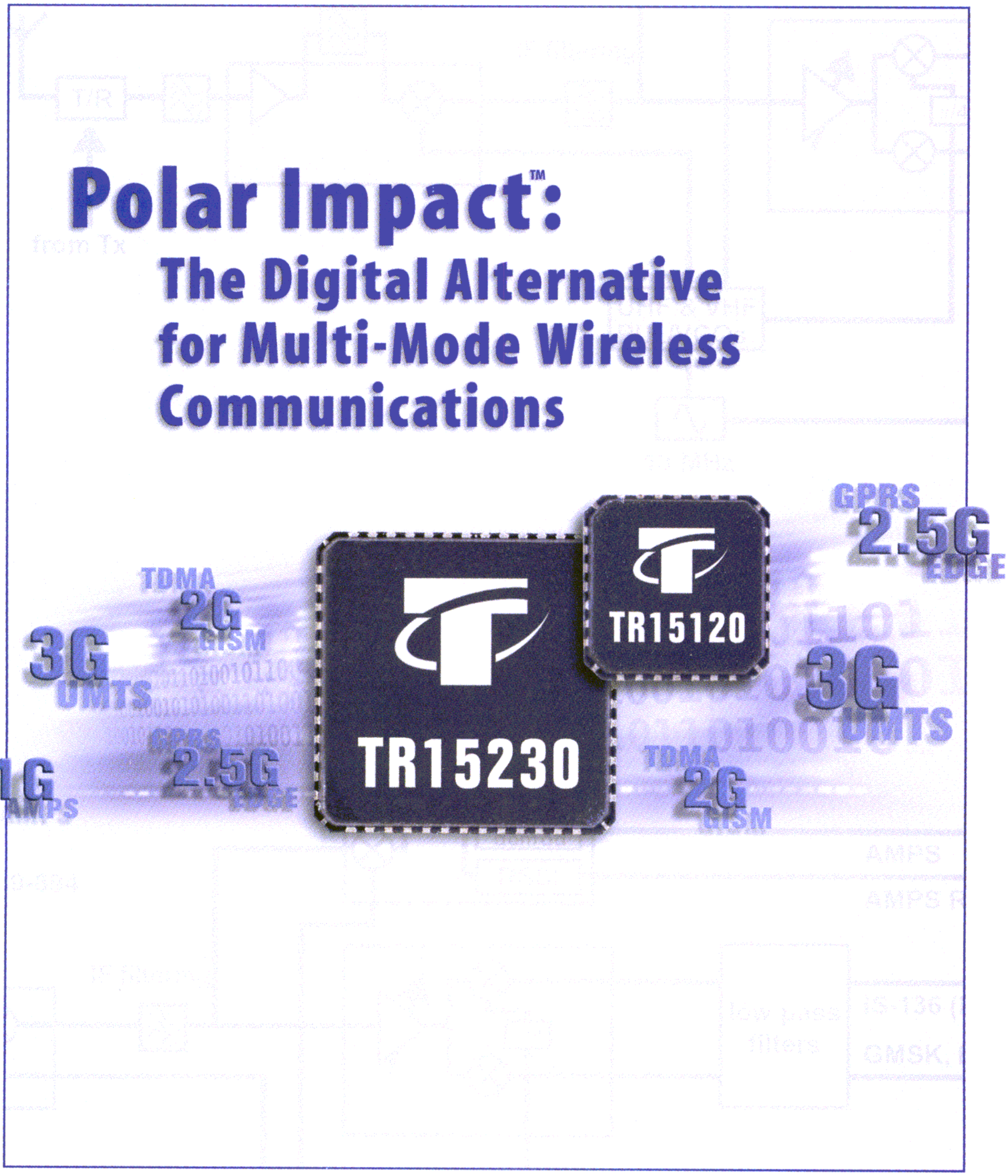
August 2001

Applied MICROWAVE & WIRELESS



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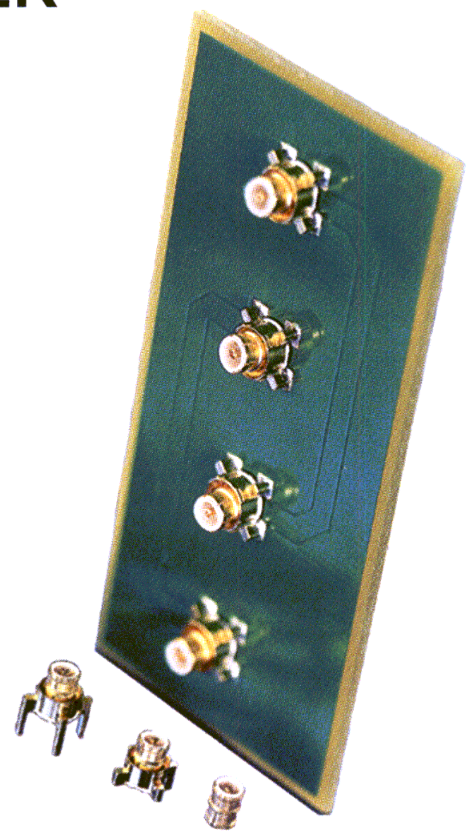

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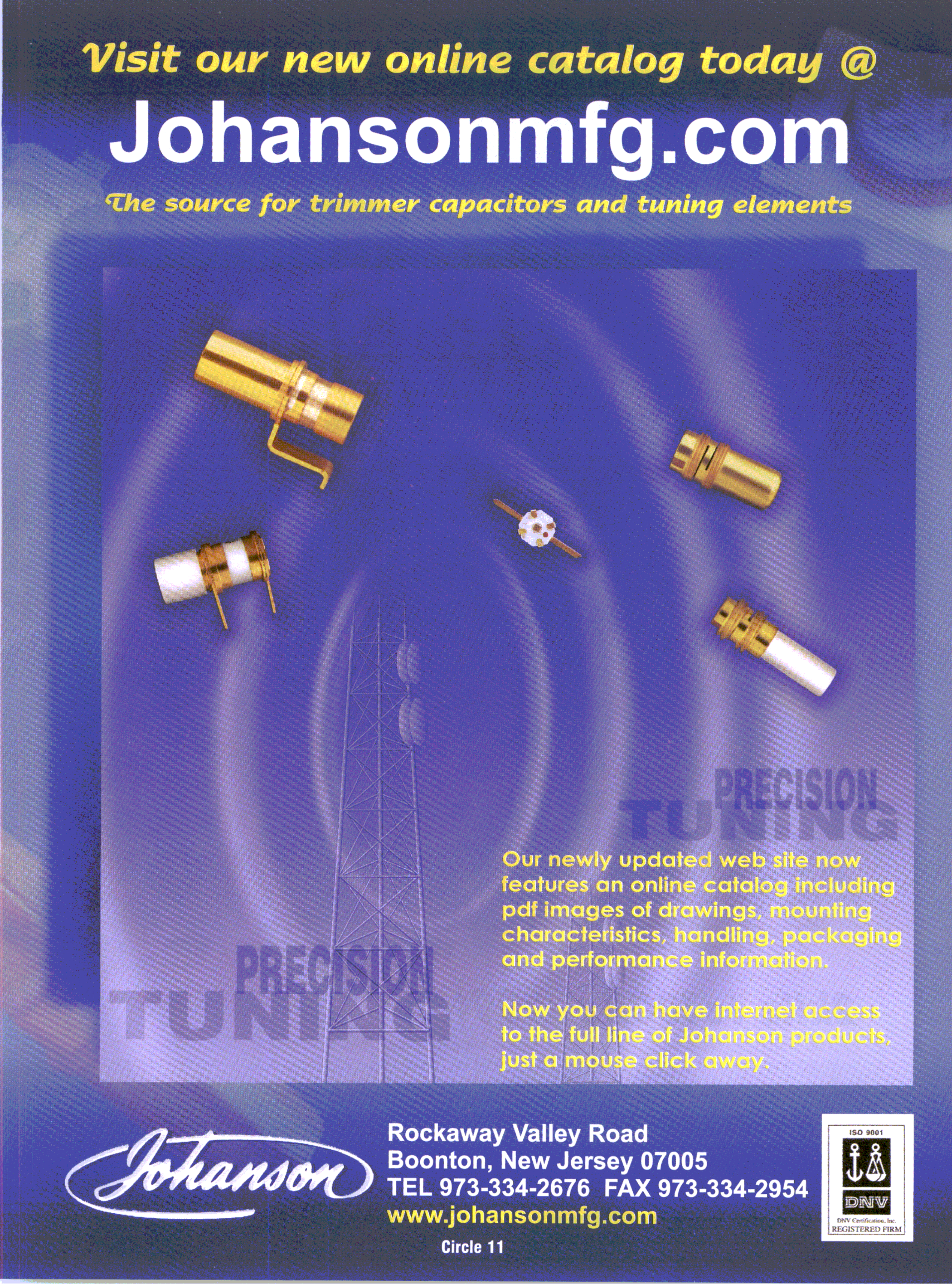
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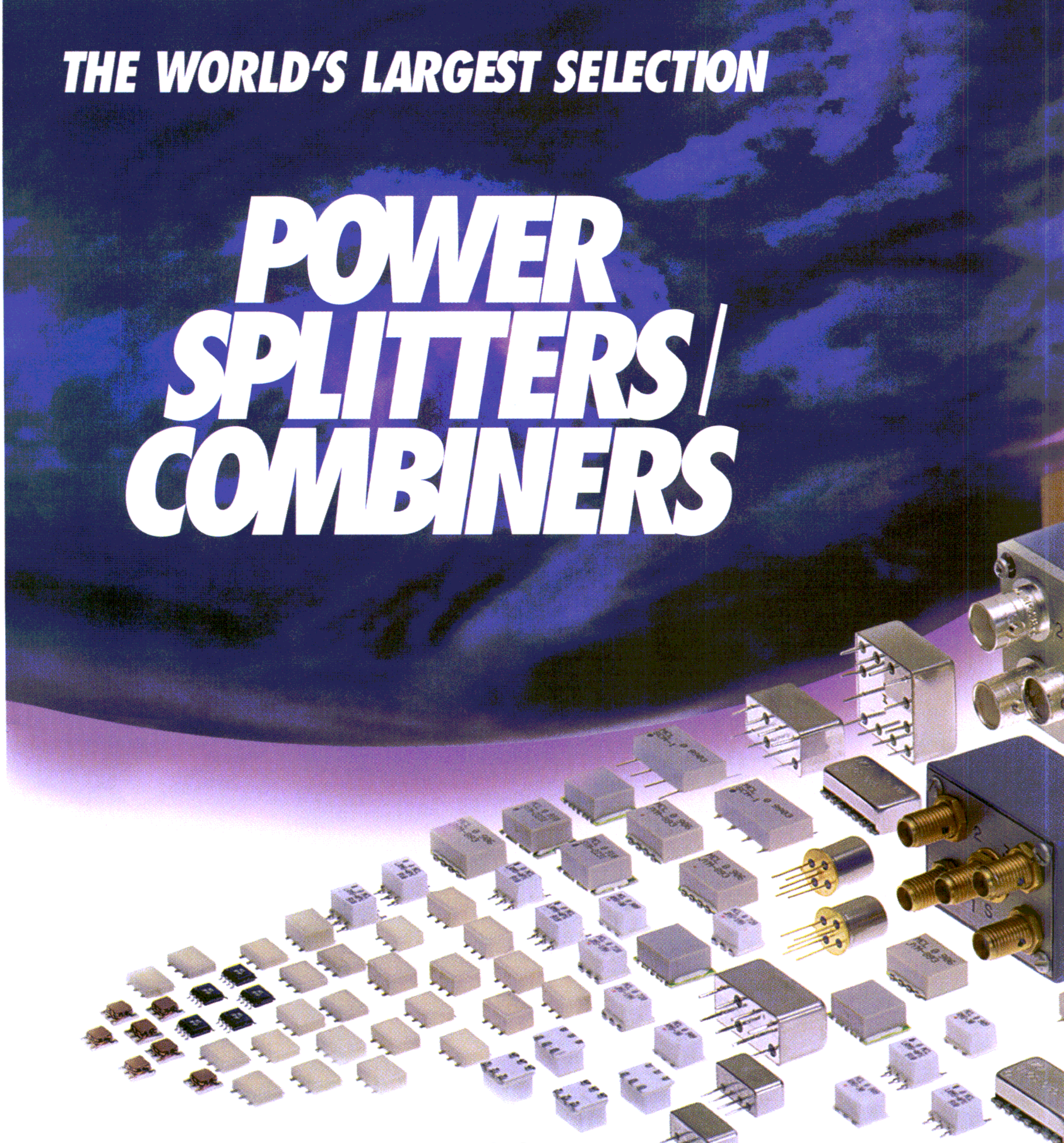

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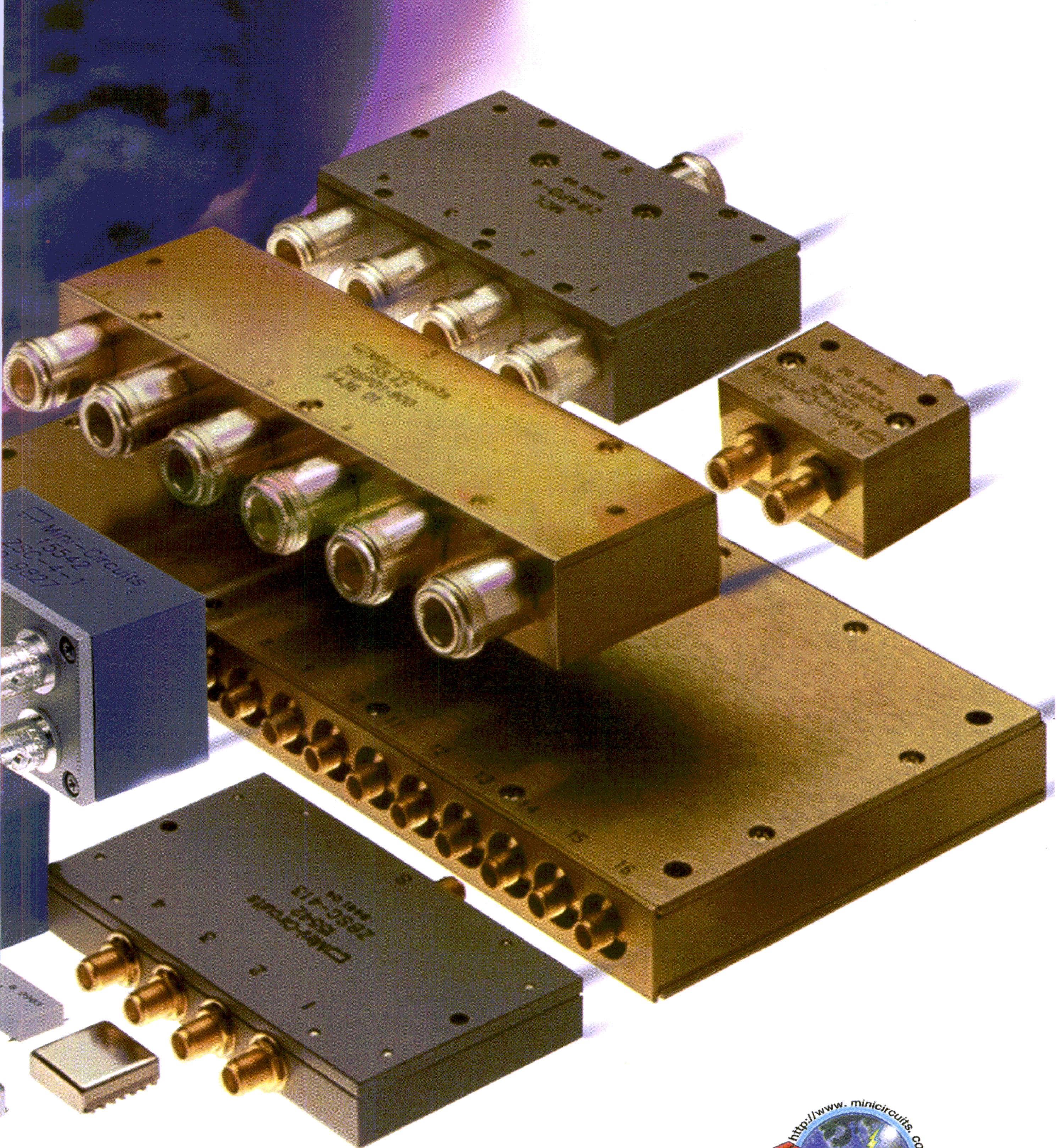

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INNOVATION

Applied
MICROWAVE & WIRELESS

August 2001
Vol. 13 No. 8

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Applied MICROWAVE & WIRELESS

August 2001
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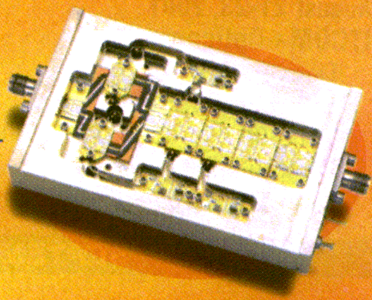
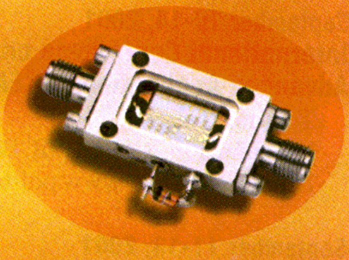
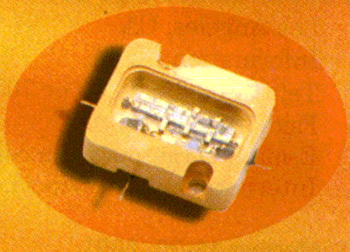
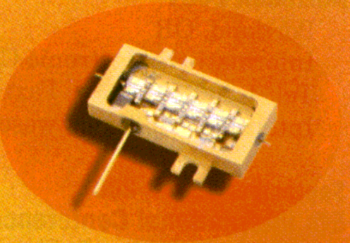
MEDIUM POWER AMPLIFIERS (UP TO 2 WATTS)								
JCA01-P01	0.5-1.0	25	3.5	1	30	40	2.0:1	250
JCA12-P01	1.0-2.0	32	3	1	30	40	2.0:1	800
JCA34-P01	3.7-4.2	30	3	1	30	40	2.0:1	750
JCA56-P01	5.9-6.4	30	3	1	30	40	2.0:1	850
JCA78-P01	7.9-8.4	30	4	1	30	40	2.0:1	900
JCA812-P02	8.3-11.7	40	5	1.5	33	40	2.0:1	1700
JCA910-P01	9.5-10.0	30	4	1	33	40	2.0:1	1300
JCA1011-P01	10.7-11.7	30	4	1	30	40	2.0:1	950
JCA1819-P01	18.1-18.6	30	5	1	27	37	2.0:1	800
RADAR & COMMUNICATION BAND LOW NOISE AMPLIFIERS								
JCA23-302	2.2-2.3	30	0.8	0.5	10	20	2.0:1	80
JCA34-301	3.7-4.2	30	1	0.5	10	20	2.0:1	80
JCA56-502	5.4-5.9	50	1	0.5	10	20	2.0:1	160
JCA78-305	7.25-7.75	27	1.2	0.5	13	23	2.0:1	100
JCA910-305	9.0-9.5	27	1.4	0.5	13	23	1.5:1	150
JCA1112-305	11.7-12.2	27	1.5	0.5	13	23	1.5:1	150
JCA1415-305	14.0-14.5	26	1.6	0.5	13	23	1.5:1	160
JCA1819-305	18.1-18.6	22	2.0	0.5	10	20	1.5:1	160
JCA2021-600	20.2-21.2	30	2.2	1	13	23	1.5:1	240
TRI-BAND AMPLIFIERS (5.85 TO 14.5)								
JCA514-201	5.85-14.5	8	7	1.5	10	20	2.0:1	100
JCA514-300	5.85-14.5	14	6	1.5	10	20	2.0:1	150
JCA514-302	5.85-14.5	22	6	1.5	20	30	2.0:1	350
JCA514-400	5.85-14.5	25	6	1.5	10	20	2.0:1	250
JCA514-403	5.85-14.5	32	6	1.5	23	33	2.0:1	500
JCA514-501	5.85-14.5	35	6	1.5	16	26	2.0:1	375
JCA514-503	5.85-14.5	41	6	1.5	23	33	2.0:1	500
ULTRA-BROAD BAND AMPLIFIERS (2.0 TO 18 GHZ)								
JCA218-200	2.0-18.0	15	5	2.5	10	20	2.0:1	90
JCA218-300	2.0-18.0	23	5	2.5	10	20	2.0:1	110
JCA218-400	2.0-18.0	29	5	2.5	10	20	2.0:1	150
JCA218-500	2.0-18.0	39	5	2.5	10	20	2.0:1	180









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Calendar

CONFERENCES

AUGUST

August 19-22, 2001
2001 IEEE Radio and Wireless Conference (RAWCON2001)
Boston, MA
Information: Dr. Michael S. Heutmaker
Tel: 609-639-3116; Fax: 609-639-3197
E-mail: heutmaker@lucent.com
Internet: http://rawcon.org

August 21-23, 2001
ITCOM+Opticomm 2001
Denver, CO
Information: SPIE
Tel: 360-676-3290; Fax: 360-647-1445
E-mail: exhibits@spie.org
Internet: http://www.spie.org/info/itcom

SEPTEMBER

September 10-14, 2001
International Conference on Electromagnetics in Advanced Applications (ICEAA 01)
Torino, Italy
Information: COREP-ICEAA 01
Internet: http://www.polito.it/iceaa01

September 11-13, 2001
PCIA GlobalXChange 2001
Los Angeles, CA
Information: PCIA
Tel: 1-800-759-0300 or 703-739-0300
Fax: 703-836-1608.
E-mail: bergerep@pcia.com
Internet: http://www.pcia.com

September 19-20, 2001
Northcon 2001
Portland, OR
Information: Electronic Conventions Inc.
Tel: 1-800-877-2668; Fax: 310-524-4100
Internet: http://www.wescon.com

September 19-21, 2001
5th International Conference on Telecommunications in Modern Satellite, Cable and Broadcasting Services (TELSIKS 2001)
Nis, Yugoslavia
Information: Dr. Bratislav Milovanovic
Tel: +381 18 529 320; Fax: +381 18 46 180
E-mail: telsiks@elfak.ni.ac.yu
Internet: http://www.telsiks.org.yu

September 24-26, 2001
EDA: Front-to-Back
Santa Clara, CA
Information: Penton Media Inc.
Tel: 1-888-947-3734

September 24-28, 2001
European Microwave Week
London, UK
Information: Nicola Jedrej
Tel: +44 20 7861 6391; Fax: +44 20 7861 6251
E-mail: njedrej@cmp-europe
Internet: http://www.eumw.com

OCTOBER

October 1-3, 2001
16th International Conference on Applied Electromagnetics and Communications (ICECOM'01)
Dubrovnik, Croatia
Information: Secretariat
Tel: +385 1 612 98 69; Fax: +385 1 612 98 70
Email: korema@fer.hr
Internet: http://www.rasip.fer.hr/korema

October 1-3, 2001
34th Connector and Interconnection Technology Symposium and Trade Show
Anaheim, CA
Information: ECA
Tel: 703-907-7547
Internet: http://www.ec-central.org

October 1-4, 2001
Communications Design Conference
San Jose, CA
Information: CMP Media
Tel: 415-278-5231; Fax: 415-278-5390
E-mail: dspworld@cmp.com
Internet: http://www.CommDesignConference.com

October 8-12, 2001
Antenna Measurement Techniques Association (AMTA) Annual Meeting and Symposium
Boulder, CO
Information: Mike Francis
Tel: 303-497-5873
Internet: http://www.amta.org/amtainfo/future.html

October 11-14, 2001
Advanced Technology Workshop on Optoelectronics Packaging
Bethlehem, PA
Information: IMAPS
Tel: 703-758-1060; Fax: 703-758-1066
E-mail: imaps@imaps.org

SHORT COURSES

University of California at Berkeley Extension

Design of Analog Integrated Circuits for Mixed-Signal Integrated Systems
San Francisco, CA . . . . . .August 6-10, 2001

Information: Continuing Education in Engineering, Tel: 510-642-4111; Fax: 510-642-0374; E-mail: course@unex.berkeley.edu; Internet: www.unex.berkeley.edu/enroll.

Besser Associates

RF and Wireless Made Simple
Mountain View, CA . . . . . .August 7-8, 2001

RF and Wireless Made Simple II
Mountain View, CA . . . . . .August 9-10, 2001

Applied RF Techniques I
Mountain View, CA . . . . . .August 13-17, 2001

Practical Design of Integrated and Discrete Wireless Circuits
Mountain View, CA . . . . . .August 20-22, 2001

RF Wireless System Design Fundamentals
Mountain View, CA . . . . . .August 22-24, 2001

RF CMOS Design
Mountain View, CA . . . . . .August 23-24, 2001

Bluetooth: Operation and Use
Mountain View, CA . . . . . .August 27-28, 2001

Behavioral Modeling
Mountain View, CA . . . . . .August 28-30, 2001

Advanced Wireless and Microwave Techniques
Mountain View, CA . . . . . .September 10-14, 2001

Short Range Wireless and Bluetooth
Mountain View, CA . . . . . .September 25-28, 2001

Information: Annie Wong, Tel: 650-949-3300; Fax: 650-949-4400; E-mail: info@bessercourse.com; Internet: www.bessercourse.com.

University of Missouri-Rolla

Grounding and Shielding Electronic Systems
Toronto, ON, Canada . . . .August 8-9, 2001
Denver, CO . . . . .September 17-18, 2001

Circuit Board Layout to Reduce Noise Emission and Susceptibility
Toronto, ON, Canada . . . .August 10, 2001
Denver, CO . . . . .September 19, 2001

Information: Sue Turner, Tel: 573-341-6061; Fax: 573-341-4992; E-mail: suet@umr.edu; Internet: www.umr.edu/~conted.

Coventor Inc.

MEMS Design and Analysis
San Mateo, CA . . . . .August 8-10, 2001
Amsterdam, Neth. . . . . . .August 29-31, 2001

Top Down MEMS Design
San Mateo, CA . . . . .August 6-7, 2001

Information: Coventor Inc., Tel: 919-854-7500; Fax: 919-854-7501; E-mail: events@coventor.com; Internet: www.coventor.com.

University of California at Los Angeles Extension

Digital Signal Processing: Theory, Algorithms and Implementations
Los Angeles, CA . . . . .August 13-17, 2001

Optical Internets
Los Angeles, CA . . . . .September 24-26, 2001

Information: UCLA Extension, Short Course Program Office, Tel: 310-825-3344; Fax: 310-206-2815.

Georgia Institute of Technology

Infrared/Visible Signature Suppression
Atlanta, GA . . . . .August 28-31, 2001

Advanced Electronic Warfare Principles
Atlanta, GA . . . . .September 17-21, 2001

Infrared Technology and Applications
Atlanta, GA . . . . .September 25-28, 2001

Basic Antenna Concepts
Atlanta, GA . . . . .September 25-28, 2001

Adaptive Array Radar Processing
Atlanta, GA . . . . .October 2-5, 2001

Principles of Modern Radar
Atlanta, GA . . . . .Oct. 29-Nov. 2, 2001

Radar Cross Section Reduction
Atlanta, GA . . . . .November 5-9, 2001

Infrared Countermeasures
Atlanta, GA . . . . .November 6-8, 2001

Information: Georgia Tech Distance Learning, Continuing Education and Outreach, Tel: 404-894-2547; Fax: 404-894-7398; E-mail: conted@gatech.edu; Internet: www.conted.gatech.edu.

Agilent Technologies

RF & Microwave Fundamentals
Winnersh, UK . . . . .August 29-31, 2001
Winnersh, UK . . . . .December 4-6, 2001

Network Analysis Measurements
Winnersh, UK . . . . .October 16-17, 2001

Spectrum Analysis Measurements
Winnersh, UK . . . . .October 18-19, 2001

Information: Tracey Bull, Tel: +44 118 9276741; Fax: +44 118 9276862; E-mail: tracey_bull@agilent.com.

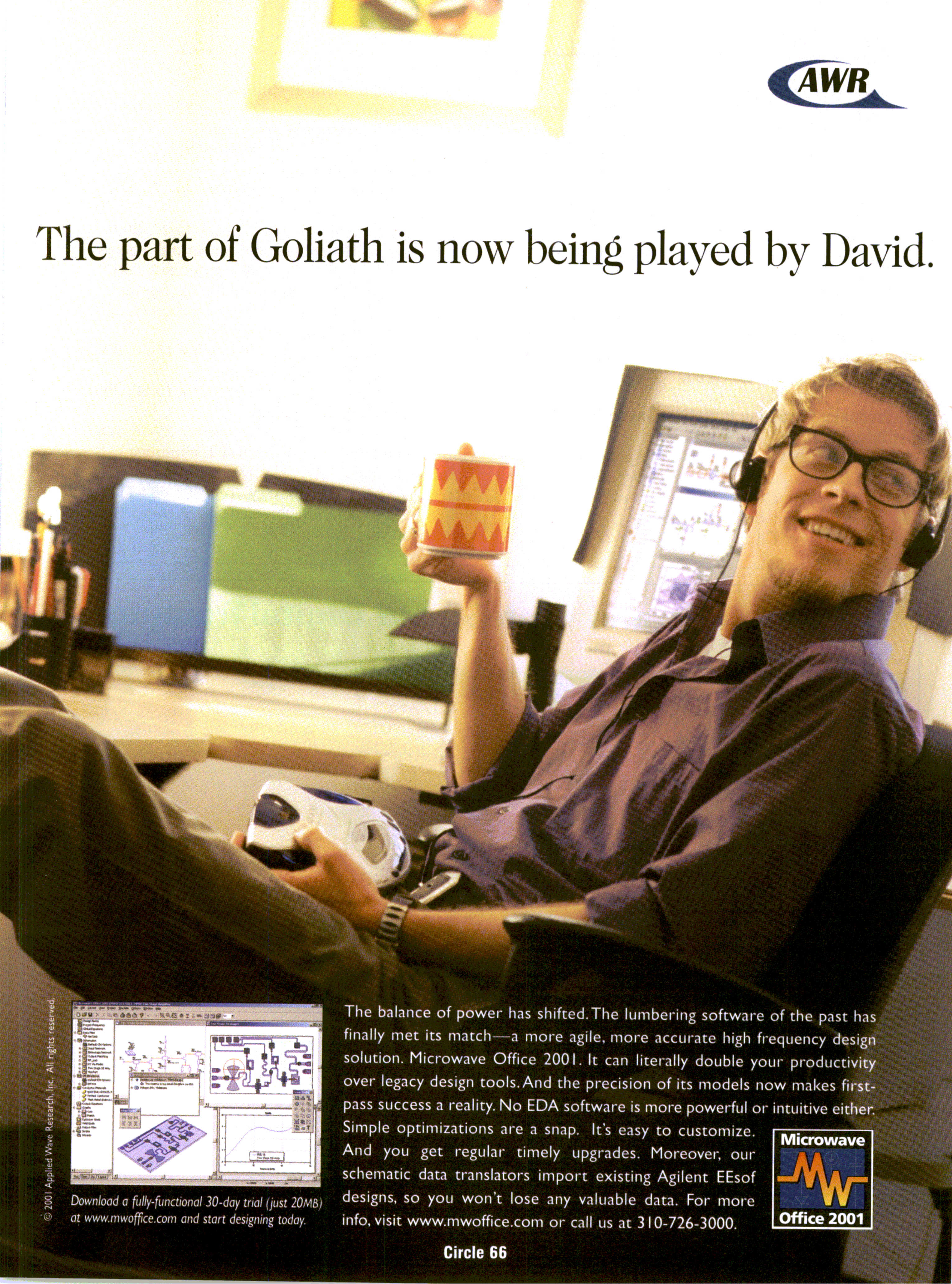
Arizona State University

Semiconductor Physics and System Reliability
Tempe, AZ . . . . .September 10-13, 2001

Information: College of Engineering and Applied Sciences, Center for Professional Development, Tel: 480-965-1740; Fax: 480-965-8653; E-mail: asu.cpd@asu.edu.

University of Wisconsin at Madison

DC Power System Design for Telecommunications
Madison, WI . . . . .September 12-14, 2001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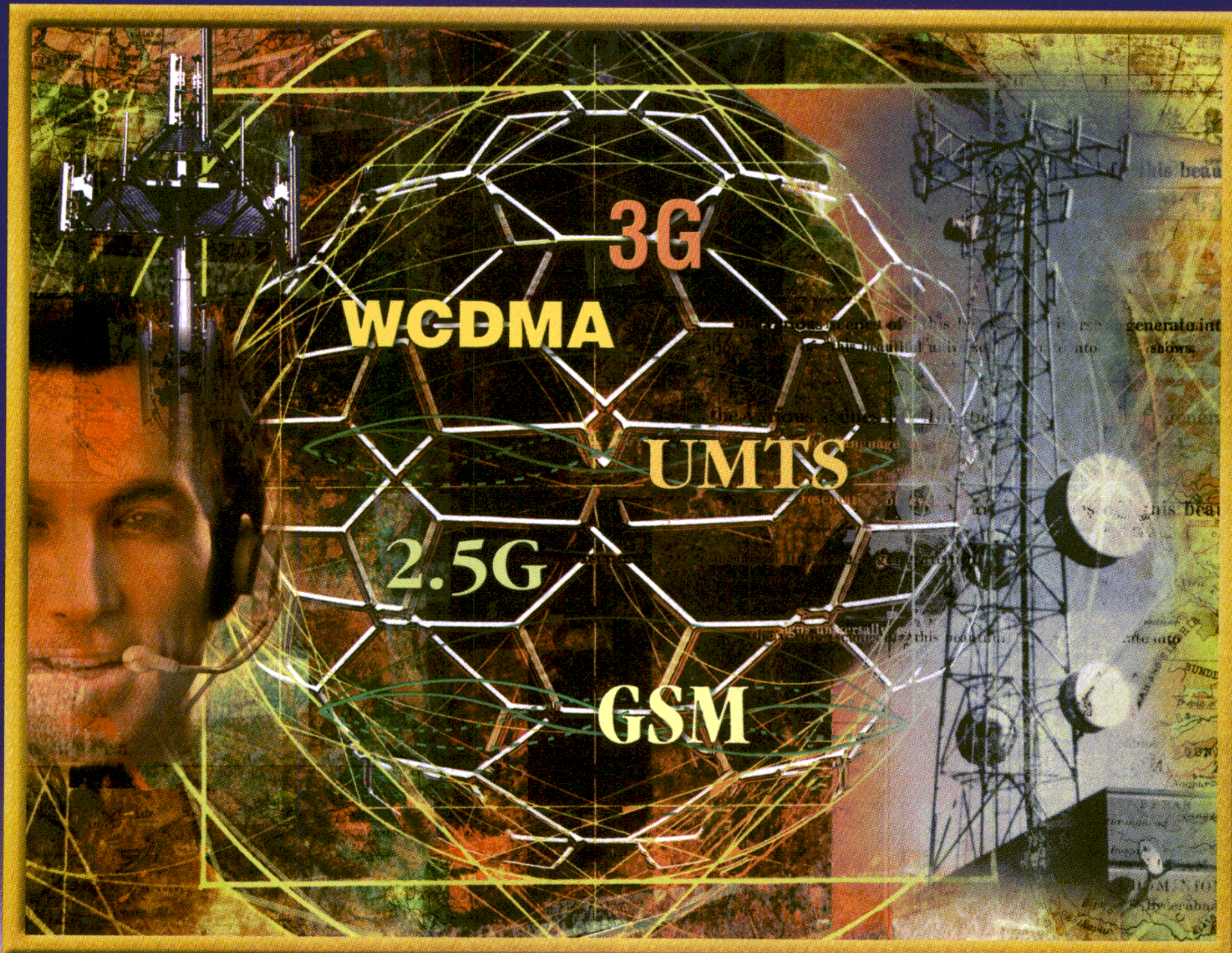
Fundamentals of Data Communcations
Madison, WI . . . . .September 20-21, 2001
Fundamentals of Wireless Data Communications
Madison, WI . . . . .September 24-26, 2001
Planning and Implementing Point-to-Point Microwave Radio Systems
Madison, WI . . . . .October 1-3, 2001
Basic Telephony and Digital Switching
Madison, WI . . . . .October 16-19, 2001
Fundamentals of Cellular and PCS Wireless Communications
Madison, WI . . . . .October 24-26, 2001
Information: Katie Peterson, Tel: 1-800-462-0876; Fax: 608-263-3160; E-mail: custserv@epd.engr.wisc.edu; Internet: http://epd.engr.wis.edu.

TTi Technology Training Initiative (Tustin Technical Institute, Inc.)
Fundamentals of Vibration for Test Applications
Santa Barbara, CA . . . . . .September 19-21, 2001
Santa Barbara, CA . . . . . .November 26-28, 2001
Test Procedures for EMI/EMC/ESD
Santa Barbara, CA . . . . . .September 27-28, 2001
Physical Measurement Techniques
Santa Barbara, CA . . . . . .October 3-5, 2001
Calibration Laboratory Management
Santa Barbara, CA . . . . . .October 8-9, 2001
Measurement Uncertainty
Santa Barbara, CA . . . . . .October 10-12, 2001
Calibration Processes
Santa Barbara, CA . . . . . .October 15-17, 2001
Introduction to Mechanical and Structural Theory
Santa Barbara, CA . . . . . .November 8-9, 2001
Fixture Design for Vibration and Shock Testing
Santa Barbara, CA . . . . . .November 12-14, 2001
Environmental Testing Procedures
Santa Barbara, CA . . . . . .November 15-16, 2001
Environmental Test Specifications
Santa Barbara, CA . . . . . .November 19-20, 2001
Mechanical Shock Techniques
Santa Barbara, CA . . . . . .November 29-30, 2001
Vibration and Shock Test Control Techniques
Santa Barbara, CA . . . . . .December 3-5, 2001
Information: Brian P. Slatery, Tel: 805-682-7171; Fax: 805-687-6949; E-mail: brian@ttiedu.com; Internet: www.ttiedu.com.



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SXT-289	1800-2500	+24	+41	15.0	5.0	105

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R.A. Wood Associates

Introductory RF & Microwaves
Lake George, NY . . . . . . .September 20-21, 2001
RF and Microwave Receiver Design
Lake George, NY . . . . . . .September 24-26, 2001
RF Power Amplifiers, Classes A thru S: How the Circuits Operate, How to Design Them, and When to Use Each
Lake George, NY . . . . . . .September 27-28, 2001
Information: R.A. Wood, Tel: 315-735-4217; Fax: 315-735-4328; E-mail: rawood@rawood.com; Internet: www.rawood.com.

Henry Ott Consultants

Electromagnetic Compatibility Engineering
Palo Alto, CA . . . . .October 2-4, 2001
Advanced Digital Design and Signal Integrity
Palo Alto, CA . . . . .October 5, 2001
Information: Henry Ott Consultants, Tel: 973-992-1793; Fax: 973-533-1442.

Monmouth University

Military Radios
West Long Branch, NJ . . .October 3-4, 2001
Dense Wavelength Division Multiplexing (DWDM)
West Long Branch, NJ . . .Oct. 31-Nov.1, 2001
Information: Mickey Kuntz, Tel: 732-571-4491; E-mail: mkuntz@monmouth.edu; Internet: www2.monmouth.edu/ctdt/specialcourses.htm.

Process Sciences Inc.

SMT Bootcamp
Boston, MA . . . . .October 15-16, 2001
Phoenix, AZ . . . . .October 18-19, 2001
Austin, TX . . . . .November 5-6, 2001
Seattle, WA . . . . .November 8-9, 2001
Information: Process Sciences Inc., Tel: 512-259-7071; Fax: 512-259-7073; Internet: www.process-sciences.com.

International Institute of Connector and Interconnection Technology (IICIT)

Basic Connector Technology
Orlando, FL . . . . .November 7-8, 2001
Basics of Fiber Optic Interconnection
Orlando, FL . . . . .November 9, 2001
Communications and Standards
Orlando, FL . . . . .November 9, 2001
Information: Suzanne Romeo, Tel: 1-800-854-4248; E-mail: sromeo@iicit.org; Internet: www.iicit.org.

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November	October 1	October 8	Industrial RF & Microwaves Attenuators & Terminations Baseband Circuits
December	November 1	November 8	New Wireless Technologies Filters Frequency Synthesizers

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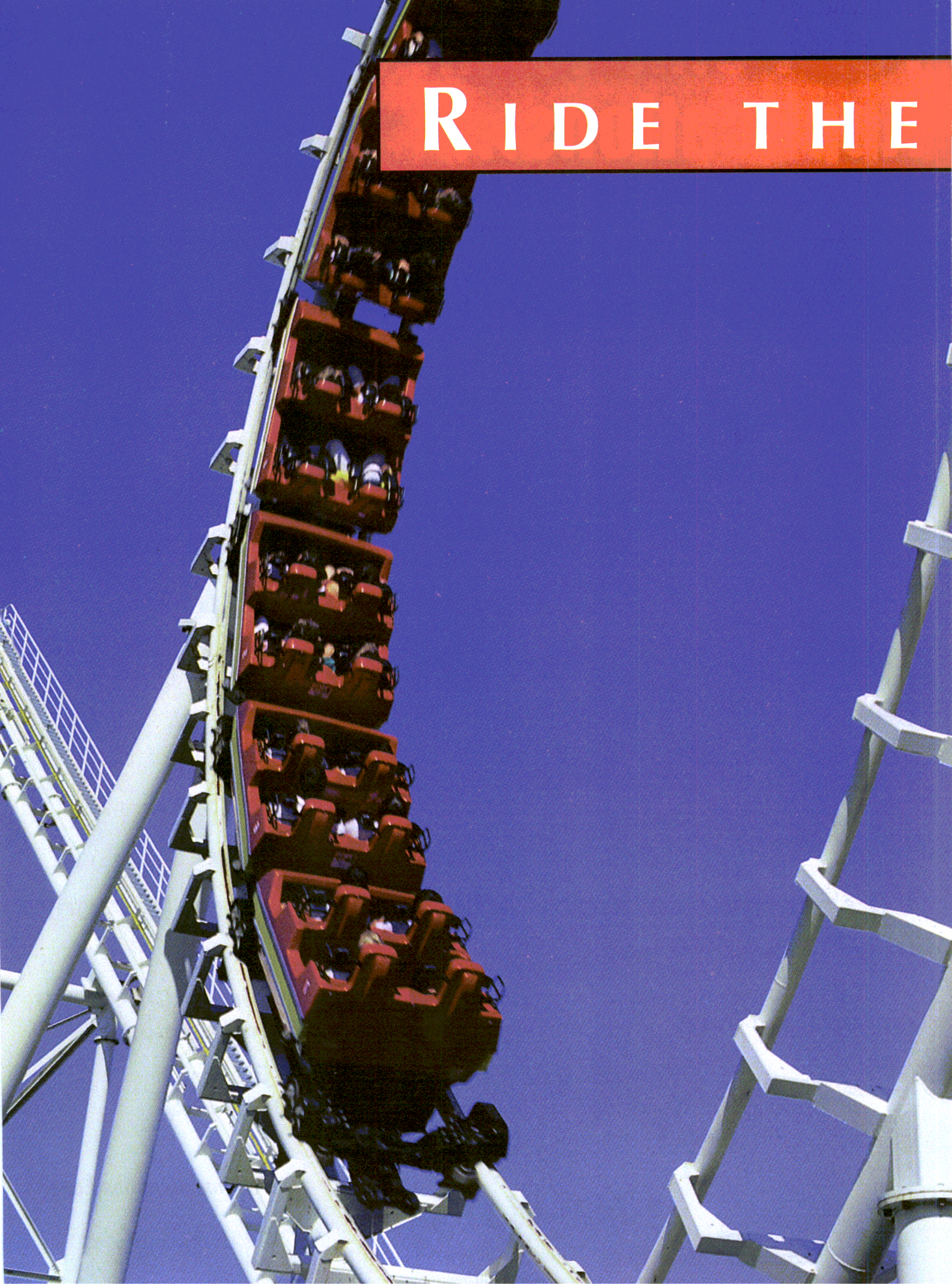


BRIEFS

• Sage Laboratories, a division of Filtronic plc, has launched a phase shifter web site at www.phaseshifters.com. The site offers an easy reference tool for designers, including a case study and a 16-page product catalog.

• Tru-Connector has introduced two new web sites highlighting the company's product lines. The main site, www.tru-con.com, offers the company's lines of standard and custom connectors and cable assemblies. A second site, www.7-16connectors.com, provides information on the company's 7-16 coaxial connectors.

• MicroMetrics has two new web sites. The company's main site, at www.micrometrics.com, features information on the company's tuning varactors, surface mount pin diodes, mixer/detectors and ceramic MEFLFs. A site focused on phase detectors is also available, at www.phasedetectors.com.

• Signal Technology Corporation Olektron Operation has launched an EW subsystems web site at www.ewsubsystems.com. The site provides information and specifications on the company's EW subsystem product line.

• Glassman High Voltage, Inc., has launched a redesigned company web site at www.glassmanhv.com. The site provides customers with information on Glassman's product lines, including specifications.

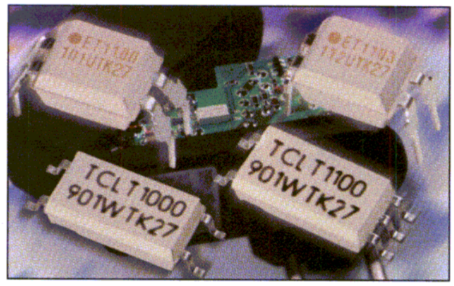
• Melcor Corporation, a subsidiary of Fedders Corporation, has completed the first phase of the expansion of its facility in Trenton, NJ. The work has expanded space for production capabilities, as well as engineering and administration.

• Galtronics has opened a new engineering support center in Tiberias, Israel, as well as renovated the existing facility there. A new 20,000-square-foot building will house administration and support personnel for the company's plastics molding assembly process.

Vishay boosts manufacturing capacity

Vishay Intertechnology, Inc., has increased manufacturing capacity for its 4-pin dual inline optocoupler devices by 25 percent this year, the company has announced. These Vishay Telefunken devices are used in a variety of electronic systems for current isolation and prevention of electric shock.

The company produces optocouplers in both standard dual line and surface-mount packages. Recent product introductions include a series of low-profile surface-mount optocoupler devices that provide reinforced isolation in a 2.2 mm high package.



Vishay optocouplers are most often used in switch-mode power supplies for mobile phones, digital cameras and computers.

Vishay, based in Malvern, PA, manufactures passive electronic components, discrete semiconductors, infrared communication devices and power and analog switching integrated circuits.

StratEdge to provide assembly, test services

StratEdge has announced that it is now providing complete assembly and test services for its high frequency ceramic packages.

The new service has been established in response to microwave customers looking to eliminate the need to work with bare die, as well as IC fabricators who want to offer prepackaged solutions. Assembly and test of DC to 50 GHz devices packaged in StratEdge products is accomplished in the company's class 100 work area.

StratEdge, based in San Diego, CA, manufactures ceramic semiconductor packaging for the high-speed digital, broadband wireless, satellite, point-to-point/multipoint and VSAT applications.

GTRAN, IQE partner for epitaxial wafters

GTRAN Inc. and IQE, Plc., have entered into a partnership that provides for IQU to supply InP HBT epitaxial wafers for use in GTRAN's next generation fiber optic products.

GTRAN provides data transponder solutions for 10 Gb/s and 40 Gb/s SONET applications. IQE provides compound semiconductor epitaxial wafers for communications.

Companies to team up for wafer inspection system

nLine Corporation, Light Age, Inc., Oak Ridge National Laboratory and InterScience will work together on a Joint Venture Advanced Technology Program to develop a new system for high aspect ratio semiconductor wafer inspection.

The system will be designed to detect defects many times smaller than current technologies can find. The new technology will also work at a much faster rate.

Microspace, IPricot to provide satellite transmission solutions

Microspace Communications Corporation and IPricot North America have formed a partnership to offer turnkey satellite data transmission solutions, using Microspace's VELOCITY broadcasting services and IPricot's IPr-S broadband router-receivers for high-speed data, video and audo applications.

Microspace, based in Raleigh, NC, provides broadcast data and audio satellite services. IPricot manufactures satellite broadband communication equipment.

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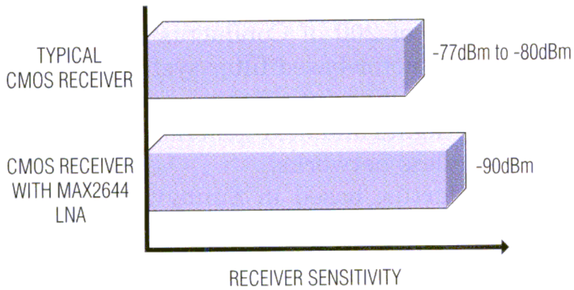
INDUSTRY'S SMALLEST 2.4GHz LNA INCREASES BLUETOOTH RECEIVER SENSITIVITY TO -90dBm

The MAX2644 2.4GHz SiGe LNA is internally matched to 50Ω at the output, saving an inductor and capacitor required in other LNA IC solutions. Total board space required is only 7mm²—ideal for space-sensitive Bluetooth™ modules.



MAX2644 LNA Features:

- 16dB Gain, 2dB NF, -3dBm Input IP3 for 7mA
- Adjustable Bias (3mA to 10mA)
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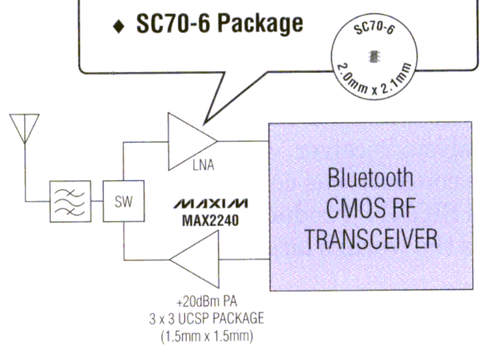
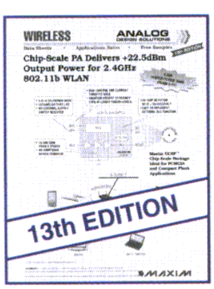


A Family of Six High-Performance SiGe LNAs are Available in the Ultra-Small SC70-6 Package, Covering Major Wireless Applications from 800MHz to 2700MHz

	PART	TEST FREQUENCY (MHz)	GAIN (dB)	NOISE FIGURE (dB)	INPUT IP3 (dBm)	ADJUSTABLE BIAS	APPLICATIONS
	MAX2642/43	900	16.7	1.3	0	Yes	900MHz ISM, cellular, PMR, cordless
NEW	MAX2644	2450	16	2.0	-3	Yes	Bluetooth, 802.11, HomeRF™, WCDMA, satellite radio, MMDS
NEW	MAX2654	1575	15	1.5	-7	—	GPS
NEW	MAX2655	1575	14	1.7	+3	Yes	GPS in cellular phones
NEW	MAX2656	1960	13.5	1.9	+1.5	Yes	PCS, DCS, WLL

Bluetooth is a registered trademark of the Bluetooth Special Interest Group.
HomeRF is a registered trademark of the HomeRF Working Group.



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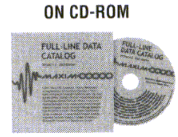

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BUSINESS AND FINANCE

Marconi acquires Northwood Technologies

Marconi has announced that its Wireless Division has purchased Northwood Technologies Inc., a Canadian wireless telecom software company. The value of the transaction is approximately $27.4 million.

Marconi will be establishing a new Strategic Business Unit for wireless network planning in Ottawa, ON, Canada, where Northwood is located.

Marconi supplies advanced communications solutions for networks and wireless worldwide.

M/A-COM SIGNIT receives Defense contract

M/A-COM SIGNIT Products has received a contract from the U.S. Department of Defense for 71 microwave receivers, with an option for up to 71 more. The value of the contract was not disclosed.

Major specifications for the products include a collection and analysis receiver with superior BER performances. The contract was competitively bid.

M/A-COM SIGNIT Products, headquartered in Hunt Valley, MD, is the world's largest producer of microwave receivers.

Endwave receives order from DMC Stratex

Endwave Corporation has received a multimillion dollar initial order for custom millimeterwave transceivers from DMC Stratex Networks. The exact value of the contract was not disclosed.

Endwave, based in Sunnyvale, CA, provides RF subsystems and products for cellular backhaul, point-to-point and point-to-multipoint applications. DMC Stratex Networks, headquartered in San Jose, CA, provides wireless solutions for cellular and broadband.

Conductus to supply superconductor system

Conductus, Inc., has signed a purchase agreement with Dobson Communications Corporation to provide a minimum of 200 of Conductus' ClearSite® systems, a superconductor-based filter system designed to expand coverage, reduce interference and increase capacity for analog, digital and next-generation high bandwidth digital wireless networks.

Conductus, based in Sunnyvale, CA, manufactures electronic components and systems based on superconductors for telecommunications markets.

BUSINESS AND FINANCE

Motorola signs network contracts

Motorola, Inc., has announced new contracts for network services, including the company's first third generation (3G) infrastructure contracts.

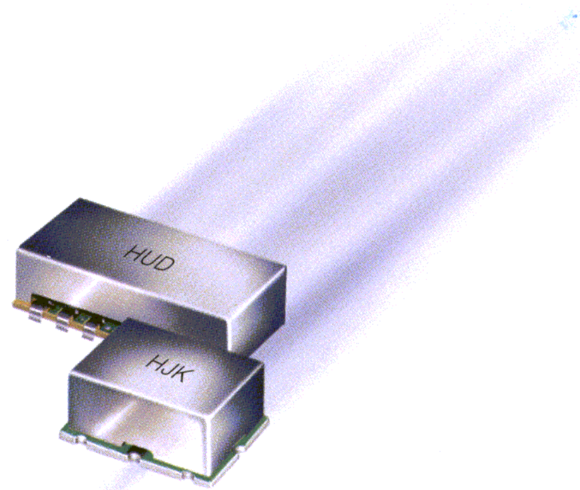
Under the 3G agreements, Motorola will provide CDMA 1X infrastructure in Portugal for Telesp Celular and Global Telecom, both controlled by Portugal Telecom. Motorola will install the system in the Sao Paulo State countryside and in the states of Parana and Santa Catarina. The combined value of the two contracts is $147 million.

Other new Motorola contracts:

- An agreement with Zhejiang Branch of China Mobile Communications Corporation and China Eastern Communications Company calls for the expanson of the GSM900 network in Zhejiang Province. The potential value of the contract is more than $100 million.
- A contract with Kuwait's Mobile Telecommunications Co. provides for expansion of the company's nationwide GSM network and for a trial of GPRS. The contract is valued at $22.5 million.
- A contract signed with four wireless telephone operating companies in northern Mexico, currently under management control of Telefonica Moviles, will provide an end-to-end CDMA expansion of the existing network. The contract is worth $41 million.
- Three contracts with China Mobile Communications Corporation call for the expansion of the existing GSM900 and 1800 networks in the Guizjou and Henan provinces and in the capital city of Beijing. The total value of the contracts is $34.4 million.
- A $150 million deal with BT Cellnet in the United Kingdom will encompass expansion of the company's existing GSM network, which covers most of the country. The contract runs through March 2003.
- A six-year agreement with Sprint will provide equipment and services for the expansion and development of Sprint's national PCS network in the United States. The contract is worth approximately $200 million over the first two years of the contract.

Motorola, based in Schaumburg, IL, provides semiconductors, integrated communications solutions, embedded electronic systems, components and network supply and infrastructure services.

Someone has the best IP3 mixers.



Best performance, best innovations, best value. Someone will always be on top. For example, while other companies offer *some* high IP3 mixers, at Mini-Circuits we've introduced an entire family of mixers incorporating unique patented technology to deliver the highest IP3 for low, medium, and high LO power levels. *IP3 as high as +38dBm!* And unlike other mixers, our HUD and HJK models require no DC power, which simplifies circuit layout and makes them very easy to use in 115 to 2300MHz applications. But while other suppliers are concentrating mainly on IP3 performance, Mini-Circuits goes beyond by providing very low conversion loss down to 6.7dB, high isolation up to 49dB, and 1dB RF compression point 3dB higher than LO power...all from a smaller, industry standard package fitting the same footprint as our popular SYM models. Nobody else has these high performance, high IP3 mixers. But even if they did, nobody but Mini-Circuits could offer them off-the-shelf at an amazing price from only $10.95 each!

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Typical Specifications:

Model*	Frequency (MHz) RF	IF	LO level (dBm)	IP3 (dBm)	▲E Factor	Conv. Loss (dB)	Isolation (dB) L-R	L-I	Price $ea. (1-9)
HJK-9	818-853	40-100	7	22	1.5	7.1	36	26	10.95
HJK-19	1850-1910	70-130	7	21	1.4	8.0	30	24	10.95
HJK-21	1850-1910	180-300	7	22	1.5	7.5	28	19	10.95
HJK-9LH	818-853	40-100	10	27	1.7	6.7	37	27	12.95
HJK-19LH	1850-1910	70-130	10	25	1.5	7.5	30	23	12.95
HJK-21LH	1850-1910	180-300	10	25	1.5	7.2	28	19	12.95
HJK-9MH	818-853	40-100	13	31	1.8	6.7	37	27	14.95
HJK-19MH	1850-1910	70-130	13	30	1.7	7.4	30	23	14.95
HJK-21MH	1850-1910	180-300	13	29	1.6	7.2	29	19	14.95
** HJK-3H	140-180	0.5-20	16	37	2.1	8.0	44	44	16.95
HJK-9H	818-853	40-100	17	33	1.6	6.7	35	31	16.95
HJK-19H	1850-1910	70-130	17	34	1.7	7.7	28	22	16.95
HJK-21H	1850-1910	180-300	17	36	1.9	7.6	28	25	16.95
** HUD-3H	140-180	0.5-20	16	37	2.1	8.1	47	45	15.95
** HUD-19SH	1819-1910	50-200	19	38	1.9	7.5	38	36	19.95

▲E Factor = [IP3 (dBm) − LO Power (dBm)] ÷ 10.
*Units protected under U.S. patents 5,416,043 and 5,600,169.
**Additional patents pending.
Size (L x W x H): HJK 0.500" x 0.375" x 0.23", HUD 0.803" x 0.470" x 0.250".

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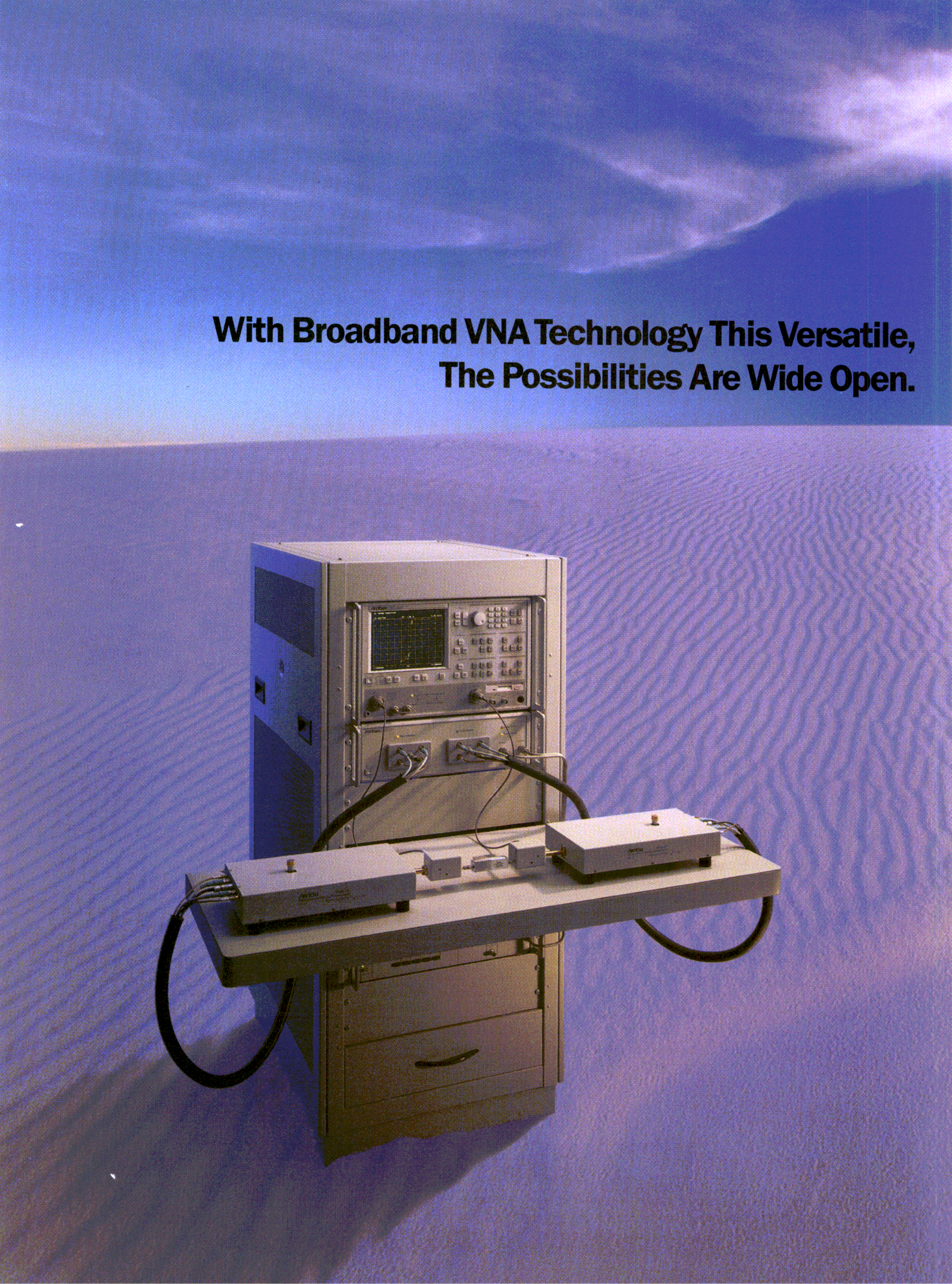
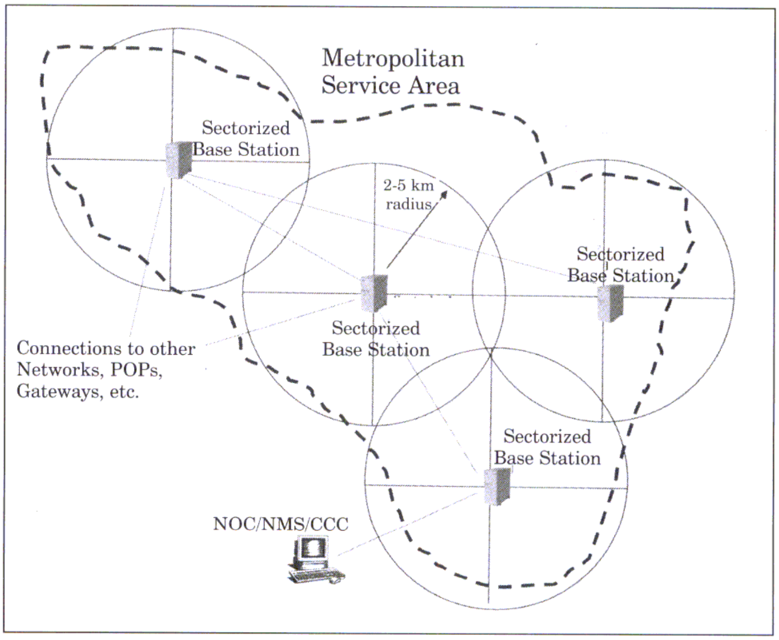

With Broadband VNA Technology This Versatile,
The Possibilities Are Wide Open.

Design and Test Considerations For Multicarrier LMDS Radios

By Erik Boch, Bob Leroux and Qiming Ren
DragonWave, Inc.

Recently, a large amount of spectrum has been made available for broadband access applications using fixed wireless access technology broadly known as local multipoint distribution system (LMDS). LMDS network systems typically employ multicell structures realized using sectorized base stations in order to provide service coverage of a given metropolitan service area (Figure 1). The attractiveness of LMDS to the service provider community lies in a variety of areas, including rapid economical coverage of large service areas; high speed, next-generation service delivery; capability to deliver IP, ATM or TDM services from a common network and base station infrastructure; and fast, low-cost deployment of end customer terminals.



▲ **Figure 1. Typical metropolitan LMDS network deployment concept.**

Globally, spectrum allocations have been assigned for broadband millimeter-wave access systems. In many cases, the amount of spectrum released is much greater than that available for any other service type. Using these large spectral allocations, the operators are able to deploy systems with very large capacities, often several Gb/s. These large capacities allow the operators to configure multistream service offerings with bandwidths that can compete with other infrastructure options at virtually all bandwidth and service category levels, allowing the networks to serve a broad range of needs ranging from residential to large enterprise.

Multicarrier transmitter requirements

When considering broadband license allocations, equipment manufacturers would ideally deploy very large bandwidth, high-speed RF carriers that minimize the overall complexities of the associated base stations. Technology limitations tend to dictate the use of a larger number of narrower bandwidth RF carriers in order to fill out the available spectrum and maximize the operators revenue flow. This larger number of carriers transporting the overall downlinked data load then drives the need for a high performance multi-carrier transmitter that is able to handle a large number of RF carriers without causing distortion.

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SPECIFICATIONS

SR-2min-min

SWITCH TYPE	SPDT			
Frequency (GHz)	DC-2	2-5	5-12.4	12.4-18
Insertion Loss (Max.)	0.2	0.3	0.4	0.7
VSWR (Max.)	1.3	1.4	1.5	1.7
Isolation (Min.)	70	60	50	40

Power Rating, RF Cold Switching: 10 Watts
Impedance: 50 ohms
Operating Power: 25° C (ma nominal)
(Failsafe): 12 Vdc at 130 ma
28 Vdc at 75 ma
Connectors, RF and Power: .018 DIA. Pins

Life: 1,000,000 operations
Switching Time: 15 milliseconds max.
Environmental Conditions: MIL-S-3928
Operating Mode: Failsafe & Latching*
Switching Sequence: Break before make
Weight: 0.6 oz
Size: .625" x .625" x .40"H

* New Latching SPDT versions now available

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Circle 72

# of Carriers	Approximate Transmitter Power Needed	Back-off from P_{1dB}
16	29	4
14	28	5
12	28	5
10	26	7
8	26	7
6	25	8
4	23	10
2	20	13
P/carrier (dBm) = 17	OTX P_{1dB} (dBm) = 33	

▲ **Table 1. Multicarrier sector transmitter back-offs for various numbers of supported carriers.**

At millimeter wavelengths, there are nominally two approaches to providing the required power levels associated with multicarrier RF transmission. The first, traveling wave tube technology, requires high to very high power, a large number of carriers per transmitter (i.e., 20 to 40 carriers), low reliability and high cost per sector. This method is also difficult to engineer for outdoor use and results in large prime power consumption and challenging back-up requirements. Conversely, solid state transmitter technology offers low to medium power, a low to medium number of carriers per transmitter (i.e., 5 to 15 carriers), high reliability and low cost per sector, as well as easier engineering for outdoor use and low prime power consumption.

When considering a very large broadband block license, 500 to 1000 MHz of spectrum is available for up and downlinking. Assuming a roughly symmetric access traffic load, the deployed downlink bandwidth would be on the order of 250 to 500 MHz, depending on the specific spectral license. When considering 30 to 50 MHz of occupancy per RF carrier, a total of 5 to 12 carriers would need to be transmitted from each sector transmitter. This capacity requirement is reasonably well matched to the capacity of a state-of-the-art solid state transmitter based on the latest PHEMT MMIC power technology. Currently, this technology provides approximately 1 to 2 watts of compressed power. Employing balanced power stages in the design of the transmitter allows this to be practically increased to the 2 to 4 watts P_{1dB} range.

Further requirements can be established through reviewing link budgeting analyses. Typically, several kilometer radius cells (3 to 5 km, depending on the rain region) with high-link availability (~99.995 percent) are required. Assuming a high gain sector antenna (~20 dBi) and high gain circular probably error (CPE) antennas (~36 dBi), a transmit power of ~17 dBm per carrier is required.

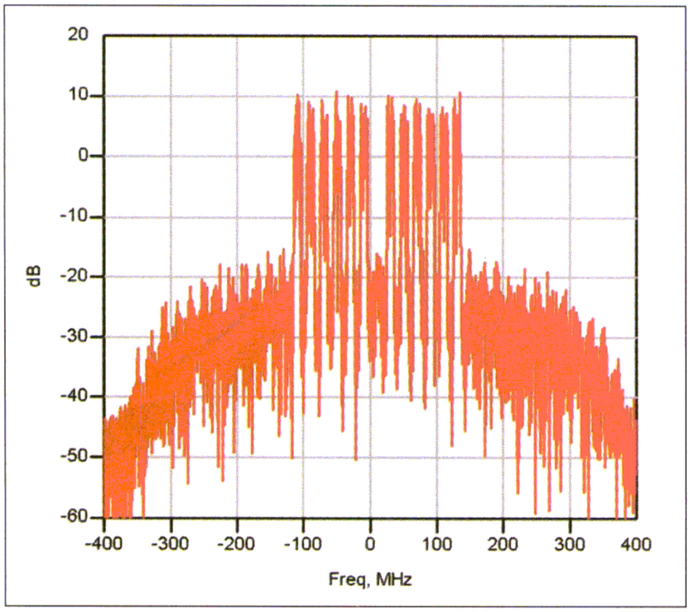
The back-off requirements of a multicarrier base station sector transmitter are shown in Table 1. This does not consider the needed intermodulation distortion performance. When a sector transmitter is driven towards compression, various nonlinearities begin to cause undesirable transmitter attributes, such as intermodulation distortion. The various RF carriers are supported by the transmitter mix in the transmitter and form spectral products. In a multicarrier scenario, these products can end up on top of the desired signals and are, therefore, not filterable. These products then effectively reduce the transmitted carrier-to-interference (C/I) ratio which the supported LMDS CPE receivers must be able to demodulate. The receivers are exposed to a number of elements that erode the basic received signal-to-noise (SNR) ratio, including intercell and intersector co-channel interference, adjacent channel interference, base station transmitter C/I and basic receiver thermal noise.

When considering various modulation schemes, degradations from various interference sources and the base station transmitter intermodulation can be treated as noise-like signals (in the broadband case) that add to the thermal noise floor, effectively reducing the receiver processing threshold. Table 2 shows some typical scenarios and how the transmitted C/I can contribute to overall sensitivity reductions in the CPE receivers that are being supported by a given multicarrier LMDS transmitter.

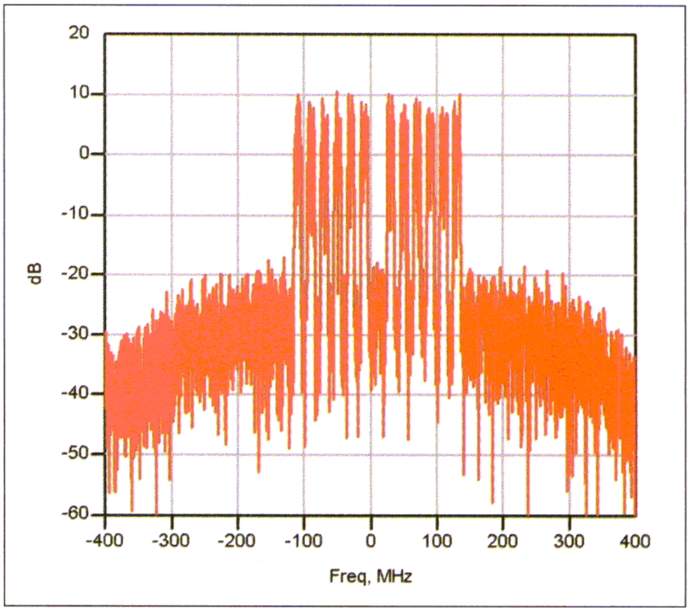
An example of the achievable transmitted waveform (without transmitter masking filters applied) is shown in Figure 2 (no linearization) and Figure 3 (with linearization). Shown is a low power DragonWave solid state sector transmitter handling 12 broadband QPSK modulated signals (~20 MHz BW). The technology employed in this transmitter allows it to produce ~20 dBm/carrier power and high-performance linearity with a P_{1dB} of only 2 watts. Figures 2 and 3 show the in-band intermodulation levels by omitting the center carrier so that the underlying IM product levels can be clearly seen. It is also possible to see the improvement provided by linearization of the sectorized transmitter. In the case with no linearization, the IM levels are 3 to 5 dB worse, making it suitable for QPSK only. The linearized unit is suitable for QPSK, 16QAM or 64QAM, making it more compatible with the latest overair MAC/PHY layers that support advanced efficiency enhancing features such as dynamic modulation selection (i.e., IEEE 802.16).

Modulation Scheme	SNR at Min Processable Signal	External Interference C/I	Allowable TX IM C/I	Resulting C/(N+I) in the receiver
QPSK	10	19	19	12
16QAM	16	25	25	18
64QAM	22	29	29	24

▲ **Table 2. Examples of noise and interference factors impacting received processing threshold.**



▲ **Figure 2. A typical LMDS sector transmitter output showing broadband carriers and associated intermodulation products (transmitter without linearization).**

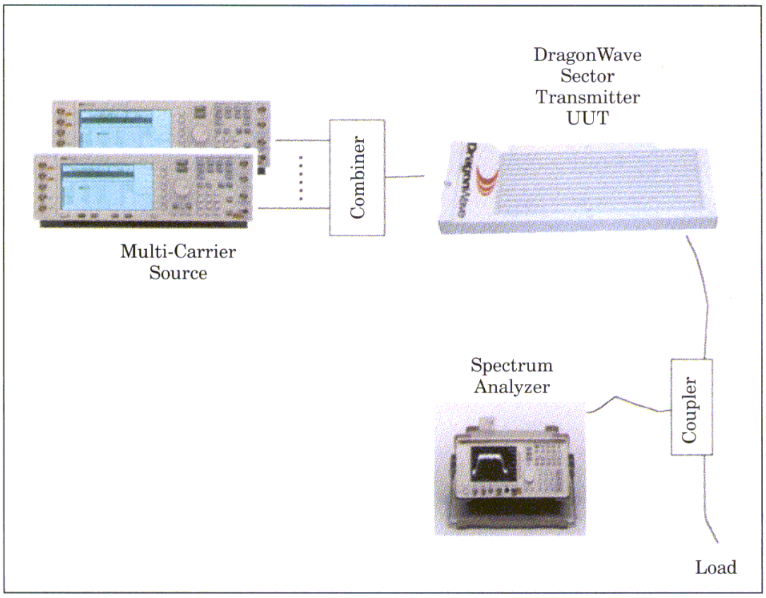


▲ **Figure 3. A typical LMDS sector transmitter output showing broadband carriers and associated intermodulation products (transmitter with linearization).**

Multicarrier test considerations

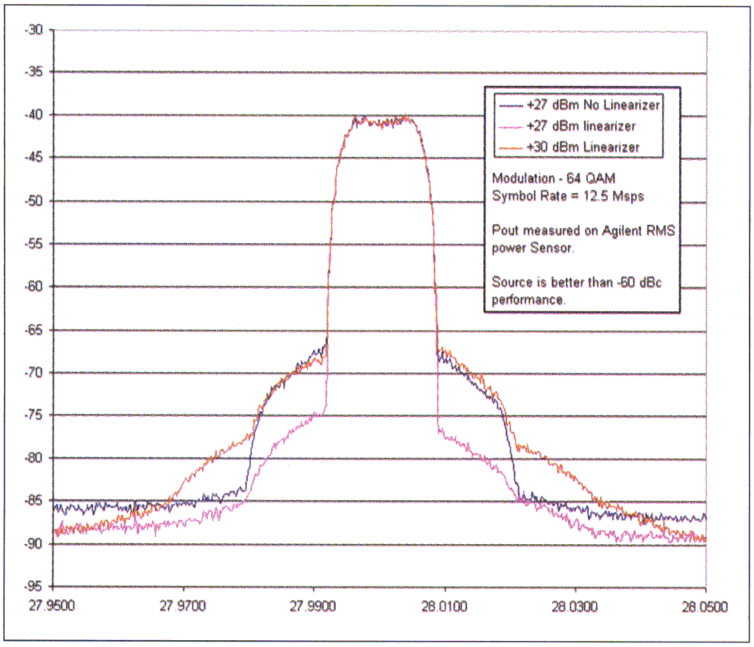
Testing the intermodulation performance of a multicarrier LMDS transmitter is reasonably straight forward. These transmitter units are typically driven at low-frequency IFs (S-band or lower) where multicarrier generators are available or constructible using low cost sources (i.e., DDS boards). The output intermodulation results are readily gathered using a conventional spectrum analyzer. Figure 4 shows a typical test setup used for this type of testing.

Several factors must be carefully considered during the setup of this test facility in order to avoid errors induced by the test setup itself:



▲ **Figure 4. Example of a test setup for multi-carrier solid state LMDS sector transmitter intermodulation testing.**

- Individual carriers generated by the test source must be fully incoherent. The incoherent signals will then produce random intermodulation products which then add up incoherently. Ultimately, this produces lower average distortion products.
- The multicarrier test source must produce carrier sidebands that are well below the measured IM product levels (>20 dB) put out by the transmitter. If this is not the case, then there is a possibility that the test source is influencing the measured IM performance levels or even causing more products to be generated.
- The test source signals should be close replicas to the actual modulated data signals that the transmitter is expected to handle during actual operation (and during type-approval exercises). The IM levels and their spectral extend are highly dependent on the specific input signals driving the transmitter.
- Care must be taken to ensure that the spectrum analyzer is not contributing to the IM products it reports. Typically, it should be operated well into the linear region (i.e., 30 dB below compression, including effects of front end attenuators). Figure 4 shows the inclusion of a coupler, which reduces output signal levels from the transmitter well into the spectrum analyzers linear range. The coupler also ensures that the transmitter is optimally loaded.



▲ **Figure 5. Measured results of the transmitter prototype.**

- If the carriers are not evenly spaced in practice, they should be randomly spaced in testing as well. Random spacings and bandwidths will reduce overall IM product levels, since the IM spectral locations also become random, thereby reducing the effects of "stacking."
- The "missing carrier" method of measuring the IM levels is fairly standard and shows the worst case levels. Care must be taken to accommodate the transmitters operating bandwidth. For example, the 12 carrier test results taken in Figure 2 and Figure 3 actually consume enough bandwidth for 13 carriers, since the center one is "missed" to allow measurement of the inband IM levels.

In order to verify the simulations, prototype units were built and tested. Results are shown in Figure 5.

Conclusion

Broadband LMDS transmitters are required in order to optimize base station rooftop equipment deployment, optimize base station costs and increase overall service revenues. Nonlinear distortion within these multi-carrier sector transmitters can be figured through the direct measurement of intermodulation (IM) distortion products produced. Using simple techniques, this measurement can be easily undertaken when test setup pitfalls are avoided. ■

Author information

Erik Boch is the chief technology officer and a co-founder of DragonWave, Inc. He holds a master's degree in electrical engineering from Carleton University in Ottawa, Ontario, Canada. He has been involved in various aspects of microwave and millimeter wave subsystem and system design for more than 15 years and has published extensively in this area. He has an extensive background in RF and network engineering from his roles at previous companies, including ComDev, Lockheed Martin and Newbridge (Alcatel). Most recently, he was AVP of Wireless Systems at Newbridge (Alcatel) in Kanata, Ontario, Canada. He may be contacted at Tel: 613-599-9991; Fax: 613-599-4225; or E-mail: Erik.Boch@dragonwaveinc.com.

Bob Leroux is the director of millimeter wave radio design at DragonWave. Prior to joining DragonWave, he worked at Nortel Networks on RF multi chip module designs, RF power amplifiers and millimeter wave design. Additionally, he worked in the Advanced RF Technology Department on various topics in the RF and microwave areas. Prior to Nortel, he was with General Instruments as an RF designer. He may be reached via e-mail at bleroux@dragonwaveinc.com.

Qiming Ren is a senior engineer with DragonWave working on LMDS and MMDS radios. He has held different positions with Nanjing Electronic Devices Institute, Gerhard-Mercator-University of Duisburg, and MIKOM GmbH (an Allen Telecom Company, Germany) working on MMIC, internal matched MESFET, linearization techniques and repeaters for mobile networks. He has published several papers in journals and conferences on microwave circuit design and linearization techniques. He received a bachelor of science degree and a master of science degree in electrical engineering from Xidian University, China, in 1985 and 1988, respectively, and a Ph.D. in electrical engineering from the Gerhard-Mercator-University of Duisburg, Germany, in 1999. He may be reached via e-mail at Qiming.Ren@dragonwaveinc.com.

Datacasting with LMDS and MMDS Systems

By Frank Creede
Logic Innovations, Inc.

The creation of open network standards to facilitate datacasting, including unicast (point-to-point), multicast (point-to-multipoint) and broadcast, has resulted in the development of hub and client receiver technology that is both cost-effective and functional. The devices in use provide an exceptional means of distributing high-speed data in point to multipoint distribution systems over satellite, traditional television broadcast, cable television and terrestrial microwave systems. Each of these systems offers unique benefits and challenges. This discussion focuses on two types of terrestrial microwave platforms — local multipoint distribution systems (LMDS) and multichannel multipoint distribution systems (MMDS).

Datacasting technology

Datacasting technology is available using a variety of protocols that include, but are not limited to, ATM, frame relay, and multi protocol encapsulation (MPE). MPE is based on the ETSI EN 301 192 standards. The hub equipment used to perform the MPE function is referred to as an Internet Protocol (IP) to Digital Video Broadcasting (DVB) Gateway. The IP to DVB Gateway acts as a router, a gateway, an encapsulator and, in some cases, a quality-of-service (QoS) engine and a statistics logging device for billing purposes. The resulting output of the IP to DVB gateway is an MPEG transport stream that is fully compatible with the open DVB standards. Thus, the IP to DVB Gateway can be used directly, or multiplexed together with other MPEG transport streams (Figure 1).

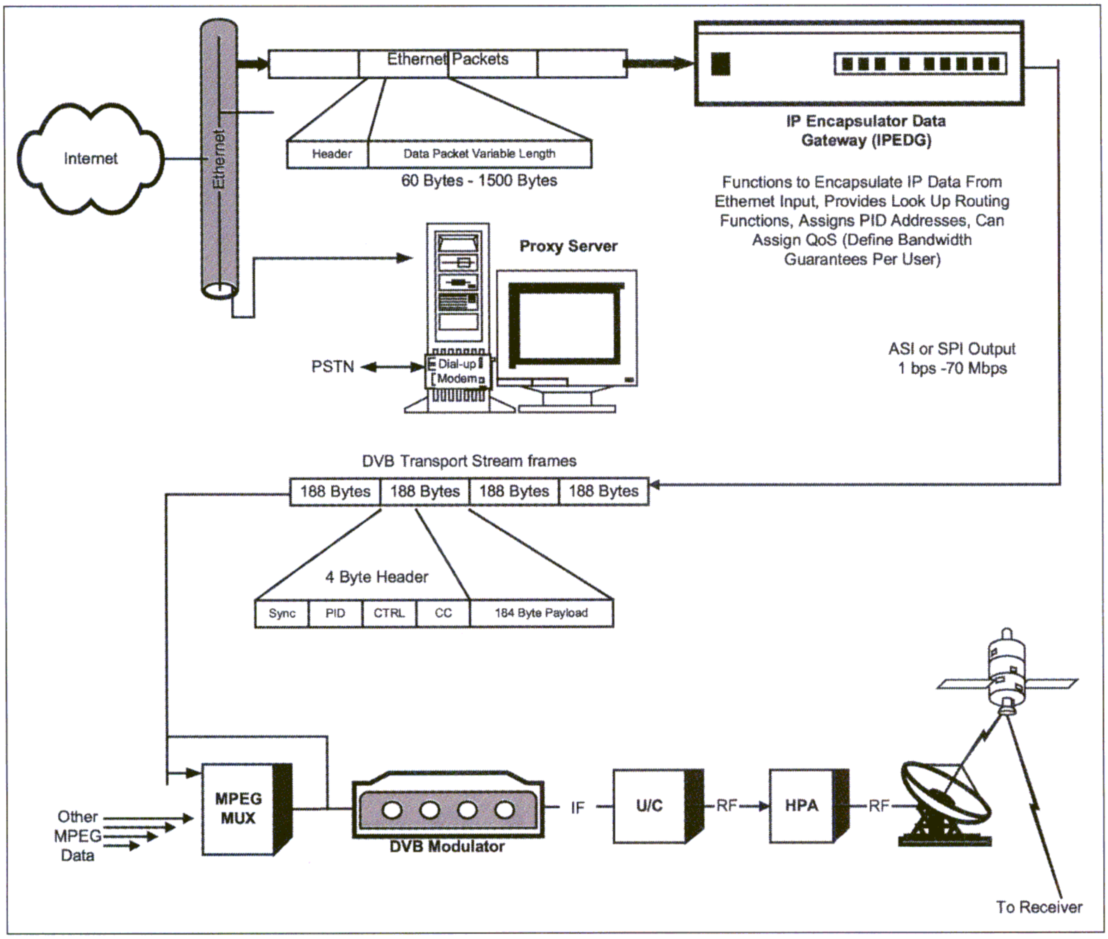
The receiver of the data transmission exploits the cost benefit of a widespread DVB open network architecture, resulting in very low-cost but high-performance data receivers for the DVB specified modulation techniques that include QPSK, 8PSK and 16/32/64/128/264 QAM. The important issue at hand is that the baseband digital architecture is the same, no matter which modulation technique is used.

MPE supports unicast, multicast and broadcast data transmissions. It offers exceptional bandwidth efficiency in the multicast and broadcast modes of transmission because the data is only transmitted one time, to a host of receiving clients. MPE systems can support one-way "pushing" of data, or two-way communications. For simplicity, only a one-way "push" system will be discussed in this article.

MPE and DVB standards are at the core of the baseband technology for datacasting over a wide range of transmission platforms. How can these standards be used in MMDS and LMDS transmission platforms?

The use of IP data encapsulation into an MPEG transport stream provides a cost- and performance-effective approach to multicasting data on a point-to-multipoint basis. Advanced encapsulation products provide a number of critical features to maximize hub and bandwidth efficiency. These include, but are not limited to:

- An advanced route-based design architecture supporting the network-centric operating paradigm.
- An integral QoS engine providing the means to both guarantee and limit data rates on a per route basis.
- A buffer status algorithm that provides a means to dynamically throttle the data from the multicast server on a route-by-route basis.



▲ **Figure 1. IP to DVB gateway functionality.**

In effect, this precludes the possibility of under or over flowing the input buffers. This allows excess capacity to be dynamically filled with productive data.

- Support for both SNMP and DCOM communications protocols for ease of integration with network management systems.

Another reason for the use of encapsulated data is the availability of cost-effective digital receivers in the form of PCI receiver cards with integral tuners and QAM demodulators.

The installation of the PCI card receivers provides the means for a direct multicast data transfer to the client PC. This data can then be used immediately or cached on the PC hard drive for instantaneous retrieval at the user's convenience.

MMDS and LMDS platform synopsis

MMDS and LMDS are both point-to-multipoint microwave systems that are licensed, usually on a basic trading area (BTA) basis. However, that is where the similarities end. The difference in the frequency bands of these systems has a crucial effect on the system design, capacity and usefulness for a datacasting application. Table 1 shows a basic comparison of these transmission platforms.

Let us consider MMDS first. In general, the favored cell architecture is a single, large macro-cell. While multicell deployments have been implemented, they are generally not efficient. The reason for this is twofold. The 2.5 GHz frequency band requires either large antennas, which are not well-received consumer client receivers, or smaller antennas with very broad antenna beams. Since practicality and cost supercede technical excellence, smaller, low-cost antennas are preferred. The consequence of such a choice is that multipath (reflections of the radiated energy from either the ground or other structures) is induced, due to reflections of the signal associated with broad antenna beams. This in turn requires that the modulation technique provides significant immunity to the effects of multipath.

Only three demodulator technologies are produced in sufficient volume to be cost-effective and also provide some immunity to multipath: 8VSB, COFDM (coded orthogonal frequency division multiplexing) and CATV demodulators using QAM. Both 8VSB and QAM use extensive equalization to counteract the multipath effects. The equalizers for 8VSB are continuing to be improved at this time but are not yet sufficiently mature to meet the requirements associated with these links. COFDM links, on the other hand, are available. They offer significant multipath immunity, and operate with lower E_b/N_0 requirements than QAM modulations. However, COFDM links do so with less spectral efficiency — that is, fewer bits/second/Hertz than higher order QAM modulation.

QAM demodulators use extensive equalization to overcome the multipath in CATV systems. However, since they were built for the CATV environment — a very high signal-to-noise environment — these demodu-

Parameter	MMDS	LMDS
Frequency band	2.5 to 2.7 GHz	28.5 to 29.5 + 31.0 to 31.3 GHz
Propagation characteristics	Good for medium range, line-of-sight, ≤50 miles Free space attenuation ~Kd^2 (or ~6 dB/octave)	Good for short range, line-of-sight, ≤5 miles Free space attenuation >Kd^2 (or >6 db/octave)
Antenna characteristics	~11 times larger than equivalent LMDS antenna with same specs	~1/11th the size of an equivalent MMDS antenna with same specs
Since practicality dictates that antennas will be of approximately the same physical size	MMDS antennas will have less directivity (i.e., broader beam-widths) than LMDS antennas	LMDS antennas will have more directivity (i.e., narrower beamwidths) than MMDS antennas
Favored cell architecture	Single, large macrocell	Multiple, small microcells
Impact of cell architecture	Limited bandwidth availability due to no frequency reuse	Large bandwidth available, which can effectively be increased by decreasing cell size
Ability to support two-way system architecture	Limited due to bandwidth, antenna characteristics and propagation characteristics	Well suited due to small cell size, large available bandwidth and highly directive antennas in reasonably small sized
Link pathology	Long range and broad antenna beams ensures significant multipath	Short range and highly directive antennas mean little or no multipath
Modulation preference	High order modulation producing more bits per second per hertz, with a strong multipath immunity (e.g., DVB–C QAM or COFDM modulations)	Lower order modulations to minimize Eb/N_0 requirements to minimize self interference (e.g., DVB Q/8PSK modulations)

▲ **Table 1. Link pathologies of LMDS and MMDS.**

lators incorporate only Reed-Solomon block decoding, foregoing the benefits that concatenated forward error correction (FEC) coding provides in dramatically reducing the threshold E_b/N_0 requirements for the demodulator. Wireless systems, on the other hand, are always limited by noise. Therefore, the use of QAM modulation in the MMDS environment imposes very high S/N and corresponding E_b/N_0 requirements on the system. These high S/N requirements produce dramatic self-interference in a cellular environment where some level of frequency reuse is the justification of a cellular deployment. The use of higher order QAM modulation effectively precludes the use of a cellular MMDS deployment and encourages a single macro-cell architecture.

In the single cell MMDS deployment, the available bandwidth is limited to the frequency band licensed, which is equal to or less than 200 MHz total. Using this limited bandwidth for two-way, interactive Internet access is certainly feasible, but does not produce broadband access to any reasonably sized population base. However, the use of datacasting, which exploits the multiplying effect of data multicast and broadcast, can provide a cost-effective and easily deployed model.

The MMDS model described is dramatically affected by the combination of bandwidth limitations, propagation characteristics and the resulting impact on preferred modulation type. The LMDS environment has similar cause and effect characteristics, but with a clearly different conclusion.

LMDS licenses are, like MMDS, issued on a BTA basis. The "A" licenses provide 1.15 GHz of bandwidth in the 28 to 31 GHz frequency band. The "B" licenses provide a mere 150 MHz of bandwidth. Operation in this frequency is clearly "line-of-sight," with free space attenuation being further increased by atmospheric absorption due to moisture and pollutants. This characteristic is actually beneficial in deploying a cellular infrastructure as it helps to reduce cell-to-cell interference.

The use of the 28 to 30 GHz range adds another critical feature to system design. The high frequency allows for the design and construction of small antennas with excellent directivity. The ability to use highly directive antennas is one of the key factors to reducing multipath. The reduction or effective elimination of multipath provides the option to select more energy-efficient modulation types, without the need for extensive equalization. DVB-QPSK is an ideal choice for modulation because it provides very low E_b/N_0 threshold requirements, is supported by mass-produced, ASIC-based demodulators and promotes the most productive frequency reuse plan for cellular deployments.

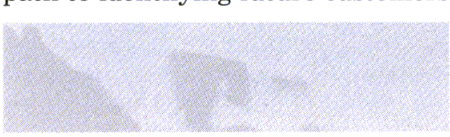
LMDS has significant bandwidth, propagation characteristics favorable to cellular infrastructures and multipath characteristics that can be controlled by design. Deploying such systems on a cellular basis provides the means of effectively multiplying the available bandwidth by the number of cells deployed and allowed for unlimited bandwidth. Therefore, LMDS systems have been designed as two-way communications systems incorporating either frame relay or ATM switching technology.

These systems provide high performance and can be rapidly deployed. The drawback is that they are expensive on a per subscriber basis due to the complex switching technology and the cost of the power amplifier for the return link.

Reducing the cost of the subscriber terminal is partially achieved by limiting the power output of the linear amplifier used for the return link. The power limitation translates to an effective operational cell radius of operation that is most commonly 2.5 miles or less. The limited distance between the hub and the client receiver further contributes to the control of multi-path and the expansion of available bandwidth.

It would appear that LMDS has all of the benefits. Regrettably, they are achieved at some significant cost on a per subscriber basis due to the cost of two-way terminal equipment. An overlay of a point-to-multipoint service, in addition to the existing two-way infrastructure provides a low cost means of expanding subscribers with an additional tier of service.

In LMDS, like in MMDS, the use of IP encapsulated data allows for the use of low-cost receivers based upon the DVB-QPSK products commonly used in satellite transmission systems. The hub equipment, i.e., the site and the transmission equipment, is assumed to be present. All that needs to be added to the hub is an IP to DVB gateway and a multicast data server. On the client side, the standard antenna with a LNB (low noise block) downconverter, downcoverting the 28 GHz to an L-band (950 to 2150 MHz) IF frequency, is standard equipment for the traditional deployments. Using a common antenna and adding a low-cost PCI based receiver card can provide the same service opportunities as in the MMDS multicast case. Additionally, it provides an effective path to identifying future customers for the less costly, higher-performance two-way communications capability. ■



Acknowledgement

Rene Savalle also contributed to this article. With more than 28 years of experience in the satellite and communications industries, he serves as the primary contact and sales director for Login Innovations' data broadcasting product line.

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Products

TEST EQUIPMENT

EMC test areas

Schaffner has introduced the Comparison Noise Emitter CNE 6507, a continuous spectrum radiated noise source with a useable output from 1.5 to 7 GHz. The portable unit can be used for carry-

ing out checks in GTEM cells, anechoic chambers and open area test sites. CNE 6507 is the first broadband source to make consistency checks possible up to 7 GHz.

Schaffner
Circle #147

Receiver for GSM/DCS

A dual band signal strength receiver for making pathloss measurements in the GSM and DCS frequency bands is now available from Practical Systems Engineering. The unit measures signals in the ranges 925 to 960 MHz and 1805 to 1880 MHz, from –20 dBm to –120 dBm.

The frequency and signal strength are displayed on the front panel LCD or can be monitored over an RS232 interface. Data can be collected and stored in a Microsoft® Excel spreadsheet. The receiver is compact, about 6 × 3 × 2 inches, and battery powered. The unit is priced at $3,295. A companion CW transmitter is also available.

Practical Systems Engineering
Circle #148

Bluetooth™ test set

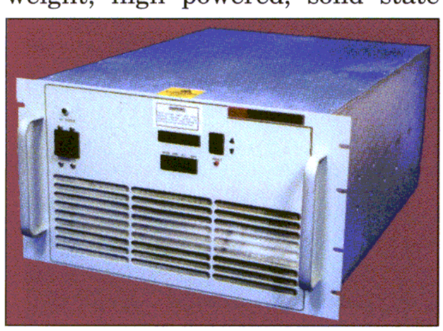
Anritsu introduces the MT8850A Bluetooth™ test set that meets the industry's demand for Bluetooth test instrumentation. The set conducts measurements in accordance with RF Test Specification V0.09, using the Bluetooth protocol stack for full implementation of test-module signaling. The set is an ideal tool for production test of Bluetooth chip sets and modules, as well as consumer products using Bluetooth radios. The MT8850A occupies only half a rack and weighs 3.5 kilograms, allowing it to fit into any ATE application. It is priced under $20,000.

Anritsu Corporation
Circle #149

AMPLIFIERS

Three new amplifiers

Ophir RF has three new amplifiers on the market, all small, lightweight, high powered, solid state



linear amplifiers. Model 5080 has a minimum linear power of 100 watts and covers the multioctave band 800 to 4200 MHz. Model 5101 has a minimum linear power of 40 watts across a 800 to 2500 MHz multioctave band. Model 5102 has a maximum linear power of 120 watts across a 800 to 2500 MHz multioctave band. All three are suited for multiband PIM testing, device testing and TWTA replacement.

Ophir RF
Circle #150

Two high-power HBT power amplifiers

Anadigics has introduced two new InGaP HBT power amplifiers for use in multi-mode, multi-band CDMA handsets that support 2.5G CDMA applications. The AWT6105

is specifically designed for cellular CDMA, CDMA-1X and AMPS applications in the 824 to 849 MHz range. The AWT6106 is targeted for PCS CDMA and CDMA-1X applications operating at 1850 to 1910 MHz. Both devices combine all of the necessary passive components for full compensation and 50-ohm input/output matching.

Anadigics
Circle #152

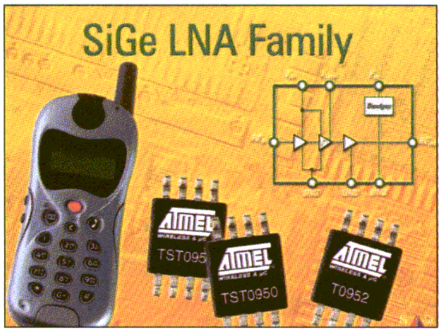
Integrated power amplifier modules

Intarsia has announced the first members of a new family of power amplifier modules for wireless and RF applications. The three PA modules are specifically designed for single- or double-band cellular phones and base stations operating in the PCS frequency band between 1.7 and 1.9 GHz. Additional power and driver amplifier modules in the family, targeted at numerous frequencies, applications and markets, are planned for release in the next six to nine months.

Intarsia Corporation
Circle #152

Triple gain amplifier

Atmel has announced a new triple gain low-noise amplifier manufactured using SiGe technology. The IC T0952 can be used for conventional superheterodyne or direct-conversion receivers in 1800 to 2000 MHz PCN and PCS mobile phone applications. The T0952, with three-stage amplifier and

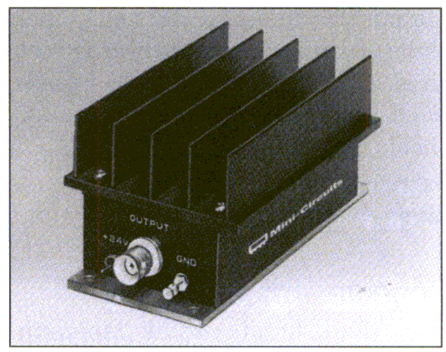


switchable gainm provides a combination of low noise (NF of 2.5 dB in high-gain mode), large signal capability (IIP3 of –8 dBm in low-gain mode) and high reverse isolation (greater than 40 dB).

Atmel Corporation
Circle #153

Coaxial amplifier

Mini-Circuits introduces the ZHL-1010-75 coaxial amplifier, which typically provides 47 dBm IP3 and 88 dBm IP2 to help reduce intermodulation products within the 50 to 1000 MHz frequency band. Additionally, this 12-volt DC, 75-ohm unit delivers 9.5 dB (minimum) gain, ±0.7 dB (maximum)

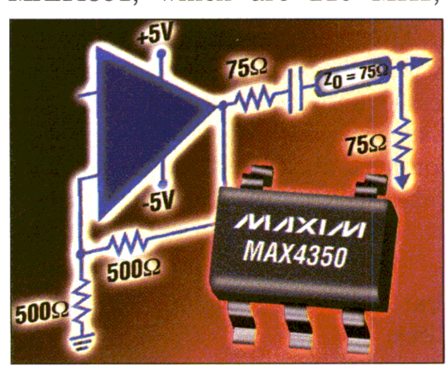


flat, and typical 30 dBm maximum power output. The unit is equipped with 75-ohm BNC-Female connectors and heat sink for operation in the –20 to +65 degrees Celsius (maximum) temperature range. It is priced at $149.95 each in quantities of one to nine.

Mini-Circuits
Circle #154

Dual-supply op amplifiers

Maxim Integrated Products has introduced the MAX4350 and MAX4351, which are 210 MHz,

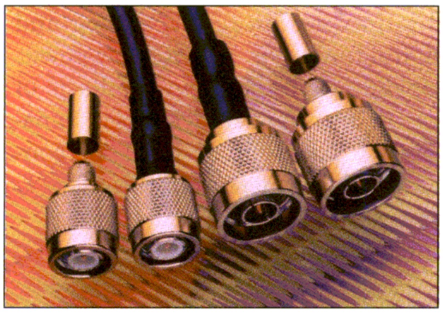


low-power, dual-supply op amplifiers available in the SC70 and SOT23 packages. The combination of Rail-to-Rail® outputs, low power and wide bandwidth in an ultra-small package makes these op amps ideal for a variety of wideband applications for the consumer market, including set-top boxes, surveillance video systems, digital cameras and CD-ROM drives.
Maxim Integrated Products
Circle #155

CABLES & CONNECTORS

Solderless connectors

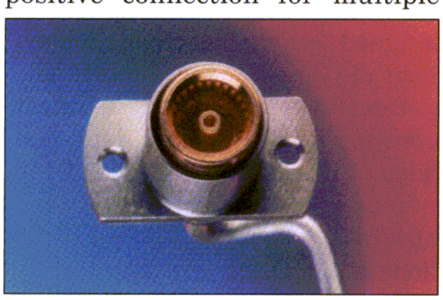
Times Microwave Systems has introduced "EZ" solderless TNC and N type connectors for its LMR-



240 low loss coaxial cables. The connectors, designated as EZ-240-TM and EZ-240-NM, have knurled coupling nuts and crimp-style outer contact attachment rings. These connectors are suited for use at the upper ISM frequency bands of 2.4 and 5.8 GHz because of their low loss and low VSWR.
Times Microwave Systems
Circle #156

BMA connector

Tru-Connector has introduced a new high frequency blind-mate slide-on connector that assures a positive connection for multiple



interconnect applications. The BMA connectors feature internal contact spring fingers to provide a positive alignment interface with minimal insertion force and allow for 0.015-inch movement without degradation of electrical performance. Accommodating a maximum of 0.050-inch axial- and ±0.020-inch radial misalignment, the BMA connectors are available for flexible and semi-rigid cables. Pricing is $22.45 each, depending on quanitity.
Tru-Connector Corporation
Circle #157

Cable assemblies

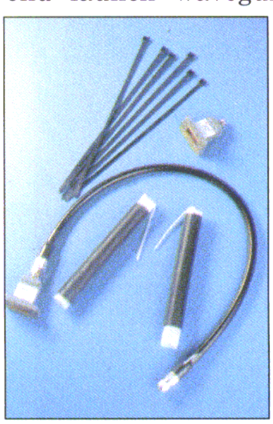
K-Jumpers are the latest high frequency cable assemblies introduced by Florida RF Labs. These assemblies incorporate patent-pending 2.9 mm (K) compatible connectors. They may be bent around a 0.250-inch radius to form

a right angle without loss of performance and may be re-bent in excess of ten times without performance degradation. The assemblies typically have better than a 1.25 VSWR to 40 GHz and feature greater than 90 dB of shielding. Currently, Florida RF Labs stocks 6- and 12-inch lengths of the K-Jumpers, with lengths available from 2 to 60 inches. Pricing for 1 foot jumpers starts at less than $45 each in quantities of 25 pieces. Custom sizes, including pre-bent low profile right angles, are also available.

Florida RF Labs
Circle #158

End launch kits

Andrew has introduced End Launch Kits for microwave site installations. The new kits include end launch waveguide-to-coaxial



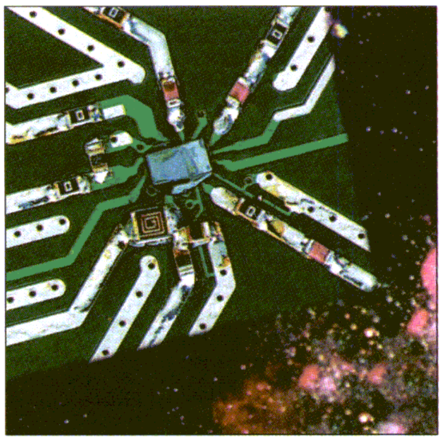
transitions, premium coaxial cable and connectors selected specifically for higher frequency microwave applications, plus a variety of accessory combinations to meet site-specific requirements. The end launch kits are currently available for the 4.4 to 5.0 GHz, 5.85 to 7.75 GHz and 7.7 to 8.5 GHz frequency bands.

Andrew Corporation
Circle #159

SEMICONDUCTORS

SiGe front end IC

Atmel has introduced its highly integrated RF Silicon-Germanium (SiGe) front end IC (including a low-noise amplifier and a power amplifier) for the radio part of long



range, 100 meter, Bluetooth™ systems in Flipchip technology. With a die size of 1.6 × 3.2 mm and a pitch size of 400 µ, it fits into the smallest applications. For easy assembly, two additional small-sized packages are also available (MLP20 with 5 × 5 mm and PSSOP20).

Atmel Corporation
Circle #160

Single-chip transmitter

An integrated, single-chip amplitude shift keyed (ASK) RF transmitter designed specifically to meet the needs of low-cost loop antenna transmitters is now available from Micrel Semiconductor. Highly integrated in SOIC-8 packaging, the MICRF102 requires only five external components and incorporates transmit power control and automatic antenna tuning. Features include 300 to 470 MHz transmit frequency, 20 kpbs (maximum) data rate, closed-loop power control, ASK modulation, 5.75 mA mean supply current at –2 dBm transmit power, a shutdown pin, 4 mA space supply current and supply voltage of 5 volts.

Micrel Semiconductor
Circle #161

Programmable transceiver

The Honeywell Solid State Electronics Center (SSEC) has introduced Radio On a Chip (ROC), a programmable, single-chip RF transceiver designed for 434, 868 and 915 MHz wireless frequency applications. The ASIC uses 0.35 micron CMOS technology and a direct-down conversion radio architecture to reduce cost; facilitate on-chip integration of RF, analog and digital functions; provide low power consumption and form the basis of future customized wireless transceivers. The ROC is ideal for consumer or business applications.

Honeywell SSEC
Circle #162

Modem chip set

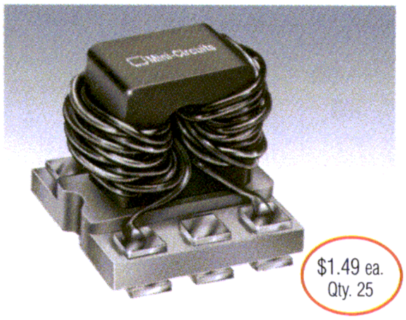
Intersil has introduced its new CommLink™ OC-3 Modem chip set and reference design for customers who are designing broadband wireless Internet and cellular

backhaul infrastructure equipment. The ISL87060 chip set is designed to enable rapid deployment of point-to-point digital radio systems that support wireless transmissions of voice, data and video at OC-3/STM-1 speeds of 155 megabits-per-second.

Intersil
Circle #163

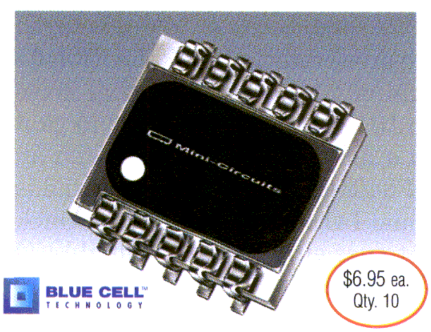
NEW PRODUCTS NO. 84

RF/IF MICROWAVE COMPONENTS



10dB "DO-IT-YOURSELF" COUPLER DELIVERS COST SAVINGS

Designed to lower costs through automated manufacturing, the TCD-10-1W from Mini-Circuits needs only a commercially available 50 ohm external chip resister, and a complete 10 to 750MHz directional coupler is realized. Electrically, this rugged 50 ohm coupler provides 10.3dB±0.5dB normal coupling with ±0.8dB (max.) flatness. Midband, typical mainline loss is 1.2dB and directivity is 18dB (typ.) The 50/75 ohm "Do-It-Yourself" TCD family contains 9 units with 9 to 20dB coupling for 5 to 1000MHz.



4950 TO 5900MHz MIXERS HAVE HIGH IP3 AND LOW HEIGHT

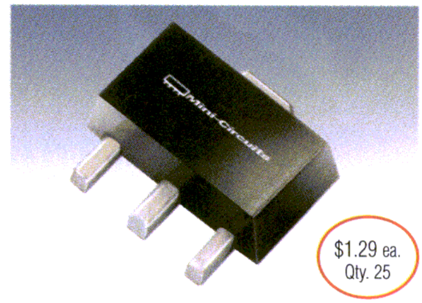
Mini-Circuits temperature stable MBA-591L BlueCell™ mixers are a low 0.070" profile solution for today's compact 4950 to 5900MHz wireless products. Typically at midband, these patented level 4 (LO) mixers offer high 15dBm IP3 to help suppress intermodulation products, 7.0dB conversion loss, and high 35dB L-R, 26dB L-I isolation bandwide. High repeatability is achieved using state-of-the-art automated manufacturing. Applications include ISM, satellite, and PCMCIA.

DC TO 6000MHz FIXED ATTENUATOR SERIES IS COST EFFECTIVE

The VAT family is a very low cost, wide band DC to 6000MHz fixed attenuator series from Mini-Circuits delivering nominal attenuation from 1 to 10dB in 1dB steps, plus 12, 15, 20, and 30dB. Equipped with SMA Type Male/Female connectors, the rugged unibody construction measures only 1.42" long (.370" diameter) and can handle 0.5 watt power (at 70ºC ambient). Ideal for impedance matching and signal level adjustment applications. Designer's kits available.

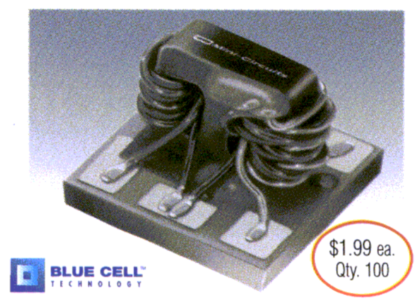
5V VCO HAS LOW PHASE NOISE 400 TO 850MHz

Mini-Circuits has introduced a 400 to 850MHz wide band surface mount voltage controlled oscillator that operates from a 5V (nominal) power supply. Typically, the JTOS-850VW operates with 0.5 to 18V (min. to max.) tuning voltage, and features low -96dBc/Hz SSB phase noise at 10kHz offset, 15-80 MHz/V tuning sensitivity, and high +8.0dBm power output suitable for LO drive to mixers. Solder plated J leads provide superior mechanical integrity over temperature.



DC TO 4GHz MMIC AMPLIFIER HAS HIGH RELIABILITY

Mini-Circuits has unveiled the GAL-55, a newly developed MMIC amplifier for DC to 4GHZ, and usable to 6GHz. When operated at 2GHz/25°C, the unit delivers high 18.5dB gain (±1.7dB typ flat DC-2GHz), maximum output power of 15.0dBm (typ, at 1dB comp.), and high 28.5dBm (typ) IP3. These 50 ohm amplifiers are housed in a small SOT-89 package with exposed metal bottom for excellent heat dissipation, and display low 100°C/W (typ, θjc) thermal resistance. Uses include cellular and PCS.



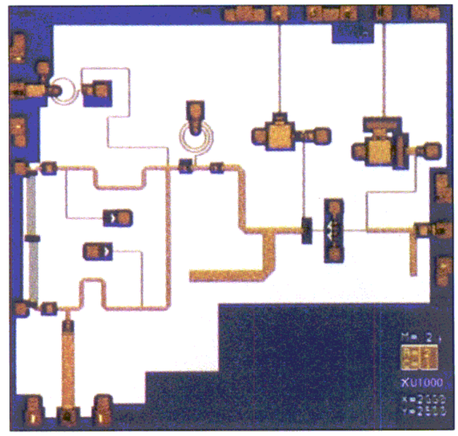
WORLD'S SMALLEST 2WAY-0° SPLITTERS 5-1000MHz

Micro-miniature SBTC-2-10 power splitters from Mini-Circuits measure only 0.15"x0.15" square, making them the smallest 2way-0° power splitters on the market for the 5 to 1000MHz band. Incorporating patent pending Blue Cell™ technology, these high performance 50 ohm units typically display low 0.5dB insertion loss (above 3.0dB), excellent 0.2dB amplitude, 1.0 degree phase unbalance, and exhibit excellent temperature stability. Leads are solder plated.

Products

GaAs MMIC up-converter

Mimix has introduced the XU1000, a totally integrated gallium arsenide (GaAs) monolithic microwave integrated circuit (MMIC) up-converter on a single chip. This device is a single fundamental mixer followed by a single stage amplifier. Using 0.15 micron gate length GaAs pseudomorphic high electron mobility transistor (pHEMT) device model technology, the up-converter covers the 17 to 27 GHz frequency band with a typical small signal gain of 0 dB and typical third order intercept point of +12 dB across the band. The device features low DC power consumption and operates at +3.0 VDC. Samples are available now from stock.



Mimix Broadband
Circle #164

LNA/SAW filter/mixer module

RF Micro Devices has introduced the RF3404, a fully integrated dual band tri-mode receive module incorporating low noise amplifiers, SAW filters and mixers for CDMA handset and PDA applications. Manufactured using an advanced SiGe process technology, the RF3404 offers cellular band gain of 25 dB with a typical noise figure of 2.0 dB and an IIP3 of –9 dBm. PCS band gain is typically 25 dB with a noise figure of 2.2 dB and an IIP3 of –9 dBm. The RF3404 measures 8 × 8 mm and is designed with an optional LO frequency divider, which provides the flexibility to use either single or dual VCO architectures. It is offered in a land grid array laminate module package.

RF Micro Devices, Inc.
Circle #165

CDMA RF synthesizer

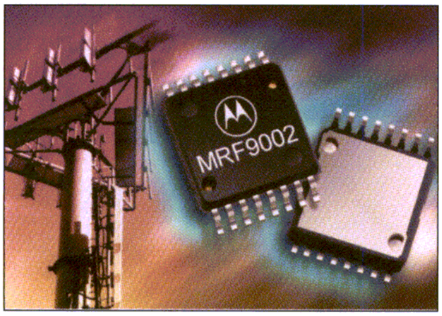
Silicon Laboratories has introduced the Si4135 CDMA RF synthesizer, the newest member of the company's Criterium™ RF synthesizer family. The single-chip Si4135 is designed for single-band, dual-band, dual-mode and tri-mode CDMA/AMPS handsets and other IS-95 wireless data applications. It is offered in a 5 × 5 mm MLP28 and is priced at $6.75 in quantities of 10,000 or more. Samples are available now, with volume production in the third quarter of 2001.

Silicon Laboratories, Inc.
Circle #166

SIGNAL PROCESSING

Broadband power MOSFET

Motorola has introduced a broadband RF power MOSFET optimized for 1.0 GHz base station applications. The MRF900R2 is a single-

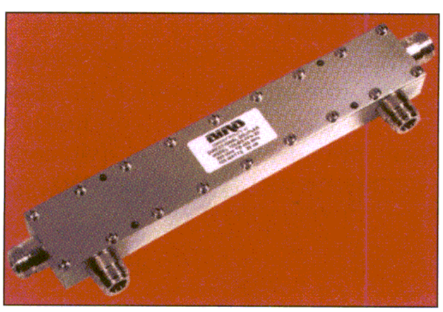


ended device individually tuned to operate at the 960 MHz frequency band and designed to be used in Class AB for 26-volt base station equipment. The MRF900R2 is an array of three 2-watt transistors in a single, surface mountable, 16-pin Power Flat Pack (PFP-16) package. Pricing is $14.40 each in quantities of 10,000 or more.

Motorola, Inc.
Circle #167

Directional coupler

Bird Component Products has expanded its line of coaxial directional couplers to include a 100-watt unit. Model 100-BC-FFN-20

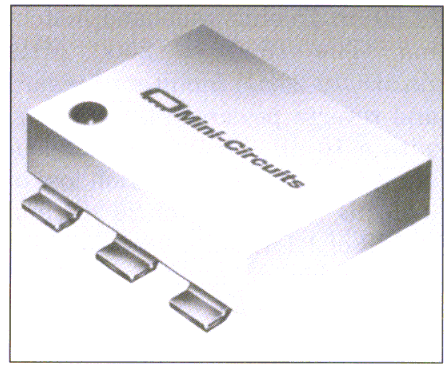


offers input power handling up to 100 watts, frequency range of 225 to 400 MHz and 20 dB coupling. Directivity is 25 dB minimum, insertion loss 1.15:1 maximum (primary and secondary lines) and frequency sensitivity is ±1.0 dB maximum. The coupler is constructed with type N female connectors.

Bird Component Products, Inc.
Circle #168

Wideband matching DC and bi-directional coupler

Mini-Circuits has introduced two new products, a wideband matching DC (ALMP-5075) and a coaxial bi-directional coupler (ZABDC10-25HP). The ALMP-5075 unit is a wideband surface mount matching pad engineered for the DC to 3000 MHz freqeuncy band and optimized to meet performance requirements



Circle 74

of 50- to 75-ohm wideband matching. The 1500 to 2500 MHz ZABDC10-25HP monitors forward and reverse power up to 10 watts, with a 10 dB ±1 dB nominal coupling value, typical insertion loss of 0.55 dB, directivity of 26 dB and VSWR of 1.1:1.
Mini-Circuits
Circle #169

I-Q modulator

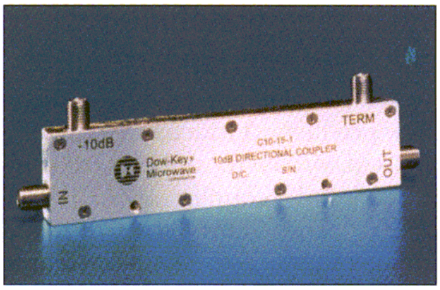
Planar Monolithics Industries has introduced the PMI Model No. PS-360-AC, an analog controlled phase shifter, high speed I and Q modulator. The modulator has been optimized for the 3.5 to 6.5 GHz frequency range. It is designed to have low spurious harmonics, low insertion loss and a VSWR of 2.0:1. It operates with ±15 VDC and is 3.25× 3.25 × 0.85 inches.
Planar Monolithics Industries, Inc.
Circle #170

RF switch for low power switching applications

M/A-COM, a unit of Tyco Electronics, has introduced a new SPDT GaAs switch suitable for low power switching applications from DC to 3 GHz. The switch operates on a positive or negative control voltages as low as 2.3 volts, offers low insertion loss (<0.4 dB) and good isolation (>15 dB) at 1.0 GHz. It is available in an ultra small SOT-363 (SC-70) plastic package and is priced under $0.40 each in quantities of 10,000 ore more.
M/A-COM, Inc.
Circle #171

Directional couplers

Dow-Key Microwave introduces a line of 10, 12 and 20 dB directional couplers. The C-10-15-1, C-12-15-1 and C-20-15-1 assemblies combine switching and passive components that address automated testing needs for RF, microwave and wireless product manufacturers. Designed to cover present and future wireless frequency ranges,

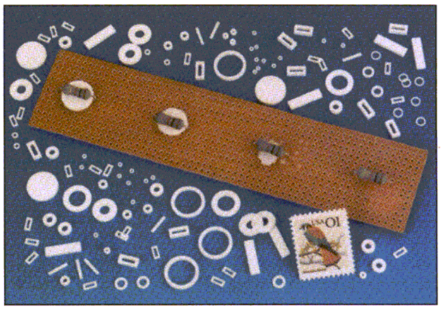


these couplers offer RF performance and have low IM properties (–100 dBc, with an upgrade to –135 dBc optional).
Dow-Key Microwave Corporation
Circle #172

MATERIALS & MANUFACTURING

Dissolvable spacers

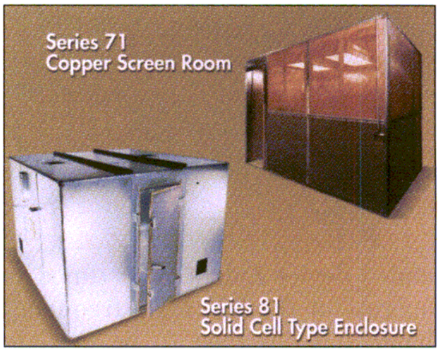
Multi-Seals has introduced Wash-Aways™ spacers, designed to provide consistent spacing between printed ciruit boards and components. These organic polymer spacers locate PCB components during soldering operations. After soldering, Wash-Aways dissolve in most water-solvent baths. This leaves uniform spacing between components and boards, which provides



free circulation of air, mechanical protection, optimum filleting and greater accessibility for inspection, cleaning and conformal coating. Wash-Aways are available in a wide range of sizes and shapes to accommodate a variety of PCB components. They contain no ionizable materials, salts, sugars, metals or soaps, and they are non-corrosive, non-conductive and non-toxic. Typical dissolving time in hot water is 2 to 80 seconds, depending on spacer thickness.
Multi-Seals, Inc.
Circle #173

Shielded enclosures

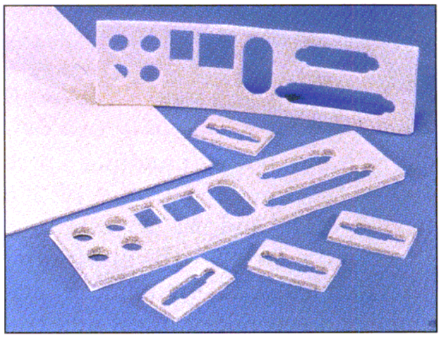
Lindgren RF Enclosures offers two shielding systems for controlling EMI/RFI noise: the Series 81 Solid Cell Type Construction Enclosure and the Series 71 Screen Room. These modular enclosures are designed to prevent malfunction of wireless communications



and electronic devices, as well as to contain disruptive radiating signals from high-emission devices. They prevent sensitive information inception and protect systems from high voltage sources and electromagnectic pulses. Applications include EMC product compliance testing, instrumentation repair, production line testing and cellular and paging service.
Lindgren RF Enclosures, Inc.
Circle #174

Conductive foam connector shields

Laird Technologies has developed a line of conductive foam connector shields. The conductive foam provides X-Y and Z axis con-



ductivity, providing enhanced EMI shielding effectiveness and grounding required by the increasing operating speeds of computer, telecom-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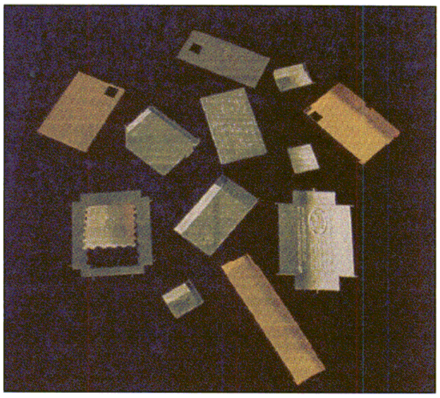
munications and aerospace equipment. Conductive foam is ideal for use in non-dynamic applications, such as input/output and other standard connector configurations. Improved Z-axis conductivity improves shielding effectiveness to more than 110 dB across a wide range of frequencies. Compression ranges from 10 to 50 percent of original uncompressed thicknesses, which are available in 0.060 and 0.125 inches.
Laird Technologies, Inc.
Circle #175

Thermoplastic compounds

RTP has developed a family of thermoplastic compounds that improve the performance of electronic devices for use with the new Bluetooth wireless communications protocol. These custom materials feature modified electrical and dielectric properties that enhance signal transmission and reception. A complementary product line provides EMI shielding to help meet FCC regulations. Compounds for Bluetooth™ technology address the three primary phenomena that occur when electromagnectic signals encounter an object. These phenomena are absorption, reflection and transmission.
RTP Company
Circle #176

RF/EMI shields with removable top covers

PEI has introduced RF/EMI shields with patented "Easy Access"™ removable top covers, designed to protect components from radio frequency/electromagnectic interference and environ-



mental hazards, as well as to provide electrical grounding. Shielding options for circuit board applications include one-piece or two-piece construction, standard materials, etched holes or patterns for component cooling and patented CDW™ (controlled depth/width) etch to hand-form at specific angles.
Photofabrication Engineering, Inc.
Circle #177

OPTIC COMMUNICATIONS

Quad channel set

The Honeywell Solid State Electronics Center (SSEC) has introduced a quad channel photo diode receiver and laser diode driver set for 10 Gb/s Ethernet fiber optic applications. Using a XAUI standard interface, both the receiver and driver meet IEEE 802.3a standards and have integrated designs that use the company's patented silicon on insulator (SOI) CMOS technology. The 3.3-volt powered quad driver accommodates soft start and hot plug operations, can disable individual channels and is gigabit interface converter (GBIC) compatible for single point failure detection.

Honeywell SSEC
Circle #178

Driver amplifier

Celeritek has introduced a new driver amplifier for external fiber optic modulators targeting high bandwidth applications. The CMM2030-BD optical wideband GaAs pre-driver amplifier provides

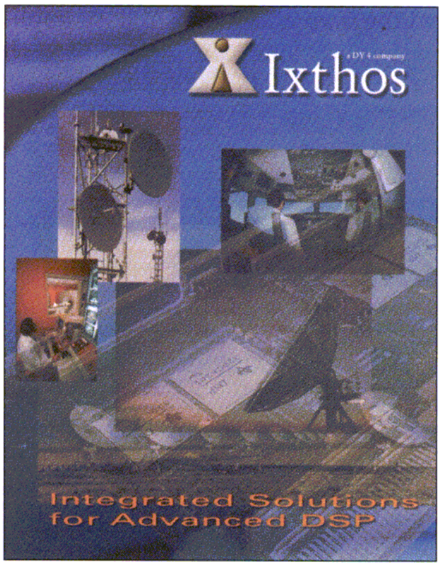
more gain in the device, reducing power consumption as much as 75 percent. The amplifier operates from 30 kHz to 32 GHz, with a linear gain reponse of 11 dB. Low internal jitter makes it ideally suited for high speed digital data applications. Pricing starts at $90 each in quantities of 5,000 or more.

Celeritek, Inc.
Circle #179

LITERATURE

Advanced DSP board and system catalog

Ixthos has published a comprehensive new product catalog. The catalog covers a broad range of advanced DSP board and system level solutions for applications ranging from commercial and wireless telecoms, digital radio and semiconductor fabrication to seismic exploration/monitoring and other data intensive applications. The full-color, illustrated, eight-page catalog details Ixthos' CHAMP (common heterogeneous



architecture for multi-processing) architecture, which features segmented data passing buses, simulatneous, high speed data transfers, four leading edge DSP processors and two industry standard PMC sites for tightly coupled I/O.

Ixthos, Inc.
Circle #180

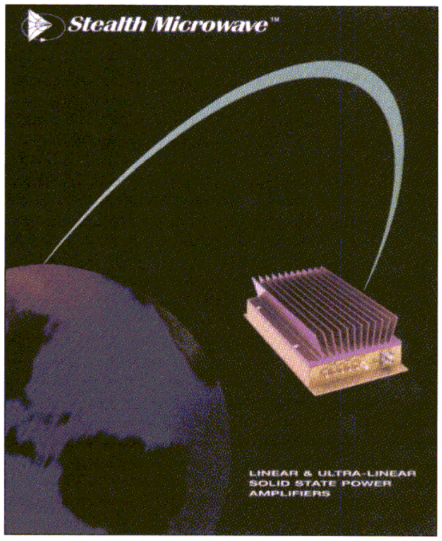
Bonding brochure

The Industrial Business Unit of Adhesives Research has introduced a new optically clear pressure-sensitive adhesive technologies brochure, as well as a new touch screen flier for the display market. The ARclear^{TM} optically clear PSA product line is available to manufacturers around the world for range of critical FPD bonding applications. AR can also custom engineer optically clear products for critical display bonding needs.

Adhesives Research, Inc.
Circle #181

Power amplifiers catalog

Stealth Microwave, a division of SSB Technologies, Inc., has a new 12-page catalog that features the company's linear and ultra-linear power amplifiers with output powers ranging from 1 to more than

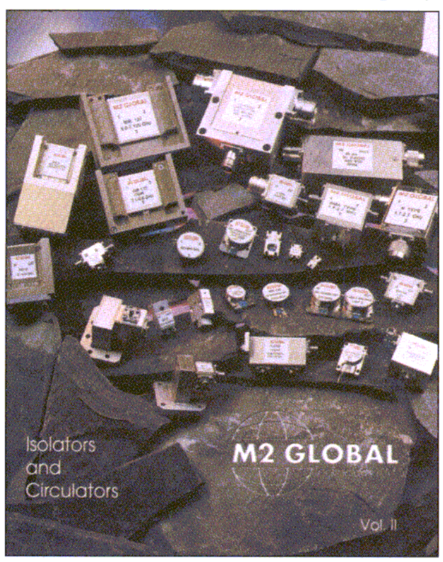


360 watts. Frequency bands range from 500 MHz to 14 GHz. A company description is also included in the catalog.

Stealth Microwave
Circle #182

Isolators and circulators catalog

M2 Global Technology has released Volume II of its company

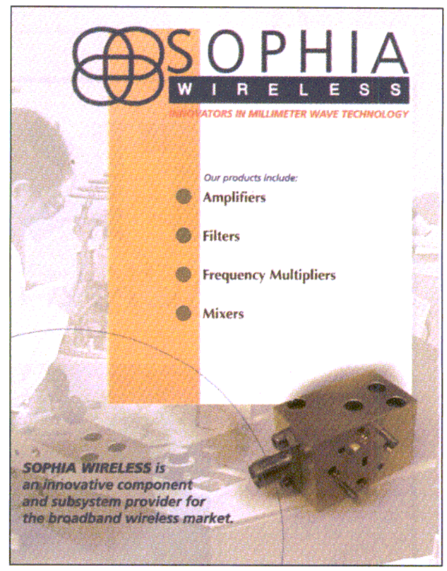


catalog, which offers a variety of isolators and circulators available in coax, wave-guide, drop-in and surface mount configurations covering the frequency range from 300 MHz to 40 GHz. The catalog describes the company's Standard Ferrite Products; however, a wide range of custom products is also available.

M2 Global Technology, Ltd.
Circle #183

Amplifiers, filters and mixers catalog

Sophia Wireless has released its new product catalog. Products featured in the article include amplifiers, filters, frequency multipliers and mixers. Sophia Wireless offers broadband point-to-point and point-to-multipoint wireless solu-



tions, which offer high performance, compact size and short time-to-market. Sophia's millimeter wave components are designed using 3-D electromagnetic simulation tools.

Sophia Wireless, Inc.
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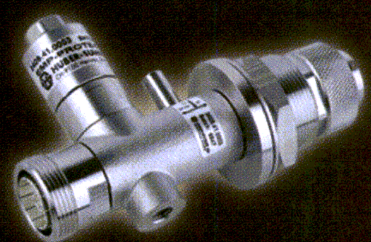

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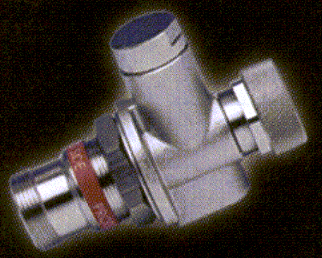

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Circle 76

Microwave Multiplexer Design Based on Triplexer Filters

By Eudes P. de Assunção, Leonardo R.A.X. de Menezes and Humberto Abdalla, Jr.
Universidade de Brasília, Departamento de Engenharia Elétrica

This article describes the design procedure for a multiplexer using the complementary triplexer filter method. This technique allows the designer to accomplish matched structures with a large range of frequencies. The required network conditions that can be realized with complementary filters are shown. The design procedure is developed for the bandpass and bandstop complementary filters connected at a common junction for narrow band applications. A stripline structure is employed to realize one triplexer. Good agreement between the experimental and theoretical results is achieved.

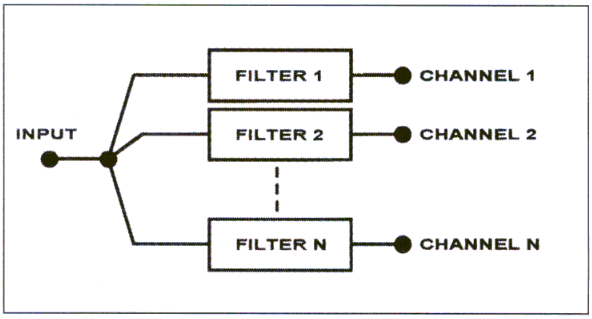

Figure 1. Diagram of a multiplexer using bandpass filters combined at a common input.

Introduction

Multiplexers split a wide frequency band into a number of signals of different frequency ranges. The separation of the desired frequency bands can be achieved by using bandpass filters combined at a common input, as shown in Figure 1. The main problem with this topology is that because filters are reflective devices, performance depends on a good impedance match between source and load inside the passband and a strong mismatch outside. If filters are carelessly connected together, undesirable mutual interaction effects appear, because the input impedance of each individual filter may be destructive outside its own passband. These effects may degrade the overall performance of the system.

One way of accomplishing a match over a wide frequency range is by using complementary filters. The sum of the input impedances will be real and constant for all frequencies. However, only minimum reactance and minimum susceptance networks can be made complementary [1]. When bandpass and bandstop complementary filters are connected in parallel or series, they present a constant-resistance input impedance. This combination constitutes a diplexer, which is the basic building block of a multiplexer. For each channel to be separated, one diplexer is needed, as shown in Figure 2.

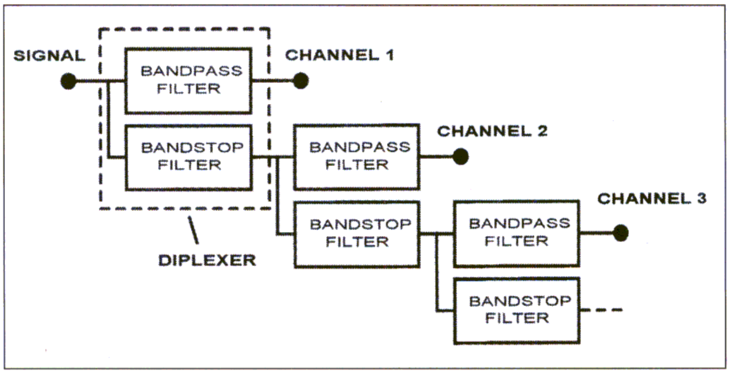

Figure 2. Diagram of a multiplexer using cascaded complementary diplexers.


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Wireless connectivity and communications systems will require antennas that fit seamlessly into home and office, public or private environments while meeting the exacting performance standards needed to support high rate digital data streams. Cushcraft Corporation has already staked out its ground as a market leader providing standard antenna products designed for concealment as well as antennas configured to application that meet those standards. Cushcraft's antennas are proven, key elements in the drive to support wireless Internet access and a whole host of additional feature laden wireless applications.
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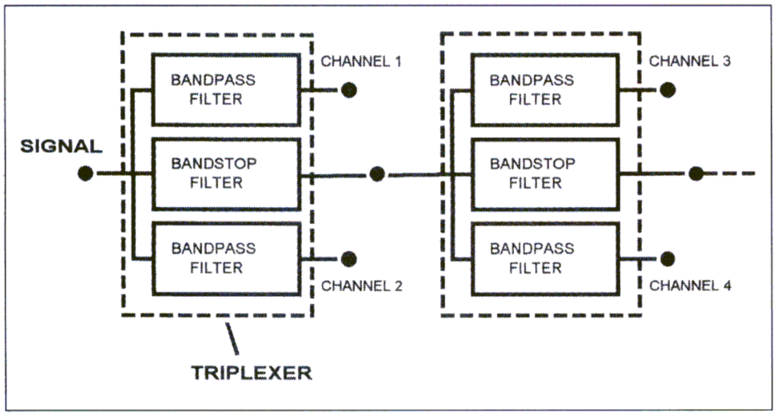
Circle 19



▲ **Figure 3. Diagram of a multiplexer using cascaded complementary triplexers.**

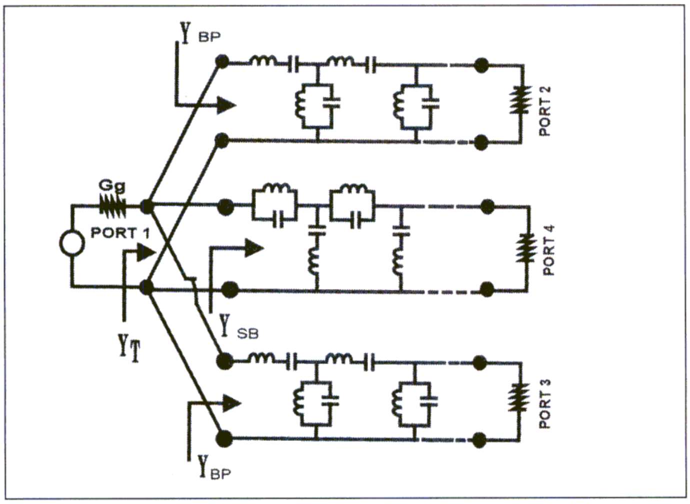
Another way to design the multiplexer is by using narrowband complementary triplexer filters [2]. The triplexer is a four-port device with a constant-resistance input impedance at the all frequencies, that separates out two contiguous channels. It consists of two contiguous bandpass filters and one complementary bandstop filter connected in parallel. It can be cascaded to obtain a multichannel system without interaction between the filter channels, as shown in Figure 3.

Complementary multiplexers

The design of complementary multiplexers is based on the construction and connection of triplexers in cascade. The triplexer consists of two bandpass filters and a bandstop filter arranged in a way that the sum of the bandwidth of the two bandpass filters is equal of the bandwidth bandstop filter. The cutoff frequencies of the stopband filter cross over at 3 dB points of the inferior cutoff frequency of one bandpass filter and the superior cutoff frequency of the other.

The filters are interconnected to produce a constant resistance input impedance at all frequencies. Figure 4 shows a schematic representation of a triplexer using bandpass and bandstop complementary filters connected in parallel [4].

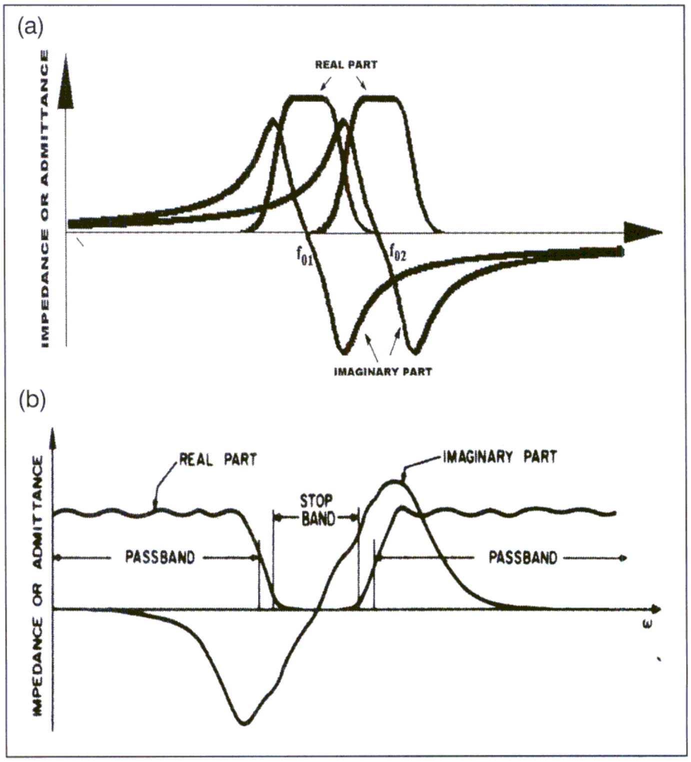
Since the networks are minimum susceptance, the input admittances of the bandpass filters and the bandstop filters have the general form illustrated in Figure 5. The input admittance of the triplexer is approximately the superposition of the input admittances of the individual filters. The design of the triplexer requires that the cutoff frequencies of each filter be such that the real part of the input admittance is approximately 0.5 mhos (normalized) for each filter. The normalized input admittance of the triplexer is shown in Figure 6. The imaginary components of the input admittances of the filters are conjugates of each other and provide a constant resistance input impedance for all frequencies [1, 4].



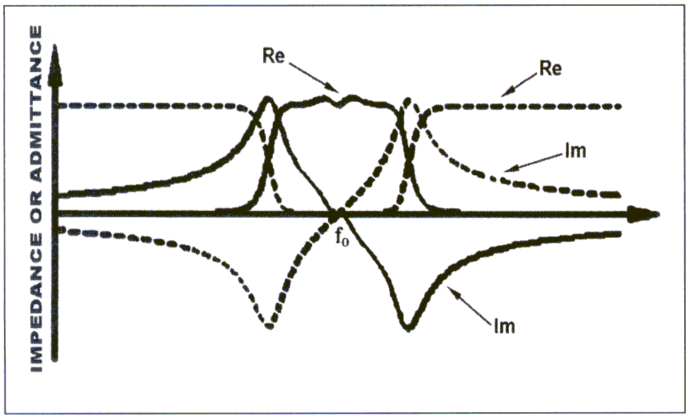
▲ **Figure 4. Diagram of parallel-connected triplexers using complementary filters.**

Design of complementary multiplexers

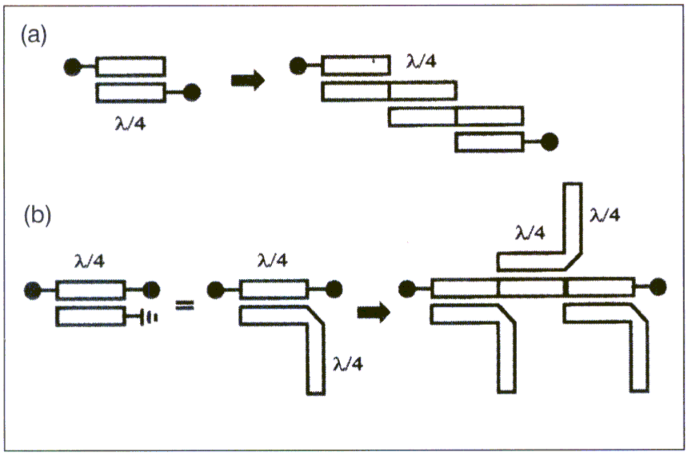
The triplexer may be used as the basic building block of multiplexers. Each triplexer separates two contiguous channels. Since each triplexer provides a constant resistance input impedance, it's possible to replace the load resistance of the bandstop filter by another triplexer, without affecting the performance of the system. Thus, several triplexers may be cascaded to separate the desired number of channels.



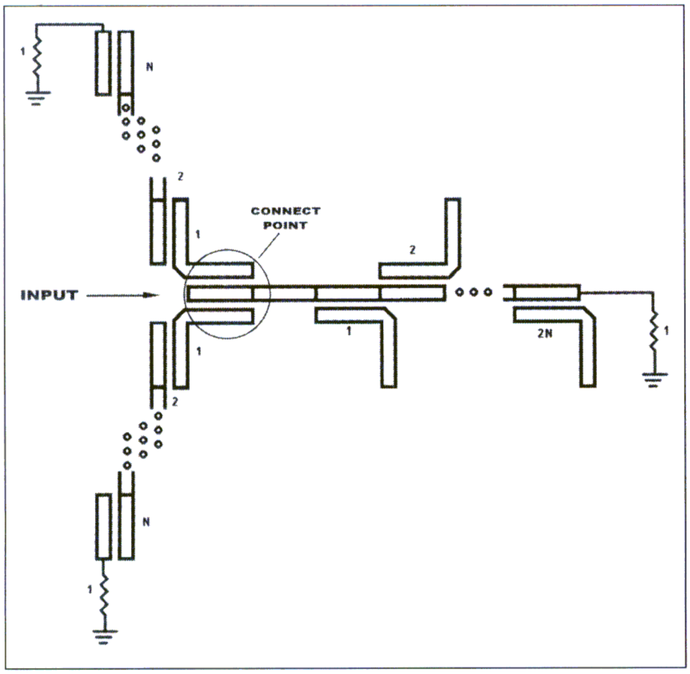
▲ **Figure 5. Input admittance of minimum-susceptance networks: (a) bandpass network characteristics; (b) bandstop network characteristics.**



▲ **Figure 6. Input admittance of the complementary triplexer.**



▲ **Figure 7. (a) Interdigital bandpass filter; (b) Parallel-coupled-resonator bandstop filter.**



▲ **Figure 8. Layout of the complementary triplexer.**

One topology of filters that is attractive for narrow channel triplexers are filters using quarter-wavelength parallel coupled sections. These filters can be designed with good accuracy, a compact structure and easy realization. The design of the filters is based on a cascade combination of quarter wavelength parallel coupled sections, as shown in Figure 7. For the bandpass filter, the input and output ports for each section are diagonally located, and the remaining terminals are open circuits. In the case of the bandstop filter, the input and output ports of each section are located on the same line, while the terminals of the other line are open and short circuits. Because of the narrow bandwidth, it is possible to replace the short circuits by open circuit quarter wavelength stubs, without disrupting the performance of the filter. Figure 8 shows the layout of the multiplexer composed by two bandpass filters and a parallel-coupled-resonator bandstop filter.

The interconnection problem

In a triplexer, adequate performance is obtained when the filters' input admittance characteristics are unaltered. This does not happen if a redundant element is introduced at the filters input ports. However, the narrow passband filter synthesis requires the introduction of at least one redundant element in the input port to achieve realizable impedance levels. Thus, the parallel connection of the filters that compose the triplexer cannot be used to obtain a complementary structure.

The interconnection problem for a narrowband triplexer can be solved by using the parallel-coupled line configuration shown in Figure 9. The center line section constitutes the redundant unit element, while the transformers (1:n) and capacitors *C* are parts of the bandpass filters. These four-port configurations allow for the interconnection of the three filters in complementary form. The appropriate choice of the transform ratio *n* allows the use of adequate impedance levels for the passband filter inner sections.

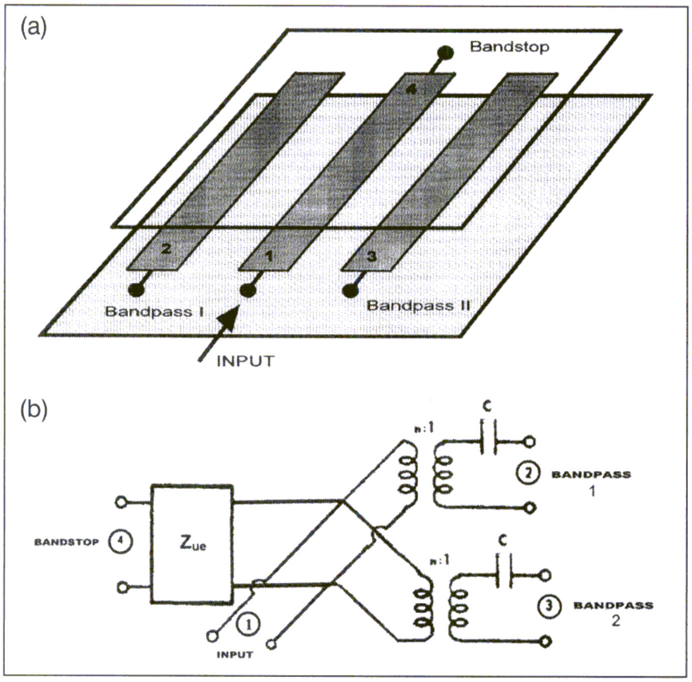
The design procedure starts by the direct synthesis in distributed parameters (exact synthesis) of the simply terminated resistive bandpass filters. The realizable impedance levels are achieved adding unitary elements of impedance Z_0 at the input and output ports of the filters. Using the Kuroda transformations, the equivalent circuit is obtained.

The bandstop filter is designed based in the composition of a redundant element and the complementary load presented by the filters.

$$Y_{in_{BS}} = 1 - Y_{in_{BP1}} - Y_{in_{BP2}} \tag{1}$$

where

$Y_{in_{BS}}$



▲ **Figure 9. (a) Interconnection network for narrowband complementary filters; (b) equivalent circuit.**

equals bandstop filter input admittance and

$$Y_{in_{BP}}$$

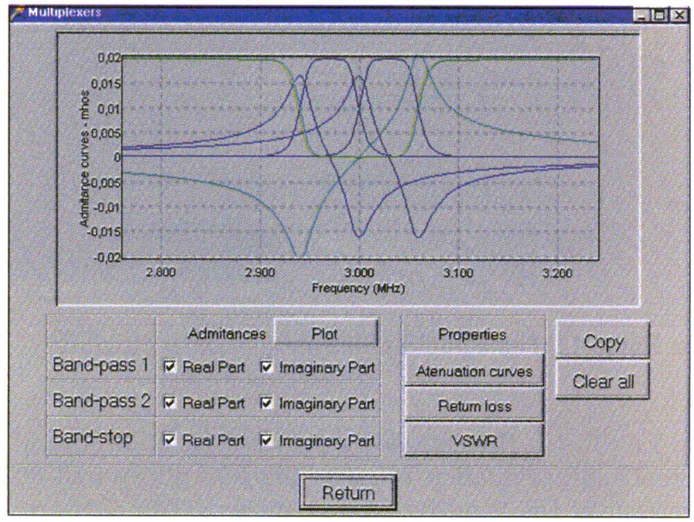
equals bandpass filter input admittance.

Design procedure

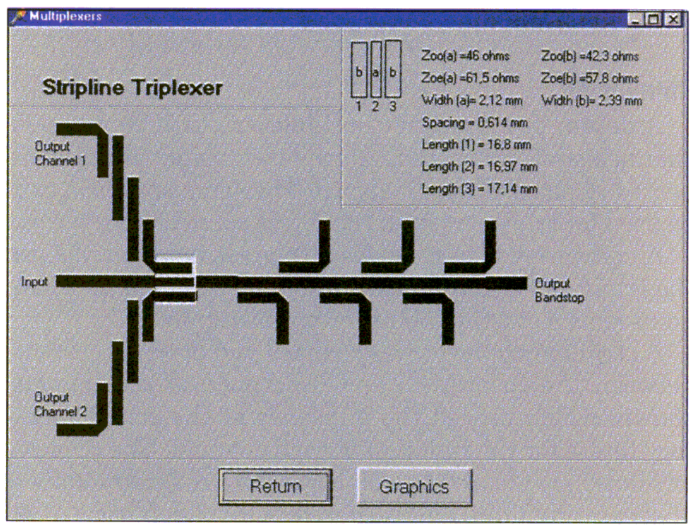
A design software program was developed for the complementary triplexer. The software contains three independent modules that execute these functions:

- Construction module of the transfer function filters. This module contains a dedicated graphic interface that permits the visualization of the frequency response and input admittances of each filter.
- Graphics visualization and analysis module of the poles and zeros of filters in the "S" Plane (complex variable plane).
- Synthesis module of the filter in lumped parameters and distributed parameters. This module provides the layout of the filter, including all calculated dimensions, taking into account the fabrication technology.

From the filter specifications and the basic parameters of the transmission structure, it is possible to access the analysis and synthesis modules of the computer program. These modules allow the realization of the circuit using all necessary data. Figure 10 shows a typical output of the frequency response module, including the admittances curves, attenuation and the return losses for each filter. The synthesis module derives the lumped



▲ **Figure 10. Frequency responses and admittance curves of the filters.**



▲ **Figure 11. Stripline triplexer design.**

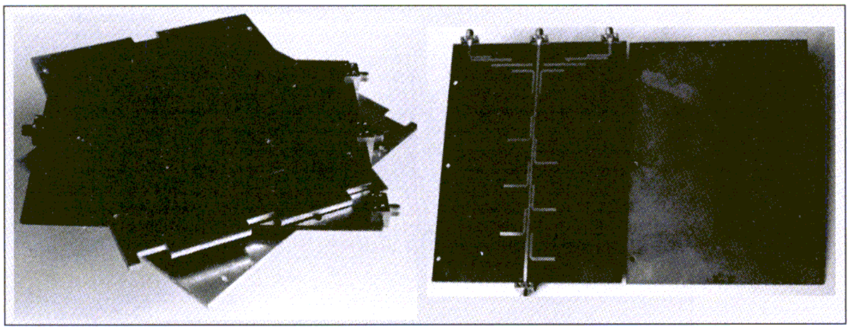
and distributed parameters. The program derives the isolated filters and then the interconnection network. A screen displaying the layout of a stripline triplexer is shown in Figure 11.

Experimental results

A triplexer with central frequency of 3.0 GHz and fractional bandwith of each channel of 2 percent was designed and tested. The design of the filters was realized by applying the exact synthesis theory followed by numerical techniques. The tuning was done using a computer-aided optimization process.

The triplexer was constructed using dielectric sheets with $\varepsilon_r = 2.17$, with ground planes having 3.048 mm spacing. A photograph of the device is shown in Figure 12; its performance is shown in Figure 13.

The insertion loss in the bandpass was approximate-



▲ Figure 12. Photographs of the complementary triplexer.

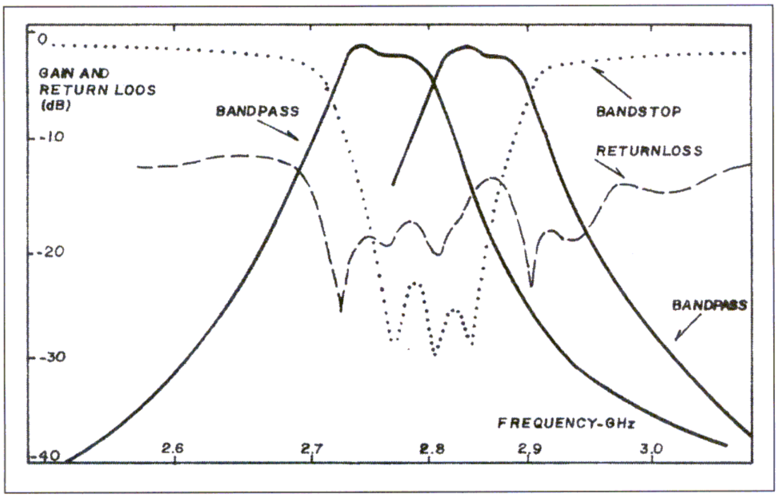
ly 1.5 dB and the crossovers occurred at 4.5 dB down. Stopband attenuation of more than 20 dB around 80 percent of the bandwidth was achieved. The measurements indicate a displacement of 7 percent at the center frequency. The return loss at frequencies outside the crossover region was worse due to the incomplete compensation of the interconnections and the loose coupling of the bandstop filter resonators.

Conclusion

A design procedure for multiplexers with contiguous channels was presented. A triplexer using filters connected in parallel was analyzed. The same approach can be used for triplexers with the filters connected in series.

A software which provides all the elements needed to the triplexer conception was implemented. The tool can be used as a starting point for optimization.

A stripline triplexer was realized and good agreement between the theoretical and experimental results was shown, which proved the efficiency of the complementary filters for the isolation of each channel. The triplexer solution compared to a diplexer has a reduced number of separating units and is therefore more compact. ■



▲ Figure 13. Insertion and return loss for the triplexer.

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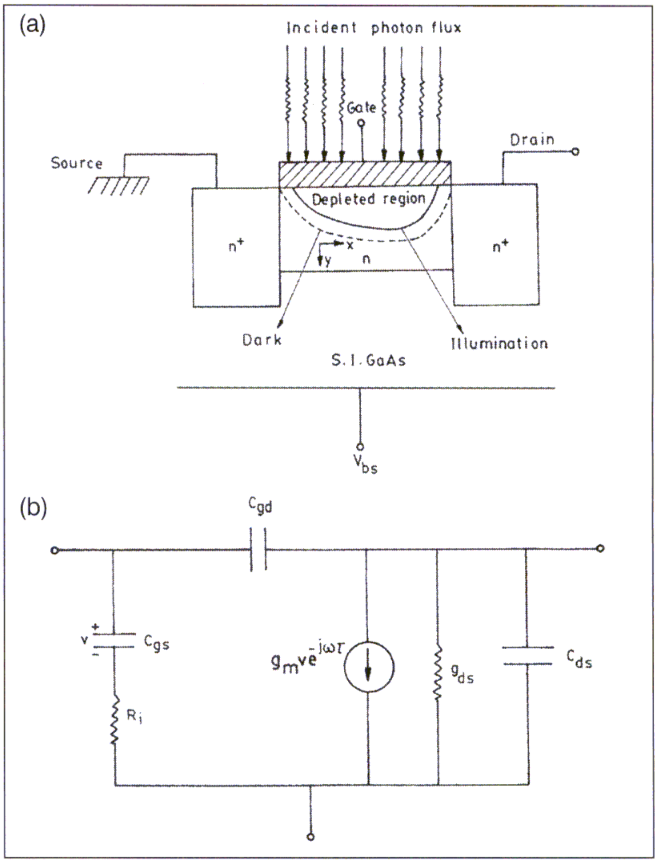
Circle 79

Unilateral Power Gain of an Optically Biased GaAs MESFET

By Srikanta Bose, Adarsh Gupta and R.S. Gupta
University of Delhi

The use of optical radiation to control the various functions and operations of gallium arsenide MESFETs has been the focus of intense research for several years. It has been shown that microwave characteristics of MESFETs can be controlled by incident optical radiation with photon energy greater than or equal to the bandgap energy in the same way as varying the gate bias in conventional electrically controlled MESFETs [1-6]. Optically biased FETs have many potential applications, such as high-speed optical detectors and converters for interaction of optical and microwave signals. The optimum noise figure of optically controlled GaAs MESFETs is lower than conventional MESFETs [5]. Therefore, high-speed, low cost, monolithically integrated optically gated GaAs MESFETs are in high demand for high-frequency application in optical communication systems.

This article discusses an analytical model that predicts the microwave characteristics of an optically biased GaAs MESFET. Admittance and scattering parameters are extracted and the unilateral power gain and maximum stable gain are evaluated; both show a significant improvement under illumination.



▲ **Figure 1. (a) Schematic structure of optically biased GaAs MESFET with active channel profile under dark (P_{opt} = 0) and illuminated conditions. (b) Equivalent circuit model for GaAs MESFET.**

Theoretical consideration

The schematic structure of an optically biased GaAs MESFET with active channel profile under dark and illuminated conditions is shown in Figure 1(a). Light radiation is allowed to fall on the gate metal along the vertical y-direction. The equivalent circuit model used to extract admittance and scattering parameters is shown in Figure 1(b).

The intrinsic *Y*-parameters for the optically biased GaAs MESFET in terms of equivalent circuit elements are given as: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CDPD
DAMPS
DCS1800
ECM
EDGE
EW
GEO
GPRS
GPS
GSM900
HFC
IFF
LEO
LMDS
LMR
MMDS
NPCS
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$$Y_{11} = \frac{R_i\left(qZL\left(F_1'' + F_2''\right) + \frac{\pi}{2}\varepsilon Z\right)^2 \omega^2}{1 + R_i^2\left(qZL\left(F_1'' + F_2''\right) + \frac{\pi}{2}\varepsilon Z\right)^2 \omega^2} + j\omega\left(\frac{qZL\left(F_1'' + F_2''\right) + \frac{\pi}{2}\varepsilon Z}{1 + R_i^2\left(qZL\left(F_1'' + F_2''\right) + \frac{\pi}{2}\varepsilon Z\right)^2 \omega^2} + qZL(F_1''' + F_2''') + \frac{\pi}{2}\varepsilon Z\right) \tag{1}$$

$$Y_{12} = -j\omega\left(qZL(F_1''' + F_2''') + \frac{\pi}{2}\varepsilon Z\right) \tag{2}$$

$$Y_{21} = \left(\frac{\left(\left(\frac{q\mu_n ZQ}{2L}\right)\left(-\frac{2}{3}F_1' - \frac{2}{3}F_2'\right) + \left(\frac{q\mu_n Z\phi\tau_n}{L}\right)\left(\frac{qN_{eq}}{\varepsilon\alpha}\right)F_{3'} + \left(\frac{q\mu_p Z}{L}\right)\left(\frac{R\tau_p}{a}\right)\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}} F_4'\right)\exp(-j\omega\tau)}{1 + jR_i\left(qZL\left(F_1'' + F_2''\right) + \frac{\pi}{2}\varepsilon Z\right)\omega}\right) - j\omega\left(qZL(F_1''' + F_2''') + \frac{\pi}{2}\varepsilon Z\right) \tag{3}$$

$$Y_{22} = g_{ds} + j\omega\left(C_{ds} + qZL(F_1''' + F_2''') + \frac{\pi}{2}\varepsilon Z\right) \tag{4}$$

where

$$F_1' = V_1\frac{3}{2}\left(2a_p\left(\frac{2N\alpha}{Q}\right)\left(\frac{2\varepsilon}{qN_a}\right)^{\frac{1}{2}}\frac{1}{2}\left(V_{bi} - V_{bs} + V_p\right)^{-\frac{1}{2}} - \frac{1}{V_1}\right) \times \left(\left(a_p^2 + \frac{V_{ds} - V_p}{V_1}\right)^{\frac{1}{2}} - \left(a_p^2 - \frac{V_p}{V_1}\right)^{\frac{1}{2}}\right) \tag{5}$$

$$F_2' = V_2\frac{3}{2}\left(-2\left(\alpha' + 1 - a_p\right)\left(\frac{2N_a}{Q}\right)\left(\frac{2\varepsilon}{qN_a}\right)^{\frac{1}{2}}\frac{1}{2}\left(V_{bi} - V_{bs} + V_p\right)^{-\frac{1}{2}} - \frac{1}{V_2}\right) \times \left(\left(\alpha' + 1 - a_p\right)^2 + \frac{V_{ds} - V_p}{V_2}\right)^{\frac{1}{2}} - \left(\left(\left(\alpha' + 1 - a_p\right)^2 + \frac{V_p}{V_2}\right)^{\frac{1}{2}}\right) \tag{6}$$

$$F_3' = \left(\frac{2\varepsilon}{qN_{eq.}}\right) \times \left(\frac{\alpha}{2}\right)\left(\exp\left(-\alpha\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}}\left(V_{bi}' + V_{ds} - V_{gs} - V_{op}\right)^{\frac{1}{2}}\right)\right) + \left(\exp\left(-\alpha\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}}\left(V_{bi}' - V_{gs} - V_{op}\right)^{\frac{1}{2}}\right)\right) + \left(\frac{q\mu_n Z\phi\tau_n}{L}\right)\left(\frac{qN_{eq.}}{\varepsilon\alpha}\right) \times \left(2\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}}\frac{1}{2\left(V_{bi}' - V_{gs} - V_{op}\right)^{\frac{1}{2}}}\right)\left(\exp\left(-\alpha\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}}\left(V_{bi}' - V_{gs} - V_{op}\right)^{\frac{1}{2}}\right)\right) \tag{7}$$

$$F_4' = \left(V_{bi}' + V_{ds} - V_{gs} - V_{op}\right)^{\frac{1}{2}} - \left(V_{bi}' - V_{gs} - V_{op}\right)^{\frac{1}{2}} \tag{8}$$

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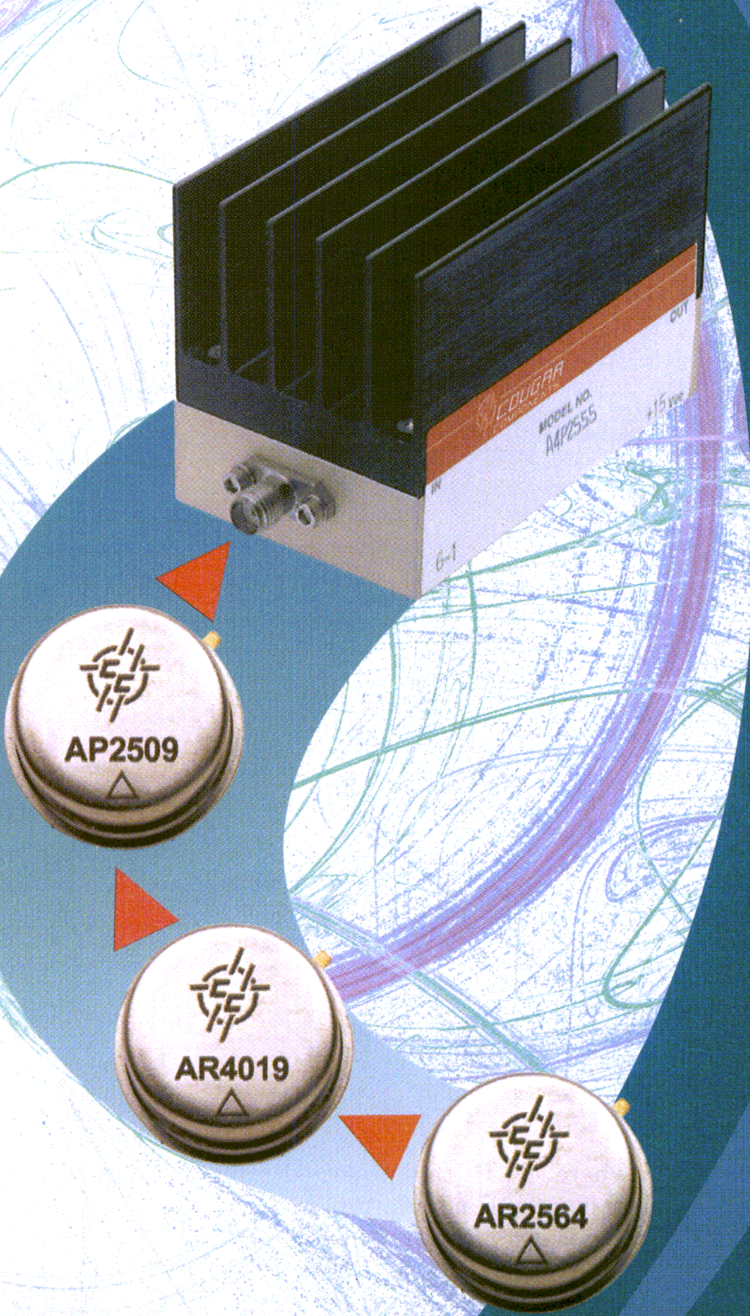

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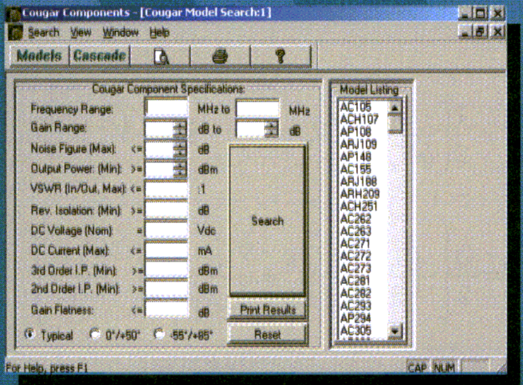

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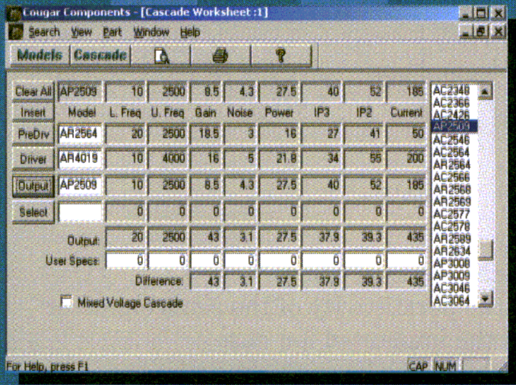

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$$F_1'' = \frac{Q}{2}\left(-\left(\frac{1}{2}\right)\left(a_p^{\,2} + \frac{V_{ds}-V_p}{V_1}\right)^{-\frac{1}{2}}\left(2a_p\left(\frac{2N_a}{Q}\right)\left(\frac{2\varepsilon}{qN_a}\right)^{\frac{1}{2}}\frac{1}{2}\left(V_{bi}-V_{bs}+V_p\right)^{-\frac{1}{2}} - \frac{1}{V_1}\right)\right) -$$
$$\frac{Q}{2}\left(-2\left(\alpha' + 1 - a_p\right)\left(\frac{2N_a}{Q}\right)\left(\frac{2\varepsilon}{qN_a}\right)^{\frac{1}{2}}\frac{1}{2}\left(V_{bi}-V_{bs}+V_p\right)^{-\frac{1}{2}} - \frac{1}{V_2}\right) \quad (9)$$

$$F_2'' = \frac{1}{2}\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}}\left(V_{bi}' + V_{ds} - V_{gs} - V_{op}\right)^{-\frac{1}{2}}\left(\phi\tau_n\alpha\left(\exp\left(-\alpha\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}}\left(V_{bi}' + V_{ds} - V_{gs} - V_{op}\right)^{\frac{1}{2}}\right)\right) - \frac{R\tau_p}{a}\right) \quad (10)$$

$$F_1''' = \frac{Q}{2}\left(-\left(\frac{1}{2}\right)\frac{1}{V_1}\left(a_p^{\,2} + \frac{V_{ds}-V_p}{V_1}\right)^{-\frac{1}{2}} - \frac{1}{V_2}\right) \quad (11)$$

$$F_2''' = \frac{1}{2}\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}}\left(V_{bi}' + V_{ds} - V_{gs} - V_{op}\right)^{-\frac{1}{2}} \times$$
$$\left(\phi\tau_n\alpha\left(\exp\left(-\alpha\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}}\left(V_{bi}' + V_{ds} - V_{gs} - V_{op}\right)^{\frac{1}{2}}\right)\right) - \frac{R\tau_p}{a}\right) \quad (12)$$

where

- q is the electron charge
- ε is the permittivity of the semiconductor
- Q is the implanted ion dose
- a is the active layer thickness
- N_a is the substrate doping concentration
- $N_{eq.}$ is the equivalent doping concentration
- ϕ is the incident photon flux
- $\tau_{n,p}$ is the life time of electron (hole)
- R is the surface recombination rate
- α is the absorption coefficient per unit length
- V_{gs} is the gate to source voltage
- V_{ds} is the drain-source voltage
- V_{bs} is the substrate to source voltage
- V_{bi}' is the built in potential at Schottky gate contact
- V_{op} is the photovoltage developed at the Schottky junction due to illumination
- $\mu_{n,p}$ is the electron (hole) mobility
- Z is the device width
- L is the gate length
- R_i is the charging resistance
- V_{bi} is the built in voltage

and

$$V_1 = \frac{qQ^2}{8N_a\varepsilon}$$

$$V_2 = \frac{qQ\sigma}{\sqrt{2\pi}\,\varepsilon}$$

$$a_p = \frac{2N_a}{Q}\sqrt{\frac{2\varepsilon}{qN_a}\left(V_{bi}-V_{bs}+V_p\right)}$$

and

$$\alpha' = \frac{R_p}{2\sigma}\sqrt{\frac{\pi}{2}}$$

where R_p is the projected range parameter of the implanted Gaussian profile and σ is the straggle parameter of the implanted Gaussian profile, V_p is the pinchoff voltage, g_{ds} is the device output conductance, C_{ds} is the drain-source capacitance, $\omega = 2\pi f$, Y_{11} and Y_{22} are the input and output admittance parameters, Y_{12} is the reverse transfer admittance parameter and Y_{21} is the forward transfer admittance parameter.

The corresponding S-parameters for optically biased GaAs MESFET are

$$S_{11} = \frac{A_1^- B_1^+ + C_1}{A_1^+ B_1^- - C_1} \quad (13)$$

$$S_{12} = \frac{D_1}{A_1^+ B_1^- - C_1} \quad (14)$$

$$S_{21} = \frac{E_1}{A_1^+ B_1^- - C_1} \quad (15)$$

$$S_{22} = \frac{A_1^+ B_1^- + C_1}{A_1^+ B_1^- - C_1} \quad (16)$$

where

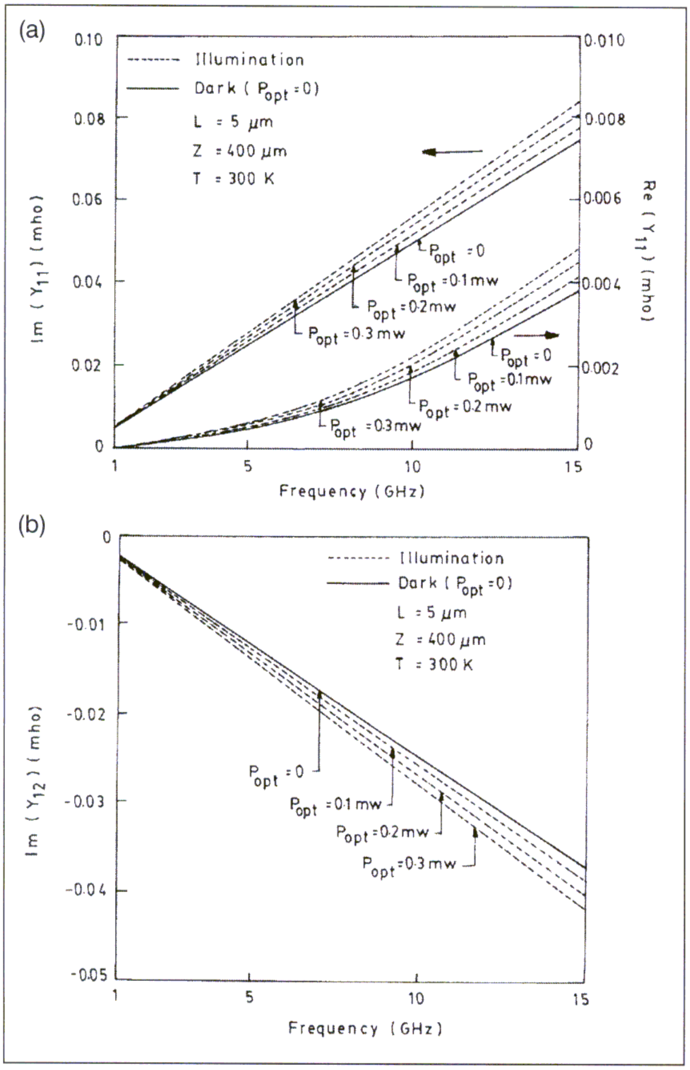
$$A^{\pm}{}_1 = 1 \pm \frac{R_i\left(qZL(F_1'' + F_2'') + \frac{\pi}{2}\varepsilon Z\right)^2 \omega^2}{1 + R_i^2\left(qZL(F_1'' + F_2'') + \frac{\pi}{2}\varepsilon Z\right)^2 \omega^2} \pm j\omega\left(\frac{qZL(F_1'' + F_2'') + \frac{\pi}{2}\varepsilon Z}{1 + R_i^2\left(qZL(F_1'' + F_2'') + \frac{\pi}{2}\varepsilon Z\right)^2 \omega^2} + qZL\left(F_1''' + F_2'''\right) + \frac{\pi}{2}\varepsilon Z\right) \quad (17)$$

$$B^{\pm}{}_1 = 1 \pm g_{ds} \pm j\omega\left(C_{ds} + qZL\left(F_1''' + F_2'''\right) + \frac{\pi}{2}\varepsilon Z\right) \quad (18)$$

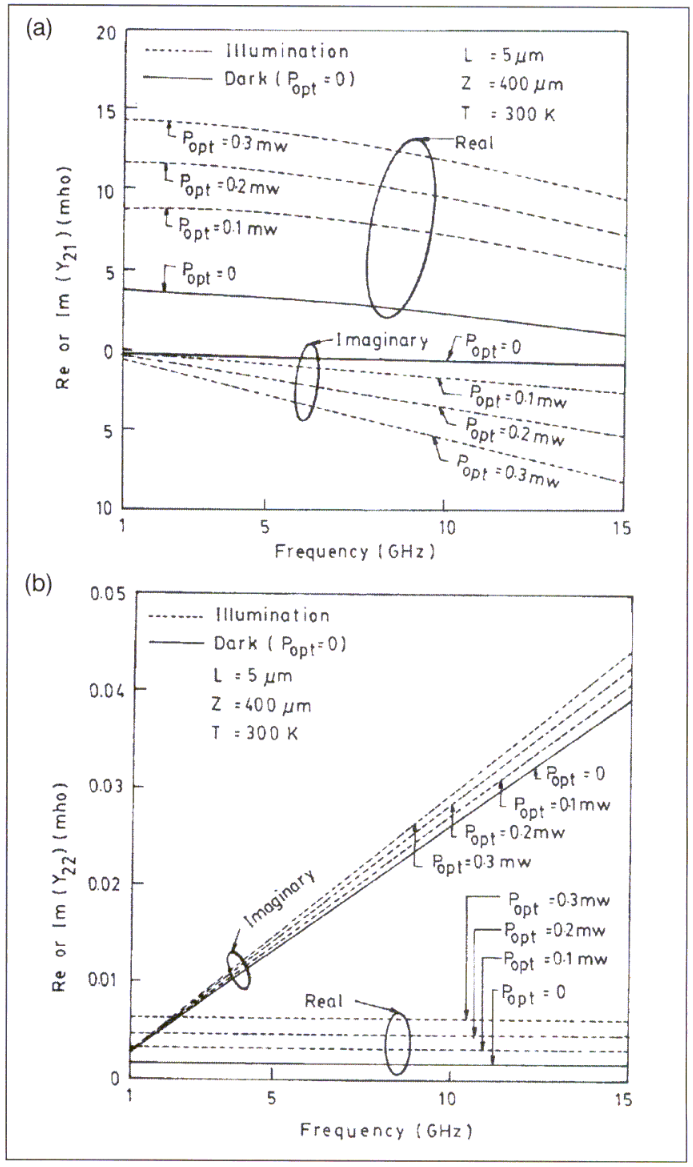
$$C_1 = -jw\left(qZL\left(F_1''' + F_2'''\right) + \frac{\pi}{2}\varepsilon Z\right) \times \left(\frac{\left(\frac{q\mu_n ZQ}{2L}\left(-\frac{2}{3}F_1' - \frac{2}{3}F_2'\right) + \left(\frac{q\mu_n Z\phi\tau_n}{L}\right)\left(\frac{qN_{eq.}}{\varepsilon\alpha}\right)F_3' + \left(\frac{q\mu_p Z}{L}\right)\left(\frac{R\tau_p}{a}\right)\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}} F_4'\right)\exp(-j\omega\tau)}{1 + jR_i\left(qZL(F_1'' + F_2'') + \frac{\pi}{2}\varepsilon Z\right)\omega}\right) - \omega^2\left(qZL\left(F_1''' + F_2'''\right) + \frac{\pi}{2}\varepsilon Z\right)^2 \quad (19)$$

$$D_1 = 2j\omega\left(qZL\left(F_1''' + F_2'''\right) + \frac{\pi}{2}\varepsilon Z\right) \quad (20)$$

$$E_1 = -2 \times \left(\frac{\left(\frac{(q\mu_n ZQ)}{2L}\left(-\frac{2}{3}F_1' - \frac{2}{3}F_2'\right) + \left(\frac{q\mu_n Z\phi\tau_n}{L}\right)\left(\frac{qN_{eq.}}{\varepsilon\alpha}\right)F_3' + \left(\frac{q\mu_p Z}{L}\right)\left(\frac{R\tau_p}{a}\right)\left(\frac{2\varepsilon}{qN_{eq.}}\right)^{\frac{1}{2}} F_4\right)\exp(-j\omega\tau)}{1 + jR_i\left(qZL(F_1'' + F_2'') + \frac{\pi}{2}\varepsilon Z\right)\omega}\right) + 2j\omega\left(qZL\left(F_1''' + F_2'''\right) + \frac{\pi}{2}\varepsilon Z\right) \quad (21)$$



▲ **Figure 2. (a) Input admittance parameter variation with frequency under dark (P_{opt} = 0) and illuminated conditions [$Q = 1.5 \times 10^{16}$ /m², $R_p = 8.61 \times 10^{-8}$ m, $\sigma = 3.83 \times 10^{-8}$ m, $\lambda = 0.827 \times 10^{-6}$ m, $a = 0.25$ μm, $R_i = 2.69\ \Omega$, $N_a = 10^{20}$/m³, $k_n = 3.1 \times 10^{-15}$ m³/s, $k_p = 3.1 \times 10^{-17}$ m³/s]. (b) Reverse transfer admittance parameter variation with frequency under dark (P_{opt} = 0) and illuminated conditions.**



▲ **Figure 3. (a) Forward transfer admittance parameter variation with frequency under dark (P_{opt} = 0) and illuminated conditions. (b) Output admittance parameter variation with frequency under dark (P_{opt} = 0) and illuminated conditions.**

The unilateral power gain (UPG) and maximum stable gain (MSG) are calculated using the relation

$$U = \frac{|Y_{21} - Y_{12}|^2}{4[\mathrm{Re}(Y_{11})\mathrm{Re}(Y_{22}) + \mathrm{Re}(Y_{12})\mathrm{Re}(Y_{12})]} \qquad (22)$$

$$MSG = \frac{|S_{21}|}{|S_{12}|} \qquad (23)$$

Results and discussion

Figures 2 and 3 show the variation of admittance parameters with frequency under dark and illuminated conditions. Figure 2(a) shows that under the illuminated condition, Y_{11} improves when the device is exposed to light radiation and a photovoltage is developed across the Schottky junction. This voltage effectively reduces the barrier height, and the depletion layer width decreases. The channel width increases reducing the channel resistance and increasing the channel conductance. The same trend is observed in other Y-parameters. The parameter Y_{21}, which primarily determines the gain of the device, shows a significant enhancement when illuminated, as shown in Figure 3(a).

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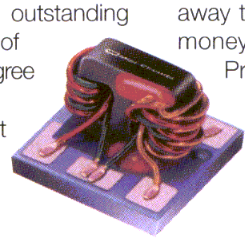

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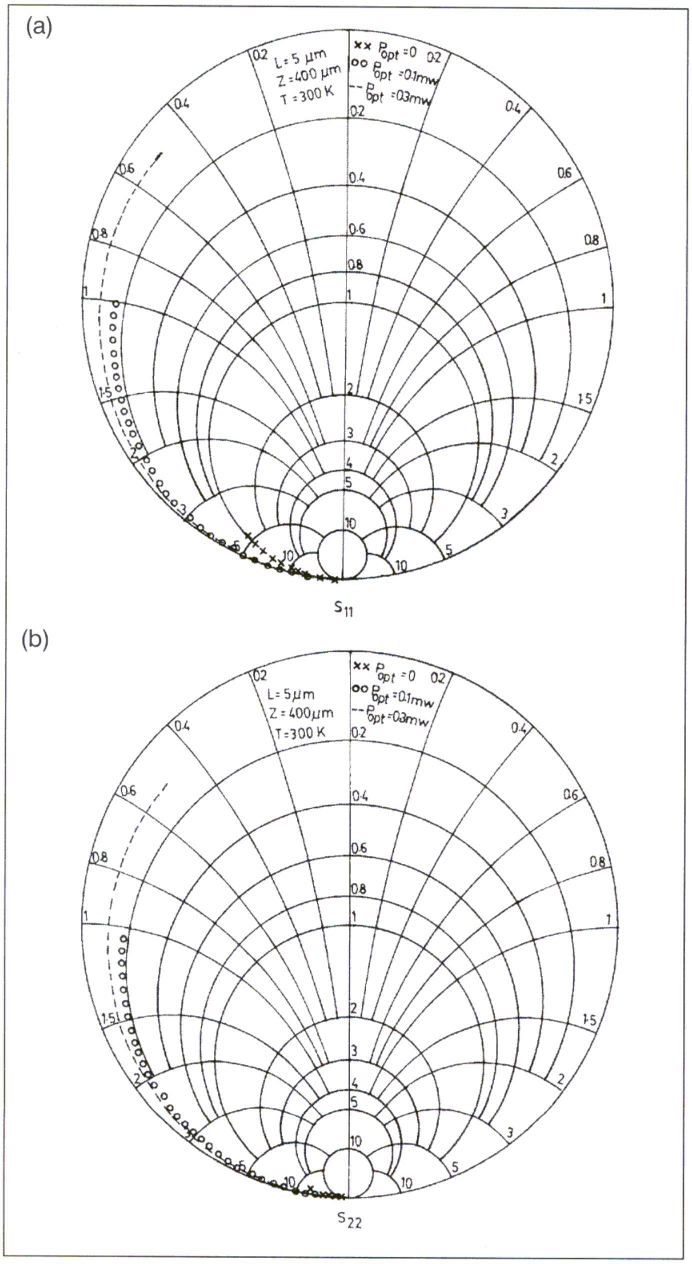
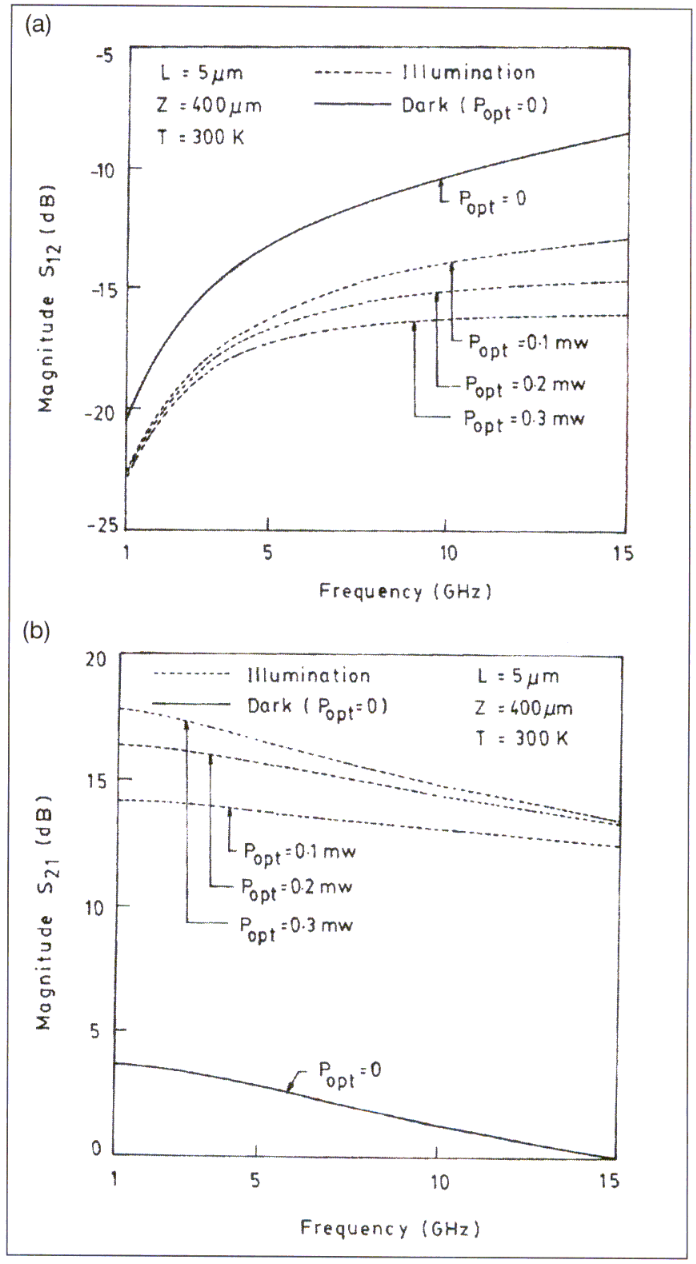


▲ **Figure 4. (a) Input reflection coefficient variation with frequency under dark (P_{opt} = 0) and illuminated conditions. (b) Output reflection coefficient variation with frequency under dark (P_{opt} = 0) and illuminated conditions.**



▲ **Figure 5. (a) Reverse transmission coefficient variation with frequency under dark (P_{opt} = 0) and illuminated conditions. (b) Forward transmission coefficient variation with frequency under dark (P_{opt} = 0) and illuminated conditions.**

Figures 4 and 5 show the variation of scattering parameters under dark and illuminated conditions. The reflection coefficients S_{11} and S_{22} are plotted on the Smith chart in Figure 4, which iillustrates the improvement in loss under illumination. Figure 5(a) shows that the reverse transmission coefficient S_{12}, is smaller under illumination compared to when under dark condition. The forward transmission coefficient S_{21} shows an almost 10 dB improvement under illumination (for example, for P_{opt} = 0.1 mW), as shown in Figure 5(b). The cause for this change is mainly the transconductance of the device, which increases under illumination [5].

Figure 6 shows the variation of unilateral power gain with frequency under dark and illuminated conditions. For a given frequency, the UPG of the device increases significantly under illumination compared to dark condition. The MSG shown in inset also behaves in a similar fashion.

Conclusion

An analytical model has been developed to predict microwave characteristics of optically biased GaAs MESFET. The admittance and scattering parameters are evaluated analytically. The plots show that there is a noteworthy change in admittance and scattering parameters of the device under illumination. A significant improvement in UPG and MSG for the device is observed under illumination. Optically biased GaAs MESFETs promise potential for optical communication systems.

Acknowledgement

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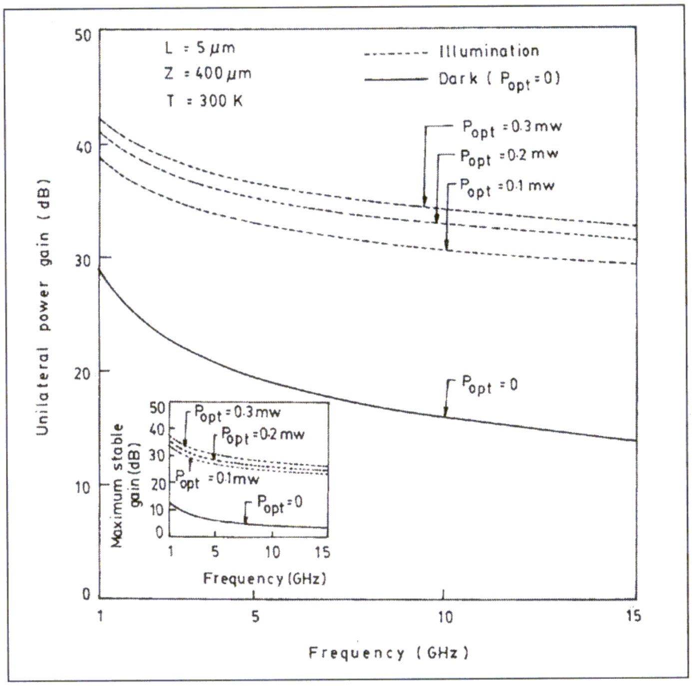

Figure 6. Unilateral power gain and maximum stable gain (inset) variation with frequency under dark (P_{opt} = 0) and illuminated conditions.

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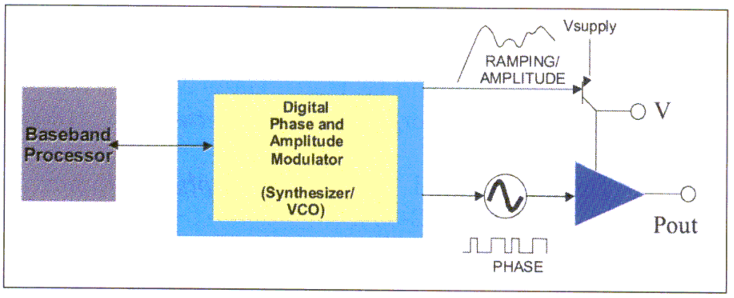
Digital Multimode Technology Redefines the Nature of RF Transmission

With each innovation in the wireless industry to improve capacity, increase data rates and provide higher quality of service to the consumer, the hardware needed to enable these improvements becomes increasingly complex. The advent of third generation standards (3G) has created new demands on current technology that are stretching capabilities beyond their limits. Without new approaches to meet these challenges, hardware systems designed to deliver new technologies will be extremely complex, costly and unreliable.



▲ **Figure 1. Tropian's Polar Impact modulation overview.**

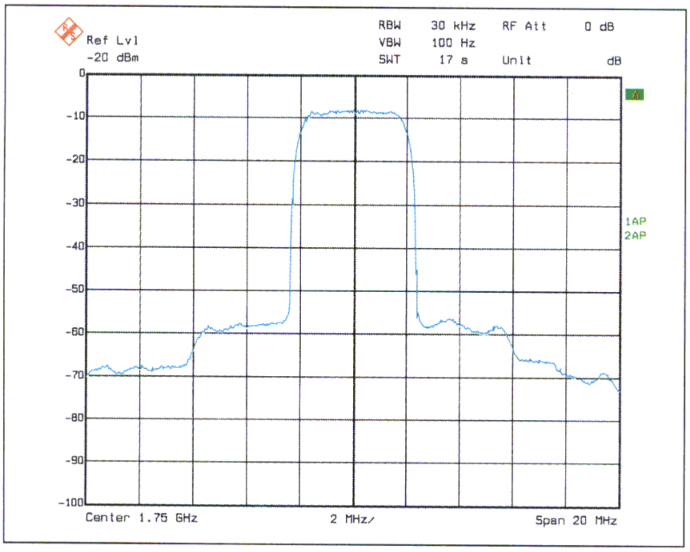
This article will detail the development of digital Polar Impact™ technology by Tropian. Various capabilities enabled by Polar Impact are presented, along with implementation considerations to optimize the robustness of this design approach. At the same time, a comparison is made between Tropian's polar modulation approach and conventional methods of power amplification currently used in the industry. An analysis is then made of various commercial applications for polar modulation and its potential impact on the communications industry. Finally, a new handset product, TimeStar™ is introduced; this is a two-chip transmitter solution that offers significant performance advantages over conventional quadrature modulation/linear amplification approaches.

A new definition for power generation

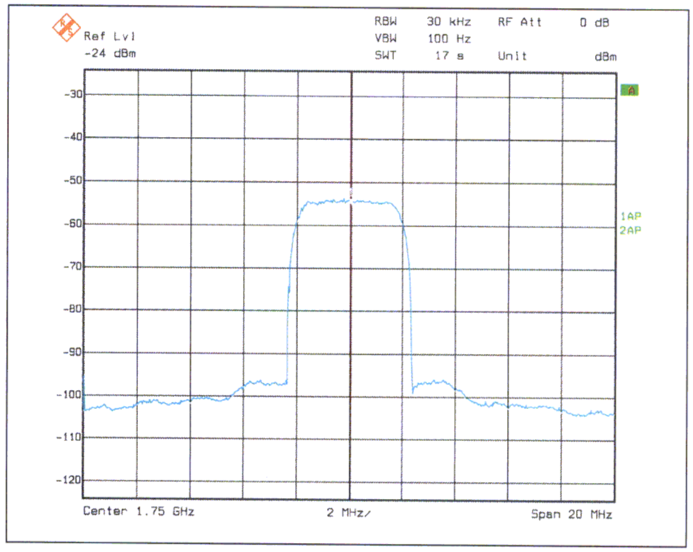
The Tropian alternative provides a complete system for power generation, combining the traditional functions of transmitter and PA into a single homogeneous solution. Features include:

- Multi-mode capability supporting UMTS, GSM, EDGE, AMPS and ANSI-136;
- Extensibility from handset to base station power levels;
- All-digital solution, eliminating the need for external devices to switch between modulation modes;
- High level of spectral purity;
- Power amplifier operated in compression, providing improved PA stability over temperature, supply, load and frequency variations;
- Loop bandwidth digitally adjusted, allowing for support of different modulation modes and consistent loop performance;
- Power control implemented via digital control, with no complicated analog control systems needed;
- Fabrication using standard bulk CMOS process.

No IQ modulator is used in the Tropian Polar Impact modulation solution. Using proprietary architecture, the signal is split into separate amplitude and phase paths (see Figure 1). Phase information digitally controlls an on-channel VCO, which drives the gate/base of the PA. The

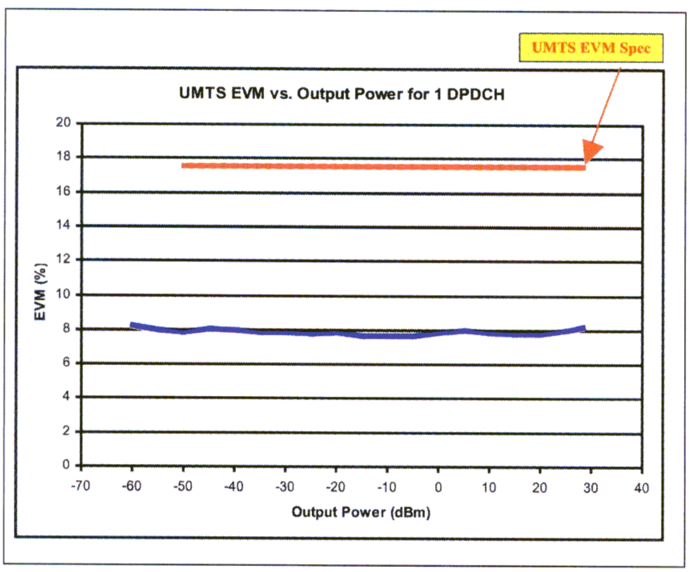


▲ **Figure 2. Power control for a handset UMTS signal where output power is +28 dBm. ACLR = –50 dBc (±5 MHz), –60 dBc (±10 MHz).**



▲ **Figure 3. Power control for a handset UMTS signal where output power is –50 dBm. ACLR = –41 dBc (±5 MHz), –48 dBc (±10 MHz).**

amplitude information is used to modulate the drain/collector of the output power transistor. Support for burst timing and power ramp control is provided to comply with ANSI and ETSI specifications. The power amplifier is driven into heavy compression, acting in a switched mode configuration. Output power is therefore directly proportional to the amplitude signal modulating the drain/collector. This signal not only transfers the information for non-constant envelope modulations such as EDGE and ANSI-136 but also provides an accurate means for power level control. Controlling power in this fashion provides a simple and robust alternative to others forms of control that rely on diode detectors subject



▲ **Figure 4. UMTS error vector magnitude versus output power with more than 8 percent margin to spec across all power levels.**

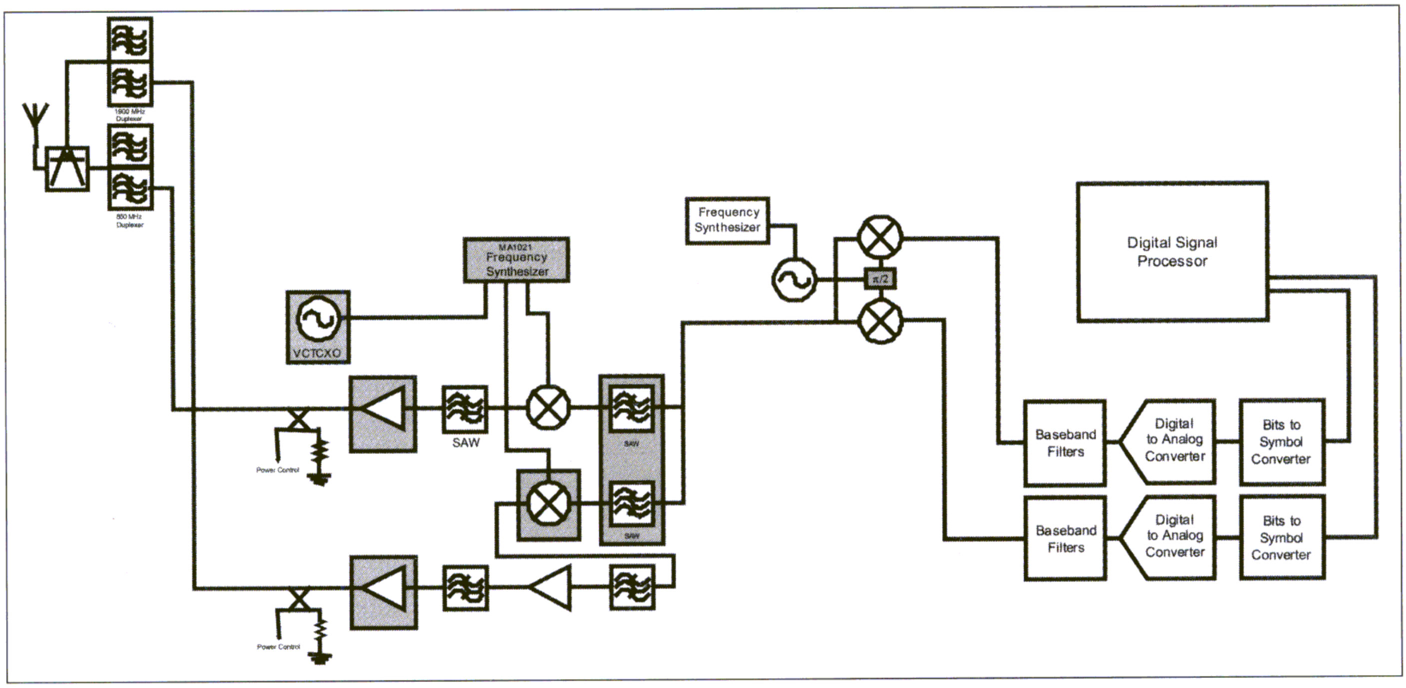
to parts variation, temperature drift and dynamic range limitations. Figures 2 and 3 depict Polar Impact power control for a handset UMTS signal. More than 80 dB dynamic range can be attained with excellent ACLR. For all power levels, error vector magnitude (EVM), one of the most widely used modulation quality metrics in digital communications, remains below 8.5 percent (the spec is 17.5 percent). This is shown in Figure 4.

Digital processing enables multimode capability

Given the proliferation of various modulation standards throughout the world, cellular consumers are often denied service as they roam between different geographical areas. These problems are particularly acute in the North American market, where AMPS, ANSI-136, GSM and IS-95 are prevalent. Limitations stem from the use of traditional superhet transmitter designs that are employed in most handsets in use today.

A typical superhet transmitter is shown in Figure 5. In most designs of this type, several upconverting mixers are used to translate frequencies from baseband to RF. In this process, narrowband SAW filters are used to attenuate various spurious signals generated by the mixers while also driving the noise floor generated by the IQ modulator down to acceptable levels. Given that each modulation standard, such as ANSI-136 and GSM, operates under a different bandwidth, providing multimode capability becomes expensive, complex and difficult to accomplish, given the real estate constraints in most handset designs.

Through digital processing of the transmit signals, Tropian overcomes these limitations to provide a true multimode capable solution. By changing a digital command, EDGE, ANSI-136, GSM or AMPS can be trans-



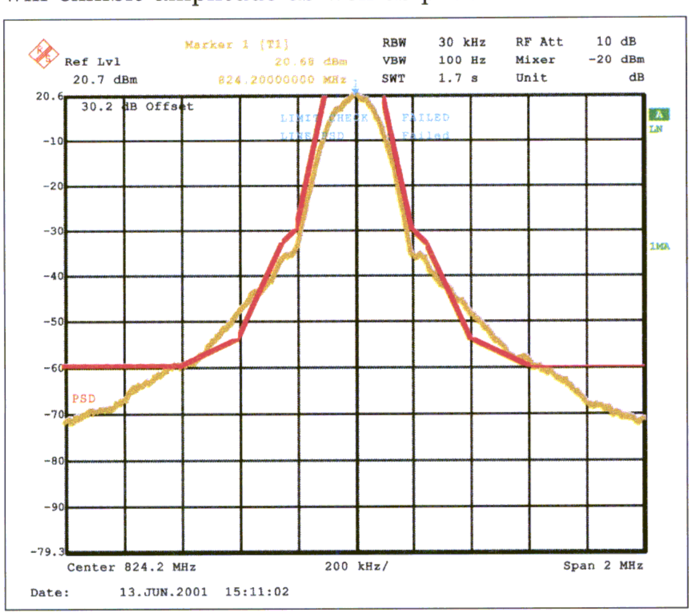
▲ **Figure 5. Typical superhet transmitter design for handsets.**

mitted by the same chipset with minimal impact on PA efficiency. This provides an excellent opportunity for network operators to expand roaming capabilities offered to customers. True multimode capability also makes Tropian's Polar Impact solution ideal for the GAIT market, enabling both ANSI-136 and GSM capability from the same handset. UMTS is currently being added to this portfolio of capabilities.

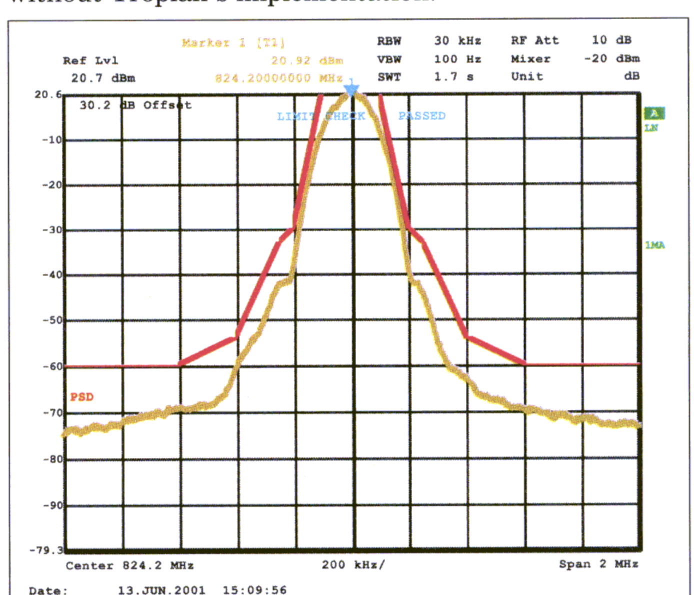
Solving switch-mode PAs for complex envelope signals

Any amplifier, when driven into heavy compression, will exhibit amplitude as well as phase distortion. The latter is usually characterized by a change in the transfer characteristic of the signal's phase as a function of drive level. This occurs when input elements of the transistor, both reactive and resistive, become a function of input drive. Distortion effects such as AM/AM and AM/PM will cause spectral regrowth and error vector magnitude problems.

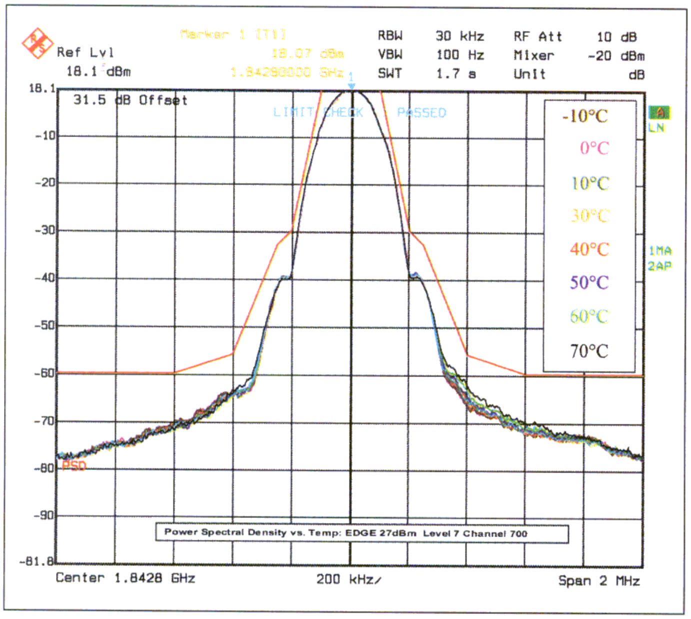
To overcome these effects, Tropian has developed a proprietary solution that digitally controls the phase and amplitude components of the signal. Figures 6 and 7 depict the power spectral density (PSD), with and without Tropian's implementation.



▲ **Figure 6. EDGE PSD showing effects of PA.**



▲ **Figure 7. EDGE PSD after Polar Impact.**



▲ **Figure 8. PSD for the base station solution, measured from –10 degrees C to +70 degree C.**

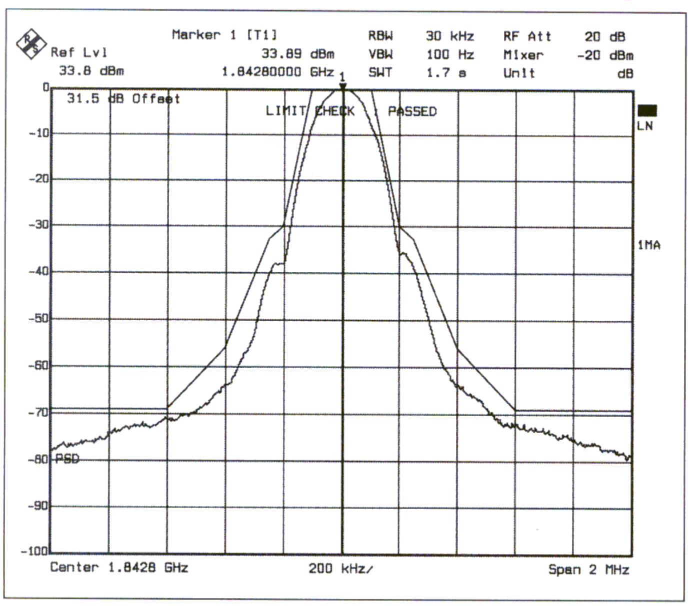
An important benefit derived by compressing the PA is the relative insensitivity of output power to variations in temperature, supply and so on. Transistor parameters such as *Vbe*, *Vt*, f_T and beta are relatively invariant when the PA is saturated. This allows the Tropian transmit system to be operated open-loop while still meeting specifications with margin over all power level changes, temperature extremes and other variations. To illustrate this relative insensitivity to variation, Figure 8 shows the PSD of an EDGE signal measured from –10 degrees C to +70 degrees C.

Very little change was also noted at cold temperatures. Operating in an open-loop configuration is not only more efficient — due to power not being coupled from the output — but also represents a more manufacturable solution.

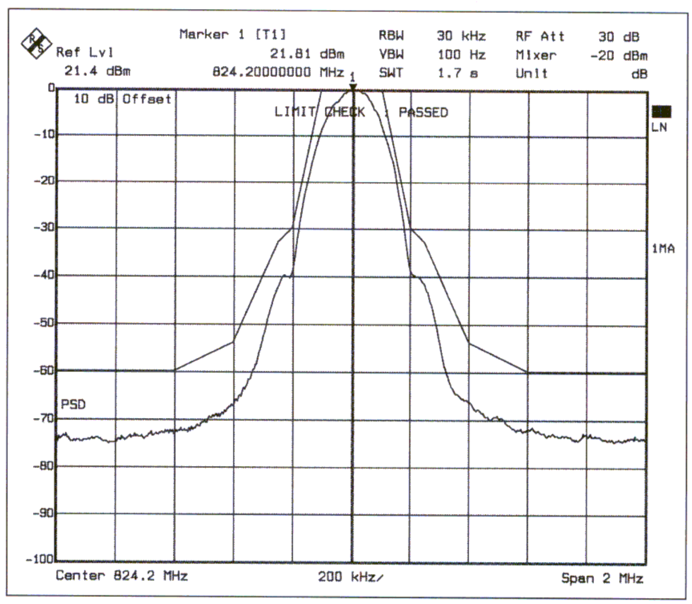
Compliance with specifications

A significant benefit presented by Tropian's digital power transmission solution is the extensive margin provided to the specifications in all modes. Any increase in the overall margin to spec translates directly into improved manufacturing yield and ultimately into lower cost of ownership. A secondary benefit of providing good spec margin is the result of fewer dropped calls due to interference from transmitters operating in adjacent channels. Also, in systems employing spread spectrum modulation such as W-CDMA, call capacity is directly proportional to the presence of noise in alternate frequency channels. Again, carrier capacity is increased with a reduction in adjacent channel interference. Typical power spectral density measurements using an EDGE signal are shown in Figures 9 and 10. Figure 9 shows a high power (20-watt) EDGE PSD plot taken from Tropian's base station hardware, while Figure 10 shows the 1-watt EDGE PSD for a handset.

An important advantage with the use of Polar Impact in meeting such specs is the consistency shown from unit-to-unit measurements. This results in a low standard deviation and improved C_{pk} (process capability). This consistency is derived from the use of digital processing of the signal from baseband through the PA. Using standard CMOS, much of the variation seen in traditional superhet transmitter designs is eliminated. Changes occurring due to temperature, supply variation and power level change are virtually nonexistent in the digital world.



▲ **Figure 9. EDGE PSD for a GSM 1800 base station at 20 watts.**



▲ **Figure 10. EDGE PSD for a GSM 1800 handset at 1 watt.**

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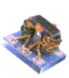

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12dB	DBTC-12-4	5-1000	0.7	21
13dB	DBTC-13-4	5-1000	0.7	18
13dB	DBTC-13-5-75	5-1000	1.0	19
		1000-1500	1.4	17
16dB	DBTC-16-5-75	5-1000	1.0	21
		1000-1500	1.3	19
17dB	DBTC-17-5	50-1000	0.9	20
		1000-1500	1.0	20
		1500-2000	1.1	14
18dB	DBTC-18-4-75	5-1000	0.8	21
20dB	DBTC-20-4	20-1000	0.4	21

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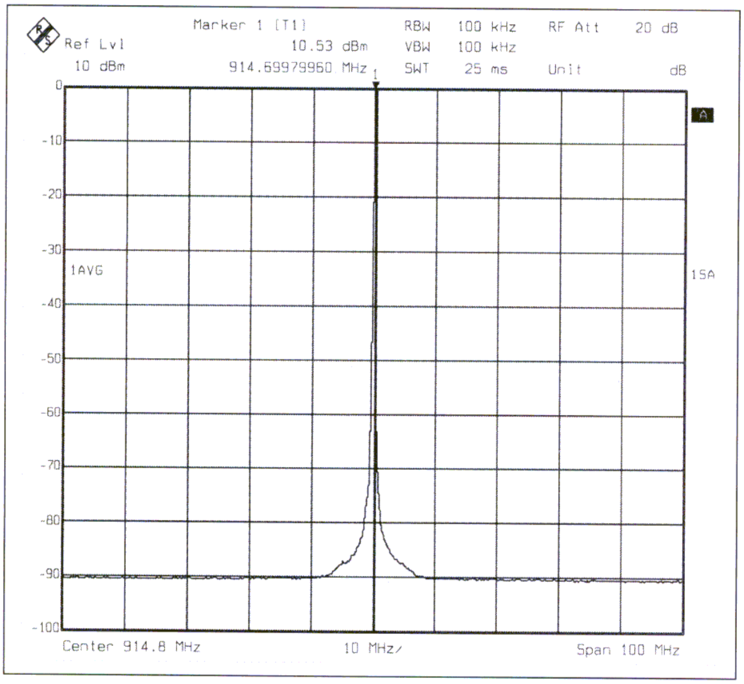
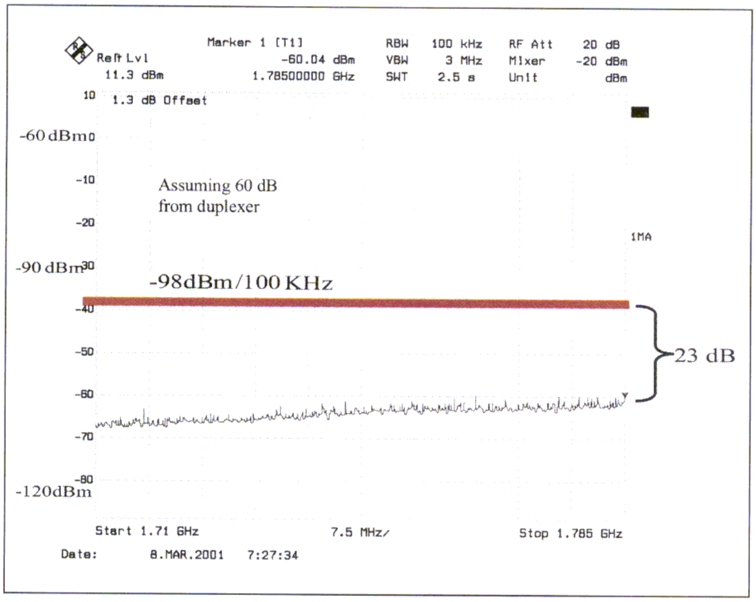


▲ **Figure 11. Handset broadband spectral purity.**

Tropian's implementation of polar modulation does not use upconverting mixers to translate low IF frequencies to RF levels. This results in the elimination of spurious signals generated by these mixers and their subsequent amplification throughout the transmit chain. A typical plot showing the broadband spectral purity of a Tropian handset design is shown in Figure 11. The carrier is centered at 914.6 MHz with a frequency span of 100 MHz (100 kHz measurement filter). A more than 90 dB spur-free dynamic range is exhibited, with the actual noise level limited by the floor of the spectrum analyzer.



▲ **Figure 12. Receive band noise for BTS design.**

The clean spectrum also benefits the base station manufacturer. Figure 12 shows receive band noise measurements for a base station application. Using a 100 kHz measurement filter and an assumed suppression of 60 dB from the duplexer, more than 23 dB of margin to spec is achieved.

With such margins, base station manufacturers will have the opportunity to perform tradeoffs between spec margin and duplexer suppression. This provides the ability to reduce duplexer costs and minimize insertion loss, thus improving efficiency.

Signal quality is another figure of merit for the quality of a transmit solution. The parameter of interest is EVM. Typical EVM numbers for both handset and base station designs remain under 3 percent rms.

Polar Impact advantage: No PA linearization

With nonconstant envelopes used in 2.5G and 3G standards, various forms of linearization have traditionally been employed in the base station market to ensure signal integrity. Commonly used types of linearization schemes include Cartestian, predistortion and feed-forward. As crest factors increase in modulation types such as W-CDMA as well as with multicarrier signals, feedforward linearization (sometimes combined with predistortion) has become the primary method for distortion correction. State of the art technology merely looks at new ways of implementing feedforward architecture without addressing fundamental problems inherent with such complicated and expensive solutions. A typical feedforward system is shown in Figure 13.

Feedforward also suffers from manufacturability problems given variations in PA gain and phase characteristics, use of delay lines, and power detection problems. This results in lengthy factory calibration procedures before deployment. The complexity of this and other linearization systems also limits factory yield and is often a source of failure in the field.

By comparison, the Polar Impact solution is shown in Figure 14. By eliminating much of the complexity involved in linearization, the Tropian solution is able to minimize the need for expensive factory calibration, troubleshooting and rework. This directly translates into improved yields and an overall more manufacturable design.

Other applications

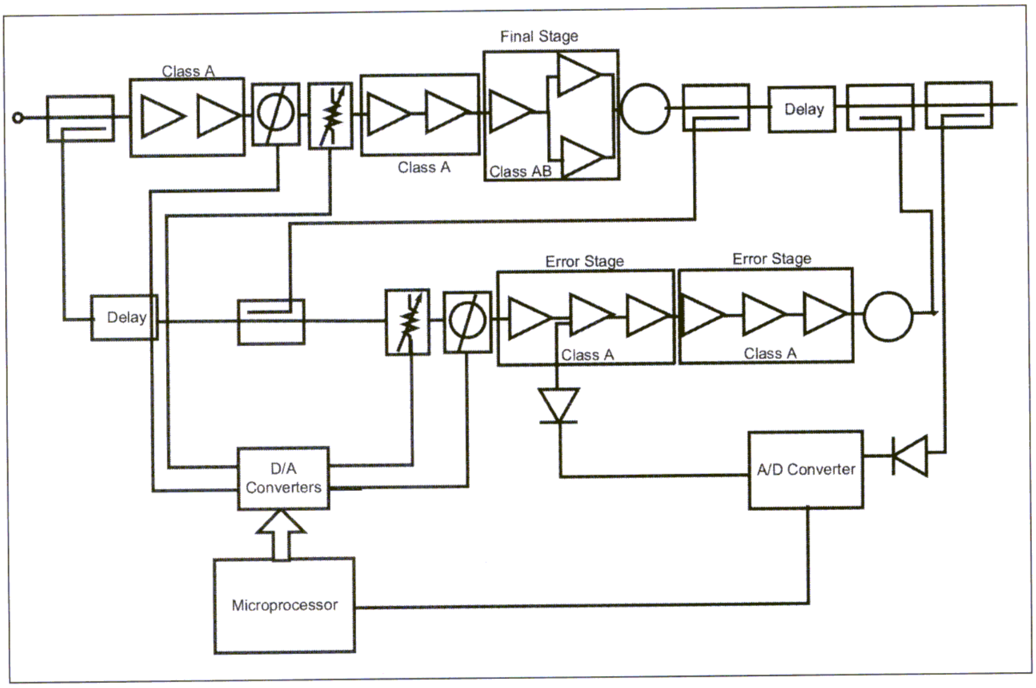
Polar Impact technology may also be used in the following applications:

- µCellular and picoCellular base stations
- Wireless Local Loop
- PBX
- Cellular repeaters

- Wireless LAN
- DSL
- Test equipment market
- Professional Mobile Radio

This list is by no means comprehensive. Other applications are now under examination for the benefits that Tropian's polar modulation technology could provide.

One such technology under active development is a Professional Mobile Radio (PMR) product called TETRA (Terrestial Trunked Radio). This is a new European standard for professional mobile radio users enabling voice and data transfer while providing cost-effective, secure and spectrum efficient communications. To coexist with other standards operating in the same frequencies of operation, adjacent channel power specifications for TETRA are extremely demanding — on the order of 60 dBc. Most conventional approaches to solving this challenge have been inadequate at best. With Polar Impact, the primary limitation to achieving these ACP specs is the phase noise of the on-channel VCO. The high costs associated with linearization circuit complexity are eliminated. A solution is provided that is stable, manufacturable and more efficient than competing solutions.



▲ **Figure 13. Schematic of a common type of feedfoward linearization system.**

TimeStar$_{TX}$™

Incorporating Polar Impact technology for cellular handset applications, TimeStar$_{TX}$ is a complete transmitter chain taking baseband input and producing RF output power. This modulator/power amplifier chipset is a cost-effective, compact solution for GAIT, GAIT/EDGE, GSM/EDGE/GPRS and D-AMPS cell phones, wireless modems and connected PDAs. All bursting and ramping profiles for each standard have been digitally implemented in the modulation and power control hardware. System development time can therefore be significantly reduced due to this all-inclusive architecture.

TimeStar also exceeds all ETSI/ANSI requirements for signal quality and produces specification-compliant RF signals compatible with existing base station receivers. UMTS capabilities for the TimeStar solution are in development.

Conclusion

With the proliferation of the various standards, frequencies and power levels used to enable wireless communications, a need is developing to produce a comprehensive solution that can accommodate these different requirements. The limitations inherent with hardware approaches to the problem are apparent. A pure digital solution that is truly capable of multimode and multifrequency operation is needed. The Polar Impact approach offers this capability while providing dramatic improvements in system performance. ■

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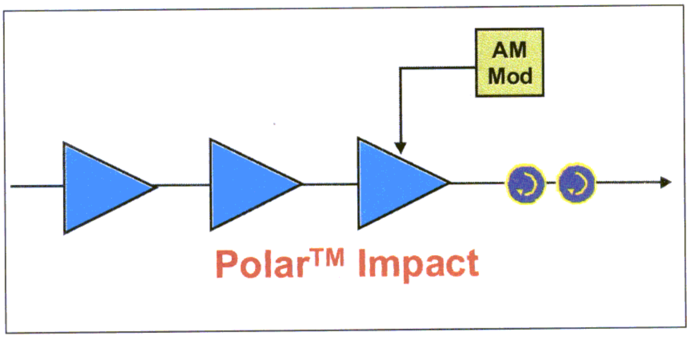


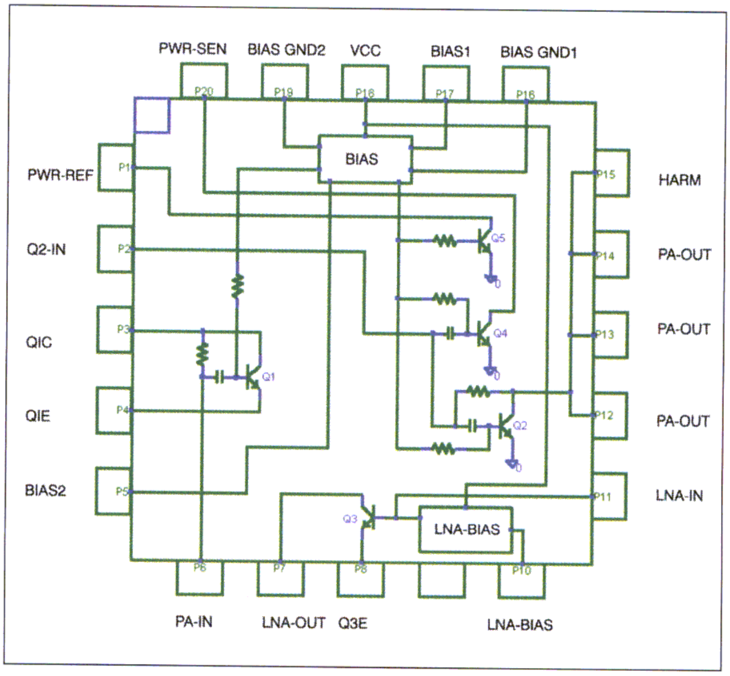
▲ **Figure 14. Polar Impact solution, with no linearization required.**

A General Purpose LNA/PA for Linear and Saturated Applications

By Dave Dening
RF Micro Devices

The RF2910 power amplifier was designed as a low-cost gallium arsenide HBT solution for portable applications that require up to 33 dBm saturated power or an equivalent linear power performance with appropriate backoff. The RF2911 power amplifier was designed for saturated applications, such as GSM. Both the LNA and PA may be tuned over a conservative frequency range of 100 MHz to 1 GHz. The amplifier combinations are packaged in a small footprint 4 × 4 mm, 20-pin package to minimize board space.

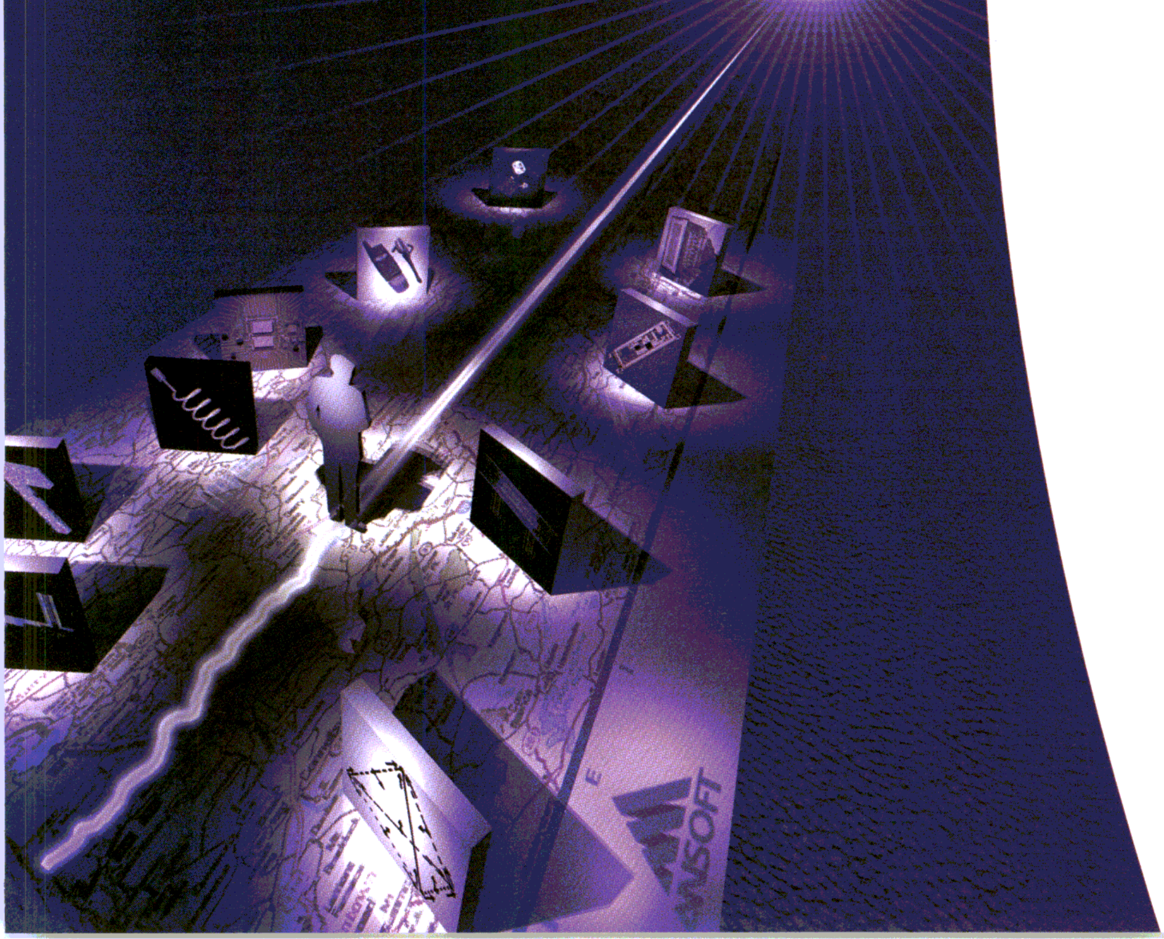
The key to the wide tuning range is breaking the power amplifier between the stages and providing external access. The low parasitic inductance provided by the package allows a reasonably low Q interstage match. The end user can then tailor the load and various matching networks to the specific application.

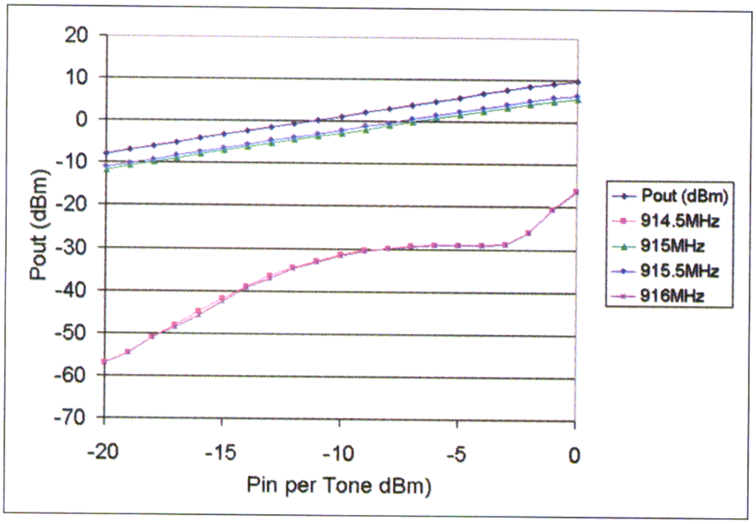


▲ **Figure 1. RF2910 block diagram and package pin-out.**

The limits to the tuning range are not absolute. The bottom limit of 100 MHz is recommended due to the size of the blocking capacitors for the power amplifier output stages. As the frequency decreases, the impedance of these capacitors increases. While this increased impedance can be accommodated in the matching network, the effect is to limit the usable bandwidth. The positive side of this effect is that the gain also increases with reduced frequency so that higher interstage impedances can be tolerated. The recommended upper frequency limit is determined by the gain and the ability to realize a useful interstage and output impedance. The 1 GHz value is more useful as a rule of thumb than the absolute limit. The amplifiers can be matched for higher frequency operation. The limiting frequency for a given application is probably the desired gain. The power amplifier has two stages, and the LNA is a single stage.

Figure 1 shows an equivalent circuit schematic of the RF2910, as well as a pin-out of the package. Feedback has been included around both stages of the power amplifier. This improves stability but requires a DC blocking element in the input-matching network. A similar blocking capacitor requirement occurs for the input match on the LNA. To avoid degrad-





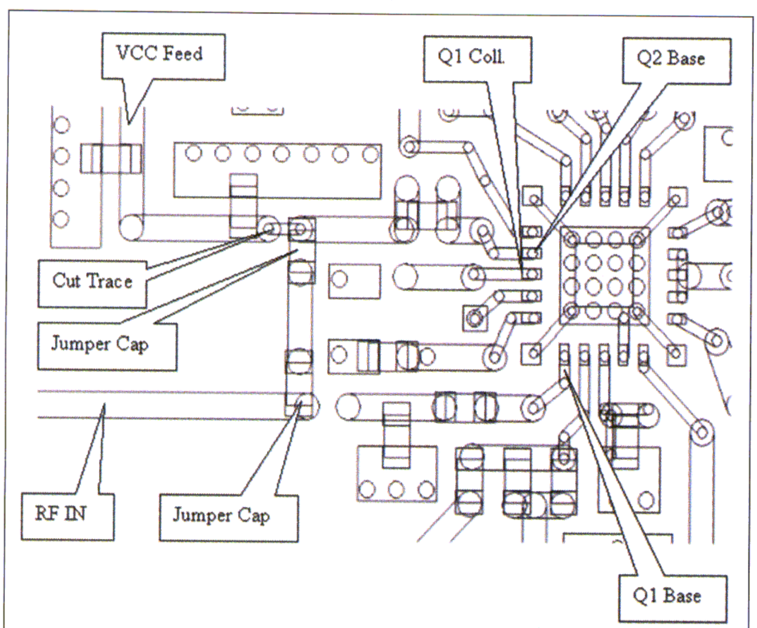
▲ **Figure 2. LNA two-tone performance.**

Frequency (MHz)	S_{11} (dB)	Gain (dB)	nF (dB)
220	–10.1	19.2	1.1
900	–12.7	9.8	1.6

▲ **Table 1. Typical LNA performance at various frequencies.**

ing the noise figure, the LNA transistor base and emitter are brought out directly to package pins. This also allows for an external bias if required, or for additional emitter inductance for lower frequency applications.

The pin-out for the RF2911 is similar to Figure 1, with the exception of the "BIAS GND2" signal, which is connected on the die and thus is not brought out. The first stage bias control, "BIAS1," shown for the RF2910



▲ **Figure 3. Section of evaluation PCB configured for output stage measurements.**

becomes the power control for the RF2911. The two chips are similar in their pin-out configurations, and the RF2910 evaluation board has been used for the development testing of the RF2911.

LNA section

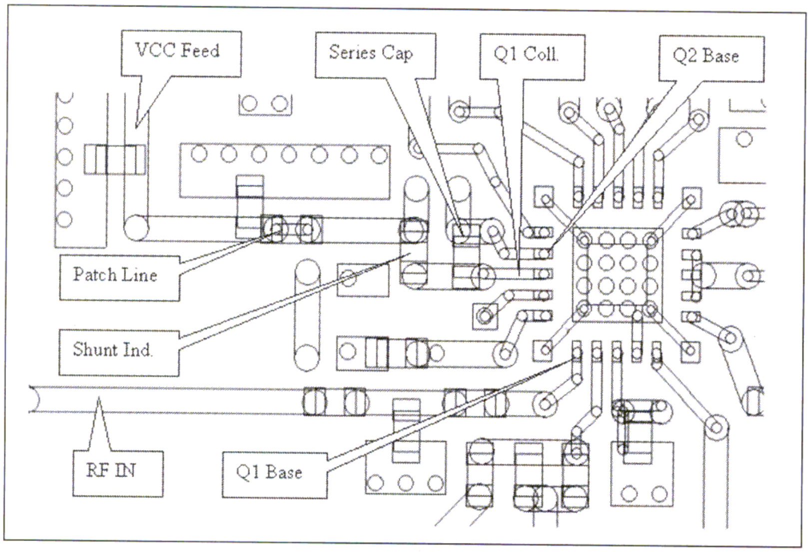
The LNA is optimized for the middle of the tuning range. However, respectable noise figures are obtained at other frequencies. The data in Table 1 was obtained by tuning the evaluation PWB for two different frequencies. Depending on the desired performance, various tradeoffs are possible to optimize noise figure, gain or input match. The data in Table 1 was obtained with the LNA-OUT pin biased at 2.5 volts, a quiescent current of 4 mA and the *Q*3E pin grounded through a trace on the evaluation board. The tuning goals were a 2:1 input VSWR with optimum noise figure. Each measurement employed a different part/test board with input and output networks tuned to that frequency.

The linearity performance of the LNA is enhanced by self-biasing, as shown in Figure 2. At low input power, the distortion limits are determined by the bias current. In this example, the collector current was set at 4 mA and the projected small signal IP3 is about 7 dBm. As the input power increases, the circuit self-biases and maintains almost a 30 dB margin between the fundamental tones and the third-order intermodulation products. During this interval, the higher order products increase in power but remain lower than the thirds. Then, at an input power of –3 dBm, the output load and the V_{CC} supply voltage (which are both externally adjustable) begin to limit the output signal swing and the distortion products resume their increasing trends. For this example, the IP3 determined by the collector bias voltage and LNA load impedance is greater than 12 dBm.

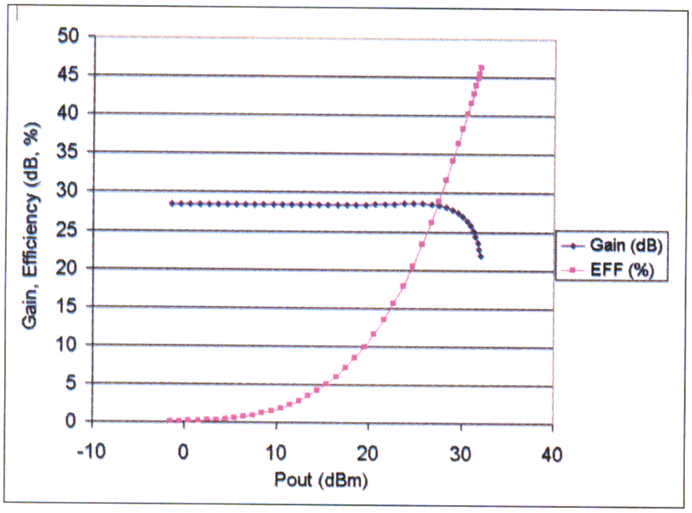
Tuning the PA

Breaking the RF2910 PA between stages is the key to its wide tuning range. External networks can then adjust the input, interstage and output matching for the desired frequency and application. The evaluation board also supports a mode where the output stage can be tuned to optimize its performance before the driver stage is connected. This mode eliminates stage-to-stage interactions and allows the output load and second harmonic termination to be optimized first.

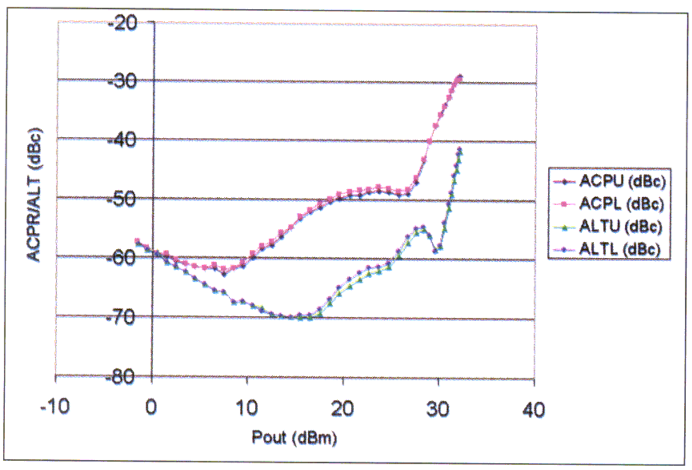
Tuning the PA on an evaluation board should start with the output stage and the desired application. Suppose the application requires a linear amp with 27 dBm linear output power at 915 MHz. A load impedance of about 3.0 – *j*1.5 ohms presented to the *Q*2 collector has been found to work well when using a 3.6-volt power supply. There is a 1.9



▲ **Figure 4. RF2910 evaluation board setup for two-stage PA operation.**



▲ **Figure 5. RF2910 tuned for 915 MHz using CDMA modulation.**



▲ **Figure 6. RF2910 linearity performance at 915 MHz with CDMA modulation.**

pF on-chip parasitic crossover capacitor between the *Q*2 collector and emitter. The inductance of the bond wires and evaluation board trace, to the second harmonic cap location, is about 2.8 nH.

The PA-OUT bond wire inductance is about 0.3 nH. (The evaluation board will allow you to slide the matching caps to compensate for any error in the inductance.) The output matching network may be created using conventional methods or software. The second harmonic should be terminated in a low impedance. The effect of the components supplying power to the device should also be considered.

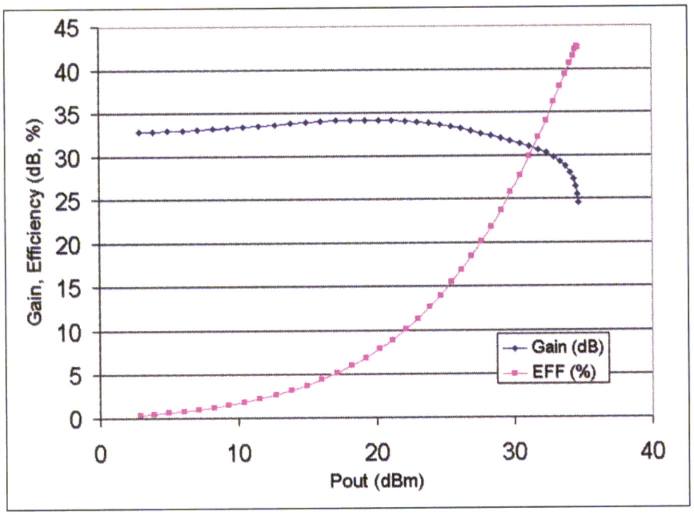
After placing the output network on the evaluation board, redirect the RF input from PA-IN/*Q*1-BASE to *Q*2base by rotating the various blocking caps as shown in Figure 3. Next, cut the V_{CC} line to the *Q*1C at the notch. A 56 pF 0402 blocking cap for the final connection works well because it is close to self-resonant. Using a network analyzer, measure the input impedance for *Q*2-IN pin (*Q*2 base in the figure) after resetting the measurement reference planes. At 915 MHz, an impedance of $2.7 + j9.3$ was measured at the last blocking cap of the *Q*2-IN node. This measurement can be used to create a temporary match for the output stage for initial tuning and later for the interstage design. While the output stage of the amplifier is powered, the second harmonic trap and the load impedance may be tuned for the desired performance.

A series *C* shunt *L* works well to match the *Q*2-IN impedance to a 50-ohm or interstage load. A series cap between *Q*2base and *Q*1*C* followed by a shunt *L* for the V_{CC} feed realizes this network. Do not forget to patch the cut in the V_{CC} feed line to *Q*1C. Next, rotate the jumpers to route the input signal back to the PA-IN/*Q*1-BASE. Then, measure the input impedance and synthesize the input-matching network. Now, tweak the load, the second harmonic termination, the interstage match and the bias points for the desired performance. Figure 4 shows the relevant section of the evaluation PCB where the power amplifier is set up for the two-stage operation.

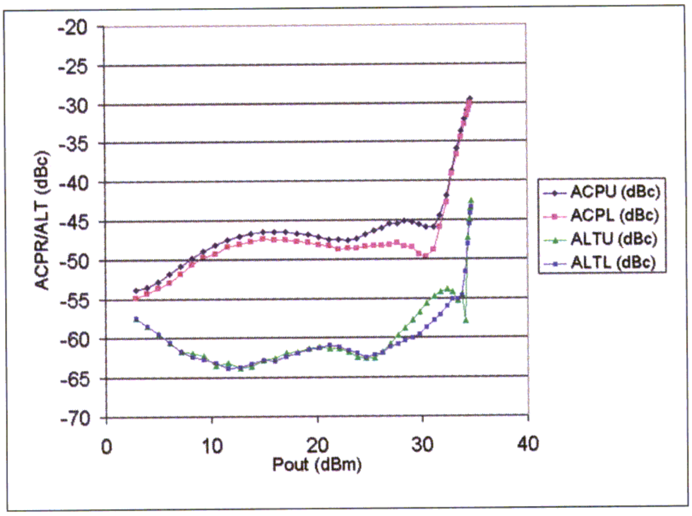
PA performance

The data in Figure 5 shows the results of this tuning procedure. A CDMA modulation was chosen to provide a comparison with other linear amplifiers designed specifically for a given application. When considering the RF2910 for applications where a standard part is available, a careful trade-off should be conducted to assure that cost, board space and performance are optimized.

Comparing Figure 5 and 6 shows that this amplifier supports a –46/–55 dBc ACPR/ALTPR at 27.5 dBm output power with about 28 percent power-added efficiency.



▲ **Figure 7. RF2910 tuned for 220 MHz using CDMA modulation.**



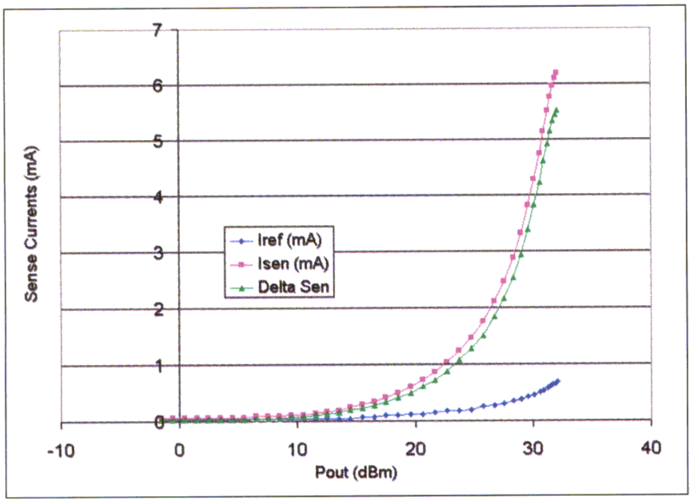
▲ **Figure 8. RF2910 linearity performance at 220 MHz with CDMA modulation.**

The key to the wide tuning range is the access to the interstage matching. Another application needed greater than one watt of linear power at 220 MHz. Figures 7 and 8 show the results of tuning an RF2910 to these specifications. This tuning pattern supports CDMA linearity requirements at greater than 31 dBm output power.

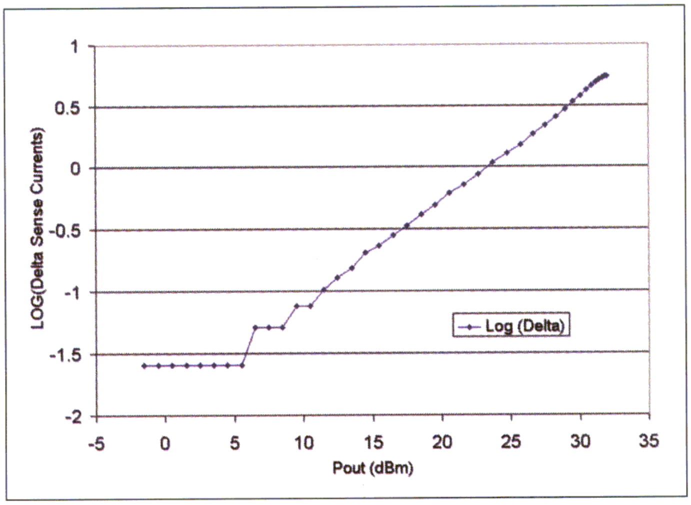
Power sense technology

The PAs in the RF2910/RF2911 chips provide indirect indication of the output power (patent pending). Transistors $Q4$ and $Q5$, as shown in Figure 1, provide this feature. $Q4$ is a scaled version of the output device ($Q2$) complete with scaled bias resistor and coupling capacitor. The collector current for $Q4$ (labeled PWR_SEN) is a reduced sample of the collector current in $Q2$. Since the output-matching network transforms the RF current in $Q2$ into output power, the RF collector current is proportional to the output power. The bias current in the $Q4$ collector produces an error in the predicted output power, which is corrected by the current in transistor $Q5$. Transistor $Q5$ is a scaled version of the output device, with a scaled bias resistor but no coupling capacitor. Thus, the collector current in $Q5$ (labeled PWR_REF) is proportional to the bias current. Subtracting the $Q5$ collector current from the Q4 collector current provides an accurate indication of the output power.

The evaluation board uses a 390-ohm pull-up resistor to V_{CC} as the current indicating element for $Q4$ and $Q5$. A future chip development will integrate this power sense and processing function. When a processor with A/D inputs is available, the following calculations may be used to indicated the output power. Figure 9 shows the measured power sense currents as a function of the output power for the board tuned to 915 MHz. The third



▲ **Figure 9. RF2910 power sense currents.**



▲ **Figure 10. RF2910 power sense currents processed into a dB scale.**

curve, labeled "Delta Sen," is the difference in the two collector currents. Since this power-sense function indicates the actual output power, then the LOG of the "Delta Sen" current versus the output power is a straight line. The LOG function converts the measured current to a dB scale.

Figure 10 illustrates this calculation and shows that the power indication is accurate over a three-decade range. The grainy structure at low power levels is due to measurement quantization accuracy.

Conclusions

The LNA/PA combinations in the RF2910 and RF2911 were designed as general purpose RFICs that can be tuned over a frequency range of 100 MHz to 1 GHz using a single board metal pattern. The LNA provides good gain, intercept performance and noise figure, while the PA sections can be tuned to provide linear output power above 30 dBm or saturated outputs greater than 34.5 dBm. The chips are supplied in a 4 mm square surface mount package to minimize board area and are priced at less than $2 each in quantity. ■

Author information

Dave Dening received a doctorate in physics from Rensselaer Polytechnic Institute in 1973 and a doctorate in electrical engineering from Virginia Politechnic Institute and State University in 1984. He has more than 20 years experience in various aspects of the microelectronics industry. He is currently a senior staff engineer in the Advanced Development Group at RF Micro Devices. He may be reached via e-mail at ddening@rfmd.com.

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Fax: 336-931-7454
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Next month in Applied MICROWAVE & WIRELESS

On our cover: Using CAD/CAE in Design

Eagleware Corporation introduces Version 8 of its GENESYS design suite, featuring the addition of a test equipment interface and other new capabilities.

New CAD/CAE products from Agilent EEsof EDA, Cascade Microtech, Coventor and others will also be featured.

Technical Features: Satellite and Space Systems

- *"DSP-Based Carrier Acquisition and Tracking for Burst TDMA Mobile Land and Satellite Receivers"*
  Mohammed K. Nezami of **Mnemonics, Inc.**, reports on all-digital carrier synchronization for burst-type TDMA signals subjected to white noise and severe frequency shift.
- *"Analysis and Design of Redundant Networks for Satellite Payloads"*
  Lorenzo Simone of Italy's **Alenia Spazio** details techniques for the design of the redundant networks employed in the transmitter section of a satellite payload.

Also featured

- *"PHEMT Technology Improves Passive Mixer Design for 3G Applications"*
  Shane Collins of **M/A-COM** describes the design of a high IIP3 FET mixer using PHEMT technology to achieve better conversion efficiency with a lower drive level.

Product Focus: Spectrum & Network Analyzers

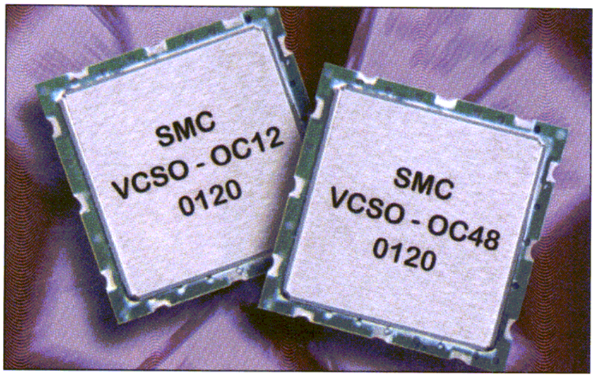
Featuring **new analyzer products** from Anritsu, IFR System, Avcom and others.

Product Focus — Oscillators

Here are some of the newest oscillator products targeted for the radio frequency and wireless market:

Voltage controlled oscillators

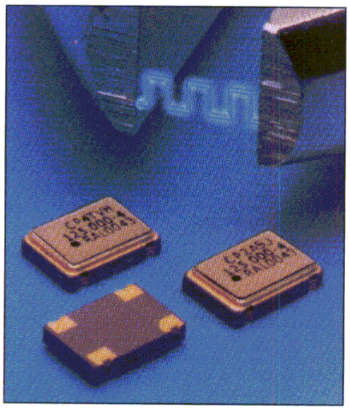
Synergy Microwave has introduced a new line of voltage controlled surface acoustic wave (SAW) oscillators (VCSOs). The VCSOs incorporate a SAW resonator in the tank circuit to achieve exceptional phase noise while maintaining excellent immunity to microphonics and vibration. The VCSO-OC12, operating at 622.08 MHz, offers –105 dBc/Hz phase noise at 1 kHz, –135 dBc/Hz at 10 kHz and –155 dBc/Hz at 100 kHz, with a pulling range of 100 kHz over 1 to 4 volts tuning range. The VCSO-OC48, operating at 2488.32 MHz, offers phase noise of –120 dBc/Hz at 10 kHz and – 140 dBc/Hz at 100 kHz, with a pulling range of more than 400 kHz. Both models operate at 5 volts, provide a +10 dBm output and are housed in 0.625 × 0.625 × 0.2 inch packages. They are suited for digital radios with high order QAM, LMDS radios, high data rate receivers and clocks for optical carriers.



Synergy Microwave Corporation
Circle #185

Programmable clock oscillators

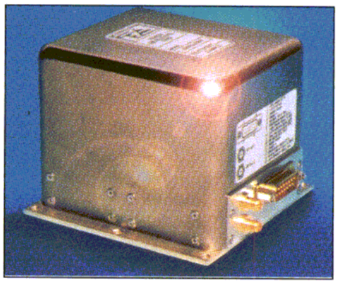
Raltron Electronics has released a new family of programmable clock oscillators for prototype development and product manufacturing. Model CP2 operates at up to 200 MHz on a 5.0-volt power supply and uses 50 mA. Model CP4 operates at up to 100 MHz on a 3.3-volts power supply and uses 30 mA. Both models are available with ±20 ppm, ±50 ppm or ±100 ppm stability and feature an output enable/disable function for use in per-channel multiplexers and other applications that require the output to be switched off to high Z.

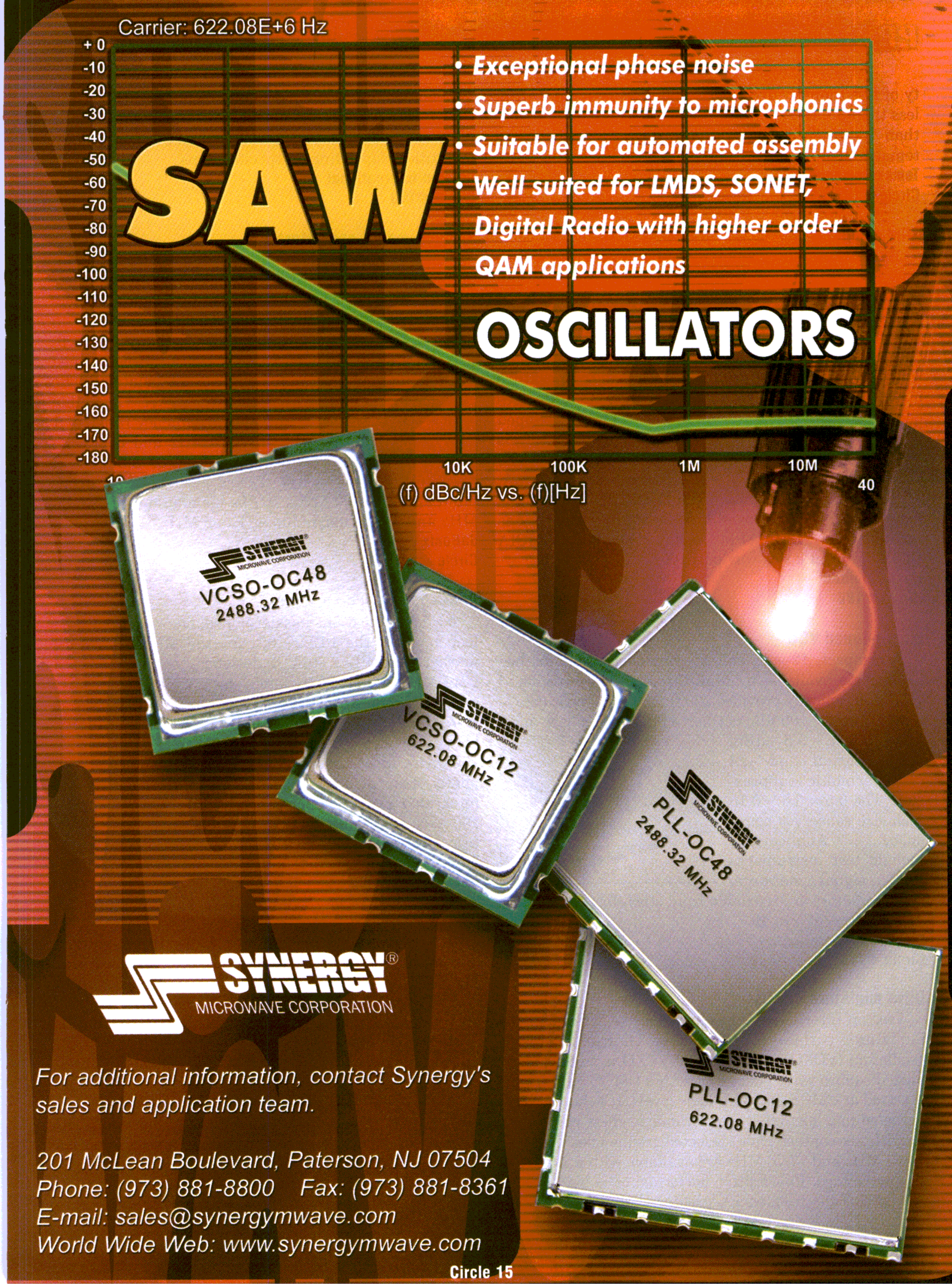


Raltron Electronics Corp.
Circle #186

Atomic clock oscillator

Temex announces the availability of a new rubidium atomic clock series, RAFS, that is approved by the European Space Agency for use in the Galileo Global Navigational System. The RAFS has a low temperature sensitivity of less then 1 × 10^{-13} degrees Celsius, required for radio-navigation applications. The RAFS exhibits short-term stabili-




Carrier: 622.08E+6 Hz
+0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
10K
100K
1M
10M
40
(f) dBc/Hz vs. (f)[Hz]
SAW
• Exceptional phase noise
• Superb immunity to microphonics
• Suitable for automated assembly
• Well suited for LMDS, SONET, Digital Radio with higher order QAM applications
OSCILLATORS
SYNERGY MICROWAVE CORPORATION
VCSO-OC48
2488.32 MHz
SYNERGY MICROWAVE CORPORATION
VCSO-OC12
622.08 MHz
SYNERGY MICROWAVE CORPORATION
PLL-OC48
2488.32 MHz
SYNERGY MICROWAVE CORPORATION
PLL-OC12
622.08 MHz
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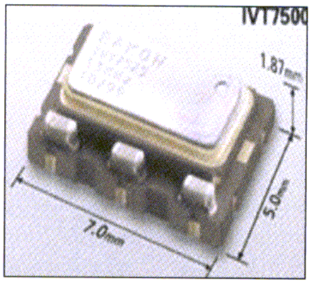
E-mail: sales@synergymwave.com
World Wide Web: www.synergymwave.com
Circle 15

ty of less than 5×10^{-14} per 10,000 seconds and drift of less than 3×10^{-13} per day. Its long-term stability of less than 1×10^{-10} for the first year is controlled by a systematic burn-in and pre-aging process.
Temex Components
Circle #187

Slim oscillator

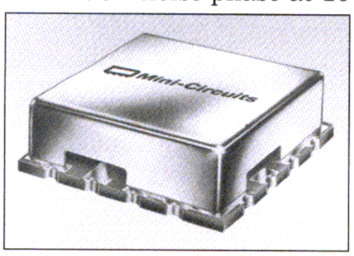
Rakon Limited expands its SMD TCXO line with a new 7 × 5 × 1.8 mm, low-cost oscillator that features an analogue IC for compensation. The IVT7500 SMD VCTCXO can operate on any supply voltage between 2.7 and 5.5 volts. Frequency stabilities are as compact as ±1 ppm over a temperature range of –40 to +85 degrees Celsius. The clipped sinewave frequency output is from 10 to 26 MHz. The oscillator consumes 1.2 mA, and its Root Allan Variance is from 0.2 to 1.0 ppb over 1 second Tau. Applications include GSM/TDMA/APMS cellular phones, PCMCIA CDPD cards and two-way pagers.



Rakon Limited
Circle #188

Linear-tuned VCO

A compact, 12-volt, voltage-controlled oscillator has been made available by Mini-Circuits. The broadband ROS-400 typically provides 200 to 380 MHz near octave band tuning, –100 dBc per hertz SSB noise phase at 10 kHz offset, 9.5 dBm power output and –24 dBc harmonic suppression. The 0.5 × 0.5 × 0.18 inch size conserves board space. Applications include test instruments such as signal generators. The oscillators are available from stock for $14.95 each in quantities of 5 to 49.



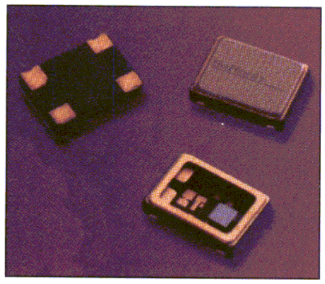
Mini-Circuits
Circle #189

Ultra miniature VCXOs

Vectron International has introduced a series of ultra miniature, surface mount voltage controlled crystal oscillators (VCXOs). The VC-800 VCXO is a quartz-stabilized square wave generator with a CMOS output and is tested at CMOS and TLL logic levels. It is hermetically sealed in a 3.2 5.0 2 mm ceramic leadless chip carrier with six contact pads. Selected frequencies between 1.544 MHz and 77.76 MHz are available with a 3.3 or 5.0 supply voltage. Phase jitter performance is better than <6 ps rms for frequencies greater than 12 MHz. The VC-800 is suited for applications including xDSL CPE, PCMCIA cards, handsets, digital video and ATM/SONET/SDH. Pricing is less than $6 each in OEM quantities, depending on specifications.
Vectron International
Circle #190

Surface-mount oscillators

SaRonix has introduced its new line of surface-mount programmable oscillators, the PrO S8002C Ceramic Series. To meet the immediate needs of design engineers in a matter of 24 to 48 hours, these low-jitter oscillators can be programmed by local distributors. The oscillators are available with a frequency range of 1 to 125 MHz and operating voltages of 3, 3.3 and 5. Period jitter is 50 ps maximum at 33+ to 90 MHz, 100 ps maximum at 5+ to 33 MHz and 167 ps maximum at 1 to 5 MHz.



SaRonix
Circle #191

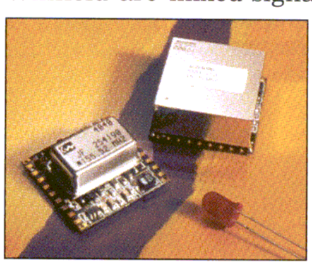
Phase-locked loop module

Z-Communications has developed a new phase-locked loop module, the PLL2716A, for the MMDS network market. The PLL2716A is designed to cover 2715 to 2717 MHz, with a 1 MHz step size. The module offers a spectral signal of –100 dBc at a 10 kHz offset and –123 dBc at a 100 kHz offset, or an RMS phase error of 1.25 degrees integrated over 100 hertz to 100 kHz. In production quantities of 1,000 pieces, the unit cost is $15.95 each.

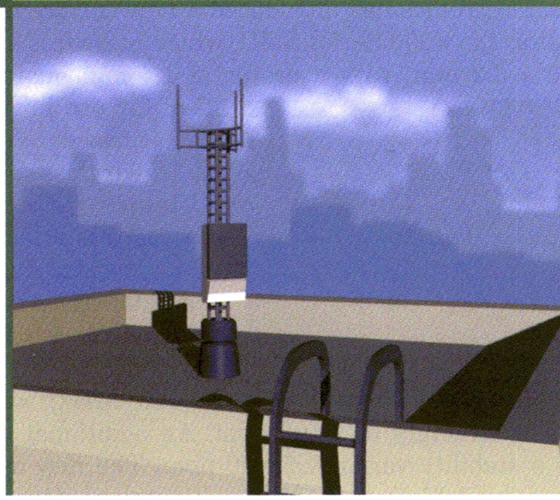
Z-Communications, Inc.
Circle #192

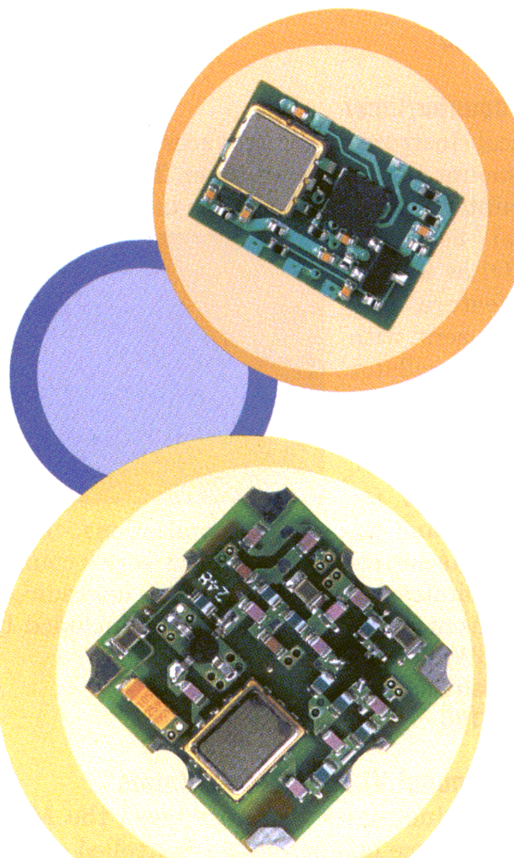
Mixed-signal phase locked loops

The new SCG4000s and SCG4500s from Connor-Winfield are mixed-signal phase-locked loops. Features include phase locked output frequency control, low jitter crystal oscillator for multiplying up to OC48, LVPECL outputs with disable function, one or two selectable reference at 8 kHz, LOR and LOL alarm, 3.3 volt DC power supply, small size (1 square inch) and frequencies of 155.52 and 166.63 MHz.



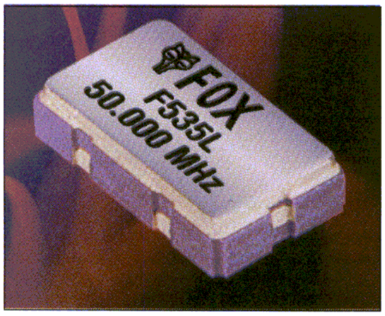
The Connor-Winfield Corporation
Circle #193





SMD oscillator

Fox Electronics has introduced a new surface mount oscillator, the F500 Series SMD, which measures a compact 5 × 3.2 mm, with a profile of 1.4 mm, making it ideal for use in microminiaturized versions of wireless and portable electronic devices. Manufactured in a ceramic package, the F500 series oscillator providse a frequency range of 1.800 to 50.000 MHz, with a frequency stability of ±100 ppm. An additional model offers a stability variant of ±50 ppm. The new oscillators are available in 3.3 and 5 volt versions. Operating temperature range is –10 to +70 degrees Celsius. An extended temperature unit provides an operating temperature range of –40 to +85 degrees Celsius. Pricing is $4 each in quantities of 1,000 or more.



Fox Electronics
Circle #194

GPIB counter/timer

Racal Instruments introduces a new benchtop or rack-mount GPIB counter/timer. This 225 MHz universal counter/timer incorporates a temperature-controlled crystal oscillator (TCXO) as a standard feature, providing users with internal oscillator stability of one part per million (0.0001 percent). Ideally suited for laboratory and test system applications, the 2201 also replaces Racal Instruments' 199X series counter/timers and facilitates legacy test system upgrading through simple front panel controls and the included LabVIEW and LabWindows CVI drivers.

Racal Instruments, Inc.
Circle #195

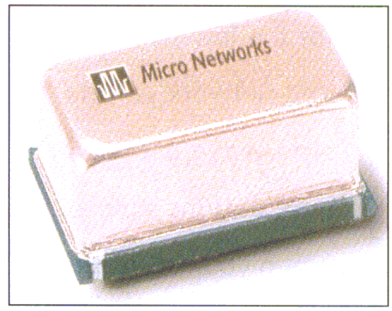
Surface mount VCXOs and oscillators

M-tron Industries has introduced the MPV3 series 3.3-volt surface mount voltage controlled crystal socillator (VCXO) and the M5R series surface-mount oscillators, both ideal for Gigabit Ethernet, xDSL, Stratum IV, SONET/SDH and PLL clock recovery applications. The MPV3 series is available in frequencies between 10.000 and 622.08 MHz and offers ±20 ppm stability over operating temperature, with .5 ps jitter performance at $f_j > 1$ kHz. The M5R series is available in frequencies between 19.440 and 622.08 MHz and provide ±20 ppm stability over operating temperature, with 1 ps jitter performance. Both series offer single and dual complementary PECL-compatible outputs. Pricing for both models starts at $15 in 10,000-piece quantities.

M-tron Industries, Inc.
Circle #196

SAW-based oscillators

Micro Networks has developed a series of voltage-controlled SAW oscillators (VCSOs), ideal for high-performance telecommunication applications. The M600 series features low phase noise and jitter over a frequency range of 300 to 900 MHz. These devices are suited for phase-locked loop applications, as well as clock and data recovery and clock smoothing circuits used in OC–12, OC–48 and OC–192 SONET/SDH systems. The M600 series is available in a 28-pin surface mount package and offers an output disable feature that forces the output into a static condition, enabling an external clock to control the output frequency.



Micro Networks
Circle #197

Series crystal

International Crystal Manufacturing has introduced the LFN1000 series crystal. Manufactured in a TO-5 (HC-35) package, the LFN1000 is suited for data transmission and microwave applications. The series offers a frequency range from 10 to 160 MHz and is specified at series resonance and optional temperatures of 25 or 75 degrees Celsius. The series resonance crystals are designed to meet the high-stability, low phase noise applications commonly required of crystals that are multiplied up to the GHz range.

International Crystal Manufacturing Co., Inc.
Circle #198

Cavity-stabilized oscillators

Gilliand Electronics offers ELVA-1's CIDO-series cavity-stabilized millimeter-wave oscillators, which produce fine-spectrum resolution and low phase noise with high output power and frequency stability. CIDOs are available in waveguide bands from 26 to 150 GHz. Standard CIDO models are supplied mounted on a finned heatsink and can maintain their operating frequency within a few megahertz over their operating temperature range of –50 to +80 degrees Celsius, with no temperature controller or heater.

Gilliand Electronics, Inc.
Circle #199

WORLD'S WIDEST SELECTION

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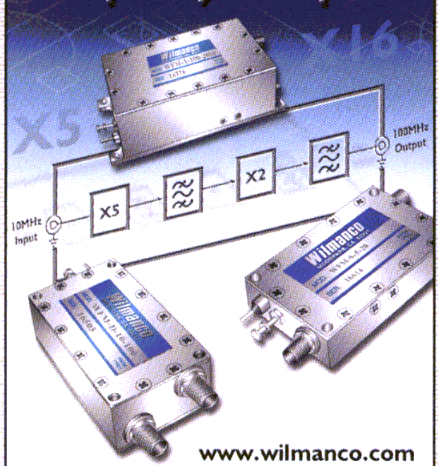

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Circle 39

The State of the Passive Components Industry

By Jiro Miyazaki
Murata Electronics North America

During the last 12 to 18 months, there has been no better analogy to explain the passive component industry's business cycle than that of climbing a mountain and reaching the highest peak. The analogy still works today, but the scenario has changed. As we collectively started venturing down the other side of the mountain, we were startled to find an avalanche in progress. No one could have predicted this. Once an avalanche starts, it's nearly impossible to stop. The challenge is to try not to get caught up in the tumble while strategizing a new plan of attack.

At Murata, we too have had a "snowy" year, but spring may not be too far off. The requirements of the industry in 2000 and 2001 unequivocally prove the law of supply and demand. Last year, the demand for electronic consumer goods was so high that most component suppliers were challenged well beyond their capacity to keep up. Factories were operating around the clock and still backlogs (in some cases up to a year) were not uncommon.

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This year, all that has changed. Many component suppliers failed to realize that the economy had lost its momentum. Reaction to this change had been slow because true product demand was hidden from component suppliers within multiply levels of the supply chain. Purchase orders that were placed and subsequently amplified throughout the supply chain were now being re-scheduled or cancelled. With the increase of available product, we entered the inventory burn-off phase.

Fortunately, there are some positive indications that the readjustment condition is nearing an end. In mid-June, the Electronic Components Association reported a slight uptick in orders, after months of steady decline. Further, some companies (including Murata) had positive book-to-bill ratios. This seems to indicate that conditions are no longer worsening and that, we hope, a recovery is drawing nearer.

While we wait for the industry to return to normal, healthy conditions, we must seize additional opportunities to drive the market and move that process along. One of the key focuses is on e-commerce. While many dot com companies have gone bust and soured even the most ardent believers, this area holds a tremendous amount of untapped potential. With increased reliance on information technology (IT), growth and expansion of B-2-B exchanges will continue to flourish in support of new supply chain management models.

Additionally, Internet access continues to grow, with consumers commanding faster, more reliable service. This, in turn, stimulates demand for broadband access technologies and wireless access via mobile devices. We are now witnessing a trend specific to the broadband outlook: STB suppliers are incorporating more functionality into their equipment, including Bluetooth™ and 802.11(b). However, there is a downside. Industry standards that are still in flux, a lack of infrastructure and competing technologies could hold back the potential for this market, resulting in slower growth than originally expected.

On the cellular phone front, the handset market is slumping, but we do expect to see recovery in the next two quarters. We base this on the following trends: web-enabled hand held (H/H) growth, 2.5G H/H (GAIT and EDGE), the integration of E-911 and fixed 3G frequencies for the United States. Things to watch here include consumer interest in I-mode H/H and a subscriber base that may be nearing saturation.

All that said, here's our bottom line: we expect strong growth for the STB segment and moderate increases for the cellular phone and DSL and cable modem markets.

We may be coming down the other side of the mountain, but we must be mindful of the avalanche that is still grumbling. We're not in the free and clear yet.

While there are many unknowns, one thing is certain — innovation will continue to drive the components and electronics industries throughout both storms and fair weather. We must continue to hope that the latter is next on the horizon. ■