlation algorithm. This algorithm determines the correlation coefficient factor for each code. Once the channels are decoded, the power in each code channel is determined.

Measuring code-domain power is essential for verifying that the component is transmitting the correct power in each of the code channels. It is also important to look at the code-domain power levels of the inactive channels, which can indicate specific problems in the component.

Non-linearity in the amplifier causes an increase in the code-domain noise level in CDMA systems. Compression can cause mixing of active code channels to produce energy in particular inactive channels. The effect is similar to two-tone testing where mixing products are created by a non-linear device. Therefore, energy appears in the non-active channels in deterministic ways. For instance, in Fig. 12, for a cdmaOne signal, code channel 1 mixes with code channels 12 and 32, causing energy to show up on channels 13 and 33. Also, channel 12 mixes with channel 32 in order to create power on channel 44. ••

Gauging GPRS in GSM networks

Global System for Mobile Communications (GSM) mobile-telephone users can transfer packet data at speeds to 115 kb/s using the new General Packet Radio Service (GPRS) capability. GPRS allows mobile GSM telephone users to stay on-line permanently while accessing Internet-provider (IP) networks directly. The adoption of GPRS points GSM in the direction of the mobile-telephone network of the future, which will be based on the Universal Mobile Telecommunications System (UMTS). An article contained within the latest version of the company magazine "bits 87" from Wavetek Wandel Goltermann (Eningen, Germany), "IP Data Transfer with GPRS in the GSM Network," provides a brief look at the use of GPRS within the GSM system.

The most important new network elements in the new system are the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN). Transmissions between network elements take place over a dedicated, IP-based backbone network. The GPRS core network links the existing GSM radio network's base-station subsystem (BSS) to the Internet or any other IP-based network.

The GSM base-station controller (BSC) is linked to the GPRS core network by frame relay through the GPRS/GSM base-station (Gigabit) interface. The packet data from the GPRS core network are transferred to the existing IP network (such as the Internet) via the GPRS/GSM interface (Gi) connection.

Additional details on the implementation of GPRS within a GSM network are contained in the article. In addition to the article on GPRS, the company magazine contains articles on parallel GSM handset testing, on local-area-network (LAN) cable testing, on digital-video-broadcast (DVB) systems, and on broadband cable-television (CATV) network testing. Copies of the 36-page "bits 87" magazine are free, from: **Wavetek Wandel Goltermann Eningen GmbH & Co., Marketing International, Postfach 1262, 72795 Eningen, Germany; (49) 712186-1616, FAX: (49) 712186-1333, e-mail: info@wwgsolutions.com, Internet: http://www.wwgsolutions.com.**

CIRCLE NO. 194 or visit www.mwrf.com

Testing SONET signals to 2.5 Gb/s

Evaluation of high-speed Synchronous Optical Network (SONET) communications systems requires sophisticated measurement equipment and/or full knowledge of complex test standards. In the case of OmniBER 719 tester from Agilent Technologies, the instrument provides the measurement flexibility and the built-in application-specific test routines to perform SONET testing at interface rates from 1.5 Mb/s to 2.5 Gb/s, including compliance to the latest International Telecommunications Union (ITU) recommendations, ITU-T 0.172, for jitter. Details on various high-speed SONET measurements are outlined in a 12-page product note from Agilent Technologies (Englewood, CO), "Complete multi-rate SONET testing to 2.5 Gb/s."

The instrument provides full control over SONET overhead functions, with a full range of controlled pointer movements according to ANSI T1.105.03 requirements, including automatic initialization and cool-down sequences. The instrument incorporates measurement filters to ITU 0.172 and 0.171 specifications, and Bellcore GR-499 requirements for tributary jitter measurements, and capability to perform a wide range of parametric tests, including frequency and optical power measurements. The instrument offers unique Asynchronous Transfer Mode (ATM) test capability at the physical and ATM layers at interface rates from 1.5 Mb/s to 2.5 Gb/s, and can perform clear-channel measurements in preparation for broadband services or for verifying wavelength-division-multiplex (WDM) performance.

The 12-page brochure features simple block diagrams that outline a series of jitter-based measurements with the instrument, including evaluation of output jitter, combined pointer and demapping jitter, jitter and wander tolerance, wander, and jitter transfer. The literature also provides basic specifications and features of the OmniBER 719 instrument, a portable, modular test tool.

Copies of the 12-page note on SONET testing, "Complete multi-rate SONET testing to 2.5 Gb/s," are free, from: **Agilent Technologies, Test and Measurement Call Center, P.O. Box 4026, Englewood, CO 80155-4026; (800) 452-4844, Internet: http://www.agilent.com.**

CIRCLE NO. 195 or visit www.mwrf.com

When you need Clarity and Power

Stanford Microdevices is the clear choice.

When clarity and power matter most, Stanford Microdevices delivers.

Stanford Microdevices, Inc. (SMI) is a leading supplier of RF integrated circuits for the wireless and wired telecommunications markets and a supplier of choice of OEMs worldwide. Stanford Microdevices continues to be on the industry's leading edge because of our superior quality, outstanding value and innovative technological advances. SMI provides the tools to create wireless communications equipment that is smaller, lighter, more powerful at market leading prices.

Our SGA 6000 series of silicon germanium MMIC amplifiers offers the high intercept point, high efficiency and high integration level at high output power desired, while providing the low noise figure and low power consumption needed for all wireless applications.

SGA-6386 has 1dB compressed output power of +20dBm, output third-order intercept point of +36dBm and 15.5dB of gain at 900MHz. Pricing on the SGA-6386 is $1.21 in quantities of 10,000 pieces with availability from stock to eight weeks.

www.stanfordmicro.com

Make us your home page!

SPECIFICATION MATRIX

	SGA-6286 SGA-6289	SGA-6386 SGA-6389	SGA-6486 SGA-6489
Frequency (GHz)	DC-3.5	DC -3.0	DC-1.8
Gain (dB)	13.8	15.4	19.7
TOIP (dBm)	34.0	36.0	34.0
P1dB (dBm)	20.0	20.0	20.0
N.F. (dB)	3.9	3.8	2.9
Supply Voltage (Vdc)	4.2	5.0	5.2
Supply Current (mA)	75	80	75

All data measured at 1GHz and is typical. MTTF @ 150C T_j = 1 million hrs. (R_{TH} = 97C/W typ)

SiGe HBT MMIC features include:

SOT-89 package

- Cascadable 50Ω
- Single voltage supply
- High output intercept
- +20dBm 1dB Compression Point
- Low current draw
- Low noise figure

86 package

STANFORD MICRODEVICES

We Deliver RF Innovation

1-800-764-6642 *U.S. Toll-Free*

1-408-616-5400 *Outside U.S.*

CIRCLE NO. 268

Line Stretchers Ease VCO Load-Pull Testing

Electronic line stretchers offer controlled phase shifts over wide frequency ranges to simplify once tedious VCO measurements.

Engineering Department

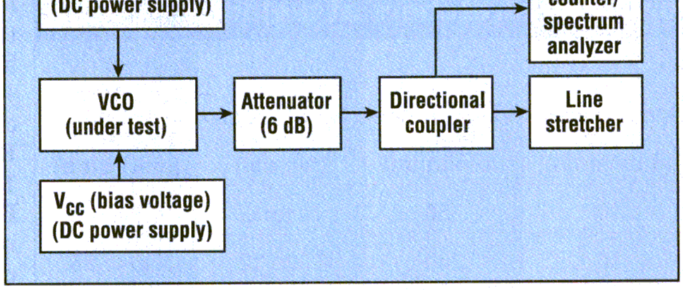
Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235; (718) 934-4500, FAX: (718) 332-4661, Internet: http://www.minicircuits.com.

VOLTAGE-CONTROLLED oscillators (VCOs) are normally designed for operation in an ideal 50-Ω environment. However, the actual loads that these oscillators must drive are considerably different. It is a standard industry practice to measure frequency variation when the VCO output realizes a load with 12-dB return loss (for all possible phase angles). This is usually performed as a manual measurement and is very time-consuming. It may take a skilled technician several minutes to several hours. Fortunately, with the development of a novel electronic line stretcher from Mini-Circuits (Brooklyn, NY), these once tedious tests can now be executed quickly and automatically.

To understand the significance of the new electronic line stretcher, it may help to review the traditional method of performing load-pull tests on a VCO. A manual measurement setup for load-pull testing of RF and microwave VCOs is shown in Fig. 1. The VCO's RF output is connected through a 6-dB attenuator and a directional coupler to the low-loss mechanical line stretcher. The directional coupler provides a low-level (reduced by the coupling factor of the component) signal for frequency monitoring with a frequency counter or spectrum analyzer. The line stretcher must at least be capable of providing a full 360-deg. phase shift over the full frequency-tuning range of the VCO.

During testing, the VCO is biased with the V_{CC} power supply. The VCO's tuning voltage, V_t, is fixed at a particular voltage in order to fix the frequency of the VCO. At this point, the mechanical line stretcher is manually tuned to cover the full 360-deg. phase shift at that tuned frequency. The maximum and minimum frequencies resulting from the phase shifts are then measured and recorded. The difference in frequencies provides the frequency shift of the VCO as a result of load pulling.

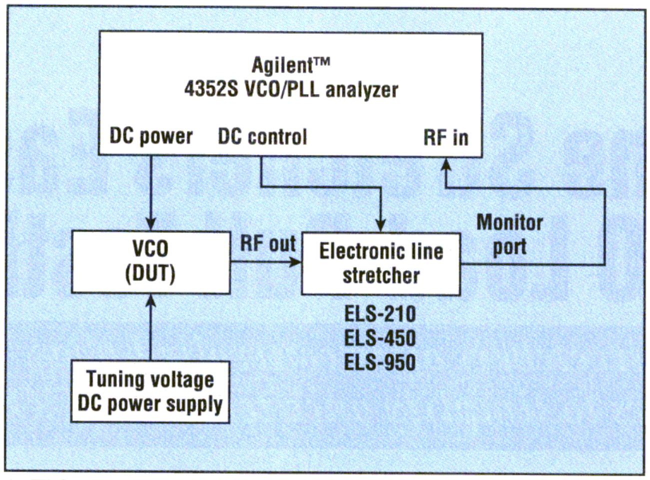
Mechanical line stretchers which can provide the full 360-deg. phase shift at frequencies above 1000 MHz are available. At lower frequencies, however, it is difficult to find continuously variable mechanical line stretchers with adequate phase-shift range for VCO load-pull testing. Due to this shortcoming, lower frequency measurements are created by adding fixed lengths of transmission lines to higher frequency line stretchers to increase the phase-shift range at lower frequencies. In addition, using precision open- and short-calibration standards as termination to the line stretcher, addi-



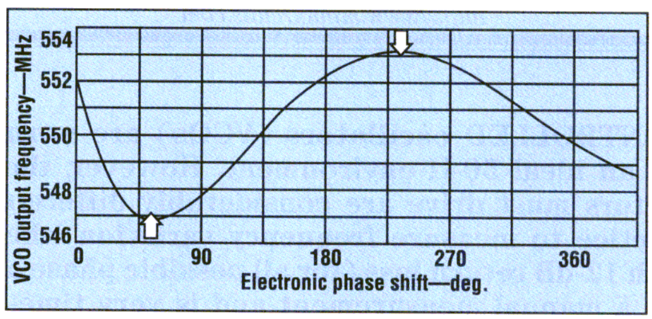
1. Traditional VCO load-pull measurements are performed with a system based on a manual line stretcher.

tional 180-deg. phase shift can be obtained.

For example, a particular mechanical line stretcher can provide a 360-deg. phase shift at 1000 MHz. The same line stretcher will only provide a phase shift of 180 deg. at one-half the frequency, or 500 MHz. To perform load-pull testing on a VCO with a carrier frequency of 500 MHz, first a frequency-extreme search (for the minimum and maximum frequencies) is performed over the 180-deg. range of the line stretcher at 500 MHz, with an open standard placed at the end of the line stretcher. The open standard is then replaced with a short standard, which provides an additional phase jump of 180 deg., and the frequency-extreme search is repeated. The minimum and maximum oscillator frequencies from both measurements are used to compute the load-pull results.



2. This automated VCO load-pull measurement system is made possible by the electronic line stretchers.



3. Measurement results show the output frequency as a function of electronic line stretcher phase shift.

VCO load-pull measurements using this approach can become tedious at lower frequencies. For measurements on a VCO with a carrier frequency of 250 MHz and a 1000-MHz line stretcher, testing must be performed in four steps. At each step, the open-short techniques must be performed and additional quarter-wavelength (at 250 MHz) transmission lines added to affect a phase jump of 90 deg. The technician performing the measurements must also take into consideration the additional insertion loss of the line stretcher, the loss of the directional coupler, the losses of the added transmission lines, and compensate the value of the attenuator.

Conventional electronic phase shifters can be used for VCO load-pull testing, but these are generally narrowband, with a full 360-deg., phase shift generally available only over a narrow range of a typical VCO's tuning range. In addition, the insertion loss of an electronic phase shift is not constant across the phase-shift range, but tends to enlarge with increasing phase shift. Phase shifters are also subject to distortion as a result of saturation.

Due to the shortcomings of conventional electronic phase shifters and mechanical line stretchers, the engineers at Mini-Circuits sought a better method for performing VCO load-pull measurements. This search resulted in the development of a line of electronic line stretchers with full 360-deg. phase shifts across wide frequency ranges (see table). The first three models in this line of electronic line stretchers includes units with an octave or more of frequency range over a total range of 110 to 950 MHz. These three-port devices feature a nominal return loss of 10 to 12 dB, with electronically adjustable phase ranges of better than 360 deg. for the fully specified operating frequency ranges. A monitor port supplies a sample of the output signal of the VCO under test at reduced amplitude for monitoring and measurement purposes.

The new electronic line stretchers are ideal for use in automated VCO load-pull test setups (Fig. 2).

As the DC control voltage is swept from +0.5 to +25 VDC, the phase angle of the load presented to the VCO changes by more than 360 deg. The VCO/PLL analyzer is set to display the frequency versus DC-control voltage (which represents a phase variation of the load). The peak-to-peak difference in the displayed frequency curve provides the load pull (Fig. 3).

Each electronic line stretcher is housed in a metal case with female SMA coaxial connectors on all ports. The metal housing measures 1.25 × 1.25 × 0.75 in. (3.18 × 3.18 × 1.91 cm). **Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235; (718) 934-4500, FAX: (718) 332-4661, Internet: http://www.minicircuits.com.**

CIRCLE NO. 51 or visit www.mwrf.com

The electronic line stretchers at a glance

Model number	Frequency range (MHz) f_L to f_U	Input power (dBm) (maximum)	Phase range (deg.) (minimum)	Return loss (dB) (typical)	Control voltage (V) (start-stop)
ELS-210	110 to 210	10	360	10 to 12	0.5 to 25
ELS-450	180 to 450	10	360	10 to 12	0.5 to 25
ELS-950	400 to 950	10	360	10 to 12	0.5 to 25

Roll Rings Offer Stable Electrical Coupling

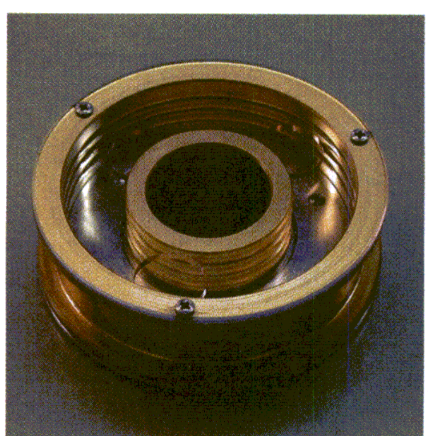
These reliable mechanisms provide a new spin on the transfer of signals and power for rotating electrical interfaces.

JACK BROWNE
Publisher/Editor

TRANSFERRING signals across rotating axes is not trivial. The task is made even more daunting in deep space, where maintenance calls must be kept to a minimum. While slip rings are often called upon for such applications, a better approach is embodied in the roll rings offered by Diamond Antenna & Microwave Corp. (Lowell, MA). The simple but elegant design approach offers high voltage and current handling capabilities for millions of revolutions of operation.

The roll-ring design concept (see figure) is based on more than 20 years of research and development (R&D). A roll ring consists of three major components: an outer ring, an inner ring, and several conductive flexures, which look like copper (Cu) wedding rings. The flexures are captivated in the annulus space between grooved concentric outer and inner rings, and moves freely in either direction on the space between the outer and inner rings with virtually no friction (or wear), but with constant and reliable electrical contact between the inner and outer rings. The inner and outer rings are precisely aligned on a common axis to maintain the constant spacing and alignment between them with the flexures in place. Precision preloaded ball bearings are used to aid the alignment between the inner and outer rings and ensure low-friction rotation of the rings. The flexures remain mechanically stable within the annulus space, much like ball bearings within a wheel axle, while also providing low-resistance coupling between the inner and outer concentric rings.

The roll rings are ideal for applications where electrical connections are needed between components where one of the components is rotating relative to the other, such as in air-traffic-control and other radar antenna systems. As a testament to their reliability, they have been installed in several electrical systems in the international space station Freedom. Once the roll rings are assembled, no further alignments are needed for long-term reliability.



A roll ring provides a reliable and dynamic electrical interface for transferring power, analog, and digital signals.

Compared to traditional slip rings, the roll rings are said to achieve torque reduction of up to two orders of magnitude. They also do not suffer the reliability problems inherent in slip rings, where the sliding action of the slip ring can cause wear and intermittent electrical contacts.

The roll rings are rated for voltages up to 3 kV, and current transfer as high as 200 A. They can be used to transfer DC power, AC signals at frequencies to 150 MHz, and digital data streams. They can be used at rotational speeds to 10,000 revolutions per minute (rpm) with high-power transfer efficiency and minimal wear. The rolling flexures require no lubrication, and are life tested to more than 350 million revolutions without maintenance.

In short, roll rings can be installed in any application that would ordinarily use a slip ring, ensuring reduced assembly and test costs, low electrical-resistance noise, minimal torque, and negligible wear debris. They are ideal for terrestrial, airborne, and payload applications, and are compatible with a variety of environments, including some fluids, vacuum, air, inert environments, and explosive gases. **Diamond Antenna & Microwave Corp., 95 Rock St., Lowell, MA 01854; (978) 458-6133, FAX: (978) 458-6618, e-mail: jgilling@diamondantenna.com, Internet: http://www.diamondantenna.com.**

CIRCLE NO. 52 or visit www.mwrf.com

PRODUCT TECHNOLOGY

Ferrite Circulator

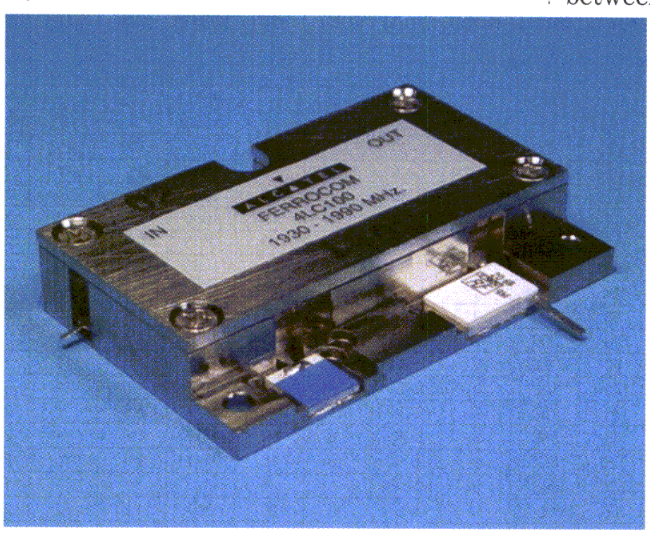
Four-Port Circulator Drops Into PCS Systems

This drop-in circulator includes a fourth port with a 20-dB attenuator for connection to reverse-power detection and warning circuitry in PCS-band base-station transceivers.

JACK BROWNE
Publisher/Editor

CIRCULATORS are an important part of cellular base-station design. These high-power components, which are based on the use of a circular disk of ferrite material, can be designed with low loss and high isolation to minimize the need for amplifier stages at a base station, especially when the loss is tightly controlled as in a personal-communications-services (PCS) four-port circulator from Alcatel Ferrocom Ferrite Products (San Jose, CA). The PCS-band circulator offers excellent electrical performance from 1930 to 1990 MHz and includes an attenuator on its fourth port to reduce signals by 20 dB.

Circulators are commonly used in cellular and systems for signal routing from an antenna to the receiver and transmitter electronics. They typically consist of a stripline or microstrip circuit with a circular ferrite disk and either a single bias magnet (in the case of microstrip) or two bias magnets (in the case of stripline). Circulators derive their name due to the circular motion of signals about the ferrite disk. One of the keys to production of high-performance RF/microwave circulators is the control of the magnetic flux imposed on these bias magnets. Given the proper magnetic strength, applied signals will be shifted in phase. Due to the phase shifts, signals will add in phase at one port (where insertion loss is at a minimum) and out of phase at another port (where isolation is at a maximum). A four-port circulator, which is formed by joining two Y-junction circulators, is ideal for switching applications in cellular and PCS transceiver systems.



This four-port circulator is designed for use in PCS systems operating from 1930 to 1990 MHz.

The four-port drop-in circulator from Alcatel Ferrocom Ferrite Products features an attenuated output port. With this port, system-level designers can connect detection circuitry and warning systems to shutdown a transmitter when excessive reverse power is measured, preventing damage to expensive transmit-band power amplifiers (PAs) and receive-band low-noise amplifiers (LNAs).

The four-port circulator (see figure) is designed for use from 1930 to 1990 MHz with 0.6-dB maximum insertion loss and typically only 0.4-dB insertion loss. The minimum isolation between ports is 40 dB, and typically 47 dB. The maximum VSWR is 1.25:1, with typical VSWR performance of 1.18:1.

The rugged PCS drop-in circulator can handle input power levels up to 100 W continuous wave (CW). The tabbed attenuator (on port 3 of the circulator) has an attenuation value of 20 dB, accurate within ±1 dB. The attenuator port can handle power levels up to 80 W CW, while port 4 is rated for reverse power levels as high as 10 W CW. The circulator is designed to maintain high performance levels at operating temperatures from –40 to +90°C. The circulator measures 1.88 × 1.22 × 0.4 in. (4.77 × 3.10 × 1.016 cm). **Alcatel Ferrocom Ferrite Products, 6385 San Ignacio Ave., San Jose, CA 95119; (408) 220-8171, FAX: (408) 229-8506, e-mail: sales_ferrocom@aud.alcatel.com, Internet: http://www.ferrocom.com.**

CIRCLE NO. 53 or visit www.mwrf.com

High-Power Transistor Boosts Aircraft Radar

This device rounds out a family of bipolar power transistors for airborne radar applications.

DON KELLER
Senior Editor

AIRBORNE-EQUIPMENT manufacturers must develop systems capable of producing ever-higher power levels to increase the range and performance of aircraft radar systems. This creates a demand for devices that can generate high-power RF signals. Responding to this demand, GHz Technology, Inc. (Santa Clara, CA) produces a line of bipolar power transistors—the distance-measurement-equipment (DME) line—specifically designed to meet next-generation avionics requirements by generating high power levels at frequencies from 1.025 to 1.150 GHz. The company recently completed this five-member DME family with the introduction of its most powerful member, the model DME 700.

With a power output of 700 W, the DME 700 offers the highest peak power among the DME family, which also includes the DME 150, DME 375, DME 375A, and DME 500 (see table). Existing DME owners can upgrade to the DME 700 to increase the range and performance of their equipment without having to change drivers.

Similar to its siblings, the DME 700 is a +50-VDC device designed to be used in a common-base configuration as a Class C amplifier in pulsed operation. Operating with a duty function of one percent and a pulse width of 10 μs, the DME 700 has a minimum power gain of 8 and can handle a maximum input power of 110 W. Its typical power droop is 0.5 dB and its maximum load-mismatch tolerance is 4:1. The transistor includes input and output prematch for broadband capability.

The device's functional characteristics include a collector-to-emitter breakdown voltage of +65 VDC, an emitter-to-base breakdown voltage of +3 VDC, and a DC current gain (h_{FE}) ranging from 20 to 80. The device can tolerate an absolute maximum collector current of 40 A. Its thermal resistance is 0.08°C/W, and its maximum operating junction temperature is +230°C.

The DME 700 employs gold (Au) thin-film metallization and diffused ballasting to achieve a high mean time to failure (MTTF). It is housed in a low-thermal-resistance 55KT package, which reduces its junction temperature and extends its lifetime. The bottom of the 55KT package is a large metallic surface, designated pin 1, which electrically connects to the device's collector and acts as a heat sink. Two metallic flanges—pins 2 and 3—extend from opposite sides of the package and electrically connect to the device's base and emitter. The package is available in two pin-configuration styles. In style 1, pin 2 connects to the base, and pin 3 connects to the emitter. In style 2, pin 2 is the emitter and pin 3 is the base. **GHz Technology, Inc., 3000 Oakmead Village Dr., Santa Clara, CA 95051-0808; (408) 986-8031, FAX: (408) 986-8120, Internet: http://www.ghz.com.**

CIRCLE NO. 54 or visit www.mwrf.com

The members of DME family of bipolar power transistors and their characteristics

Part number	Power out (W)	Power in (W)	Minimum gain	V_{cc} (VDC)	VSWR load	Frequency (GHz)
DME 700	700	110	8.0	50	4:1	1.025 to 1.150
DME 500	500	125	6.0	50	10:1	1.025 to 1.150
DME 375A	375	85	6.5	50	30:1	1.025 to 1.150
DME 375	375	75	7.0	50	30:1	1.025 to 1.150
DME 150	150	25	7.8	50	20:1	1.025 to 1.150

www.dilabs.com

High Q High Power

Porcelain Capacitors

Kilowatts, Kilovolts, high RF currents? If this is your working environment, Dielectric Laboratories has the capacitor solutions and engineering expertise to make your design the winner in today's market.

Quality
Choice
Reliability
Performance

Applications

- High RF power
- Medical electronics
- Semiconductor manufacturing
- Inductive heating
- Broadcast

Features

- High Q, Ultra low ESR
- Temperature stable Dielectrics
- Proven power handling capabilities
- Non-magnetic termination available

Visit us on the web!

DLI DIELECTRIC LABORATORIES
A DOVER TECHNOLOGIES COMPANY

CIRCLE NO. 226

Call The Solutions Exper
At Dielectric La
2777 Route 20 East, Cazenovia, NY 130
Ph: 315-655-8710 • **Fax:** 315-655-81

Multipurpose Analyzers Tackle Group-Delay Tests

Group-delay measurements can be made simply and easily, without the need for complex error-correction techniques, calibration, and a vector network analyzer.

JACK BROWNE
Publisher/Editor

GROUP delay is widely used in the microwave industry as the measure of an active or passive component's phase linearity. In a filter, for example, the manner where group delay varies across the passband and stop bands can provide insights into the filter's effects on phase-modulated signals. While group-delay measurements are usually in the domain of expensive vector network analyzers (VNAs), they can be performed more economically, using the 6840 series of microwave system analyzers (MSAs) from IFR (Wichita, KS) equipped with Option 22. The new option equips these multipurpose microwave analyzers to measure and simultaneously display amplitude and group delay.

The 6840 series of MSAs currently includes seven models, operating over a total frequency range of 1 MHz to 26.5 GHz. Each unit features a synthesized frequency source, a three-input scalar network analyzer (SNA), and a high-performance spectrum analyzer. The synthesized source exhibits harmonic levels of − 55 dBc and phase noise of only − 106 dBc/Hz offset 10 kHz from a 1-GHz carrier.

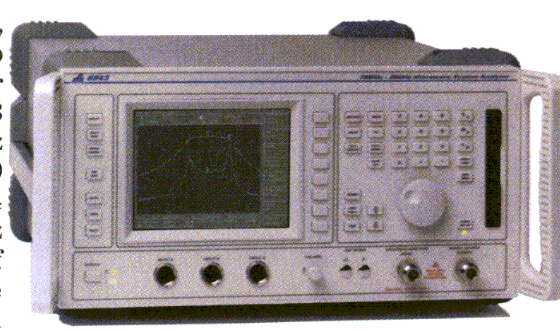
Individual models in the 6840 line include models 6841 (source range of 1 MHz to 3 GHz and spectrum-analyzer range of 1 MHz to 4.2 GHz), 6842 (source range of 10 MHz to 8.4 GHz and spectrum-analyzer range of 10 MHz to 20 GHz), 6843 (source range of 10 MHz to 20 GHz and spectrum analyzer range of 10 MHz to 20 GHz)[see figure], 6844 (source range of 10 MHz to 24 GHz and spectrum-analyzer range of 10 MHz to 24 GHz), 6846 (source range of 10 MHz to 8.4 GHz and spectrum-analyzer range of 10 MHz to 24 GHz), 6847 (source range of 10 MHz to 20 GHz and spectrum-analyzer range of 10 MHz to 26.5 GHz), and 6848 (source range of 1 MHz to 3 GHz and spectrum-analyzer range of 10 MHz to 20 GHz).

When equipped with option 22, the MSAs can now be equipped for group-delay measurements. All control and measurement software is provided internally by the MSA, and the group-delay functions are accessed via 6840 series front-panel softkeys.

In the spectrum-analyzer approach to group-delay measurements used with the MSAs, the source is frequency modulated with a known low-frequency signal and applied to the device under test (DUT). After passing through the DUT, the signal is demodulated and the recovered low-frequency content is compared in phase with the phase of the original modulated signal. The envelope delay is the average value of group delay over the modulated signal bandwidth. The bandwidth of the modulated signal is known as the measurement aperture and needs to be small in comparison with the group-delay variations for accurate measurements.

In an MSA, the source and receiver can be made independent of each other so that the stimulus can be set to one frequency while the receiver makes measurements at another frequency. As the group-delay measurement is derived from the modulation envelope and the modulation is preserved through a frequency translation, direct characterization with no extra mixers is possible.

The group-delay measurement range of the 6840 instruments is 1 ns to 10 μs, with 0.1-ns resolution and absolute accuracy of 0.5 ns. P&A: $30,000 to $60,000 (6840 series) and $3400 to $5000 (group-delay option); 4 to 6 wks. **IFR Systems, Inc., 10200 W. York St., Wichita, KS 67212; (800) 835-2352, (316) 522-4981, FAX: (316) 522-1360, Internet: http://www.ifrinternational.com.**



The 6840 series of microwave system analyzers (MSAs) consists of seven models, including the 10-MHz-to-20-GHz model 6843.

CIRCLE NO. 55 or visit www.mwrf.com

DSPs Cut Power And Add Cellular Channels

This line of power-efficient DSPs can process as many as 64 wireless voice channels or 64 ADSL data lines with as little as 1.5-W power consumption.

JACK BROWNE

Publisher/Editor

WIRELESS systems usually require a series of trade-offs between coverage and power. Digital signal processors (DSPs) can provide the speed and power to handle increasing voice and data traffic, but at the expense of power. Fortunately, the StarPro™ 2000 family of DSPs from the Microelectronics Group of Lucent Technologies (Allentown, PA) is designed for the least compromise in this particular wireless system trade-off. The DSPs offer the capacity to process up to 64 wideband-code-division-multiple-access (WCDMA) base-station voice and data channels and provide speech coding and echo cancellation for as many as 64 wireless voice channels and/or V.90 data channels.

The 16-b StarPro 2000 DSPs can also handle as many as 64 full-rate asymmetric-digital-subscriber-line (ADSL) channels for high density in upgraded voice and data networks. The DSPs are fabricated with Lucent's power-efficient COM-2 0.16-μm complementary-metal-oxide-semiconductor (CMOS) process.

They are the first products based on the StarCore SC140 DSP core designed by Lucent and Motorola (Phoenix, AZ). Each StarPro 2000 chip contains three SC140 DSP cores. The cores combine to provide as many as 3600 million multiply-and-accumulate (MAC) operations per second at the maximum clock rate of 300 MHz. Even at that clock rate, the DSPs consume only 1.5 W of power internally.

Each of the three SC140 DSP cores accounts for 1200 million MACs at 300 MHz, or 3600 million instructions per second (MIPS) for an equivalent reduced-instruction-set-computing (RISC) chip. The StarPro 2000 DSPs can achieve 12 MAC operations per clock cycle. The memory subsystem support surrounding the DSP core includes an 8-kB instruction cache, an 8-kB data cache, and 16 kB of local data memory. The DSPs also incorporate a programmable interrupt controller (PIC) with 32 levels of priority and a debug port with instruction trace. In addition, the StarPro 2000 DSP chip features 768 kB of shared static random-access memory (SRAM)—a generous amount of system memory for instruction and data storage that supports high channel density at low cost.

Data transfers between the three DSP cores, peripherals, the 768 kB of on-chip SRAM, and external memory are controlled with a proprietary high-speed bus known as Daytona. Designed for fast access with low latency, the bus offers 32-b address and 128-b split-transaction operation at the DSP's core frequency.

The StarPro 2000 DSP contains three serial input/output (I/O) units that are compatible with a wide range of standards, including T1, E1, and ST bus, and support buffering of time-division-multiplex (TDM) data. Two direct-memory-access (DMA) channels support each of these I/O units. Block-memory transfers anywhere in the memory space are accomplished with eight memory-to-memory DMA channels.

A parallel interface unit (PIU) provides the interface to off-chip peripheral devices, a host microcontroller, or application-specific integrated circuit (ASIC). It features synchronous burst transfer for high throughput, a 32-b address bus, a 32-b data bus, a passive parallel port with flexible addressing modes, and enough buffering to minimize external device overhead. In addition, the DSPs contain two 32-b external memory interface units (MIUs) with interfaces for off-chip peripheral devices and memory.

The StarPro 2000 DSPs are housed in a 561-contact PBGAM1T 31 × 31-mm ball-grid-array (BGA) package. They are supported by system-on-chip (SOC) development tools operating under Lucent's LuxWORKS debugging environment. The DSPs will be available in sample quantities by April of next year, and in production quantities by next summer. P&A: $100 (100,000 qty.). **Lucent Technologies, Microelectronics Group, Customer Response Center, Room 30L-15P-BA, 555 Union Blvd., Allentown, PA 18103; (800) 553-2448, FAX: (610) 712-4106, Internet: http://www.lucent.com.**

CIRCLE NO. 56 or visit www.mwrf.com

MICROWAVES & RF DIRECT CONNECTION ADS

TO ADVERTISE CALL JOANNE REPPAS (201) 666-6698

Microwaves & RF

New and Current Products Presented By The Manufacturer

DIRECT CONNECTION ADS

For futher information circle the appropriate number on the Reader Service Card.

To Advertise Call Joanne Reppas (201) 666-6698

IR transceiver links handhelds

The model CHX1200 infrared (Ir) data-communications transceiver module is a 6.8 × 2.8 × 2.2-mm unit that operates from a supply voltage of +2.7 to +3.6 VDC. The module typically draws 95 μA at +3.3 VDC and operates over a temperature range of −30 to +85°C to ensure IR connectivity in all environmental conditions. The CHX1200 is the smallest of these devices on the market for short-range data links from cell phones, personal digital assistants (PDAs), and other handheld appliances. The unit is compliant to the Infrared Data Association (IrDA) specification for low-power serial infrared data exchange (IrMC), and transfers data at 115.2 kb/s at distances up to 20 cm to other similar mobile devices. It integrates an IRED emitter, a personal-identification-number (PIN) photodiode detector, a DC-to-AC-coupled light-emitting-diode (LED) driver, and a fully differential receiver/decoder. The only additional component required for a complete solution is a single capacitor. The CHX1200 can be used to replace larger infrared data-communications-transceiver modules. **Calibre, Inc., 1762 Technology Dr., Suite 226, San Jose, CA 95110; (408) 573-3890, FAX: (408) 573-3899, Internet: http://www.calibre-inc.com.**

CIRCLE NO. 71 or visit www.mwrf.com

PA boosts wireless data

Model CHP2230-PPM is a linear-efficient, three-stage, 1920-to-1980-MHz power amplifier (PA) developed for wideband-code-division-multiple-access (WCDMA), third-generation (3G) cellular handsets and infrastructure systems. The indium-gallium-arsenide (InGaP) heterojunction-bipolar-transistor-(HBT) amplifier module is part of the True Triangle™ product line. This 50-Ω- matched 6-mm square PA module for high-bandwidth wireless data markets offers 50-percent size reduction to comparable solutions that are specifically targeted to maximize linear efficiency for challenging wireless data applications. It provides 30-percent linear power-added efficiency (PAE) at 28 dBm under 3X WCDMA modulation. The amplifier operates at voltages as low as +3.2 VDC from a single positive supply, and provides 30-dB gain. The amplifier provides electrical stability and low thermal resistance. Minimum matching elements (eliminating up to 14 external elements) and with no negative supply helps reduce circuit-board space by approximately half that of currently available solutions. **Celeritek Marketing, 3236 Scott Blvd., Santa Clara, CA 95054; (408) 986-5060, FAX: (408) 986-5095, e-mail: truetriangle@celeritek.com, Internet: http://www.celeritek.com.**

CIRCLE NO. 72 or visit www.mwrf.com

Low-cost amps span DC to 3 GHz

Model BBA-320 is a broadband amplifier with 20-dB typical small-signal gain from DC to 3 GHz. The amplifier, which operates from a single +3-VDC supply, achieves typical output power of +11 dBm with a noise figure of less than 3.9 dB. A second unit, model BBA-516, operates from a single +5-VDC supply. It delivers 16-dB typical small-signal gain from DC to 3 GHz with +18 dBm maximum output power. P&A: $10.80 (1000 qty., both devices). **Linx Technologies, 575 SE Ashley Pl., Grants Pass, OR 97526; (541) 471-6256, FAX: (541) 471-6251, Internet: http://www.linxtechnologies.com.**

CIRCLE NO. 73 or visit www.mwrf.com

Splitter/combiner suits broadband cable

The model CX4002 RF splitter/combiner can divide one input signal into two matched outputs or combine two input signals into one output at frequencies from 5 to 1000 MHz. It is ideal for applications such as cable-network amplifiers and nodes, cable modems, set-top boxes, Internet appliances, and cable telephony. The splitter/combiner can handle 1 W of RF power and maintains a VSWR of 1.1:1 over its entire frequency range. Typical isolation is 30 dB from 5 to 400 MHz and 21 dB to 1000 MHz. The device is housed in a 0.310 × 0.255-in. (7.87 × 6.48-mm) package. **Pulse Engineering, 12220 World Trade Dr., San Diego, CA 92128; (858) 674-8100, FAX: (858) 674-8262, Internet: http://www.pulseeng.com.**

CIRCLE NO. 74 or visit www.mwrf.com

Q-band isolators serve LMDS

Two Q-band microstrip isolators offer a bandwidth of at least 2-GHz for local-multipoint-distribution-service (LMDS) applications. The model 2W9NT spans the frequency range of 34 to 36 GHz, and the model 2WN9R covers 37 to 39.5 GHz. The isolators have a metallized ground plane and offer isolation in excess of 20 dB. Typical insertion loss is 0.8 dB and maximum insertion loss is 0.9 dB. Forward power-handling capacity is 0.5 W and maximum VSWR is 1.3:1. The devices can operate at temperatures from −30 to +60°C. **Renaissance Electronics Corp., 1300 Mass Ave., Boxborough, MA 01719; (978) 263-4994, FAX: (978) 263-4944, Internet: http://www. rec-usa.com.**

CIRCLE NO. 75 or visit www.mwrf.com

Reverse amp targets interactive devices

The model ARA2000S12 reverse amplifier integrated circuit (IC) is designed for use in interactive digital cable terminals and Internet-protocol telephony systems to boost signals traveling from the user's interactive device to the service provider. Applications include high-speed cable modems, cable-television (CATV) interactive set-top boxes, and telephony-over-cable systems. It is designed to be compatible with Broadcom, Conexant, and Texas Instruments' upstream-modulator solutions. The hybrid IC uses gallium-arsenide (GaAs) as well as silicon complementary-metal-oxide semiconductor (Si CMOS) technologies and features a three-wire, serial-to-parallel bus architecture. Its integrated step attenuator has a range of 0 to 56 dB in 1-dB steps. Typical noise figure is 1.7 dB, while typical harmonic distortion is −64 dBc. The amplifier operates from a single +5-VDC power supply. **ANADIGICS, 35 Technology Dr., Warren, NJ 07059; (908) 668-5000, FAX (908) 668-5132, Internet: http://www.anadigics. com.**

CIRCLE NO. 76 or visit www.mwrf.com

Divider/combiner spans 18 to 26.5 GHz

The model PS8-116 eight-way power divider/combiner operates from 18 to 26.5 GHz and offers a minimum isolation of +17 dBm. The device features a maximum insertion loss of 2.8 dB and a VSWR of 1.6:1. Amplitude flatness is ±0.5 dB and phase balance is ±12 deg. The divider/combiner is housed in a rugged aluminum package with female SMA connectors. **Microwave Communications Laboratories, Inc., 7255 30th Ave. North, St. Petersburg, FL 33710; (727) 344-6254, FAX: (727) 381-6116, Internet: http://www.mcli.com.**

CIRCLE NO. 77 or visit www.mwrf.com

Hybrid amp boasts high gain

The model PTH 32007 hybrid power amplifier (PA) operates from 2.12 to 2.17 GHz and boasts a nominal gain of 25 dB. It is intended for applications requiring linear amplification and has a typical power output of 23 W at the 1-dB compression point. The high-impedance-technology (HIT) device can act as a high-gain driver or as a final output device. It is designed to operate with 50-Ω source and load impedances and includes bias circuitry with temperature compensation. Small-signal flatness is typically ±0.2 dB and VSWR is typically 1.2:1. It operates from a +26-VDC power supply and is housed in a J-type package having an overall footprint of 1.21 in.^{2} **Ericsson Microelectronics, Inc., 675 Jarvis Dr., Suite 101, Morgan Hill, CA 95037; (408) 778-9434, FAX: (408) 779-3108, Internet: http://www.ericsson.com.**

CIRCLE NO. 78 or visit www.mwrf.com

Test set simulates airborne radar targets

The monopulse beacon test set provides the signals necessary to simulate air-traffic-control-beacon-interrogator (ATCBI) radars, including air-traffic-control radar-beacon systems (ATCRBS) and mode-select-beacon-system (Mode-S) transponders. The test set generates the necessary signals to measure ATCBRS and Mode-S receiver performance, and it allows technicians to measure overall system sensitivity (OSS) through remote operation. The test set simulates as many as 32 ATCRBS- and/or Mode-S-compliant targets per scan up to 255 nautical miles in range and can operate in continuous-wave (CW) or pulsed-wave RF modes. It can trigger pulsed signals or target reports by internal, external, or decoded RF interrogations. Its azimuth information is synchronized to antenna-pedestal data. The test set can be controlled through its general-purpose interface bus (GPIB) from either a Microsoft-Windows-based host computer or the radar system, and includes a Pentium-based laptop computer. **Freestate Electronics, Inc., 6530 Commerce Ct., Warrenton, VA 20187; (540) 349-4727, FAX: (540) 349-4740, Internet: http://www.fse-inc.com.**

CIRCLE NO. 79 or visit www.mwrf.com

VCXO covers 77.76 to 155.52 MHz

The model 348 voltage-controlled crystal oscillator (VCXO) operates at +3.3 VDC and is available at frequencies from 77.76 to 155.53 MHz. It is designed specifically for a number of communications-related applications, including Gigabit Ethernet, asynchronous transfer mode (ATM), synchronous transmission module, level one (STM-1), synchronous transport signal, level 3c (STS-3c), Synchronous Optical Network (SONET), and optical carrier, level 3c (OC-3c). The output of the oscillator can be specified as either emitter-coupled logic (ECL) or positive emitter-coupled logic (PECL). The oscillator operates at temperatures from −40 to +85°C and is housed in an industry-standard, 6-pin, J-leaded ceramic package measuring 9 × 14 mm. **Oak Frequency Control Group, 100 Watts St., Mt. Holly Springs, PA 17065; (717) 486-3411, FAX: (717) 486-5920, Internet: http://www.ofc.com.**

CIRCLE NO. 80 or visit www.mwrf.com

MMIC amp boosts wireless Internet

The model SGA-5486 silicon-germanium (SiGe) monolithic-microwave-integrated-circuit (MMIC) amplifier operates at frequencies to 900 MHz for applications such as home RF, wireless Internet, and IEEE 802.11. The amplifier has a gain of 20 dB and an output power of +17 dBm at its 1-dB intercept point. Its output third-order intercept point is +31 dBm and it has a noise figure of 2.8 dB at 900 MHz. The chip operates from a single-supply voltage as low as +3.5 VDC and typically draws 60 mA. It is available in industry-standard, miniature SOT89 and SOT23-5 surface-mount packages. **Stanford Microdevices, Inc., 522 Alanor Ave., Sunnyvale, CA 94086; (800) 746-6642, FAX: (408) 739-0970, Internet: http://www.stanfordmicro.com.**

CIRCLE NO. 81 or visit www.mwrf.com

Millimeter amps span 40 to 60 GHz

The 4060 series of millimeter-wave, field-effect-transistor (FET)-based amplifiers operates from 40 to 60 GHz and is particularly suited for use in microwave video-distribution systems (MVDS) and specialized millimeter-wave test equipment. The amplifiers offer gain as high as 40 dB, saturated output power to +20 dBm, and a VSWR that is no higher than 2.2:1. The devices have internal voltage regulation and are available with or without temperature-compensation circuitry. **Link Microtek Ltd., Intec 4.1, Wade Rd., Basingstoke, Hants RG24 8NE, United Kingdom; +01256 355771, FAX: +01256 355118, Internet: http://www. linkmicrotek.com.**

CIRCLE NO. 82 or visit www.mwrf.com

PHEMT amp spans 6 to 12 GHz

The model AML 612P4401 pseudomorphic high-electron mobility transistor (PHEMT) amplifier operates from 6 to 12 GHz and provides 44-dB gain with ±2-dB flatness. Power output is 1 W, maximum noise figure is 2.5 dB, and input and output VSWR is 1.8:1. The amplifier operates at a power-supply voltage from +12 to +15 VDC and draws a nominal 700 mA. It is housed in a 2.00 × 0.80 × 0.35-in. (5.08 × 2.03 × 0.89-cm) package. **AML Communications, Inc., 1000 Avenida Acaso, Camarillo, CA 93012; (805) 388-1345, FAX: (805) 484-2191, Internet: http://www.amlj.com.**

CIRCLE NO. 83 or visit www.mwrf.com

Package is size of diode chip

Ideal for voltage-controlled oscillators (VCOs), two models of silicon (Si) varactor tuning diodes are now available in a new surface-mount monolithic package (SMMP). The new package design approaches the size of a diode chip, yet can be handled using surface-mount technology (SMT). Model GVD60100 has a C-V characteristic designed for low-voltage VCO applications. Model GVD60200 has a characteristic well-suited for wide-bandwidth VCO designs. Both models boast high-quality factor (Q). The new package design uses photolithographic methods at wafer fabrication to connect to the diode. Since this connection technique is more exact than wire-bonding, it is possible to tightly control the parasitic package inductance. Operation is optimized at approximately 2 GHz, and is possible to 10 GHz. **Sprague-Goodman Electronics, Inc., 1700 Shames Dr., Westbury, NY 11590; (516) 334-8700, FAX: (516) 334-8771, e-mail: info@spraguegoodman.com, Internet: http://www.spraguegoodman.com.**

CIRCLE NO. 84 or visit www.mwrf.com

Attenuators span DC to 18 GHz

The BW-S10W2 line of fixed attenuators operates from DC to 18 GHz and provides 10-dB nominal attenuation with ±0.6-dB accuracy below 12.4 GHz and ±1.1-dB accuracy above 12.4 GHz. The 50-Ω attenuators can handle 2-W average or 125-W peak power and can operate at temperatures from −55 to +100°C. They are available in a 0.850 × 0.312-in. (2.16 × 0.792-cm) package that is ideal for matching and test set up. **Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235-0003; (718) 934-4500, FAX: (718) 332-4661, e-mail: sales@minicircuits.com, Internet: http://www.minicircuits.com.**

CIRCLE NO. 85 or visit www.mwrf.com

Attenuator provides phase-free operation

The model A3P-64-0AE is a digitally controlled, PIN-diode, phase-invariant attenuator boasting virtually phase-free operation over a dynamic range of 45 dB from 6 to 18 GHz. At any attenuation up to 20 dB, the unit exhibits a flatness versus attenuation of less than ±0.9 dB and a delta phase of less than ±5 deg. The phase-invariant attenuator demonstrates monotonic performance with 8 b (1 B) of TTL-compatible binary logic, a VSWR of less than 2.0:1, and a total switching speed of less than 350 ns. The unit is packaged to form, fit, and function as an industry-recognized standard. **G.T. Microwave, Inc., 2 Emery Ave., Randolph, NJ 07869; (973) 361-5700, FAX: (973) 361-5722, e-mail: gtmicrowav@aol.com, Internet: http://www.GTmicrowave.com.**

CIRCLE NO. 86 or visit www.mwrf.com

Attenuator boasts high accuracy

Model 100-SA-MFN-120 is a 120-dB attenuator that features an attenuation accuracy of ±1.5 dB. The convection-cooled unit boasts a 100-W average and 2000-W peak-power rating. This 50-Ω attenuator provides a frequency range of DC to 1 GHz with a VSWR of 1.15:1. The package is 9.15 × 2.75 × 2.75 in. (23.24 × 6.99 × 6.99 cm) with an approximate weight of 52 oz. Male or female type-N connectors are available. **BCP, 10950 72nd St. N., Suite 107, Largo, FL 33777-1527; (727) 547-8826, FAX: (727) 547-0806, e-mail: sales@birdfla.com, Internet: http://www.birdfla.com.**

CIRCLE NO. 87 or visit www.mwrf.com

Diplexer serves GSM and DCS

The model W9180DE dual-band miniature-cavity diplexer is designed for 900-MHz Global System for Mobile Communications (GSM) and 1.8-GHz Digital Communication System (DCS) signals. The unit covers the full DCS and GSM bands with less than 0.3-dB insertion loss with between-band isolation of greater than 65 dB. Return loss is greater than −18 dB in all ports and power capability is greater than 50 W in both bands. The diplexer eliminates the need for two tower-feed cables at the base station and features SMA or type-N connectors on a package measuring 1.5 × 3.0 × 5.0 in. (3.81 × 7.62 × 12.70 cm). **Wireless Technologies, 4183 Haile Lane, Springdale, AR 72762; (877) 420-7983, (501) 750-1046, FAX: (501) 750-4657, e-mail: wireless@ipa.net, Internet: http://www.diplexers.net.**

CIRCLE NO. 88 or visit www.mwrf.com

Assemblies increase packing density

The GPO™ and GPPO™ cable assemblies combine flexibility with semirigid performance for systems in need of increased packaging density. The 0.065-in. (0.165-cm)-diameter cable boasts an attenuation value of 1.80 dB/ft at 18 GHz, a minimum bend radius of 0.2 in. (0.508 cm), and an operating temperature of −50 to 125°C. The snap-together, blindmate connection of the cable assemblies helps provide system stability against severe vibration conditions. **Storm Products-RF/Microwave Group, 116 Shore Dr., Hinsdale, IL 60521; (888) 347-8676, (630) 323-9121, Internet: http://www.stormproducts.com.**

CIRCLE NO. 89 or visit www.mwrf.com

OCXOs target SONET switching

A new range of miniature oven-controlled crystal oscillators (OCXOs) for cell-phone base stations and Stratum 3 synchronous-digital-hierarchy (SDH)/Synchronous Optical Network (SONET) switching is now available. The model CFPO-6 range is stable to within ±0.02 PPM and spans across the −20 to +70°C temperature range at output frequencies that range from 4 to 40 MHz. The OCXOs can also cover frequencies up to 60 MHz at ±0.25-PPM stability. Specifications include low-crystal aging effects to within $\pm 3 \times 10^{-10}$ per day or ±0.05 PPM per year after 30 days operation with a phase noise of −140 dBc/Hz at 100 kHz and −145 dBc/Hz at 1 kHz from 10 MHz. Voltage control of output frequency is available to ±4 PPM. **C-MAC Frequency Products, 4222 Emperor Blvd., Suite 300, Durham, NC 27703-8466; (919) 941-0430, FAX: (919) 941-0530, e-mail: cfp@america.dfpwww.com, Internet: http://cfpwww.com.**

CIRCLE NO.90 or visit www.mwrf.com

Contactless Phase Shifters:

World-First 'Contactless' Brings Better Reliability under All Conditions

Designed by KMW for low insertion loss and good stability under hard environmental conditions, these Contactless Phase Shifter (:CPS) will provide the linear characteristic of phase and low IMD performance

Standard Connectorized CPS

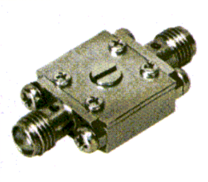

KPH90OSCL000


KPH90OSCL001

Product Code No.	A type : KPH90OSCL000 B type : KPH90OSCL001		
Frequency Range	~ 1GHz	1 ~ 2GHz	2 ~ 3GHz
Insertion Loss (Max.)	0.15dB	0.25dB	0.35dB
VSWR (Max.)	1.25:1	1.25:1	1.25:1
Incremental Phase Shift	90 degree min. @ 2GHz		
Electrical Delay	125 psec min.		
Nominal Impedance	50 ohm		
I/O Port Connector	SMA(F) / SMA(F)		
Average Power Handling	20W @ 2GHz		
Temperature Range	-30°C ~ +60°C		
Dimension (inch)	A type : 1.496*1.102*0.457 B type : 1.225*1.102*0.457		

Miniature CPS


KPH30OSCL000


KPH35OSCL000

Product Code No.	Drop-In type (KPH30OSCL000)			Connectorized type (KPH35OSCL000)		
Frequency Range	~ 1GHz	1 ~ 2GHz	2 ~ 2.5GHz	~ 1GHz	1 ~ 2GHz	2 ~ 3GHz
Insertion Loss (Max.)	0.15dB	0.25dB	0.35dB	0.15dB	0.25dB	0.35dB
VSWR (Max.)	1.3:1	1.3:1	1.3:1	1.25:1	1.25:1	1.25:1
Incremental Phase Shift	30 degree min. @ 2GHz			35 degree min. @ 2GHz		
Electrical Delay	41.7 psec min.			48.6 psec min.		
Nominal Impedance	50 ohm			50 ohm		
I/O Port Connector	Drop-In			SMA(F) / SMA(F)		
Average Power Handling	30W @ 2GHz			30W @ 2GHz		
Temperature Range	-30°C ~ +60°C			-30°C ~ +60°C		
Dimension (inch)	0.709*0.433*0.244			0.630*0.551*0.244		

13131 East 166th Street, Cerritos, CA 90703-2202
1-800-8320-KMW • www.kmwinc.com
tel: 562-926-2033 • fax: 562-926-6133

CIRCLE NO. 374

KMW
RF & Microwave Products

Isolators cover 400 to 800 MHz

High-power, low-loss ultra-high-frequency (UHF) band isolators and circulators are available with stripline tab interfaces to operate in the 400 to 800 MHz TV and communications frequencies. In bandwidths up to 20 percent, these units are rated for 250 W CW with typical specifications of 20-dB isolation, 0.25-dB maximum loss, and 1.25 maximum VSWR. SMA connectors are available. The package measures 2.0 × 2.0 × 5.8 in. (5.08 × 5.08 × 14.73 cm). **UTE Microwave, Inc., 3500 Sunset Ave., Asbury Park, NJ 07712; (732) 922-1848, FAX: (732) 922-1848, e-mail: info@utemicrowave.com, Internet: http://www.utemicrowave.com.**

CIRCLE NO. 91 or visit www.mwrf.com

MESFET targets PAs

Designed to serve as an output stage in power amplifiers (PAs), model NES1720P-140 is a 140-W, high-gain, high-efficiency, partially-matched, twin-transistor L-Band, gallium-arsenide (GaAs) metal-semiconductor field-effect transistor (MESFET) boasting 200-GHz instantaneous bandwidth, supporting its ability to serve 1.7-, 1.8-, and 1.9-GHz applications simultaneously. The unit features 42-percent typical high power-added efficiency (PAE), reducing power consumption. Its low thermal resistance results in cooler operation and the ability to operate at higher bias current, achieving higher linearity. Specifications include 11-dB typical linear gain and 0.4°C/W thermal resistance. When this twin-transistor device is partially matched, its two sides can be combined externally in either a balanced or push-pull configuration. The GaAs MESFET chips feature tungsten-silicide (WSi_2) gates for high reliability, silicon-dioxide (SiO_2) and silicon-nitride (SiN_2) passivation for surface stability, and plated heat sinks for reduced thermal resistance. **California Eastern Laboratories, 4590 Patrick Henry Dr., P.O. Box 54964, Santa Clara, CA 95054-1817; (408) 988-0279, FAX: (408) 988-0279, Internet: http://www. cel.com.**

CIRCLE NO. 92 or visit www.mwrf.com

AlN loads target PCS applications

A new line of aluminum nitride (AlN) loads for cellular and personal-communications-services (PCS) applications boasts superior performance. The use of AlN elements in the loads can alleviate worldwide concern for beryllium-oxide (BeO) use and disposal. The AlN loads have a DC-to-3-GHz frequency range with a VSWR of 1.10:1 from DC to 1 GHz and a 1.15:1 VSWR to 3 GHz. The AlN loads are available in 2-to-100-W packages with BNC, 7/16, type-N, and TNC male and female connectors. **BCP, 10950 72nd St. N., Suite 107, Largo, FL 33777-1527; (727) 547-8826, FAX: (727) 547-0806, e-mail: sales@birdfla.com, Internet: http://www.birdfla.com.**

CIRCLE NO. 93 or visit www.mwrf.com

LNA serves mobile applications

The model JCA3031-K01 Ka-band low-noise amplifier (LNA) for geostationary-satellite-orbit (GSO)/fixed-satellite-source (FSS), non-geostationary-satellite-orbit (NGSO)/FSS, and mobile applications spans 30 to 31 GHz with at least 42-dB gain and a gain flatness of ±1.5 dB. The LNA boasts a power output of at least +10 dBm at the 1-dB compression point, with a typical noise figure of 5 dB. Customized versions are available, with options for alternative gain specification, temperature compensation, and drop-in packages. **JCA Technology, Inc., 4000 Via Pescador, Camarillo, CA 93012; (805) 445-9888, FAX: (805) 987-6990, e-mail: jca@jcateh.com, Internet: http://www.jcateh.com.**

CIRCLE NO. 94 or visit www.mwrf.com

Software upgrade increases functionality

Improvements in functionality have been added to the model 2398 spectrum analyzer through a software upgrade. The analyzer combines the flexibility of a small portable unit for wireless infrastructure, TV-broadcast, or cable-TV (CATV) field testing, with quality measurement in production or laboratory environments. It boasts a frequency range from 9 kHz to 2.7 GHz along with innovative features such as a split-screen operation for simultaneously tracking two signals, low phase noise, and wide input range. The 2398 software version 1.55b includes many upgrades. The trigger mode (free run, video, line, and external) is now stored when the instrument state is stored. Improvements have been added to the marker noise function, allowing the video detector to reset to its original mode before the marker-noise function is selected. The win mode now supports independent vertical scale settings for the upper and lower zones allowing multiple functions to be observed simultaneously. **IFR, 10200 W. York St., Wichita, KS., 67215-8999; (800) 835-2352, (316) 522-4981, e-mail: info@ifrsys.com, Internet: http://www.ifrsys.com.**

CIRCLE NO. 95 or visit www.mwrf.com

PIN diodes target WCDMA

Models SMP1320 and SMP1340 are two series of plastic-packaged, surface-mountable, PIN diodes. These diodes are designed for high-speed, high-performance, wireless-switch applications from 10 MHz to beyond 2 GHz. They feature low resistance and low capacitance, making them ideal for wideband-code-division-multiple-access (WCDMA) applications. **Alpha Industries, 20 Sylvan Rd., Woburn, MA 01801; (781) 935-5150, FAX: (617) 824-4564, Internet: http://www.alphaind.com.**

CIRCLE NO. 96 or visit www.mwrf.com

Shielding gasket speeds installation

The model 125G28 shielding gasket features a "quick-release" backing on its double-sided, pressure-sensitive tape to speed installation time for RF-interference/electromagnetic-interference (RFI/EMI) shielding. Since the backing is slightly wider than the adhesive, it is easy to remove during installation. The low-profile beryllium-copper (Be-Cu) gasket measures 0.06 × 0.28 in. (0.15 × 0.71 cm). **Tech-Etch, Inc., 45 Aldrin Rd., Plymouth, MA 02360; (508) 747-0300, FAX: (508) 746-9639, e-mail: sales@tech-etch.com, Internet: http://www.tech-etch.com.**

CIRCLE NO. 97 or visit www.mwrf.com

Power dividers

A 152-page catalog details power dividers, directional couplers, high-power dual directional couplers, diode detectors, directional detectors, waveguide couplers, and 90- and 180-deg. hybrids. Waveguide adapters; coaxial terminations; low-, medium-, and high-power waveguide terminations; coaxial attenuators; continuously variable attenuators; interdigital and bandpass filters; as well as connectorized isolators and circulators are also presented. Drop-in isolators and circulators, voltage- and digitally-controlled PIN-diode attenuators, PIN-diode and electromechanical switches, free-run and phase-locked oscillators (PLOs), and power amplifiers (PAs) are also specified. Custom designs are available. **Microwave Communications Laboratories, Inc.;** *(727) 344-6254, e-mail: sales@mcli.com.*

CIRCLE NO. 61 or visit www.mwrf.com

Electronic components

Connectors, cable assemblies, integrated circuits (ICs), sockets, semiconductors, transistors, and diodes are offered in a 280-page catalog. Rectifiers, crystals, oscillators, inductors, coils, filters, capacitors, resistors, potentiometers, thermistors, switches, and relays are specified. Wire, cable, test equipment, batteries, transformers, power supplies, and optoelectronics are included. **Digi-Key Corp.;** *(800) 344-4539, (218) 681-6674, FAX: (218) 681-3380, Internet: http://www.digikey.com.*

CIRCLE NO. 62 or visit www.mwrf.com

Spectrum analyzers

Test-and-measurement equipment is covered in a 32-page catalog. AC voltage sources, amplifiers, spectrum analyzers, calibrators, component testers, data-communications equipment, frequency counters and timers, as well as function generators are specified. Optical equipment, Microwave equipment, multimeters, voltimeters, oscilloscopes and accessories, plotters, power supplies, probes and accessories, and data-acquisition (DAQ) equipment are also listed. **Naptech Test Equipment, Inc.;** *(800) 336-7723, FAX: (707) 995-7145, e-mail: sales@naptech.com, Internet: http://www.naptech.com.*

CIRCLE NO. 63 or visit www.mwrf.com

Segmented reflectors

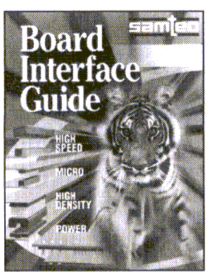
Off-the-shelf composite segmented reflectors are discussed in a six-page brochure. Radomes, dichroic subreflectors, and segmented reflectors are presented. Product applications and features are provided. **Pacific Radomes, Inc.;** *(408) 727-4777, FAX: (408) 727-4114, e-mail: info@pacificradomes.com, Internet: http://www.pacificradomes.com.*

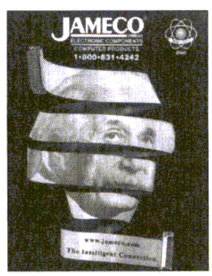
CIRCLE NO. 64 or visit www.mwrf.com

Board interconnects

High-speed and high-density interface areas are discussed in a new guide. Micro board-to-board, power-to-board, card-to-board, cable-to-board, and integrated-circuit (IC)-to-board interconnects are offered. A review of flex design and application-specific product capabilities is included. New matched-impedance interfaces are also featured. **Samtec, Inc.;** *(800) SAMTEC-9, (812) 944-6733, FAX: (812) 948-5047 e-mail: info@samtec.com, Internet: http://www.sam tec.com.*

CIRCLE NO. 65 or visit www.mwrf.com





Integrated circuits

A 150-page catalog features components that are suitable for original equipment manufacturers (OEMs). Integrated circuits (ICs), test equipment, computer products, input/output (I/O) cards, transformers, and power supplies are featured. **Jameco;** *(800) 831-4242, (650) 592-8097, FAX: (800) 237-6948, (650) 592-2503, e-mail: info@jameco.com, Internet: http://www.jameco.com.*

CIRCLE NO. 66 or visit www.mwrf.com

Power supplies

High-voltage, high-current, and high-performance power supplies, systems, and components are described in an eight-page brochure. Specifications include output voltage ratings, input and output electrical parameters, and environmental parameters. Application information is provided. **NWL;** *(800) 742-5695, FAX: (609) 298-1982, e-mail: nwlinfo@nwl.com, Internet: http://www.nwl.com.*

CIRCLE NO. 67 or visit www.mwrf.com

DC blocks

Cables and connectors are available from a 162-page catalog. Adapters, attenuators, circulators, coaxial cables and connectors, DC blocks, detectors, and directional couplers are listed. Isolators, limiters, phase trimmers, power dividers, shorts, switches, terminators, and waveguide-to-coax adapters are featured. **Pasternack Enterprises;** *(949) 261-1920, FAX: (949) 261-7451, e-mail: sales@pasternack.com, Internet: http://www.paster nack.com.*

CIRCLE NO. 68 or visit www.mwrf.com

Mobile communications

A brochure discusses a complete international and approval program of technological services for the mobile communications industry, including digital cellular handsets, base-transceiver stations, accessories, as well as repeaters and ancillaries. **CETECOM, Inc.;** *(510) 252-1700, FAX: (510) 252-0559, Internet: http://www.cetecom.de.*

CIRCLE NO. 69 or visit www.mwrf.com

EMC test solutions

A 152-page catalog is designed to help design and test engineers meet current electromagnetic-capability (EMC) test-compliance requirements. A complete line of integrated EMC instrumentation systems, services, and test solutions is detailed for industrial, commercial, telecom, and automotive industries. Electronic growth in-vehicle management and equipment, complete RF-conducted and radiated test-system assembly, and design of systems are covered. **Schaffner EMC, Inc.;** *(732) 225-9533, FAX: (732) 225-4789, e-mail: ehoward@schaffner.com, Internet: http://www.schaffner.com.*

CIRCLE NO. 70 or visit www.mwrf.com

MICROWAVES & RF ENGINEERING CAREERS

RATES	DEADLINES	SALES STAFF
Effective January 1, 2000 $205 per column inch Commissionable to agencies	Space reservation: 5th of month preceding issue date Ad material to: Penton Media Inc., Classified Dept.,611 Route 46 West,Hasbrouck Heights, NJ 07604	Call Customer Service Dept. (201) 393-6083 Fax(201) 393-0410

In most cases, advertisements contained in Electronic Design employment section indicate that the companies are equal opportunity employers. The Federal Civil Rights Act of 1964, and other laws, prohibit discrimination in employment based on race, color, religion, national origin, sex or for any reason other than lack of professional qualification for the position being offered. It should be noted that employment advertisements in Electronic Design are published for the readers convenience and in no way, to the best of our knowledge, promote unlawful discrimination.

*Domestic Edition only

**International Edition only

This index is provided as an additional service by the publisher, who assumes no responsibility for errors or omissions.

MARKETING AND ADVERTISING STAFF

GROUP PUBLISHER
Craig Roth
(201) 393-6225
e-mail: croth@penton.com

DIRECT CONNECTION ADS
Joanne Reppas
(201) 666-6698
e-mail: jrepfran@aol.com

DIRECTOR, ELECTRONICS EVENTS
Bill Rutledge
(201) 393-6259
FAX: (201) 393-6297
e-mail: brutledge@penton.com

RECRUITMENT ADVERTISING
Call Customer Service Dept.
(201) 393-6083
FAX: (201) 393-0410

NORTHERN CA, NORTHWEST
Gene Roberts
Regional Sales Manager
Penton Media, Inc.
San Jose Gateway
2025 Gateway Place, Suite 354
San Jose, CA 95110
(408) 441-0550
e-mail: groberts@penton.com

NEW YORK, NEW ENGLAND, MIDWEST, MID-ATLANTIC, CANADA
Paul Barkman
Regional Sales Manager
Penton Media, Inc.
611 Route #46 West
Hasbrouck Heights, NJ 07604
(908) 704-2460
FAX: (908) 704-2496
e-mail: pbarkman@penton.com

SOUTHWEST, SOUTHEAST, SOUTHERN CA
Mary Bandfield
Regional Sales Manager
Penton Media, Inc.
501 N. Orlando Avenue
Winter Park, FL 32789
(407) 629-8745
FAX: (407) 629-8715
e-mail: mbandfield@penton.com

MIDWEST, MID-ATLANTIC
Paul Barkman
Regional Sales Manager
Penton Media, Inc.
611 Route #46 West
Hasbrouck Heights, NJ 07604
(908)391-8735
FAX: (201) 393-6297
e-mail: pbarkman@penton.com

PRODUCTION
Robert D. Scofield
(201) 393-6253
e-mail: rscofield@penton.com

ISRAEL
Igal Elan, General Manager
Elan Marketing Group
2 Habonim Street
Ramat Gan, Israel 52462
Phone: 011-972-3-6122466
011-972-3-6122467
011-972-3-6122468
FAX: 011-972-3-6122469

TAIWAN, R.O.C.
Charles C.Y. Liu, President
Two-Way Communications Co., Ltd.
11F/1, No. 421
Sung Shan Road
Taipei 110, Taiwan, R.O.C.
Phone: 886-2-727-7799
FAX: 886-2-728-3686

INDIA
Shivaji Bhattacharjee
Information & Education Services
1st Floor, 30-B, Ber Sarai Village,
Near I.I.T. Hauz Khas, Behind
South Indian Temple
New Delhi, 110016 India
FAX: 001-91-11-6876615

ITALY
Cesare Casiraghi
Via Napo Torriani 19/c
1-22100 Como - Italy
Phone: 39-31-261407
FAX: 39-31-261380

FRANCE
Emmanual Archambeaulld
Defense & Communication
10 Rue St. Jean, 75017 Paris,
France
Phone: 33-4294-0244
FAX: 33-4387-2729

SPAIN
Luis Andrade, Miguel Esteban
Espana
Publicidad Internacional
Sepulveda, 143-38
08011 Barcelona, Spain
Phone: 011-34-93-323-3031
FAX: 011-34-93-453-2977

SCANDINAVIA
Paul Barrett
I.M.P. Hartswood
Hallmark House
25 Downham Road
Ramsden Heath
Billericay, Essex
CM 11 1PV
United Kingdom
Phone: 44-1268-711-560
FAX: 44-1268-711-567

GERMANY, AUSTRIA, SWITZERLAND
Friedrich K. Anacker
Managing Director
InterMedia Partners GmbH (IMP)
Deutscher Ring 40
42327 Wuppertal
Germany
Phone: 011-49-202-271-690
FAX: 011-49-202-271-6920

HOLLAND, BELGIUM
William J.M. Sanders, S.I.P.A.S.
Rechtestraat 58
1483 Be De Ryp, Holland
Phone: 31-299-671303
FAX: 31-299-671500

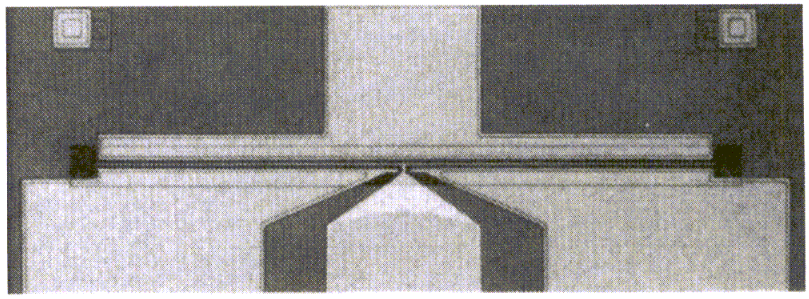
JAPAN
Hiro Morita
Japan Advertising
Communications, Inc.
Three Star Building
3-10-3 Kanda Jimbocho
Chiyoda-ku, Tokyo 101,
Japan
Phone: 81-3-3261-4591
FAX: 81-3-3261-6126

PORTUGAL
Paulo Andrade
Ilimitada-Publicidade
Internacional. LDA
Av. Eng. Duarte Pacheco
Empreedimento das
Amoreiras-Torre 2
Piso 11-Sala 11
1070 Lisboa, Portugal
Phone: 351-1-3883176
FAX: 351-1-3883283

EUROPEAN OPERATIONS
Paul Barrett, Mark Whiteacre,
David Moore
Phone: 44-1268-711-560
FAX: 44-1268-711-567
John Maycock
Phone: 44-1142-302-728
FAX: 44-1142-308-335
Hartswood, Maycock Media
Hallmark House
25 Downham Road
Ramsden Heath
Billericay, Essex
CM 11 PV. U.K.

CZECH REPUBLIC
Robert Bilek
Production International
Slezska 61, 13000 Praha 3
Czech Republic
Phone: 011-42-2-730-346
FAX: 011-42-2-730-346

KOREA
BISCOM
Jo Young Sang
Rm. 521 Midopa Bldg. 145
Dan Ju-Dong
Chongno-Gu
Seoul 110-071 Korea
Phone: 027397840
FAX: 027323662



Almost 24 years ago, Hewlett-Packard Co. (Palo Alto, CA) broke new ground in low-noise amplification with the introduction of the model HFT-1000 low-noise gallium-arsenide (GaAs) field-effect transistor (FET). Selling for $135, the 1-µm device promised 2.9-dB typical noise figure and 8.9-dB associated gain at 8 GHz, with a usable range of 2 to 12 GHz.

Microwaves & RF August Editorial Preview

Issue Theme: Wireless Applications

News

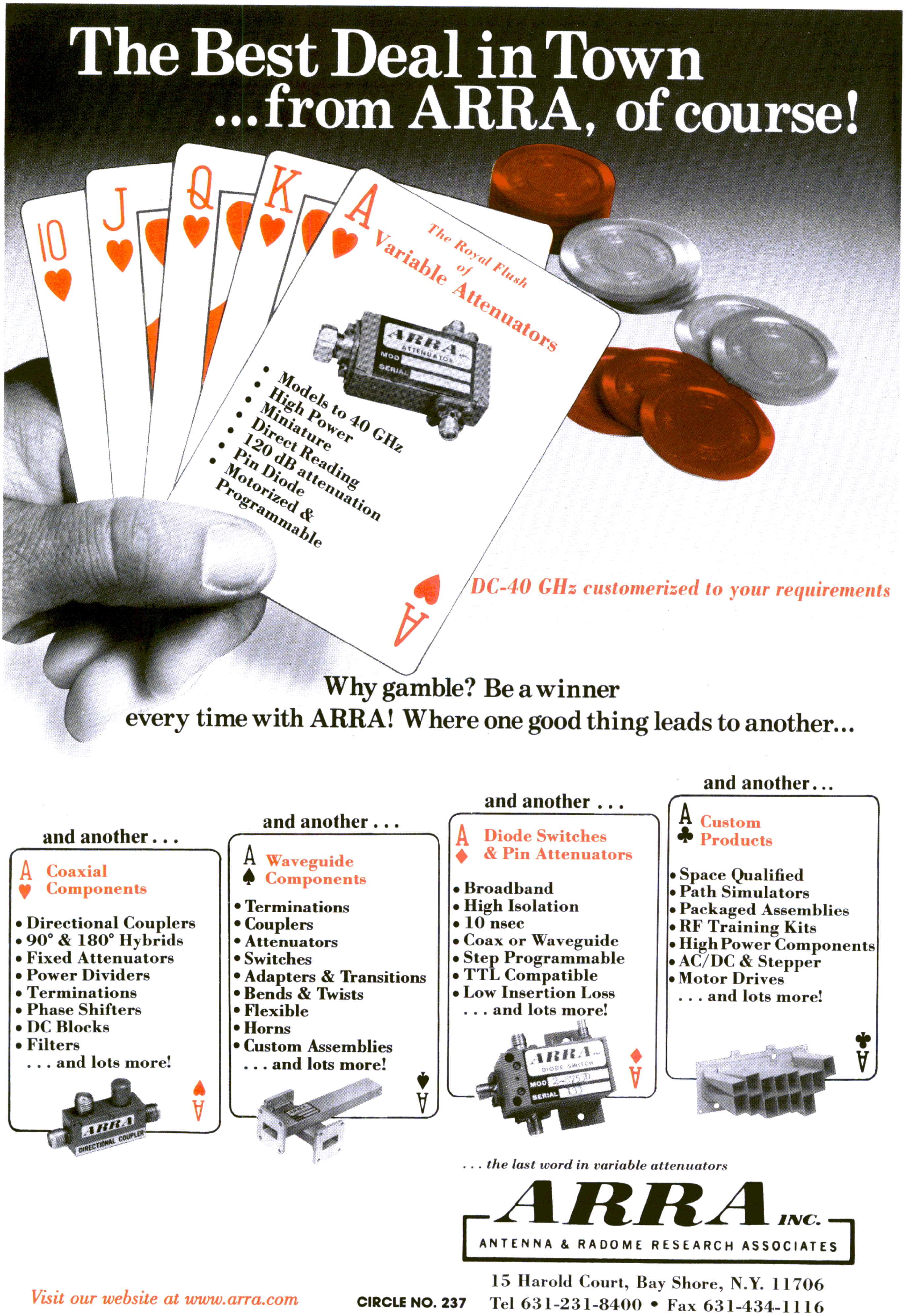
Wireless technology is truly ubiquitous, at least in the form of pagers and cellular telephones. Perhaps the best is yet to come, since projections for wireless applications, such as Bluetooth devices, wireless local-area networks (WLANs), and wireless Internet devices loom large. Many Bluetooth integrated circuits (ICs) are already on the market, as well as a handful of end products. And WLAN devices and products are growing in number. But Bluetooth and WLANs operate at 2.4 GHz. Can they coexist? For some answers, do not miss this Special Report on the latest wireless applications.

Design Features

The Design Feature section leads off with the latest work from Ulrich Rohde, well known for his design contributions in low-noise oscillators and frequency synthesizers. In August, Rohde describes techniques for the improved linear analysis of voltage-controlled oscillators (VCOs), as well as methods for predicting the spurious performance of fractional-N frequency synthesizers. Authors from Micronetics Wireless will explore the modeling of short-range indoor wireless systems. An author from Agilent Technologies will provide an introduction to the general-packet radio service (GPRS) of Global System for Mobile Communications (GSM).

Product Technology

August's Product Technology section explores a lineup of new products supporting wireless applications, including an improved version of a high-performance quadrature digital upconverter integrated circuit (IC) for high-speed wireless and wired data transmissions. The device's 14-b architecture provides enhanced signal-to-noise ratio and dynamic range. Additional product stories will highlight a line of high-power transistors for millimeter-wave applications and multicarrier power amplifiers (PAs) for base stations.



The Best Deal in Town
...from ARRA, of course!
The Royal Flush of Variable Attenuators
ARRA INC. ATTENUATOR MOD SERIAL
• Models to 40 GHz
• High Power
• Miniature
• Direct Reading
• 120 dB attenuation
• Pin Diode
• Motorized & Programmable
DC-40 GHz customerized to your requirements
Why gamble? Be a winner every time with ARRA! Where one good thing leads to another...
and another . . .
Coaxial Components
• Directional Couplers
• 90° & 180° Hybrids
• Fixed Attenuators
• Power Dividers
• Terminations
• Phase Shifters
• DC Blocks
• Filters
. . . and lots more!
ARRA DIRECTIONAL COUPLER
and another . . .
Waveguide Components
• Terminations
• Couplers
• Attenuators
• Switches
• Adapters & Transitions
• Bends & Twists
• Flexible
• Horns
• Custom Assemblies
. . . and lots more!
and another . . .
Diode Switches & Pin Attenuators
• Broadband
• High Isolation
• 10 nsec
• Coax or Waveguide
• Step Programmable
• TTL Compatible
• Low Insertion Loss
. . . and lots more!
ARRA DIODE SWITCH MOD SERIAL
and another . . .
Custom Products
• Space Qualified
• Path Simulators
• Packaged Assemblies
• RF Training Kits
• High Power Components
• AC/DC & Stepper
• Motor Drives
. . . and lots more!
. . . the last word in variable attenuators
ARRA INC.
ANTENNA & RADOME RESEARCH ASSOCIATES
15 Harold Court, Bay Shore, N.Y. 11706
Tel 631-231-8400 • Fax 631-434-1116
Visit our website at www.arra.com
CIRCLE NO. 237