

FOR DESIGNERS AT HIGHER FREQUENCIES

Microwaves & RF

**Military
Electronics
Issue**

NEWS

Surveying the needs
of military electronics

DESIGN FEATURE

Extend the limits
of oscillator analysis

PRODUCT TECHNOLOGY

VXI-based synthesizers
add wideband modulation

Multilayer technology miniaturizes components

Power Divider/Combiner

2-Way

0.8 to 1.2 GHz
0.3" x 0.25" x 0.1"

4-Way

1.6 to 2.2 GHz
0.5" x 0.375" x 0.1"

Hybrid / Coupler

0.8 to 2.2 GHz
0.5" x 0.375" x 0.060"

Mixer

1.5 to 4.5 GHz
0.3" x 0.275" x 0.1"

SYNSTRIPE
TECHNOLOGY

Visit us at: www.mwrf.com

RF SUB-SYSTEM



Someone once said, "I want a cell phone that costs less." And you've been paying for it ever since.

They expect you to cut costs without cutting corners. Easy for them to say, right? Here's where Agilent Technologies can help. We've already designed the next-generation wireless mobile manufacturing test solutions. We call it doing our job. You'll call them a lifesaver.

Why? For starters, these solutions are from the industry leader in cellular manufacturing test. And they're faster than ever. So you can speed through test. Plus improve test margins and yield with greater accuracy. Which means you'll get more phones out the door—at a lower cost than ever before. Not to mention being able to reconfigure tests quickly and easily for all your new designs.

Want to start reducing your test costs right away? Visit our web site. Or give us a call at the number below. And we'll help make it happen. Suddenly that dream of cutting costs looks like a reality.

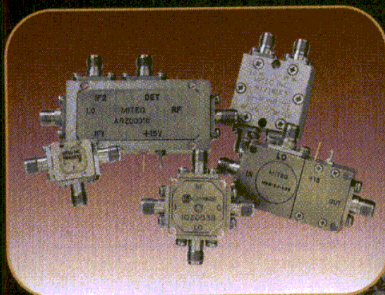
www.agilent.com/find/wireless

1-800-452-4844*, Ext. 6948



Agilent Technologies
Innovating the HP Way

MITEQ FROM COMPONENTS TO SYSTEMS

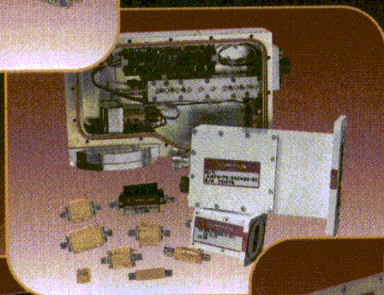


MIXERS TO 60 GHz

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

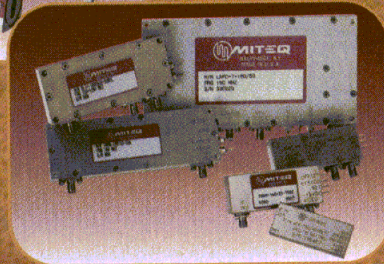
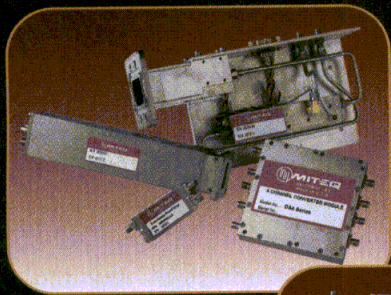
AMPLIFIERS TO 60 GHz

- Octave to ultra-broadband
- Noise figures from 0.35 dB
- Power to 10 watts
- Temperature compensated
- Cryogenic



INTEGRATED SUBASSEMBLIES TO 60 GHz

- Integrated up/downconverters
- Monopulse receiver front ends
- PIN diode switches
- Ultra-miniature switch matrices
- Missile receiver front ends
- Switched amplifier/filter assemblies

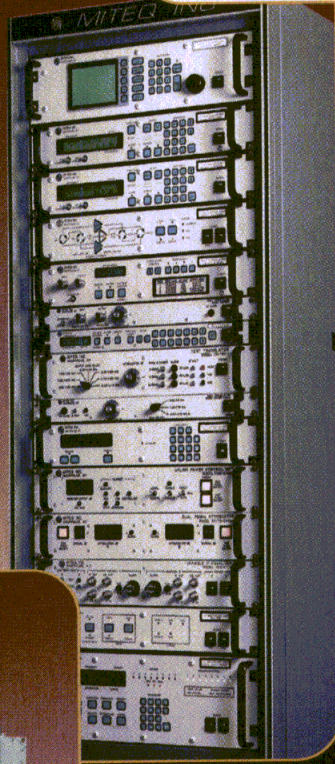


IF AND VIDEO SIGNAL PROCESSING

- Logarithmic amplifiers
- Constant phase-limiting amplifiers
- Frequency discriminators
- AGC/VGC amplifiers
- I/Q processors
- Digital DLVAs

SATCOM EARTH STATION EQUIPMENT TO Ka-BAND

- Synthesized up/downconverters
- Test translators
- LNA systems
- 1:N redundancy units
- INMARSAT products
- FM modems



FREQUENCY SOURCES TO 40 GHz

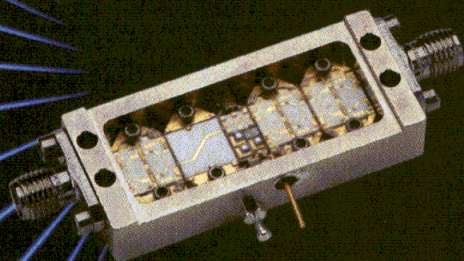
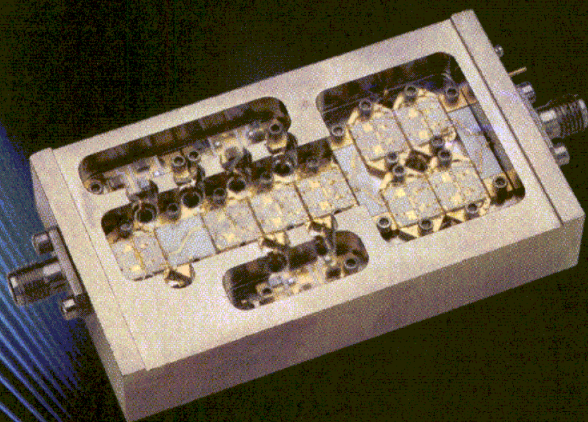
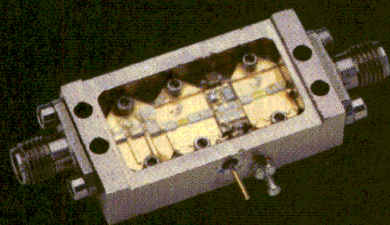
- Free-running VCOs/DROs
- Phase-locked cavity oscillators
- Phase-locked coaxial resonators
- Synthesizers for SATCOM
- Fast-tuning communication synthesizers



MITEQ
 TEL: (631) 436-7400
 FAX: (631) 436-7430
 100 Davids Drive, Hauppauge, NY 11788
 www.miteq.com
 CIRCLE NO. 255

AMPLIFIERS

for every application



JCA
TECHNOLOGY

DELIVERY IN 2-4 WEEKS ARO

4000 Via Pescador, Camarillo, CA 93012
(805) 445-9888 Fax: (805) 987-6990
email: jca@jcatech.com • www.jcatech.com

ULTRA BROAD BAND

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA018-203	0.5-18.0	20	5.0	2.5	7	17	2.0:1	250
JCA018-204	0.5-18.0	25	4.0	2.5	10	20	2.0:1	300
JCA218-506	2.0-18.0	35	5.0	2.5	15	25	2.0:1	400
JCA218-507	2.0-18.0	35	5.0	2.5	18	28	2.0:1	450
JCA218-407	2.0-18.0	30	5.0	2.5	21	31	2.0:1	500

MULTI OCTAVE AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA04-403	0.5-4.0	27	5.0	1.5	17	27	2.0:1	550
JCA08-417	0.5-8.0	32	4.5	1.5	17	27	2.0:1	550
JCA28-305	2.0-8.0	22	5.0	1.0	20	30	2.0:1	550
JCA212-603	2.0-12.0	32	5.0	3.0	14	24	2.0:1	550
JCA618-406	6.0-18.0	20	6.0	2.0	25	35	2.0:1	600
JCA618-507	6.0-18.0	25	6.0	2.0	27	37	2.0:1	800

MEDIUM POWER AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-P01	1.35-1.85	35	4.0	1.0	33	41	2.0:1	1000
JCA34-P02	3.1-3.5	40	4.5	1.0	37	45	2.0:1	2200
JCA56-P01	5.9-6.4	30	5.0	1.0	34	42	2.0:1	1200
JCA812-P03	8.0-12.0	40	5.0	1.5	33	40	2.0:1	1700
JCA1218-P02	12.0-18.0	22	4.0	2.0	25	35	2.0:1	700

LOW NOISE OCTAVE BAND LNA'S

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-3001	1.0-2.0	40	0.8	1.0	10	20	2.0:1	200
JCA24-3001	2.0-4.0	32	1.2	1.0	10	20	2.0:1	200
JCA48-3001	4.0-8.0	40	1.3	1.0	10	20	2.0:1	200
JCA812-3001	8.0-12.0	32	1.8	1.0	10	20	2.0:1	200
JCA1218-800	12.0-18.0	45	2.0	1.0	10	20	2.0:1	250

NARROW BAND LNA'S

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-1000	1.2-1.6	25	0.75	0.5	10	20	2.0:1	80
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	0.5	10	20	2.0:1	90
JCA56-401	5.4-5.9	40	1.0	0.5	10	20	2.0:1	120
JCA78-300	7.25-7.75	27	1.2	0.5	13	23	2.0:1	120
JCA910-3000	9.0-9.5	25	1.2	0.5	13	23	1.5:1	150
JCA910-3001	9.5-10.0	25	1.2	0.5	13	23	1.5:1	150
JCA1112-3000	11.7-12.2	27	1.1	0.5	13	23	1.5:1	150
JCA1213-3001	12.2-12.7	25	1.1	0.5	10	20	2.0:1	200
JCA1415-3001	14.4-15.4	35	1.4	1.0	14	24	2.0:1	200
JCA1819-3001	18.1-18.6	25	1.8	0.5	10	20	2.0:1	200
JCA2021-3001	20.2-21.2	25	2.0	0.5	10	20	2.0:1	200

Features:

- Removable SMA Connectors
- Competitive Pricing
- Compact Size

Options:

- Alternate Gain, Noise, Power, VSWR levels if required
- Temperature Compensation
- Gain Control

CDMA Gets Wide!



Extend your product's
performance with
TAS' 3G CDMA
test solution.



Wideband CDMA stretches old algorithms to new limits. Algorithms such as RAKE finger tracking and wideband channel estimation. These key ingredients of wideband 3G designs must perform over a broad range of environments. *Environments that change...Quickly.*

That's the reason the TAS 4500 FLEX5 RF Channel Emulator comes equipped with a powerful new dynamic channel emulation mode called 3GPDP (Power-Delay Profiles). Use 3GPDP to test your receiver designs under the most challenging RF channel conditions. FLEX5 meets all W-CDMA and cdma2000 test specifications. But why stop there? Program 3GPDP's Moving Propagation and Birth-Death channel models to emulate any environment you can dream up.

TAS is a SPIRENT Communications company. SPIRENT Communications is at the leading edge of wireless and broadband communication technology advancement. Our test solutions are integral to the development and deployment of next-generation communication technology. To find out more about SPIRENT or TAS and our products, visit our web site or give us a call.

www.taskit.com

IMPROVE Your PCS Receiver's PERFORMANCE With NEC's New, Miniature Low Cost FETs

NE34018 HEMT FETs:

GREAT PERFORMANCE, NEW LOW PRICE...

- +23 dBm Output IP_3 @ 2 GHz
- 0.7 dB NF, 15 dB Gain @ 2 GHz
- Ultraminiature SOT-343 package
- 70¢ in 100K quantities



Housed in SOT-343 packages (right), these NEC HEMTs are nearly half the size of conventional SOT-143 devices.

VERSATILE NE76118 MESFETs:

- 0.8 dB Noise Figure @ 2 GHz
- 13.5 dB Associated Gain @ 2 GHz
- Use as an oscillator, 2nd stage LNA, or buffer amp
- 61¢ in 100K quantities

SUPER LOW NOISE NE334S01 HJ FETs:

- 0.25 dB Noise Figure @ 4 GHz
- 16 dB Associated Gain @ 4 GHz
- Miniature plastic four pin package
- 99¢ in 100K quantities

NEC

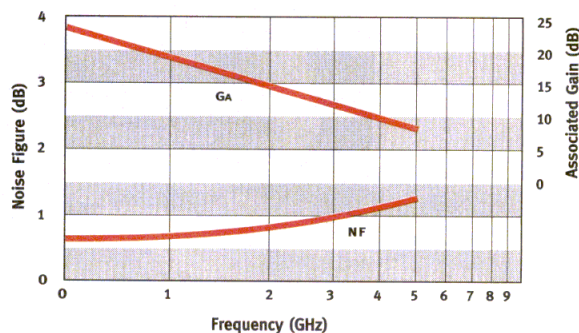
Visit us at MTT-s Boston
BOOTH 1925
June 11 - 15

Need a high performance first stage LNA for your PCS, GPS, or WLAN receiver? Our NE34018 GaAs HEMT delivers! You get low noise and high output IP_3 all in a low cost, superminiature SOT-343 plastic package. Nearly half the size of a conventional SOT-143 device, the NE34018 can help miniaturize your handheld wireless receiver design — while maximizing its performance. The NE34018 is just one in a family of

miniature plastic transistors from NEC.

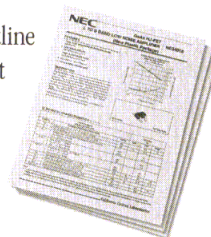
Want more information? Visit our website or call our 24-hour automated Fax Hotline. We'll get you data in minutes!

NE34018 NOISE AND GAIN PERFORMANCE



For instant Product Data visit us at:
www.cel.com

Or call our 24-hour Fax Hotline
at 800-390-3232 and request
Document #144
(U.S. and Canada)



CEL California Eastern Laboratories

4590 Patrick Henry Drive ■ Santa Clara, CA 95054 ■ 408 988-3500 ■ www.cel.com

DISTRIBUTORS: Arrow (800) 525-6666 Repton (888) REPTON

Mouser (800) 346-6873 Electro Sonic (800) 567-6642 (CANADA)

Microwaves & RF

Visit us at
www.mwrf.com

131

Multilayer Technology Delivers High-Performance Miniature Components

A multilayer concept, yielding low cost, shrinks many building-block components of RF front ends.



COVER FEATURE

DEPARTMENTS

- 13**
Feedback
- 17**
Editorial
- 23**
The Front End
- 42**
Editor's Choice
- 44**
Financial News
- 48**
People
- 50**
Educational Meetings
- 52**
R&D Roundup
- 110**
Bookmark
- 129**
Application Notes
- 166**
New Products
- 170**
New Literature
- 175**
Infocenter
- 176**
Looking Back
- 176**
Next Month

NEWS

- 29**
Defense Spending Choices Force A Balancing Act

SOFTWARE SOLUTIONS

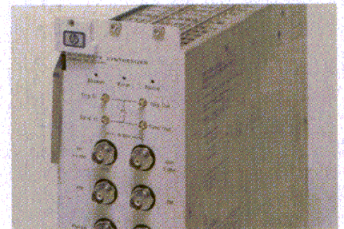
- 113**
Software Simplifies Physical Modeling
- 116**
CD-ROM Contains Powerful Analysis Tools
- 119**
SPICE Program Sweetened With Features
- 122**
System-Design Tool Augments Model Libraries
- 124**
Math Program Adds Functions, Toolboxes
- 126**
Signal-Processing Packs Extend Math Software

DESIGN FEATURES

- 55**
Advancing The Analysis Of Microwave Oscillators
- 71**
Refining CDMA Mobile-Phone Power Control
- 78**
Accurately Compute PLL Active-Filter Parameters
- 85**
Model And Build A Ku-Band DRO
- 93**
Couplers Shrink HF/VHF/UHF Designs
- 97**
EM-Based Models Improve Circuit Simulators

PRODUCT TECHNOLOGY

- 140**
VXI Synthesizer



- Sports Wideband Modulation**
- 144**
Phase-Locked DRO Achieves Low Noise And Cost At 26 GHz
- 150**
LDMOS Device Powers WCDMA Amplifier
- 158**
Integrated RF Synthesizer Conserves Space And Power
- 160**
GaAs FETs Offer Improved Specifications

 Penton

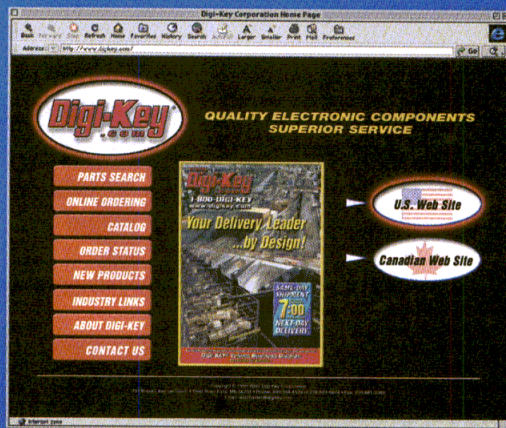


SUBSCRIPTION ASSISTANCE AND INFORMATION POSTMASTER: Please send change of address to *Microwaves & RF*, Penton Media, Inc., 1100 Superior Ave., Cleveland, OH 44114-2543. For other subscription information or assistance, please call (216) 696-7000 and have a copy of your mailing label handy.

Microwaves & RF (ISSN 0745-2993) is published monthly, except semi-monthly in December. Subscription rates for US are \$80 for 1 year (\$105 in Canada, \$140 for International). Published by Penton Media, Inc., 1100 Superior Ave., Cleveland, OH 44114-2543. Periodicals Postage Paid at Cleveland, OH and at additional mailing offices.

Canada Post International Publications Mail (Canadian Distribution Sales Agreement Number 344311). CAN. GST #R126431964.

Point...



Click...



Done!



The Website of Preference*

- ✓ Value of Overall Content
- ✓ Product Search Engine
- ✓ Product Order Mechanism
- ✓ Ease of Navigation
- ✓ Access Speed

*Electronic Buyers' News, Website Audit, June 28, 1999

*Electronic Engineering Times, Website Audit, June 28, 1999

*Cahners Research, How Engineers Worldwide Use the Internet, Nov. 9, 1999

*Beacon Technology Partners, Distributor Evaluation Study, Nov. 1999

www.
Digi-Key®
.com

1-800-DIGI-KEY
www.digikey.com

© 1999-2000 Digi-Key Corporation

Time is of the Essence!

Get to work faster with our rapid transit system:

TURBO EXPRESS

The faster you get the product you need, the faster you can get to work on building or testing the products and systems you sell. That's why we originated **EXPRESS** service—an innovative vehicle that guarantees overnight delivery of over 100 types of Weinschel microwave and RF components including:

- Fixed Attenuators
- High Power Fixed Attenuators
- Terminations and Loads
- Power Splitters and Dividers
- Adapters and Directional Couplers

TURBO EXPRESS is a joint effort with New England's noted distributor Sickles Distribution Sales. They maintain a large inventory of standard Weinschel products and ship your order overnight to any destination in the United States and Canada. They accept VISA or MASTERCARD or your purchase order. Just dial the **EXPRESS** number, **1-800-542-4457**.

Sickles Distribution is increasing the efficiency with which we respond to your expedited needs. Applications and engineering questions should still be directed to our headquarters in Maryland.

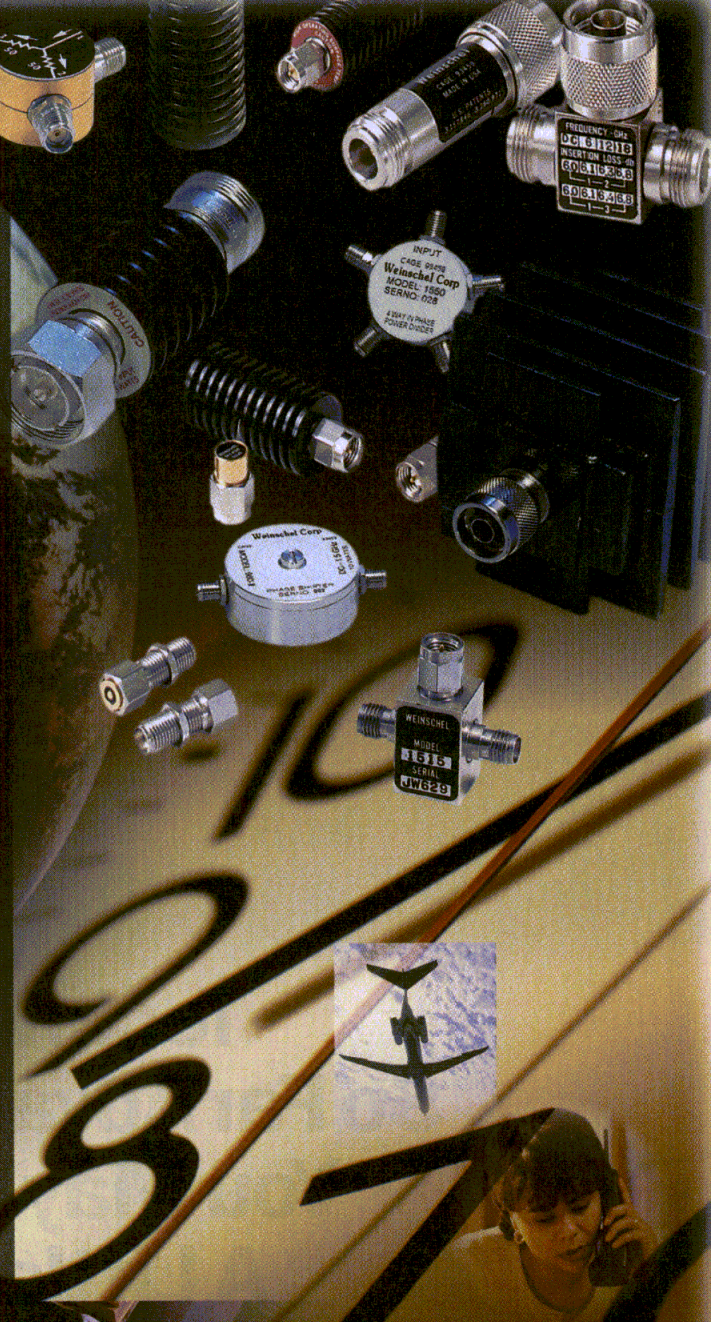


Weinschel

CORPORATION

An MCE Company

5305 Spectrum Drive, Frederick, Maryland 21703-7362
800-638-2048 • Tel: 301-846-9222 • Fax: 301-846-9116
e-mail: sales@weinschel.com • Web: www.weinschel.com



EXPRESS
800-542-4457

Sickles Distribution Sales

Weinschel

CORPORATION

An MCE Company

5305 Spectrum Drive, Frederick, Maryland 21703-7362
800-638-2048 • Tel: 301-846-9222 • Fax: 301-846-9116
e-mail: sales@weinschel.com • Web: www.weinschel.com

EXPRESS
1-800-542-4457

Fax Sickles at 781-863-0684
e-mail: sales@rsickles.com



CERTIFIED
ISO 9001



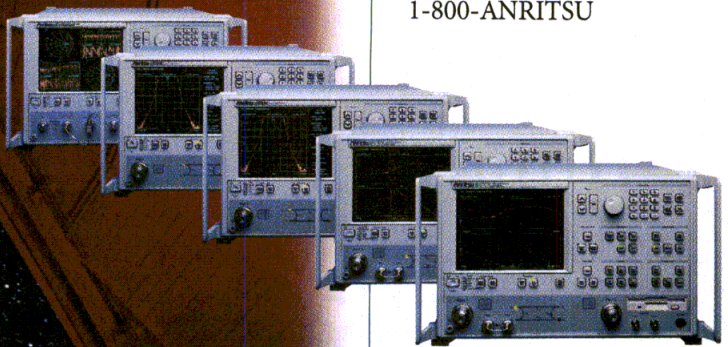
Accredited by the Council
for Accreditation (RVA)



National Accreditation
Program

Certificate No. 94-289C

www.us.anritsu.com
1-800-ANRITSU



Anritsu's Lightning VNAs: The Next Generation.

Go ahead, look around out there. You'll be hard pressed to find anything like Anritsu's "C" Series VNAs. Covering 40 MHz to 65 GHz, their technology is simply unmatched anywhere in the VNA universe.

Featuring sleek, single-unit, bench-top designs. A faster power sweep that accelerates distortion and gain compression measurements. Plus, an internally controlled AutoCal system designed to simplify instrument setup, speed calibration and enhance measurement accuracy. All backed with a no-questions-asked, 3-year warranty.

For a closer look at the new Lightning "C" Series, including our new 50 GHz and 65 GHz units, call 1-800-ANRITSU or check out our website at www.us.anritsu.com.

Anritsu's New VNAs.
Light years ahead.

**Come See Lightning And
More At IEEE-MTT-S 2000
In Booth #2125.**

Technology So Far Advanced, You May Need A Little Help Finding Anything Close.

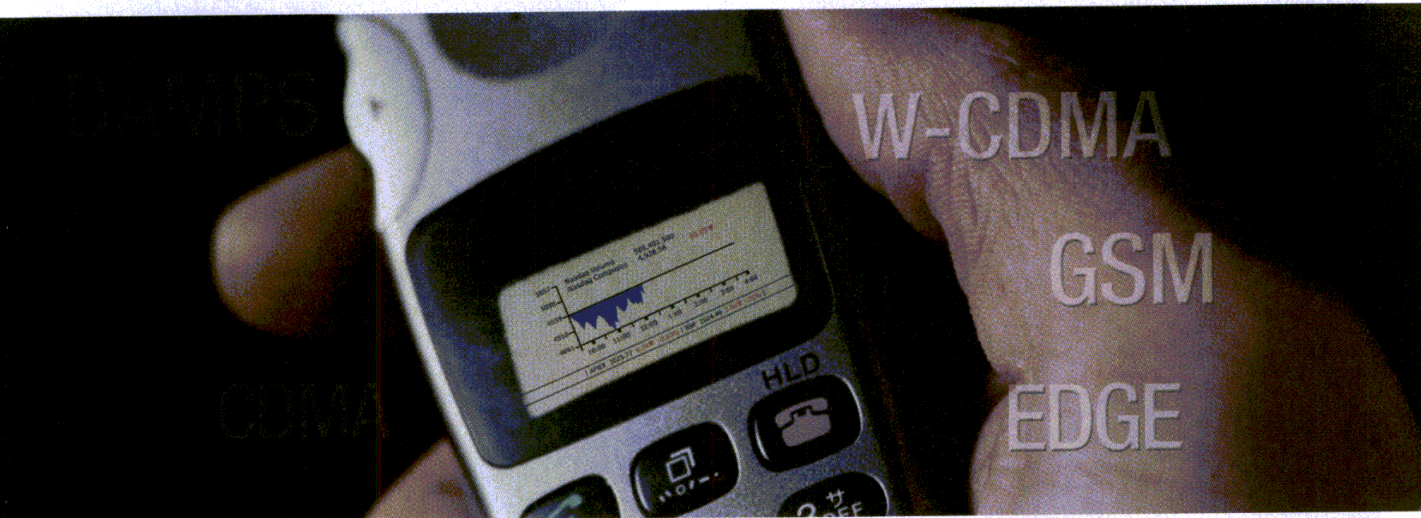


Lightning Vector Network Analyzers

©2000 Anritsu Company Sales Offices: United States and Canada, 1-800-ANRITSU, Europe 44(01582)433200, Japan 81(03)3446-1111, Asia-Pacific 65-2822400, South America 55(21)527-6922, <http://www.anritsu.com>

Anritsu

THE FIRST ADC TO DELIVER BOTH 14 BITS AND 65 MSPS.



The AD6644 high-performance ADC enabling the future of software radio.

Today, cellular signals contain far more than just voice. New data standards such as DAMPS, GSM, EDGE, CDMA, and WCDMA require highly-programmable radio receivers in the



The AD6644 is part of the SoftCell™ chipset, which enables smaller, more powerful base stations.

cellular base station, including high-performance ADCs such as the new AD6644. The AD6644 accurately digitizes multiple channels of all 2G and 3G air signals (30 MHz wide) with extremely low noise ($\text{SNR} = 74 \text{ dB}$) and low distortion ($\text{SFDR} = 100 \text{ dB}$). No other ADC offers this combination of band-

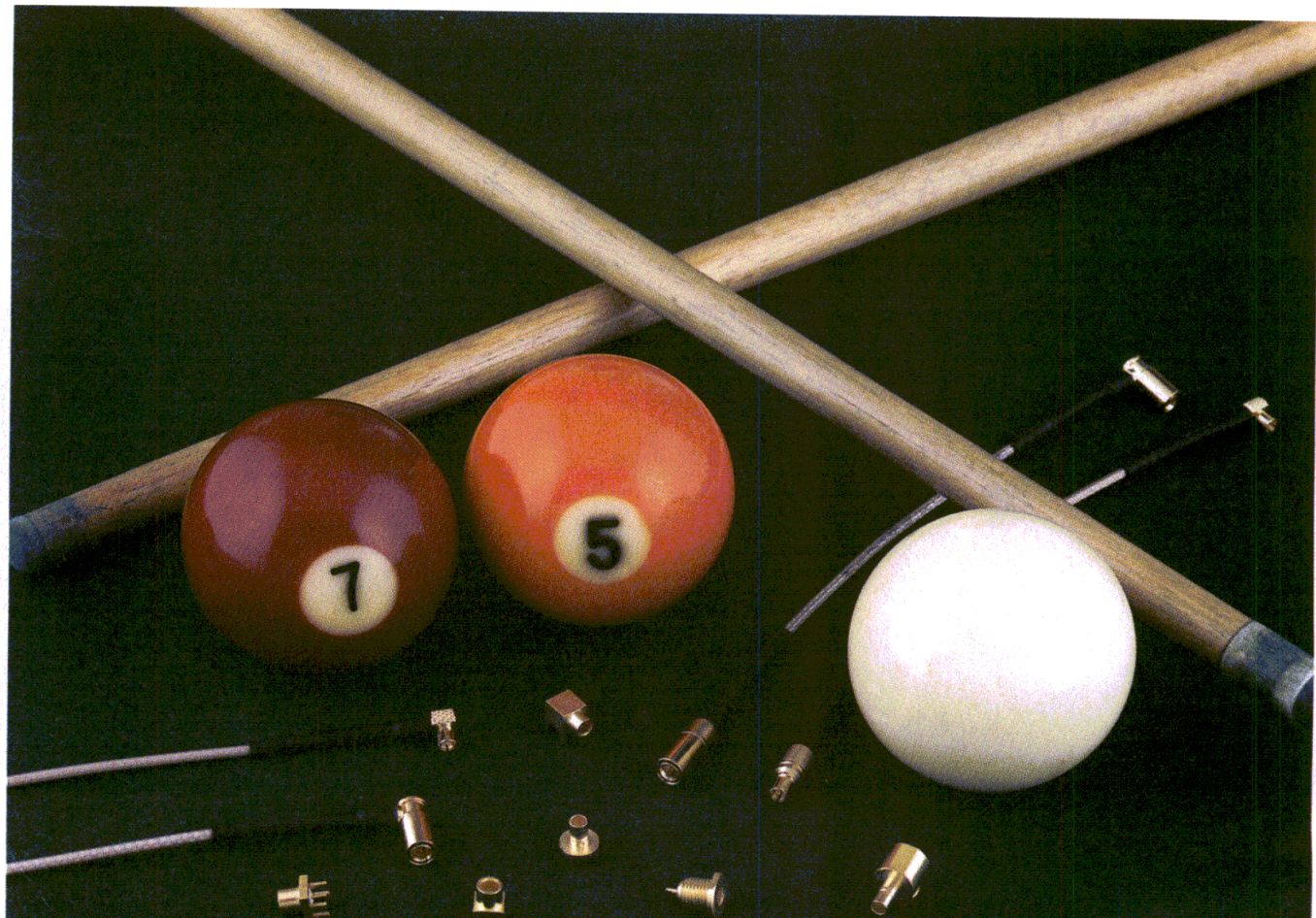
width, signal integrity, and dynamic range. Future radios using the AD6644 will be smaller, less costly to manufacture, and reprogrammable to easily meet emerging standards. Available now, the AD6644 comes in a 52-lead LQFP, and costs just \$39.* The future of software radio is shipping today with high-performance ADCs from Analog Devices.



For more information and to register for a free CD titled
Advanced Signal Processing for Wireless,
Visit www.analog.com/fastadcs or call 1-800-ANALOGD.

THE WORLD'S NUMBER ONE BRAND FOR HIGH-PERFORMANCE ANALOG ICs.

SoftCell is a trademark of Analog Devices, Inc. *USD 1,000s, recommended resale, FOB U.S.A. Ad Code 2304



True 75 Ohm Connectors

**Featuring Mini 75 Ohm SMB and
75 Ohm MCX Connectors**

- Plugs and Jacks
- PC Mount Plugs and Jacks
- In-series adapters
- Between series adapters
- End Launch
- Terminations

**Mini 75 Ohm SMB and 75 Ohm MCX
Features and Benefits**

- True 75 Ohm impedance
- Increasing signal speed
- Efficient signal and data transfer
- Optimum performance
- Low VSWR
- Mate with their 50 Ohm counterparts

JOHNSON
Components®

1.800.247.8256
www.johnsoncomp.com

Motorola & Richardson— Keeping Worldwide RF Customers in Balance

Motorola and Richardson Electronics offer the perfect balance of exceptional products and services.

Motorola's broadcast, PCN and cellular components are incomparable in performance, and Richardson provides the stability of unrivaled global logistics and engineering support.

High power, low cost and small packages are just a few of the advantages of Motorola's RF components. When combined with Richardson's global, technical and logistical support, you get the perfect balance of exceptional products and services.

Motorola and Richardson Electronics — providing global solutions for all your RF component needs.

PCN PRODUCT

Device	Frequency	Voltage	Oper. Gain (Typ.)	Output Power
MRF18060A/AS	1805-1880 MHz	26 Volts	13.0 dB	60 Watts CW
MRF18060B/BS	1805-1880 MHz	26 Volts	13.0 dB	60 Watts CW
MRF18090A/AS	1930-1990 MHz	26 Volts	13.5 dB	90 Watts CW
MRF18090B/BS	1930-1990 MHz	26 Volts	13.5 dB	90 Watts CW
MRF19030/S	1930-1990 MHz	26 Volts	13.0 dB	30 Watts PEP
MRF19045/S	1930-1990 MHz	26 Volts	14.0 dB	45 Watts PEP
MRF19060/S	1930-1990 MHz	26 Volts	12.5 dB	60 Watts PEP
MRF19085/S	1930-1990 MHz	26 Volts	12.5 dB	90 Watts PEP
MRF19125/S	1930-1990 MHz	26 Volts	12.5 dB	125 Watts PEP
MRF21125/S	1930-1990 MHz	28 Volts	12.0 dB	125 Watts PEP
MRF21180/S	1930-1990 MHz	28 Volts	11.3 dB	160 Watts PEP

CELLULAR

Device	Frequency	Voltage	Oper. Gain (Typ.)	Output Power
MRF9180	880 MHz	26 Volts	17.0 dB	180 Watts PEP
MRF9085/S	880 MHz	26 Volts	17.0 dB	85 Watts PEP
MRF9045/S	945 MHz	28 Volts	18.0 dB	45 Watts PEP
MRF9045M	945 MHz	28 Volts	16.0 dB	45 Watts PEP

BROADCAST

Device	Frequency	Voltage	Oper. Gain (Typ.)	Output Power
MRF372	470-860 MHz	28 Volts	14.0 dB	180 Watts PEP
MRF373A/AS*	470-860 MHz	28 Volts	11.2 dB	100 Watts PEP
MRF374A*	470-860 MHz	28 Volts	12.0 dB	100 Watts PEP

* Under development.



MOTOROLA



**Richardson
Electronics**

Engineered Solutions



Visit Richardson's
online catalog at
catalog.rell.com

More than 60 locations worldwide to serve you. E-mail: ssc@rell.com, Internet: www.rfpowernet.com/motorola.asp, Toll Free: 800-RF Power or 800-737-6937 (U.S. & Canada), Australia: Castle Hill, ACN 069 808 108, +61 (2) 9894-7288, Bayswater, ACN 069 808 108, +61 (3) 9738-0733, Brazil: São Paulo, +55 (11) 820-6199, China: Shanghai, +86 (21) 6440-0807, Colombia: Sante Fe de Bogota, DC, (57-1) 636-1028, France: Colombes Cedex, +33 (1) 55.66.00.30, Germany: Puchheim, +49 (89) 890 214-0, Hamburg, +49 (40) 555 88 410, Italy: Sesto Fiorentino (FI), +39 (055) 420831, Agrate Brianza (MI), +39 (039) 653145, Roma, +39 (06) 41.73.37.51, Japan: Osaka, +81 (6) 6314-5557, Tokyo, +81 (3) 5215-1577, Korea: Seoul, +82 (2) 539-4731, Mexico: Mexico City, +52 (5) 674-2228, Guadalajara, +52 (3) 645-4641, Netherlands: Amsterdam, +31 (20) 446 7070, Philippines: 63-2-633-9480, Singapore: +65 487-5995, Spain: Madrid, +34 (91) 528 3700, Barcelona, +34 (93) 415 8303, Sweden: Stockholm, +46 8 564 705 90, Taiwan: Taipei, +886 (2) 86915238, Thailand: Bangkok, +66 (2) 749-4402, Turkey: Içlevent Istanbul, +90 212 264 3721, United Kingdom: Lincoln, +44 (1522) 542631, Slough, +44 (1753) 733010, Vietnam: Ho Chi Minh City, +84 8.811.1919. For other international inquiries call Corporate Headquarters: LaFox, IL (630) 208-2200, Fax (630) 208-2550, MK0518 ©2000 Richardson Electronics, Ltd.

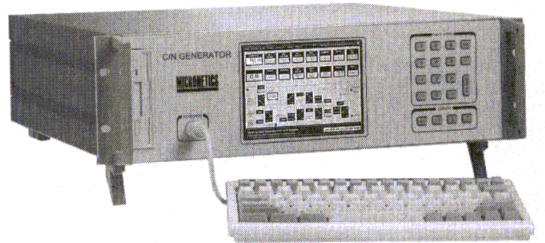
1-800-RF-POWER

• www.rfpowernet.com/motorola.asp • ssc@rell.com

Motorola is a registered trademark of Motorola, Inc.

CIRCLE NO. 333

SETTING A NEW STANDARD IN NOISE & INTERFERENCE TESTING



70/140 MHz modem and L-Band models available.

Micronetics brings you a technological advantage in satellite modem testing. The CNG 70/140 Noise & Interference Test Set features a unique, menu-driven user interface, flexible software, and built-in disk drive for easy upgrades. Add to that a built-in power measurement system — complete with calibrator — and you've got an incredibly accurate and reliable test set that's designed for today's environment. For details, call 603-883-2900 x312. Or to view our complete CNG Series, including our new models for L-Band testing, visit our web site at www.micronetics.com.

MICRONETICS
test equipment

26 Hampshire Drive, Hudson, NH 03051

BIOMEDICAL ISSUES

To the editor:

Regarding Dr. Kumar's letter that appeared in April's Feedback (p. 13), concerning my February article (p. 105) "Studying Biomedical Issues Of High-Frequency Radiation," I wanted to note that the list of references had been chosen primarily for their tutorial value and that I had deliberately avoided using recent controversial papers in the wireless area. Interested readers can find my report on cell-phone-related biomedical issues in the AP-S Turnstile column (*IEEE Antennas and Propagation Magazine*, Vol. 41, December 1999, pp. 98-99).

Also, it may be noted that in a letter to the editor in the February 2000 issue of the *IEEE AP-S Magazine* that Dr. J.M. Osepchuk cautioned readers about "Electrophobia," currently focused toward wireless base stations, and exploitation of Electrophobia by peddlers of shielding devices..."

Rajeev Bansal
Professor

*Dept. of Electrical and Computer
Engineering
University of Connecticut
Storrs, CT*

TRANSISTOR WEBSITE

To the editor:

I have read April's editorial (p. 17) and feel that our website should be of interest to your readers and is worthwhile reviewing. The address is: <http://www.gaascode.com>.

For 12 years, GaAs Code has specialized in using device physics as the basis of practical software tools and services for those using, building, and designing microwave circuits around GaAs FETs and HEMTs. For the last two years, we have manufactured and sold a pulsed-measurement instrument which measures the dynamic current-voltage characteristics that a device will follow under RF conditions. The dynamic I(V) characteristics are almost always different from the static (or DC) measured characteristics for all device types that the

instrument measures—heterojunction bipolar transistors (HBTs), silicon (Si) bipolar transistors, high-electron mobility transistors (HEMTs), field-effect transistors (FETs), and diodes.

We have also found Pete Conrad's website reviews absorbing and helpful—and a quick way to see what is out there on the congested web.

James Bridge
GaAs Code

Please comment

Microwaves & RF welcomes mail from its readers. Letters should be typewritten and must include the writer's name and address. The magazine reserves the right to edit letters appearing in "Feedback." Address letters to:

Jack Browne
Publisher/Editor

Microwaves & RF
Penton Media, Inc.
611 Route 46 West
Hasbrouck Heights, NJ 07604

- FEATURED PRODUCT -

Comblin Filters in 10 days

**Order online and save
an additional 5%!**



Series Number	: 315
Select any Fo	: from 750MHz to 3500MHz
Insertion Loss @ Fo	: <2dB
-1dBc passband	: 1.5%Fo minimum
Response	: 5 pole Chebyshev design
Prototype Price	: <\$400.00
Shipment	: 2 weeks after receipt of order

RF and Microwave Filters to 18GHz

TTE®

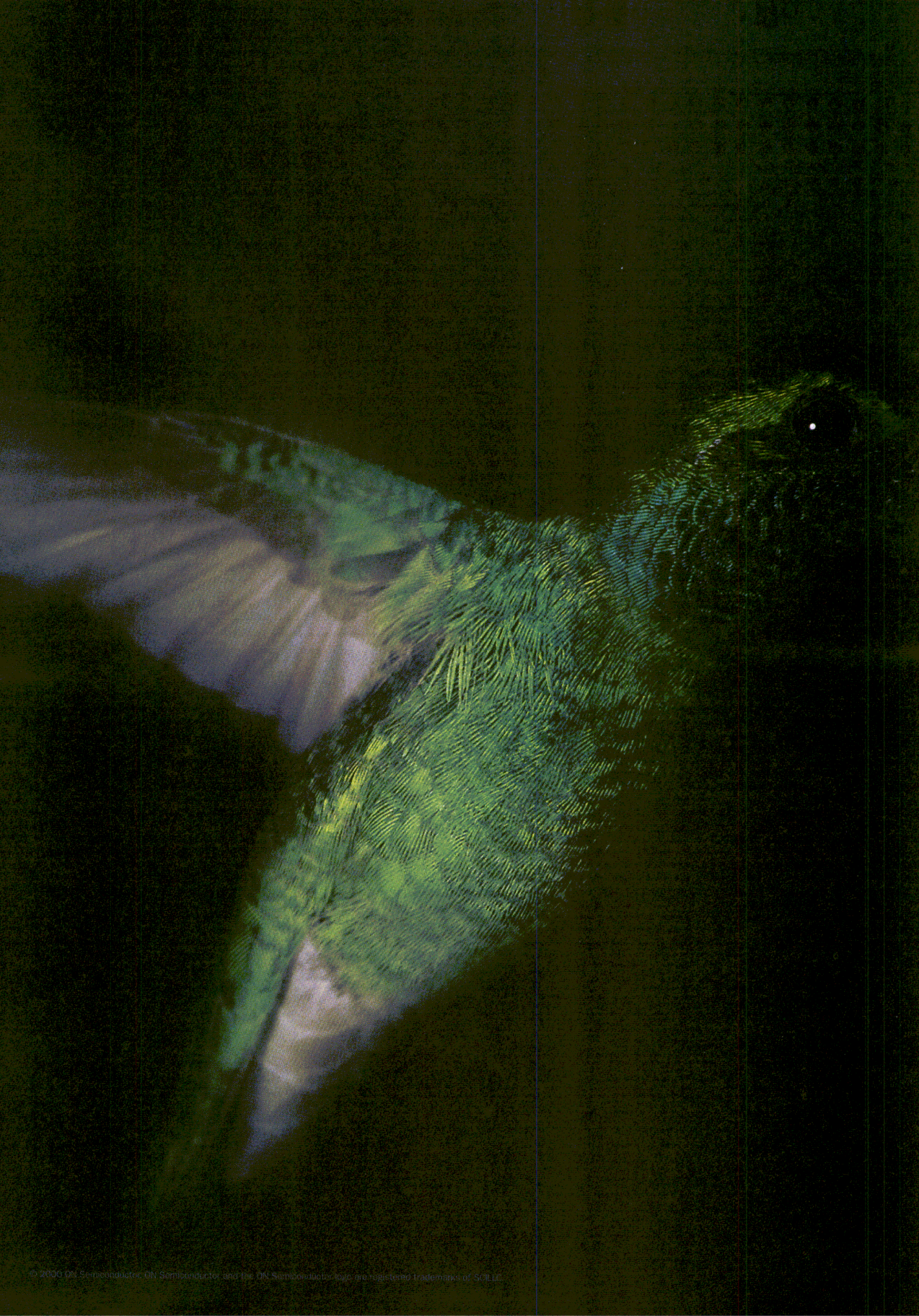
www.tte.com

TTE, Inc, Los Angeles, CA • 800.776.7614 / 310.478.8224 • FAX 800.473.2791 / 310.445.2791

America's Filter Specialist Since 1956

CIRCLE NO. 426 or visit www.mwrf.com

MICROWAVES & RF • JUNE 2000



So very small, yet so very fast.



Introducing ECLinPS silicon logic parts. Maximum speed. Minimum jitter and skew. ECLinPS, a groundbreaking and cost-effective solution, can move your data at speeds up to 6Gbits per second. With skew as low as 25ps. And jitter less than 1ps. ECLinPS. Because the most amazing feats of engineering are those that optimize, not compromise.



ON Semiconductor

CIRCLE NO. 236

www.onsemi.com/broadband-ecl

tyco / Electronics

M/A-COM

Shaping the
future of
wireless.

OpenSky™

Wireless Private Networks

M/A-COM provides an integrated digital voice and data communications network solution to the Public Safety, Transportation, Transit and Utilities Markets.

Semiconductors

Portables and Infrastructure

Today the cellular telephone is used primarily as a mode of voice based communication. M/A-COM provides semiconductor products which will help transform today's mobile phones into tomorrow's wireless voice and data terminals.

Fixed Wireless

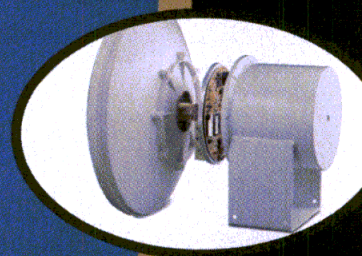
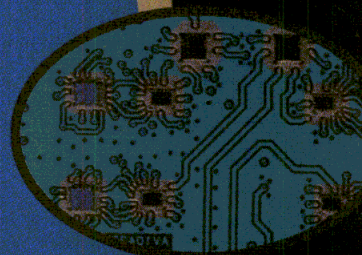
Local Multipoint Distribution Systems

LMDS uses high-powered radio signals to transmit voice, video and data communications. It offers full two-way symmetric and asymmetric communications between a single base station point to various customer premise location within a clear line-of-sight.

Automotive

Sensors and Telematics

M/A-COM is a leader in the development of wireless products designed to enhance automotive information and safety. Applications include autonomous cruise control, collision avoidance radar and GPS.



CIRCLE NO. 387

W W W . m a c o m . c o m

ORGANIZING A SHOW FOR THE MILITARY

Military electronics is the focus of this issue. Military electronics was once the mainstay of this industry, until the spread of wireless and general commercial opportunities began in the late 1980s. In the wake of the "gold rush" toward commercial customers, military systems developers have often been left behind. But government defense spending has stabilized, and the military electronics economy is fairly healthy for those high-frequency-electronics firms that chose to remain in this area.



Typically, as privately held high-frequency firms prepare their Initial Public Offerings (IPOs) by highlighting their commercial business, they tend to downplay revenues from military sources. Ironically, it has been the military applications, such as electronic-warfare (EW), electronic-countermeasures (ECM), and radar systems, which have traditionally driven the state of the art in electronics. The spread-spectrum technology, which is now commonplace in cordless telephones and wireless local-area networks (WLANs), was developed originally for secure battlefield communications.

Traditionally, military budgets have funded the research and development of advanced electronics technologies, with many of these technologies eventually filtering to the consumer level. But with the growth and lure of global communications markets, many of the former suppliers of military electronics have shifted their business plans away from the military and more toward commercial and consumer customers. Military system designers have made tremendous strides in adapting commercial-off-the-shelf (COTS) hardware to their designs, but COTS components do not fill all military design needs.

With ever-expanding commercial business, military customers must compete with commercial customers for the hardware, software, and test equipment they need to upgrade current systems and develop new systems. And they have few dedicated trade shows to learn about new technologies and solutions. Until now.

The Military Electronics Show is scheduled for November 7-9, 2000 in the Ronald Reagan Center (Washington, DC). Sponsored by *Microwaves & RF*, this show is for design engineers concerned with military-grade components and systems. It is not about COTS and it is not another wireless show. It is meant to provide a single venue where engineers can learn more about the technologies and products that impact their military and aerospace designs, from jammer amplifiers to radar-warning receivers.

The Military Electronics Show will present technical sessions on all levels of military component and system design, including software simulation and test techniques, and will offer an exhibition area for manufacturers to showcase their latest hardware, software, and test equipment. If you'd like to get involved as a technical presenter or as an exhibitor, drop me a note at jbrowne@penton.com.

Military designers have been ignored for more than a decade. It's time someone paid attention to them.

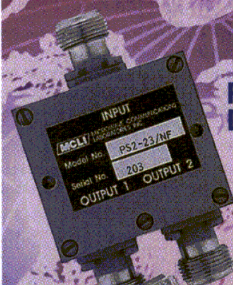
Jack Browne
Publisher/Editor

Precision

MCLI

RF-Microwave Components

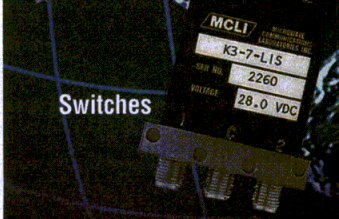
- Immediate Delivery
- High Performance
- Low Cost
- Superior Selection
- 0.005 - 26.5 GHz
- New Catalog Available



Power Dividers



Directional Couplers



Switches

- Power Dividers
- Couplers
- Switches
- Hybrids
- Isolators/Circulators
- Attenuators
- Terminations
- Oscillators
- Filters
- Amplifiers
- Waveguide
- Custom Designs

ISO 9001
Compliant!

See Online Catalog at:
<http://www.mcli.com>

1-800-333-MCLI (6254)

Fax: (727) 381-6116

Microwave
Communications
Laboratories Inc.
7255 30th Avenue North
St. Petersburg, FL 33710
<http://www.mcli.com>

MICROWAVE COMMUNICATIONS LABORATORIES INC. Toll Free: 1-800-333-6254

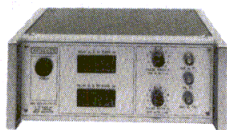
CIRCLE NO. 425 or visit www.mwrf.com

Digital Delay Generators

30 ns to 5 ms

AVX-DD Series

Single & dual channels ~ featuring IEEE-488 GPIB control

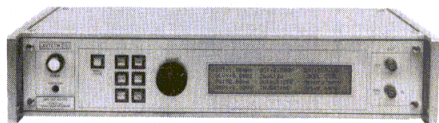


- Single & dual channels
- GPIB control available
- 30 ns to 1 μ s delays
- 30 ns to 9.999 μ s delays
- 30 ns to 999.999 μ s delays
- Jitter as low as 40 ps

Data sheets and pricing on the Web! <http://www.avtechpulse.com>

The four models in the AVX-DD-A digital delay generator series feature low jitter adjustable delays in the range of 30 ns to 1 μ s (Model AVX-DD-A4-PS), 30 ns to 9.999 μ s (Model AVX-DD-A1-PS), 100 ns to 999.999 μ s (Model AVX-DD-A2-PS), and 100 ns to 5.0 ms (Model AVX-DD-A3-PS). All models are available in single or dual output channel versions. Dual output units feature two independent delay controls. The A1, A2 and A3 models feature adjustable output pulse widths. The GPIB computer control feature is standard on the -A3 model and optional on the -A4 model.

Call us or visit our web site for information or to request our new 113 page catalog (Cat. No. 10) featuring over 500 models including pulsers, laser diode drivers, amplifiers and more.



AVTECH
ELECTROSYSTEMS

NANOSECOND
WAVEFORM ELECTRONICS
SINCE 1975

BOX 265, OGDENSBURG
NY, 13669-0265
1-800-265-6681
(315) 472-5270
Fax: (613) 226-2802
e-mail: info@avtechpulse.com
<http://www.avtechpulse.com>

UK: LYONS INSTR., WALTHAM CROSS
JAPAN: MEISHO CORP., TOKYO
FRANCE: K.M.P. ELECT., CLAMART
GERMANY: FOIC, HAMBURG

CIRCLE NO. 404 or visit www.mwrf.com

Your Chemical Milling Experts

Precision Photo-Fab is your quality solution for high precision, metal parts and components produced with the chemical milling process

- Cost saving alternative to stamping
- Fast turnaround – prototypes/quotes
- Superior quality – tolerances within $\pm 10\%$ metal thickness
- Expertise – engineering and CAD design assistance
- Complete capabilities – forming, painting, subassembly, etc.

PRECISION
PHOTO-FAB INC
Your Quality Solution

Call for a free
sample kit
800-875-1093

Fax: (716) 821-9399

Website: precisionphotofab.com

E-mail: ppfi@aol.com

CIRCLE NO. 431 or visit www.mwrf.com

Microwaves & RF

A Penton Publication

Group Publisher Craig Roth—(201) 393-6225

Publisher/Editor Jack Browne—(201) 393-6293

Managing Editor Peter Stavenick—(201) 393-6028

Senior Editor Gene Heftman—(201) 393-6251

Senior Editor Don Keller—(201) 393-6295

Special Projects Editor Alan ("Pete") Conrad

Copy Editor John Curley ■ Mitchell Gang

Editorial Assistant Dawn Prior

Contributing Editors Andrew Laundrie ■ Allen Podell

MANUFACTURING GROUP

Director Of Manufacturing Ilene Weiner

Group Production Director Mike McCabe

Customer Service Representative

Dorothy Sowa—(201) 393-6083 or FAX: (201) 393-0410

Production Coordinators Lu Hlavaty, Judy Osborn, Eileen Slavinsky

Digital Production Coordinators Mike Turro, Leilani Lockett, Pat Boselli

ART DEPARTMENT

Group Art Director Peter K. Jeziorski

Associate Group Art Director Anthony Vitolo

Staff Artists Linda Gravell ■ James Miller ■ Michael Descul

Art Coordinator Wayne M. Morris

Reprints Reprint Services (651) 582-3800

Circulation Manager Nancy Graham—(216) 696-7000

Vice President/Group Director John G. French

Penton
Penton Media, Inc.

Chief Executive Officer Thomas L. Kemp

President/Chief Operating Officer Daniel J. Ramella

Chief Financial Officer Joseph G. NeCastro

Chief Technology Officer Gary W. Hargreaves

Executive Vice President/Group President David B. Nussbaum

Executive Vice President/Group President James W. Zaremba

Senior Vice President/Human Resources Katherine P. Torgerson

Vice President/Investor Relations Mary E. Abood

Editorial Office

Penton Media, Inc.

611 Route #46 West, Hasbrouck Heights, NJ 07604

Phone: (201) 393-6286, FAX: (201) 393-6297

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

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

Single Copies

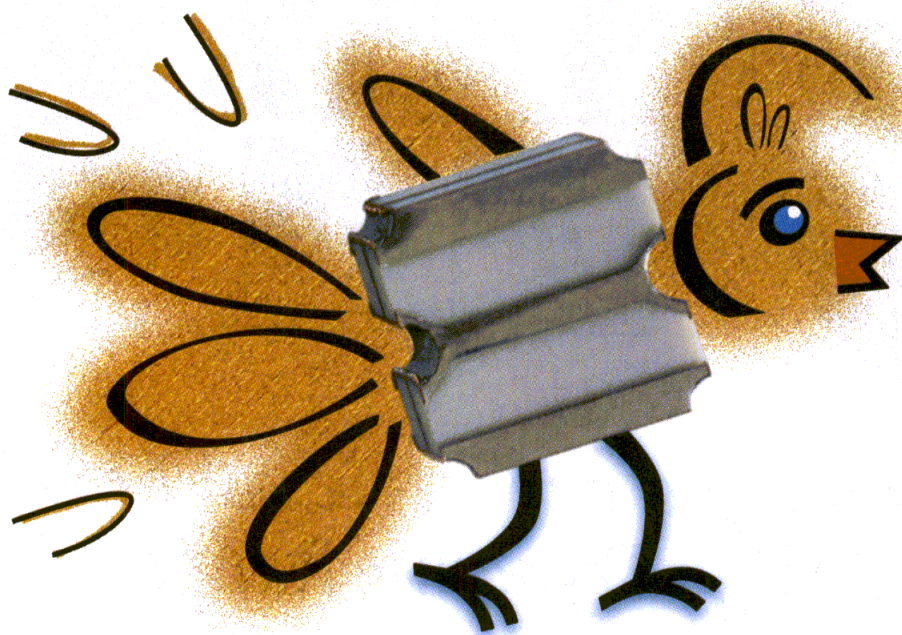
	1 Yr. (Surface)	1 Yr. (Air Mail)	Regular Issues	PDD Only
U.S.	\$ 75.00	—	\$10.00	\$100.00
Canada	\$100.00	\$135.00	\$12.00	\$125.00
Mexico	\$120.00	\$174.00	\$14.00	\$125.00
All other countries	\$135.00	\$243.00	\$16.00	\$125.00

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

Back issues of MicroWaves and Microwaves & RF are available on microfilm, microfiche, 16-mm, or 35-mm roll film. They can be ordered from Xerox University Microfilms, 300 North Zeeb Rd., Ann Arbor, MI 48106. For immediate information, call (313) 761-4700. Copying: Permission is granted to users registered with the Copyright Clearance Center, Inc. (CCC) to photocopy any article, with the exception of those for which separate copyright ownership is indicated on the first page of the article, provided that a base fee of \$1.25 per copy of the article plus 60 cents per page is paid directly to the CCC, 222 Rosewood Dr., Danvers, MA 01923. (Code 0745-2993/00 \$1.25+.60) Copying done for other than personal or internal reference use without the expressed permission of Penton Media, Inc., is prohibited. Requests for special permission or bulk orders should be addressed in writing to the publisher.

Copyright© 2000 by Penton Media, Inc. All rights reserved. Printed in the U.S.

Introducing an
infinitely smarter and safer
way to cross the road.



Introducing the Xinger® Crossover from Anaren — a simple solution for the age-old problem of "getting to the other side."

Xinger®

You can now cross any RF and DC line combination and avoid dangerous intersections within low- and high-frequency applications such as NMT, GSM, UMTS, MMDS and HiperLan.

The Xinger Crossover's multilayer-stripline packaging provides optimal line-to-line isolation to ease signal transmission and is a low-cost alternative to bulky, multilayer boards. RF-DC and RF-RF components are available — each with a tiny footprint of 0.2" x 0.2", a frequency range of 0 to 6GHz, and an insertion loss of less than 0.1dB and a return loss of less than 20dB at 6GHz. The RF-RF version also maintains an isolation higher than 25dB.

The Xinger Crossover is designed for surface mounting via tape or reel for quick circuit board assembly.

So, whether you want DC current capability or RF performance, the Xinger Crossover is the safest — and soundest — way to get to the other side.

Call today to find out more about the Crossover and the entire line of Xinger* products, including the balun and the mini-Xinger — exclusively from Anaren.

* Patent pending on the Crossover component and patent awarded on the Xinger packaging technology.

Questions? Contact Anaren at crossover@anaren.com

800-544-2414 > www.anaren.com

In Europe, call 44-2392-232392

Visa/MasterCard accepted (except in Europe)

ISO 9001 certified

CIRCLE NO. 317

Anaren

What'll we think of next?™



FROM WATKINS-JOHNSON

NEW FETs

*Introducing a new series of Low Noise
and High Dynamic Range FETs*

FH1

*For wireless
applications
to 3GHz*

FHF1

*For wireless
applications
above 3GHz*

**Cutting-edge performance at
an amazingly low price**

- ✓ **DC-6GHz**
- ✓ **IP3 up to 45dBm**
- ✓ **Noise Figure Down to 1.5dB**
- ✓ **Low Cost SOT-89 Package**
- ✓ **Proven WJ Quality and Reliability**

WJ's new series of FETs combines low noise, high dynamic range, and up to 20 dB of gain. Call our toll free number, fax us at 650-813-2447 or e-mail us at wireless.info@wj.com to request data sheets and a complete catalog.

The Wireless Edge™



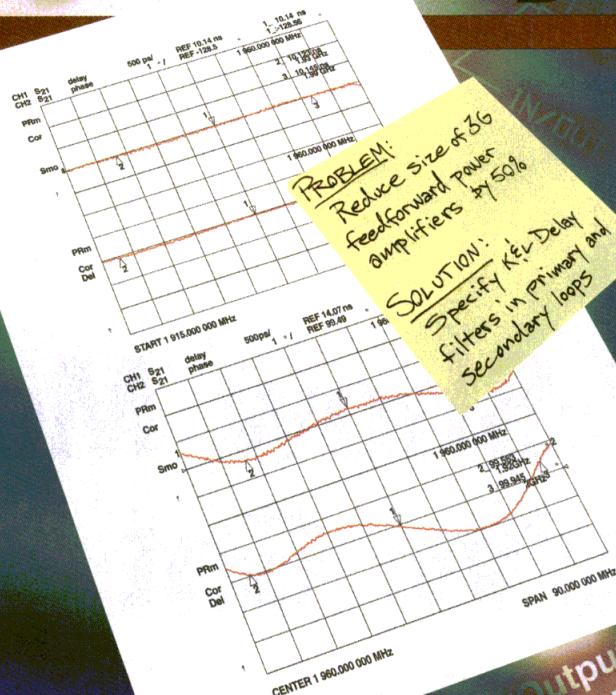
WATKINS-JOHNSON

1-800-WJ1-4401

Distributed In U.S.A. by Microwave Components: 800-282-4771; Nu Horizons Electronics: 888-747-6846; Richardson Electronics: 800-348-5580.
In Europe call WJ: +44-1252-661761 or your local Richardson Electronics Office: France: (01) 55 66 00 30; Germany: (089) 800 21 31; Italy: (055) 420 10 30 UK: (01753) 733010;

3G

Design In Build Out

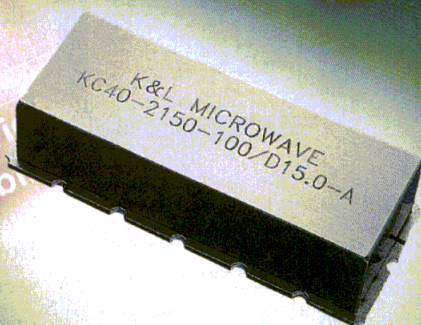
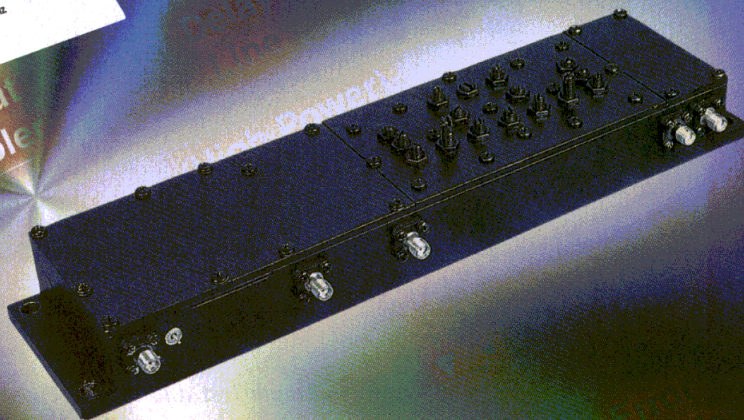


Wireless Products

K&L

PPrimary loop delay filter assemblies integrate high power cavity delay filters, couplers and isolators into a single compact module for performance improvement, space savings and cost reduction.

SSecondary loop miniature delay filters utilize a Patent Pending topology to provide delay equalization. The filters exhibit excellent delay and phase flatness in a miniature surface mount package. The 3G model measures a mere 1.5" L x 0.60" W x 0.4" H and can be mounted directly onto your PWB with pick and place machinery.



Order On-Line

New! Buy K&L Filters over the web
www.klmicrowave.com

USA

Phone: 410-749-2424

FAX: 410-749-2788

www.klmicrowave.com • E-mail: wireless@klmicrowave.com

EUROPE

Phone: 44-(0)-1262 605500

FAX: 44-(0)-1262 605504

K&L

MICROWAVE INCORPORATED

A DOVER TECHNOLOGIES COMPANY

CIRCLE NO. 262



Show Me What You've Got

[I need impartial
comparisons and a way
to buy right away]



Tough test and measurement equipment choices? When you need to compare apples to apples to make a purchasing decision, TestMart—a unique Web-based service where you can buy or sell with confidence—is just a click away.

- Unbiased product comparisons with advanced search tools
- 750,000 comprehensive specifications on over 15,000 products
- Application Engineers are available online or toll-free
- All of your test and measurement equipment requirements, 24/7



Gone are the hassles of piecing together inadequate information from one-dimensional sources. Our integrated Compare Specs tool and secure commerce areas allow you to determine whether to buy, lease or rent new and refurbished equipment and to sell your underutilized equipment online.

Finally, the power to make timely, cost-effective decisions is in your hands from research through delivery.

Now, go try it. We're ready when you are.

www.testmart.com

toll free 1-888-665-2765
CIRCLE NO. 392

TVS Solution Prevents ESD Failures On 10/100-Mb/s Ethernet LANs

NEWBURY PARK, CA—Semtech Corp. announced that it has leveraged its proprietary EPD TVSSM technology to produce the first transient-voltage-suppression (TVS) integrated circuit (IC) designed specifically to prevent failures from static discharges when connecting local-area-network (LAN) cables to routers, hubs, bridges, and NIC cards.

The SR2.8 TVS array protects high-speed-data interfaces from electrostatic discharge (ESD) to the IEC 1000-4-2, Level 4 standard. The SR2.8 incorporates four surge-rated, low-capacitance steering diodes and a TVS diode in a single package. Operating at only +2.8 VDC, the SR2.8 array configuration allows the user to protect two high-speed-data or transmission lines simultaneously.

"High-speed LANs—especially those carrying low-voltage RGB signals—are especially vulnerable to latch-up from static discharge, particularly cable-discharge effect (CDE), which occurs when you move cables during installation or re-routing," says Tom Dugan, Semtech's marketing director of protection products. "Developed with our EPD TVS advantage, the SR2.8's superior electrical characteristics prevents the resulting latch-up or destruction of delicate sub-5-V complementary-metal-oxide-semiconductor (CMOS) line transceivers in a way that other manufacturers have been unable to attain."

Delays In Wire Line Broadband Boost Wireless Broadband Market

OYSTER BAY, NY—The arrival of broadband technologies to the wireless neighborhood has been delayed by problematic rollouts, raising the value of the wireless broadband market, according to new findings from Allied Business Intelligence, Inc. (ABI). The limitations of conventional wired broadband technologies have become evident. Line congestion and slow deployments of digital subscriber line (DSL)

and cable modems have proven to be constant hurdles faced by many service providers, consultants, and their customers.

As a result, service providers are turning to wireless technologies. These technologies include local-multipoint-distribution-system (LMDS), multichannel-multipoint-distribution-system (MMDS), and personal-communications-services (PCS) systems operating in the various industrial-scientific-medical (ISM) bands (900 MHz, 2.4, 5.1, and 5.8 GHz). These technologies are expected to gain more than nine million broadband subscribers by 2005 (see table), according to a recent ABI research report, "LMDS, MMDS, and ISM 2000: Global Markets and Trends for Fixed Wireless Broadband."

"These wireless systems will be used to provide fiber and high-speed copper equivalents to otherwise underserved customers," states ABI senior analyst Andy Fuentes.

MMDS, including the 3.4-to-3.7-GHz worldwide standard for fixed wireless access, is expected to lead the market with 70-percent share in 2005, largely in the residential and small-office, home-office (SOHO) markets. LMDS will continue to make inroads into the market for high-value customers, accounting for 60 percent of subscriber revenues in 2005.

LMDS will continue to make inroads into the market for high-value customers, accounting for 60 percent of subscriber revenues in 2005. Traditional wire-line and wireless carriers will join small ISPs in using a collection of bands (largely unlicensed) and technologies to address dark spots in their coverage areas.

Broadband fixed WLL technologies subscribers, world market, 2000 to 2005

Year	Subscribers (millions)
2000	0.2
2001	0.9
2002	2.0
2003	3.9
2004	6.2
2005	9.4
CAAG	113 percent

Products for a Wireless World

- LAN
- IMT2000
- WLL
- PCS
- WAN
- MMDS
- W-CDMA
- SATCOM
- LMDS
- mmW/Microwave Radio

MIXERS

RF Surface Mount Microwave Open Carrier

- High IIP3
- 10kHz to 26.5 GHz
- Industry Standard Packaging
- Delivery from Stock
- Best Price-Performance ratio in the Industry

Stellex offers the broadest line of RF and Microwave Mixers and Frequency Doublers in the industry, covering 10kHz to 26GHz. Stellex RF Surface Mount and Microwave Open Carrier Mixers provide the fundamental building blocks for frequency conversions used in a broad spectrum of wireless applications. When performance and price matter, discover the value of innovative off - the - shelf solutions from Stellex.

To meet your demanding system specs, *specify Stellex!*

1-800-321-8075

Part Number	Frequency RF & LO	Frequency IF	LO Drive Level	Isolation (typ) LO/RF	Input IP3 (typ)	Conversion Loss (typ)	Package Style
CSM1-10	10 to 1,500 MHz	1 to 500 MHz	+10 dBm	40 dB	19 dBm	7.5 dB	Surface Mount
CSM1-13	10 to 1,500 MHz	1 to 500 MHz	+13 dBm	40 dB	22 dBm	7.5 dB	Surface Mount
CSM1-17	10 to 1,500 MHz	1 to 500 MHz	+17 dBm	40 dB	27 dBm	7.5 dB	Surface Mount
CSM2-10	10 to 2,800 MHz	10 to 2,000 MHz	+10 dBm	30 dB	20 dBm	7.5 dB	Surface Mount
CSM2-13	10 to 2,800 MHz	10 to 2,000 MHz	+13 dBm	30 dB	22 dBm	7.5 dB	Surface Mount
CSM2-17	10 to 2,800 MHz	10 to 2,000 MHz	+17 dBm	30 dB	27 dBm	7.5 dB	Surface Mount
MC4107	2 to 10 GHz	DC to 2 GHz	+7 dBm	40 dB	11 dBm	6.0 dB	Open Carrier
MC4110	2 to 10 GHz	DC to 2 GHz	+10 dBm	40 dB	14 dBm	6.0 dB	Open Carrier
MC4113	2 to 10 GHz	DC to 2 GHz	+13 dBm	40 dB	17 dBm	6.0 dB	Open Carrier
MC4120	2 to 10 GHz	DC to 2 GHz	+20 dBm	40 dB	23 dBm	6.5 dB	Open Carrier
MC4507	4 to 22 GHz	DC to 4 GHz	+7 dBm	32 dB	11 dBm	6.0 dB	Open Carrier
MC4510	4 to 22 GHz	DC to 4 GHz	+10 dBm	32 dB	14 dBm	6.0 dB	Open Carrier
MC4513	4 to 22 GHz	DC to 4 GHz	+13 dBm	32 dB	17 dBm	6.0 dB	Open Carrier
MC4520	4 to 22 GHz	DC to 4 GHz	+20 dBm	32 dB	23 dBm	6.5 dB	Open Carrier

* Connectorized test units available for evaluation

visit us on the web at

www.stellexms.com

**The best high performance mixers
available have a new name...**



Stanford Research Park • 3333 Hillview Avenue, Palo Alto, CA 94303-1223
Tel: 1.800.321.8075 • FAX 650.813.2030

CIRCLE NO. 261

California Law Enforcement Benefits From WAN Technology

ORANGE, CA—Global Pacific Wireless Internet, a division of Worldwide Wireless Networks, Inc. (WWWN), has been selected by the city of Garden Grove and its police department to construct a wireless broadband network connecting its police substations. WWWN's integrated wireless Internet network will deliver aerial high-speed wide-area-network (WAN) connectivity to the Garden Grove Police Department's 10 police substations. These substations are strategically located throughout the city to act as support stations in areas that need extra patrol and police presence. The Garden Grove Police Department chose WWWN's wireless network and its system to serve as its primary wireless WAN connection and Internet backbone connectivity because the system enables any Garden Grove Police Department employee to access all police records and data that are available at the main police-station computer and can rapidly transfer that information wirelessly to the substations.

WWWN's wireless WAN and its system can be rapidly deployed and relocated for wireless remote-access applications. The WAN's performance and reliability will quickly enable the Garden Grove Police Department to access various state and federal records in virtually seconds, cutting down on valuable response time.

Lead Is Eliminated From BGA Packages

LEXINGTON, MA—STMicroelectronics has announced the successful development of lead-free ball-grid-array (BGA) and micro-BGA packages. The new packages, where conventional tin/lead (SnPb) solder balls are replaced by a tin/silver/copper (SnAgCu) alloy, were developed within the ECOPACK® program that ST has been pursuing as part of its commitment to achieve total environmental neutrality.

Lead is widely used throughout the electronics industry and, in particular, has always been a critical component of the solder used for printed-circuit-board (PCB) assembly. For the same reason, it is also widely used in semiconductor packaging—for coating the leads of through-hole packages, for die attach of power packages, and for the balls of BGA packages. In fact, the conventional BGA packages currently in production have a lead content up to 15 percent, the highest of any semiconductor package.

"Lead has always been extensively used in the electronics industry and its elimination poses major challenges to semiconductor manufacturers. However, ST is fully committed to finding alternatives to toxic metals, even when current international regulations allow their continued use, and the development of lead-free BGA packages is an important milestone," says Carlo Cognetti, ST's corporate package development and engineering director.

Class Of Reduced SAR Embedded Antennas Introduced

CANNES, FRANCE—As handsets get smaller, meeting the specific-absorption-rate (SAR) requirements will present a challenging dilemma for wireless handset designers. How will tomorrow's antenna technology significantly reduce SAR while improving effective radiated power (ERP)? The answer may lie in a family of reduced SAR embedded antennas that was recently introduced by RangeStar Wireless.

RangeStar's reduced SAR embedded antenna is specifically designed to provide wireless design manufacturers with a solution to meet current European and Federal Communications Commission (FCC) SAR requirements—one that does not depend on shielding or power reduction. RangeStar has worked for the past several years to develop this class of internal antennas that significantly reduces SAR, which allows original equipment manufacturers (OEMs) to increase power in order to improve ERP.

"The impact of the reduced SAR embedded antenna is increased performance and maximum ERP," says David McCartney, executive vice president of RangeStar. "RangeStar's embedded antenna allows wireless designers to fully maximize output while meeting the requirements of the FCC and other international guidelines."

Weighing in at only 2 g (nominal), the antenna offers a gain of 1 to 2 dBi while operating in the 800-to-1900-MHz bands. The internal antenna can provide a 4-dB front-to-back ratio that relates to an average SAR measurement of 1.5 W/kg. In addition, the reduced SAR embedded antenna provides the unique ability to be mounted over components on the printed-circuit board (PCB) [i.e., the duplexer].

Market Demands Increase For InGaP HBTs And PHEMTs

SOMERSET, NJ—EMCORE Corp.'s Electronic Materials Division (E2M) recently announced the completion of the first phase of expansion at its fabrication facility to meet increased market demand for its indium-gallium-phosphide (InGaP) heterojunction-bipolar-transistor (HBT) and pseudomorphic-high-electron-mobility-transistor (PHEMT) products used in wireless and fiber-optic communication devices. The additional 2000 sq. ft. of fabrication space will accommodate up to six additional high-throughput TurboDisk® epitaxial wafer platforms and support expansion of the division's characterization capabilities. The first phase of expansion nearly doubles production capacity for 4- and 6-in. (10.16- and 15.24-cm) wafers. EMCORE also has launched a second phase of expansion that will again double production capacity for these products.

"Recent orders for both PHEMT and HBT epitaxial materials for wireless have resulted in a 300-percent increase in E2M's six-month backlog since the beginning of FY00," says Reuben Richards, president and CEO of EMCORE. "We are currently shipping both 4-in. and 6-in. InGaP HBTs and PHEMTs to our wireless customers for power amplifiers for GSM (Global System for Mobile Communications), TDMA (time-division-multiple-access), and CDMA (code-division-multiple-access) multiband wireless handsets and to our fiber-optic customers for high-speed digital components for OC-48 and OC-192 fiber-optic communication."

"We are seeing rapid growth in the demand for both 4-in. and 6-in. InGaP HBT wafers, as designers and manufacturers have realized the performance and reliability advantages of InGaP HBTs compared to conventional AlGaAs HBTs," says Craig Farley, vice president of E2M. "Recent high-volume orders for PHEMT wafers from major wireless component manufacturers have demonstrated that MOCVD (metal-organic-chemical vapor deposition) epitaxial material is superior to MBE for both HBT and PHEMT applications."

Declining Investment In Research And Development Alerts Defense Industry

WASHINGTON, DC—The Aerospace Industries Association (AIA) continues to be alarmed as the Defense Department chips away at its investment in research and development (R&D). The FY 2001 budget proposes a half billion dollar decrease in RDT&E funding from the FY 2000 budget. After adjusting for inflation, FY 2001 RDT&E is at the lowest level in 18 years. AIA has proposed a plan to increase investment in aerospace R&D over five years. AIA's plan calls for a \$2 billion increase in Defense Department funding of aerospace RDT&E in FY 2001.

The Defense Department's long-term research budget is even more alarming. The FY 2001 budget proposal would further reduce RDT&E investments in Fiscal Years 2002 to 2005. This steady decline in research investment is likely to have a negative effect on the quality of equipment provided to America's men and women in uniform. Strong investment in R&D is critical to national security, economic well being, and international competitiveness.

High-Speed Internet Access For Public Places Introduced

NEW ORLEANS, LA—Lucent Technologies recently announced the ORINOCO high-speed wireless Internet-access and networking system. Building upon Lucent's WaveLAN wireless local-area network (WLAN) for business and enterprise, the ORINOCO family now adds new home-networking products as well as products that are designed to provide secure, high-speed Internet access in public hot spots such as universities, office complexes, and airports.

Whether for home, office, or travel, all of these systems use the same ORINOCO personal-computer (PC) radio card. Formerly known as the WaveLAN PC card, the ORINOCO PC card provides high-speed wireless networking and secure Internet access for laptop and desktop computers, as well as a wide range of mobile computing devices. The ORINOCO system also includes various access points that act as base stations for the wireless users and provides a high-speed connection to the Internet.

Based upon the industry standard IEEE 802.11 (Wi-Fi)-compliant technology, ORINOCO provides 11-Mb/s speed over the unlicensed 2.4-GHz spectrum, with ranges up to 1200 ft. The Lucent Technologies ORINOCO PC card fits into almost any laptop or mobile computing device and is compatible with other 802.11-compliant systems, including the popular Apple AirPort™ system.

dreams made real.

Honey, you're gonna hate me, but I gotta work late. It took one hundred years to connect the first billion people. The second will take only five. The wireless revolution is at hand. And Agilent is testing and creating components for all of it. From handsets to networks, we're helping to bring wireless to the world. And making sure it works. Even if that means overtime.



Agilent Technologies

Innovating the HP Way

Agilent Technologies is a new company comprised of the former Hewlett-Packard test and measurement, chemical analysis, semiconductor components and medical products businesses. www.agilent.com

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

DAC14135 Combines Multiple Carriers, Reducing Basestation Cost and Size

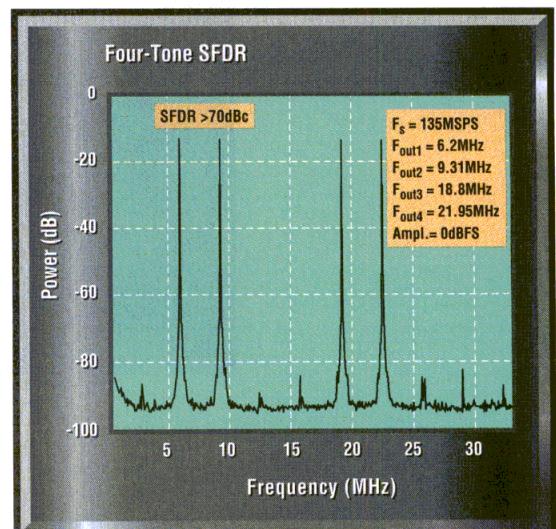
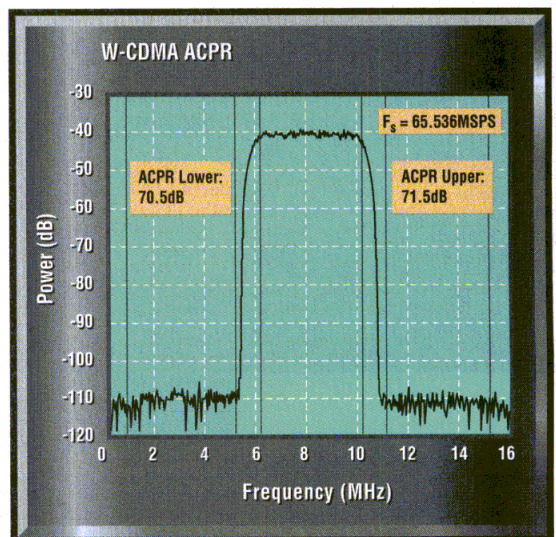
- Wide dynamic range with:
 - 85dBc SFDR @ 1MHz
 - 70dBc SFDR @ 20MHz
- TTL/CMOS (+3.3V or +5V) Inputs
- 48-pin TSSOP provides small footprint
- Low 185mW power dissipation
- Costs less than \$10


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

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

Evaluation Board Available at:
www.national.com

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



©1999 National Semiconductor Corporation. National Semiconductor and  are registered trademarks of National Semiconductor Corporation. Price shown is for 1K units in USD, FOB Santa Clara, CA. All rights reserved.

 **National**
Semiconductor®

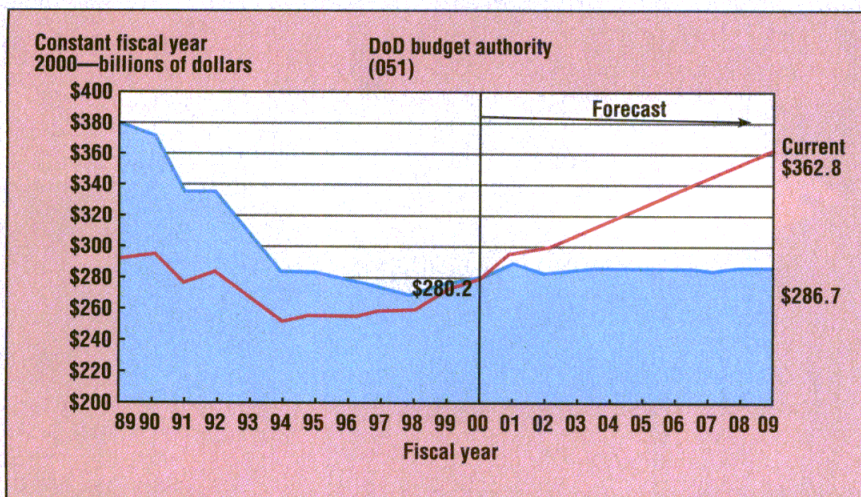
Defense planners must walk a fine line to cut costs, keep forces ready, and maintain the high quality that has characterized military systems over the years.

Defense Spending Choices Force A Balancing Act

GENE HEFTMAN

Senior Editor

FEW issues of federal government spending evoke more public debate than the amount of money requested by the military each year to defend the national interests of the US. Between now and 2010, approximately \$270 to \$300 billion of taxpayers' money (in constant Year-2000 dollars) will be spent each year to maintain US defense forces at a high state of readiness. But to maintain that state, the country must, in the words of the 35th Annual 10 YR Defense Electronics Forecast (1999) of the Government Electronics and Information Technology Association (GEIA), "address the affordability challenges of being the world's only remaining superpower." Until very recently, it was doubtful that sufficient political and economic will existed to spend the money necessary to upgrade and modernize the military as defense budgets plummeted during the 1990s (Fig. 1). However, budget surpluses from a booming economy over the next few years could keep appropriations on an even keel and allow the military to restore some of the fighting capability that reduced spending has diminished over the years (note the virtually constant expenditure level in constant dollars from 2000 to 2009 in the GEIA's budget forecasts in Fig. 1).

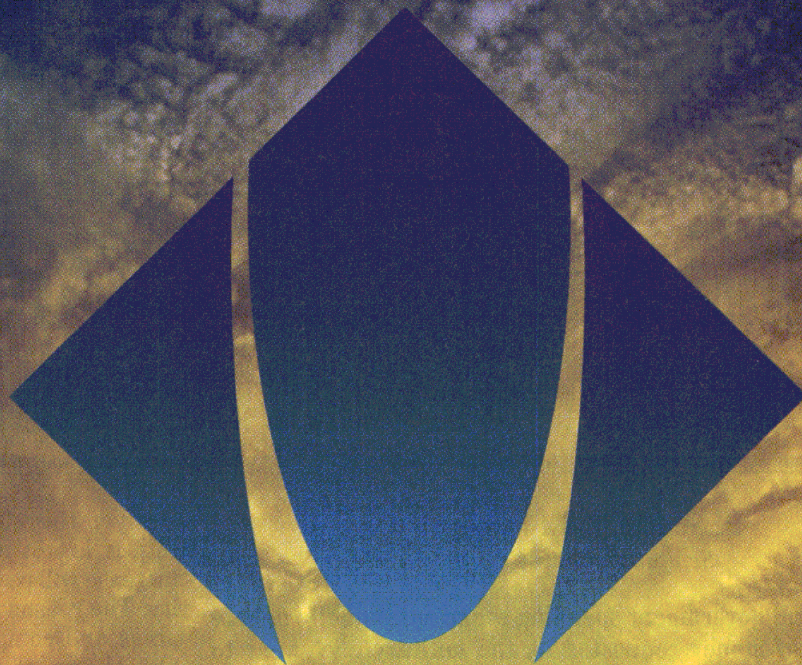


1. After a decade of decline, the US military budget will rise slightly (in constant dollars) over the next decade according to the latest forecast of the GEIA.

Given this slight uptick in spending, it is not clear how much the increase will restore military capability. The reason is that a host of variables and complex scenarios make the shape of tomorrow's armed forces and how it is equipped highly unpredictable (see "Electronics Are A Secret Weapon In The Military Budget," *Microwaves & RF*, June 1999, p. 27, and "Military Retrenchment Spells Electronics Growth," *Microwaves & RF*, June 1998, p. 37.) In the GEIA's view, the spending cuts on equipment of the last decade have created a giant shortfall from what is needed to maintain a modern military force (see table). However, the Forecast concedes that "Post-Cold War Force structure reductions . . . have reduced current requirements from those of the 1974-1993 period." On the other hand, the Forecast refers to a recent Congressional Budget Office (CBO) study that found that planned rates of procurement are still far short of the levels required to modernize the armed forces. The third column of the table lists the annual purchases necessary to sustain today's forces, assuming a broad number of variables, equipment lifetimes, and other assumptions. In light of current and projected budgets shown in Fig. 1, it is doubtful that the monies available will be able to satisfy the ambitious purchase schedule laid out by the GEIA.

To be sure, modernization and improved equipment are necessary to keep the US as the world's number one military superpower. The question is the affordability issue. How

R F P O W E R F O R 3 G N E T W O R K S



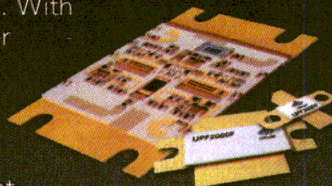
UltraRF

L D M O S

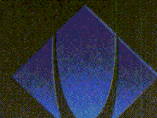
Your wireless networks can't wait to move to 3rd generation technology. But retrofitting and enhancing your existing infrastructure presents some serious challenges.

UltraRF has the high power LDMOS solutions. With the highest power density available, combined with high efficiency and linearity, you can now meet the stringent demands of the emerging 3G air interface standards within both power and cost budgets.

And UltraRF is shipping gold LDMOS and bipolar transistors for all current cellular bands and standards at power levels from 5 to 1000W in both industry standard packages and highly integrated ceramic based power amplifier modules.



For an UltraRF databook or to speak with an UltraRF design engineer about LDMOS solutions for your 3G infrastructure call 877-206-5657, email info@ultrarf.com, or www.ultrarf.com



UltraRF™

160 Gibraltar Court
Sunnyvale, CA 94089-1319 USA
Phone: 408 745 5700
Fax: 408 541 0139

England +44 (0) 118 934 3838
Finland +358 (0) 8 551 4435
Stockholm +46 (0) 8 471 8400
Gothenburg +46 (0) 31 726 8353
Uddevalla +46 (0) 522 641 400
Norway +47 (9) 333 86271

Deferring equipment replacement has created an aging force

	Average annual purchases			Annual purchases needed to sustain today's forces*
	1974 to 1993	1994 to 1999	2000 to 2005	
Tanks, artillery, and other armored vehicles	1485	24	28	623 to 872
Helicopters	124	44	30	155 to 263
Fighter/attack aircraft	308	44	72	174 to 232
Other aircraft	38	10	17	45 to 59
Ships	17	7	8	8 to 10

*Range of annual purchases needed reflects effect of different assumptions on length of service lives.

much is the US willing to spend to maintain supremacy? The short answer is not as much as the military is used to. This means that military systems must not only meet the high-performance and reliability standards of the past, but must do so on skimpier budgets. As far back as 1983, the government thought it had the answer with the Commercial-Off-The Shelf (COTS) initiative, but in the year 2000 it is still not clear how the program can keep the US armed forces on the cutting edge.

On its face, using commercial components where possible in place of those made specifically for the military at much higher cost is a logical method for reducing the cost of defense equipment and systems. Moreover, the armed services get the benefit of the latest commercial technology, which is constantly improving by virtue of the competitive forces of the marketplace driving companies to outdo one another in the race for profits and business success. The reality is far more complex

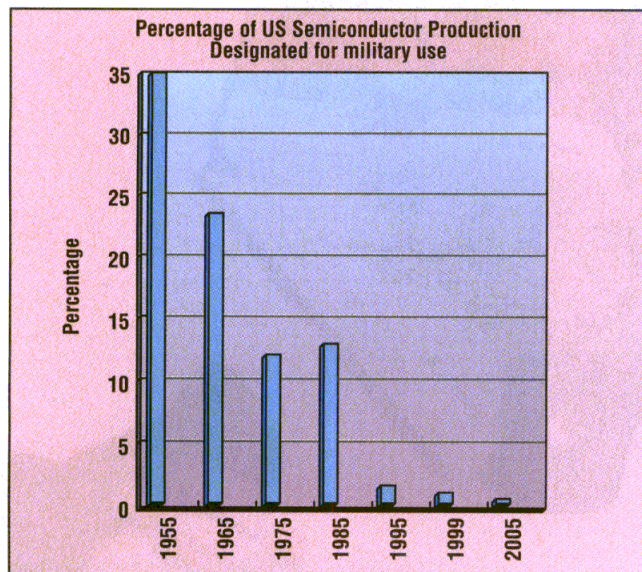
for the simple reason that defense spending is not what it used to be, and manufacturers have more lucrative opportunities in commercial markets.

"Defense contractors expect to buy low volumes at commercial prices," says Peter Milliken, Product Line Manager of Semiconductor Products and Services at UPMC Micro-electronic Systems (Colorado Springs, CO), a supplier of semi-custom and stan-

dard VLSI integrated circuits (ICs) to aerospace and defense markets. "They also want access to advanced semiconductor technologies like systems-on-a-chip (SOC), but the intellectual property (IP) to do that has been pretty pricey," he adds. A chip manufacturer cannot afford an up front cost of approximately a half-million dollars for a potential volume of 100 or even 1000 pieces. And the government does not want to absorb a royalty for a device that is not a guaranteed success. In short, the government wants advanced technology but the cost and accessibility issues are proving difficult to resolve.

Another example of the price/volume dilemma experienced by Miliken is the plastic packaging issue. Surface-mount plastic packaging is desirable in some space-vehicle applications to reduce the weight of large pin-count IC packages and reduce board-space requirements, but the volumes needed by defense contractors run only approximately 1000 pieces over five years. But assembly manufacturers who do plastic packaging require anywhere from 2500 to 10,000 pieces to make the job profitable, effectively cutting off that option. Since ceramic-package lot sizes are economic in 250-piece lots, the company is forced to use that technique.

"The whole goal of the Dr. Perry mandate (Dr. William Perry was Secretary of Defense in 1994 when the COTS rules went into effect) is to use commercial products in military applications where you can," says Tom Terlizzi, Vice President and General manager of Aeroflex Circuit Technology (Plainview, NY). "Instead of military specifications for an integrated circuit, a performance specification is used. Rather than specifying the part to the finest detail, it is left up to the manufacturer to do what he best knows how to do," he adds. But such COTS programs have met with mixed results. Some specifications have been too relaxed, while others are not stringent enough. A commercial part cannot simply be used in a military application, according to Terlizzi. "You must know the device physics and where it can be used," he states. With



2. The nation's semiconductor manufacturing resources devoted exclusively to military devices are declining rapidly, as shown in this bar graph from *Revolution in Miniature*, by Braun & McDonald.

*No tricks
required to
get your
catalog.*

*With
Ericsson
a simple
request is all
it takes to get
the information
you need.*

*To receive your Ericsson
catalog, short form or
interactive CD-ROM,
Visit our website at
www.ericsson.com/rfpower
or Email us at
rfpower@ericsson.com.*



Delivering Technology Choices

Ericsson Microelectronics

RF Power Products

1-877 GOLDMOS (465-3667) United States
+46 8 757 4700 International

ERICSSON 

Ericsson Delivers **GOLDMOS™** FETs

Product Number	Frequency Mhz	P _{OUT} Watts	Gain dB	Supply Voltage	Package Number	Internal Matching
To 1.0 GHz – GOLDMOS FET						
PTF 10136	1000	6	18.0	28	20244	N
PTF 10147	1000	10	15.0	26	20244	N
PTF 10137	1000	12	13.0	28	20244	N
PTF 10007	1000	35	12.0	28	20222	N
PTF 10052	1000	35	12.0	28	20235	N
PTF 10015	1000	50	12.0	28	20235	N
PTF 10031	1000	50	12.0	28	20222	N
PTF 10139*	1000	60	12.0	28	20235	N
PTF 10138*	1000	60	12.0	28	20222	N
PTF 10009	1000	85	12.0	28	20230	N
PTF 10049	470–860	85	12.0	32	20240	I
PTF 10159	470–860	120	12.0	32/28	20240	I
PTF 10019	860–900	70	13.0	28	20237	I
PTF 10133	860–900	85	13.0	28	20237	I
PTF 10100	860–900	165	12.0	28	20250	I
PTF 10162	860–960	18	14.0	26	20222	N
PTF 10036	860–960	85	11.0	28	20240	I
PTF 10160*	860–960	85	15.0	26	20248	I/O
PTF 10020	860–960	125	11.0	28	20240	I
PTF 10149	921–960	70	15.0	26	20252	I
1.0–2.2 GHz – GOLDMOS FET						
PTF 10111	1500	6	15.0	28	20222	N
PTF 10107	2000	5	11.0	26	20244	N
PTF 10135	2000	5	11.0	26	20249	N
PTF 10041*	2000	12	10.0	26	20249	N
PTF 10053	2000	12	10.0	26	20244	N
PTF 10021	1400–1600	30	11.0	28	20237	I/O
PTF 10125	1400–1600	135	11.5	28	20250	I/O
PTF 10045	1600–1650	30	10.0	28	20222	N
PTF 10112	1800–2000	60	11.0	28	20248	I/O
PTF 10153*	1800–2000	60	12.5	28	20248	I/O
PTF 10120	1800–2000	120	10.0	28	20250	I/O
PTF 10043	1900–2000	12	11.0	26	20222	I
PTF 10035	1900–2000	30	11.0	28	20237	I/O
PTF 10123*	2100–2200	5	11.0	28	20244	N
PTF 10119	2100–2200	12	10.0	28	20222	I
PTF 10048	2100–2200	30	10.0	28	20237	I/O
PTF 10122	2100–2200	50	10.0	28	20248	I/O
PTF 10134*	2100–2200	100	10.0	28	20250	I/O

Note: An "*" next to the product part number indicates the specifications are preliminary and subject to change without notice. Please contact your sales representative for further product information. Complete product information is available on our Website at: www.ericsson.com/rfpower.

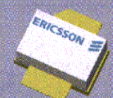
Packages are not to scale.



20222



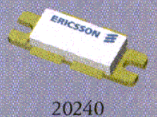
20230



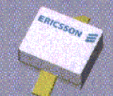
20235



20237



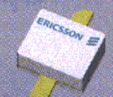
20240



20244



20248



20249



20250



20252

military budgets shrinking and commercial business growing, it is becoming difficult to get commercial chipmakers to build products for the military.

An example of what spending cut-backs and COTS have wrought is illustrated in Fig. 2. This bar graph shows the percentage of US semiconductor production devoted to defense systems, and projects what lies

ahead over the next five years. Over a span of half a century, the percentage fell from 35 percent in 1955 to near zero by the year 2005. This is at the core of present and future semiconductor procurement problems for military hardware. Unless military requirements align themselves with the types of devices produced for commercial systems, obtaining the

necessary electronics for advanced systems will be difficult.

STANDARDIZING IS KEY

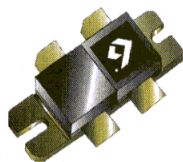
Among suppliers of components and equipment to the defense industry, there is broad consensus that the military must use more COTS-type ICs, including the use of standard products wherever possible. Such is the case even for contractors whose sole business is military. One way to accomplish this, according to Dave Martell, Director of Business Development for Microwave Products at Zeta-IDT (San Jose, CA), a supplier of RF power products and systems to the Department of Defense, is the use of a standardizing technique called platforming. "Say you're building seven different types of radar and you need a synthesizer," he says, "Maybe there is a way to use one 'Brand X' synthesizer for all seven types. Then you can go out and get a quotation for a higher volume of parts and get the benefits of economies of scale." Today, the military is using more standard parts than ever, and the idea of non-recurring-engineering (NRE) charges is frowned upon.

The same sentiment is echoed by Carl Fisher, Manager of Business Development at MPD Technologies, Inc. (Hauppauge, NY), a manufacturer of high-power solid-state amplifiers for the aerospace and defense industry. Many of the company's military products are built to specification and are unique. Still, Fisher says, "Standard power modules are at the heart of our amplifier systems. The power modules that we build apply to a high-frequency system, whether it's 1 kW or 10 kW; we use the same modules in each product." And these modules are designed to be upgradeable as technology evolves. As an example, they are using laterally-diffused-metal-oxide-semiconductor (LDMOS) power devices wherever possible, but the next generation of power semiconductors could be the highly touted but as yet unproven silicon-carbide (SiC) technology. So the modules must be designed to accept SiC devices when it becomes a viable technology.

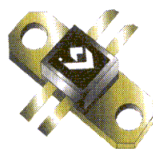
Some RF Design Engineers Are Pressured Into Choosing the Wrong MOSFET



**Experienced Design Engineers
Specify POINT NINE Transistors
RUGGED Vertical
MOSFETS**

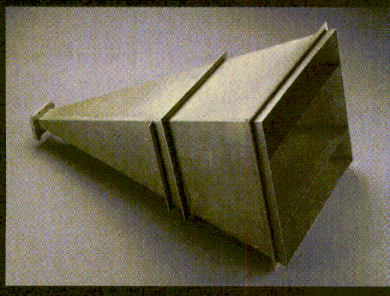
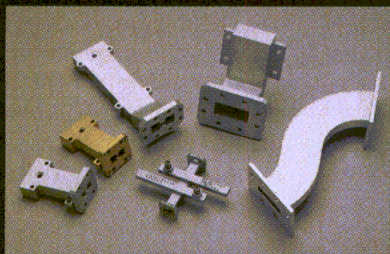
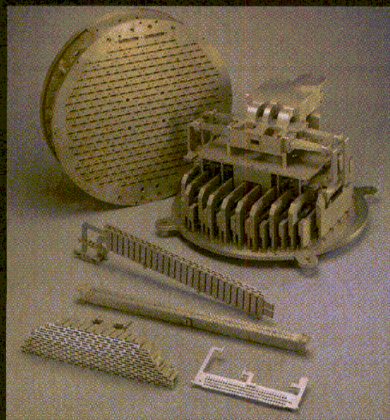


POINT NINE
Technologies, Inc.



2697 Lavery Court #8 • Newbury Park, CA 91320
(805) 375-6600 • Fax: (805) 375-6602
www.rfmosfet.com

CMT WAVEGUIDE COMPONENTS AND ASSEMBLIES



**THE SUBTLE DIFFERENCE BETWEEN MASTERING
THE ART OR MERELY BUILDING PRODUCT**

The CMT Philosophy

Quality First
Unsurpassed Technical Performance
Relentless Customer Service
Dedicated Delivery
Competitive Pricing

Engineered like no other Waveguide Assemblies

Contact us today about the waveguide solution you need.



Continental Microwave & Tool Company, Inc.

— A Chelton Microwave Company

Continental Microwave & Tool Company, Inc., 11 Continental Drive,
Exeter, NH 03833 Tel: 603-775-5200 Fax: 603-775-5201
e-mail sales@contmicro.com www.contmicro.com

ISO 9001 Certified



Visit us at
MTTS booth #406
Enter to win a Chelton
golf umbrella

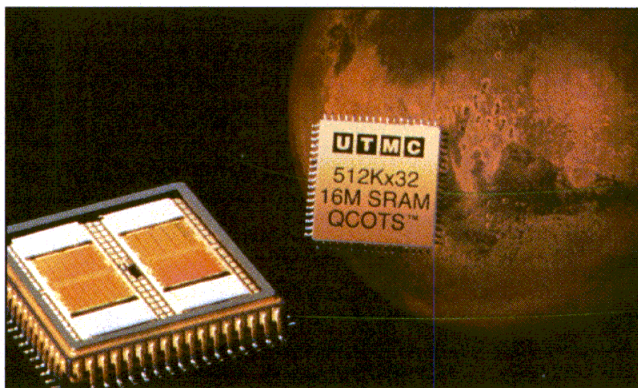
Test-equipment manufacturers are following the lead of semiconductor- and equipment-makers when it comes to employing COTS principles and standardized components. The Aerospace, Defense, and Broadband Communications Group of Agilent Technologies (Palo Alto, CA) is a major advocate of the COTS concept when it comes to the automatic test equipment (ATE) required for military hardware. Rick Pearson, general manager of the group, claims that one way to do that is "to leverage from the commercial market using the best possible solutions from the communications world." Even when building custom test equipment to spec that uses standard off-the-shelf test equipment, Pearson says that "To meet customer requirements we can modify some of the software and download-

able firmware. But to make hardware modifications, the market must be large enough to justify those changes."

The fact is, test-equipment makers and defense contractors alike are trying to get away from the mil-spec and custom-systems approach and use as

much COTS as possible in test systems. Doing so would reduce test-equipment costs, permit open industry standards, and take advantage of the latest advances in technology. The biggest stumbling block is the Test Program Set (TPS), which is the software that directs the instru-

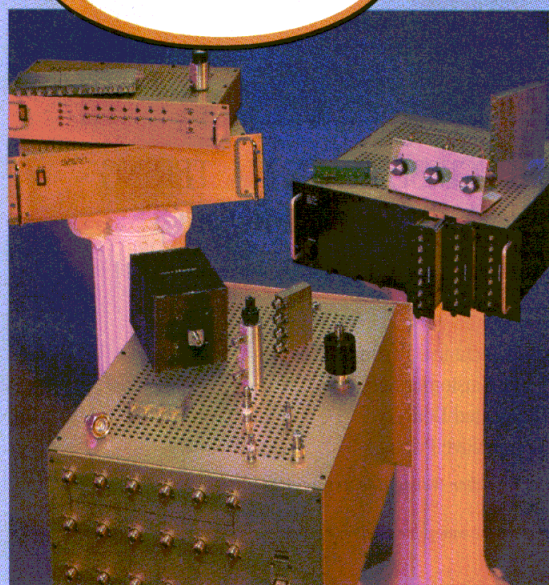
ments performing the tests. This is the high-cost item in the test gear and Agilent, together with other manufacturers, is devising methods to permit new instruments to be plugged into a test set without affecting the TPS, which would yield large cost savings when instruments must be changed. The concept is called test-asset interchangeability, and its purpose is to allow a particular test asset (instrument) to be replaced with an alternative of sufficient capability, but of a different design or from



3. Four 4-Mb memory devices are housed in this multi-chip-module (MCM) SRAM from UTMC Microelectronic Systems. Designed for space and military systems, such packaging saves space and weight in satellite systems.



PROVEN.



Now entering our fourth decade, JFW Industries is a *proven* leader in the design and production of innovative RF solutions. Whether your project calls for fixed **attenuators** and **terminations**, manually and electronically controlled **attenuators**, **RF switches**, **power dividers** or **programmable RF test**

systems and switch matrices; JFW's dedicated customer service and engineering personnel can provide application specific components and sub-systems at catalog prices with an off-the-shelf attitude. For more information, please contact us or visit our web site at www.jfwindustries.com

JFW Industries, Inc.

Specialists in Attenuation and RF Switching

TEL (317) 887-1340 • Toll Free 1 (877) 887-4539 • FAX (317) 881-6790

5134 Commerce Square Dr. • Indianapolis, Indiana 46237

Internet- <http://www.jfwindustries.com>

E-mail- sales@jfwindustries.com

ISO 9001 Certified

PERFECT PARTNERS

RF WIDEBAND TRANSISTORS FROM PHILIPS & AVNET

Design engineers are discovering that Avnet Electronics Marketing is the perfect partner for access to Philips' wide variety of RF wideband transistors.

Philips offers you



advanced technologies in silicon bipolar and double polysilicon processes for improved RF performance. This includes higher transition frequencies, lower noise performance, higher efficiency and

much more. A dedicated business group for RF and Microwave technology and products, the largest RF inventory in the world, and hybrid and custom component manufacturing capabilities are just a few reasons that make Avnet the perfect partner. Shouldn't you have a perfect partner too?

Philips RF Wideband Transistors

Type	Case	Ratings			f_T (GHz)	I_T (mA)	Characteristics, typical					
		V_{CE0} (V)	I_C (mA)	P_{TOT} (mW)			F (dB)	G_{um} (dB)	@ (MHz)	F (dB)	G_{um} (dB)	@ (MHz)
PMBTH10	SOT23	25	40	400	0.6	1-20						
PMBTH81	SOT23	20	40	400	0.6	1-20						
BFS17W	SOT323	15	50	300	1.6	2-20	4.5		500			
BFR92AT	SC-75*	15	25	300	5	3-30	2	14	1000	3	8	2000
BFT92W	SOT323	15	35	300	4	3-30	2.5	17	500	3	11	1000
BFR93AT	SC-75*	12	35	300	5	5-40	1.5	13	1000	2.1	8	2000
BFQ67T	SC-75*	10	50	300	8	3-30	1.3	13	1000	2.2	8	2000
PBR941	SOT23	10	50	360	8	3-30	1.4	15	1000	2	9.5	2000
PRF947	SOT323	10	50	250	8	3-30	1.5	16	1000	2.1	10	2000
PRF949	SC-75*	10	50	150	8	3-30	1.5	16	1000	2.1	10	2000
PRF957	SOT323	10	100	270	8	5-50	1.3	15	1000	1.8	9.2	2000
BFR505T	SC-75*	15	18	150	9	1-10	1.2	17	900	1.9	10	2000
BFR620T	SC-75*	15	70	300	9	3-30	1.1	15	900	1.9	9	2000
BFC520	SOT353	8	70	1000	9	3-30	1.3	31	900	1.5	19	2000
BFE520	SOT353	8	70	100	9	3-30	1.2	17	900	1.9	10	2000
BFM520	SOT363	8	70	100	9	3-30	1.1	15	900	1.9	9	2000
BFG520W/X	SOT343	15	70	500	9	3-30	1.6	17	900	1.8	11	2000
BFG540W/X	SOT343	15	120	500	9	10-60	1.9	16	900	2.1	10	2000
BFG11W/X	SOT343	8	500	760	9	50-150					7	1900
BFG403W	SOT343R	4.5	3.6	16	17	5-5	1	20	900	1.6	22	2000
BFG410W	SOT343R	4.5	12	54	22	2-15	.9		900	1.2	22	2000
BFG425W	SOT343R	4.5	30	135	22	3-30	.8		900	1.2	20	2000
BFG480W	SOT343R	4.5	250	360	18	30-150	1.2		900	1.8	16	2000
BFG21W	SOT343R	4.5	200	600	18	50-250					12	1900

* New Small SS-MINI SC-75 Package

GET YOUR FREE DESIGNER'S SAMPLE KIT

Call us at 1-800-261-9602 ext. 304 or visit us at
www.em.avnet.com/rfm/philipswb.html

Avnet and the AV logo are registered trademarks of Avnet, Inc.



CIRCLE NO. 292

a different manufacturer without affecting the TPS. To accommodate interchangeability, Agilent has developed a measurement subsystems architecture (MSA). Under MSA, asset-control modules permit obsolete instruments to be replaced with newer modules while still providing the same answers as the original instrument.

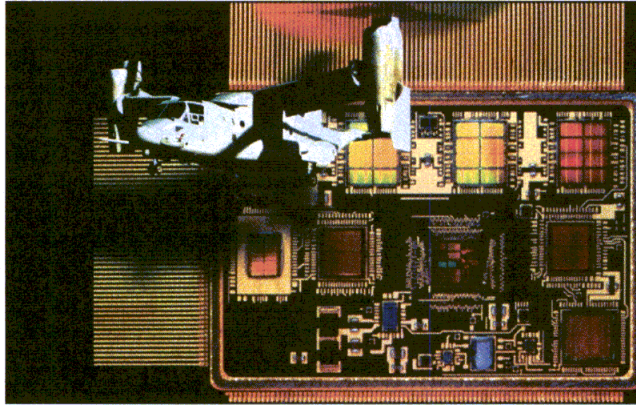
CONQUERING OBsolescence

Military systems are designed to have long lifetimes, often for 10 years or more. Today's commercial equipment generally lasts for only a few years as business tries to keep consumers buying with new bells and whistles to keep the cash registers ringing. While consumer products require a constant influx of

new technology—semiconductor and otherwise—military products must have a steady flow of devices that will be available for the life of the system. But given the reductions in military spending over the past decade, it is

virtually impossible for IC manufacturers to continue to supply and stock 10-year old devices when commercial markets are so much more lucrative. Thus, electronic defense systems need some means of continuing to function as the circuits that drive them become obsolete.

The armed forces understand the problem, which is one of the reasons for the COTS initiative. Moreover, it is necessary for military hardware to incorporate the latest technology for maximum effectiveness. One of the techniques being used by chip makers to avoid obsolescence and keep within the spirit of COTS is the multi-chip module (MCM), a hybrid type of IC that takes advantage of advanced technology by packaging complex functions in a single IC package using multiple



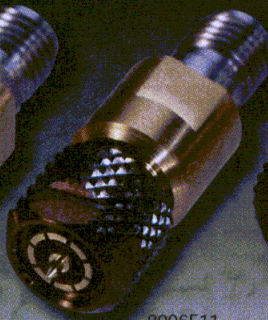
4. A high-performance system such as this 64-b super-scaler microprocessor with cache memory from Aeroflex Circuit Technology can be packaged in an MCM for defense electronics systems. This packaging technique meets military needs for a COTS IC that incorporates the latest in processor technology.

NEW FROM MAURY QT3.5mm™ Quick Test Connectors & Adapters*

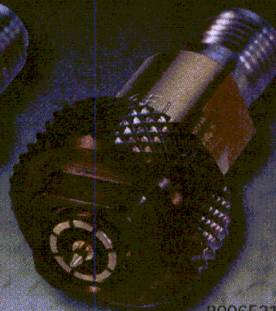
- Excellent Repeatability/ Low VSWR
- Quick & Easy Push-On/ Pull-Off Design
- Guide Sleeve Design For Automated Applications
- Designed for Long Life



8006E1
No Nut



8006E11
3/8" Nut



8006E21
9/16" Nut



8006Q1
Guide Sleeve

ELECTRICAL SPECIFICATIONS

MODEL	FROM	TO	FREQ RANGE (GHz)	VSWR (GHz)
8006E1	QT3.5mm™ (m) with no nut	3.5mm (f)	DC — 26.5**	DC — 16.0, 1.05 16.0 — 26.5, 1.08
8006E11	QT3.5mm™ (m) with 3/8" dia. nut	3.5mm (f)		
8006E21	QT3.5mm™ (m) with 9/16" dia. nut	3.5mm (f)		
8006Q1	QT3.5mm™ (m) with guide sleeve	3.5mm (f)		

** Slightly reduced VSWR specifications to 34 GHz.

Other available configurations include:

- 7mm • Type N (f & m) • NMD2.4mm(f) • NMD3.5mm (f)

*U.S. Patent Pending

REPEATABILITY

REPEATABILITY	DC — 18.0 GHz	18.0 — 26.5 GHz
Push-On Mode	> 45 dB	> 40 dB
Torque Mode	> 50 dB	> 50 dB
Hand Torque	> 50 dB	> 50 dB

For more information contact
our **SALES DEPARTMENT** at
Tel: (909)987-4715 • Fax: (909) 987-1112
Email: maury@maurymw.com

Visit us on the World Wide Web at
<http://www.maurymw.com>



**MAURY MICROWAVE
CORPORATION**
2900 Inland Empire Blvd., Ontario, CA 91764, USA

CIRCLE NO. 423 or visit www.mwrf.com

MICROWAVES & RF ■ JUNE 2000

RF LDMOS

Move Up to the Next Generation with Motorola

As digital standards increasingly dominate the wireless communication market, Motorola's RF LDMOS continues to be the industry's technology of choice. And, Motorola continues to develop and improve its patented RF LDMOS design and has recently extended



performance on new 4th generation RF LDMOS products. The newest product introductions incorporate the latest process improvements and the most advanced technology. With a dedicated business group for RF & Microwave products and services, local market resources for support, plus one of the largest RF inventories in the world, Avnet Electronics Marketing is uniquely positioned to be your source for RF LDMOS products from Motorola.

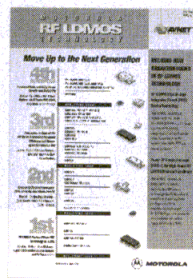
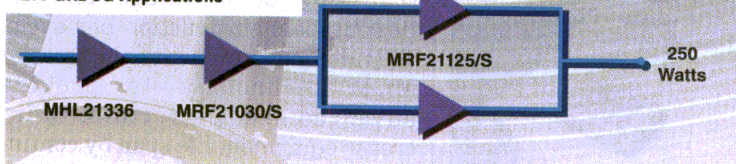
Advantages* of Motorola's HV4x4 RF LDMOS Transistors:

- Higher Gain
- Higher Efficiency
- Higher Impedances
- Improved Thermal Ratings
- Increased Power
- Higher Reliability
- Smaller Package Size Per Watt
- Internally Matched
- ESD Protection

1.9 GHz PCN/PCS Applications



2.1 GHz 3G Applications



For a copy of Motorola's RF LDMOS Selector Guide, visit our Web site at

www.em.avnet.com/rfm/motldmos.html
or call 1-800-261-9602 ext. 302.

IN STOCK AT



* Compared to previous generations of Motorola RF LDMOS

Avnet and the AV logo are registered trademarks of Avnet, Inc. Motorola is a registered trademark and DigitalDNA and the DigitalDNA logo are trademarks of Motorola, Inc.

chips. At Analog Devices (Greensboro, NC), Bob Barfield, product marketing manager for the Multichip Products Business Unit states that "We're trying to look across multiple organizations, multiple customers, and multiple programs to define somewhat generic functions. These can be things such as direct IF conversion, analog-to-digital converters

(ADCs) and others, and they would be released as standard products, hence a COTS product. The idea is to promote that functionality to gain widespread acceptance among users, which is in tune with what COTS is trying to do."

The company offers several grades of these functions including one that is fully tested across the full military


temperature range to guarantee the performance. But for applications that do not require such stringent testing—called ruggedized industrial grade—less screening is performed, resulting in a less-expensive part. Whatever the grade, however, all devices are produced on the same manufacturing line. One of the benefits of the MCM approach for military applications is that a package can be designed with a specific functionality and pinout arrangement. As semiconductor technology improves, the devices inside the package can be upgraded with advanced versions but the functionality and pinout remain the same. This allows military hardware to be upgraded with the latest technology without necessitating changes to the original design.

An example of the MCM approach is a 16-Mb static random access memory (SRAM) from UTMC Microelectronic Systems for use in satellite applications (Fig. 3). The device packages four 4-Mb memory die using both sides of the substrate in a 68-lead ceramic flatpack, which increase packaging density and conserves space and weight. The company claims that this type of module is less than half the size and weight of four individual SRAMs, and offers lower cost/bit. It is also a radiation hardened (rad-hard) part rated for a total-dose exposure of up to 30 krd(Si) and can be shielded up to 100 krad(Si) for operation in geosynchronous orbits.

MCM technology is featured in a MIPS microprocessor package that contains a 64-b superscaler processor chip together with 2 MB of embedded cache memory from Aeroflex Circuit Technology (Fig. 4). The package is a 280-lead ceramic flatpack aimed at military and high-reliability markets. The processor is a high-speed type that can issue one integer and one floating-point instruction per cycle. This device represents the goal of MCM technology—to provide advanced semiconductors, to increase equipment life span by continuously upgrading performance in a small footprint, and to provide an orderly migration path for future products by upgrading with new devices as they become available.●●

- Quality
- Reliability
- Performance

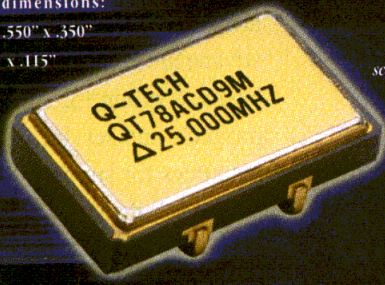
q-tech.com



high-reliability crystal oscillators

solutions in surface mount design

dimensions:
.550" x .350"
x .115"



screening per
MIL-PRF-
55310
Level
B

ruggedized
surface
mount
designs

Frequency
Range:
.01 Hz
to 300 MHz

Product Range Includes:
TTL, HCMOS, AC MOS,
Low Voltage 3.3 V,
and ECL Clocks
•XOs •VCXOs
•Sine Wave


Q-TECH

Corporation

10150 West Jefferson Blvd.
Culver City, CA 90232

Tel: 310.836.7900 www.q-tech.com Fax: 310.836.2157

new!
ultra-mini
for commercial
digital applications



CIRCLE NO. 430 or visit www.mwrf.com

MICROWAVES & RF ■ JUNE 2000

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

Since then, tens of thousands of microwave amplifiers and assemblies have been delivered into applications including: ESM, radar systems, missiles, UAVs, seekers and decoys.

CTT's products contain the latest advancements in thin-film, GaAs FET MIC and MMIC technology. These high quality products include:

- Low-Noise Amplifiers
- Medium Power Amplifiers
- High Power Amplifiers
- Limiting Amplifiers
- Amplifier Subassemblies

As military budgets have continued to shrink, the threats have continued to become more lethal and diverse. CTT has, however,

continued to incorporate excellence in engineering and production technology into our products in order to make your programs – whether new or upgrade – effective.

Our goal is to be the number one supplier of amplifiers and subassemblies in the marketplace. In fact, we are currently supplying replacements for many hard-to-find assemblies – including those formerly provided by **Avantek**.

Give us a call to find out how our commitment can support your success.

*Coverage
without
compromise
continues.*



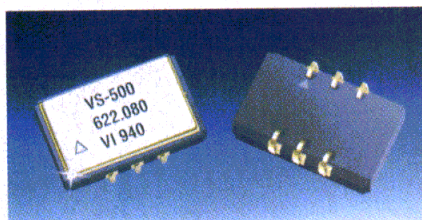
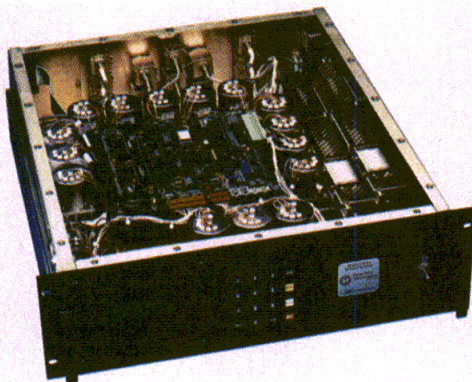
3005 Democracy Way
Santa Clara, CA 95054 USA
Phone: 408-988-8521
FAX: 408-986-9097
www.cttinc.com

Coaxial switch matrix supports 100 outputs

The model 2201 coaxial, bidirectional, normally open-switch matrix is configured with one input and can have up to 100 outputs. It operates from DC to 18 GHz and is ideal for use in automatic test equipment (ATE), environmental/laboratory test equipment, and programmable patch panels and interconnects. The matrix has a switching speed of 50 ms and an impedance of 50 Ω . It includes a solid-state controller with a front-panel liquid-crystal-display (LCD) screen and a keypad for manual override and RS-232,

RS-422, and IEEE-488 general-purpose-interface-bus (GPIB) remote interfaces. The bidirectional open-switch matrix operates at temperatures from 0 to +50°C and is enclosed in a 5.5 × 19 × 20-in. (13.97 × 48.26 × 50.80-cm) rack-mountable housing. Options include rack slides. **Dow-Key Microwave Corp., 4822 McGrath St., Ventura, CA 93003-7718; (805) 650-0260, FAX: (805) 650-1734, Internet: <http://www.dowkey.com>.**

CIRCLE NO. 58 or visit www.mwrf.com



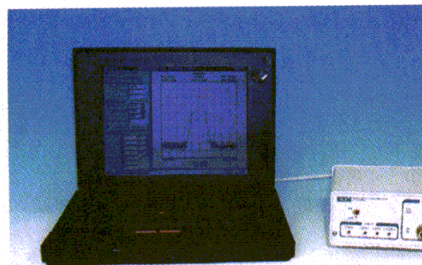
SAW-based VCO offers low jitter

Model VS-500 standing-acoustic-wave (SAW)-stabilized, voltage-controlled oscillator (VCO) operates at the fundamental frequency of its internal SAW filter. It boasts high stability and high quality factor (Q) for low phase jitter over a wide operating temperature range. The VCO is available at operating frequencies from 155 MHz to 1 GHz and is ideal for clock smoothing and frequency translation in telecommunications applications. Typical jitter is 3 ps for the 622.08-MHz version and 6 ps for the 155-MHz version. The VCO has complementary outputs with emitter-coupled-logic (ECL) and positive-emitter-coupled-logic (PECL) levels. The oscillator is housed in a hermetically sealed, J-lead, surface-mount package. **Vectron, International, 166 Glover Ave., Norwalk, CT 06856-5160; (203) 853-4433, FAX: (203) 849-1423, Internet: <http://www.vectron.com>.**

CIRCLE NO. 59 or visit www.mwrf.com

Software boosts spectrum analyzer's capabilities

The model PA2500 personal-computer (PC)-based spectrum analyzer spans 100 kHz to 2500 MHz and includes software that provides sophisticated capabilities and facilitates analysis. In conjunction with a notebook computer, the Windows[™]-compatible software provides several automatic features, including markers, spectrum memories, max hold, peak search, and signal track. The software can display multiple spectrums, each with its own settings. It can also take advantage of the Windows multi-tasking capability by displaying the output of

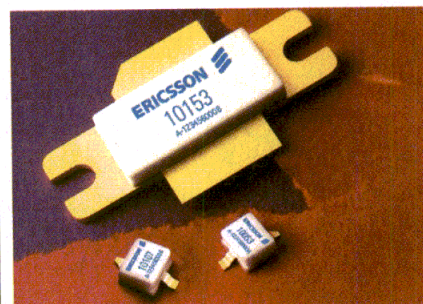


several PA2500 analyzers simultaneously. **DKD Instruments, 750 Amber Way, Nipomo, CA 93444; (805) 929-2285, FAX: (805) 929-5983, Internet: <http://www.dkdist.com>.**

CIRCLE NO. 60 or visit www.mwrf.com

Power transistors serve base stations

Three RF power transistors operate from 1.8 to 2.0 GHz for use in base stations serving Global System for Mobile Communi-



cations (GSM)-800, digital Advanced Mobile Phone Service (D-AMPS), and enhanced data for global evolution (EDGE). Model PTF10107 can deliver 5 W of RF power, model PTF10053 provides 12 W of output power, and model PTF10153 yields 60 W. The GOLDMOS transistors exhibit 33.5-dB gain, which is typically 3 dB higher than their bipolar counterparts. Return loss for the PTF10107 is -27 dB at 1.975 GHz. The PTF10107 and PTF10053 measure 4 × 5 mm, and the PTF10153 measures 20 × 34 mm, including flanges. **Ericsson Components, 715 North Glenville Dr., Richardson, TX 75081; (877) 374-2642, FAX: (972) 583-5005, Internet: <http://www.ericsson.com>.**

CIRCLE NO. 61 or visit www.mwrf.com



The reason you should never have to choose between quality of test and speed of test.

People everywhere depend on the products you test. Yet your company depends on you to get those same products tested and out the door at once.

To help you win this balancing act, we've designed an incredible range of network analyzers. With more variations and price points than anyone—for testing frequencies from 10 Hz to 110 GHz. Agilent Technologies offers an expanded line of microwave transmission/reflection network analyzers. So you'll be able to find the best network analyzer for every job. To test thoroughly—and of course, quickly.

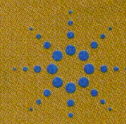
To receive Agilent's *Network Analyzer Family Selection Guide*, or information about our trade-in/trade-up offers for select products, visit our web site. Or call us at the number listed below. With so many people depending on you to make their designs real, it's good to know you can count on Agilent for a full range of solutions.

More options for the exact level of performance you need.

4395A	10 Hz to 500 MHz
4396B	100 kHz to 1.8 GHz
8712ET/ES	300 kHz to 1.3 GHz
8714ET/ES	300 kHz to 3 GHz
8753ET	300 kHz to 3/6 GHz
8753ES	30 kHz to 3/6 GHz
8719ET	50 MHz to 13.5 GHz
8720ET	50 MHz to 20 GHz
8722ET	50 MHz to 40 GHz
8719ES	50 MHz to 13.5 GHz
8720ES	50 MHz to 20 GHz
8722ES	50 MHz to 40 GHz
8757D	10 MHz to 110 GHz
8510C	45 MHz to 110 GHz

*ET indicates Transmission Reflection
ES indicates S-parameter*

www.agilent.com/find/na



Agilent Technologies
Innovating the HP Way

Argentina (54 1) 787-7115 • Austria (01) 25000-7006 • Australia 1 800 629 485 • Belgium (32/2) 778-34-17 • Brazil (55-11) 7297-8600 • Canada 1-877-894-4414 • Czech Republic (420) 2 61307111 • Denmark (45) 45 99-10-00 • Finland (3589) 8972 2100 • France (01) 69 29 41 14 • Germany (0180) 524-5330 • Greece (30/1) 7264045 • Hong Kong (852) 2599 7889 • Hungary (36) 1 4616111 • India (91 11) 690 6156 • Ireland (01) 615 8222 • Israel 972 (03) 536-03-80 • Italy (39 02) 92-122-241 • Japan (81/3) 3331-6111 • Korea (82 2) 769 0800 • Malaysia 1 800 88 8848, (6 03) 291 0213 • Mexico 525-5-256-4294 • Netherlands (020) 547 7272 • Norway (47) 22 73 57 59 • Philippines (632) 814 1063 • Poland (48) (022) 8067700 • PRC 800 810 0188, 186 101 6564 5239 • Singapore 1800 375 8100 Spain (34) 91 631 1323 • Sweden (46/8) 444 22 77 • Switzerland (01) 735 72 36 • Taiwan 080 212 535, 0800 47868 press 1 • Thailand (66 2) 661 3999, (088) 225 802 • United Kingdom (01344) 366666 • Venezuela (58-2) 207-8357 • * Telephone Charge per Unit Time = 0.24 DM/Min

© 2000 Agilent Technologies TMM10944/INTL

AT&T Rides The Roller Coaster

Before AT&T's initial public offering (IPO) of stock in its wireless phone unit in late April, the biggest US IPO belonged to United Parcel Service, Inc. (UPS), when it raised \$5.5 billion last year. AT&T easily eclipsed that mark by taking in \$10.62 billion on sales of 360 million shares at \$29.50 each. The shares

represent 16 percent of the company's wireless group, giving it a market capitalization of \$68.15 billion. They will trade as a "tracking" stock on the New York Stock Exchange (NYSE) under the symbol AWE (a tracking stock provides investors with an economic interest but not an ownership stake in the

company).

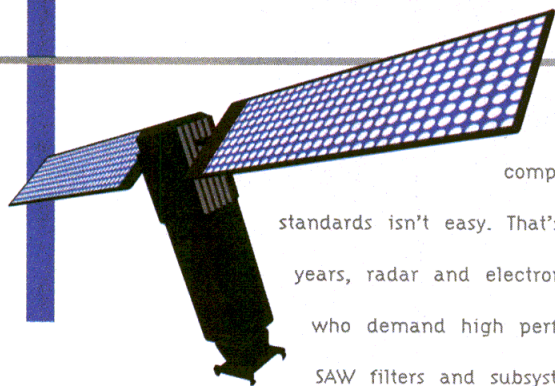
Although the wireless unit runs the third-largest wireless network in the US with 12.2 million subscribers and had revenues of \$7.6 billion last year, it reported a net loss of \$400 million. This occurs at a time when wireless communications is expanding rapidly, and robust growth is forecast for cell-phone use.

The number of wireless phone users grew by 16.8 million last year, the biggest single-year gain on record. But building the wireless infrastructure is costly. AT&T spent \$2.4 billion last year on system build out and plans to invest another \$4.1 billion this year. Fortunately, the wireless unit will receive approximately \$7 billion from the IPO to support this growth while the remaining \$3.6 billion will go to AT&T.

The euphoria of the IPO, however, was short lived. Within a few days, AT&T posted an earnings drop for the first quarter of 2000, despite the fact that wireless services revenues rose by 40 percent, to \$2.1 billion from \$1.5 billion in 1999. The company announced quarterly earnings that met analyst's expectations, but also said that revenue growth for the full year would be approximately 9 percent less than last year's. The latter statement sent the wrong message to Wall Street as AT&T shares fell 14 percent (or \$7) to close at \$41.94 on May 2. This was the biggest one-day decline in the stock since the crash of 1987. As of this writing, the stock was still headed downward, closing at \$38.44. Meanwhile, AWE continued to hold its own, closing at \$30.31 on the same day.

In addition to projecting a drop in earnings for the year, the company has business and technical concerns that could spell trouble in the future. Up to 6200 jobs may be cut by 2001 to offset high marketing expenses and lower long-distance rates. And its time-division-multiple-access (TDMA) air-interface wireless technology is not compatible with competing technologies such as wide-band code-division multiple access (WCDMA), the standard that many believe will dominate the field in third-generation (3G) wireless technology.♦♦

Build For The Future With Sawtek!



Building precision

components to rugged military

standards isn't easy. That's why for more than 20

years, radar and electronic warfare professionals

who demand high performance have relied on

SAW filters and subsystems from Sawtek. We've

gone to Mars aboard Pathfinder. We circle the Earth in communications

satellites. We were with our armed forces in Desert Storm and continue to

support national security with state-of-the-art technology. For oscillators, delay

lines and all your filtering needs, **depend on the leader...depend on Sawtek.**

When You're Building America's
Wireless Future, Depend on Sawtek...

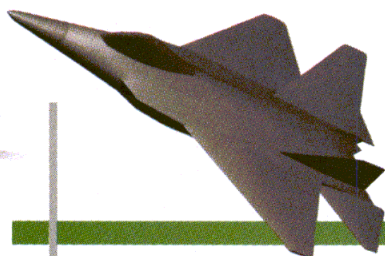
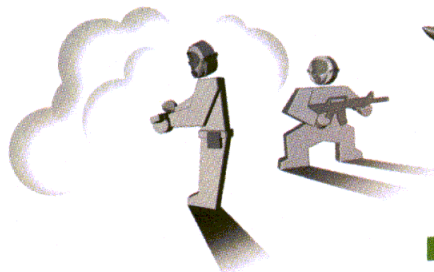
We're Leading the Way!

Call us today or visit our NEW website.

www.sawtek.com/mrf

Phone (407) 886-8860

Fax (407) 886-7061



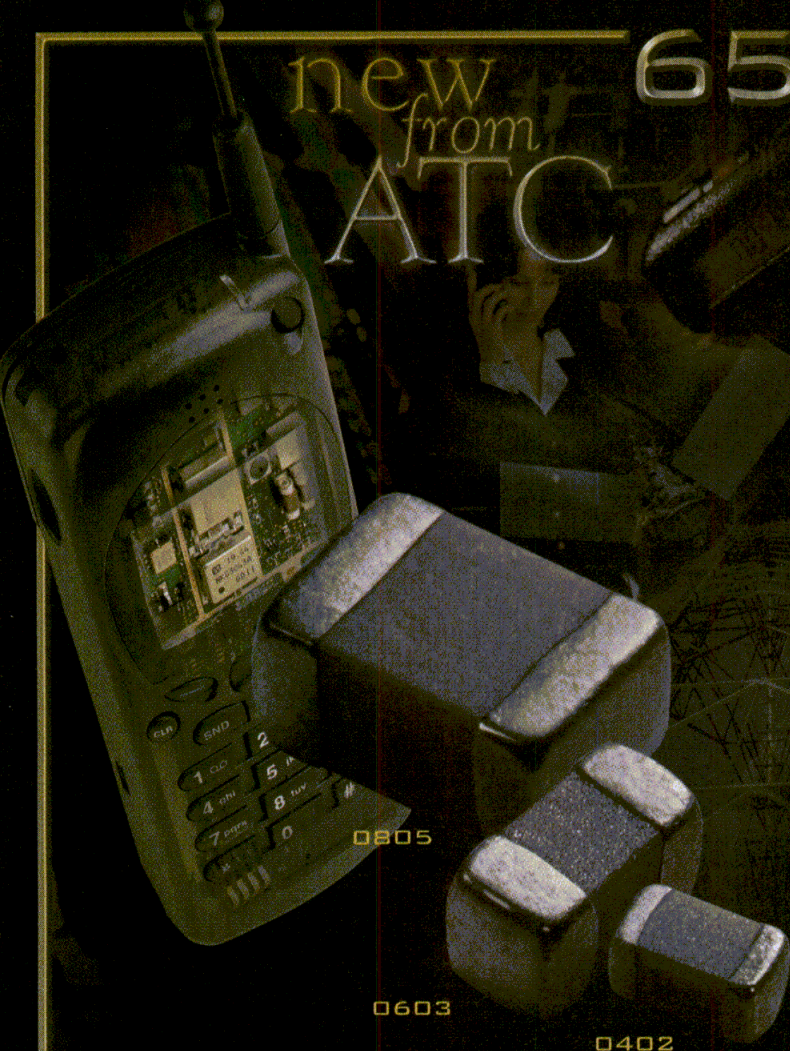
Visit Sawtek at booth #2715 at the IEEE MTT-S Symposium,
June 13-15, 2000, in Boston, Massachusetts.

SAWTEK
INCORPORATED

new
from
ATC

650 SERIES RF CAPACITORS

A LOW COST
PERFORMER, TAILORED
TO SUPPORT
HIGH VOLUME
WIRELESS APPLICATIONS



*American
Technical
Ceramics*

- **AVAILABLE CASE SIZES:**

0402, 0603, 0805

- **TYPICAL ESR AT 1 GHZ:**

0402/0603 120 m Ω

0805 100 m Ω

- **VALUE RANGE:**

0402 0.1 TO 15 PF

0603 0.1 TO 47 PF

0805 0.2 TO 150 PF

FOR A FULL DATASHEET ON THE 650 SERIES:

Click here
www.atceramics.com/products/650.html

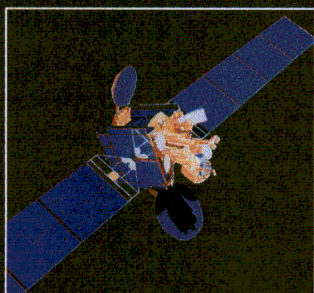


PHONE: 631-622-4700 • E-MAIL: SALES@ATCERAMICS.COM

ISO 9002
REGISTERED
COMPANY

**THE
ENGINEERS'
CHOICE™**

More than 20 years experience supplying
HIGH PERFORMANCE
INTERCONNECTS FOR...



Spaceflight...

where our interconnects have more than *ten years* of *space heritage*. Outstanding *thermal stability* over wide temperature spans and *low outgas* materials. Special products to meet demanding *PIM* specifications.

Defense Electronics...

for needs ranging from high power to high density. *Flexible* and *semi-rigid* products to withstand the severe conditions of shipboard, airborne or ground-based operations. A low-density PTFE dielectric *reduces attenuation* by up to 30% over conventional materials.

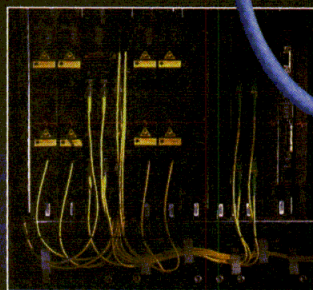


Radar...

systems, including phased array. Products and processes optimize *phase tracking* over frequency and temperature. *Miniature* products with *blindmate* connector interfaces such as GPO™ and GPPO™ allow increased packing density.

Telecom...

systems and test gear. Our *microwave* products provide *clear signal* transmission even as SONET rates exceed 10 Gb/sec; our *optical* products provide the same *transparent performance* outside the electrical world.

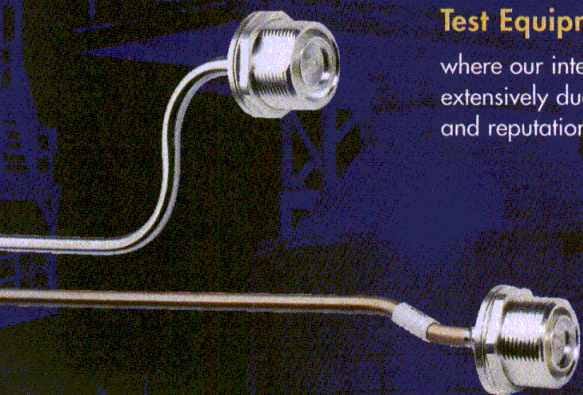
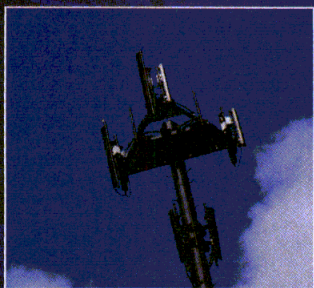
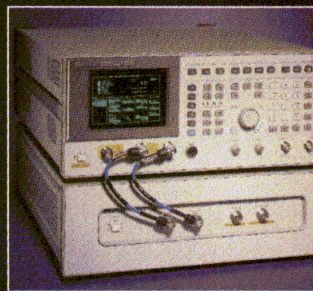


Wireless...

systems. The *outstanding thermal stability* of our semi-rigid products eliminates dielectric expansion during automated soldering processes.

Test Equipment / Systems...

where our interconnects are used extensively due to their *rugged construction* and reputation for consistent performance.



RF/MICROWAVE GROUP
116 Shore Drive • Hinsdale, IL 60521
TEL 630.323.9121 • FAX 630.323.9398
TOLL FREE 888.347.8676
www.stormproducts.com

storm
PRODUCTS CO. ■ DESIGN & MANUFACTURING ■

CIRCLE NO. 217

Contracts

EMS Technologies, Inc.—Has announced a second order from P-Com, Inc. to supply antennas for P-Com's point-to-multipoint (PMP) wireless telecommunications network. P-Com's fixed wireless networks connect a central hub to several "points" over a shared wireless spectrum.

Motorola, Inc.—Has announced the signing of a further expansion contract with Etisalat worth more than \$16 million. Work will start immediately in the northern United Arab Emirates to deploy Motorola Network Solutions Sector (NSS) market-leading Horizonsystems infrastructure solutions to provide additional coverage and capacity on a macrocellular (wide-area) and microcellular (high-density defined area) basis.

COMSAT Corp.—Under the terms of a contract with a maximum value of \$111.9 million over a five-year period, COMSAT Mobile Communications (CMC) will provide the US Navy with global satellite service over the Inmarsat system for high-speed data, voice, and multimedia communications.

Lucent Technologies and KMW—Have reached a general purchase agreement in high-technology components for IMT-2000.

Giga-tronics, Inc.—Revealed that its Instruments Division has received an order in excess of \$2.3 million for its three-slot VXI microwave synthesizer. The order came through Midoriya Electric Co. Ltd., Instruments Division's distributor in Tokyo, Japan, and is for ultimate delivery to Advantest Corp. for use in automatic test systems.

Communications and Power Industries Holding Corp.-Microwave Power Products Division (CPI-MPP)—Announced that it has awarded a contract for the production of 29 dual-pulsed traveling-wave-tube (TWT) assemblies by ITT Industries' Avionics Division. This award is a follow-on to an earlier contract received in 1998.

Sanders—Signed a 42-month, \$4.2 million US Government contract to develop an adaptive scan scheduler that will increase the likelihood of identifying and surviving a broad range of guided missile threats.

Spectrum Signal Processing, Inc.—Announced a contract with Analog Devices, Inc. (ADI) to develop math libraries for ADI's TigerSHARC[®] digital-signal-processing (DSP) architecture. The TigerSHARC math libraries consist of math functions, real and complex vector functions, matrix functions, filters, Fast Fourier transforms (FFTs), and a variety of statistical functions.

REMEC, Inc.—Has entered into a production agreement expected to result in approximately \$27 million in sales of base-station products to a major mobile telecommunications-network equipment manufacturer.

Fresh Starts

SCC Communications Corp.—Has expanded its Wireless Phase I and Phase II service offerings with 9-1-1Connect.SM Whenever a subscriber to a contracted wireless carrier calls 911, SCC will ensure that critical infor-

mation is immediately routed to the appropriate public-safety answering point (PSAP) through SignalSoft's leading-edge W911 and Location Manager software applications.

RangeStar Wireless, Inc. and Molded Interconnect Device (MID), LLC—Announced that they have entered into a strategic manufacturing agreement. The alliance brings together RangeStar's embedded (internal) antenna design and integration with MID, LLC injection-molded plastic and selected metallized applications.

dBm, LLC—Has finalized an agreement to purchase the satellite test-equipment line from Telecom Analysis Systems of Eatontown, NJ.

Simplex Solutions, Inc.—Announced the acquisition of Snaketech, a developer of integrated-circuit (IC) verification technology used in system-on-a-chip (SOC) design.

UltraRF—Announced the appointment of Sangus as a manufacturer's representative to cover Sweden, Norway, Denmark, and Finland.

Agilent Technologies, Inc.—Signed an agreement to acquire the Optical Technology Center (OTC) from Telecom Italia's central research laboratory, CSELT. Agilent will acquire 50 OTC research employees and modern facilities in Turin, Italy, including advanced laboratory equipment and the research center's patent portfolio.

Vitesse Semiconductor Corp.—Agreed to acquire all of the equity interests of Orologic, Inc. for \$450 million in common stock. Orologic is a fabless semiconductor company that develops high-performance system-on-a-chip (SOC) solutions that enables data-packet processing at OC-48 and OC-192 rates.

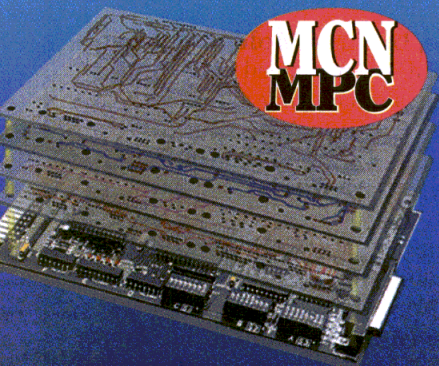
Alpha Industries, Inc.—Has signed a definitive agreement to acquire privately held Network Device, Inc. of Sunnyvale, CA. Network Device provides advanced technology gallium-arsenide (GaAs) integrated-circuit (IC) design and fabrication, especially heterojunction bipolar transistor (HBT), to the growing markets for wireless telephones and other wireless technologies.

Remtec, Inc.—Has acquired Tecmark Plating Services, and equipped the 13,000-sq.-ft. facility with state-of-the-art electrolytic and autocatalytic plating lines. The expanded facility is also supported by an on-site analytic laboratory and X-ray system for advanced quality control and research-and-development (R&D) activity. Designed specifically for plating of ceramic boards and crystals, the enhanced facility now offers improved cycle times and a production capability of 50,000 metalized ceramic panels per month.

SignalSoft Corp.—Has acquired BFound.com, a Victoria, British Columbia-based company experienced in mobile-asset tracking on the Internet. The acquisition allows SignalSoft to immediately offer a variety of asset-tracking services to wireless markets worldwide.

Mobilocity, Inc.—Announced its official operational launch and the opening of its New York City headquarters. Mobilocity's website is <http://www.mobilocity.net>.

MICROWAVE TECHNOLOGY REACHING INTO THE NEXT MILLENNIUM



MCN/MPC YOUR ONE SOURCE FOR MICROWAVE CIRCUITS

For Fine Line Etching
with tolerances to .0003",
Complex Plating/
Machining, Laser Cutting,
Multilayer/Hybrids,
or Metal-backed Boards
including Plated thru Holes -
Modular Components National/
Maryland MPC is your
one source for Microwave
Circuit Boards.

MODULAR COMPONENTS NATIONAL, INC.

2302 Industry Court, PO Box 453,
Forest Hill, MD 21050
410/879-6553 Fax: 410/838-7629
E-mail: sales@mcn-mmmpc.com
<http://www.mcn-mmmpc.com>



MARYLAND MPC LLC

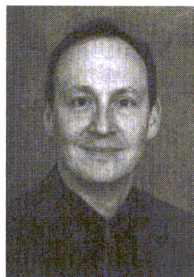
81 Old Ferry Road, Lowell, MA 01854
978/452-9061 Fax: 978/441-0004
E-mail: sales@mcn-mmmpc.com
<http://www.mcn-mmmpc.com>

PEOPLE

Harris Corp.—Samuel D. Wyman III to president and general manager of the Microwave Communications Division; formerly general manager of Digital Microwave Corp.'s Seattle, WA operations. Also, Daniel R. Pearson to president and general manager of the Communications Products Division (CPD); formerly vice president and general manager of strategic management and business development for the Government Communications Systems Division (GCSO).

RangeStar Wireless—John Harris to chairman, president, and CEO; formerly senior vice president of Uniden America.

Barry Industries, Inc.—Michael J. Gregory to vice president of manufacturing; formerly in charge of the MRP and ISO9000 programs. James K. Wood to director of marketing; formerly held senior marketing positions with several Canadian manufacturers.



GREGORY



WOOD

Alpha Industries, Inc.—Tom Leonard to chairman of the board of directors; formerly president and chief executive officer. Also, David Aldrich to president, CEO, and membership on the board of directors; formerly president and chief operating officer.

Hirose Electric (USA), Inc.—Rocco J. Melchione to vice president of sales and marketing of the Americas; formerly sales and marketing manager.

Quad Systems Corp.—Ted Shonek to chief executive officer; will continue to serve as president.

Richardson Electronics—Kevin C. Oakley to vice president and general manager of the Medical Systems Group; formerly senior vice president at Infimed, Inc.

CTS Corp.—Donald R. Schroeder to vice president of business development and chief technology officer; formerly vice president of sales and marketing.

Interconnect Devices, Inc. (IDI)—Anne Bush to the position of central regional sales manager; formerly inside account manager. Also, Jay Preister to product specialist; formerly employed in circuitry testing with Lucent Technologies.

Lawrence Behr Associates, Inc.—Will Daugherty to director of product marketing; formerly director of marketing at Seaward International, Inc.

Unitek Miyachi Corp.—Mark Rodighiero to vice president of the Laser and Systems Division; formerly vice president of engineering.

CPI Satcom Division—Robert Blanchfield to director of materials; formerly director of materials at ARGOSYSTEMS, Inc.

Leitch Technology Corp.—Margaret Craig to president of Leitch, Inc.; formerly president of Snell & Wilcox's US operation.

CMP Media/Miller Freeman—Mike Buetow to editor in chief of *PC FAB* magazine; formerly communications director for IPC.

Filtronic Solid State—Tally Costa to national director of sales and marketing for semiconductor products; formerly regional sales manager for Richardson Electronics.



COSTA



TIERNEY

Kanthal Global—Brian Tierney to divisional manager of the Niagara Falls, NY facility; formerly manager of quality and engineering for the Niagara Falls, NY facility.

Seiko Instruments USA, Inc. Fiber Optics Group—Mark Kim to senior production manager; formerly operational manager with Xylan.

Designing for the future of...

- New integrated multi-chip switch matrix products.
- Patented SMT "robust lead" circulator available for pick & place automation.

...Wireless Infrastructure

- New PHEMT switches and converters for high linearity, low current applications.

...Wireless Handsets

- Advanced global automation technology and fab capacity to meet today's market demand.

...Volume Manufacturing

- Broad-based technologies providing reliable and high performance integrated solutions for the aerospace and defense industries.

...Aerospace

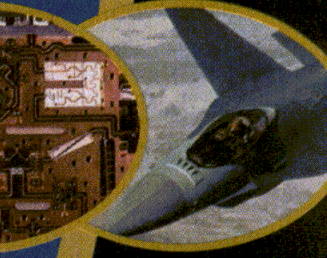
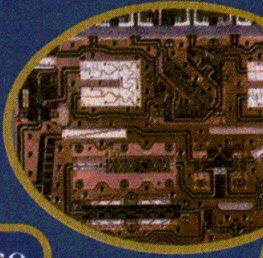
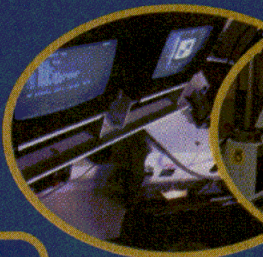
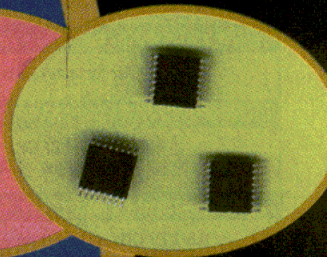
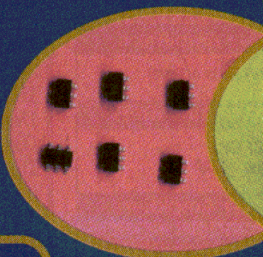
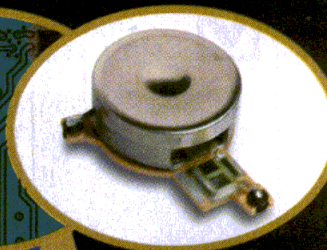
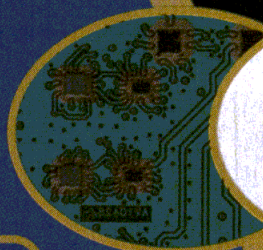
Visit us at MTT-S and speak directly to
M/A-COM DESIGN ENGINEERS.

Wireless Products: Booth #2107

Aerospace Products: Booth #401

CIRCLE NO. 388

www.macom.com

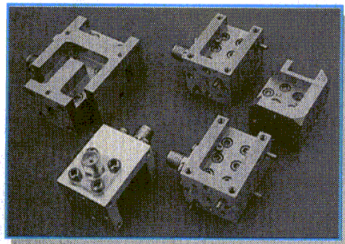




Your Reliable Source



**For Millimeter-Wave
Products and GaAs
FET & MMIC Amplifiers**



Broadband Low-Noise Amplifiers

0.5-60.0 GHz (octave/multi-octave)

Narrowband Low-Noise Amplifiers

From 0.5-110 GHz
Noise figure as low as 0.4 dB

Broadband High Power Amplifiers

0.8-29.0 GHz (octave/multi-octave)
Up to 20W output power @P1dB

Narrowband Power Amplifiers

0.5-110 GHz
Up to 20W output power @P1dB

Active/Passive Frequency Multipliers

0.5-110 GHz
Multiplication factors up to x12

Injection-Locked Amplifiers

30-100 GHz
High millimeter wave power output

Millimeter-Wave Sources

Gunns, FETs, IMPATTs, PLOs, ILOs and VTOs

Millimeter-Wave Receiver Products

Harmonic Mixers, LOs, Up/Downconverters,
PIN Switches, Detectors

Antenna Products

Horns, Feeds, Lens Reflectors, OMTs,
Polarizers, Filters, Diplexers

Ferrite and Waveguide Components

Isolators, Circulators, Couplers, Power Dividers/
Combiners, Waveguide Bends, Twists, Transitions

Subsystems and Instruments

**We always do the right things
at the right price.**

**Call us today
for a quotation!**

QuinStar Technology, Inc.

24085 Garnier Street
Torrance, CA 90505

Tel: (310) 320-1111/Fax: (310) 320-9968

sales@quinstar.com
www.quinstar.com

EDUCATIONAL MEETINGS

Short Courses

Infrared Technology and Applications

June 20-23 (Las Vegas, NV)
Georgia Institute of Technology
Continuing Education
Atlanta, GA 30332-0385
(404) 385-3502, FAX: (404) 894-7398
e-mail: conted@gatech.edu
Internet: <http://www.conted.gatech.edu>

Microwave Antenna Measurements Short Course

June 20-23 (Northridge, CA)
California State University, Northridge
Northridge, CA 91330-8295
Shirley Lang, Program Administrator
(818) 677-2146, FAX: (818) 677-5982
e-mail: shirley.lang@csun.edu
Internet:

<http://www.ecs.csun.edu/~crs/mam>

Digital Communications Engineering

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

Digital Transceiver Design

July 10-12 (Oxford, England)
University of Oxford
Department of Continuing Education
Oxford OX1 1PT, England
Dee Broquard
0-1865-286959, FAX: 0-1865-286956
e-mail: dee.broquard@conted.ox.ac.uk

Synthetic Aperture Radar

Technology and Applications
July 17-21 (Ann Arbor, MI)
University of Michigan
Center for Professional Development
2121 Bonisteel, Suite 273
Ann Arbor, MI 48109-2092
(734) 647-7200, FAX: (734) 647-7182
Internet: <http://www.cpd.engin.umich.edu>

Near-Field Antenna Measurements and Microwave Holography

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

Meetings

Embedded Systems Conference Summer

July 10-12 (Sheraton Boston Hotel and
Hynes Convention Center, Boston, MA)
CMP Media, Inc.
(800) 789-2223
e-mail: esc@cmp.com
Internet:

<http://www.embedded.com/summer>

2000 IEEE International Symposium on Antennas and Propagation and USNC/URSI National Radio Science Meeting

July 16-21 (Doubletree Hotel, Salt Lake
City, UT)
IEEE Antennas and Propagation Society
and the 2000 International Union of

Radio Science

Magdy F. Iskander, General Chair
University of Utah
(801) 581-6944
e-mail: iskander@ee.utah.edu
Internet:

<http://www.ext.usu.edu/confer/aps2000>

2000 International Conference on Subsurface Sensing Technologies and Applications (SSTA 2000)

July 30-August 4 (San Diego, CA)
Texas A&M University
Department of Electrical Engineering
Cam Nguyen
(409) 845-7469, FAX: (409) 845-6259
e-mail: cam@ee.tamu.edu
Internet: <http://ee.tamu.edu/subsurface-sensing-conference>

NIWeek2000—The Worldwide Conference on Measurement and Automation

August 16-18 (Austin Convention Center,
Austin, TX)
National Instruments
Austin, TX 78759-3504
(800) 258-7022, (512) 683-9300
e-mail: niweek@ni.com

Internet: <http://www.ni.com/niweek>

2000 IEEE International Symposium On Electromagnetic Compatibility

August 21-25 (Washington, DC)
IEEE Electromagnetic Compatibility
Society

William Duff, Chairman
Computer Sciences Corp.
(703) 914-8450, FAX: (703) 914-8499
e-mail: wduff@csc.com

ISSSTA 2000 IEEE Sixth

International Symposium on Spread Spectrum Techniques & Applications

September 6-8 (Parsippany, NJ)
IEEE Communications Society and Center
for Communications and Signal
Processing Research

New Jersey Institute of Technology (NJIT)
Newark, NJ 07102

Clare Naporano
(973) 596-8474, FAX: (973) 596-8473
e-mail: Clare@megahertz.njit.edu

EMC Europe 2000—4th European Symposium on Electromagnetic Compatibility

September 11-15 (Brugge, Belgium)
TI-KVIV

Mrs. Peys
Desguinlei 214
B 2018 Antwerpen Belgium
32/(0)3 216 09 96, FAX: 32/(0)3 216 06 89
e-mail: emc2000@conferences.ti.kviv.be

Internet: <http://www.ti.kviv.be/conf/emc2000.htm>

2000 IEEE Bipolar/BiCMOS Circuits and Technology Meeting

September 24-26 (Marriott City Center
Hotel, Minneapolis, MN)

IEEE Electron Devices Society, the IEEE
Solid State Circuits Society and the
IEEE Twin Cities Section

Janis Jopke, Conference Manager
CCS Associates
Eden Prairie, MN
(612) 934-5082, FAX: (612) 934-6741
e-mail: jjopke@aol.com

How to make Cell Phones Smaller and Lighter?

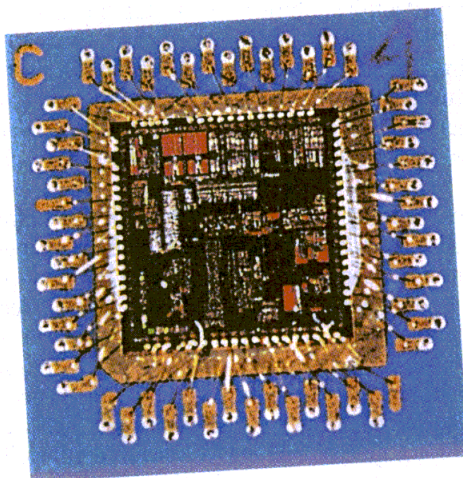
BGA with Integrated Components using DuPont Green Tape™

National Semiconductor is a leader in applying the LTCC advantages of high-density interconnect capability, ability to integrate passive components and functions, and low-loss performance. In a recent design, National chose to combine its advanced ICs for wireless communications with Green Tape™, DuPont's brand of LTCC tape dielectric material, to provide optimum performance in the smallest possible package.

Challenge: **Decreased Size and Cost,** **Improved Performance for** **Wireless Devices**

Portable wireless applications have quickly become the main driver for smaller, more cost-effective packaging and interconnects. For example, in the last few years, cell phones have evolved into lightweight, palm-size devices with a host of new functions. Their weight has decreased by a factor of 10, and the wholesale selling price by 75 percent.

OEM designers are now learning that integrating IC and package design to take advantage of the



unique properties of Low Temperature Co-fired Ceramic (LTCC) technology can yield decreased size and improved performance in wireless devices.

Solution: **Green Tape™ LTCC Allows** **for High I/O Counts in Chip** **Scale Package**

National's newest chipsets use Green Tape™ packaging capabilities to provide a chip scale package that can accommodate the high I/O counts of a highly integrated RF analog front end using micro BGA (ball grid array) technology. The current package, only 9 x 9 mm, can provide 81 I/Os in a micro BGA array, plus topside pads for wire-bonding that interconnects to the

BGA pads on the backside. The high number of I/Os allows for multiple grounds to improve RF performance, while the embedded multilayer structure contains 14 RF bypass capacitors constructed using a combination of high-K and low-K dielectrics.

The performance of the frequency synthesizer function can be enhanced through the use of an embedded VCO resonator that provides a high Q, and therefore lower phase noise, than that available using a VCO resonator located on the silicon.

This approach, co-designing the silicon and LTCC elements to achieve optimized size and performance, demonstrates the use of co-integration for wireless applications requiring smaller package size and higher performance at the lowest possible cost.

For more information,
call DuPont at 1-800-284-3382,
press 3, or visit the DuPont
Microcircuit Materials website at
<http://www.dupont.com/mcm>.



Shorting-post analysis aids patch-antenna design

Microstrip patch antennas (MPAs) are promising candidates for miniaturized mobile-communication handsets. A method for reducing the lateral dimensions of an MPA consists of loading the antenna with one or several shorting posts, which are metallic vias connecting the patch to the ground plane. A via's position and dimensions are a way to reduce the resonant frequency of an MPA, which in turn, affects the MPA's dimensions. Until now, only experimental and simulation information has been available for dealing with vias. Recently, however, Rebekka Porath of Philips Research Laboratories (Aachen, Germany) developed a full analytical theory for calculating the full spectrum of resonant frequencies of a shorting-post MPA. Specifically, the zero mode of an unloaded MPA plays a central role in reducing the operating frequency of a shorting-post device. The theory permits complete calculation of all relevant antenna parameters and can be extended to multiple shorting posts. See "Theory of Miniaturized Shorting-Post Microstrip Antennas," *IEEE Transactions on Antennas and Propagation*, January 2000, Vol. 48, No. 1, p. 41.

Smart antennas bolster broadband wireless-access networks

A significant market opportunity exists for providing fixed broadband wireless access (BWA) to residential, business, and small-office, home-office (SOHO) locations. Successful BWA systems need to be scalable, have high spectrum efficiency and high bit rates, and be easy to deploy at the infrastructure and subscriber ends. According to Khurram Sheikh of Sprint Advanced Technology Laboratories (Burlingame, CA), David Gesbert of Gigabit Wireless, Inc. (Mountain View, CA) *et al.*, smart-antenna (SA) technology offers important leverages to enable such features. The authors provide an overview of the various BWA architectures and the challenges facing each. Next, they cover SA technology and the best applications for BWA architectures. These include array gain, diversity gain, co-channel interference reduction, angle reuse [space-division multiple access (SDMA)], spatial multiplexing, and channel estimation. The authors contend that a multiple-antenna system can increase spectrum efficiency by three to 10 times, while also enhancing other desirable features. See "Smart Antennas for Broadband Wireless Access Networks," *IEEE Communications Magazine*, November 1999, Vol. 37, No. 11, p. 100.

Shield plastic parts to prevent interference

The increased use of plastic housings in computers and telecommunications equipment requires shielding techniques to protect the sensitive electronics inside the cases from external interference (EMI). This is accomplished through the use of conductive coatings applied to the plastic substrate. Determining the proper coating involves many factors according to Brian C. Jackson of Enthone-OMI UK (Woking, UK) and Thomas W. Bleeks of Enthone-OMI, Inc. (West Haven, CT). First, they explain the key issues that determine the performance of a conductive coating when applied to plastic—adhesion, conductivity, durability, cost, appearance, and others. Then, a number of different methods for applying the coating are explained such as electroless, electroplated, conductive paint, and vacuum metallizing. Each method has its pros and cons, but overall, electroless coating provides the best shielding performance. Another key factor in shielding is the package mechanical design, since EMI leakage between mating joints and surfaces is the primary reason that shielding effectiveness is reduced. See "Performance Characteristics of Conductive Coatings for EMI Control," *Interference Technology Engineers' Master (ITEM)*, *The International Journal of EMC*, 1999 edition, p. 125.

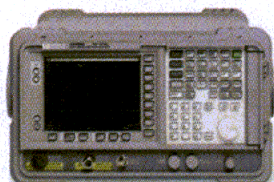
Measure ADC noise by cross correlation

A problem in characterizing high-speed, medium-resolution analog-to-digital converters (ADCs) is obtaining accurate measurements of time-varying noise with traditional test setups. Some low-noise ADCs exceed the test capabilities of laboratories, so Giovanni Chiorboli and Massimo Fontanili of the Dipartimento di Ingegneria dell'Informazione, University of Parma (Parma, Italy) devised a new technique to increase the measurement accuracy of time-varying noise. It is a dual-channel method (using two similar ADCs) based on the noise measurement of the distribution function of the cross-correlated noise between the two channels. The cross correlation between the two channels is used to estimate the noise of the test setup. This is what differentiates the author's method from all others; the contribution of the test setup can be distinguished from the effective ADC noise, and it is not effected by quantization noise and converter nonlinearities. See "Cross-Correlation Noise Measurement in A/D Converters," *IEEE Transactions on Instrumentation and Measurement*, December 1999, Vol. 48, No. 6, p. 1282.

NOW SERVING



A spectrum analyzer can be an extremely useful tool.
Once it's your turn.



3 GHz for \$11,250*

Agilent's ESA-L Series
Spectrum Analyzer

- 1.5, 3.0 & 26.5 GHz frequency coverage
- +/- 1.1 dB amplitude accuracy
- 4 ms sweep time
- 3 year warranty

Affordable Spectrum Analysis for every bench. Your days of sharing equipment are numbered. Because starting at \$7,500*, Agilent Technologies' ESA-L series of spectrum analyzers are affordable enough to have on every bench. And accurate enough to deserve the space. How accurate? The ESA-L series has background auto-alignment for continuous calibration. The frequency accuracy of a continuously phase-locked synthesizer. And a dynamic range wide enough for just about any distortion test. Not to mention best-in-class measurement speed. When you need product specs and application information, it's as easy as visiting our web site. And if you're ready to buy, you can simply do that online too. You can even call and talk to another engineer. All of this is done with one purpose in mind: helping you meet any challenge that comes along. Including making sure it's always your turn.

www.agilent.com/find/ESA-L



Agilent Technologies
Innovating the HP Way

Argentina (54 1) 787-7115 • Austria (01) 25000-7006 • Australia 1 800 629 485 • Belgium (32/2) 778-34-17 • Brazil (55-11) 7297-8600 • Canada 1-877-894-4414 • Czech Republic (420) 2 61307111 • Denmark (45) 45 99-10-00 • Finland (3589) 8872 2100
France (01) 69 29 41 14 • Germany (0180) 524-6330* • Greece (30/1) 7264045 • Hong Kong (852) 2599 7889 • Hungary (36) 1 4618111 • India (91 11) 690 6156 • Ireland (01) 615 8222 • Israel 972 (03) 538-03-80 • Italy (39 02) 92-122-241
Japan (81/3) 3331-6111 • Korea (82 2) 769 0800 • Malaysia 1 800 88 8848; (6 03) 291 0213 • Mexico 525-5-258-4294 • Netherlands (020) 547 7272 • Norway (47) 22 73 57 59 • Philippines (632) 814 1083 • Poland (48) (022) 6087700 • PRC 800 610 0189, (86 10) 6564 5238
Singapore 1800 375 6100 • Spain (34) 91 631 1323 • Sweden (46/8) 444 22 77 • Switzerland (01) 735 72 36 • Taiwan 080 212 535, 0800 47866 press 1 • Thailand (66 2) 661 3999, (088) 225 802 • United Kingdom (01344) 366666 • Venezuela (58-2) 207-8357
*Telephone Charge per Unit Time = 0.24 DM/Min ©2000 Agilent Technologies ADGPF007/INTL

Practice is over...

it's time to perform.

In a modern era one company has been at the forefront of advanced electronics systems for the defense, aerospace, and communications industries: Zeta.

Doing business for over 30 years!

When your system calls for a level of performance that's beyond prevailing standards you need more than a product, you need a solution.

At Zeta we provide solutions that include a full range of microwave products and subsystems specifically designed for use in missile guidance, ground support equipment, radar, satellite communications, data links and other demanding applications. Our customers include United States government agencies, foreign governments, as well as major military and commercial contractors.

So, when you are called on to perform, place your trust in a name you know . . . Zeta.

Crystal Stabilized Sources

Frequency Multipliers

Frequency Synthesizers

Comb Generators

Receivers

Frequency Converters

Microwave Subsystems

ZETA

Advancing The Analysis Of Microwave Oscillators

This return to the virtual-ground-based transmission analysis method for resonators and oscillators explores how to obtain the correct loop-transmission parameters.

Stan Alechno

Design Engineer

W. Z. R. RAWAR, Poligonowa 30,
04051, Warsaw, Poland; e-mail:
alechno@wa.onet.pl.

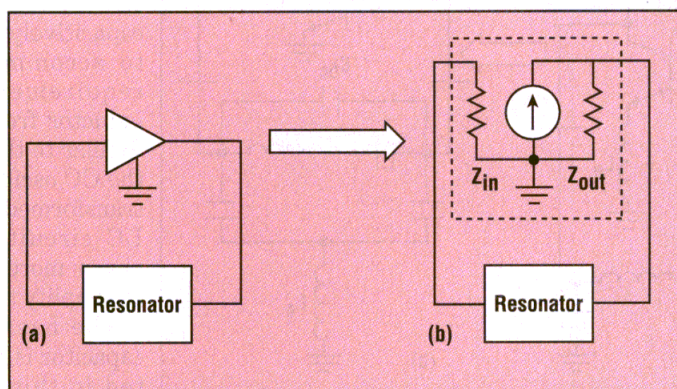
ANALYSIS of microwave oscillators requires imagination. Oscillator phenomena are often vaguely described by traditional approaches, such as the negative-resistance method. But a technique called transmission analysis with a virtual ground, where an oscillator is characterized as a feedback loop composed of amplifier and resonator sections, can provide much-needed insights into oscillator behavior.

Oscillator-transmission analysis with a virtual ground can provide a clear view of oscillator mechanics.¹ When examining an oscillator, it is often not obvious what the input signal is, where it is, or how it is being amplified. In cases where signal routing appears confused, the task of defining an oscillator's transmittance parameters becomes nearly impossible. But by using a virtual ground as a reference point for an oscillator circuit, it is often possible to bring order to chaos. By properly isolating the amplifying device in an oscillator circuit, the reference point can generally be found (Fig. 1).

The active device in Fig. 1b is

shown as the source, although it is initially unidentified. The noise across input impedance Z_{in} is magnified by the controlled source (the active device) and channeled back through the resonator when in proper phase. This source may be difficult to detect in actual circuits, even when the ground or reference point is fixed. But regardless of how an engineer chooses the ground point, even when it is made as large as the entire bottom metal coating of a printed-circuit board (PCB), it may not account for the problem of isolating the noise source. When analyzing an oscillator, a particular layout should not be a constraint, but rather a circuit should be examined in terms of how the noise "sees" the circuit. In order to do this, the virtual-ground analysis approach is essential. To illustrate this, several basic oscillator topologies with bipolar junction transistors (BJTs) will be examined.

An old joke among desperate design engineers is that when an oscillator is needed, the best approach is to design an amplifier, and when an amplifier is needed, design an oscillator. The two most popular oscillator configurations (Figs. 2a and b) were discovered in just this way, as unstable amplifiers

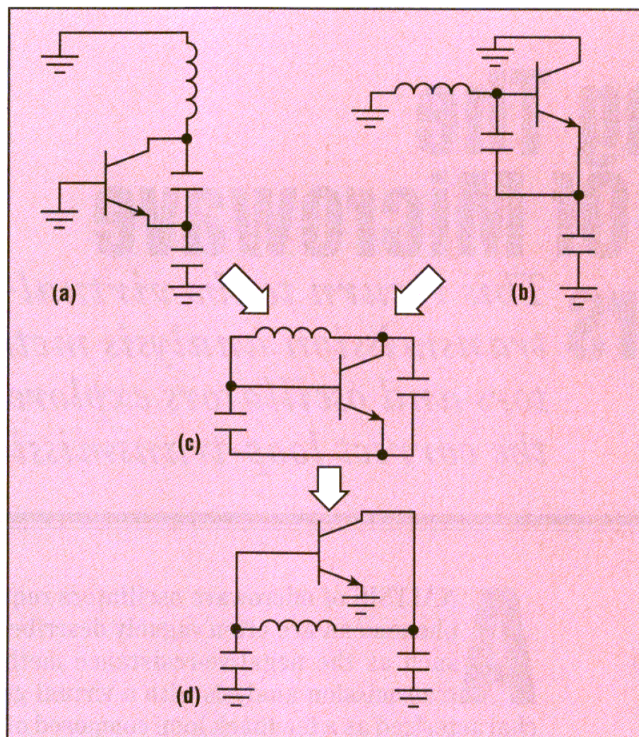


1. By isolating the active device in an oscillator circuit (a), a reference point for analysis (b) can usually be found.

based on transistor common-base and collector (emitter-follower) circuits, respectively. The inductive-capacitive (LC) components show what is needed to worsen an amplifier or improve an oscillator. All bias components are neglected in these cases since they would only complicate the transformations. The output circuits are also of secondary concern and should be omitted when basic topologies are compared. When taking the point of view of the noise, it cannot be readily discerned in either topology, unless the topologies are redrawn as Fig. 2c or even Fig. 2d.

The circuits of Figs. 2a, 2b, and 2c represent the three main oscillator families, although in essence they are the same, since noise acts within and upon them in the same way. The differences in their layouts only disguise the similarities of the circuits. The basic oscillators are made more dissimilar with different output signal topologies and additional resonator components. Any names for special oscillators have not been used in this article to avoid any ambiguities in the analysis of these basic oscillator types. For the sake of this analysis, reducing a design to a common-base (CB), common collector (CC), or common-emitter (CE) topology based on a BJT active device will be attempted. The next step will be to determine how power is coupled out of the oscillator circuitry and what (if any) special frequency-stability components are used.

The CB oscillator (Fig. 2a) typically channels output signals through capacitive coupling from the collector, with the DC supply provided through the inductor. Although the load for this source is typically 50 Ω , the coupling capacitance and



2. The basic oscillator topologies include (a) common-base (CB), (b) common-collector (CC), and (c) common-emitter (CE) types, which can be redrawn into a common configuration (d) for analysis.

the inductance can be used to transform the load and to channel power out of the oscillator more effectively. In redrawing Fig. 2a to Fig. 2d, the load and the coupling capacitance are placed in parallel with the inductor in order to analyze the complex resonator in isolation to determine the actual resonator loss and frequency.

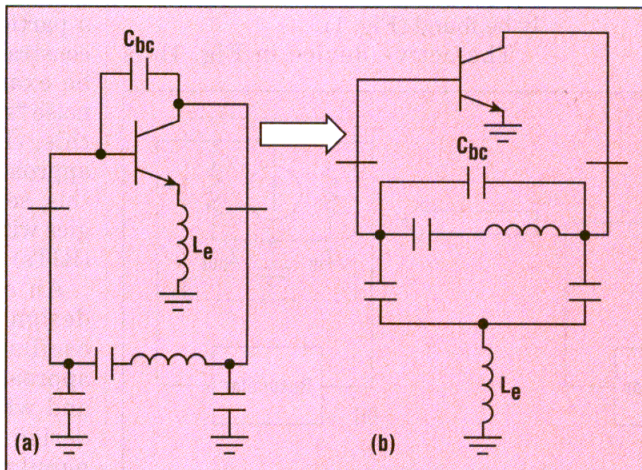
This basic oscillator is often designed with a surface-acoustic-

balance.

The CC oscillator configuration (Fig. 2b) usually couples output signals from the collector, although for analysis purposes this should no longer be thought of as a common-collector topology. It is convenient to form the load with a transistor, thus creating a complex amplifier.¹ In transforming the basic CC configuration to that of Fig. 2d, the load is in

series with the collector, effectively increasing its output impedance. As with the CB case, the load is capacitively coupled in order to accommodate the DC requirements using the inductor from the collector. Similar to the previous case, the CC oscillator load can be transformed with this simple LC circuit to couple out power more effectively (and to simplify the analysis).

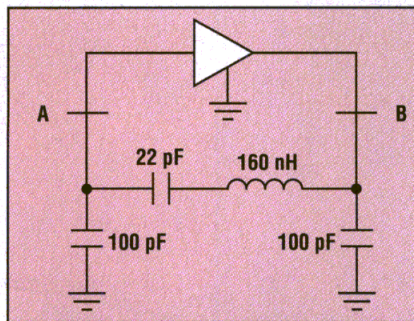
The base-emitter (BE) capacitor is frequently omitted in this configuration, especially at high frequencies, since the transistor's



3. This basic oscillator with shunt-capacitance coupled series resonator helps to visualize the path of noise.

internal base-to-emitter capacitance is generally sufficient. Furthermore, omitting the BE capacitor corresponds well with low-transistor phase shifts at microwave frequencies as well as the desired transistor-impedance transformation.¹ In order to fulfill the DC requirements, a capacitor is needed in series with the inductor of Fig. 2b. By balancing the value of this capacitor with the value of the inductor, high-frequency stability can be obtained. In this way, an effective LC resonator is achieved: the shunt-capacitance coupled series resonator.¹

The CE oscillator is often used with a feedback loop. For example, a two-port SAW resonator can replace the LC components shown in Fig. 2d, arranged in series with microstrip lines or with an inductor to achieve the required phase conditions. It should be noted, however, that Fig. 2d was intentionally drawn differently than Figs. 2a or b. The LC elements of Fig. 2d were grouped



4. This example shows a basic oscillator stabilizing loop at 100 MHz.

together and separated from the transistor to highlight the feedback loop, with the active device shown to resemble the ideal controlled source of Fig. 1. The natural feedback loop shows how noise circulates in the oscillator, and it must be set off to understand the noise mechanisms and to find the proper transmittance.

The natural feedback loop shows how the noise circulates in the oscillator and this is needed to set off in order to understand the action and

find the right transmittance. Although the topologies of Figs. 2a and b are often useful, they do not clearly illustrate the mechanics of the oscillator, and should be transformed to the equivalent form of Fig. 2d. This can be performed in two steps: by first removing the actual ground into a single node, and second by inserting the virtual ground at the active device noise, which is common to the controlling and controlled branches, in this case the emitter.¹

Before determining the loop transmittance, it is necessary to account for the non-ideal characteristics of the source. The undesired transmission or bilateral action of the transistor shows as a nonzero S_{12} value for the device. At low frequencies, this reverse transmission can often be neglected, but at higher frequencies, it becomes more critical. The main source of the problem has to do with the base-collector capacitance of the device. To some degree, this capacitance is included when designing an

Expanding New Horizons



DLVAs

- Up to 80dB Dynamic Range
- 10MHz to 20GHz Frequency Range
- Up to 40MHz Video Bandwidth
- Truly DC-Coupled
- Hybrid MIC/MMIC Reliability
- Temperature Compensated
- CW/Noise Immunity
- High Speed

Attenuators

- Up to 120dB Dynamic Range
- 10MHz to 20GHz Frequency Range
- Octave and Multi-Octave Band
- Linearized, Digital or Voltage Controlled
- Pin Diode and MMIC Reliability
- High Speed
- High Power

Switches

- SPST to SP64T
- 10MHz to 27GHz
- Low Insertion Loss
- Ultra High Speed
- Reflective and Absorptive
- Pin diode & MMIC Reliability
- 100dB+ Isolation
- High Power

American Microwave Corporation

7311 G Grove Road, Frederick, MD, 21704

TEL: 301.662.4700 FAX: 301.662.4938

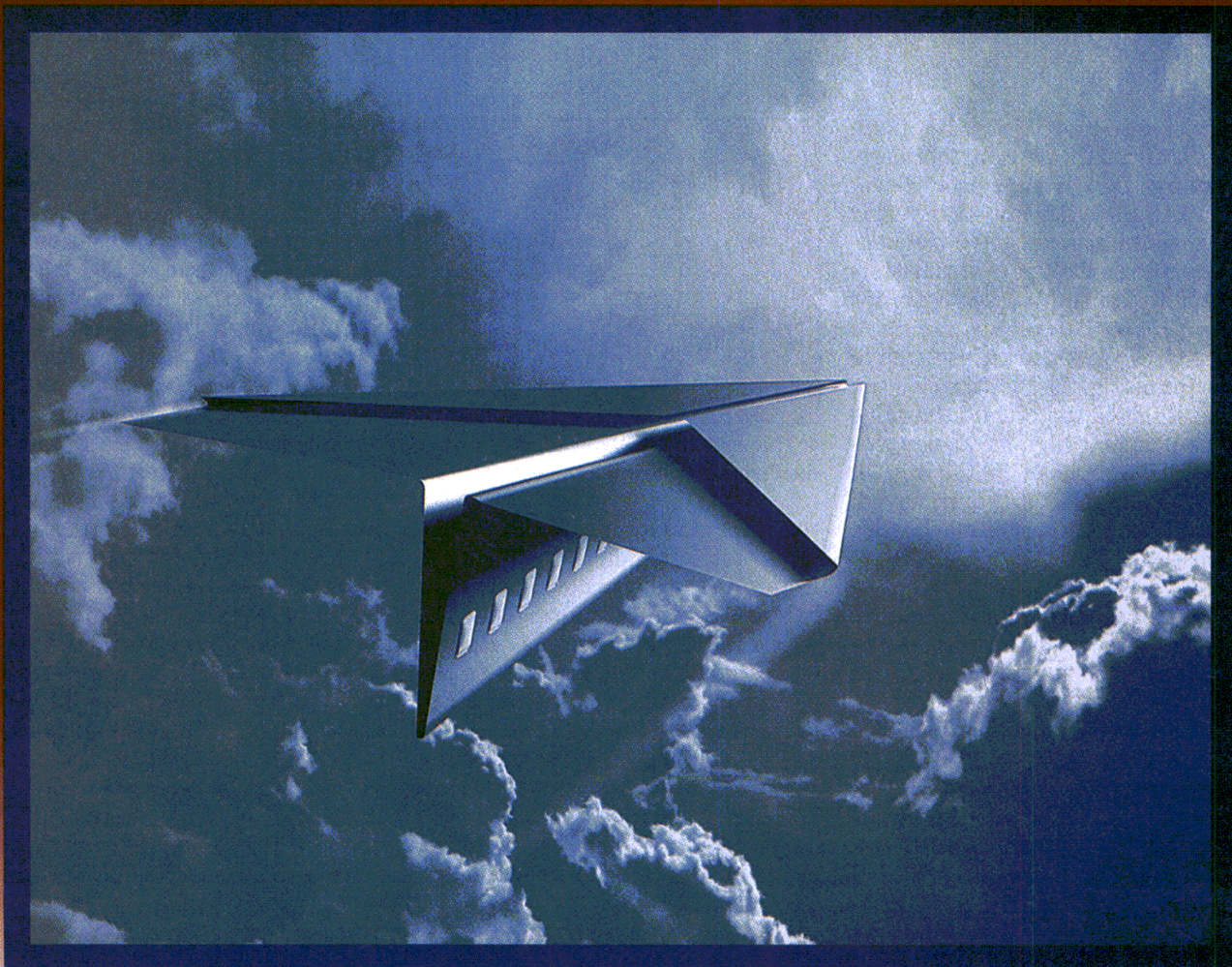
www.amwave.com

Area Sales Reps Wanted



CIRCLE NO. 400 or visit www.mwrf.com

MICROWAVES & RF ■ JUNE 2000



Imagine the possibilities.

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

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

biased with a single voltage and provide wide bandwidth, high gain and exceptional linearity.

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

NGA - InGaP MMIC 50 Ohm Gain Block Amplifiers

Model	Freq Range (GHz)	Vd (V)	Id (mA)	Gain (dB)	PldB (dBm)	IP ₃ (dBm)	Thermal Resistance (°C/W)
NGA-186	0.1-6.0	4.1	50.0	12.5	14.6	32.9	120
NGA-286	0.1-6.0	4.0	50.0	15.5	15.2	32.0	120
NGA-386	0.1-5.0	4.0	35.0	20.8	14.5	25.8	144
NGA-486	0.1-6.0	5.0	80.0	14.8	18.3	39.5	118
NGA-586	0.1-6.0	5.0	80.0	19.9	18.9	39.6	121
NGA-686	0.1-6.0	5.9	80.0	11.8	19.5	37.5	121

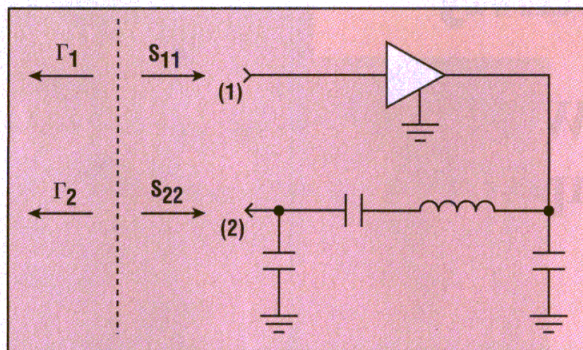
Data at 1 GHz and is typical of device performance.



www.stanfordmicro.com • 800-764-6642

oscillator based on forward-transmission magnitude and angle. Looking for an essential solution, it may be useful to take the noise viewpoint once more. To visualize this situation, Fig. 3 shows a basic oscillator with shunt-capacitance coupled series resonator. The internal BC capacitance is set off here as well as the series (internal and external) parasitic inductance in the emitter. Although the transistor's physical capacitances are rather complex, they will be examined here only in the linear terms of small-signal S-parameters.

In an analysis of noise, the base-collector capacitor, C_{BC} , together with the intentionally added resonator, makes the task somewhat more complex. The solution involves taking the parasitic feedback into account. A concern is the parasitic feedback inductance in the emitter, which can be accounted for by insert-



5. This is a description of two possible open-loop analysis settings in terms of reflection coefficient.

ing the virtual ground at the true emitter electrode, even within the internal circuitry of the transistor (for analysis purposes).

Removing the effects of feedback in the noise path can isolate the single feedback loop and the real resonator. To do this, the modified transistor S-parameters must be calculated, for example, by inserting the appropriate negative values of C and L to cancel the base-collector capaci-

tance and emitter inductance in the analysis. In practice, it is possible to minimize the effects of S_{12} for microwave transistors from -20 to -40 dB by compensating for the base-collector capacitance in this matter, with even greater efficiency achieved by canceling the emitter inductance. Once the real feedback loop is isolated, it is possible to proceed with the true transmission analysis.

For a nearly ideal oscillator such as that of Fig. 3, this type of analysis may appear simple, with two appropriate analysis points clearly shown. Yet, unlike an amplifier, the source- and load-terminating impedances in an oscillator cannot always be a simple $50\ \Omega$. By applying low-frequency voltage analysis some years back,⁴ this analysis was initiated for oscillators in order to find the proper source and load terminating impedances. In order to extend this

Expanding New Horizons

Products

- Successive Detection Log Video Amplifiers
- Low Noise Amplifiers
- Phase Shifters/Modulators
- Threshold Detectors
- Limiter/Detectors
- Detectors

Capabilities

- 0.1 to 20GHz, 80dB, High Speed, Connectorized or Drop-in, MIL-STD-883 Available
- 0.1 to 20GHz, up to 40dB, Low Noise (4dB), ± 2 dB Flatness
- 0.1 to 20GHz (Octave/Multioctave), Analog or Digital Control, High Speed, ± 90 Degrees
- 0.1 to 20GHz, High Speed and Sensitive, Hard or Soft Limiting
- 0.1 to 20GHz, High Speed and Sensitive
- 0.1 to 20GHz, High Speed and Sensitive

Also Available: Frequency Discriminators and Receiver Front Ends

Planar Monolithic Industries, Inc.

7311 G Grove Road, Frederick, MD, 21704

TEL: 301.662.4700 FAX: 301.662.4938

Area Sales Reps Wanted



Reach the Pinnacle of High Linearity

With EiC's NEW EC-1089 Broadband Amplifier

EiC's new InGaP HBT broadband amplifier takes you to the top with up-to-the-minute technology in affordable packages. Perfect for today's high performance applications, such as wireless and infrastructure, the EC-1089 delivers high linearity, high reliability and an SOT-89 plastic package. The low cost broadband amplifier has cutting edge specifications and optimal performance, as well as superior linearity.

Our newest amplifier features:

- Advanced Indium Gallium Phosphide Heterojunction Bipolar Transistor (InGaP HBT) technology
- A high OIP3 of >42dBm
- A high MTTF value
- A low thermal resistance
- Optimal performance for wireless applications

Call us for information and prices on our InGaP HBT Gain Block series: EC-1019, EC-1078 and EC-1119 — reliable, highly linear broadband amplifiers.

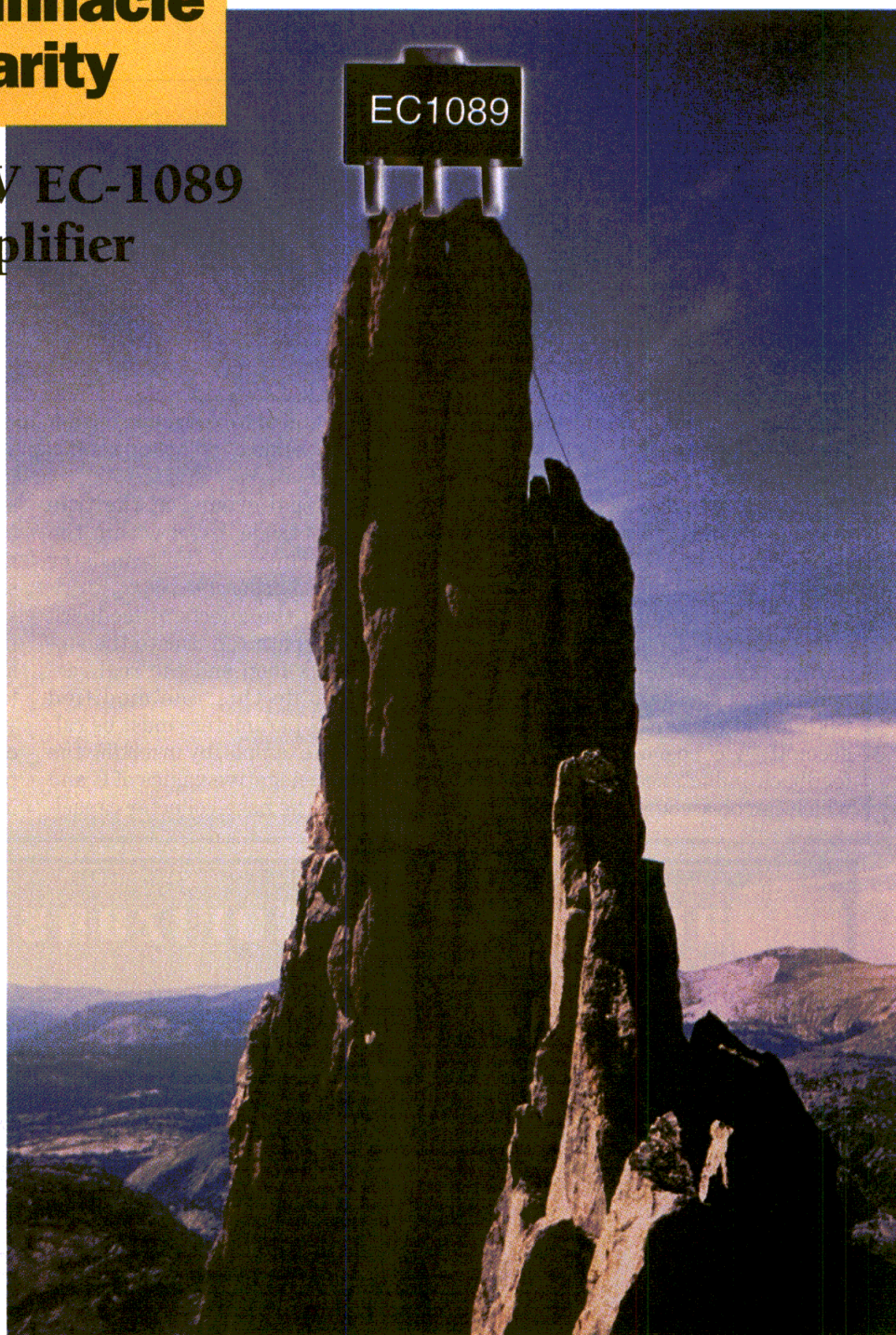
In 1997 we established our own GaAs HBT fab in Fremont, CA. We specialize in high frequency circuits suitable for use in a wide range of applications such as wireless, handset, base stations, WLL, CATV and satellite communications in the RF and microwave frequency range.

EiC is fast becoming a leader in affordable RFIC production.

Visit us on the web at:
www.eiccorp.com

Call for pricing:
510-979-8999

CIRCLE NO. 301



SPECIFICATION MATRIX						
P/N	Gain	Output P1dB	Output IP3	3Øj	ΔTj	BW
NEW! EC-1089	15dB	23.5dBm	>42dBm	~ 85°C/W	~ 65°C	DC-2.5 GHz
EC-1019	18.5dB	19dBm	34dBm	120°C/W	40°C	DC - 3 GHz
EC-1078	19.5dB	21dBm	37dBm	120°C/W	60°C	DC - 3 GHz
EC-1119	14.8dB	18.6dBm	36dBm	150°C/W	60°C	DC - 3 GHz



MTT SHOW BOSTON

EiC Corp.

Excellence in Communications

45738 Northpoint Loop West
Fremont, CA 94538, USA
Tel: 510.979.8999
Fax: 510.979.8902
E-mail: sales@eiccorp.com



analysis to a general form with S-parameters, a basic oscillator feedback loop example may help (Fig. 4).

The shunt-C coupled series LC resonator for this example was calculated according to the procedure given in reference 1—for a center frequency (f_0) of 100 MHz, a loaded quality factor (Q_L) of 10, and a characteristic system impedance (Z_0) of 50 Ω . The resultant phase shift is approximately -140 deg. and the loss for a practical inductor Q_0 of 100 amounts to 0.8 dB. For analysis purposes, this will be assumed as an ideal gain element in Fig. 4, matched to the resonator, where S_{11} , S_{12} , and $S_{22} = 0$; $Z_0 = 50 \Omega$; $S_{21} = 3$; and the phase shift = 140 deg.

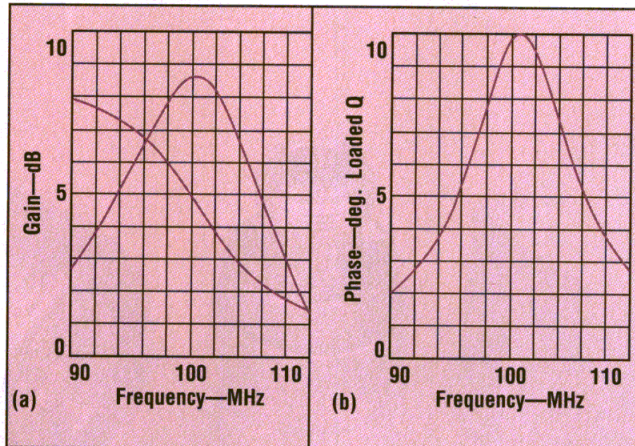
With these assumptions, the amplifier is unilateral, otherwise the circuit would have an additional feedback loop that could not be visual-

ized explicitly. Looking for an appropriate oscillator-loop transmittance, it is necessary to differentiate between an absolute feedback loop by applying the virtual-ground concept to the external transistor circuitry and, if needed, to the internal feedback loop as described earlier. Find-

ing a "break" point for the loop is critical to the analysis.

Assuming an ideal amplifier with 50- Ω input and output ports, one would expect that the loop could be broken at either point A or B. Unfortunately, a real 50- Ω impedance is rarely achieved, and a return loss of 20 dB is probably an accurate value in terms of analysis, with a return loss of 10 dB as quite tolerable for achieving reasonable precision in predicting the transmittance. Furthermore, if a particular transistor impedance is significantly reactive, it could be artificially excluded from the transistor and included within the resonator (for analysis purposes) for good separation between the active and reactive parts of the loop.

Some transistors may present very-high imped-



6. Exemplary 50- Ω -based transmittance and loaded Q for the oscillator open loop as in Fig. 5 with resonator values provided in Fig. 4 are shown.

Expanding New Horizons

Low Noise Amplifiers/Supercomponents

- 10MHz to 20GHz - Octave/Multioctave
- Gains up to 50dB
- Gain Flatness ± 2 dB
- Gain variation ± 2 dB over Temperature
- MIC/MMIC Reliability

Planar Electronics Technology

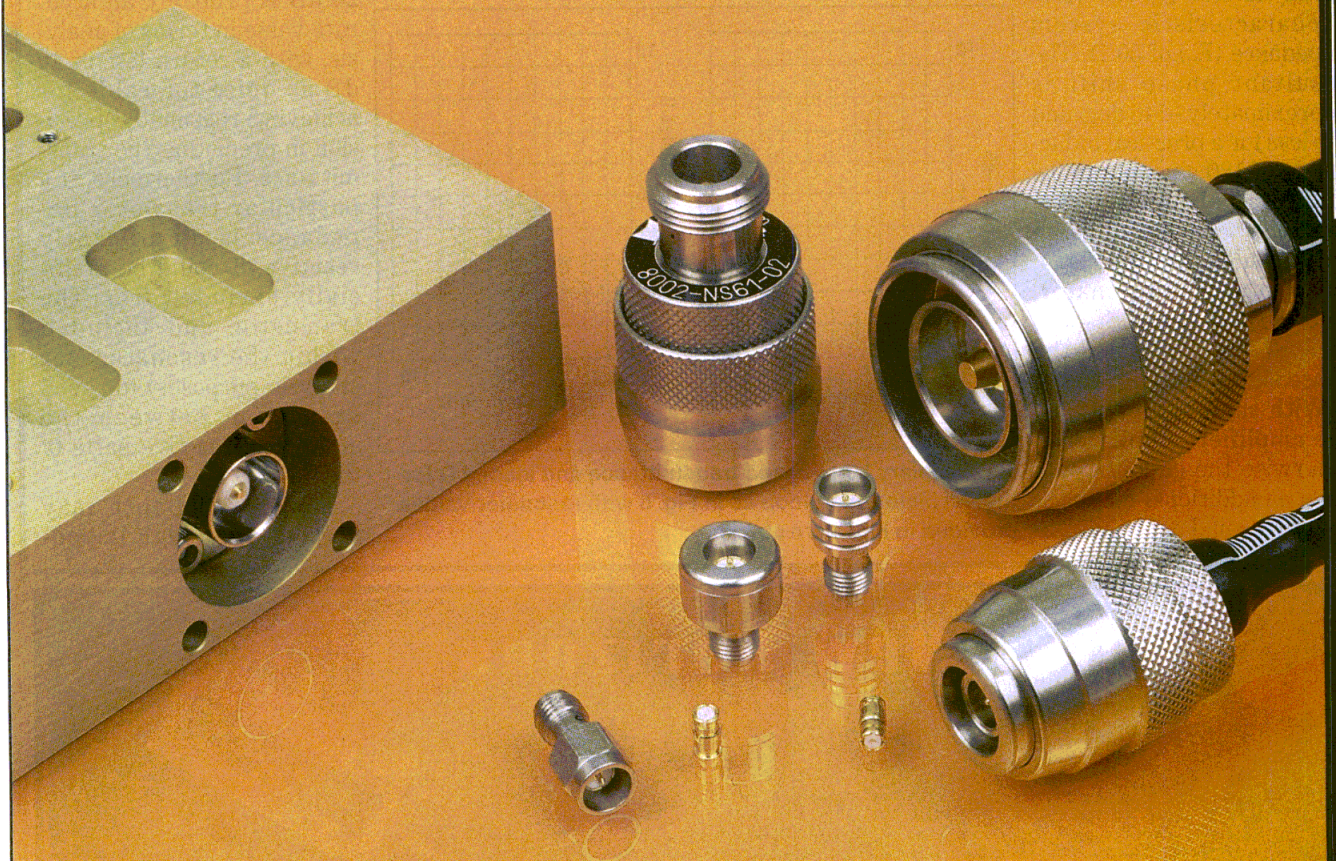
7311 G Grove Road, Frederick, MD, 21704

TEL: 301.662.5019 FAX: 301.662.4938

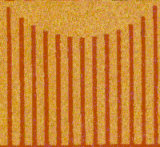
Area Sales Reps Wanted

PLANAR
electronics technology

Quick Connections



THE PUSH-ON CONNECTORS AND CONNECTOR SAVERS
WERE DEVELOPED TO ELEMİNATE ALL THE TIME CONSUMING
TIGHTENING, TORQUING AND LOOSENING OF CONNECTORS!
7/16 PUSH-ON, BMA, N PUSH-ON, SBX, SBY, SMA PUSH-ON,
SMA REVERSE SEX PUSH-ON, SMP, TNC PUSH-ON



Spectrum
Elektrotechnik GmbH

80905 Munich, Germany
P.O. Box 45 05 33

Fax: {49}-(89)-354-804-90,

country code city code

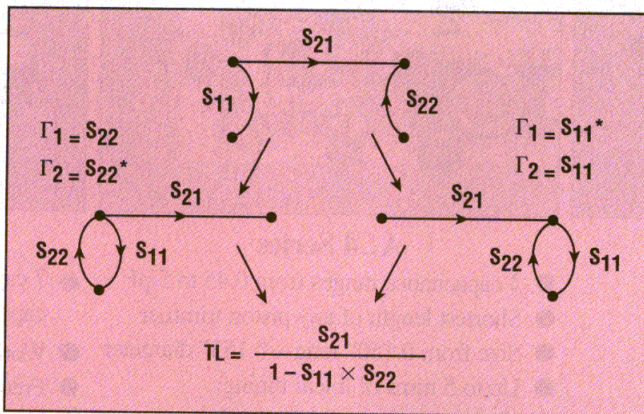
Telephone: {49}-(89)-354-804-0

country code city code

e-mail: [speclek @ CompuServe.com](mailto:speclek@CompuServe.com)

quickconnections99adv.pm6

ances, resulting in high losses and mismatches in the loop. In order to break apart sections of a loop or oscillator design for analysis, a simple rule of thumb is to make the breaks in a way so that the sections or blocks show the same impedances after the break as before it. Assuming the ideal 50- Ω amplifier of Fig. 4 and breaking the loop at its input (point A), an analysis would proceed with an excitation from the source impedance Z_S at the amplifier input with the resonator loaded by load impedance Z_L . Setting Z_L is simple, since it must equal the amplifier input impedance of 50 Ω . But setting Z_L is not straightforward, since it represents the complex impedance of one side of the resonator. But modern circuit simulators, such as Genesys 7 from Eagleware (Stone Mountain, GA), support



7. The loop transmittance can be derived graphically by application of analysis impedances conditions to a two port representing the disconnected oscillator loop.

analysis with complex impedances as well as impedances described in S-parameter files. In this way, the resonator, with a transistor at its input, can be analyzed as a one-port S-parameter file (resonator.s1p) that can then be applied as the input impedance for analysis of the loop. The results may seem flawed, with

cancellation of transmission just at the middle of the passband, but the approach can lead to the proper solution.

Breaking the loop should preserve a single impedance interaction. Terminating one broken end with the impedance of the second end should accomplish the preservation of a single impedance interaction with the use of its own conjugate impedance. The rule for terminating broken loops is "one load, one match."

This could be applicable in a twofold manner for a particular loop point, either by loading the output and matching the input or loading the input and matching the output. In general, it should be also valid in any condition and any loop point. To verify this, the example can be used to check the postulates. The two analysis possibilities can be described from

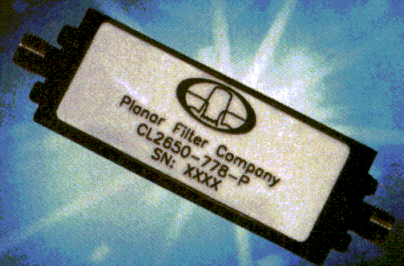
Expanding New Horizons

Products

- RF/Microwave Filters
- Diplexers/Multiplexers
- Switched Filter Banks
- Notch/Tunable Filters
- Bias Tees
- Integrated Subassemblies
- Receiver & Down Converters

Features

- DC to 27GHz
- Low Loss, High Q
- 3dB Bandwidths from 0.01% to 100%
- High Power
- Broadband Rejection
- Custom Packaging Available
- Filter/LNA Integration

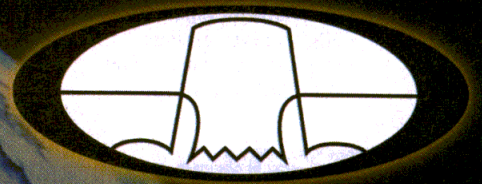


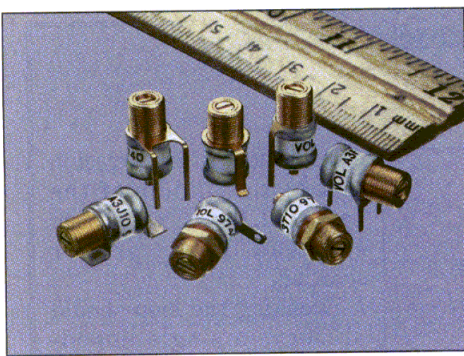
Planar Filter Company

7311 G Grove Road, Frederick, MD, 21704

TEL: 301.662.7024 FAX: 301.662.4938

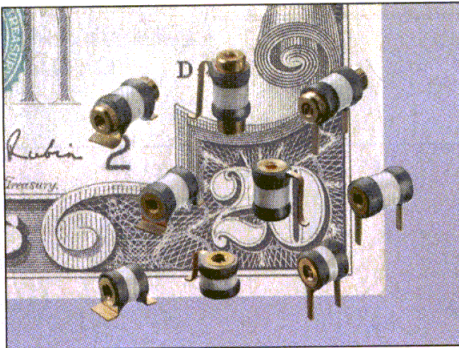
Area Sales Reps Wanted





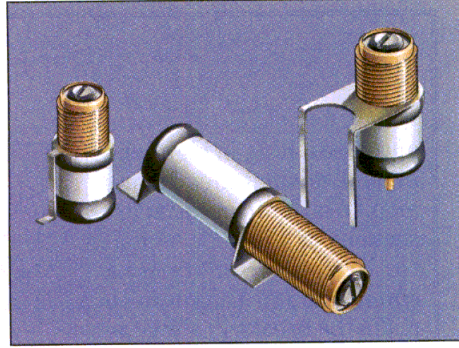
A-3 Series

- Capacitance range: 1 to 10 pF
- Self-resonance 2.3 GHz at 10 pF
- Working voltage up to 1000 VDC
- 10 turns of linear tuning
- Drop-in replacement for expensive air piston trimmers
- High reliability solid dielectric



A-4 Series

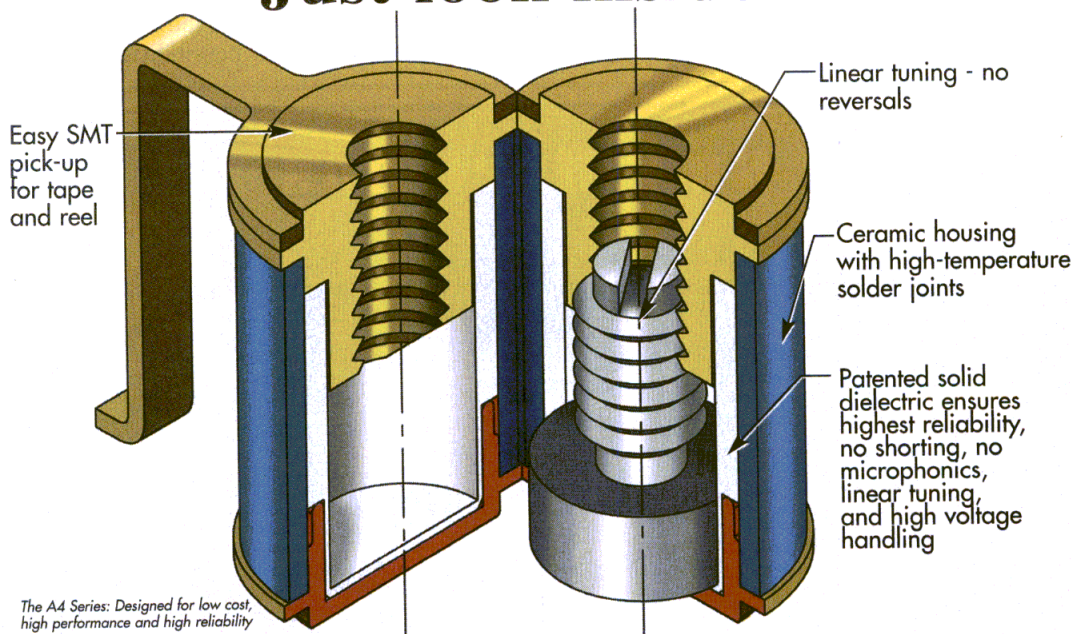
- 3 capacitance ranges from 0.45 to 5 pF
- Shortest length of any piston trimmer
- Size from 0.150" long x 0.155" diameter
- Up to 5 turns of linear tuning
- High reliability solid dielectric
- Replaces expensive sapphire trimmers



HV Series

- 7 capacitance ranges with max capacitance from 4 pF to 55 pF
- Working voltage up to 1000 VDC
- Frequency up to 1.5 GHz
- Up to 29 turns of linear tuning
- Sealed construction, 40 psi
- Various mounting styles
- Non-magnetic versions

What makes Voltronics trimmer capacitors the world's best? Just look inside...



Voltronics trimmer capacitors provide:

- Long-term reliability designed-in
- Low cost - under \$1 in quantity
- Self-resonant frequency range to 5 GHz
- Lowest profile in the industry
- Available on tape-and-reel
- High-voltage options
- Capacitance ranges from 0.2-1.0pF to 1.5-55pF

**Only Voltronics trimmers
give you all this...
for less than \$1**

Voltronics 
CORPORATION

The Trimmer Capacitor Company

Call Voltronics today, or check out our
complete catalog on-line at
www.voltronicscorp.com

100 Ford Road • Denville, NJ 07834
973.586.8585 • FAX : 973.586.3404
e-mail: info@voltronicscorp.com

Fig. 5:

$$\begin{cases} \Gamma_1 = S_{11}^* \\ \Gamma_2 = S_{11} \end{cases} \quad (1a)$$

$$\begin{cases} \Gamma_1 = S_{22} \\ \Gamma_2 = S_{22}^* \end{cases} \quad (1b)$$

With the ideal amplifier of Fig. 5, the first possibility reduces to a simple 50- Ω termination analysis. Taking the exemplary values, it is possible to achieve the characteristics of Fig. 6 for this ideal circuitry.

Similarly, if the amplifier exhibits any pure resistance at its input then, according to the postulate just listed, it can be taken as a source/load-analysis termination. This second possibility is not so apparent, however. It requires the use of a one-port S-parameter file (resonator.slp) mentioned earlier to set the excitation impedance function and similarly (but using conjugate values) to set the load impedance function. The conjugate file can be created from the derived resonator.slp file by inverting all angle signs (with the help of a text editor). The files are then applied analysis impedances to obtain the transmittance results similar to a 50- Ω analysis.

To examine this approach further for a complex-impedance amplifier, but with the same loop, a design trick can be used. The 100-pF capacitor at point A can be divided into two 50-pF capacitors in parallel, with one attached to the transistor and the other isolated. This can then be seen as a new break for point A in the loop. The twofold analysis that was presented before is then applied to this new configuration (a circuit simulator with the capability of setting the port impedances as complex variables would be useful), providing the same results as earlier. The same approach at point B will provide similar results.

A point in the loop is still needed for the transmittance analysis, but between the series capacitor and the inductor. Ideally, conjugate impedance files could be found for this break point,

applied as complex-analysis impedances that would yield the results similar to the analysis of Fig. 6. And the real effort would be placed on performing the calculations rather than on the analysis settings.

The question was asked earlier: How is it possible to break the oscillator loop and then terminate it in microwave S-parameter analysis, to obtain the right transmittance? One approach is to perform the analysis (or measurement) with any analysis impedance (such as 50 Ω , and then calculate the desired transmittance. Any S-parameters derived with the standard setting should be sufficient to calculate the desired characteristics. What is desired is to find the function of loop transmittance, TL (S_{21} , S_{11} , S_{22}).

A complete derivation with detailed transformation would be too long here, but it can be briefly described. The first step is to find a general expression for a two-port transmittance with generalized source/load impedances. Next, by inserting the analysis impedance conditions of eqs. 1a or 1b into that expression, the desired final function can be obtained. To accomplish the first step, the impedance Z-matrix can be advantageous as independent from external impedances. The useful relationships are gathered in references 5 and 6.

The task can be outlined as follows: take the initial S-parameters (analyzed or measured) with a standard impedance ($Z_0 = 50 \Omega$), determine the Z-parameters normalized initially to Z_0 , renormalize them to general

impedances, and achieve the actual S_{12} upon the renormalized Z-parameters. The important point in the procedure is the normalization itself. Usually when transforming network parameters, the Z-parameters are normalized as Z_{ii}/Z_0 . When the input/output characteristic impedances Z_1 , Z_2 are unequal yet real, then normalization should take place as Z_{11}/Z_1 , $Z_{21}/\sqrt{Z_1} \times Z_2$, Z_{22}/Z_2 .

Now, it is a matter of dealing with a completely general situation, that is, generalized S-parameters, with arbitrary reference impedances. Normalization of Z-parameters should now be referenced to real parts of these impedances, that is Z_{11}/R_1 , $Z_{21}/\sqrt{R_1} \times R_2$, Z_{22}/R_2 where:

$$R_1 = \text{Re}(Z_1), \text{ and}$$

$$R_2 = \text{Re}(Z_2)$$

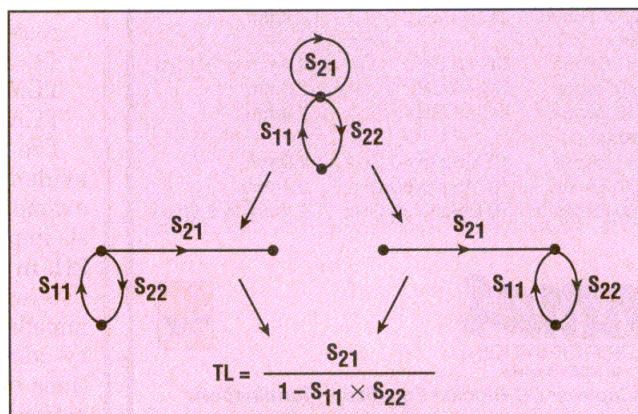
After all transformation and simplification, the required expression can be described as:

$$S_{21}' = S_{21} \cdot \sqrt{r_1 \cdot r_2} \cdot \frac{(1 - \Gamma_1) \cdot (1 - \Gamma_2)}{(1 - S_{11} \cdot \Gamma_1) \cdot (1 - S_{22} \cdot \Gamma_2)} \quad (2a)$$

where:

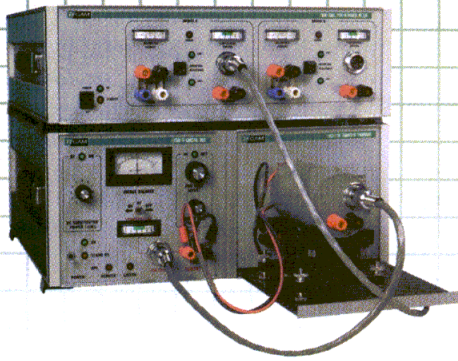
all variables that are referred to standard, initial reference impedances Z are usually assumed to be 50 Ω . Even when the S-parameters are from analysis or measurement within a 50- Ω system, the new arbitrary reference impedances Z_1 and Z_2 are described by the relevant reflection coefficients Γ_1 and Γ_2 . Describing them in terms of reflection coefficients is designed in order to simplify equations, yet Γ_1 and Γ_2 alone are not sufficient here and their parts: $r_1 = \text{Re}(Z_1)/Z_0$ and $r_2 = \text{Re}(Z_2)/Z_0$ must appear independently as a result of normalization to $\text{Re}(Z_1)$ and $\text{Re}(Z_2)$.

Equation 2a can be checked with the aid of a circuit simulator, analyzing a known two-port network within the arbitrary reference impedances and comparing the results with those computed from eq. 2a. It is useful to describe two simplified versions of the expression with eq. 2b used



8. This flow graph represents an oscillator loop and its two disconnection variances.

POWER SENSOR CALIBRATORS



**Win with
TEGAM's
Industry
Standards**

SYSTEM II

If you are not calibrating power sensors today, you will be tomorrow!

Advancements in Radio Frequency research and development are resulting in the increased use of RF power meters and attenuators in design and production test applications. TEGAM's RF calibration and measurement instruments continue to provide the complete solutions you need to support these instruments today and into the future.

TEGAM's SYSTEM II and VM-7 products are the world's fastest and most accurate Power Sensor Calibration and RF Attenuation Measurement Systems.

TEGAM makes it easy by providing a full selection of GPIB programmable instruments, from 100 KHz to 40 GHz.

Whether you are planning to expand your capabilities or are specifying your first system... you need to know TEGAM to get a good start!

Contact TEGAM at 1-800-666-1010, send e-mail to sales@tegam.com or visit our website at www.tegam.com to find your local representative.



THE GLOBAL SOURCE FOR PROVEN
TEST & MEASUREMENT TECHNOLOGY

TEN TEGAM WAY • GENEVA, OHIO 44041
PHONE 440-466-6100 • FAX 440-466-6110

CIRCLE NO. 427 or visit www.mwrf.com

for real (although not equal) reference impedances Z_1 and Z_2 :

$$S_{21}' = S_{21} \cdot \frac{\sqrt{(1 - \Gamma_1^2) \cdot (1 - \Gamma_2^2)}}{(1 - S_{11} \cdot \Gamma_1) \cdot (1 - S_{22} \cdot \Gamma_2)} \quad (2b)$$

The second version (eq. 2c) is for real and equal reference impedances Z different from the initial Z_0 :

$$S_{21}' = S_{21} \cdot \frac{1 - \Gamma^2}{(1 - S_{11} \cdot \Gamma) \cdot (1 - S_{22} \cdot \Gamma)} \quad (2c)$$

It is now time to substitute the impedance-analysis conditions 1a and 1b into general expression 2a to obtain the required loop transmittance TL . From the assumptions, using either of the expressions should reduce to the same form. Although complicated in appearance, the substitutions yield the simple form:

$$TL = \frac{S_{21}}{1 - S_{11} \cdot S_{22}} \quad (3)$$

This function can be readily implemented in a modern circuit simulator to find the true loop transmittance without any requirement for special reference impedances. This has been successfully accomplished within Genesys 7, which now includes post-processing capabilities, achieving the same results as obtained earlier with the termination-impedance settings.

The script needed in Genesys 7 for the transmittance derived with post-processing is:

```
using linear1.sch1
x=.rect[s21]
y=.rect[s11]
z=.rect[s22]
TL=x/(1-y*z)
TLM=db20(TL)
TLA=ang(TL)
```

The usefulness of this approach is evident when applied to a difficult example,² where the required analysis impedance was approximately 10 kΩ. In attempting an open-loop analysis with this type of termination impedance, results are unsatisfactory compared to individual simulations of transistor/resonator combinations. This is because the C_{BC} and C_{BE} capacitances (which are fractions of a picofarad), manifest them-

First-class performance at coach-class prices.

40 & 50 GHz Components



50EH



TS400F

5153

Attenuators

Model 40A/AH	DC-40 GHz
Model 40EH	DC-40 GHz
Model 50EH	DC-50 GHz

Terminations

Model TS400	DC-40 GHz
Model TE400	DC-40 GHz
Model TE500	DC-50 GHz

Adapters

5151 Series	DC-40 GHz	2.4mm to 2.9mm
5170 Series	DC-40 GHz	2.9mm
5148 Series	DC-50 GHz	2.4mm

DC Blocks

8141 Series	10 MHz to 40 GHz	2.9mm
8177 Series	10 MHz to 50 GHz	2.4mm
8180 Series	10 MHz to 50 GHz	2.4mm to 2.9mm

Frequency

Connectors



inmet
CORPORATION
An MCE Company



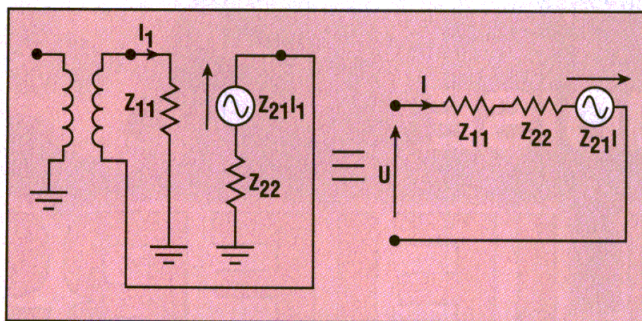
Manufacturer of Attenuators • Adapters • DC Blocks • Equalizers • Terminations

300 Dino Drive • Ann Arbor, MI 48103 USA • Phone 888-244-6638 or 734-426-5553 • FAX 734-426-5557

Visit us on the Web at www.inmetcorp.com

CIRCLE NO. 409 or visit www.mwrf.com

selves with serious effects at these high impedances. However, their effects are only felt in the analysis since, in the actual circuitry, they have negligible effects due to larger shunt resonator capacitances.



9. This illustration shows the negative impedance analysis within the oscillator loop represented in terms of Z-parameters.

Taking the loop transmittance (TL) as the analysis goal preserves the real impedance interaction, showing reasonable results despite the non-unilateral transistor. This non-unilateral characteristic means that the TL depends slightly on the analysis impedance chosen, although variations are acceptable in practice. For the most precise analysis, single feedback should be achieved first, as described earlier, by extracting the unilateral gain element and transferring its internal feedback into the resonator.

The earlier symbolic derivations could be somewhat complex to follow in full detail. But the task at hand can be somewhat simplified through the use of a flow-graph technique.^{5,6} Figure 7 shows a graphic representation of an open loop as a unilateral S-parameter two-port network with the two analysis impedance conditions applied as seen in eq. 3.

Note that at the end where the conjugate impedance is attached, there is no reflected wave (ideal impedance matching), so no arrows are marked. Obtaining the transmittances of the two resultant simple graphs is straightforward according to universal flow-graph rules. As Fig. 8 shows, there are two possible ways to disconnect the loop graph, at the beginning or at the end of the S_{21} arrow. The two ways lead to one general loop-transmittance expression.

The loop-transmittance expression was expressed in S-parameters and normal in microwaves. Z-parameters were only used to facilitate derivation. Nevertheless, it is also possible to express the TL function in terms of impedances, yielding the even simpler form:

$$TL = \frac{Z_{21}}{Z_{11} + Z_{22}} \quad (4)$$

This description, just quotient of transimpedance to the sum of input/output impedances, compares with common "negative resistance" analyses. They are usually obtained in any oscillator branch, providing some insight as to where and if the circuitry is expected to oscillate. But what is their relation to the true loop transmittance? An ideal circuit similar to that in Fig. 9 will be used here to receive a general explanation.

$$Z = \frac{U}{I} = \frac{I \cdot Z_{11} + I \cdot Z_{22} - Z_{21} \cdot I}{I} = Z_{11} + Z_{22} - Z_{21} \quad (5)$$

Let the loop be represented as one Z-parameter two-port network with an ideal transformer inserted to represent the impedance function within the loop. The resultant Z function is derived along with the transformation. Comparing this result to eq. 4, a similarity can be seen since both generally have transimpedance and input/output impedances. The difference is in the operator, with division in contrast to subtraction. Transmittance provides the required loop description in terms of gain, corresponding directly to the practical oscillator parameter gain margin, usually maintained above 5 dB.●●

References

1. Stan Alechno, "Analysis Method Characterizes Microwave Oscillators," *Microwaves & RF*, November 1997 to February 1998.
2. Stan Alechno, "The Virtual Ground in Oscillator Design—A Practical Example," *Applied Microwave & Wireless*, July 1999.
3. Stan Alechno, "Microwave Switched VCO With Microstrip Branch Resonator—The Virtual Ground In Practice," October 1999.
4. Stan Alechno, "Analysis of the Cascode Crystal Oscillator," *RF Design*, May 1997.
5. "S-Parameter Techniques for Faster, More Accurate Network Design," Hewlett-Packard Application Note 95-1.
6. "S-Parameter Design," Hewlett-Packard Application Note 154.

Sprague Goodman SURFcoil® Inductors & Transformers

SMT TUNABLE RF COILS

- Inductance from 14 nH to 680 μ H
- Tuning range up to $\pm 7.5\%$
- Five terminal pad layout allows for a variety of inductor and transformer configurations

SMT AIR COIL

- Inductance from 5.3 to 43.0 nH
- 2 sizes:
3.7 x 4.4 x 3.2 mm
7.1 x 4.4 x 3.2 mm

SMT TRANSFORMERS

- Encapsulated 4.5 x 3.4 x 3.1 mm
- Bobbin wound 4.4 x 4.4 x 3.3 mm
- Dual aperture cores
Baluns
Directional couplers
Power splitters
2 windings (with and without tap)
3 sizes: 4.5 x 4.5 x 2.8 mm
5.7 x 5.7 x 4 mm
6.5 x 5.7 x 4 mm

SURFcoil® SMT CHIP INDUCTORS

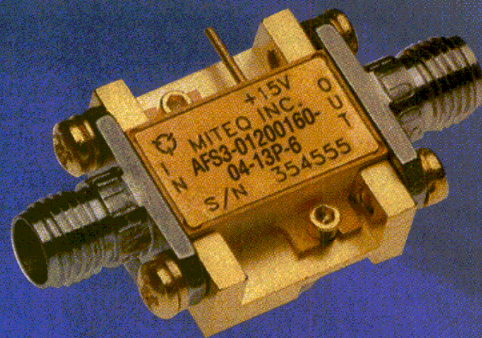
- Inductance from 2.2 nH to 1 mH
- 13 model series in 6 sizes:
1.0 x 0.5 x 0.5 mm (0402)
1.6 x 0.8 x 0.8 mm (0603)
2.00 x 1.25 x 1.25 mm (0805)
2.5 x 2.0 x 1.6 mm (1008)
3.2 x 2.5 x 2.2 mm (1210)
4.5 x 3.2 x 3.2 mm (1812)
- Shielded, unshielded, ferrite core and nonmagnetic models
- Operating temp: -40° to +85°C
- Carrier and reel standard

For information on these and our other quality products, visit our website or phone, fax or write today.

**SPRAGUE
GOODMAN**

1700 Shames Drive, Westbury, NY 11590
Tel: 516-334-8700 • Fax: 516-334-8771
Website: <http://www.spraguegoodman.com>

AFS SERIES... MORE THAN JUST LOW NOISE



AMPLIFIERS

Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
--------------	-----------------------	-----------------------	---------------------------	-------------------------	-------------------	--------------------	---------------------------------------	---------------------------

TEMPERATURE COMPENSATED AMPLIFIERS

AFS3-01000200-15-TC-6	1-2	36-40	1.00	1.5	2.0:1	2.0:1	+5	125
AFS3-02000400-15-TC-6	2-4	22-26	1.00	1.5	2.0:1	2.0:1	+5	125
AFS3-02000400-15-TC-6	2-4	22-26	1.00	1.5	2.0:1	2.0:1	+5	125
AFS2-04000800-20-TC-2	4-8	18-22	1.00	2.0	2.0:1	2.0:1	+5	100
AFS3-04000800-18-TC-4	4-8	26-30	1.00	1.8	2.0:1	2.0:1	+8	150
AFS2-02000800-40-TC-2	2-8	14-19	1.50	4.0	2.0:1	2.0:1	+5	100
AFS3-02000800-30-TC-4	2-8	22-27	1.50	3.0	2.0:1	2.2:1	+8	150
AFS2-08001200-30-TC-2	8-12	12-16	1.00	3.0	2.0:1	2.0:1	+5	100
AFS3-08001200-22-TC-4	8-12	24-28	1.00	2.2	2.0:1	2.0:1	+8	150
AFS4-12001800-30-TC-8	12-18	22-26	1.00	3.0	2.0:1	2.0:1	+8	250
AFS4-06001800-35-TC-6	6-18	22-26	1.00	3.5	2.0:1	2.0:1	+8	250
AFS6-06001800-35-TC-8	6-18	30-34	1.00	3.5	2.0:1	2.0:1	+8	400
AFS4-02001800-45-TC-5	2-18	18-24	1.50	4.5	2.2:1	2.2:1	+8	175

Note: All specifications guaranteed -54 to +85°C.
Many other frequencies, noise figures and gain windows are available.

OPTIONS:

- CRYOGENIC
- LIMITING
- VARIABLE GAIN
- LIMITER INPUT
- TTL CONTROLLED
- HIGH DYNAMIC RANGE
- EQUALIZED GAIN
- BUILT-IN TEST
- DETECTED OUTPUT
- MILITARY VERSIONS
- SPACE QUALIFIED

Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
--------------	-----------------------	-----------------------	---------------------------	-------------------------	-------------------	--------------------	---------------------------------------	---------------------------

HIGHER POWER AMPLIFIERS

AFS4-00050100-25-25P-6	0.5-2	36	1.50	2.5*	2.0:1	2.5:1	+25	325
AFS3-00100100-23-25P-6	.1-1	38	2.00	2.3	2.5:1	2.5:1	+25	280
AFS3-00100200-25-27P-6	.1-2	33	1.50	2.5	2.0:1	2.5:1	+27	300
AFS3-00100300-25-23P-6	.1-3	25	1.50	2.5	2.0:1	2.5:1	+23	300
AFS3-00100400-26-20P-4	.1-4	26	1.50	2.6	2.0:1	2.0:1	+20	250
AFS4-00100600-25-20P-4	.1-6	32	1.50	2.5	2.0:1	2.0:1	+20	300
AFS4-00100800-28-20P-4	.1-8	30	1.50	2.8	2.0:1	2.0:1	+20	300
AFS4-00101200-40-20P-4	.1-12	20	1.50	4.0	2.0:1	2.0:1	+20	300
AFS4-00501800-60-20P-6	.5-18	25	2.75	6.0	2.5:1	2.5:1	+20	350
AFS5-00102000-60-18P-6	.1-20	25	3.00	6.0	2.5:1	2.5:1	+18	360
AFS3-01000200-20-27P-6	1-2	33	1.50	2.0	2.0:1	2.0:1	+27	350
AFS3-02000400-30-25P-6	2-4	28	1.50	3.0	2.0:1	2.0:1	+25	250
AFS3-04000800-40-20P-4	4-8	20	1.00	4.0	2.0:1	2.0:1	+20	200
AFS4-08001200-50-20P-4	8-12	22	1.25	5.0	2.0:1	2.0:1	+20	200
AFS6-12001800-40-20P-6	12-18	28	2.00	4.0	2.0:1	2.0:1	+20	375
AFS6-06001800-50-20P-6	6-18	23	2.00	5.0	2.0:1	2.0:1	+20	365
AFS4-02001800-60-20P-6	2-18	23	2.50	6.0	2.5:1	2.0:1	+20	350

*Noise figure degrades below 100 MHz. Please consult factory for details.
Note: Noise figures increase below 500 MHz in bands wider than .1-10 GHz.

This is only a small sample of our extensive list of standard catalog items.
Please contact Dave Krautheimer at (631) 439-9413 or e-mail dkrautheimer@miteq.com
for additional information or to discuss your custom requirements.

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



Model Number	Frequency Range (GHz)	Gain (Min.) (dB)	Gain Flatness (±dB)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
MODERATE BAND AMPLIFIERS								
AFS2-00700080-05-10P-4	.7-.8	30	0.50	0.45	1.5:1	1.5:1	+10	90
AFS2-00800100-05-10P-4	.8-1	30	0.50	0.45	1.5:1	1.5:1	+10	90
AFS3-01200160-05-13P-6	1.2-1.6	40	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-01400170-05-13P-6	1.4-1.7	40	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-01500180-04-13P-6	1.5-1.8	40	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-01500250-06-13P-6	1.5-2.5	36	0.50	0.60	2.0:1	2.0:1	+13	150
AFS3-01700190-04-13P-6	1.7-1.9	36	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-01800220-05-13P-6	1.8-2.2	36	0.50	0.50	1.5:1	1.5:1	+13	150
AFS3-02200230-04-13P-6	2.2-2.3	36	0.50	0.40	1.5:1	1.5:1	+13	150
AFS3-02300270-05-13P-6	2.3-2.7	34	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-02700290-05-13P-6	2.7-2.9	32	0.50	0.50	1.5:1	1.5:1	+13	150
AFS3-02900310-05-13P-6	2.9-3.1	32	0.50	0.45	1.5:1	1.5:1	+13	150
AFS3-03100350-06-10P-4	3.1-3.5	29	0.50	0.6	1.5:1	1.5:1	+10	150
AFS4-03400420-06-13P-6	3.4-4.2	40	0.50	0.60	1.5:1	1.5:1	+13	225
AFS3-04400510-07-5P-4	4.4-5.1	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-04500480-07-5P-4	4.5-4.8	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05200600-07-5P-4	5.2-6	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05400590-07-5P-4	5.4-5.9	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-05800670-07-5P-4	5.8-6.7	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS3-07250775-06-5P-4	7.25-7.75	30	0.50	0.60	1.5:1	1.5:1	+5	100
AFS3-07900840-07-5P-4	7.9-8.4	30	0.50	0.70	1.5:1	1.5:1	+5	100
AFS4-08500960-08-5P-4	8.5-9.6	32	0.75	0.80	1.5:1	1.5:1	+5	125
AFS3-09001100-09-5P-4	9-11	26	0.50	0.90	1.5:1	1.5:1	+5	100
AFS4-09001100-09-5P-4	9-11	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS4-10951175-09-5P-4	10.95-11.75	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS4-11701220-09-5P-4	11.7-12.2	32	0.75	0.90	1.5:1	1.5:1	+5	125
AFS2-12201280-10-8P-4	12.2-12.8	14	0.75	1.00	1.5:1	1.5:1	+8	80
AFS4-12201280-10-12P-4	12.2-12.8	27	0.75	1.00	1.5:1	1.5:1	+12	200
AFS4-12701330-13-10P-4	12.7-13.3	27	0.75	1.30	1.5:1	1.5:1	+10	175
AFS4-13201400-14-10P-4	13.2-14	24	0.75	1.40	1.5:1	1.5:1	+10	175
AFS4-14001450-14-10P-4	14-14.5	24	0.75	1.40	1.5:1	1.5:1	+10	175
AFS4-20202120-20-8P-4	20.2-21.2	20	1.00	2.00	1.5:1	1.5:1	+8	175
AFS4-21202400-22-10P-4	21.2-24	18	1.00	2.2	2.0:1	2.0:1	+10	100
OCTAVE BAND AMPLIFIERS								
AFS3-00120025-09-10P-4	.12-.25	38	0.50	0.9	2.0:1	2.0:1	+10	175
AFS3-00250050-08-10P-4	.25-.5	38	0.50	0.8	2.0:1	2.0:1	+10	125
AFS3-00500100-05-10P-6	.5-1	38	0.75	0.5	2.0:1	2.0:1	+10	150
AFS3-01000200-05-10P-6	1-2	38	1.00	0.5	2.0:1	2.0:1	+10	150
AFS3-01200240-05-10P-6	1.2-2.4	34	1.00	0.5	2.0:1	2.0:1	+10	175
AFS3-02000400-06-10P-4	2-4	30	1.00	0.6	2.0:1	2.0:1	+10	125
AFS3-02600520-10-10P-4	2.6-5.2	28	1.00	1.0	2.0:1	2.0:1	+10	150
AFS3-04000800-07-10P-4	4-8	30	1.00	0.7	2.0:1	2.0:1	+10	125
AFS3-08001200-09-10P-4	8-12	26	1.00	0.9	2.0:1	2.0:1	+10	125
AFS3-08001600-15-8P-4	8-16	26	1.00	1.5	2.0:1	2.0:1	+8	80
AFS4-12002400-25-10P-4	12-24	20	2.00	2.5	2.0:1	2.0:1	+10	85
AFS4-12001800-18-10P-4	12-18	26	1.00	1.8	2.0:1	2.0:1	+10	125
AFS4-18002650-28-8P-4	18-26.5	18	1.75	2.8	2.5:1	2.2:1	+8	150
MULTIOCTAVE BAND AMPLIFIERS								
AFS1-00040200-12-10P-4	.04-2	15	1.50	1.2	2.5:1	2.0:1	+10	75
AFS3-00300140-08-10P-4	.3-1.4	33	1.00	0.8	2.0:1	2.0:1	+10	150
AFS2-00400350-12-10P-4	.4-3.5	22	1.50	1.2	2.0:1	2.0:1	+10	80
AFS3-00500200-08-15P-4	.5-2	38	1.00	0.8	2.0:1	2.0:1	+15	125
AFS3-01000400-09-10P-4	1-4	30	1.50	0.9	2.0:1	2.0:1	+10	125
AFS3-02000800-09-10P-4	2-8	26	1.00	0.9	2.0:1	2.0:1	+10	125
AFS4-02001800-23-10P-4	2-18	25	2.00	2.3	2.0:1	2.0:1	+10	175
AFS4-06001800-22-10P-4	6-18	24	2.00	2.2	2.0:1	2.0:1	+10	150
AFS4-08001800-22-10P-4	8-18	26	2.00	2.2	2.0:1	2.0:1	+10	150
ULTRA WIDEBAND AMPLIFIERS								
AFS3-00100100-09-10P-4	.1-1	38	1.00	0.9	2.0:1	2.0:1	+10	150
AFS3-00100200-10-15P-4	.1-2	38	1.00	1.0	2.0:1	2.0:1	+15	150
AFS3-00100300-11-10P-4	.1-3	32	1.00	1.1	2.0:1	2.0:1	+10	150
AFS3-00100400-13-10P-4	.1-4	28	1.00	1.3	2.0:1	2.0:1	+10	150
AFS3-00100600-13-10P-4	.1-6	28	1.25	1.3	2.0:1	2.0:1	+10	125
AFS3-00100800-14-10P-4	.1-8	25	1.50	1.4	2.0:1	2.0:1	+10	125
AFS4-00101200-22-10P-4	.1-12	28	1.50	2.2	2.0:1	2.0:1	+10	175
AFS4-00101400-23-10P-4	.1-14	24	2.00	2.3	2.5:1	2.5:1	+10	200
AFS4-00101800-25-10P-4	.1-18	25	2.00	2.5	2.5:1	2.5:1	+10	175
AFS4-00102000-30-10P-4	.1-20	20	2.50	3.0	2.5:1	2.5:1	+10	175
AFS4-00102650-40-8P-4	.1-26.5	18	2.50	4.0	2.5:1	2.5:1	+8	175

Note: Noise figure increases below 500 MHz in bands greater than 0.1-10 GHz.



MICROWAVE WIRELESS



Your Best Choice & Easy Selection For Wireless Telecommunication.

Offering Design

- From 10KHz to 5GHz
- Good Reliability
- Temperature Compensated & Low Insertion Loss
- High Frequency Selectivity
- Small & Light
- Custom Design Available

■ **Contact us today to save development time & cost with good quality.**

■ **To get more information, visit our website to download data sheet and application.**

www.koreasangshin.com

■ **Needs Our Co-Operator.**

SANGSHIN KOREA SANGSHIN ELECTRIC CO., LTD

Head office & Plant, Zip 339-810

614-1, Wolhari, Suhmyon, Yunkikun, Choongnam, Republic of Korea
TEL. 82-415-865-9000 FAX. 82-415-865-9339, 865-9229 E-mail : ksebuzz@kornet.net

Seoul Branch

115-16, Buma B/D Nonhyun-dong, Kangnam-ku, Seoul, Republic of Korea
TEL. 82-2-548-7691 FAX. 82-2-548-7690 E-mail : ksejhkim@kornet.net

Refining CDMA Mobile-Phone Power Control

A versatile RF chip set provides the performance to maintain power control for maximum capacity in CDMA wireless communications systems.

Issy Kipnis

R&D Manager

Agilent Technologies, Semiconductor Products Group, 39201 Cherry St., Newark, CA 94560-4697; (510) 505-5624, FAX: (510) 505-5560, e-mail: issy_kipnis@agilent.com, Internet: <http://www.agilent.com>.

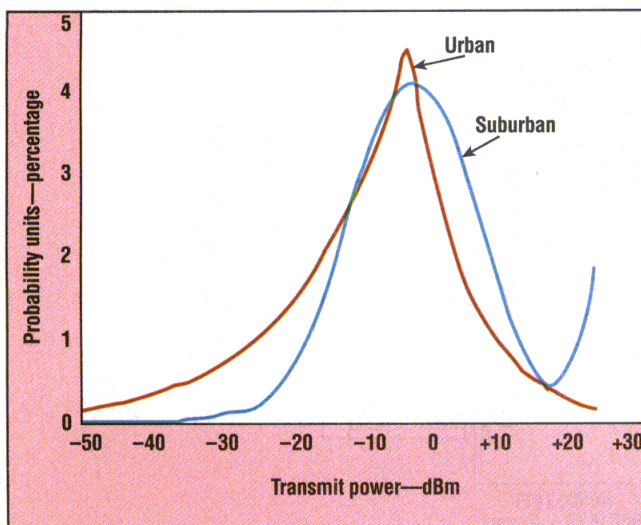
CAPACITY in a code-division-multiple-access (CDMA) system is determined not only by the total number of users on a particular channel and a particular cell, but also by the power received by the base station from each user's handset. Thus, it is important to have handsets transmit at the lowest possible power to optimize CDMA capacity.

To achieve the lowest possible handset transmit power, CDMA systems implement a very tight power control and take advantage of the natural low rate of voice activity in normal speech, reducing the transmission rate when voice activity is low and, hence, lowering the average transmit power. The base station establishes a very tight closed-loop control of the output power of each handset, commanding it to increase or decrease its power by 1 dB every 1.25 ms. As a handset station tra-

verses a cell, its output power will be decreased when it approaches the base station, and it will be increased as it gets farther away from the center of the cell. Figure 1 shows typical statistical profiles for the handset transmit power generated from actual field-test data from deployed CDMA units, for urban and suburban topographies.¹ It is clear

that the average transmit power of the handset (+10.6 dBm suburban, +5.4 dBm urban) is significantly lower than the maximum.

Using adaptive bias techniques in the RF section of a handset, closed-loop operation delivers the required linearity at high output power with enough "headroom" to support a reasonable manufacturing margin, while simultaneously exhibiting low current consumption at average transmit power to provide enhanced standby and talk-time performance. The current consumption at high output power is important because it challenges the thermal design of the handset. Figure 1 illustrates the probability that the handset spends little time transmitting at the maximum output power and, hence, the current consumption at that point has only a minor influence on talk time. Therefore, the real figure of merit for CDMA mobile phones should be the statistical-average current consumption (I_{μ}), which is the current consumption integrated over the user's statistical profile. In fact, the industry-standard method of measuring talk time consists of continuously sweeping the output power of the handset from -50 to +23 dBm according to the statistical profiles shown in Fig. 1.¹



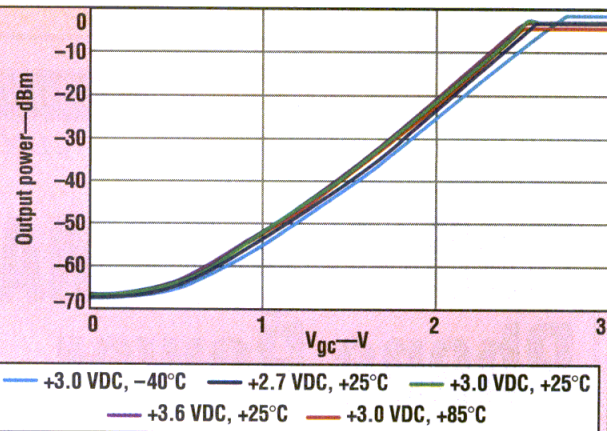
1. This plot shows the probability distribution of mobile-station transmit power in a CDMA system.

Figure 2 shows the block diagram of a tri-mode RF chip set from Agilent Technologies (Newark, CA). The transmit chain consists of three elements: a modulator/variable-gain-amplifier (VGA) intermediate-frequency (IF) chip, an upconverter/RF VGA chip, and an impedance-matched power-amplifier (PA) module. The receive chain comprises two low-noise amplifiers (LNAs) with bypass-switch integrated circuits (ICs), a downconverter chip, and an IF VGA/demodulator chip.

TRANSMIT GAIN CONTROL

The modulator/VGA IC (model HPMX-7411) contains a quadrature modulator, a variable-gain IF amplifier, a negative-resistance cell to generate the local-oscillator (LO) signal, and a voltage-controlled-oscillator (VCO) buffer amplifier. For CDMA applications, the differential in-phase (I) and quadrature (Q) signals are received from the baseband proces-

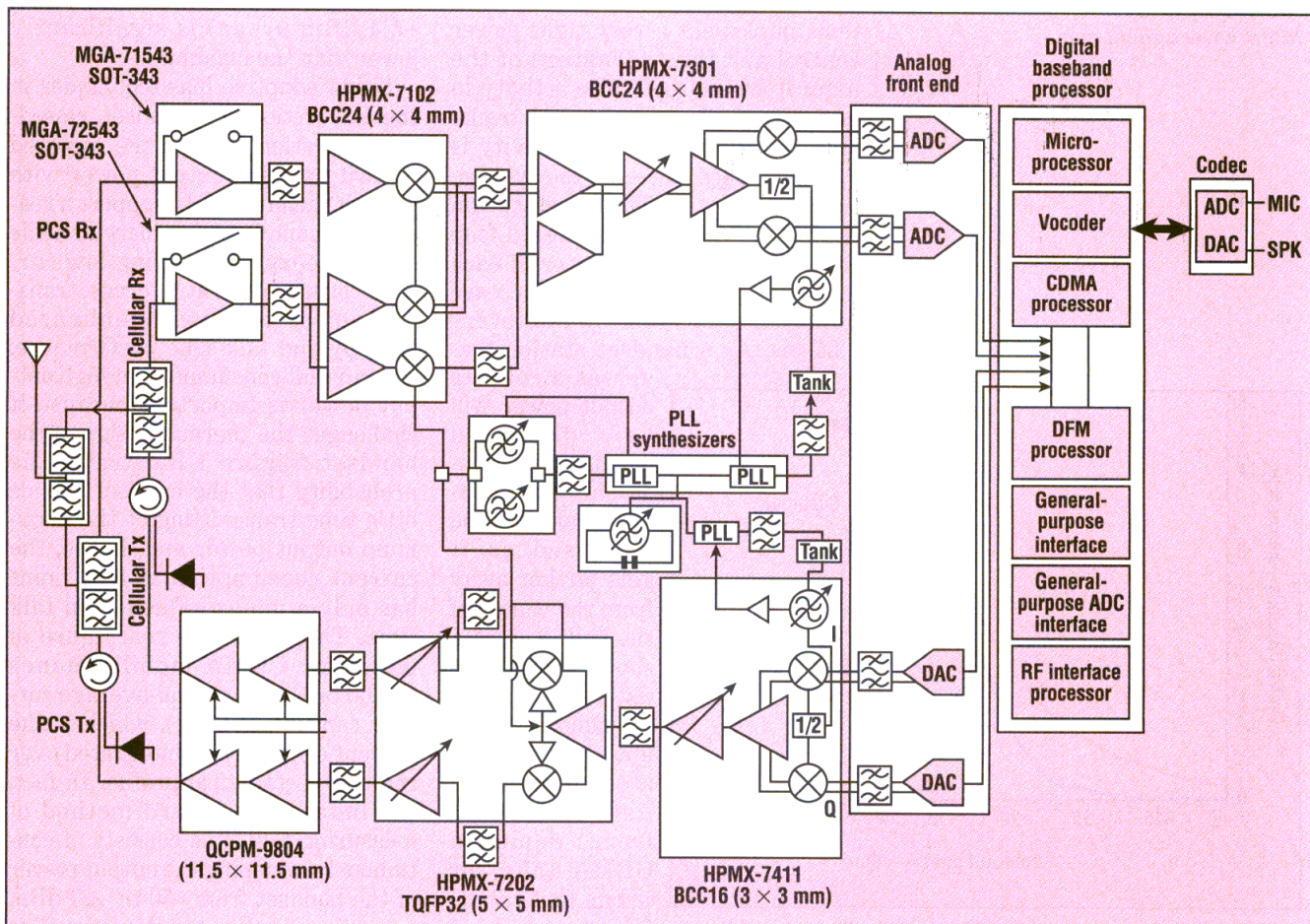
sor and applied directly to the input of the mixers. The on-chip negative-resistance cell with an external tank network tuned to two times the frequency of the LO ($2f_{LO}$) operates as a VCO, feeding a broadband divide-by-two circuit that drives the I and Q mixers in quadrature. The modulated signal is then applied to the VGA. For frequency-modulation (FM) applications, the FM is directly applied to the tank of the VCO at twice the modulation frequency. The signal goes through the divide-by-two circuit, and is applied to the mixers. The I and Q mixers are latched to permit the FM signal to pass into and through the VGA without frequency conversion. The complete signal path, including the nega-



3. These measurements show the output power versus gain control over temperature and bias variations for the modulator/amplifier IC.

tive-resistance cell, employs differential circuitry to provide high common-mode noise suppression. The broadband quadrature divide-by-two circuit is implemented using a toggle flip-flop topology. The modulator can also operate with an injected LO signal.

Figure 3 shows the measured performance at the output of the VGA. At the typical 130 MHz IF, the IC consumes 30 mA from a +3-VDC sup-

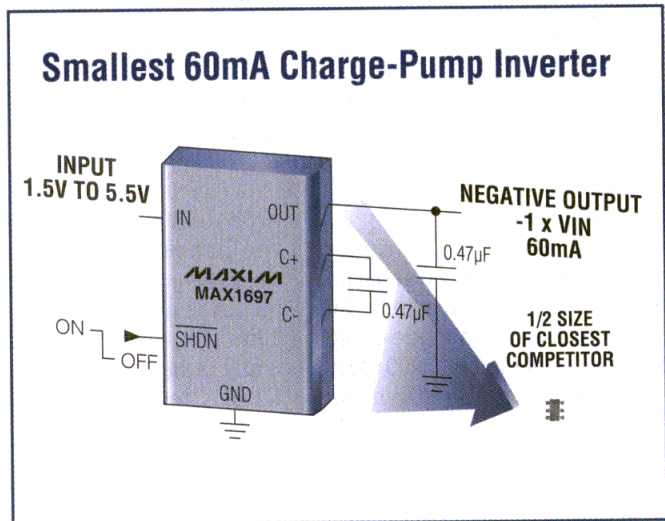


2. This block diagram illustrates a tri-mode RF chip set from Agilent Technologies for CDMA and AMPS applications.

HIGHEST CURRENT SOT23 CHARGE PUMP

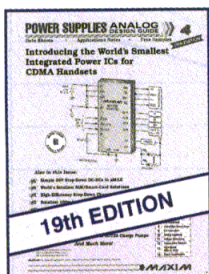
60mA Addition to Industry's Largest Selection

- ◆ Highest Guaranteed Output Current:
60mA (MAX1697)
- ◆ Lowest Quiescent Current:
50µA (MAX1720)
- ◆ Smallest External Capacitors:
0.1µF (MAX871)
- ◆ Lowest Output Resistance:
12Ω (MAX1697)
- ◆ Most Switching Frequency Options:
12, 35, 125, 250, or 500kHz
- ◆ 0.1µA Logic-Controlled Shutdown
(all 6-pin SOT23 devices)



PART	PACKAGE	FUNCTION	OUTPUT CURRENT (mA)	SWITCHING FREQUENCY (kHz)	CAPACITORS (µF)	FEATURE
MAX1697	SOT23-6	Inverter	60	12 to 250	0.47	Highest Output Current
MAX1719/20/21	SOT23-6	Inverter	25	12/125	0.33	0.1µA SHDN (or $\overline{\text{SHDN}}$)
MAX870/71	SOT23-5	Inverter	25	125/500	0.10	Smallest Capacitors
MAX828/29	SOT23-5	Inverter	25	12/35	3.30	Industry Standard
MAX1682/83	SOT23-5	Doubler	25	12/35	3.30	Doubler Function

Maxim offers the broadest selection of charge pumps in the ultra-small SOT23 package for use as GaAsFET biases, LCD supplies, and analog measurement supplies. These charge pumps invert or double an input voltage (1.5V to 5.5V) using two small external capacitors. No inductors are required. Switching frequencies are available from 12kHz to 500kHz to allow trade-offs between lowest quiescent current and smallest external capacitors.



FREE Power Supplies Design Guide – Sent Within 24 Hours!
Includes: Reply Cards for Free Samples and Data Sheets

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

MAXIM
www.maxim-ic.com

2000 EDITION!
FREE FULL-LINE DATA CATALOG
ON CD-ROM



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

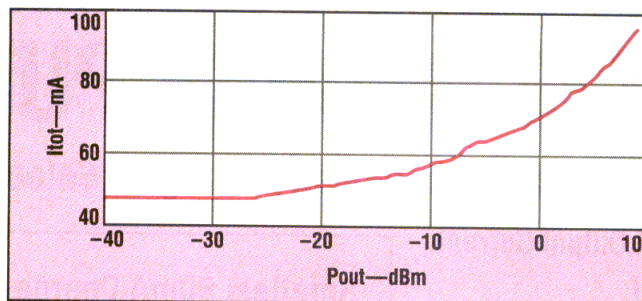
Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.
Distributed by Maxim Distribution, Arrow, Avnet Electronics Marketing, CAM RPC, Digi-Key, Elmo, Nu Horizons, and Zeus.
Distributed in Canada by Arrow and Avnet Electronics Marketing.

MAXIM is a registered trademark of Maxim Integrated Products. © 2000 Maxim Integrated Products.

ply and delivers -2 dBm into an 800- Ω effective differential load with an adjacent-channel power ratio (ACPR) of -62 dBc/30-kHz signal separation. The modulator has unadjusted carrier and sideband suppression of 30 dB with an injected LO power of -10 dBm. The VGA provides 60 dB of linear gain control with a control voltage of +0.3 to +2.5 VDC. At full gain, the output noise power is -138 dBm/Hz.

The upconverter/VGA (model HPMX-7202) contains three separate transmit chains that are enabled through band-select and mode-select digital controls: CDMA at 1900 MHz, CDMA at 800 MHz, and Advanced Mobile Phone Service (AMPS). The CDMA chains consist of a double-balanced upconverter mixer and an RF VGA with adaptive bias. As the gain in the driver is reduced—and, hence, the output power decreases—the current consumption is reduced. The AMPS chain consists of a double-balanced mixer and a fixed-gain driver. LO buffers are included in all chains.²

Figure 4 shows the measured total current consumption for the upconverter/driver RF ICs versus output power for a constant ACPR of -55 dBc/30 kHz (this ACPR was selected arbitrarily). By integrating the current consumption (Fig. 4) over the



4. The total current consumption versus output power for the upconverter/driver IC is plotted for an ACPR of -55 dBc/30 kHz.

probability distribution function of the handset (Fig. 1), a statistical average-current consumption of only 56 mA is obtained (suburban model). This illustrates the advantage of using adaptive-bias techniques in CDMA mobile phones. The upconverter/driver consumes $I_{\mu} = 56$ mA and delivers +9 dBm of output power with an ACPR of -55 dBc at 30 kHz. In AMPS mode, the RF IC consumes 43 mA and delivers +8-dBm output power.

The PA module (model QCPM-9804) is a fully matched two-stage dual-band tri-mode amplifier housed in an 11.5 \times 11.5-mm printed-circuit assembly. It consists of four separate ICs—one driver and one output-stage IC for each band. As in the upconverter/driver RF IC, dynamic bias techniques are used to achieve a low statistical average-current consumption. The current consumption

of the PA can be adjusted by varying a control voltage. Figure 5 shows the performance of the PA when it operates with a very simple two-state current control adjustment. An ACPR of -47 dBc/30 kHz is achieved at the highest output power and it improves markedly as the power decreases. The PA operates in the high-state mode at high output power, and is switched to

the low-state mode at some transition power in order to save current. By integrating the current consumption of each element in the transmit chain over the probability distribution function of the handset, the chip set achieves an I_{μ} of 280 mA for the complete transmit chain, from I-Q mixer input to the antenna.

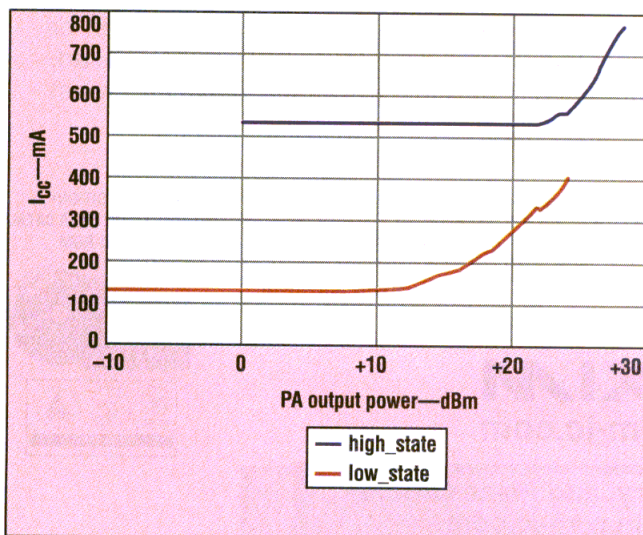
The probability distribution functions of the handset transmit power shown in Fig. 1 also apply to the receive power, since the open-loop power control of a CDMA phone dictates a known relation between the receive and transmit power: The transmit power (P_T) is given by:

$$P_T = -73 - P_R \text{ dBm}$$

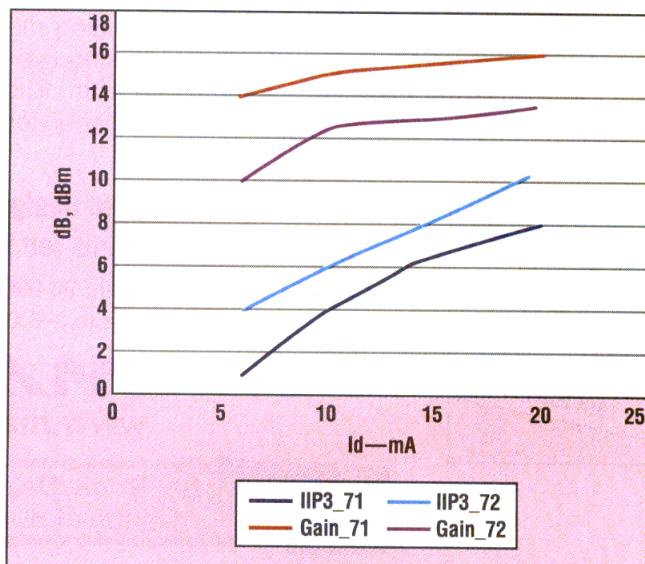
where:

P_R = the receiver power (in dBm).

Note that a value of -76 dBm would be substituted for the person-



5. The power-amplifier current consumption versus output power is plotted for operation with a two-state current control adjustment.

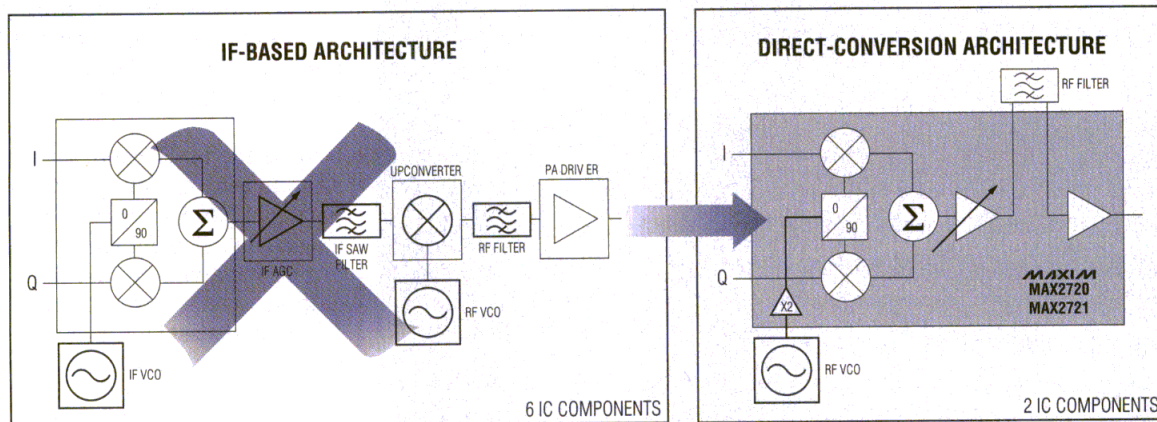


6. These measurements show gain and input third-order intercept point versus current for the receiver LNA ICs.

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

Ideal for Wideband CDMA Wireless Local Loop Systems

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



MAX2720/MAX2721 Features:

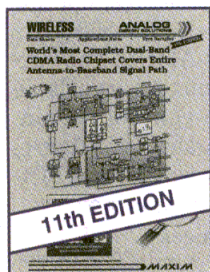
- ◆ 1.7GHz to 2.1GHz RF Output (MAX2720)
- ◆ 2.1GHz to 2.5GHz RF Output (MAX2721)
- ◆ 35dB Gain Control Range
- ◆ Integrated PA Driver with +13dBm Output P1dB
- ◆ Full LO or 1/2 LO Frequency Input
- ◆ 33dB Carrier Suppression
- ◆ 40dB Sideband Suppression
- ◆ +2.7V to +3.3V Single Supply
- ◆ 1μA Shutdown Mode

Why Direct Conversion?

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

Other Applications:

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



FREE Wireless Design Guide – Sent Within 24 Hours!
Includes: Reply Cards for Free Samples and Data Sheets

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

MAXIM
www.maxim-ic.com

2000 EDITION!
FREE FULL-LINE DATA CATALOG
ON CD-ROM



NEW!

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

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.

Distributed by Maxim Distribution, Arrow, Avnet Electronics Marketing, CAM RPC, Digi-Key, Elmo, Nu Horizons, and Zeus.

Distributed in Canada by Arrow and Avnet Electronics Marketing.

MAXIM is a registered trademark of Maxim Integrated Products. © 2000 Maxim Integrated Products.

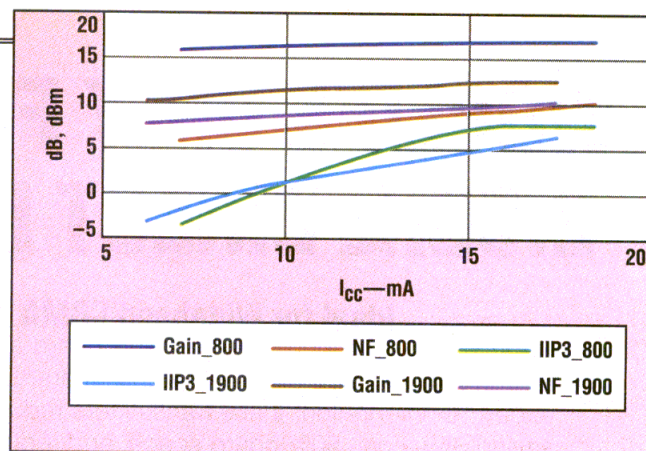
DESIGN FEATURE

CDMA Power Control

al-communications-services (PCS) band.

The basic concept for the receive chain is to provide variable current consumption in the RF components so that high linearity at high current can be achieved when needed, while operating the receive chain at low current consumption the majority of the time. Models MGA-71543 and

MGA-72543 ICs each contain an LNA with a bypass switch. These devices have two main features. First, the current consumption is 0 mA when the part is in



7. These measurements show gain, noise figure, and input third-order intercept point versus current for the PCS and CDMA mixers.

bypass mode. Second, the linearity and current consumption when the part is in LNA mode can be adjusted externally. The gain and noise figure of the receiver components in the chip set were designed so that the LNA is statistically in the bypass mode, drawing zero current the majority of the time.

Figure 6 shows the measured gain and input third-order intercept point versus device current for the LNA. The MGA-71543 and MGA-72543 have typical noise figures of 1.3 and 1.5 dB, respectively. As an example of the advantage provided by the dynamic bias of the LNA, the MGA-72543 delivers an input third-order intercept point (IIP3) of +10 dBm at 20 mA. If the LNA is switched to bypass mode when the received power is -80 dBm (24 dB above the minimum required), the statistical average-current consumption of the LNA is only 6 mA (suburban model).

The HPMX-7102 contains three single-balanced mixers that are enabled through band-select and mode-select digital controls: one for 1900 MHz CDMA, one for 800 MHz CDMA, and one for AMPS. The current/linearity of all mixers is variable through a voltage-controlled pin. Figure 7 shows the gain, noise figure, and IIP3 versus current for the PCS and cellular CDMA mixers. ••

References

1. Stage 4 system performance tests, CDMA Development Group, April 1998.
2. K. Carter *et al.*, "A CDMA/FM Upconverter And Variable-Gain Driver Amplifier Integrated Circuit," *Symposium Digest, 1999 IEEE RFIC Symposium*, 1999, pp. 81-84.

For further reading

H. Morkner, M. Frank, and S. Yajima, "A Miniature PHEMT Switched-LNA For 800 MHz To 8 GHz Handset Applications," *Symposium Digest, 1999 IEEE RFIC Symposium*, 1999, pp. 109-112.

SUBSYSTEM SOLUTIONS

RF & Microwave

Look to Cougar for analog and mixed analog-digital solutions of hybrid, MMIC, and mixed hybrid-MMIC subsystem configurations. We develop designs built upon the strengths of our component expertise to provide practical and efficient subsystem solutions.

- expanded capabilities include subsystem and multi-function solutions
- enhanced functionality in reduced space
- improved efficiency
- reduced cost
- prompt schedules
- increased reliability



Signal Processing Components & Subsystems

COUGAR
COMPONENTS

ISO 9001 &
MIL-PRF-38534
Certified

290 Santa Ana Court, Sunnyvale, CA 94086
408-522-3838 • fax: 408-522-3839 • web: www.cougarcorp.com
e-mail: cougar.amps4@cougarcorp.com

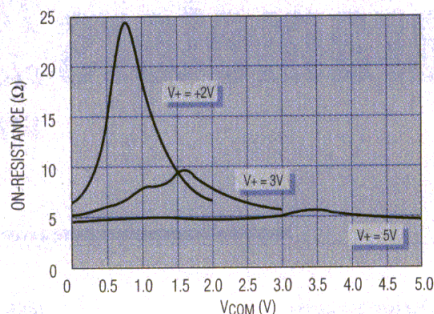
WORLD'S FASTEST, LOWEST ON-RESISTANCE 4066

New Quad Switch Family Features 12ns Switching Times and 10Ω Ron

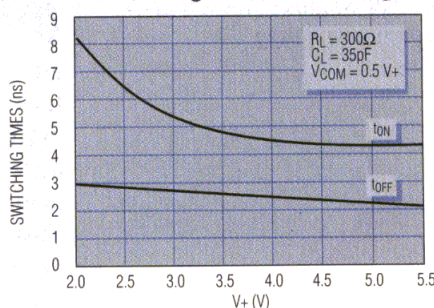
The MAX4614–MAX4616 family of quad SPST switches is pin compatible with the industry-standard 74HC4066 and MAX4610. **They offer 10-times-lower on-resistance, 4-times-faster switching, and 20-times-better matching and flatness specs than their predecessors.** These improvements instantly enhance the performance of high-end audio equipment, pixel switching applications, and video on-demand systems.

- ◆ **Low R_{ON} (10Ω max at 5V)**
- ◆ **Fast Switching Speeds (12ns t_{ON}, 10ns t_{OFF})**
- ◆ **Pin Compatible with Industry-Standard 74HC4066 (MAX4614)**
- ◆ **2.0V to 5.5V Specified Supply Operation**
- ◆ **Low R_{ON} Match and Flatness Between Channels (1Ω max)**
- ◆ **High Off-Isolation (-85dB @ 100kHz)**
- ◆ **Low Crosstalk (-96dB @ 100kHz)**
- ◆ **Guaranteed Low Leakage Current (1nA max at +25°C)**
- ◆ **TTL/CMOS Logic Input Control**
- ◆ **Available in Tiny 14-Pin TSSOP, SOIC, and DIP Packages**

On-Resistance vs. V_{COM}

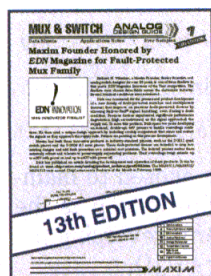


Switching Time vs. Voltage



Upgrade Your Industry-Standard 74HC4066 Today!

PART	FUNCTION	SWITCH STATES		R _{ON} (Ω max)	R _{ON} MATCH/FLATNESS (Ω max)	SWITCHING TIMES (ns)		INDUSTRY- STANDARD PINOUT
		NO	NC			t _{ON}	t _{OFF}	
MAX4614	Quad SPST	4	—	10	1	12	10	74HC4066/ MAX4610
MAX4615	Quad SPST	—	4	10	1	12	10	MAX4611
MAX4616	Quad SPST	2	2	10	1	12	10	—



FREE Mux & Switch Design Guide – Sent Within 24 Hours!
Includes: Reply Cards for Free Samples and Data Sheets

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

MAXIM
www.maxim-ic.com

2000 EDITION!
FREE FULL-LINE DATA CATALOG
ON CD-ROM



NEW!

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

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.

Distributed by Maxim Distribution, Arrow, Avnet Electronics Marketing, CAM RPC, Digi-Key, Elmo, Nu Horizons, and Zeus.
Distributed in Canada by Arrow and Avnet Electronics Marketing.

MAXIM is a registered trademark of Maxim Integrated Products. © 2000 Maxim Integrated Products.

Accurately Compute PLL Active-Filter Parameters

This method optimizes active-filter elements and is readily implemented with a simple computer algorithm.

David Rosemarin

Consultant

P.O. Box 739, Shaarei Tiqwa 44810,
Israel; (972) 3-9063632.

ACCURATE circuit and subsystem simulation continues to challenge high-frequency engineers, who are being increasingly forced to address time-to-market concerns. In a previous article¹, an analysis approach was developed to achieve precise calculation and optimization of the element values for passive lowpass filters used in phase-locked-loop (PLL) current-charge pumps. In this article, an analysis of active fourth-order lowpass filters is performed. By implementing this analysis approach with a computer algorithm, fast and exact synthesis is achieved—eliminating the trial and error often involved in the design of these filter circuits. Two kinds of phase detectors are discussed: the voltage type and the current-charge-pump type.

Figure 1 shows a common PLL circuit. The sensitivity of the voltage-type phase detector is given by:

$$K_p (\text{in } V / \text{rad}) = V_{cc} / 2 / \pi \text{ or } V_{cc} / 4 / \pi \quad (1)$$

depending on the type of phase detector used.

The sensitivity of the voltage-controlled oscillator (VCO) is:

$$K_o (\text{in } \text{rad} / \text{sec} / V) = 2\pi K_v = 2\pi \Delta F / \Delta V \quad (2)$$

The divider ratio is N. The PLL filter uses an operational amplifier and

is shown in Fig. 2. The following time constants are defined:

$$T_1 = R_1 C_1 \quad (3a)$$

$$T_2 = R_2 (C_1 + C_2) \quad (3b)$$

$$T_3 = R_2 C_2 \quad (3c)$$

$$T_4 = R_3 C_3 \quad (3d)$$

After some calculations, the transfer function of the loop filter can be found by:

$$F(s) = -(1 + sT_2) / sT_1 / (1 + sT_3) / (1 + sT_4) \quad (4)$$

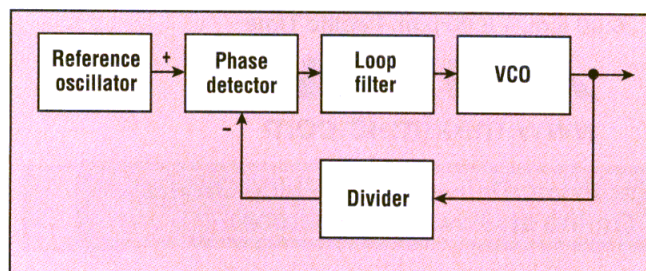
The open-loop gain of the PLL is:

$$A(s) = -K_p K_o F(s) / s / N \quad (5)$$

The minus sign is chosen to maintain a negative feedback loop as the operational amplifier is reversing the signal. Substituting $s = j\Omega$,

$$A(j\omega) = -K_p K_o (1 + j\omega T_2) / (1 + j\omega T_3) / (1 + j\omega T_4) / (N\omega^2 T_1) \quad (6)$$

And the open-loop phase is:



1. This simple block diagram represents the basic structure of a PLL.

WORLD'S SMALLEST PA BOOSTS BLUETOOTH RADIO RANGE TO 100m!

Class I +20dBm Output Power at 2.5GHz

The MAX2240 2.4GHz power amplifier raises the bar for maximizing performance and feature set in the smallest package! Available in the 9-pin, 3x3 ultra-chip-scale-package (UCSP) measuring only 2.43mm², this device occupies only 16% the board space of the competitor's 8-pin MSOP package. The small size makes it ideal for use in Bluetooth modules.

MAX2240 BOOSTS RANGE FROM 10m to 100m!



MAX2240 is ideal for Bluetooth Class I devices operating in changing environments, such as notebook PCs, cellular phones, and access points.

COMPARE THE DIFFERENCE:

MAX2240

9-PIN UCSP
1.56mm x 1.56mm

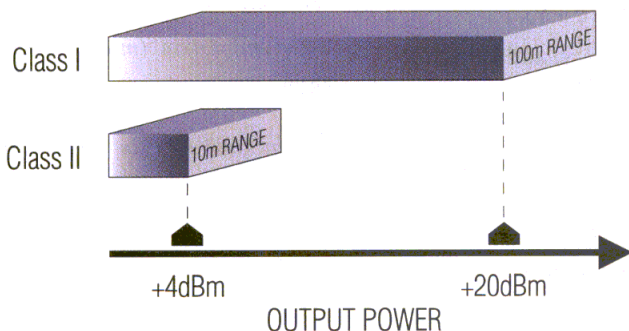


COMPETITION

8-PIN MSOP
4.9mm x 3.0mm

UCSP FITS INTO THE SMALLEST MODULE!

BLUETOOTH POWER CLASSES

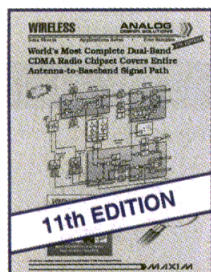


MAX2240 Features:

- ◆ 2.4GHz to 2.5GHz Operation
- ◆ +20dBm Output Power
- ◆ 4 Digital Power Control Steps
- ◆ Bluetooth Power Class 1 Compliant
- ◆ Integrated Input 50Ω Match
- ◆ 1μA Shutdown Mode
- ◆ Single +2.7V to +5.0V Supply

Applications:

- ◆ Bluetooth
- ◆ HomeRF
- ◆ 802.11 FHSS WLAN
- ◆ 2.4GHz ISM Proprietary Radios



FREE Wireless Design Guide – Sent Within 24 Hours!

Includes: Reply Cards for Free Samples and Data Sheets

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

MAXIM
www.maxim-ic.com

**2000 EDITION!
FREE FULL-LINE DATA CATALOG
ON CD-ROM**



NEW!

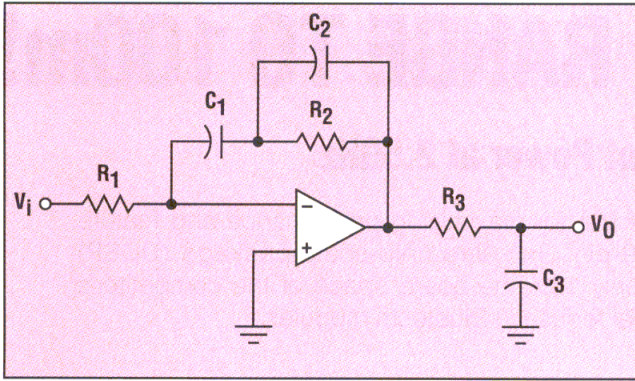
**Get Price, Delivery, and Place Orders
Online at www.maxim-ic.com**

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.

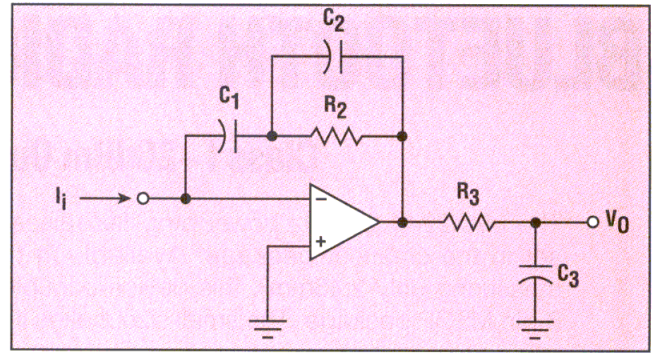
Distributed by Maxim Distribution, Arrow, Avnet Electronics Marketing, CAM RPC, Digi-Key, Elmo, Nu Horizons, and Zeus.

Distributed in Canada by Arrow and Avnet Electronics Marketing.

MAXIM is a registered trademark of Maxim Integrated Products. © 2000 Maxim Integrated Products.



2. This schematic shows a fourth-order active PLL filter.



3. This schematic shows a fourth-order charge-pump PLL filter.

$$\varphi = \pi + \tan^{-1}(\omega T_2) - \tan^{-1}(\omega T_3) - \tan^{-1}(\omega T_4) \quad (7)$$

The parameter ω_0 is defined as the angular frequency that maintains:

$$|A(j\omega_0)| = 1 \quad (7a)$$

The following phase values are also defined:

$$\alpha = \tan^{-1}(\omega_0 T_2) \quad (8a)$$

$$\beta = \tan^{-1}(\omega_0 T_3) \quad (8b)$$

$$\gamma = \tan^{-1}(\omega_0 T_4) \quad (8c)$$

And the phase margin, ϕ , is defined as:

$$\phi = \varphi - \pi = \alpha - \beta - \gamma \quad (9)$$

The function $\phi(\omega)$ has a maximum point. If this point is set at ω_0 , then the phase margin will be minimal at that point. This is equivalent to the requirement that the derivative of $\phi(\omega)$ is zero at ω_0 , that is:

$$d\phi / d\omega|_{\omega=\omega_0} = 0 \quad (10)$$

Using eq. 7,

$$d\phi / d\omega|_{\omega=\omega_0} = T_2 / [1 + (\omega_0 T_2)^2] - T_3 / [1 + (\omega_0 T_3)^2] - T_4 / [1 + (\omega_0 T_4)^2] = 0 \quad (11)$$

By multiplying by φ_0 and using eq. 8:

$$\tan(\alpha) / [1 + \tan^2(\alpha)] - \tan(\gamma) / [1 + \tan^2(\gamma)] = \tan(\beta) / [1 + \tan^2(\beta)]$$

Using the identity:

$$\tan(x) / [1 + \tan^2(x)] = \sin(2x) / 2$$

$$\sin(2\alpha) - \sin(2\gamma) = \sin(2\beta) \quad (12)$$

From eq. 9:

$$\beta = \alpha - (\phi + \gamma)$$

Defining $m = (\pi + \gamma)$ and substituting back into eq. 12 yields:

$$\sin(2\alpha) - \sin(2\gamma) = \sin[2\alpha - 2m]$$

$$\sin(2\alpha) - \sin(2\gamma) = \sin(2\alpha) \cos(2m) - \cos(2\alpha) \sin(2m)$$

Defining, for convenience, $x = \sin(2\alpha)$, and using the identity $\cos = (1 - \sin^2)^{0.5}$ yields:

$$x [1 - \cos(2m)] - \sin(2\gamma) =$$

$$-\sin(2m) \sqrt{1 - x^2}$$

Squaring leads to:

$$x^2 [1 + \cos^2(2m) - 2\cos(2m)] + \sin^2(2\gamma) - 2x \sin(2\gamma) [1 - \cos(2m)] = \sin^2(2m) [1 - x^2]$$

$$x^2 [2(1 - \cos(2m))] - 2x \sin(2\gamma) [1 - \cos(2m)] + \sin^2(2\gamma) - \sin^2(2m) = 0$$

And using the identities:

$$2\sin^2(m) = 1 - \cos(2m) \text{ and } -\sin^2(2m) = 4\sin^2(m)\cos^2(m)$$

$$x^2 [4\sin^2(m)] - 4x \sin(2\gamma) \sin^2(m) + \sin^2(2\gamma) - 4\sin^2(m)\cos^2(m) = 0$$

$$x^2 - x \sin(2\gamma) + \sin^2(2\gamma) / [4\sin^2(m)] - \cos^2(m) = 0 \quad (13)$$

Solution of this quadratic equation provides:

$$x = 0.5 \sin(2\gamma) + \sqrt{0.25 \sin^2(2\gamma) + \cos^2(m) - \sin^2(2\gamma) / [4\sin^2(m)]}$$

Results of example 1

Pole f_4	Pole f_3	Zero f_2	Gain margin	Closed-loop attenuation (dB)		
				at 1 kHz	at 10 kHz	at 100 kHz
527.451	527.451	43.542	19.3	33.54	91.59	151.56
1000	349.4366	43.1074	21.4	32.82	89.54	149.49
10000	249.8609	41.6560	38.6	32.19	75.11	132.14
100000	242.2475	41.4455	58.4	32.36	72.36	115.33
∞	241.4214	41.4214	∞	32.38	72.35	112.35

Most importantly, when you specify Synergy, you benefit from an uncompromising dedication to the

Our engineering, sales and applications team will answer technical questions and help with your custom designs.



SYNERGY[®]
MICROWAVE CORPORATION
CIRCLE NO. 214

CIRCLE NO. 214

See Us At Booth #506



PLAYS WELL WITH OTHERS

Xpedion has created a new breed of EDA tools for use in designing wireless communication systems and circuits.

The Xpedion GoldenGate™ family delivers next generation wireless simulation and modeling solutions for RF and microwave design teams looking for a superior alternative, all integrated with their existing Unix and Windows EDA environments.

Simulation support includes RF Linear, Harmonic-Balance and Envelope Transient analyses for detailed circuit design. Xpedion's revolutionary model compiler, incorporating patent-pending neural network technology, delivers high-performance, highly accurate models that enable precise design trade-offs during system simulation.

Contact us today to learn more about GoldenGate and our special introductory packages for Unix and Windows.

Phase Noise
and Krylov
support now in
GoldenGate
2.0!

www.xpedion.com

1-877-XPEDION

info@xpedion.com



$$\begin{aligned}
 &= 0.5 \sin(2\gamma) + \sqrt{0.25 \sin^2(2\gamma)} \\
 &\quad [1 - 1/\sin^2(m)] + \cos^2(m)\} \\
 &= 0.5 \sin(2\gamma) + \sqrt{0.25 \sin^2(2\gamma)} \\
 &\quad [-\cos^2(m)/\sin^2(m)] + \cos^2(m)\} \\
 &= 0.5 \sin(2\gamma) + \cos(m) \sqrt{1 - [\sin^2(2\gamma)/2/\sin(m)]^2}
 \end{aligned}$$

Substituting back the value of m provides:

$$\begin{aligned}
 x &= 0.5 \sin(2\gamma) + \cos(\phi + \gamma) \sqrt{1 - [\sin^2(2\gamma)/2/\sin(\phi + \gamma)]^2} \quad (14)
 \end{aligned}$$

Since $x = \sin(2\alpha)$ and the sine has the same sign in the first two quadrants, it is impossible to differentiate between them (For example: for $\alpha = 15$ or 75 , $x = \sin(30) = \sin(150) = 0.5$).

To overcome this problem, use the tangent that has different signs. Using the identity:

$$\begin{aligned}
 \tan(\alpha) / [1 + \tan^2(\alpha)] \\
 &= 0.5 \sin(2\alpha) = x/2
 \end{aligned}$$

gives:

$$\tan^2(\alpha) - [2/x]\tan(\alpha) + 1 = 0$$

then:

$$\tan(\alpha) = 1/x + \sqrt{1/x^2 - 1} \quad (15)$$

From eq. 9,

$$\beta = \alpha - \phi - \gamma \quad (16)$$

And from eq. 8,

$$\omega_0 T_3 = \tan(\beta) \quad (17)$$

From eq. 6, evaluate the absolute value of $A(j\omega)$ at ω_0 :

$$\begin{aligned}
 |A(j\omega_0)| &= 1 = [K_p K_o / (N\omega_0^2 T_1)] \\
 &\sqrt{\{(1 + (\omega_0 T_2)^2) / (1 + (\omega_0 T_3)^2) / (1 + (\omega_0 T_4)^2)\}}
 \end{aligned}$$

Using eq. 8:

$$\begin{aligned}
 T_1 &= [K_p K_o / (N\omega_0^2)] \\
 &\sqrt{\{(1 + \tan^2(\alpha)) / (1 + \tan^2(\beta)) / (1 + \tan^2(\gamma))\}}
 \end{aligned}$$

And using the identity:

$$\begin{aligned}
 \sqrt{1 + \tan^2(x)} &= |1/\cos(x)| \\
 T_1 &= [K_p K_o / (N\omega_0^2)] \\
 &\text{abs}\{\cos(\beta)\cos(\gamma)\cos(\alpha)\} \quad (18)
 \end{aligned}$$

Defining f_2 as the frequency of the zero and f_3 and f_4 as the frequencies of the poles of the open-loop gain, then:

$$\begin{aligned}
 T_2 &= 1/(2\pi f_2); \\
 T_3 &= 1/(2\pi f_3); \\
 T_4 &= 1/(2\pi f_4); \quad (19)
 \end{aligned}$$

And using $\varphi_0 = 2\pi f_p$ and eq. 8:

$$\alpha = \tan^{-1}(f_0 / f_2) \quad (20a)$$

$$\beta = \tan^{-1}(f_0 / f_3) \quad (20b)$$

$$\gamma = \tan^{-1}(f_0 / f_4) \quad (20c)$$

For the PLL design, the known parameters are phase-detector sensitivity K_p , VCO sensitivity K_o , and divider ratio N . The selected param-

IMA

**INTEGRATED
MICROWAVE
ASSEMBLIES**



When you need to satisfy the most critical performance, size/weight and reliability requirements, our complex IMAs can combine all the components you need to complete your subsystem.

MADE TO ORDER

Send for our new IMA brochure today!

From the people you trust...



GENERAL MICROWAVE

a herley company

General Microwave Corporation
425 Smith Street • Farmingdale, NY 11735-1198
TEL: 631-630-2000 • FAX: 631-630-2066
<http://www.GeneralMicrowave.com>

CIRCLE NO. 407 or visit www.mwrf.com

ters are loop angular frequency φ_0 , phase margin ϕ , and f_4 , which is the frequency of the pole of R_3 and C_3 .

To realize the PLL calculation:

1. Calculate γ from eq. 20.
2. Calculate x from eq. 14.
3. Calculate $\tan(\alpha)$ from eq. 15 and derive α .
4. Derive f_2 from eq. 20. $F_2 = f_0 / \tan(\alpha)$.
5. Calculate β from eq. 16.
6. Derive f_3 from eq. 20. $f_3 = f_0 / \tan(\beta)$.
7. Calculate T_1 from eq. 18.
8. Calculate T_2, T_3 , and T_4 from eq. 19.
9. Choose C_3 . Derive R_3 from eq. 3. $R_3 = T_4 / C_3$.
10. Choose C_1 . Derive R_1 from eq. 3. $R_1 = T_1 / C_1$.
11. Calculate R_2 and C_2 from eq. 3. $R_2 = (T_2 - T_3) / C_1$
 $C_2 = T_3 / R_2$.

The current flowing into the operational amplifier in Fig. 2 is V_{CC} / R_1 . The sensitivity of the voltage-phase detector is $K_p = V_{CC} / 2 / \pi$. The sensi-

tivity of the current charge-pump phase detector is $K_d = I / 2 / \pi$. It means that $K_p = K_d / R_1$. If arbitrarily one selects $R_1 = 1$, K_d can be substituted for K_p in the equations, especially in eq. 18, to get the design for the current charge-pump phase detector using Fig. 3. Step 10 of the design summary has to be changed. C_1 is no longer selectable. From eq. 3, it can be seen that $C_1 = T_1$.

A PLL design is required with the following parameters:

1. The phase detector used is a current charge pump type with a current of 1 mA.
2. Phase-detector sensitivity (in A/rad) = $10^{-3} / 2\pi$.
3. VCO sensitivity (in MHz/V) = 4.
4. K_0 (in rad/sec/V) = $8\pi \cdot 10^6$.
5. Divider ratio = 10^5 .
6. Loop filter required $f_0 = 100$ Hz.
7. Phase margin = 45 deg.
8. Different frequencies, f_4 , for the pole have been chosen.

The results are shown in the table. Analysis of the closed-loop gain was

performed by a computer-aided-engineering (CAE) program.²

The maximum attenuation results from choosing a multiple pole ($f_4 = f_3$). The results are shown in line one in the table. In line two, f_4 was chosen as $10f_0$, with only a small decrease in attenuation. Lines three and four are for $f_4 = 100f_0$ and $1000f_0$, respectively. In line five, the pole of f_4 is eliminated. The loop is a regular third-order loop. With $f_4 = 1000$, eq. 18 yields $T_1 = 0.2448 \mu s$ and $C_1 = 0.2448 \mu F$. From eq. 19, $T_2 = 3692.058 \mu s$, $T_3 = 455.462 \mu s$, and $T_4 = 159.155 \mu s$. C_3 is selected as $0.1 \mu m$. And from eq. 3, $R_3 = 1591$, $R_2 = 13218$, and $C_2 = 0.03445 \mu F$.

A simulation using the program in ref. 3 produced results identical to those shown in the table. ●●

References

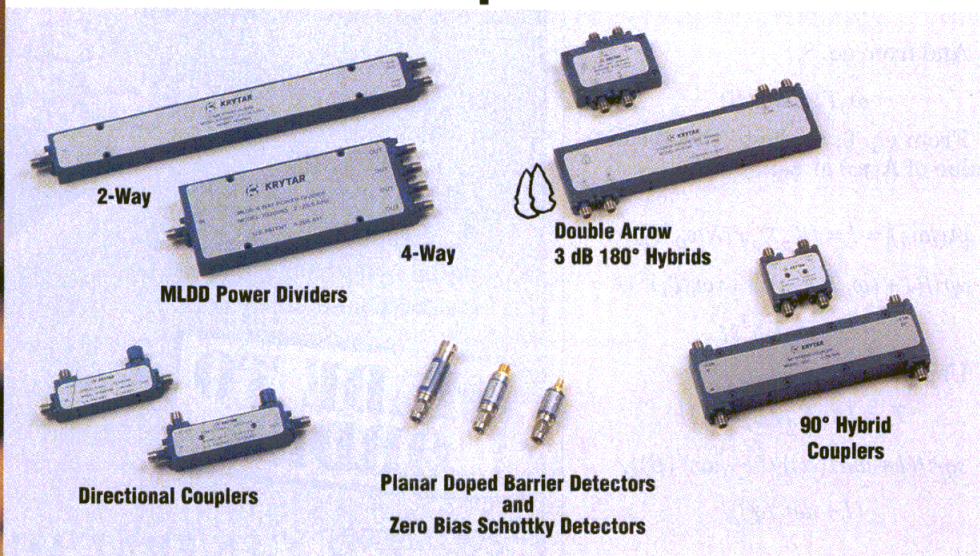
1. D. Rosemarin, "Accurately Compute PLL Charge-Pump Filter Parameters," *Microwaves & RF*, February 1999, pp. 89-94.
2. E.L. Unruh, *Linear Phase-Locked-Loop Control System Analysis*, Artech House, 1991.
3. D. Rosemarin, "Technique Provides Simple Analysis of PLL Functions," *Microwaves & RF*, November 1993, pp. 89-91.

For further reading

U. Rohde, *Digital PLL Frequency Synthesizers: Theory and Design*, Prentice-Hall, 1983.

A winning move, Krytar components!

Microwave Components DC-50 GHz



Visit our website, www.krytar.com



KRYTAR

1292 Anvilwood Court, Sunnyvale, CA 94089
Tel. (408) 734-5999 Fax (408) 734-3017

Model And Build A Ku-Band DRO

Ku-Band DRO, Part 2

One key to designing a high-performance dielectric resonator oscillator (DRO) lies in accurately modeling the electrical effects of the resonator.

Olivier Bernard

Applications Engineer

California Eastern Laboratories, 4590 Patrick Henry Dr., Santa Clara, CA 95054-1817; (408) 988-3500, FAX: (408) 988-0279, Internet: <http://www.cel.com>.

LAST month, the basics of dielectric resonator oscillators (DROs) were reviewed, along with the role of nonlinear simulation in the design of a low-noise DRO. Design theory outlined techniques for achieving good frequency stability as well as a target phase-noise specification at the design frequency of 11.25 GHz. The conclusion of this two-part article shows how to model the dielectric resonator (DR) and how to translate this design theory into the construction of a practical DRO.

Linear simulation, using the Touchstone formatted S-parameter files (*.s2p), can help create a first-approximation DRO design. Although an oscillator is essentially a saturated (nonlinear) circuit under steady-state operation, a linear simulation will provide a good initial circuit layout before fine-tuning the design in a nonlinear simulator. For both simulations, considerable care must be taken to

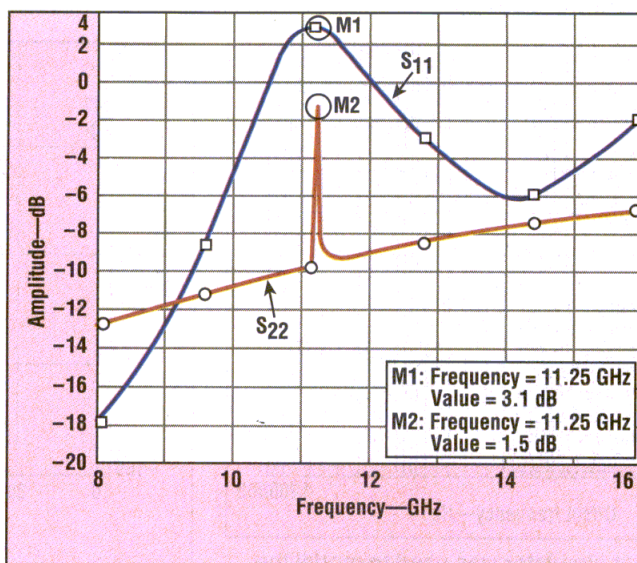
account for the many component and circuit-board parasitic elements in the simulation. At Ku-band, parasitic elements of 0.5 nH can amount to an impedance of 40 Ω . Therefore, an accurate simulation resulting in a minimum of board tuning in the laboratory can only be achieved through careful modeling of all components used by the design, including:

1. Using models for the 0603 resis-

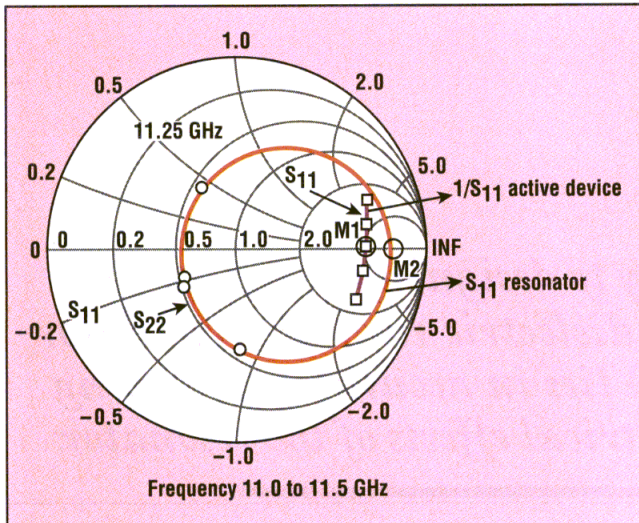
tors and capacitors that include parasitic elements. Most manufacturers of such components now provide an accurate high-frequency model.

2. Carefully modeling transmission lines (lengths and widths), especially in regard to impedance steps, crosses, and open stubs with capacitive effects.

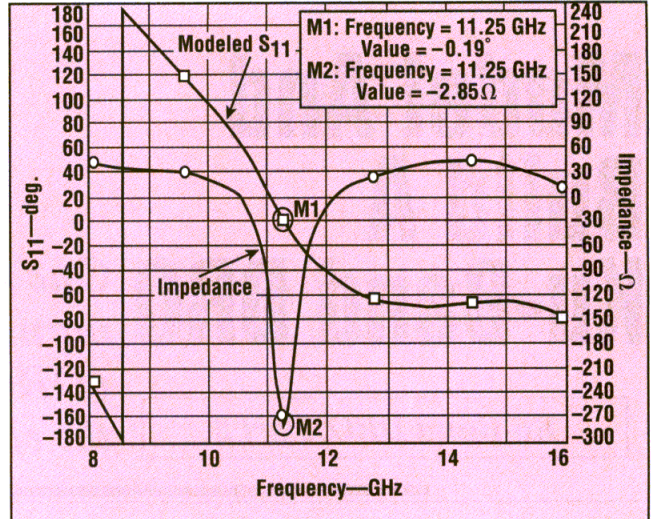
3. Using an accurate model of the board characteristics including loss-tangent effects and



4. Linear circuit simulation was used to determine the S_{11} and S_{22} transmission losses from the FET and DR.



5. Linear circuit simulation was used to determine the S_{11} and S_{22} reflection coefficients from the FET and DR.



6. The linear circuit simulator was used to predict the negative resistance of the NE72218 MESFET device.

metal-deposition thickness.

4. Utilizing via holes and via pads instead of perfect grounds where appropriate.

The resonator is modeled as a parallel resistor-inductor-capacitor (RLC) circuit with values of L and C adjusted to provide the proper resonant frequency (11.25 GHz) and Q factor.

The resonant frequency is:

$$f_0 = 1/2\pi^{0.5}$$

with L and C being the equivalent model inductive and capacitive elements of the resonator.

The Q is defined as:

$$Q_0 = (2\pi)[(\text{maximum energy}$$

stored)/(energy dissipated per cycle)]

For simulation purposes, Q_0 can be shown as:

$$Q_0 = (\omega_0/2)(d\phi/d\omega)$$

where:

ω_0 = the resonant frequency (= $2\pi f_0$), and

ϕ = the phase of the resonator impedance.

For a parallel resonator at resonance:

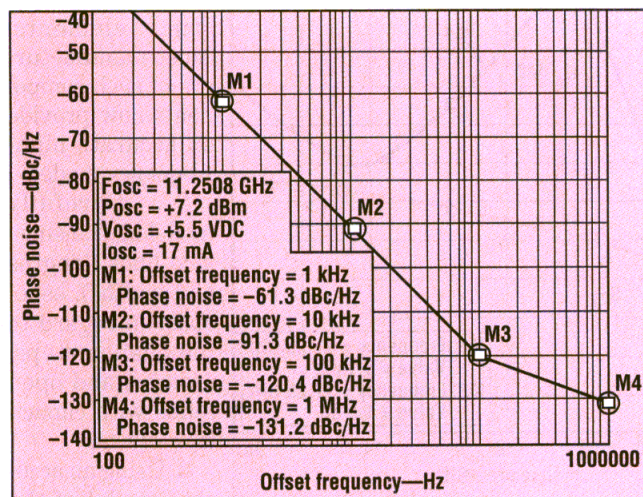
$$Q_0 = R/L\omega_0$$

because:

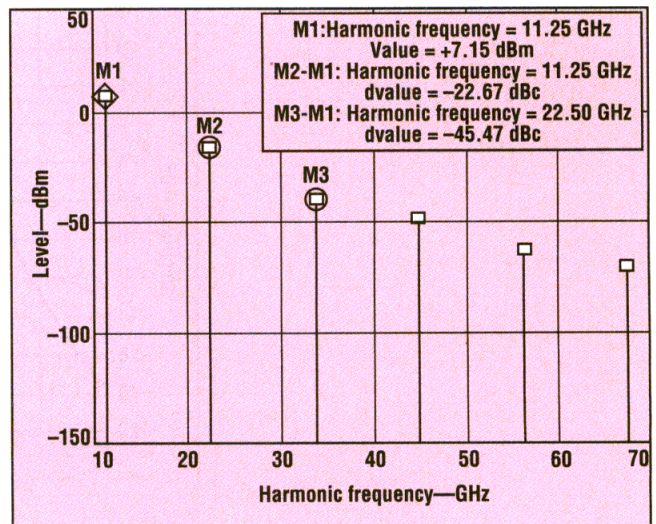
$$d\phi/d\omega = 2R/L$$

at resonance.

Therefore, the value of R defines the DR's unloaded Q. As the frequency selectiveness of the resonator increases, its phase noise decreases. Also, off resonance, this derivative diminishes, causing the Q to decrease. Such a resonator model is also provided by Trans-Tech through their program DR. In the model, the DR is then coupled to the 50- Ω transmission line through a transformer where the ratio (n) simulates the coupling coefficient (β) (at distance d). When β (or n) is



7. The nonlinear circuit simulator was used to model the phase noise of the 11.25-GHz dielectric resonator oscillator.



8. The nonlinear circuit simulator was also able to model the harmonic levels expected from the DRO.

In the race to get to hardware...

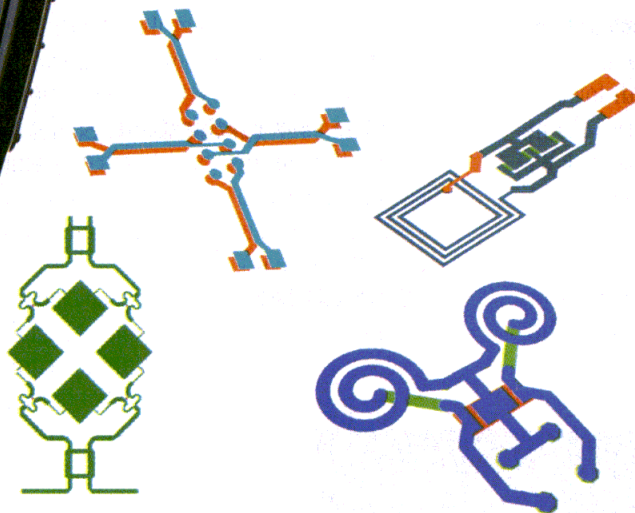
Ensemble gives you room to move

Whether you are designing a Si RFIC for Bluetooth, a high performance GaAs power amplifier for 3G, or a multi-band planar antenna, Ensemble's advanced planar electromagnetic field solver helps you reduce die space, predict EM coupling, and calculate antenna radiation.

Use Ensemble to compute S-parameters and full wave fields for on-chip components such as spiral inductors, capacitors, thin-film resistors, and interconnects in microstrip, stripline, slotline, and coplanar waveguides.

Ensemble handles realistic circuits with straight and curved traces, radiation, multiple layers, open plus closed cavities, and packaging effects.

Ensemble offers an easy-to-use interface, DXF import, a graphical post-processor, optimization, parametrics, industry leading fast solver technology, and integration with other products in the Serenade Design Environment.



Ensemble allows you to design complex planar antennas and on-chip components like spiral inductors, vias and interconnects.

For your free evaluation copy of Ensemble, or any of the tools in Ansoft's Serenade Design Environment call 412-261-3200 or send e-mail to info@ansoft.com

Design Freedom

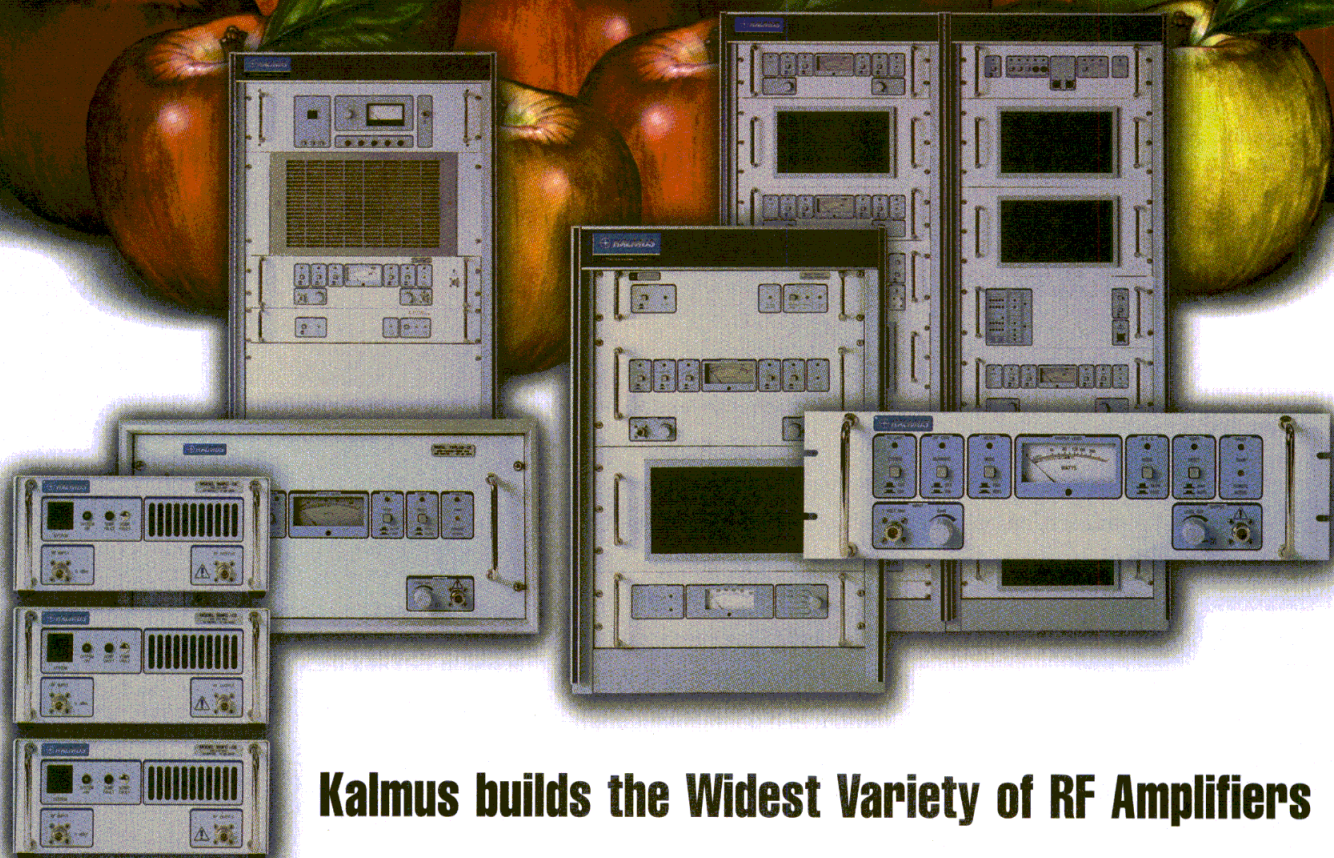


high performance EDA

www.ansoft.com

CIRCLE NO. 250

The Choice is Yours



Kalmus builds the Widest Variety of RF Amplifiers

We specialize in amplifiers.

Kalmus gives you a genuine choice of performance, features and bandwidth for any application that requires RF power amplifiers. From radar, MRI, EMC and high energy physics to EW, communications, broadcast and automotive - Kalmus has the right amplifier.

Choice means savings. Kalmus has worked closely with our customers to develop the industry's widest variety of RF amplifiers. We offer solid-state, cavity and tube amplifiers in broad-band, narrow-band or single frequency configurations. From 10 kHz to 10 GHz and beyond,

from a few watts to several kilowatts, there's an amplifier in each frequency and power range with just the features you want. You won't end up buying more than you need.

Built to your specifications. Sometimes there isn't an existing Kalmus RF (or microwave) amplifier that satisfies your particular application. In that case - we'll build it! Kalmus has been meeting all our customer's needs for nearly thirty years.

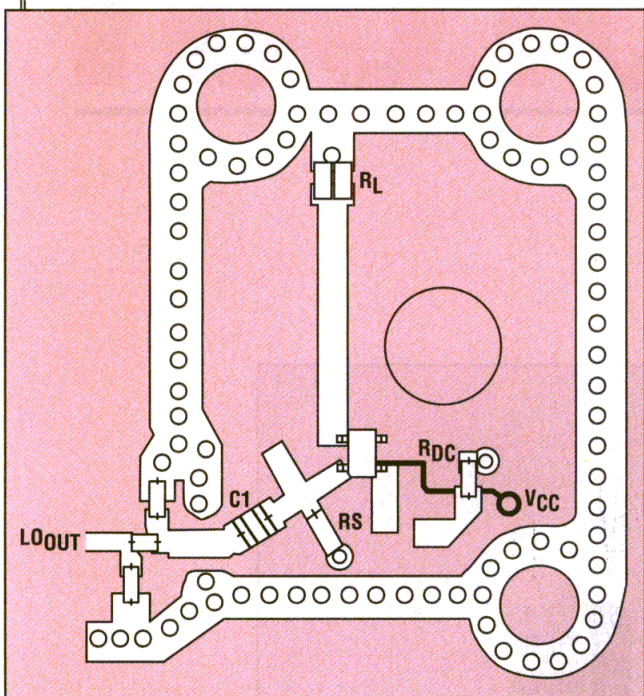
Contact Kalmus. For more specific details on our complete line of RF and microwave amplifiers, and the name of your nearest Kalmus representative, just visit our web site or call us toll free (US) direct.



The RF Amplifier Company

11807 North Creek Parkway South, Suite 109, Bothell, WA 98011 • Phone: (800) 344-3341 • (425) 485-9000 • Fax: (425) 486-9657
E-mail: kalmus@kalmus.com • Web: www.kalmus.com

CIRCLE NO. 303



9. The following circuit layout was used to assemble the DRO.

adjusted, the increased or decreased coupling is characterized by the insertion loss of the bandstop filter as seen in Fig. 4. This coupling coefficient will eventually be fine-tuned in the nonlinear simulation to minimize phase noise while keeping an appropriate output power, but initially should be set so that the filter's insertion loss is less than the reflection gain provided by the active device on the gate port (-1.5 dB versus +3.1 dB in Fig. 4) Figure 5 also shows the coupled DR's reflection coefficient in the DR plane of reference in a Smith chart to be compared to the FET's reflection coefficient.

Once the DR is modeled (in terms of the parallel RLC network), physical placement of the puck on the board needs to be simulated. This is achieved through a transformer where transform-ratio n defines the amount of coupling and through a 50- Ω transmission line which introduces the desired amount of phase and adjusts the loop phase. The first location approximation will be performed under small-signal conditions. However, as the device saturates and its S-parameters change accordingly, a refinement will be conducted for best output power and phase-noise performance during the nonlinear simulation.

From the negative-resistance amplifier section, it is known that the common-drain amplifier should be set so that:

- Its drain will be AC shorted at the frequency of interest, providing the required feedback to unstabilize the FET. This is performed through an open stub on the drain that is close to a quarter wavelength. The stub is also isolated from the DC supply with a high impedance quarter-wavelength line followed by another quarter-wavelength open stub. Adjusting

TL8 will mostly move the negative-resistance peak up and down in frequency. Its length was adjusted so that the maximum negative resistance occurred at 11.25 GHz (Fig. 6).

- The source reactance will define the amount of negative resistance at the gate. This is achieved by adjusting a transmission line in the linear-circuit schematic in conjunction with the oscillator-output network (matched to 50 Ω) and the self-biasing network. The transmission line was adjusted to provide approximately +3 dB gate-reflection coefficient but could be increased to provide a higher return gain. However, too much return gain could provide unwanted spurious oscillation due to the non-perfect return loss of the 50- Ω load shorting the gate beyond the DR's placement. A short open stub models the FET's second source pin.

- It will provide a negative resistance on the gate port and a good output match into 50 Ω .

- The phase delay of the transmission line must be set to 0 deg. so that the first condition is respected and a steady-state oscillation occurs.

For a better understanding of the simulation, designers should consider the parameter $1/S_{11}$ of the active device, since $\Gamma_{in} \times \Gamma_R \pm 1$ is of interest, as well as making sure that $\Gamma_{in} > (1/\Gamma_R)$

(continued on p. 164)

Experience the Nexyn Innovation

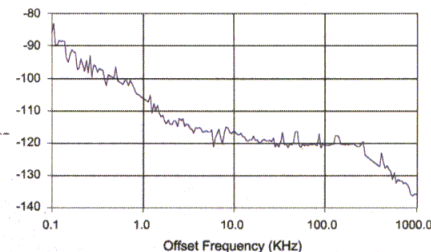
QUIET!

Now
Delivering

and PRECISE

LMDS Phase Locked DROs
New Products! Details on website

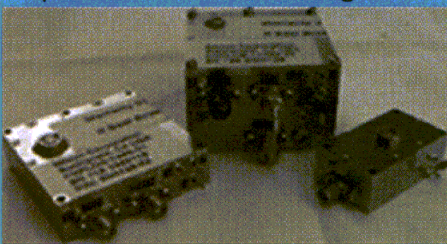
13.2 GHz Phase Noise (HP E5500)



Phase Noise at 13.2 GHz (Typical)

100 Hz	- 86 dBc/Hz
1 KHz	-106 dBc/Hz
10 KHz	-118 dBc/Hz
100 KHz	-122 dBc/Hz
1 MHz	-135 dBc/Hz

- Free Running/Phase Locked DRO
- Reliable and Rugged Design
- Extremely Low Microphonics
- 10-200 MHz External Reference
- Frequency: 4 to 18 GHz
- Power output: +13dBm
- Spurious: -80 dBc
- -10 to +65 C (wider range options)
- Internal Ref/Dual Loop options
- LMDS Transceiver Subassemblies
- Up/Down Converter Designs



Nexyn Corporation
678 Bend Drive
Sunnyvale, CA 94087

Tel: (408) 732-0793

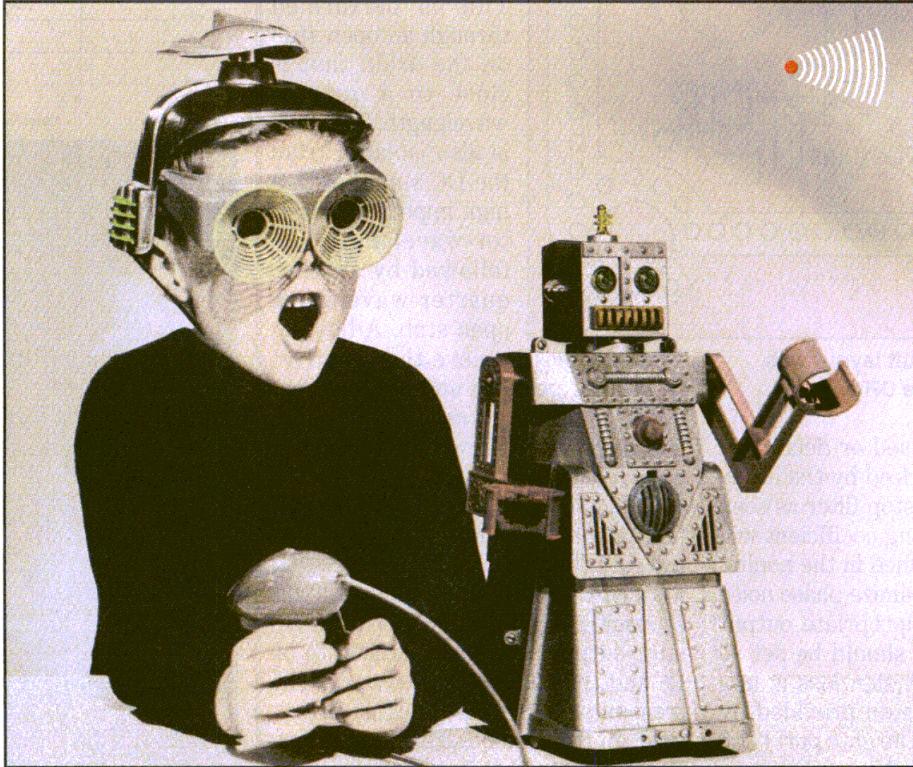
Fax: (408) 730-0378

Visit our website at www.nexyn.com

Excellent Technical Support
Guaranteed Performance and
Competitive Pricing
(Seeking Sales Reps)

CIRCLE NO. 413 or visit www.mwrf.com

TECHNOLOGY



CAPABILITIES

Get a grip on **technology**, and you're in
complete control.

That's why we use **six advanced process technologies** to create RFMD's
communications components. Si BJT,
Si Bi-CMOS, GaAs HBT, SiGe HBT,
GaAs MESFET, Si CMOS – we have what
it takes to get your project rolling.

We invented **Optimum Technology Matching®**
to pair application needs with process
performance. That's why our chips feature
the best possible combination of **power,**
efficiency and **integrated function.**

Don't toy with **technology** – unless you're
playing with **the very best.**

TECHNOLOGY – it sets us apart.



Proprietary, State-Of-The-Art
RF Integrated CircuitsSM

7628 Thorndike Road
Greensboro, NC 27409-9421

Phone 336.664.1233

Fax 336.931.7454

Mention technology when contacting us.



www.rfmd.com

TM & © 2000, RF Micro Devices, Inc.

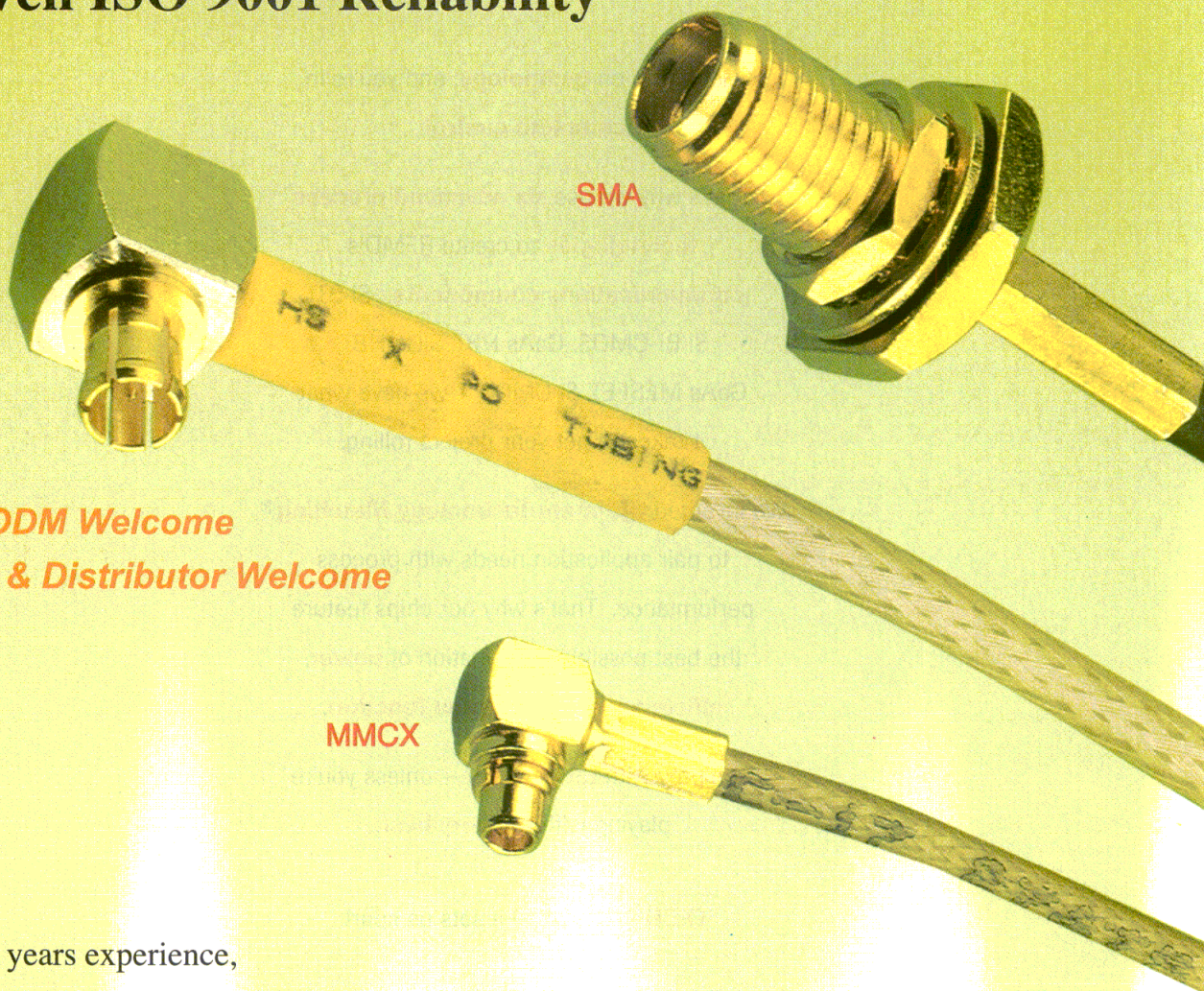
CIRCLE NO. 240

YEAR 2000's GOOD PARTNER

for RF/Microwave Coaxial Connectors
Coaxial and Flexible Semi-Rigid Cable Assemblies
Proven ISO 9001 Reliability

MCX

SMA



OEM & ODM Welcome

Agency & Distributor Welcome

MMCX

Over 35 years experience,
with the capability of manufacturing 300MHz ~ 26GHz
RF connectors for GPS system, Cellulation, Antenna/Cable, Data
transmission, Satellite transmission, Aviation equipment,
Microwave components, wireless system application.

For the year 2000 outstanding partner, CHIN NAN welcome
any of your inquiry.



CHIN NAN[®] Precision Electronics Co., Ltd.

No. 22-1, Jen Ho Rd., Tainan, Taiwan

Tel: 886-6-267-8303~5 Fax: 886-6-267-8337

E-mail: market@chinnan.com.tw

web site: <http://www.chinnan.com>

CIRCLE NO. 249



Couplers Shrink HF/VHF/UHF Designs

A novel approach to designing directional couplers delivers highly integrated solutions with excellent broadband coupling flatness.

Leo G. Maloratsky

Principal Engineer

Rockwell Collins, 1100 West Hibiscus Blvd., Melbourne, FL 32901; (407) 953-1729, FAX: (407) 953-1646, e-mail: lgmalora@mbnotes.collins.rockwell.com

MINIATURE coupled-line directional couplers are indispensable components in most wireless and avionics systems, and can be found in other RF systems as well. Unfortunately, the classical quarter-wavelength directional coupler designed to operate in the very-high-frequency (VHF) and ultra-high-frequency (UHF) ranges has large dimensions that make it difficult to apply to miniaturized RF devices. However, a new type of coupled-line directional coupler described in this article offers a viable alternative for miniature-RF applications.

One of the most useful coupler structures is the four-port network formed by two coupled lines positioned close enough to each other to share electric and magnetic fields (Fig. 1). This coupled-line directional coupler is a completely symmetric (axes of symmetry XX and YY) four-port network (Fig. 2a). Analysis and synthesis of this coupler can be

achieved through the mirror-reflection method.^{1,2}

The coupler can be represented by independent even and odd modes. In the even mode (Fig. 2b), currents in both lines are equal and co-directional. In the odd mode (Fig. 2c), currents are equal and opposite. The final currents are obtained by superpositioning the two modes.

According to the mirror-reflection method,

homogeneous coupled lines are calculated with characteristic impedances Z_{0e} (even mode) and Z_{0o} (odd mode). It should be noted here that Z_{0e} is not equal to Z_{0o} because partial capacitances between the lines are different for even and odd modes. Perfect matching of a coupled-line directional coupler occurs when:²

$$Z_{0e}Z_{0o} = 1 \quad (1)$$

where:

$$Z_{0e} = z_{0e}/z_0, \text{ and}$$

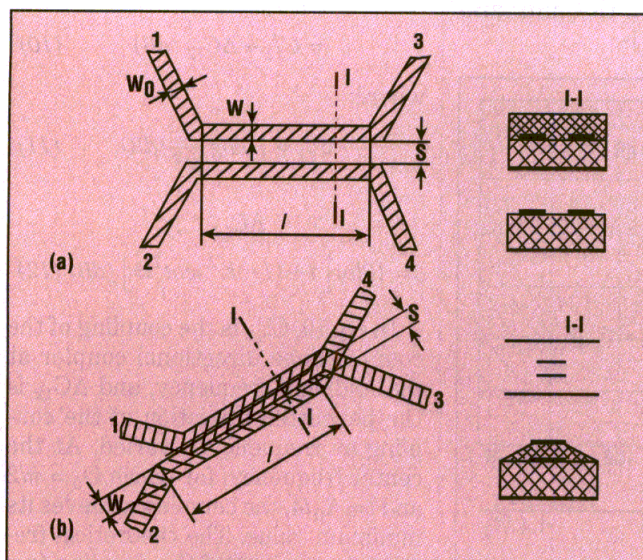
$Z_{0o} = z_{0o}/z_0$ are normalized characteristic impedances.

Note that eq. 1 does not depend on frequency or the length of the coupled lines. The scattering matrix of the ideally matched coupler can be derived from:²

$$[S] = \begin{bmatrix} 0 & S_{12} & S_{13} & 0 \\ S_{12} & 0 & 0 & S_{13} \\ S_{13} & 0 & 0 & S_{12} \\ 0 & S_{13} & S_{12} & 0 \end{bmatrix} \quad (2)$$

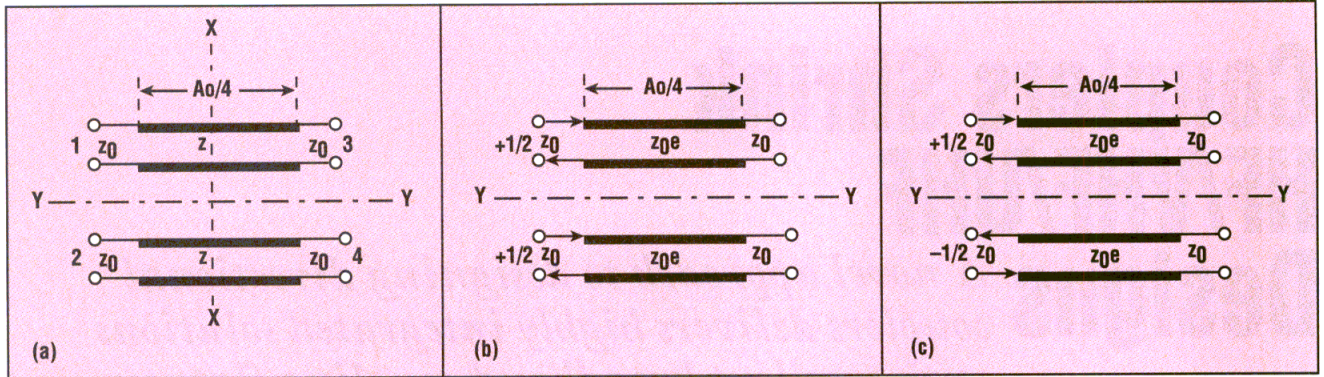
where:

$$S_{12} = \frac{i(Z_{0e} - Z_{0o})\sin\Theta}{2\cos\Theta + i(Z_{0e} + Z_{0o})\sin\Theta} \quad (3)$$



1. This is a diagram of an edge-coupled-line coupler (a). This is a diagram of a broadside-coupled-line coupler (b).

Directional Coupler



2. These diagrams show the equivalent four-port network of a coupled-line directional coupler (a), the equivalent circuit for even mode (b), and the equivalent circuit for odd mode (c).

$$S_{13} = \frac{2}{2\cos\Theta + i(Z_{0e} + Z_{0o})\sin\Theta} \quad (4)$$

where:

$\Theta = 2\pi l/\Lambda$ = the electrical length of the coupled lines, and

Λ = the guide wavelength.

The quadrature phase difference between output ports 2 and 3 is evidenced by multiple "i" by which eq. 3 differs from eq. 4:

$$\arg \frac{S_{13}}{S_{12}} = \pi / 2 \quad (5)$$

Quadrature eq. 5 between output signals does not depend on frequency. For fixed frequency, quadrature does not depend on the length of the coupled lines.

A signal propagating from port 1 to port 3 on one transmission line produces a coupled signal in the opposite direction—from port 4 to port 2—on

the other transmission line. For this reason, this coupler is known as a contradirectional or backward-wave coupler.

The coupled-line coupler offers ideal matching and isolation that are independent of frequency and coupled-line length (see eq. 2), but the coupling and insertion losses (see eqs. 3 and 4) change with frequency and with coupled-line length. The maximum signal in the coupled port 2 occurs when the length of coupling structure is $\Lambda_0/4$.

where:

Λ_0 = the midband guide wavelength in the coupled lines.

This wavelength depends on the parameters of the transmission lines, the permittivity of the substrate, and the center frequency f_0 .

The module of coupling (voltage-coupling factor) for the midband operating frequency is:

$$K = |S_{12}|_0 = \frac{Z_{0e} - Z_{0o}}{Z_{0e} + Z_{0o}} \quad (6)$$

Equation 6 can be rearranged to provide:

$$Z_{0e} = \sqrt{\frac{1+K}{1-K}}, \quad Z_{0o} = \sqrt{\frac{1-K}{1+K}} \quad (7)$$

Using eq. 7, eqs. 3 and 4 can be rewritten in the following form:

$$|S_{12}|^2 = \frac{K^2 \sin^2 \Theta}{1 - K^2 \cos^2 \Theta} \quad (8)$$

$$|S_{13}|^2 = \frac{1 - K^2}{1 - K^2 \cos^2 \Theta} \quad (9)$$

From eq. 8, the frequency characteristics of the coupling are:

$$\begin{aligned} C_{12} &= 10 \log \frac{1}{|S_{12}|^2} \\ &= 10 \log \frac{1}{K^2} [1 + (1 - K^2) \cot^2 \Theta] \\ &= C_{12}^0 + \Delta C_{12} \text{ (dB)} \end{aligned} \quad (10)$$

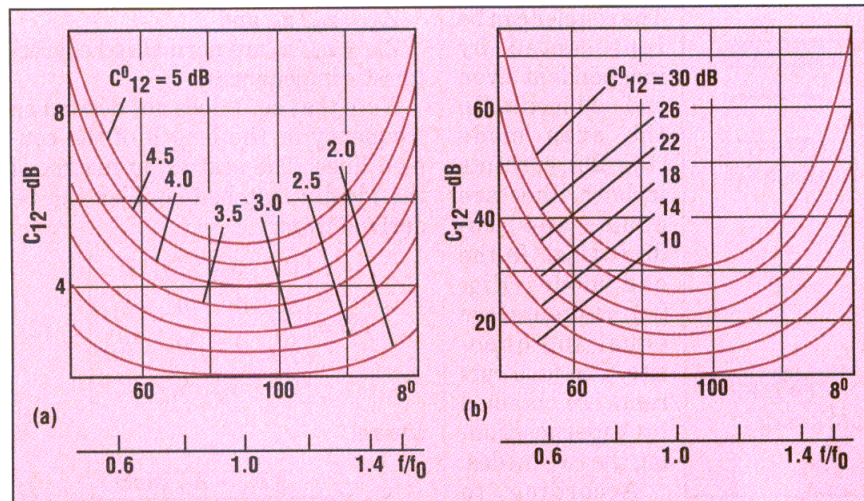
where:

$$C_{12}^0 = 10 \log \frac{1}{K^2} \text{ (dB)} \quad (11)$$

$$\Delta C_{12}$$

$$= 10 \log [1 + (1 - K^2) \cot^2 \Theta] \text{ (dB)} \quad (12)$$

In eq. 10, C_{12}^0 is the coupling of the coupled lines directional coupler at the midband frequency, and ΔC_{12} is the permitted deviation of the coupling as frequency is varied. At the center frequency, for which $\Theta_0 = \pi/2$ and $l = \Lambda_0/4$, the coupling achieves its minimum value. The theoretical frequency response of the coupling (eq. 10) is shown in Fig. 3 for tight and weak coupling.

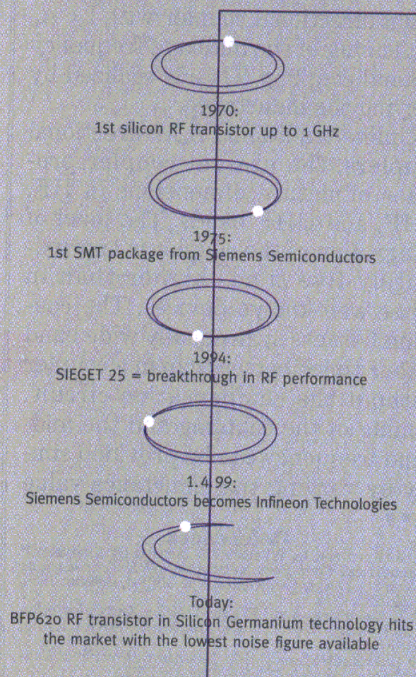


3. Coupling versus electrical length and relative frequency for the coupled-line couplers with tight (a) and weak (b) coupling can be seen.

With a noise figure of 0.65 dB,
we can't be QUIET about our
BFP620 Silicon Germanium
RF TRANSISTOR.

{PERPETUAL THINKING PROCESS}

INFINEON CYCLE



BFP620 electrical characteristics @ 1.8 GHz; 2 V:

Noise Figure	0.65 dB
Power Gain	21 dB
Input IP_3 capability ($I_c = 6$ mA)	10 dBm
I_c max	80 mA
V_{CE0}	2.8 V

high linearity and high gain along with low power consumption. The BFP620 provides outstanding performance and cost advantages for a wide range of wireless applications: cellular and cordless phones to pagers and much more. Visit us at:

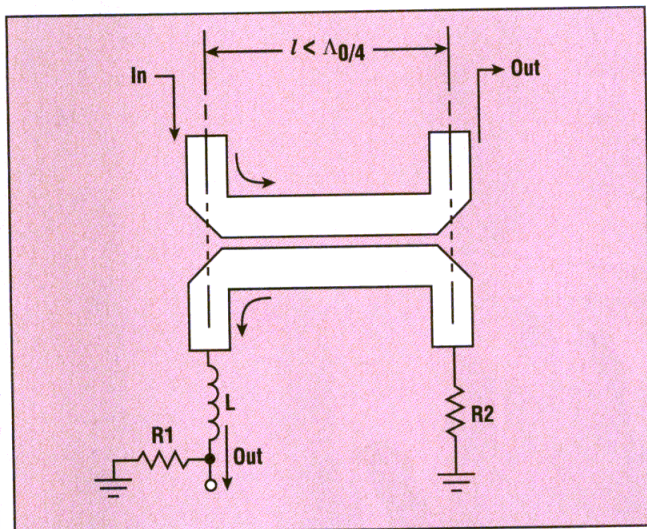
www.infineon.com/SiGe

Quiet! The BFP620, Infineon's first Silicon Germanium RF transistor, features a Noise Figure of just 0.65 dB at 1.8 GHz – unique for bipolar transistors. Our latest innovation, assembled in a standard SOT-343 SMT package, delivers



Never stop thinking.

Infineon Technologies – A Siemens Company.



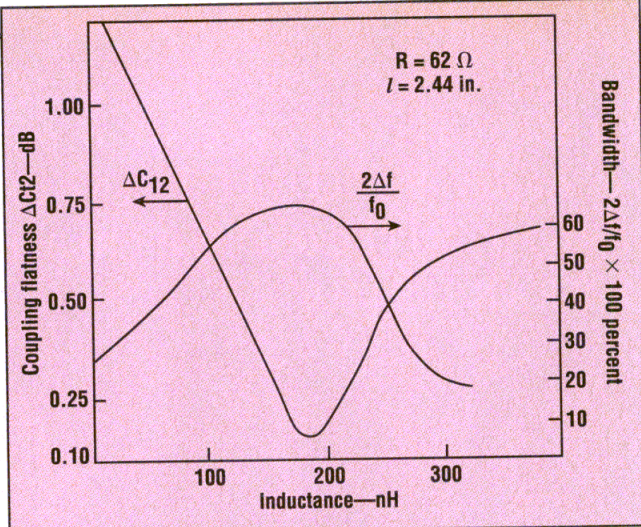
4. A miniature coupled-line directional coupler with compensation network can be seen.

In the VHF and UHF range, the classic directional coupler with a coupled-line length of $\lambda_0/4$ has large dimensions, which makes it difficult to build. Figure 4 shows a new micro-miniature directional coupler³ comprised of two coupled lines that have a very short geometric length (less than $\lambda_0/4$). This length depends on several requirements, including midband frequency, insertion loss, coupling, matching, and directivity.

The main problem of the short coupled-line coupler is that its degree of coupling varies with frequency (Fig. 3). A special compensation circuit is used to diminish this effect. The secondary line output is electrically con-

nected with series inductor L and shunt resistor R_1 (Fig. 4). The other end of the secondary line is terminated with resistor R_2 , where the value is equal to the impedance of the secondary line. The inductance value depends on the coupling flatness, midband frequency, and coupling value. The value of the shunt resistor R_1 depends on the impedance of the secondary line and inductance value.

Figure 5 illustrates the experimental relationship between inductance and coupling flatness ΔC_{12} for a frequency of 127 MHz and a bandwidth of 20 percent, and the relationship between inductance and bandwidth for a coupling line having a length of



5. Experimental characteristics of a 127-MHz microstrip directional coupler having coupled-line length $l = 2.44$ in. (6.20 cm) and shunt resistor $R_1 = 62 \Omega$ are shown. The relationship between inductance L and coupling flatness ΔC_{12} can be seen. The relationship between inductance L and bandwidth $2\Delta f/f_0$ 100 percent for a coupling flatness of 0.1 dB is also shown.

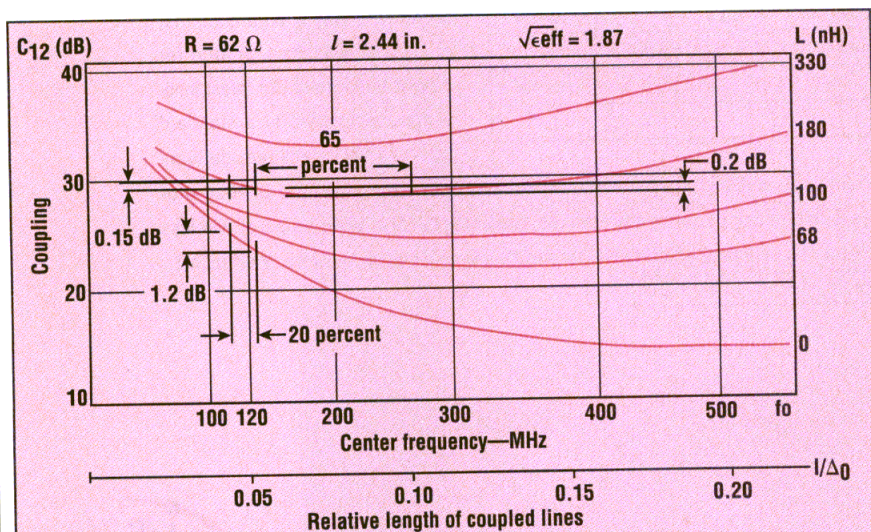
2.44 in. (6.20 cm) and a shunt resistor $R_1 = 62 \Omega$. Figure 6 illustrates the experimental relationship between coupling, the center frequency (or relative length of coupled lines l/λ_0), and inductance for the same directional coupler.

Experiments have shown that for 20-percent bandwidth, the present microstrip directional coupler with $L = 180$ nH, $R_1 = 62 \Omega$, $f_0 = 127$ MHz has a coupling flatness of ± 0.05 dB, a directivity of more than 23 dB, an insertion loss of less than 0.15 dB, a VSWR of less than 1.15, and length $l = 0.05 \lambda_0$ (five times less than a traditional directional coupler with $l = \lambda_0/4$). Tuning of the midband frequency (f_0) and coupling (C_{12}) is realized by varying the inductance.

Unlike traditional $\lambda_0/4$ directional couplers, the present coupler provides miniature dimensions in HF, VHF, and UHF bands. The level of integration of the coupler is approximately five times higher than in other well-known devices. The coupling flatness in an equally wide band is four times better than in a coupler without the compensation circuit. Tuning of the coupling and the midband frequency can be provided simply by varying the inductance value L .

References

1. J. Reed and G. Wheeler, "A Method Of Analysis Of Symmetrical Four-Port Networks," *IRE Transactions Microwave Theory Techniques*, Vol. MTT-4, October 1956, pp. 246-252.
2. L. Maloratsky and L. Yavich, *Design And Calculation Of Microwave Elements On Strip-Line*, Soviet Radio, Moscow, 1972.
3. L. Maloratsky and J. Ide, *Miniature Directional Coupler*, Patent USA #5,424,694, June 13, 1995.



6. An experimental relationship among C_{12} , center frequency f_0 , and inductance L is seen here.

EM-Based Models Improve Circuit Simulators

This new modeling approach uses full-wave analysis tools to obtain accurate models and operates at high speed to perform numerical techniques.

Murray Shattuck

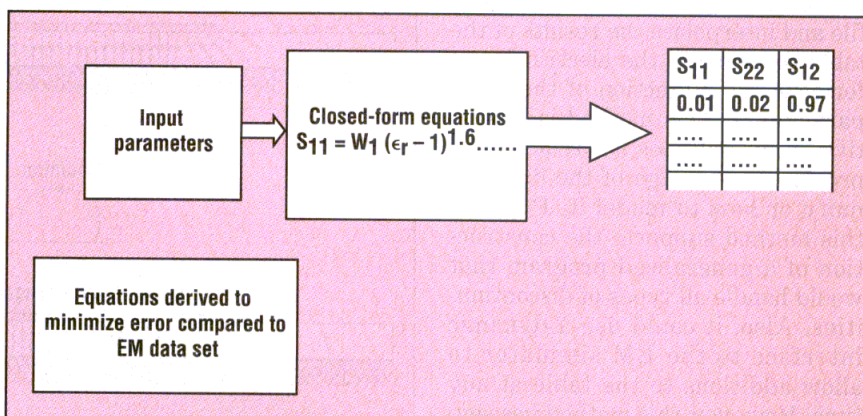
Applied Wave Research, 2089
Meadow Sweet Lane, Erie, CO 80516;
e-mail: murray@mwoffice.com.

SOPHISTICATED software programs that model the RF electrical characteristics of individual components and overall systems are the cornerstone of modern high-frequency design. These programs have introduced several numerical techniques that improve design performance and manufacturing yield, but the techniques require the program to simulate the behavior of each component thousands—if not millions—of times. Modeling shortcuts have been devised to minimize simulation time, but they lose accuracy as frequency increases.

This article addresses a modeling approach that uses full-wave analysis tools to obtain accurate electrical discontinuity models while operating at speeds that are sufficient to perform numerical techniques such as optimization and design centering. The article presents a general discussion of the steps required to realize this type of system, and concludes with a sample implementation of this system as it models a microstrip lowpass filter circuit. The purpose of this article is to introduce this technique within a commercially available

microwave computer-aided-design (CAD) package.

One impractical but obvious approach to creating electromagnetic (EM)-based models (Fig. 1) is to combine a circuit simulator with an EM simulator to automatically perform simulations of discontinuities based on the given input parameters. Unfortunately, this method is not computationally efficient enough to support tuning, optimization, or yield analysis of complex circuits. Despite the practical limitations, this method does have several significant advan-

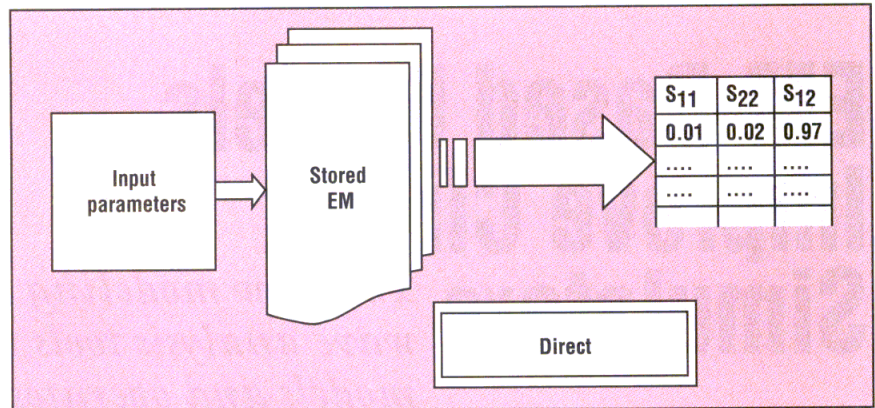


1. Closed-form equations are designed to minimize error when compared to EM simulations.

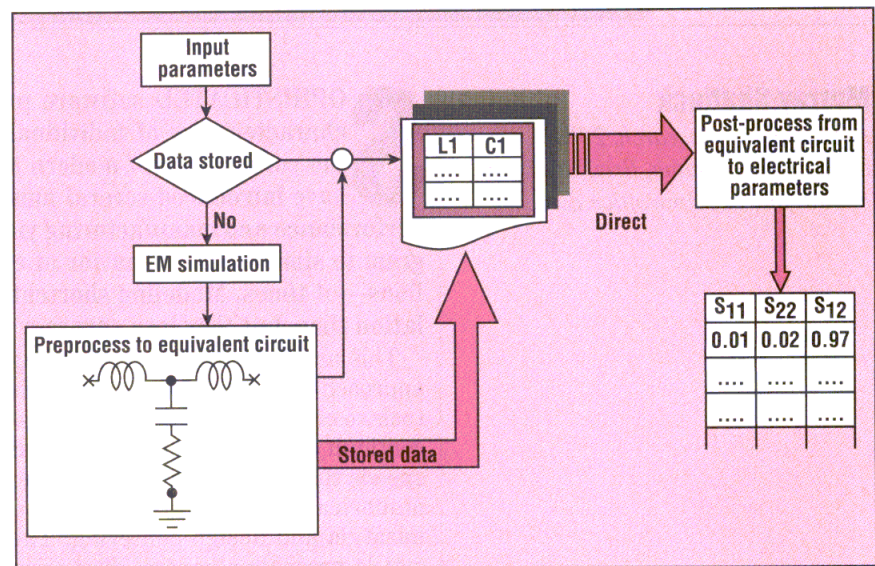
tages that drastically improve the design process for the user. First, the accuracy of the model is equivalent to the accuracy of the underlying EM simulation engine. Second, automatic generation of EM structures can save considerable time and eliminate human error. Lastly, the dynamic range of the discontinuity model can be improved to take into account a wider variety of dielectric materials and impedances than closed-form equations.

An alternative approach (Fig. 2) stems from the classical method of model development. Closed-form equations from an analytically solvable problem similar to the problem at hand are derived by mapping the input parameters into this closed-form solution. Based on a large amount of data, this mapping is modified to minimize error between measurements (EM simulations in this case) and the output of the model. Since the end result of this method is a closed-form equation, it results in a computationally efficient implementation that is ideal for the high number of evaluations required by the circuit simulator. In theory, this method of model generation has numerous advantages and would be the perfect solution, except for one drawback: it is a non-systematic approach of model development. Each model must be addressed individually, and the accuracy and quality of the model strongly depends on the developer's ability to choose suitable equations to map the input parameters.

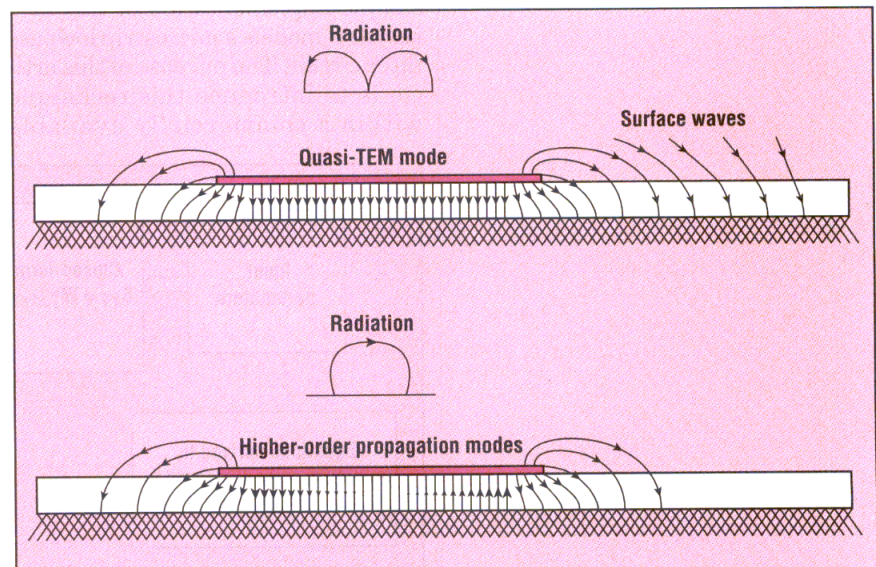
Yet another possibility is to store the results of the EM simulations in a file and interpolate the results of the table to estimate the electrical performance as a function of the input parameters. This method is attractive because it does not require any previous knowledge of the discontinuity or how to model it. Further, this method supports the construction of a generalized program that would handle all types of discontinuities. Also, it could use a dynamic interface to the EM simulator to allow additions to the table at any time. However, this method has several major problems that complicate its application. The composite electri-



2. This diagram shows a parameterized model using direct interpolation of stored EM simulations.



3. This is a flow chart of the proposed EM-based discontinuity parameterized model.



4. This diagram shows a portion of the possible propagating modes on a microstrip line.



See us at MTT
Booth #1421

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

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

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

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

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

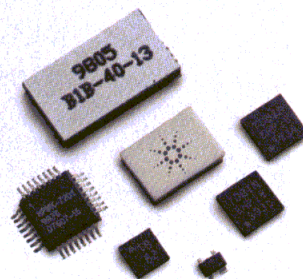
At Agilent we listen to your needs to help you reach the right solution—fast.



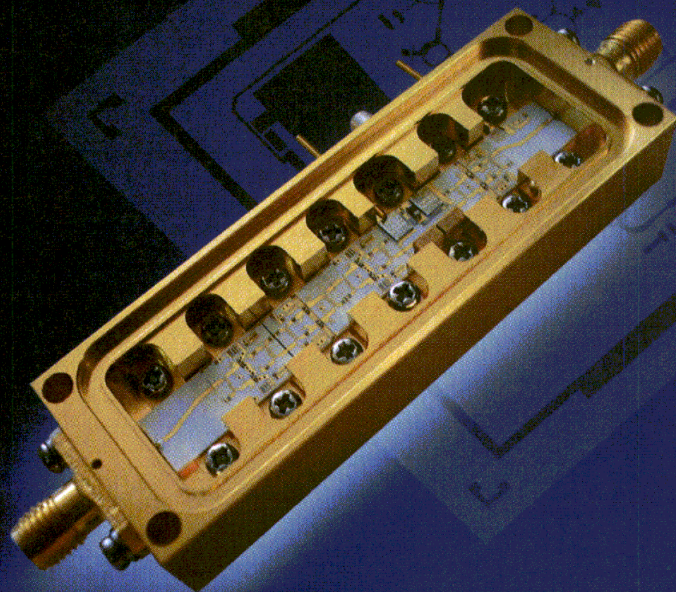
See how fast you can move with the flexibility of the CDMAAdvantage RF chipset. Visit our website to see product specifications and our latest technologies.

www.agilent.com/view/cdmadvantage

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



Agilent Technologies
Innovating the HP Way



State-of-the-Art Thin Film Technology

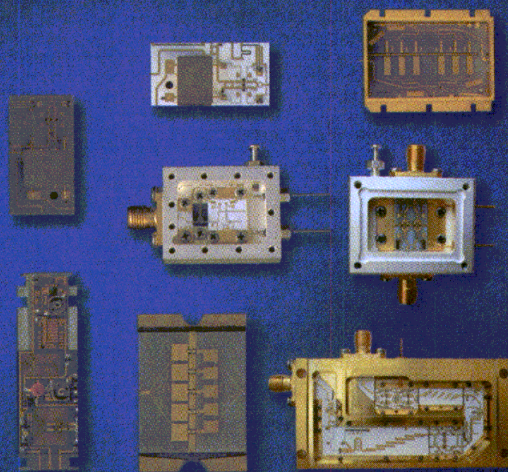
With innovative foundry service for today and beyond, KMW can satisfy the most critical performance and reliability requirements for your products with complete technical support.

We offer foundry services for thin film microwave circuits, which include mask processing, thin film patterned substrate fabrication and assembly services.

- Mask Fabrication
- Sputtering
- Electroplating
- Photolithography
- Laser Drilling
- Dicing
- Laser trimming
- Thermostatic Wedge Bonding
& Parallel Gap Welding
- Eutectic Die Bonding Epoxy Mounting

KMW accepts orders that range from sample to production quantities.

Contact us today.



CIRCLE NO. 393

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

EM Discontinuities

cal parameters can have quickly varying characteristics with the potential for step changes in parameters (for example S-parameter phase, or Y-parameters going to infinity). Interpolation across these types of discontinuities in the data can result in gross errors at these locations, which forces sampling of the input parameters on a finer interval. Finally, the amount of computer memory required to store the interpolation samples could quickly become unrealistic. This problem expands exponentially as the number and range of the input parameters are increased.

The approach used within Microwave Office's EM-based discontinuity models is a derivative of the last technique, which overcomes the disadvantages while retaining a systematic approach to the modeling process. In this approach (Fig. 3), the EM-simulated data are first preprocessed, resulting in the component values of a passive equivalent circuit. After correctly determining a suitable equivalent circuit, the resulting component values are noted to behave relatively benignly as a function of the input parameters and without discontinuous steps in value. The interpolation is then performed on these sampled component values and the resulting equivalent circuit is used to evaluate the electrical parameters of the circuit.

This approach allows the data to be sampled at a coarser interval, thus minimizing the number of EM simulations and the amount of computer memory required for a particular simulation. In addition, this approach provides some physical interpretation of the ongoing changes as a function of the input parameters, supporting a better grasp of the problem. Another benefit of this type of modeling is that it always can be constrained so that the resulting output electrical parameters are representative of a causal system that conserves energy. In the interpolation of S-parameters, for example, it is possible and highly likely that the resulting system will create energy at some interpolation points. This is especially true when the modeling of lossless discontinuities as an interpolation error creates loss on one side

Mini OCXO Consumes <0.45 Watts

205 SERIES

210 SERIES

230 SERIES

240 SERIES

250 SERIES

260 SERIES

400 SERIES

500 SERIES

ENTER

PRODUCT PROFILE

Thermal stability from $\pm 1.25\text{E}-006$ to $\pm 3.50\text{E}-006$ over a 100°C temp. range --- Hermetically sealed package --- Low power consumption of $<0.45\text{W}$ @ $+25^\circ\text{C}$ --- Ideal for battery powered apps. --- Tuned to exact specs. --- Call: 978-465-6064

Frequency Range	38 MHz to 200 MHz
Aging	5.00E-009/day 5.00E-007/yr
Phase Noise, 10Hz offset	-80 dBc/Hz
100 kHz offset	-160 dBc/Hz
Output	+7 dBm
Crystal Cut	AT
Package Size	14 pin DIL x .394" (10mm) h

MTI
MTI-MILLIREN TECHNOLOGIES, INC.
MADE IN THE USA

INFO. SOURCE

www.mti-milliren.com

CIRCLE NO. 429 or visit www.mwrf.com

Are cosite interferers taking a bite out of your RF performance?

Pole/Zero's digitally tuned filters are your best protection against cosite interference.

- Outstanding RF performance
- High Q narrowband filters
- Constant percent bandwidth and insertion loss
- Off-the-shelf economy

For catalog information, visit our Web site at www.polezero.com.

POLE ZERO
CORPORATION

5530 UNION CENTRE DR • WEST CHESTER, OH 45069 • (513) 870-9060

CIRCLE NO. 422 or visit www.mwrf.com

MICROWAVES & RF ■ JUNE 2000

101

Cellular — Satellite — Mobile Communications...Hitachi Metals Has The Solution!

The world's gone mobile. Your design demands top performance. Specify Hitachi Metal's microwave components and get your design moving today.

The international mobile marketplace demands high performance. Your design requires microwave components with low losses, superior response characteristics, and minimum volume. You need components from Hitachi Metals.

Need to save circuit board area and package volume? Designed with our superior "Multi-Layered" technology, Hitachi components require minimal volume and circuit board area. Specify Hitachi.

Specify Hitachi, a major international supplier of electronic components. Hitachi, setting the highest quality and reliability standards in the world.

RF TRANSFORMERS

CIRCULATORS, ISOLATORS

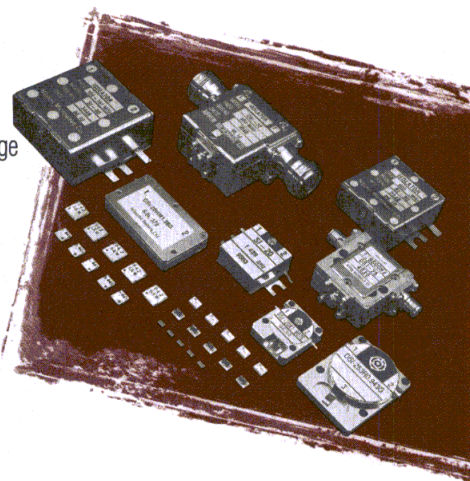
COMBINERS AND SPLITTERS

COUPLERS

DOUBLE AND SINGLE BALANCED MIXERS

LOW PASS FILTER, BAND PASS FILTER

ANTENNA SWITCHES, DIPLEXER



Hitachi Metals America, Ltd.

2101 S. Arlington Heights Rd., Suite 116
Arlington Heights, IL 60005
Tel: (847) 346-7200 Fax: (847) 364-7279
www.hitachimetals.com

CIRCLE NO. 408 or visit www.mwrf.com

DESIGN FEATURE

EM Discontinuities

while creating gain on the other side. Processing the problem as an equivalent circuit eliminates this problem. Further, if loss is to be included in the model, resistive terms can be added to the model.

One must control the size of the data base by limiting the range of the input parameters. The allowable range of the independent input parameters and the sample frequency determine the quantity of data within the filled interpolation data base. In the case of the selected interpolation model, the required sampling for a particular error tolerance depends on the complexity of the interpolation method and the local stability of the function being interpolated. Selection of input-variable ranges should be studied in the context of several frames of reference. First, one must look at the parameter as seen by the end user and consider what he or she considers to be a reasonable range. Secondly, one must take a close look at the capabilities of the EM simulator and determine over what range reliable data can be obtained using an automated-collection process. Finally, one should look at the physical properties of the discontinuity to determine the limits of single-mode propagation.

Single-mode propagation is usually the limiting factor and often occurs at input-variable values that are lower than the user desires. However, once multimode propagation is reached, the entire modeling system, as proposed, begins to introduce significant errors. If one of the transmission lines constructing the discontinuity supports more than one propagating mode, the circuit simulator will inaccurately predict the circuit interactions because it does not support multimode propagation within the other models. To support this system, the EM simulator would be required to determine the generalized scattering matrix of the discontinuity, separating each mode into an effective electrical port. Further, the circuit simulator would have to support multimode excitation of all models. Beyond the guided modes of a conductor, one must also investigate the alternate modes of propagation such as radiation and the excitation

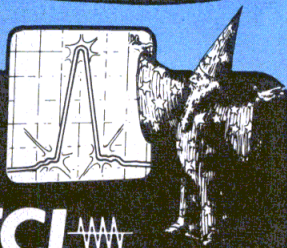
-165 dBc/Hz NOISE FLOOR CRYSTAL OSCILLATOR!

40-120 MHz

0.5 cu. in.

P₀ +13dBm

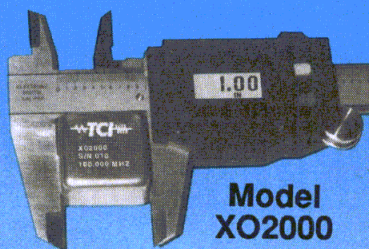
CALL US!



TCI
THE SOURCE SOURCE

Techtrol Cyclonetics Inc.

815 Market Street
New Cumberland, PA 17070
TEL: 717-774-2746 • FAX: 717-774-6799
e-mail: techtrol@paonline.com
Website: www.tci-ant.com



**Model
XO2000**

- Frequency Stability:
± 5 ppm over 0° to +50°C
- Supply Voltage: +12 VDC
- Aging: 1 ppm/year
- Phase Noise:

10 Hz	- 85 dBc/Hz
100 Hz	-122 dBc/Hz
1 KHz	-152 dBc/Hz
10 KHz	-165 dBc/Hz
100 KHz	-165 dBc/Hz
- Size: 1.0" X 1.0" X 0.5" high
- VCXO version available

CIRCLE NO. 418 or visit www.mwrf.com

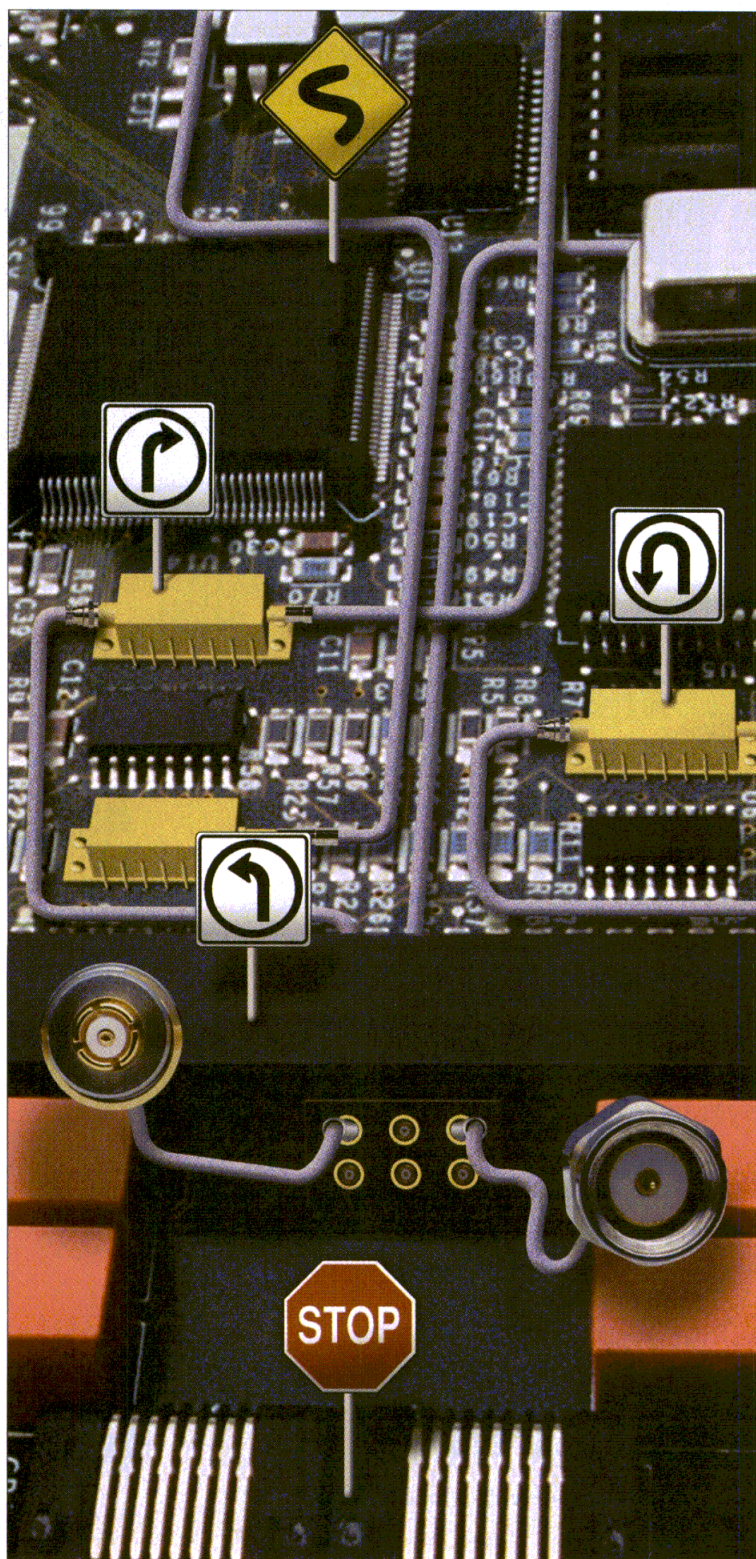
Test and
Measurement
Index ▶Semiconductor
Intellectual
Property Index ▶DSP Design
Center ▶Foundry Design
Center ▶Interconnect
Index ▶*Introducing*

5 more reasons for our

220,000 *registered users*
to point to www.questlink.com.

**QUESTLINK**The #1 info-commerce site for the electronics industry.SMwww.questlink.com

Our cables make the turns that drive other cables crazy.



Gore High Density Microwave Cable Assemblies are the most reliable way to maximize flexibility and performance.

Gore high density microwave cable assemblies are the ideal choice for routing high speed digital and microwave signals within your module and back-plane hardware. Combined with either standard or custom connectors, our flexible assemblies are easy to route and connect while maintaining superior electrical and mechanical performance.

Gore high density assemblies are available in a variety of connector styles and cable sizes ranging from 0.047" to 0.120" O.D. Gore has an extensive design library and with over a 20-year history, you can be sure each connector and cable construction is optimally matched.

Superior Product Performance

- Small bend radius for tight routing situations
- Excellent flex properties
- Superior shielding: over 90dB/ft through 18GHz
- Exceptional phase properties

1 (800) 445-GORE

in North America or

+49/9144-6010

in Europe

Visit our website at: www.gore.com



© Copyright, 2000 W. L. Gore & Associates, Inc. Gore and Design are trademarks of W. L. Gore & Associates, Inc.

CIRCLE NO. 222

EM Discontinuities

of dielectric-waveguide modes or surface waves. Figure 4 depicts a portion of the possible propagating modes on a microstrip line. Depending on the type of EM simulator used, excitation of these modes can result in significant errors in the electrical parameters, thus propagating errors into the model. As multimode guided propagation is approached, the electrical parameters begin to behave violently, significantly varying from the desired response of the junction. All of this indicates that the upper limit of the input variables should be set before this occurs. Although this often disappoints the user, implementation of such a limit is in his or her best interest and will result in better designs.

For a particular set of discontinuity dimensions, excitation of these undesired modes is typically a function of frequency. Thus, choosing the upper frequency limit is in direct conflict with selecting the ranges of the dimensional parameters. If the finite frequency limit is set for a particular substrate, the conflict between frequency, dimensions, and the user's desires is not resolved. Consider a microstrip step example. If a user is working at 70 GHz on 100 μm GaAs, the width limitation for this discontinuity, based on elimination of higher order modes, may be 100 μm . However, a different user working at 20 GHz on the same substrate should not have that same limitation.

In an attempt to resolve this problem, the author takes the following approach, illustrated in a two-dimensional sense in Fig. 5. For each EM simulation and at a particular set of dimensions, estimates of the onset of higher-order modes and limitations due to the EM simulator are obtained. The limitation with lowest frequency is then reduced by a certain percentage to avoid problems at its onset. EM simulation then proceeds to this frequency limit, and the frequency limit is stored within the interpolation table. Upon interpolation of the electrical parameters, the lowest frequency limit of all points used in the interpolation determines the upper frequency limit within that space. Since these limits are dynamic and require significant calculations, a

LPKF's Rapid PCB Prototyping:

LPKF provides on-site PCB prototyping solutions for today's RF and Microwave Engineer:

- Superb accuracy & cutting quality
- Direct download of CAD files
- Intuitive, user-friendly operation
- Handles circuits up to 75 GHz on all common substrates from FR4 to Teflon even flexible circuits
- Get production quality prototypes in as little as 10 minutes
- Chemical free, clean & safe

Off-shelf Systems and Custom Solutions:

- Selection of models and customized options
- Special tools for RF applications
- Multilayer capability
- Worldwide support & service

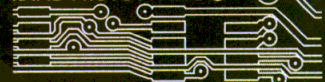
Superb
On-site

Fast

Control Turnaround

More information?

RAPID PROTOTYPING



1-800-345-5753

www.lpkfcadcam.com

info@lpkfcadcam.com

LPKF Laser & Electronics

North America: U.S.A

503.454.4200 · fax 503.682.7151

Germany: +49-51 31-70 95-0

UK&Ireland: +44-1344-455046

Japan: +81-3465-7105

Australia & New Zealand:

+61-2 9654-1873.

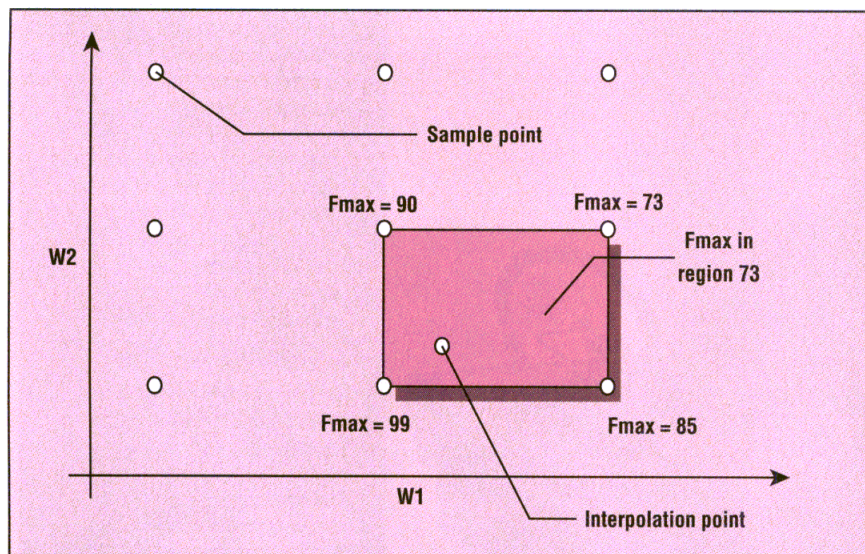
Check LPKF web site for more locations and "Instant Contact"

HERING Advertising - Germany © 2000, LPKF Laser & Electronics. All rights reserved.



CIRCLE NO. 434 or visit www.mwrf.com

MICROWAVES & RF ■ JUNE 2000



5. This graphic shows a method of determining the upper frequency limit within an interpolation cell.

system of warning the user of the changing limit is required.

A complete system of EM-based discontinuities using the described system has been implemented in microstrip. This system uses a three-dimensional (3D), planar, full-wave EM simulator incorporating the spectral-domain method of moments (MOMs). The system has also been interfaced to the Microwave Office 2000 simulation environment through the user-accessible modeling interface. To test the models, a user would ask, "What type of difference will these EM-based discontinuity models have on a real-world circuit with multiple discontinuities?" To test this, a simple lowpass filter circuit with a cutoff frequency of 5.5 GHz was designed in 30-mil microstrip with $\epsilon_r = 2.94$. The filter design consists of multiple microstrip discontinuities, including MTEEs, MSTEPs, MBENDS, and MOPENS. The circuit was modeled with the closed-form and EM-based models. Figures 6 and 7 show a layout and photograph of the lowpass filter.

It should be noted that this circuit was designed to operate at frequencies where the closed-form models have degraded. Due to the fabrication materials and processes available, tests were conducted on 30-mil substrates with a relative dielectric constant of 2.94 at frequencies up to 10.5 GHz. While not an extremely

high frequency, the scale of the discontinuities tested supports multimode propagation at 13 GHz on the widest lines. If one were to scale these tests to a 10-mil substrate, test frequencies of 31.5 GHz would be required. Using a 100- μm substrate, test frequencies would exceed 80

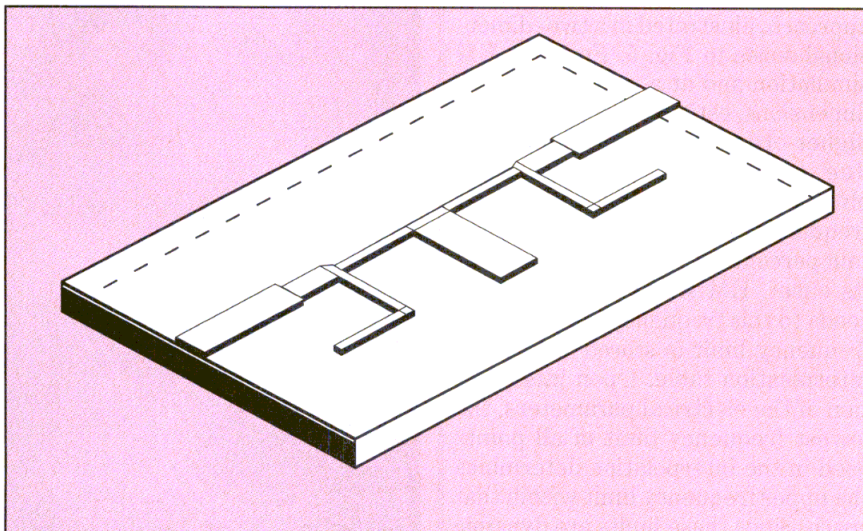
GHz.

The fabrication and test processes can introduce errors that cause the measurement to differ from the simulations. These include calibration errors, variations in the dielectric constant of the substrate, and dimensional variations in the etching process. Calibrations were made at the end of the SMA connectors on a vector network analyzer (VNA), but the transitions from coax to microstrip were not removed. Further errors should be expected from the effects of inter-element coupling and radiation.

Figure 8 includes a rectangular plot of the circuit simulations and filter measurements. The use of the EM-based models significantly improves the accuracy of the simulation in the passband of the filter. In fact, the discrepancies between the measurement and the circuit simulation could easily be explained by the uncalibrated coax-to-microstrip transition. In the stopband, however, the measurement shows some significant variations from both circuit simulations. This is especially true near the transmission nulls that are caused by the two open-circuited stubs. It is in these regions, where high currents are present on the shunt stubs, that radiation and cou-

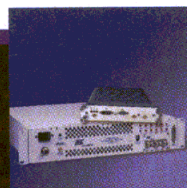
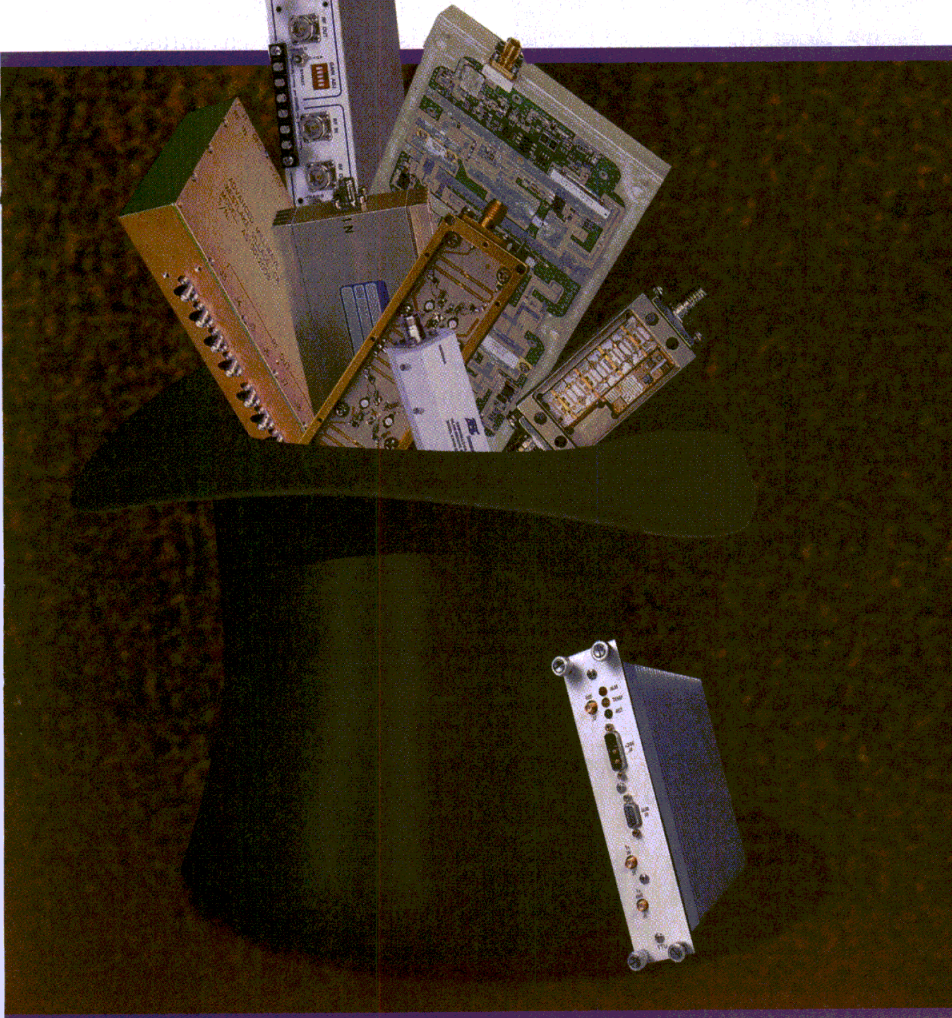
Parameter tolerances for yield analysis

Parameter	Nominal value	Tolerance	Distribution
ϵ_r	2.94	2 percent	Uniform
H	30 mil	± 1 mil	Uniform
Etch	0	± 1 mil	Uniform



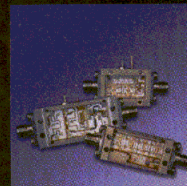
6. This is the layout of the prototype lowpass filter.

NEED A MAGIC TIME-TO-SOLUTION PARTNER?



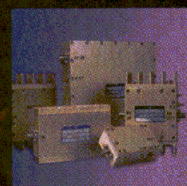
Linear Power Amplifiers for Wireless Communications

- Single- & multi-channel; modulation independent; for cellular, PCS, 2.4 GHz & 3.5 GHz WLL applications



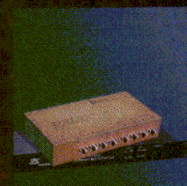
MIC Microwave Amplifiers

- Low noise, medium power; narrow, octave & ultra-broadband amplifiers for commercial, military & fiber optic communications



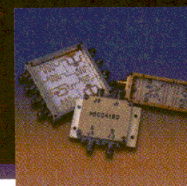
High Intercept Multi-octave Linear Design Amplifiers

- HF, VHF, UHF, SHF & L-band spectrum for use in signal distribution, surveillance & IF applications



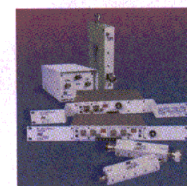
Multicouplers

- Standard & custom designed low noise, high intercept receiving multicouplers for wireless communication, military & public safety bands



Monopulse Tracking Components

- Low loss & high isolation; implemented in microstrip technology for the military & civilian test range market



Two-way Messaging

- Ultra-low noise; tower-mounted receive amplifiers and multicouplers for advanced two-way messaging



Application-specific Transmit or Receive Amplifiers

- High power transmit for all air interface specifications; low noise receive & signal processing products & subsystems

IT'S OUR CUSTOM.

AML does more than design and manufacture amplifier-related products. We offer a level of expertise and a breadth of skills and technologies second to none. AML is an ISO 9001 certified company uniquely equipped to provide



**AT AML,
SIZE
REALLY
DOESN'T
MATTER.**



custom solutions in any size production run, from very small to high volume rates — no matter how complex the design. Plus, we have the ability to ship product in record time. It's no illusion. In the 30 MHz to 21 GHz arena, AML is your magic time-to-solution partner. To find out more, call 805.388.1345, e-mail sales@amlj.com or visit www.amlj.com

AML
Communications

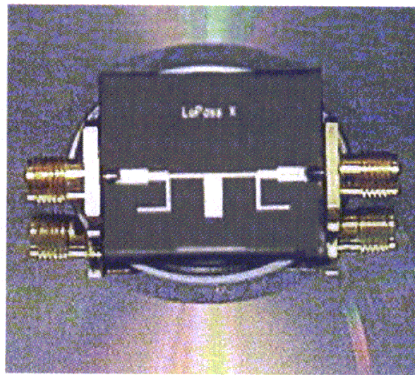
**SEE US AT MTT-S
BOOTH 2900**

pling between the circuits are highest. A full-wave EM simulation of the filter has shown these effects, verifying that conclusion.

With improved confidence in the circuit simulations using the EM-based models, one can harness the Monte Carlo analysis available within Microwave Office to evaluate the sensitivity of the design to fabrication tolerances. Figure 8 also shows the statistical variation in the scattering parameters using the EM-based models. Three input parameters were assigned the tolerances shown in the table.

The variable "etch" refers to the fabrication process that is used to pattern the conductor. The line widths and lengths are modified through equations in the circuit simulator to reflect the appropriate changes in an over- or under-etched condition.

Yield analysis shows that the stopband is not extremely sensitive to manufacturing tolerances. There-



7. This is a photograph of the prototype lowpass filter.

fore, one would expect that, even with the coupling and radiation effects predicted by the full-wave simulation, these effects are relatively immune to fabrication tolerance. The passband, on the other hand, experiences some dramatic changes with the specified tolerances. From this point, one could perform various other analyses available within Microwave Office to improve the

design. Examples include performance optimization to improve the nominal response, or design centering to optimize the yield for a particular set of manufacturing tolerances. It is in this regime that the EM-based models show their advantage over full-wave EM simulation, and result in an improved design.

It has also been shown that the EM-based discontinuity models offer significant improvements in the accuracy of circuit simulations. With this new accuracy, one can have increased confidence in the numerical optimizations and yield analysis performed within the circuit simulator. The benefits of EM-based discontinuity models within the Microwave Office simulation environment are clear from this example. However, the EM-based discontinuity models will not replace the usefulness of the EM simulator to evaluate the effects of radiation and inter-element coupling. Ultimately, it is the intelligent application of multiple

Like what you see? Need more information?
Do you want it now?
www.mwrf.com

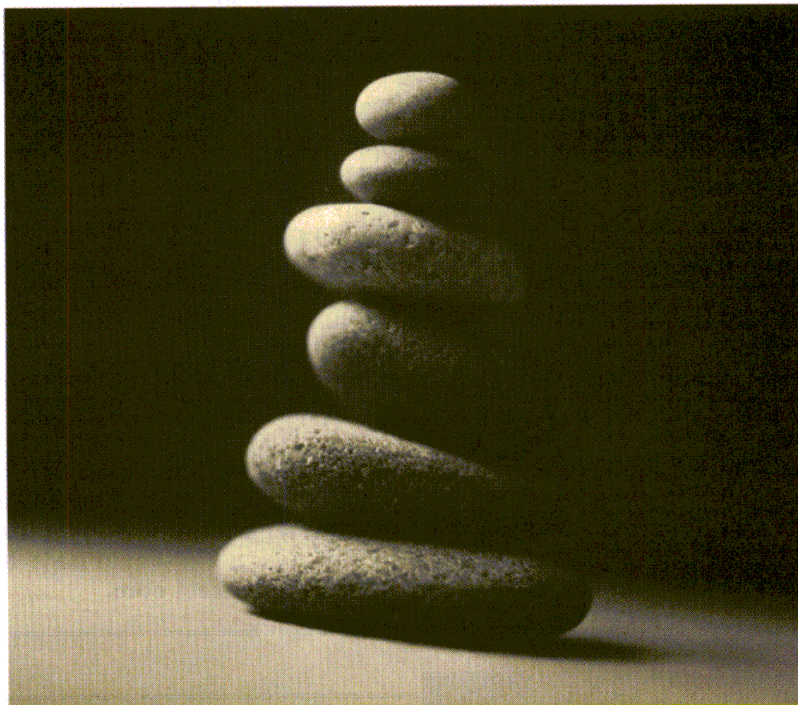


Visit the *Microwaves & RF* website at:
www.mwrf.com and click the instant inquiry
 button to request information seen in this
 issue or visit the manufacturers links for
 direct access to all
Microwaves & RF advertisers.

**Microwaves
& RF**

Penton

611 Rte. 46 West, Hasbrouck Heights, NJ 07604



Balance is everything. Yin and yang. Light and darkness. Technology and the knowledge to use it. While the latter may not seem crucial to the average person, to you it is life. Which is why we will be there. With the right technology. The right insight. At the right time. You'll get the attention you need to give you the freedom you want. The commitment, frankly, you deserve. The support that, when combined with technological innovation, yields balance. Because, as we all know, without balance, you cannot stand alone.

www.agilent.com/find/component_test



Agilent Technologies
Innovating the HP Way

Argentina (54 1) 787-7115 • Austria (01) 25000-7006 • Australia 1 800 829 485 • Belgium (32/2) 778-34-17 • Brazil (55-11) 7297-8600 • Canada 1-877-894-4414 • Czech Republic (420) 2 61307111 • Denmark (45) 45 99-10-00 • Finland (3589) 8872 2100
France (01) 69 29 41 14 • Germany (0180) 524-8330 • Greece (30/1) 7264045 • Hong Kong (852) 2599 7889 • Hungary (36) 1 4618111 • India (91 11) 690 6156 • Ireland (01) 615 8222 • Israel 972 (03) 539-03-80 • Italy (39 02) 92-122-241
Japan (81/3) 3331-6111 • Korea (82 2) 769 0800 • Malaysia 1 800 88 8848, (6 03) 291 0213 • Mexico 525-5-258-4294 • Netherlands (020) 547 7272 • Norway (47) 22 73 57 59 • Philippines (632) 814 1083 • Poland (48) (022) 6087700 • PRC 800 810 0189, (86 10) 6564 5238
Singapore 1800 375 8100 • Spain (34) 91 631 1323 • Sweden (46/8) 444 22 77 • Switzerland (01) 735 72 36 • Taiwan 080 212 535, 0800 47866 press 1 • Thailand (66 2) 661 3995, (088) 225 802 • United Kingdom (01344) 366666 • Venezuela (58-2) 207-8357
*Telephone Charge per Unit Time = 0.24 DM/Min

©2000 Agilent Technologies ADEP5986003/INTL

IS-95 CDMA and cdma2000

Vijay K. Garg

IS-95 CDMA and cdma2000 covers two of the key standards for modern digital wireless communications systems: Interim Standard 95 (IS-95) code-division multiple access (CDMA) and cdma2000. The text provides guidelines for parameters of a CDMA network and outlines a migration path for CDMA to third-generation (3G) CDMA systems.

The book's opening chapter introduces the reader to the major attributes of CDMA and access technologies that are used for cellular personal communications services.

The second chapter reviews the different types of spread-spectrum (SS) systems currently employed in modern communications systems.

Chapter 3 discusses the digital voice-encoding systems for CDMA and wideband CDMA.

Chapter 4 discusses the concepts of diversity reception where multiple

signals are combined to improve system signal-to-noise ratio (SNR).

Chapter 5 covers the functional entities of the wireless network and the interfaces between them.

Chapter 6 presents a high-level description of the IS-95 CDMA air interface.

Chapter 7 covers how to introduce a CDMA carrier in an existing Advanced Mobile Phone Service (AMPS) or time-division-multiple-access (TDMA) system.

Chapter 8 discusses the IS-95 call-processing states that a mobile station goes through in getting to a traffic channel while Chapter 9 reviews the layering concept protocols for IS-95 CDMA.

Chapters 10 and 11 cover soft handoff and power control and the parameters used to identify a mobile station.

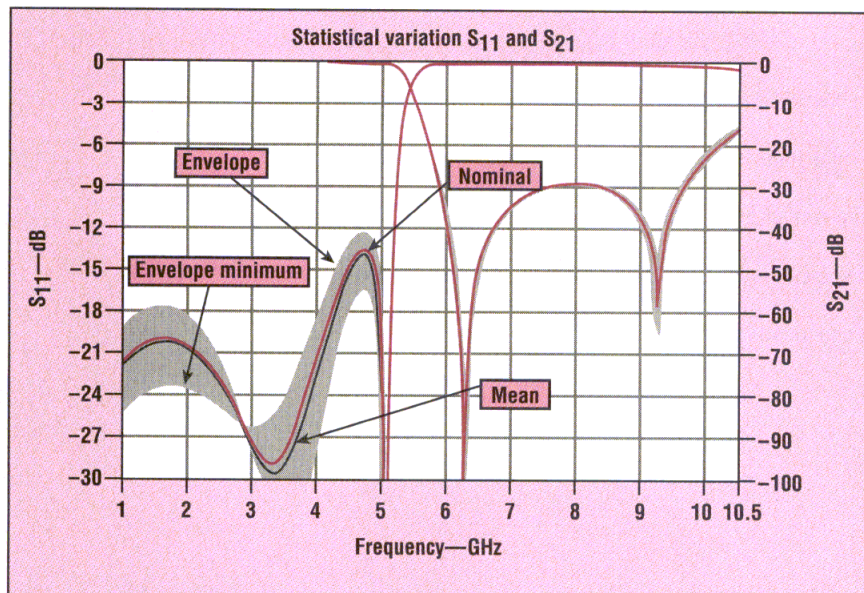
Chapter 12 presents the basic

guidelines for engineering a CDMA system including propagation models, link budgets, and link capacity. Chapter 13 reviews the procedures for calculating the capacity of a CDMA system.

Chapter 14 reviews standards for data services supported by CDMA cellular PCS systems presenting highlights of the Telecommunications Industry Association (TIA) IS-99, TIA IS-637, and TIA IS-657 standards while Chapter 15 is dedicated to a review of cdma2000 radio-transmission technology (RTT) that uses CDMA to satisfy the needs of 3G wireless communication systems. (2000, 423 pp., hardcover, \$75.00, ISBN: 0-13-087112-5.) **Prentice Hall PTR, One Lake St., Upper Saddle River, NJ 07458; (800) 382-3419, FAX: (201) 236-7141, Internet: <http://www.phptr.com>.**

DESIGN FEATURE

EM Discontinuities



8. This is a rectangular plot of the circuit simulations and filter measurements.

simulation methods that result in the best-performing designs and the fastest time to market.

For further reading

Fang Wang, Vijaya K. Devabhaktuni, and Q.J. Zhang, "A Hierarchical Neural Network Approach To the Develop-

ment of Library of Neural Models for Microwave Design," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 46, No. 12, December 1998, pp. 2391-2403.

P.M. Watson, K.C. Gupta, and R.L. Mahajan, "Development of Knowledge Based Artificial Neural Network Models for Microwave Components," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 46, No. 5, May 1998.

John W. Bandler, Mostafa A. Ismail, Jose Ernesto Rayas-

Sanchez, Qi-Jun Zhang, "Neuromodeling of Microwave Circuits Exploiting Space-Mapping Technology," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 47, No. 12, December 1999, pp. 2417-2427.

Norbert H.L. Koster and Rolf H. Jansen, "The Microstrip Step Discontinuity: A Revised Description," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-34, No. 2, February 1986, pp. 213-223.

Akifumi Nakatani, Stephen A. Maas, and Jesse Castaneda, "Modeling of High Frequency MMIC Passive Components," *IEEE MTT-S Digest 1989*, pp. 1139-1142.

Brian Easter, "The Equivalent Circuit of Some Microstrip Discontinuities," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-23, No. 8, August 1975, pp. 655-660.

Mohamad D. Abouzahra, "On the Radiation from Microstrip Discontinuities," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-29, No. 7, July 1981, pp. 666-668.

Peter Benedek and Peter Silvester, "Equivalent Capacitances for Microstrip Gaps and Steps," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-20, No. 11, November 1972, pp. 729-733.

Peter Silvester and Peter Benedek, "Equivalent Capacitances of Microstrip Open Circuits," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-20, No. 8, August 1972, pp. 511-516.

Peter Silvester and Peter Benedek, "Microstrip Discontinuity Capacitances for Right-Angle Bends, T Junctions, and Crossings," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-21, No. 5, May 1973, pp. 341-346.

Alistair F. Thomson and Anand Gopinath, "Calculation of Microstrip Discontinuity Inductances," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-23, No. 8, August 1975, pp. 648-654.

M. Kirschning, R.H. Jansen, and N.H.L. Koster, "Measurement and Computer-Aided Modeling of Microstrip Discontinuities By An Improved Resonator Method," *IEEE MTT-S International Microwave Symposium Digest*, May 31-June 3, 1983, pp. 495-497.

Brian C. Wadell, *Transmission Line Design Handbook*, Artech House, Boston, MA, 1991, pp. 289-330.

K.C. Gupta, Ramesh Garg, Inder Bahl, and Prakash Bhartia, *Microstrip Lines and Slotlines*, Artech House, Boston, MA, 1996, pp. 179-200 and pp. 255-263.

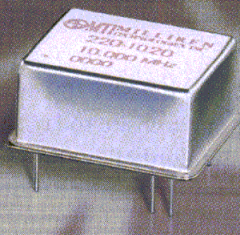
K.C. Gupta, Ramesh Garg, and Rakesh Chadha, *Computer-Aided Design of Microwave Circuits*, Artech House, Boston, MA, 1981, pp. 189-197.

Douglas C. Montgomery, *Design and Analysis of Experiments*, John Wiley & Sons, New York, 1997.

It takes an innovative
R&D team to design
an oscillator so
precise, so reliable
and so small.

It takes a robust
manufacturing facility
to crank out
thousands of them.

Want both?



MTI quartz oscillators are designed for demanding applications. They offer superior reliability and phase noise performance across large, repeatable production quantities. As the first to challenge rubidium devices, we've set the benchmark for size vs. output, and continually meet the tough requirements of Stratum III and IIIe standards. Our modern headquarters in Newburyport, Massachusetts has the team and the equipment to deliver the quantities you need with the performance you demand.

For technical and pricing information visit our web site, or call us toll free at 888-MTI-1101.



MTI-MILLIREN TECHNOLOGIES, INC.

www.mti-milliren.com

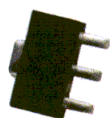
CIRCLE NO. 277



More power equals more freedom.

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

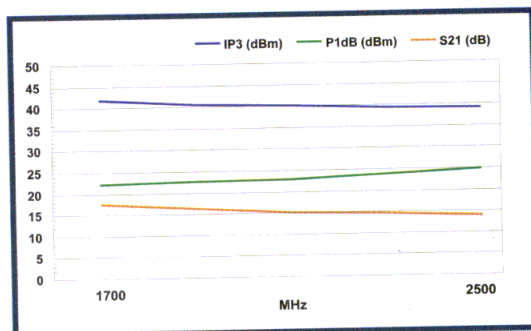
Stanford Microdevices introduces the SXT-289 — the perfect driver amplifier for today's and tomorrow's advanced communication infrastructure equipment.



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

linearity performance in a small form-factor plastic SOT-89 with backside ground.

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



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



www.stanfordmicro.com • 800-764-6642

Software Simplifies Physical Modeling

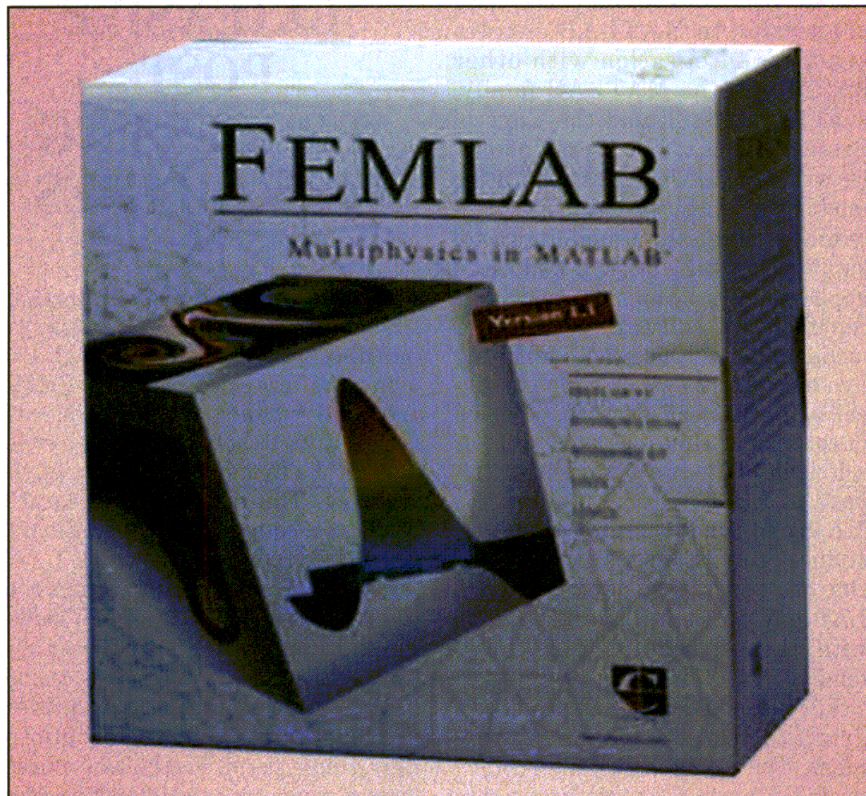
This tool enables users to solve problems in chemical and electrical engineering, structural mechanics, and multidisciplined areas using partial differential equations.

PARTIAL DIFFERENTIAL EQUATIONS (PDEs) ARE THE mathematical foundations for a host of important areas in engineering and physics. Electromagnetics, structural mechanics, fluid dynamics and heat transfer are a few examples of areas that are described with PDEs. FEMLAB from COMSOL, Inc., (Burlington, MA) simplifies the application of PDEs to these complex problems, using the well-established finite-element method of analysis.

FEMLAB (see figure) was designed for PDE-based multiphysics modeling, simulation, parametric analysis, and optimal design on a desktop personal computer (PC)

or Unix workstation. The program is shipped with a large library of predefined models for chemical, electrical, and mechanical engineering.

The equation-based foundation of



FEMLAB is a powerful problem-solving program based on the use of partial differential equations within the MATLAB environment.

Software Simplifies Physical Modeling

the software enables simulation in an extremely broad range of scientific and engineering fields. Some of the application areas include electromagnetics, fluid dynamics, structural mechanics, heat transfer, chemical reactions, semiconductor simulation, and wave propagation. Each mode is based on its particular PDE model. In a physics mode, the desired model can be set up without any explicit formulation of the underlying PDE. The multiphysics capabilities of the program make it possible to combine any set of physics modes and equation-based modes, providing full freedom in modeling. Model libraries include acoustics, chemical engineering, electromagnetic (EM), and equation-based along with fluid dynamics, geophysics and heat transfer. Other libraries include semiconductor device models, structural mechanics, and wave-propagation models.

FEMLAB is designed to run on top of MATLAB from The Mathworks, Inc. (Natick, MA). The close connection to MATLAB enables seamless integration with other products in the MATLAB family, such as Simulink and the Control System Toolbox. For users unfamiliar with MATLAB and its application modules, the basic program is a high-level mathematical modeling tool supported with a host of dedicated applications programs. For example, Simulink is a software package for modeling, simulating, and analyzing dynamical systems. It supports linear and nonlinear systems, modeled in continuous time, sampled time, or a hybrid of the two. Models developed in FEMLAB can be saved as MATLAB functions for parametric studies or iterative design purposes. One can export models to the MATLAB environment for incorporation with other products in the MATLAB family.

For modeling, Simulink provides a graphical block-diagram environment. The Control System Toolbox provides functions specialized to control engineering, and is a collection of algorithms, which implements common control-system design, analysis,

and modeling techniques. By combining FEMLAB with Simulink or the Control System Toolbox, it is possible to use highly accurate models of physical phenomena in the simulations or systems design.

The FEMLAB software allows operators to seamlessly move between an equation-based interface and the physics applications, where models are built using properties that are tailored for the specific application area. Any combination of physics applications and equation-

THE FEMLAB PROGRAM IN COMBINATION WITH MATLAB PROVIDES EXTENSIVE POST- PROCESSING CAPABILITIES.

based applications are supported, thereby providing the freedom of multiple modeling approaches. By using the interface between FEMLAB and Simulink, it is a simple matter to explore these accurate physics models in a dynamic simulation environment. The result is an accurate model of a complex multidisciplinary physics system.

The FEMLAB program brings the power of numerical analysis into multiphysics applications through an interactive interface. Many models can be built through the physical quantities involved, rather than the equations describing them. Users can model intense nonlinear-coupled multiphysics applications with ease. There is no inherent limitation on simultaneous simulation of many physical phenomena. The pro-

gram's solvers handle the conversion to equations and their solution in a fully automated way. Users create models through a graphical user interface (GUI) or by writing custom MATLAB, C, or Fortran code.

The FEMLAB program in combination with MATLAB provides extensive post-processing capabilities. Several solutions can be visualized at the same time using colored surfaces, contours, lines, streamlines, height, and vector field plots. One can save and load models developed in the GUI either as binary code in a model MAT file or as a MATLAB M-code in an M-file.

The FEMLAB application program interface (API) allows users to write MATLAB functions and methods to create customized GUI components for specific applications. The programs large model library contains completed models from different application areas. The models can be used to acquaint one with the programs operation and serve as a starting point for building new models.

The hard-copy documentation furnished with the program is excellent with many examples and tutorials. Included are a users guide and introduction, a reference guide, structural-mechanics guide, an application-interface guide, and a model-library manual. Also included are an automatic-control manual for heat experiments and a computational-electromagnetics manual.

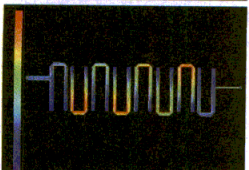
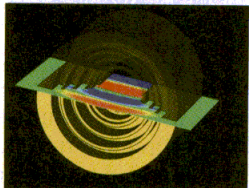
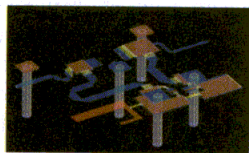
The PC version of the program requires a computer with Windows 95, Windows 98, Windows NT 4.0, or Windows 2000, MATLAB Version 5.3, a minimum of 16-b color graphics capability, and a minimum of 128 MB of random-access memory (RAM). P&A: \$2995 single-user license Windows. **COMSOL, Inc., 8 NE Executive Park, Suite 310 Burlington, MA 01803; (781) 273-3322, FAX: (781) 273-6603, e-mail: info@comsol.com, Internet: <http://www.comsol.com>, <http://www.femlab.com>.**

CIRCLE NO. 525 or visit www.mwrf.com

ALAN ("PETE") CONRAD
Special Projects Editor

SONNET[®] EM[®] SUITE + CST MICROWAVE STUDIO[™] DESIGN SUCCESS

Smart Solutions.



High frequency EM software from Sonnet

Are your high frequency designs taking you to the school of hard knocks? Tired of taking educated guesses on your circuits, packages, antennas, connectors, waveguides or interconnects? Spending too much time on lab experiments for prototyping?

Sonnet can provide you with a world of solutions and support for 3D Planar and Full 3D problems. The Sonnet[®] em[®] Suite has been an industry standard for accuracy and reliability in 3D Planar EM analysis for over 10 years. Today, Sonnet is pleased to offer North American customers the considerable power of full 3D time-domain EM analysis and design through CST MicroWave Studio[™]. Parameterize, analyze and optimize your high frequency 3D designs faster than you dreamed possible. Our Deans of Technical Support will guide you quickly to success...if you even need them.

Smart Solutions Create Successful Designs



www.sonnetusa.com

Sonnet Software, Inc.
toll free: 877/7-SONNET
877/776.6638
phone: 315/453.3096
fax: 315/451.1694
info@sonnetusa.com

MicroWave Studio is a product of CST of America, Inc.

CIRCLE NO. 319

Sonnet[®] and em[®] are registered trademarks of Sonnet Software, Inc.
MicroWave Studio[™] is a trademark of Computer Simulation Technology

CD-ROM Contains Powerful Analysis Tools

This free collection of software tools includes a capacitor modeling software program and a multilayer circuit-design program based on low-temperature-cofired-ceramic (LTCC) foundry services.

CAPACITOR MODELING TOOLS CAN EXPEDITE THE design process for selecting the right capacitor to suit a particular circuit. Version 3 of CapCad is such a tool, and it is offered free of charge as part of a complementary compact-disc-read-only-memory (CD-ROM) software and data collection from Dielectric Laboratories (Cazenovia, NY).

The handy capacitor program determines SPICE parameters and models S_{21} parameters, S_{11} parameters, Z-parameters, Y-parameters, quality factor (Q), or equivalent capacitance for single and multilayer capacitors. Modeling can be performed over temperature or frequency and the results can be saved and exported in standard SPICE (S2P)-file format.

The main toolbar in the CapCad Version 3 contains 11 buttons that provide direct selection of the menu items. The first button will open an existing S2P data file for viewing. The remaining buttons provide the user with a choice of seven capacitor types and a bias-filter-network design. Capacitor types include the company's DiCap, T-Cap, Border Cap, and Gap Cap models, along with many multilayer capacitors. In addition, a miniature RF blocking network and a broadband DC block are available for modeling purposes.

All of the capacitor selection windows allow users to specify selected parameters for a capacitor to be modeled. These include size, voltage rating, material, capacitance, tolerance, and termination impedance. A parameter can be changed by selecting the desired parameter type with a mouse click or by using the tab key, and then selecting a value from the drop-down list. Changing the associated section of a part number will

also change a parameter.

Graphics plots are available for all of the components through the device plot window. The window defines the device for those parameters that are plotted with a choice of rectangular or Smith chart. Any two devices can be plotted for comparison. When two devices are selected, two device plot windows are visible. Device parameter data can be plotted over a frequency range at a fixed temperature or over a temperature range at a fixed frequency.

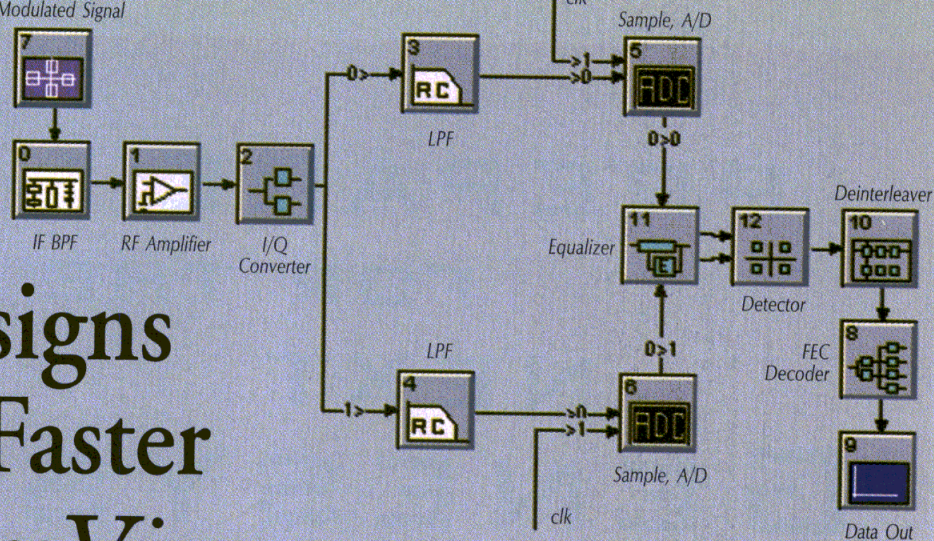
The CD-ROM offers DiPak™ Design Kit, a component model library that interfaces with the Series IV computer-aided-engineering (CAE) design suite from Agilent Technologies (Santa Rosa, CA). These models, with the CAE program, allow operators to design multilayer circuits based on low-temperature-cofired-ceramic (LTCC) foundry services. The DiPak Design Kit contains five libraries of simulation models, layout macros, design-rule-checking functions, schematic symbols, and palette bitmap files. P&A: free. **Dielectric Laboratories, Inc., 2777 Rte. 20 East, Cazenovia, NY 13035; (315) 655-8710, FAX: (315) 655-8179, Internet: <http://www.dukabs.com>.**

CIRCLE NO. 526 or visit www.mwrf.com

ALAN ("PETE") CONRAD
Special Projects Editor

Get Your Comm Designs to Market Faster Using *SystemView*[®]

BY ELANIX



Mixed-Mode Receiver System Simulation

You've tried other software, but you simply haven't found the digital and analog design tools you need in a single integrated environment. Until now. SystemView by ELANIX bridges the gap between digital and analog design. SystemView provides the tools you need to model your complete system, from RF to bits.

■ End to End Comm Systems

Design and test digital/analog communications systems such as CDMA, GSM, DVB, QPSK, and QAM. Includes your choice of error correcting encoders/decoders and modulators/demodulators.

■ Bit-True DSP Design

Supports all major fixed and floating-point processors. Simulates accurately to the bit level. Generates overflow, underflow and carry flags.

■ Distortion-True RF/Analog Design

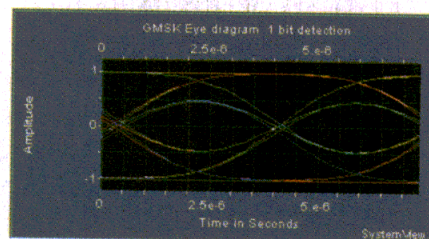
Includes circuit components such as distortion-true mixers, amplifiers, RLC circuits, opamp circuits, etc. Allows creation of complete TX/RX systems, including propagated noise figure.

■ Interface to MATLAB[®]

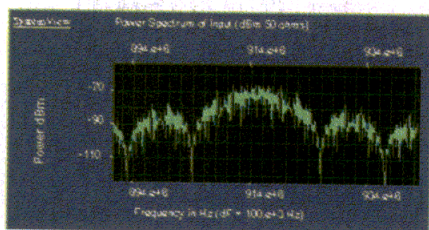
Use the new SystemView M-link[™] option to incorporate MATLAB, Simulink[®] and third party libraries and systems into your SystemView design.

■ Attend a FREE SystemView Design Seminar in Your Area

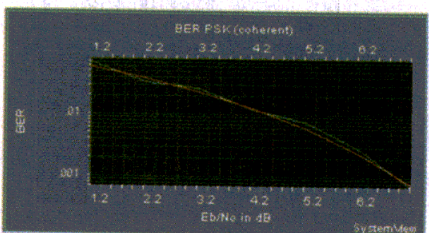
Attend a FREE half-day seminar to see how SystemView can improve time to market and reduce cost. Seminars cover the design flow from algorithm design to implementation, using a QPSK system as the design example. Call Elanix or browse our web site for dates and locations.



GMSK Eye Diagram (1-bit Detection)



Input Power Spectrum



Theoretical vs. Actual BER (Coherent PSK)

What They're Saying About SystemView

"No other program with so much simulation power is as easy to use. When you finish a session with SystemView you realize that you've spent all the time applying engineering principles and none of the time struggling with the computer."

-Richard Chick, MIT Lincoln Labs-

"We use SystemView very heavily, not only in the brainstorming/prototyping stage, but also throughout the development process — right up to the point where we're actually building silicon."

-Steven Hall,
CommQuest Technologies-

"For digital filter design, SystemView was indispensable due to its accurate simulation of the fixed point arithmetic mode employed on the actual DSP processor used in my design."

-Bisla Balvinder,
Itron-

Request or download your FREE evaluation software today:

1-800-5-ELANIX
www.elanix.com



PREPARE FOR THE NEXT GENESYS

Continuing a 15 year tradition of excellence,

Eagleware announces the new version 7 of its

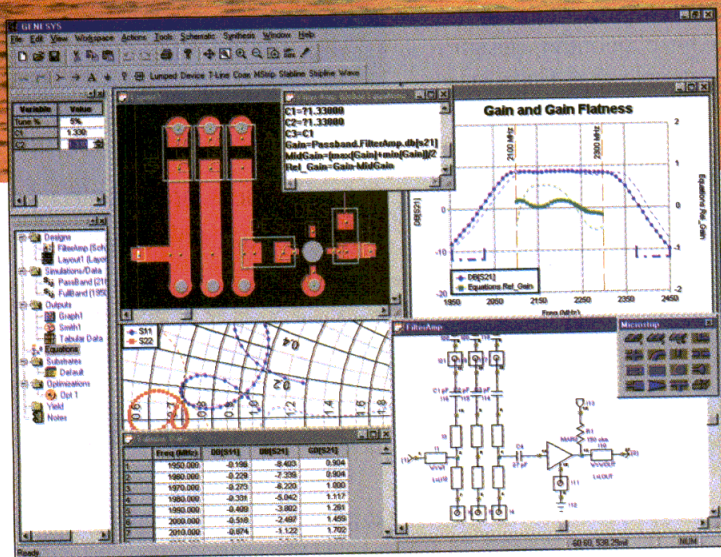
GENESYS software. A new GUI, new multi-layer
capability in the EM simulator, a faster simulation

engine and much more. Now even faster, even

easier and just as affordable. For more

information call us or visit our website at

www.eagleware.com



fast, easy, affordable

EAGLEWARE
RF and Microwave Design Software
tel: 770.939.0156 | fax: 770.939.0157

SPICE Program Sweetened With Features

The latest version of this full-featured SPICE package offers more than 14,000 models and a host of new features, including parameter sweeps and real-time waveform displays.

ANALOG AND DIGITAL DESIGNERS HAVE LONG agreed upon one thing: SPICE is a powerful simulation tool for both types of circuits. SPICE, which is an acronym for simulation program with integrated-circuit (IC) analysis, can be used for frequency- and time-domain analysis of mixed analog and digital circuits and systems. The latest version of IsSpice4 from Intusoft (San Pedro, CA) carries on the tradition of the original Berkeley SPICE program by remaining compatible with standard SPICE files and engines, such as the XSPICE simulator from Georgia Tech (Atlanta, GA). IsSpice4 is bundled with SpiceNet, a schematic-entry program that manages multiple-circuit configurations, and IntuScope, a programmable waveform viewer. The programs, along with more than 14,000 models, are integrated into a seamless package with the help of ActiveX technology from Microsoft.

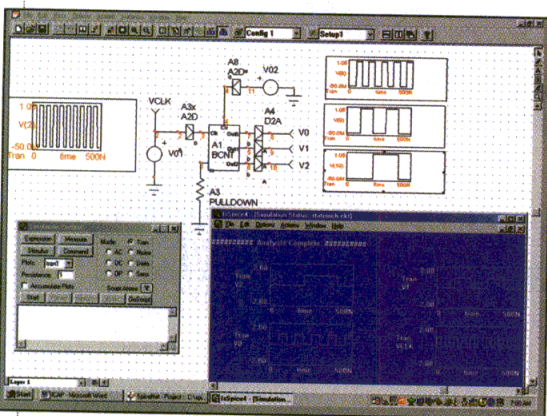
More than 1000 new models have been added to the latest version of the software, including more than 50 new primitive digital elements, such as flip-flops and state machines and a new binary counter (see figure). The program also includes a 12-state logic simulator for simulation of full mixed-signal analog/digital circuits.

Borrowing from the open-architecture XSPICE software, IsSpice4 incorporates new modeling options, including tools using a nonproprietary analog hardware-description language (HDL) based on C language. Similar to traditional SPICE models, the XDL models based on XSPICE (and now IsSpice4) are created with C subroutines. Code describing a model's behavior is linked to the simulator through an external file (Windows DLL)

rather than being bound within the executable program. This allows new models to be added, and old models changed externally, without having to recompile IsSpice4.

The IsSpice4 simulator uses the Microsoft ActiveX technology to provide an automation interface allowing the simulator to be controlled with external scripts as well as the internal scripts implemented in Berkeley SPICE3. Intusoft is the only commercial SPICE vendor that implements and extends the script language introduced with Berkeley SPICE3. This allows IsSpice4 to make and record sophisticated measurements of circuit performance. The measurements include rise time, gain margin, or propagation delay. These automatic measurements are set up and made available to the user through the SpiceNet schematic package.

The simulator itself works by formulating the Kirchoff-current-law (KCL) equations, summing the cur-



THIS SIMULATION SCREEN shows a binary counter.



High Performance and Low Cost Electromagnetic Simulation and Optimization Tools

From: **Zeland Software, Inc.**, 39120 Argonaut Way, Suite 499, Fremont, CA 94538, U.S.A.,
Phone: 510-797-8109, Fax: 510-797-8241, E-mail: zeland@zeland.com, Web: <http://www.zeland.com>

Products:

IE3D Planar and 3D Electromagnetic Simulation and Optimization Package

FIDELITY Time-Domain FDTD Full 3D Electromagnetic Simulation Package

Applications:

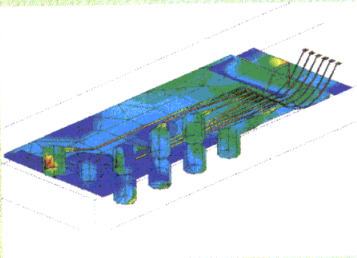
Microstrip, CPW, striplines, suspended-strip lines, coaxial Lines, rectangular waveguides, high speed digital transmission lines, 3D interconnects, PCB, MCM, HTS circuits and filters, EMC/EMI, wire antennas, microstrip antennas, conical and cylindrical helix antennas, inverted-F antennas, antennas on finite ground planes, and other RF antennas.

Features:

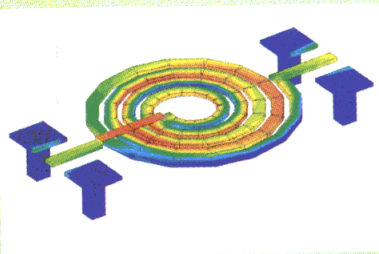
- MS-Windows graphic interface for interactive construction of geometry
- High efficiency and flexibility MOM and FDTD simulation engines
- Non-uniform automatic meshing and de-embedding
- Modeling 3D metallic and dielectric structures
- Built-in robust and efficient electromagnetic optimization
- Accurate modeling of metallic thickness, thin substrate and lossy dielectric materials
- Mixed electromagnetic simulation and nodal analysis for large scale simulation
- Cartesian and Smith Chart display of S-, Y- and Z-parameters, VSWR
- RLC parameter extraction compatible with SPICE
- 2D and 3D display of current distribution, radiation patterns and near field
- Calculation of antenna and scattering parameters including directivity, efficiency and RCS
- Current and near field animation

IE3D Simulation Examples and Display

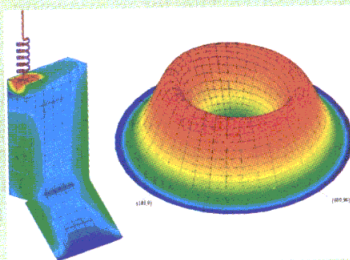
The current distribution on an AMKOR SuperBGA model at 1GHz created by the IE3D simulator



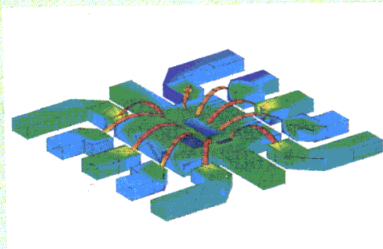
IE3D modeling of a circular spiral inductor with thick traces and vias



The current distribution and radiation pattern of a handset antenna modeled on IE3D

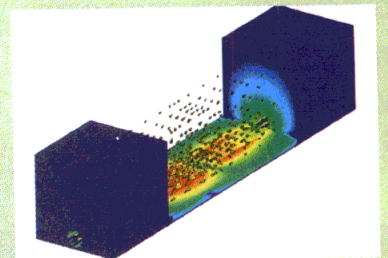


IE3D modeling of an IC Packaging with Leads and Wire Bonds

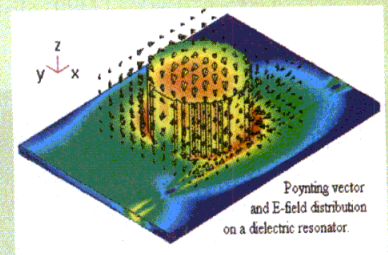


FIDELITY Examples

The near field and Poynting vector display on a packaged PCB structure with vias and connectors



FIDELITY modeling of a cylindrical dielectric resonator and the Poynting vector display



Zeland Software, Inc. provides excellent technical support and services.

Zeland Software, Inc. is also the north American exclusive representative for the LINMIC product from Jansen Microwave GmbH

SPICE Program Sweetened With Features

rents at each node in a network, and setting the result equal to a constant. This admittance matrix is modified in SPICE3 to set the independent voltage sources and in XSPICE to contain state variables. The matrix itself is referred to as a modified-nodal-admittance (MNA) matrix. For DC and operating-point analysis, the MNA matrix solution is iterated, and the new MNA values are recomputed for each iteration until a stable result is achieved. Certain circuits, such as flip-flops, can cause the simulator to oscillate between stable solutions. When this happens, the simulator uses certain heuristic techniques to stabilize itself.

For transient solutions, it is necessary to linearize a circuit about its nonlinear operating point at each time point. The dynamic circuit changes with time are accounted for by iterating the solution until the error estimate at the next time point is less than a preset amount. IsSpice4 uses several techniques to reduce the computational load, including forward prediction of the states and node voltages for the next time step and bypassing of the matrix-load operation for parts that have little or no change in their inputs.

AC analysis is considerably simpler. Once the operating point is established, a small-signal equivalent circuit is created and a single matrix solution is performed for each frequency. Since no iterations are required, the solution is exact, other than for errors created by the finite computer word length. AC analysis is therefore more precise and faster than transient analysis.

IsSpice4 is designed to work with SpiceMod, a SPICE modeling spreadsheet to create an unlimited number of SPICE models from a manufacturer's data sheets. SpiceMod produces accurate models that can be used with any Berkeley SPICE compatible program. SpiceMod is also integrated with ICAP/4, Intusoft's analog and mixed-signal circuit-design system. The models and subcircuits created in SpiceMod can be immediately used in SpiceNet

schematic diagrams and IsSpice4 circuit simulations. The software documentation is excellent with easy-to-follow instructions and examples. P&A: \$2984 and up; stock. **Intusoft, P.O. Box 710, San Pedro, CA 90733-0710; (310) 833-0710, FAX:**

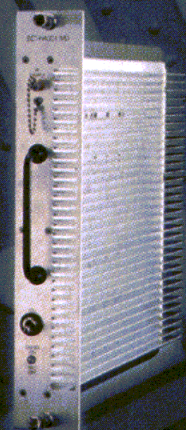
(310) 833-9658, e-mail: info@intusoft.com, Internet: <http://www.intusoft.com>.

CIRCLE NO. 527 or visit www.mwrf.com

ALAN ("PETE") CONRAD
Special Projects Editor

35 W PCS CDMA Power Amplifiers

Choose REMEC Q-bit as part of your Total Microwave Solution

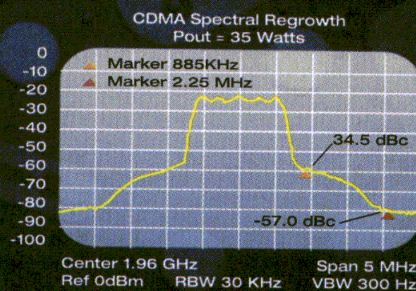


QBS-950



QBS-951

Frequency	1930 - 1900 MHz
Gain	39.5 ± 1.0 dB
VSWR In	1.6:1
VSWR Out	1.3:1
P1dB	45.4 dBm
Current	18000 @ 35 W CDMA
Voltage	+28 V
Temperature	0°C to +60°C



The Total Microwave Solution

Email inquiries to sales@remecq-bit.com
Visit our website at www.remecq-bit.com

1-800-226-1772

REMEC Q-bit, Inc.
2144 Franklin Drive
Palm Bay, FL 32905-4021
Fax 321.727.3729

REMEC
Building solutions
through teamwork.

CIRCLE NO. 421 or visit www.mwrf.com

System-Design Tool Augments Model Libraries

The latest edition of a powerful system-level software tool includes new communications function libraries along with contributions from numerous partners.

MILITARY AND COMMERCIAL SYSTEM DESIGNERS have found a useful tool in SystemView from Elanix (Westlake Village, CA). Since its introduction in 1991, this computer-aided-engineering (CAE) package for the personal computer (PC) has been used to model the behavior and performance of major systems. Now, the latest version of the package (Version 4.5) adds an advanced communications library to help designers of next-generation systems.

SystemView (see figure) incorporates functions and model libraries that allow users to design and develop advanced systems based on analog, RF, digital, and logic functions. Designs can include custom or predefined signal sources, external data files, or even real-time data. SystemView can readily model any of the advanced modulation formats used in modern communications systems, including frequency-shift-keying (FSK) modulation, quadrature-phase-shift-keying (QPSK) modulation, quadrature amplitude modulation (QAM), time-division-multiple-access (TDMA) schemes, and code-division-multiple-access (CDMA) schemes.

Version 4.5 of SystemView adds functions useful to engineers involved in CDMA system design, including a new Walsh code generator, encoder, and decoder. Plus/minus limit parameters have also been added to all opamp circuits, and an inductive-capacitive (LC) lowpass-filter model allows operators to design elliptical filters.

SystemView now con-

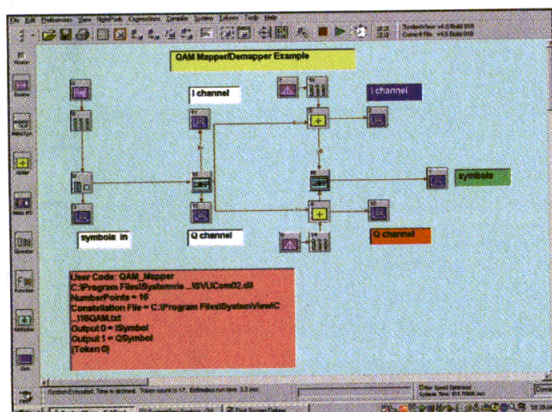
tains the Real Time DSP Architect (RTDA), a software module which links with the Code Composer Studio development environment from Texas Instruments (Dallas, TX). This development environment and the RTDA include support for the TMS320C54x family of digital signal processors (DSPs), including the TMS320C59 and 5410 evaluation boards.

SystemView 4.5 includes integration with design tools from Xpedition Design Systems (Santa Clara, CA). Release 4.5 also includes new third-generation (3G) wireless design software developed in partnership with EnTegra Ltd.

This release of the software also includes a powerful digital-subscriber-line (DSL) analysis tool. The DSL software library enables developers of asymmetric DSL (ADSL), Second Generation High Data Rate DSL (HDSL-2), and related copper (Cu)-pair modems to easily test their designs. **Elanix, Inc., 5655 Lindero Canyon Rd., Westlake Village, CA 91362; (800) 535-2649, FAX: (818) 597-1427, e-mail: elanix@elanix.com, Internet: <http://www.elanix.com>.**

CIRCLE NO. 528 or visit www.mwrf.com

*ALAN ("PETE") CONRAD
Special Projects Editor*



A TYPICAL DESIGN SCREEN in SystemView includes symbolic tokens to represent various component and system functions and sources.

High Performance

RF & Microwave Signal Processors



HIGH IP3

With the introduction of the Synergy High IP3 series, Synergymicrowave Corporation has taken the industry by storm. This new series of mixers, couplers, and filters is designed to provide the highest level of performance in the industry. The High IP3 series is available in a wide range of power levels, from 10W to 100W, and is designed to provide the highest level of performance in the industry. The High IP3 series is available in a wide range of power levels, from 10W to 100W, and is designed to provide the highest level of performance in the industry.

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

MIXERS

HIGH POWER

COUPLERS

TRANSFORMERS

FILTERS

COUPLERS

SYNTHESIZERS

SPLITTERS COMBINERS

MODULATORS

FRACTIONAL N

SYNTHESIZERS

division N

fractional

SYNERGY

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

For more information, contact Synergymicrowave Corporation at (973) 881-8800 or visit our website at www.synergymicrowave.com.

SYNERGY MICROWAVE CORPORATION
201 McLEAN BOULEVARD, PATERSON, NJ 07504
(973) 881-8800 FAX (973) 881-8361
E-MAIL: sales@synergymicrowave.com
WEB SITE: www.synergymicrowave.com

201 McLean Boulevard, Paterson, NJ 07504
Tel: (973) 881-8800 Fax: (973) 881-8361
E-mail: sales@synergymicrowave.com
Web Site: www.synergymicrowave.com

Math Program Adds Functions, Toolboxes

This widely used mathematical modeling program has added useful new functions as well as some optional toolboxes for communications systems and components.

MATHEMATICS IS THE BASIS FOR MOST HIGH-FREQUENCY analyses. It is also the basis for a software tool widely used by high-frequency design engineers, MATLAB from The MathWorks (Natick, MA). The latest version of this program offers an improved user interface, a number of enhancements, and several new optional toolboxes.

The latest version of MATLAB offers new features for enhanced support for integer data types. The program features reduced storage requirements and a new plot editor for interactive modification of figure properties and plot annotation. It also offers support for the new NASA standard Hierarchical Data Format-Earth Observing System (HDF-EOS) code. The program includes gateways to grid, point, and swath objects, support for reading and writing Portable Network Graphics (PNG) images, a suite of visualization functions for volumetric data, differential-equation solvers for mass matrices, a revamped, browser-based M-file profiler, and the capability to generate summary reports in HTML format.

MATLAB includes hundreds of functions for data analysis and visualization, numeric and symbolic computation, engineering and scientific, graphics, modeling, simulation, prototyping, programming, application development, and graphical-user-interface (GUI) design. Combined with the optional toolbox, Simulink, the program provides users with an interactive tool for modeling, simulating, and analyzing dynamic systems.

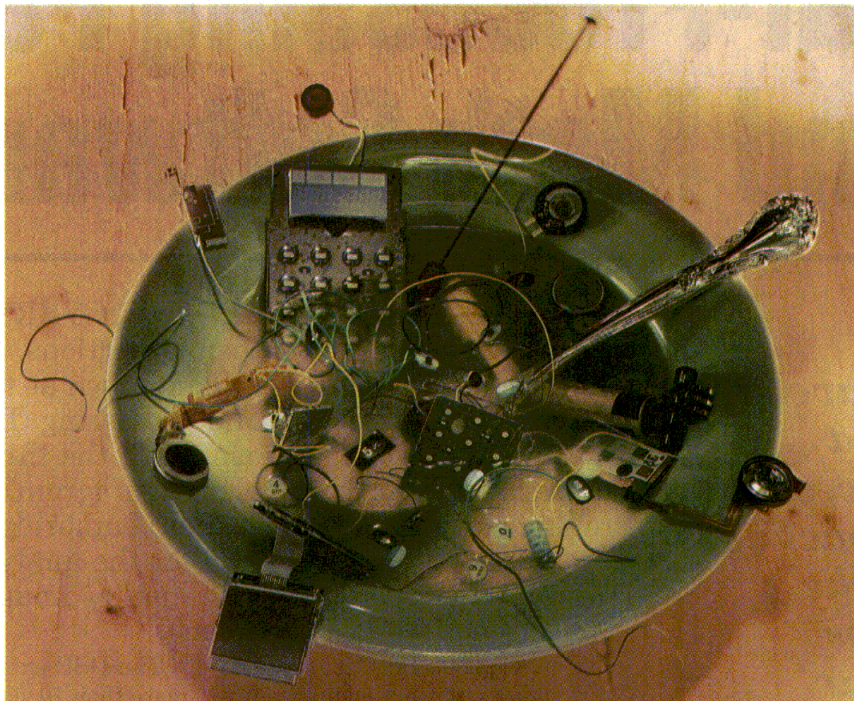
Simulink is also the host for additional toolboxes. These additional toolboxes include a quantized-filtering toolbox and a signal-processing

toolbox. The former provides extensible design, analysis, and prototyping tools for fixed-point and custom precision floating-point filters used in digital-signal-processing (DSP) applications. It supports the simulation and bit-true analysis of these filters with a wide range of precision. In addition, a code-division-multiple-access (CDMA) reference blockset is available for Simulink. It contains a collection of Simulink blocks for creating and simulating the CDMA IS-95A standard systems for wireless communications.

A graphical event-driven simulation with stateflow capability allows an operator to graphically model event-driven behavior within Simulink. Stateflow simplifies the simulation of protocols, synchronization loops, and control-logic signals that activate the time-driven datapath components of complex signal-processing and communications systems. Other toolboxes are available for control design and analysis as well as additional signal and image processing. P&A: \$1900 (MATLAB basic); stock. **The MathWorks, Inc., 3 Apple Hill Dr., Natick, MA 01760-2098; (508) 647-7000, FAX: (508) 647-7101, Internet: <http://www.mathworks.com>.**

CIRCLE NO. 529 or visit www.mwrf.com

ALAN ("PETE") CONRAD
Special Projects Editor



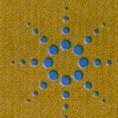
With the right software, you could avoid design integration problems.

When design teams can't communicate across design disciplines, it's a recipe for trouble. Today's competitive marketplace demands that engineers work together using the same platform across DSP, analog and RF. Agilent Technologies' Advanced Design System Software helps optimize your design process by letting you do just that.

Advanced Design System Software allows multiple design teams to co-simulate and co-design in an integrated environment—using the same interface and database. Design collaboration decisions happen easily and early in the development process. Plus, design data can be shared between vendors, customers, and design partners, enabling seamless data transmission.

All of this will help eliminate problems at integration time. That's no small benefit, considering you'll reduce iterations, time to market, costs and grief. Because we know you're always hungry for ways to be more competitive.

www.agilent.com/find/integrated-eda

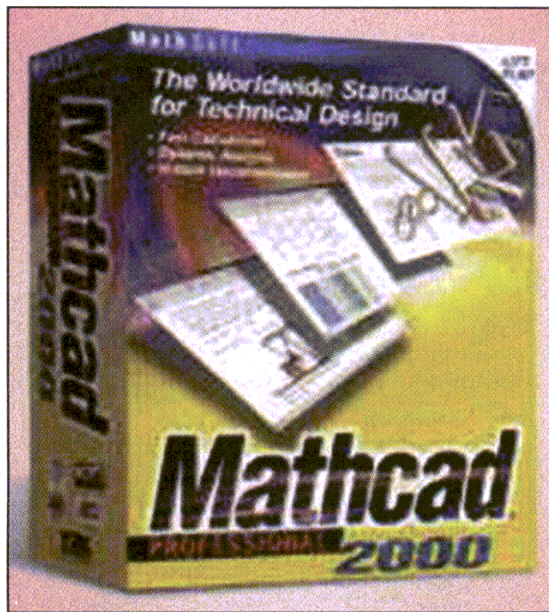


Agilent Technologies

Innovating the HP Way

Signal-Processing Packs Extend Math Software

A trio of wavelet-, image-, and signal-processing extension packages enhances the capabilities of a popular mathematics-based analysis software tool.



MATHCAD 2000 PROFESSIONAL can be equipped with a number of new extension packs, including modules for image processing, DSP, and wavelets.

MATH SOFTWARE IS USED FOR EVERYTHING FROM financial analysis to weather predictions. It is also useful for solving engineering problems such as the analysis and development of digital-signal-processing (DSP) algorithms for communications systems. With the three latest extension packages, the powerful math program, MathCAD 2000 Professional from MathSoft, Inc. (Cambridge, MA) becomes a creative and analytical tool for the analysis of advanced DSP functions, for the processing of images, and for the application of wavelet functions.

MathCAD 2000 Professional (see figure) offers a user-friendly environment for accurately solving and analyzing a broad array of technical problems. The software offers advanced math functionality and visualization capabilities to perform the most demanding calculations quickly and easily. Proprietary IntelliMath™ technology automates common routines for increased speed and productivity. MathCAD 2000 allows operators to integrate text, math, and graphics into a single worksheet to easily visualize and annotate complex calculations.

MathCAD 2000 Professional's unique "live" interface automatically updates results, with minimal recalculation work. The program features easy-to-use equation entry and editing based on standard mathematical notation (rather than command-line programming), plus automatic unit conversion.

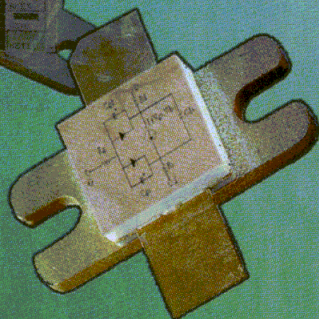
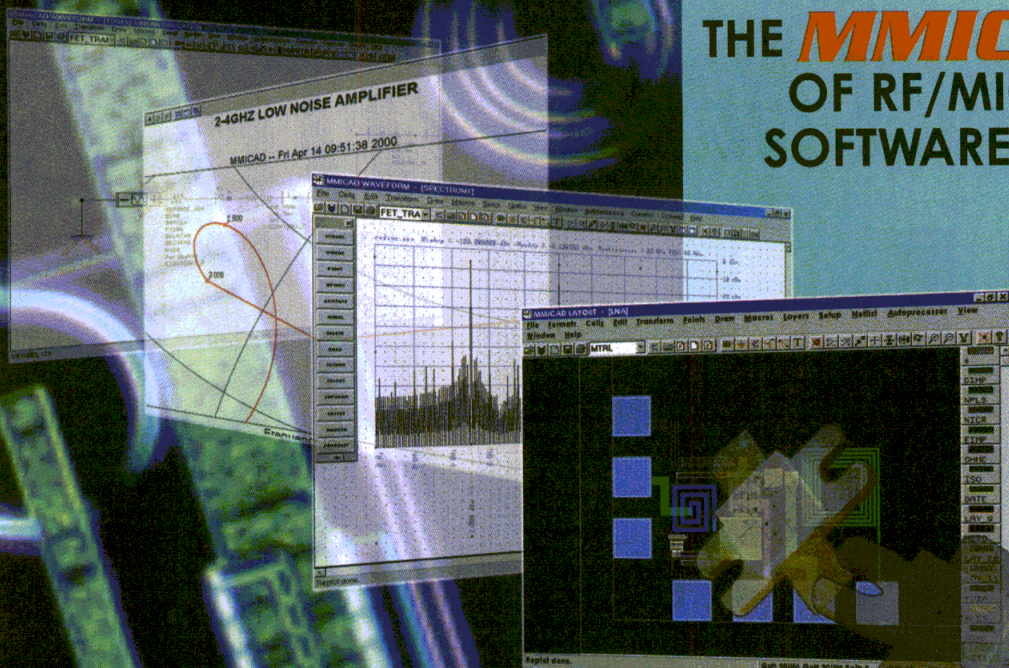
The DSP extension pack includes more than 70 signal-processing functions suited for audio and high-frequency electronics analysis as well as in telecommunications system analysis. A companion extension pack for wavelets features more than 60 wavelet functions that cover five orthogonal and biorthogonal families for use in signal reconstruction, noise reduction, data compression, and special numerical methods.

The image-processing extension pack, with more than 140 image-processing functions, provides a powerful solution for iterative exploration and investigative analysis. With its extensive image processing, analysis, and visualization capabilities, this extension pack is ideal for research scientists and engineers, design engineers, system analysts, and image specialists working on imaging or multimedia product development. P&A: \$499.00; stock. **MathSoft, Inc., 101 Main St., Cambridge, MA 02142-1521; (617) 577-1017, FAX: (617) 577-8828, Internet: <http://www.mathsoft.com>.**

CIRCLE NO. 530 or visit www.mwrf.com

ALAN ("PETE") CONRAD
Special Projects Editor

THE **MMICAD™** SUITE OF RF/MICROWAVE SOFTWARE SOLUTIONS



- Schematic Capture
- Linear Circuit Simulation
- Time Domain Transient Simulation
- Filter Synthesis
- Layout
- Data Acquisition
- Test Equipment Control
- Yield Analysis
- Small & Large Signal Modeling



MMICAD

...the right tool for the job

OPTOTEK

62 Steacie Drive • Kanata, ON • Canada K2K 2A9

Tel: 613-591-0336 • Fax: 613-591-0584

sales@optotek.com • www.optotek.com

CIRCLE NO. 304

EE Product News Offers

ON-LINE

*Reader
Service!*



Vendor Instant Access

Visit the *EE Product News* website and take advantage of **VIA** (Vendor Instant Access).

With VIA, you can request information from vendors appearing in *EE Product News* by **e-mail, mail, phone, fax, or by linking directly to the vendors' website!**

www.eepn.com

Designing VCOs and their buffers

Voltage-controlled oscillators (VCOs) are the tunable frequency sources widely used in communications receivers. An application note (AN1034) from California Eastern Laboratories (Santa Clara, CA) reviews the process by which designers choose their VCO topologies based on performance, size, and DC power requirements, and even provides a design example at 1.7 GHz using the company's UPA series of dual transistors.

The UPA series of silicon (Si) transistors mount two chips within a common six-pin surface-mount plastic package. The devices can be used as dual transistors or in a cascode configuration. One of the applications for the devices is for a VCO and buffer amplifier for cellular-telephone frequency synthesizers. In this type of application, the VCO must exhibit low phase noise in order to meet the requirements for digital modulation and bit-error rate (BER). The VCO must also operate on low supply voltages (below +3.5 VDC). The buffer amplifier is required to boost output power and provide load-pull isolation.

The UPA827TF is a member of the UPA family chosen for this VCO design. It provides low-noise performance past 3 GHz and features a gain-bandwidth product in excess of 12 GHz, which is more than enough for an L-band oscillator.

The application note follows the basic rules of low-noise oscillator design set forth by Ulrich Rohde in his fine article "Designing Low-Phase-Noise Oscillators" (from *QEX* magazine, October, 1994). The rules include: 1. Maximize the loaded quality factor (Q) of the tuned circuit in the oscillator; 2. Choose an active device that has a low-flicker corner frequency; 3. Maximize the power at the input of the oscillator; 4. Choose a varactor diode with a low equivalent noise resistance; and 5. Keep the voltage tuning gain to the minimum value required.

The application note reviews the choice of topology for the VCO design, using nonlinear circuit simulations to analyze the choices, as well as the choice of resonator, which turns out to be a coaxial resonator. A nonlinear model for the coaxial resonator is developed with the help of a free computer program called COAX available from Trans-Tech, Inc. (<http://www.trans-techinc.com>, Adamstown, MD).

The application note is available for download from the company's website at <http://www.cel.com> or free upon request from: **California Eastern Laboratories, Inc., 4590 Patrick Henry Dr., Santa Clara, CA 95054-1817; (408) 988-3500, FAX: (408) 988-0279, Internet: <http://www.cel.com>.**

CIRCLE NO. 194 or visit www.mwrf.com

Applications suit a 40-GHz coaxial connector

Wideband applications require wideband interconnections. The K connector from Anritsu Co. (Morgan Hill, CA) is one such broadband interconnection, with a range in excess of DC to 40 GHz. It is compatible with other connector types including 3.5-mm and SMA connectors. An application note details the performance of the connector and applications for different configurations of the connector system. The application note is available free of charge from Anritsu Co. as part of a product catalog, "Precision RF & Microwave Components."

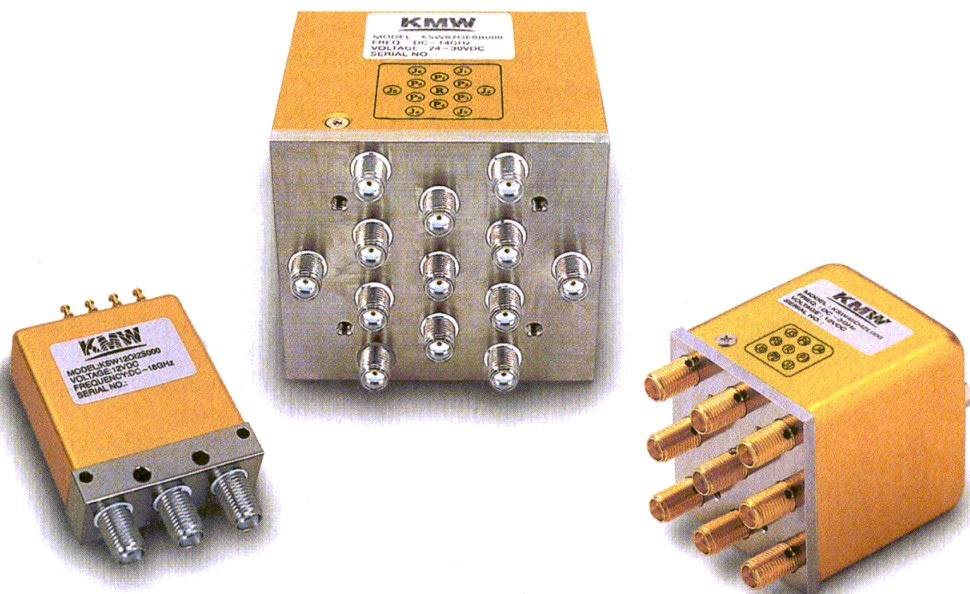
The K connector was first introduced in the early part of the 1980s. It brought continuous frequency coverage from DC to 40 GHz in a single interconnection, whereas components and systems had previously relied on more narrowband (26.5 to 40 GHz) waveguide interconnections to pass signals into and out of components. The K connector employs a precision glass bead in its launcher assembly that is appropriate for use with designs fabricated on soft Duroid as well as hard ceramic alumina substrates. The bead has a unique 0.30-mm center conductor that introduces minimal discontinuities, yielding better than 20-dB return loss at 40 GHz and better than 25-dB return loss below 18 GHz.

The K connector launchers do not rely on an epoxy pin to secure the center conductor, as commonly used in SMA connectors. Without the epoxy pin, the outer conductor remains solid, eliminating the leakage path common to pin-captivated coaxial connector designs. The K connector is available in a variety of configurations, including screw-in and flange-mount designs for use with packages and enclosures, and cable-mounted connectors.

For more on the K connector, ask for a copy of the product catalog. Copies of the catalog and its application note are free, from: **Anritsu Co., Microwave Measurements Div., 490 Jarvis Dr., Morgan Hill, CA 95037-2809; (800) ANRITSU, Internet: <http://www.anritsu.com>.**

CIRCLE NO. 195 or visit www.mwrf.com

Designed for Ultimate Quality



Your Complete Switching Solution from KMW

■ 6P7T switch is designed for IMT2000 (6-sector Redundancy)

Product Code No.	KSW120I2S000	KSW6704AB001	KSW45048L000
Switch Type	SPDT	6P7T	4P5T
Frequency Range	DC ~ 18GHz	DC ~ 3GHz	DC ~ 3GHz
Insertion Loss (Max.)	0.2 ~ 0.5dB	0.2dB	0.2dB
VSWR (Max.)	1.15:1 ~ 1.5:1	1.15:1	1.15:1
Isolation (Min.)	80 ~ 60dB	80dB	80dB
Operating Mode	TTL Latching with IND.	Latching with IND.	Latching
Actuating Voltage /Current (Max.)	12Vdc \pm 10% /240mA (@12Vdc, 25°C)	20 ~ 30Vdc /95mA (@24Vdc, 25°C)	24 ~ 30Vdc /85mA (@26Vdc, 25°C)
I/O Port Connector	SMA(F) / SMA(F)	SMA(F) / SMA(F)	SMA(F) / SMA(F)
RF Power Handling	100W CW (@1GHz)	200W CW (@1GHz)	250W CW (@1GHz)
Dimension (inch)	1.339*1.575*0.528	2.441*2.043*2.177	1.626*1.874*1.626

Higher Frequency available on Multi-Pole Multi-Throw, up to 18GHz

Power Handling capability of 4P5T Switch, up to 250W CW & 4Kw Peak @1GHz

Slim type 6P7T Switch, 2.409*1.417*2.216 (inch), also available.

■ Available Options

Internal Termination, Indicator Circuitry, Suppression Diode, TTL Logic, Self De-Energizing Circuitry, Various I/O Connector type, Other Operating Voltage

■ 5 million life cycle SPDT switch is available now.



13131 East 166th Street, Cerritos, CA 90703-2202
1-800-8320-KMW • www.kmwinc.com
tel: 562-926-2033 • fax: 562-926-6133
CIRCLE NO. 276

KMW
RF & Microwave Products

Technology Delivers High-Performance Components

A simple multilayer concept, yielding high performance and low cost, has been developed to shrink the many building-block components of RF front ends.

Synergy Engineering Staff

Synergy Microwave Corp., 201 McLean Ave., Paterson, NJ 07504; (973) 881-8800, FAX: (973) 881-8361, e-mail: sales@synergymwave.com, Internet: <http://www.synergymwave.com>.

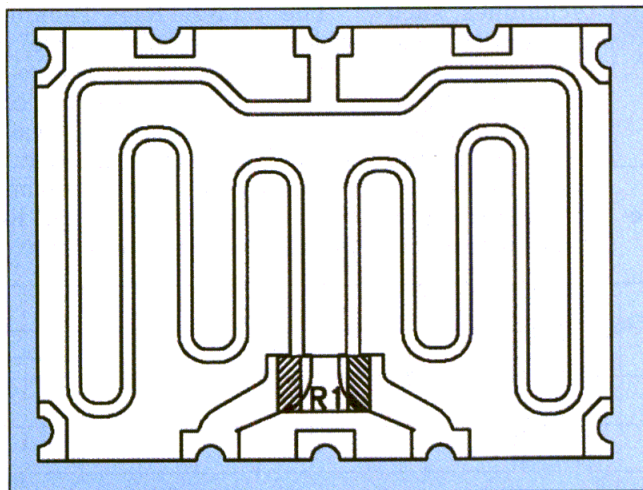
MINIATURIZATION drives many high-frequency designs. Compact components are needed not only to make handsets smaller and power efficient, but also to make infrastructure equipment, such as line-of-sight radios and cell sites, as unobtrusive as possible. After evaluating the many transmission-line approaches available to them, the engineers at Synergy Microwave Corp. (Paterson, NJ) chose to develop one of their own, a patent-pending approach to high-frequency circuitry known as SYNSTRIP® Technology. The technology has already been applied to the fabrication of extremely compact power dividers/combiners and broadband high-frequency mixers in support of the high-frequency drive for miniaturization.

The demands for smaller wireless systems require smaller RF/microwave function blocks without compromising performance. A key is to realize the ultimate design through cost-effective fabrication techniques. A variety of planar trans-

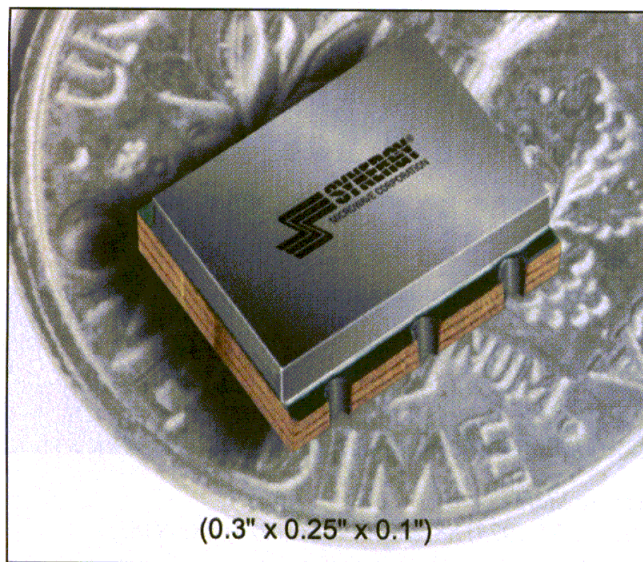
mission structures are available for high-frequency designers attempting to develop miniature surface-mount components. These structures include microstrip, stripline, suspended stripline, and coplanar waveguide. Substrate materials with high dielectric constants as well as multilayered circuit approaches have also been attempted in efforts to achieve true miniaturization of RF/microwave components. RF/microwave multilayer technology is considerably different from conventional multilayer approaches associated with, for example, personal computers (PCs), in that it is necessary to extensively model the layers in an RF/microwave design, including the polyamide layer that separates the transmission-line layers.

Fortunately, the advent of three-dimensional (3D) electromagnetic (EM) simulation software is making the task to a great extent simpler to the designer. However, in a commercial market, the chosen technology should ultimately lead to smaller size through standard low-cost fabrication processes that assure a high degree of repeatability and provide the required performance.

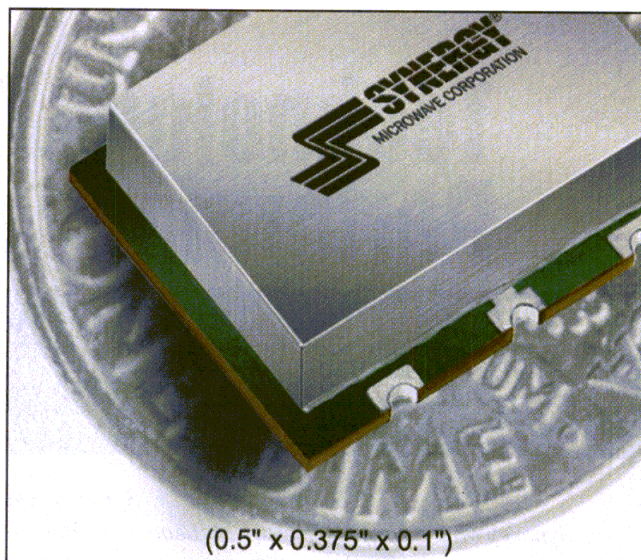
SYNSTRIP Technology provides an ideal



1. This is a conventional layout for a two-way power splitter for cellular-band applications designed with microstrip.



2. Two-way power splitters for the GSM cellular band and the PCS band were developed with the new SYNSTRIP Technology.



3. This four-way power splitter was developed for applications from 1800 to 2200 MHz using the new SYNSTRIP Technology.

solution to this pressing problem. The technology has led to the realization of miniature power splitters and

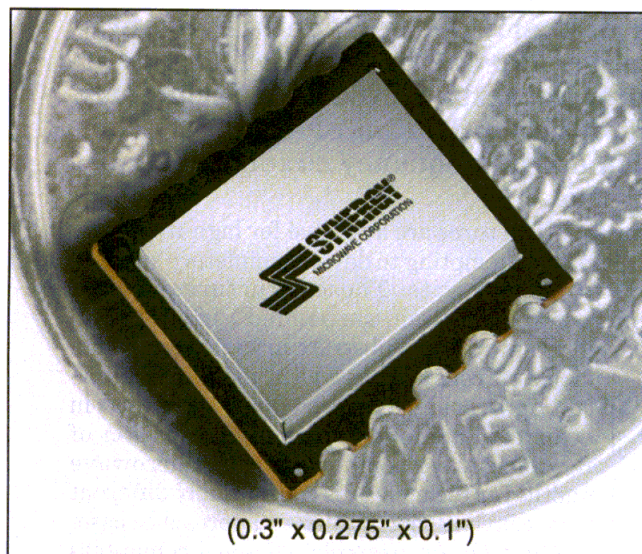
broadband RF/microwave mixers with high levels of performance. The circuits are fabricated on low-cost, ceramic-filled soft substrates using standard printed-circuit-board (PCB) fabrication processing.

The salient feature of Synergy's SYNSTRIP Technology is that it has brought about a fusion of well-known planar transmission-line techniques, such as microstrip and stripline. RF/Microwave energy propagation in a "mixed mode" is the key to achieving a reduction in size

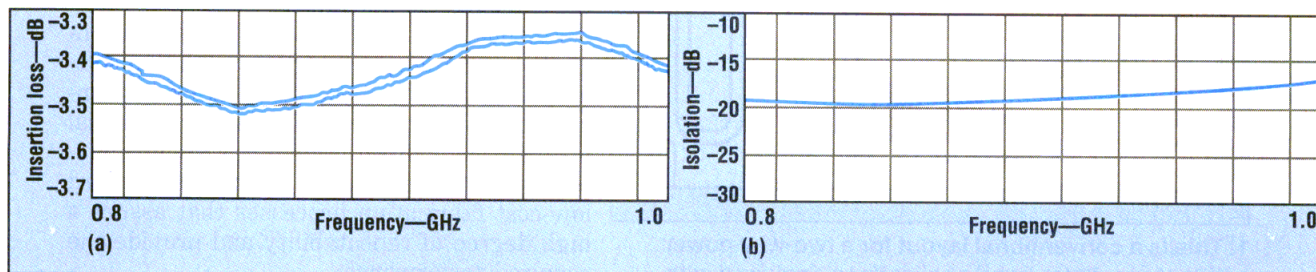
without sacrificing performance. Figure 1 shows the layout for a two-way power splitter for cellular-band applications designed with conventional microstrip. The smallest size possible with this approach is 0.5×0.375 in. (1.27×0.95 cm). The meandering lines are evident at a number of points, leading to coupling between lines and resulting in discontinuities (and degradation in performance). In order to achieve reasonable performance, the coupling effects must be accurately modeled and accounted for in the final design.

MIXED MODE

The SYNSTRIP Technology, which uses the "mixed-mode" propagation concept, eliminates these problems. The mixed-mode concept enables a designer to optimally distribute a circuit in different layers involving different transmission media. The meandering of lines is greatly reduced, thereby avoiding

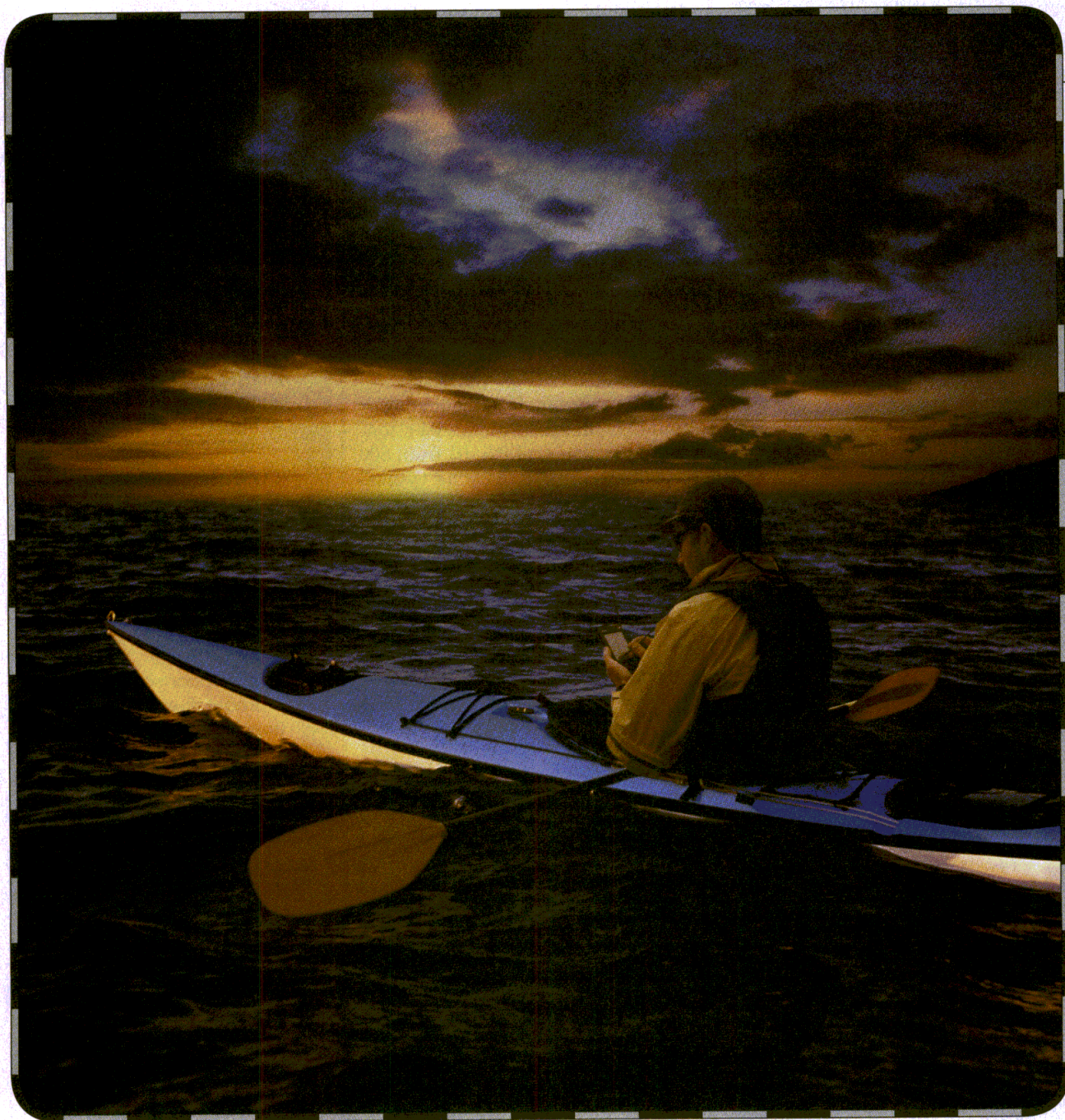


4. The SYNSTRIP Technology was used to create an extremely compact balun design for broadband double-balanced RF/microwave mixers.



5. The measured performance of the two-way power splitter is well suited for cellular and PCS applications.

He just placed a market order.
But got bread and milk instead. Isn't 3G great?



COMPUTING
TELECOM
VIDEO



Mobile Equipment Test Tools Is it the air interface? The signaling interface? As you design the latest network elements, look to us for a complete family of test tools that ensure they make great connections. In fact, our mobile infrastructure tools have successfully tested fast packets in 2.5G GPRS technology, time and again. Want to avoid getting your signals crossed? Call 800-426-2200 x3054 or visit www.tektronix.com/3G

Tektronix®

©2000 Tektronix, Inc. All rights reserved. Tektronix and the Tektronix logo are registered trademarks of Tektronix, Inc. All others are properties of their holders.

CIRCLE NO. 300

MICROWAVE SOLUTIONS Stocked Amplifiers

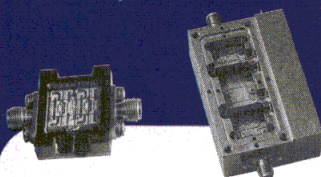
Microwave Solutions is now offering the following amplifiers as stocked products. Same day shipment on orders received by 5PM EST, upon credit approval.

FEATURES:

- ⇒ Voltage Regulation
- ⇒ Reverse Polarity Protection
- ⇒ RF Open/Short Circuit Protection
- ⇒ Unconditionally Stable
- ⇒ Competitive Pricing
- ⇒ Quick Delivery

APPLICATIONS:

- ⇒ Test and Setup Systems
- ⇒ Satellite Tracking
- ⇒ VSAT & EW Systems
- ⇒ Radar or Point-to-Point Terrestrial
- ⇒ Communication Systems

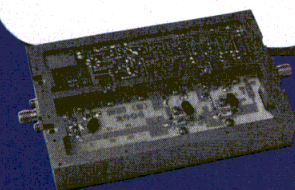


Model:	MSH-4573301-DI	MSH-5455402-DI
Freq.:	2.0-6.0GHz	4.0-8.0GHz
Gain:	32.0dB min.	26.0dB min.
N.F.:	3.5dB max.	6.0 dB max.
	2.0 dB Typ.	
Pout:	+12.0dBm min.	+20.0dBm min.
VSWR:	2.0:1/2.0:1	2.0:1/2.0:1
DC Pwr.:	+12VDC@150mA	+12 VDC@150mA

Model:	MSH-6343408-DI	MSH-7264401-DI
Freq.:	8.0-12.0GHz	8.0-18.0GHz
Gain:	23.0dB min.	16.0dB min.
N.F.:	3.0dB max.	5.0dB max.
	2.0dB Typ.	3.5dB Typ.
Pout:	+18.0dBm min.	+16.0dBm min.
VSWR:	2.0:1/2.0:1	2.0:1/2.0:1
DC Pwr.:	+12 VDC@150mA	+12VDC@130mA

Model:	MSH-6546602	MSD-3488401-TTL
Freq.:	8.0-12.0GHz	.05-3.0GHz
Gain:	34.0dB min.	30.0dB min.
N.F.:	4.0dB max.	10.0dB max.
	3.0dB Typ.	
Pout:	+30.0dBm min.	+30.0dBm min.
VSWR:	2.0:1/2.0:1	2.0:1/2.0:1
DC Pwr.:	+15 VDC@1.13A	+15 VDC@1.0A

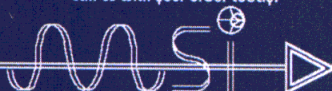
⇒ Pout is measured at 1dB Compression Point.



To compete in today's Global market, MSI continues to offer affordable, highly reliable, military and commercial state-of-the-art amplifiers.

Today, our mission remains the same - To supply the highest quality microwave components at the lowest possible price.

Call us with your order today!



Microwave Solutions, Inc.

National City, CA 91950
1-800-9MSI-AMP Fax: (619) 474-7003
e-mail: sales@microwavesolutions.com
http://www.microwavesolutions.com

COVER FEATURE

coupling effects and discontinuities. The SYNSTRIP Technology has been applied to the successful design of two- and four-way power splitters. The two-way power splitters, designed for use in the Global System for Mobile Communications (GSM) and personal-communications-services (PCS) bands, measure only 0.3×0.25 in. (0.76×0.64 cm) [Fig. 2]. The four-way power splitter, which operates from 1600 to 2200 MHz, measures only $0.5 \times 0.375 \times 0.15$ in. ($1.27 \times 0.95 \times 0.38$ cm) [Fig. 3]. The SYNSTRIP Technology was also applied to the development of a broadband balanced/unbalanced (balun) for use in broadband double-balanced mixers (Fig. 4).

The two-way surface-mount power divider achieves typical insertion-loss performance of 0.5 dB from 800 to 1000 MHz (Fig. 5). The typical port-to-port isolation is 19 dB. The typical input voltage standing-wave ratio (VSWR) is 1.50:1 and the typical output VSWR is 1.30:1. The two-way power divider achieves maximum amplitude imbalance between ports of 0.5 dB and phase imbalance of a mere 4 deg.

The four-way power splitter is equally impressive. It achieves a maximum insertion loss of 0.8 dB across the 1800-to-2200-MHz frequency range (Fig. 6). The typical port-to-port isolation is 19 dB. The typical input VSWR is 1.50:1 and the typical output VSWR is 1.30:1. The four-way power divider achieves maximum amplitude imbalance between ports of 0.5 dB and phase imbalance of 8 deg.

BROADBAND MIXER

Mixers are traditionally difficult to miniaturize due to their matching structures, using broadband balanced/unbalanced (balun) components. A typical layout for a standard high-frequency mixer using distributed baluns for impedance matching the RF and local-oscillator (LO) ports (50Ω externally) to the low impedances of the mixer diodes is realized using planar-circuit approaches. These baluns are normally formed on 10-mil-thick soft substrate materials with a dielectric constant of 2.2. The approach

Microwaves & RF

Penton

Electronics Engineering Career Center

Careers for electronic, electrical, microwave and wireless design and development engineers and engineering management in the computer hardware, software, communication systems, industrial controls, medical, avionics, automotive and consumer electronics industries.

www.eecareers.com

EMPLOYERS:

- Post your job openings
 - Within 24 hours/update weekly
 - More than 5,000,000 visits per month
- Banner/Sponsorship ads promote direct candidate flow to your HR office or website
- Direct access to more than 140,000 resumes on-line
- Use our HR Center

JOB SEEKERS:

- FREE resume posting
- E-mail your resume
- Find jobs by company name, category or function

**EMPLOYERS:
CALL FOR ON-LINE
DEMO**

**TIM WAGNER
216-931-9631**

Put this powerful recruitment tool to work for your company within a 24 hour period

www.eecareers.com

*the on-line
recruitment solution*

Specs are what you are given...
brilliance is what you give back.

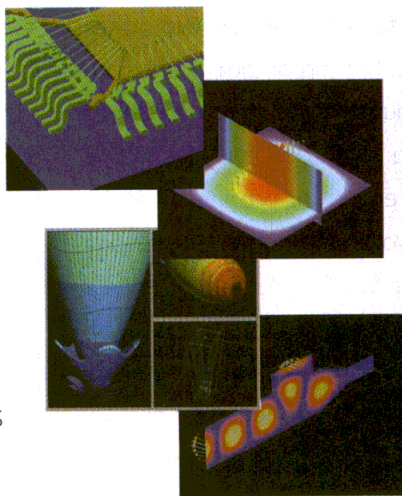
begin with Ansoft HFSS

Design microwave transitions, connectors, waveguides, IC packaging, on-chip components, antennas, antenna feed networks, and EMI compliance.

Success is something that engineers, the world over, are realizing with Ansoft's High Frequency Structure Simulator (HFSS). They recognize that using 3D electromagnetic simulation to extract electrical parameters is the right solution for tough design challenges. Ansoft HFSS is preferred because the intuitive interface simplifies design entry, the field solving engine automatically converges to accurate solutions, and the powerful post-processor provides unprecedented insight into electrical performance.

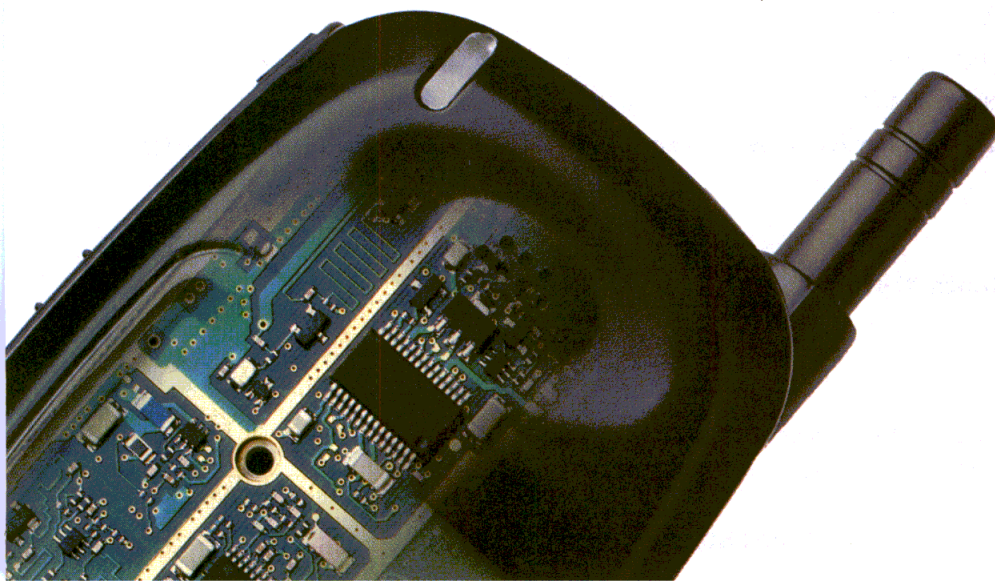
And now with Optimetrics™, the new parametric analysis and optimization module, Ansoft HFSS is the most powerful electromagnetic design tool on the market.

For a free evaluation copy of Ansoft HFSS or any of the tools in Ansoft's Serenade Design Environment call 412-261-3200 or send e-mail to info@ansoft.com.



Use Ansoft HFSS to calculate and optimize fields and s-parameters

Amaze



high performance EDA

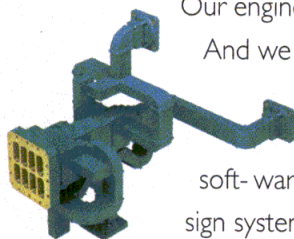
www.ansoft.com

CIRCLE NO. 271



The fastest tools help us engineer the finest waveguide components.

THE SHORTEST DISTANCE BETWEEN DESIGN AND DONE.



Our engineers are at the top of their profession. And we make it our business to provide them with the finest tools available. Aside from employing proprietary MDL software, they work with computerized design systems, utilizing SolidWorks to render 3-D models and Ansoft HFSS to compute a full complement of performance characteristics. Then our skilled professionals manufacture, braze, finish, and test every product right here in our plant. So design challenges become reality in impressively little time.

CALL US TODAY.

Quality from CAD to crate is what has made MDL the largest manufacturer of high quality cast components and waveguide packages in the world. Call an MDL specialist today at **1-800-383-7750** or visit us at **www.micro-dev-labs.com**.

WAVEGUIDE CAST BENDS & TWISTS

WAVEGUIDE FEED ASSEMBLIES

MONOPULSE COMPARATORS

ROTARY JOINTS

MICROWAVE FILTERS

ROTARY SWITCHES

WAVEGUIDE TO COAX ADAPTERS

WAVEGUIDE PRESSURE WINDOWS

COMMERCIAL WAVEGUIDE ASSEMBLIES

See us at MTT-S, Booth #1816



Microwave Development Laboratories, 135 Crescent Road, Needham Heights, MA 02494
Fax: 781-453-8629 / e-mail: mdlsales@micro-dev-labs.com

Like what
you see?
Need more
information?
Do you want
it now?

www.mwrf.com



Visit the
Microwaves & RF
website at:

www.mwrf.com and click the
instant inquiry button to request
information seen in this issue or
visit the manufacturers links for
direct access to all *Microwaves & RF*
advertisers.

**Microwaves
& RF**

 **Penton**

611 Rte. 46 West,
Hasbrouck Heights, NJ 07604

COVER FEATURE

requires a carrier plate or housing to integrate the balun/mixer structure into a subsystem. The typical size of such a mixer is 0.5×0.25 in. (1.27×0.64 cm). Such a design is well known in the high-frequency industry, but it is extremely difficult to miniaturize further.

Fortunately, SYNSTRIP Technology provides a means to create truly miniature mixers by designing the structure in 3D. The technology was applied to the design of double-balanced microwave mixers that rival the size and performance of gallium-arsenide (GaAs) mixers. The surface-mount SYNSTRIP mixer (Fig. 7) measures only 0.3×0.275 in. (0.76×0.69 cm), with an RF and LO range of 3 to 4 GHz (typical) and an intermediate-frequency (IF) range of DC to 600 MHz. The maximum conversion loss is only 9 dB, with typical performance of 8 dB. The LO-to-RF isolation is better than 20 dB (and typically 25 dB), and the LO-to-IF isolation is better than 15 dB (and typically 17 dB). The mixer can be supplied for use with a wide range of LO drive levels, from approximately +7 to +20 dBm.

The key to these mixers is the design of the broadband-matching networks. By using the multilayer SYNSTRIP technology, fabricated on soft substrate materials, the mixer consists of a broad-side-coupled balun for RF and LO impedance matching that is printed on both sides of a 5-mil-thick, ceramic-filled soft substrate with a dielectric constant of 10. The balun structure is bonded to a 25-mil-thick substrate, also with a dielectric constant of 10, which acts as a base. The only component that must be mounted in this assembly is a quad diode, which is placed on the top layer.

SYNSTRIP APPROACH

The SYNSTRIP approach considerably reduces fabrication requirements and costs. The simple structure is straightforward in order to manufacture in high-volume quantities, with high yield as well as repeatable performance. This novel assembly approach eliminates other techniques that are based on hard alumina substrates with thick-film technology and chip diodes, which require bonding.

FOLLOW THE LEADER

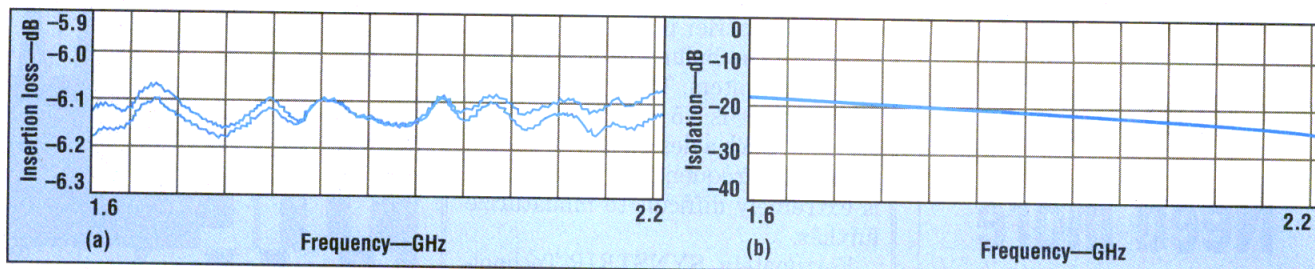
johansonmfg.com

Johanson

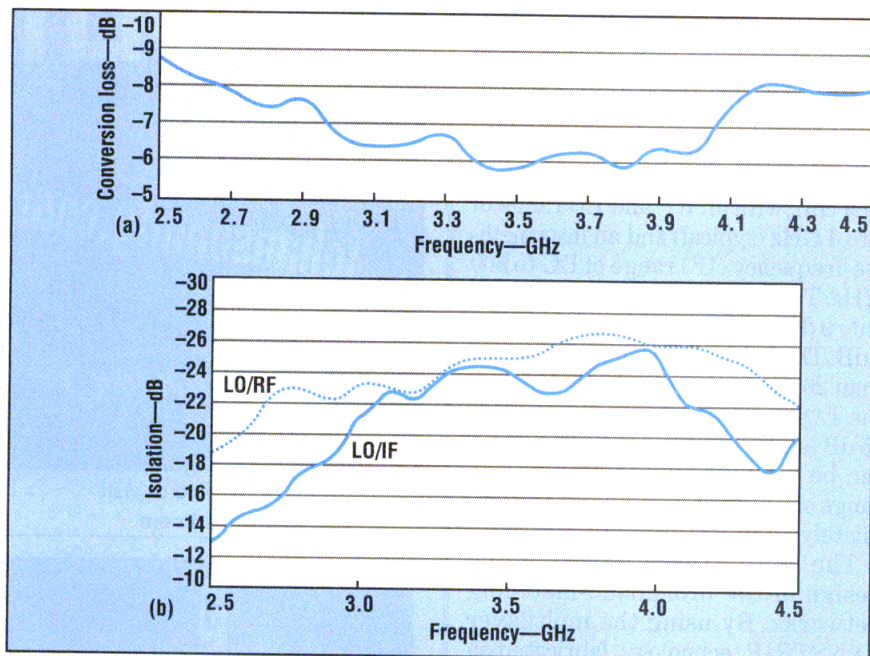
CIRCLE NO. 435 or visit
www.mwrf.com

VIEW CURRENT AND
BACK ISSUES OF **Microwaves
& RF**

www.mwrf.com



6. The measured performance of the four-way power splitter demonstrates the electrical advantages of the new SYNSTRIP Technology.



7. SYNSTRIP Technology contributes to the performance of a compact double-balanced mixer designed for use from 3 to 4 GHz.

In short, SYNSTRIP Technology is a novel, yet straightforward approach to the design and fabrication of low-cost, miniature RF and microwave components for wireless applications. This straightforward approach eases fabrication requirements and translates into a manufacturing process with high yield and good repeatability. SYNSTRIP Technology offers the possibility for extremely compact RF and microwave components, such as broadband mixers and power dividers/combiners, leading to the further miniaturization of RF and wireless systems as well as subsystems. **Synergy Microwave Corp., 201 McLean Ave., Paterson, NJ 07504; (973) 881-8800, FAX: (973) 881-8361, e-mail: sales@synergymwave.com, Internet: <http://www.synergymwave.com>.**

CIRCLE NO. 51 or visit www.mwrf.com

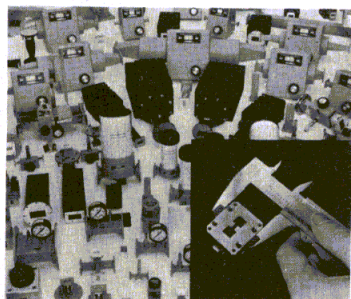
Waveguide Components

OFF-THE-SHELF OR CUSTOM DESIGNS

• Attenuators • Couplers • Switches • Loads • Terminations • Adapters • Assemblies • Horns • Ferrite Components



We're Ready When You Are... Next Day Delivery Of Catalog Components



From The Largest Inventory Of Waveguide Components In The Industry
RECTANGULAR, MM-WAVE, & DOUBLE-RIDGED COMPONENTS

CUSTOM DESIGNS

Custom designs are a Waveline specialty. If you don't see the product or design in our catalog, we probably have your "special" in our design files. Waveline now offers a complete line of Pin Diode Switches, Attenuators & Phase Shifters. Waveline has the expertise and capabilities to integrate waveguide and solid-state designs for subassemblies.

CALL OR WRITE

waveline®

P.O. Box 718, West Caldwell, NJ 07006
(973) 226-9100 Fax: 973-226-1565
E-mail: wavelineinc.com



CIRCLE NO. 419 or visit www.mwrf.com

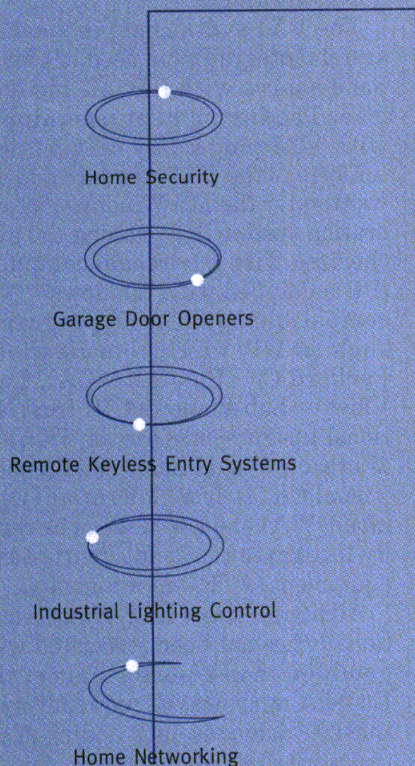
MICROWAVES & RF ■ JUNE 2000

We've gone to great lengths
to create the world's most
SENSITIVE RF Chipsets.

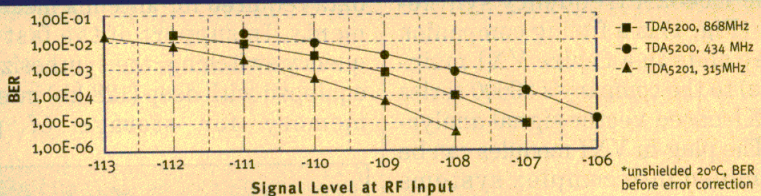


{PERPETUAL THINKING PROCESS}

INFINEON CYCLE



Bit Error Rate Performance of RKE Receivers (Manchester encoded)*



TO get from point A to point B, try Infineon's single-chip RF transmitters and receivers. With -110 dBm receiver sensitivity at 434MHz or -107 dBm at 868MHz**, you're assured the highest level of sensitivity available for short-range radio requirements. As a result, noisy environmental effects are minimized. Plus, the highly-integrated ASK and ASK/FSK receivers simplify design, reduce system cost and increase reliability. Infineon's ASK & FSK integrated transmitters are designed for low-power operation (2.1-4.0 volts DC) with few external parts. Phone your distributor to learn more about the range of frequencies of our TDA5100 transmitter and TDA5200/5210 receiver families and to order your evaluation kit. Or begin your sensitivity training at our website.

(**50 Ohm source impedance, BER=2E-3 (before error correction), average power level, Manchester encoded data rate=4kbit/s, 280 kHz IF filter bandwidth)

www.infineon.com/RKE



Never stop thinking.

VXI Synthesizer Sports Wideband Modulation

This compact and rugged microwave frequency synthesizer features low-noise performance with flexible internal and external modulation capabilities.

JACK BROWNE

Publisher/Editor

MODULARITY implies flexibility. This is the case with the E6432A microwave synthesizer from Agilent Technologies (Santa Rosa, CA). Leveraging the modular VXI format, the frequency synthesizer offers a basic range of 10 MHz to 20 GHz, but also a host of flexible options for expanding modulation and other capabilities to fit the needs of commercial and military testing.

The E6432A frequency synthesizer (Fig. 1) is a fitting companion (three slots in a C-size VXI main-frame) to the company's 89600 series of VXI-based vector signal analyzers. The plug-in VXI modules can be assembled into complex systems with or without modulation capabilities, including multichannel receivers for surveillance and signal analysis (see "VXI Receivers Scan VHF/UHF Range," *Microwaves & RF*, August 1998, p. 168). The E6432A is designed to operate with a host computer and a monitor, either as a stand-alone synthesizer or as part of a larger test system.

The E6432A microwave frequency synthesizer provides precise 1-Hz frequency resolution and a tunable output-power range of -20 to +20 dBm. An option offers an output-power range of -90 to +16 dBm. The power resolution in both cases is 0.02 dB. Engineers who are involved with antenna analysis and testing will take heart in the E6432A's fast 400- μ s frequency-switching speed (as fast as 80 μ s under some conditions for closely spaced frequencies), which supports capturing the massive multiple power and frequency

data required for antenna measurements. In support of the fast frequency switching, the synthesizer is equipped with deep (128-kb) internal memory for storage of pro-

grammable memory points and related data. Data entries can include settings for frequency, amplitude, attenuation, settling time, and blanking, along with a marker.

The synthesizer supports frequency-switching dwell times of 5 μ s to 32 ms. In addition, comprehensive trigger modes allow an operator to make the most efficient use of programmed frequency selections. The E6432A also supports rapid switching between amplitude levels, requiring less than 50 μ s to switch between two amplitudes in its output-power range.

The VXI synthesizer is ideal for system integrators in need of a wideband source with flexible modulation. The instrument is equipped with VXI plug&play drivers that conform to the VXI standard and are written for the MS Windows NT operating system. By teaming the synthesizer with a personal computer (PC) equipped with WindowsTM NT-compatible application programs, such as HP VEE from Hewlett-Packard Co. (Palo Alto, CA), LabView or LabWindows/CVI from National Instruments (Austin, TX), and Microsoft Visual Basic or Microsoft Visual C/C++ from Microsoft (Redmond, WA), the E6432A can be readily integrated into automatic-test-equipment (ATE) environments.

Although the VXI format traditionally has not been associated with good low-noise performance, the E6432A microwave frequency synthesizer achieves outstanding spectral purity. Harmonic levels, for ex-



1. The E6432A VXI microwave frequency synthesizer covers a range of 10 MHz to 20 GHz with 1-Hz resolution and an assortment of modulation formats.

Get Your Hands On Some Serious Microwave Firepower.

Let's face it - technology waits for no one. Your alliance with strong microwave suppliers today will be critical to your success tomorrow. Through strategic acquisitions, and focused research and development, the Herley Microwave Products Group continues to meet the expanding requirements of large EW system integrators. But don't let our prominence in the defense/aerospace arena be misleading. We've proven ourselves in the global commercial marketplace too. Click on www.herleympg.com and learn more about our growing arsenal of components, MFAs, and subsystems.



HERLEY-MDI
A HERLEY INDUSTRIES COMPANY



GENERAL MICROWAVE
A HERLEY INDUSTRIES COMPANY



ROBINSON
LABORATORIES, INC.
A HERLEY INDUSTRIES COMPANY

HERLEY Microwave Products Group

www.herleympg.com

ample, are typically better than -65 dBc from 2 to 20 GHz, and are typically better than -35 dBc from 10 MHz to 2 GHz. Spurious responses are better than -60 dBc across the full operating band, and typically better than -70 dBc. The single-sideband (SSB) phase noise is -70 dBc/Hz offset 100 Hz from the carrier and -93 dBc/Hz offset 10 kHz from the carrier.

TRIMMING NOISE

Several steps were taken in the basic design to reduce noise. For example, the E6432A uses proprietary DC-to-DC converters, each with its own shielded enclosure, to minimize noise introduced by the power supplies. In addition, the VXI synthesizer features a patented gasketing technique that helps provide good suppression of RF interference (RFI) and electromagnetic interference (EMI). The synthesizer itself is based on a unique frequency architecture, where a voltage-controlled oscillator (VCO) is used to generate fundamental tones from 20 to 40 GHz. These signals are then translated to the 10-MHz-to-20-GHz range through a proprietary broadband microwave mixer. The mixer itself is an impressive design, operating over an RF and local-oscillator (LO) range of greater than 20 to 40 GHz.

The E6432A microwave frequency synthesizer boasts a wide range of modulation capabilities, including ports for conventional external analog-modulation sources, such as amplitude modulation (AM), frequency modulation (FM), and pulse modulation. It also features a new wideband in-phase (I) and quadrature (Q) modulator with a 40-MHz bandwidth for creating any number of complex modulation formats. With a modulation source, such as an arbitrary waveform generator or a function generator, the E6432A can generate AM with depths from 0 to 40 dB at rates to 100 kHz. The instrument can produce FM deviations from 50 kHz to 8 MHz at FM rates of 200 kHz to 8

MHz. Also, pulse modulation is available at on/off ratios of better than 80 dB for rise/fall times of 10 ns and minimum pulse widths of 15 ns.

Perhaps the real modulation power in the E6432A, however, lies in its optional broadband I/Q modulator. When teamed with a VXI arbitrary waveform generator (Fig. 2), such as the model 3153 waveform generator from Racal Instruments

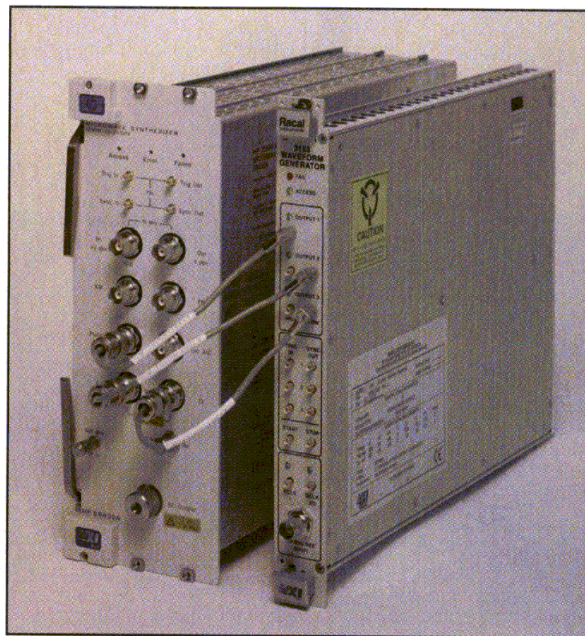
mode, self-test, and calibration panels. When the wideband I/Q modulator option is selected, the calibration panel is also augmented with an I/Q modulation calibration panel that allows operators to correct for phase and amplitude unbalances on external modulation sources. The E6432A's plug&play instrument driver also contains a comprehensive on-line help system with complete documentation of the instrument's operation.

SIGNAL SOFTWARE

A soon-to-be announced software package, Signal Studio[™], will allow operators to load external signal files into the E6432A and the 3153 waveform generator for exotic signal generation. These files may originate from the company's own software suite, the Advanced Design System (ADS), or from math programs, such as Matlab from The MathWorks, Inc. (Natick, MA). The Signal Studio software performs the file processing and compiling necessary to prepare the files for use by the waveform generator, then stores the files or downloads them to the waveform generator to create test signals from simulations or actual measurements of radar systems.

The E6432A VXI microwave frequency synthesizer packs a lot of power into a small package. With the I/Q modulator option and an external wideband waveform generator, the synthesizer can be programmed for virtually all existing digital modulation formats in commercial communications. In addition, due to its modulation capabilities and fast switching speed, the synthesizer is an ideal choice for aerospace and military test applications. **Agilent Technologies, Inc. (subsidiary of Hewlett-Packard Co.), Test and Measurement Organization, 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052; Internet: <http://www.agilent.com>.**

CIRCLE NO. 52 or visit www.mwrf.com



2. The E6432A VXI microwave frequency synthesizer can be teamed with an external waveform generator, such as the 3153 waveform generator from Racal Instruments (Irvine, CA), to produce complex digital modulation.

(Irvine, CA), the E6432A can produce carriers with a wide range of digital modulation formats, including quadrature amplitude modulation (QAM), frequency-shift-keying (FSK) modulation, minimum-shift-keying (MSK) modulation, and quadrature-phase-shift-keying (QPSK) modulation.

The E6432A is designed for use with an external monitor, as well as with a VXI mainframe and an external computer. The monitor shows a virtual synthesizer front panel, provided as part of the plug&play instrument driver. The virtual front panel supports direct control of RF output power, leveling, automatic level control, and modulation. It also provides access to various function panels, including configuration, list-

When your system designs call for high performance, **LOW PROFILE**, low cost, frequency **SYNTHESIZERS**, look into Synergy Microwave's JPLH & JPLL series of frequency synthesizers.

Available in surface mount packages, standard models cover the frequency range of 1000 to 2500 MHz and come in optimized signal bandwidths.

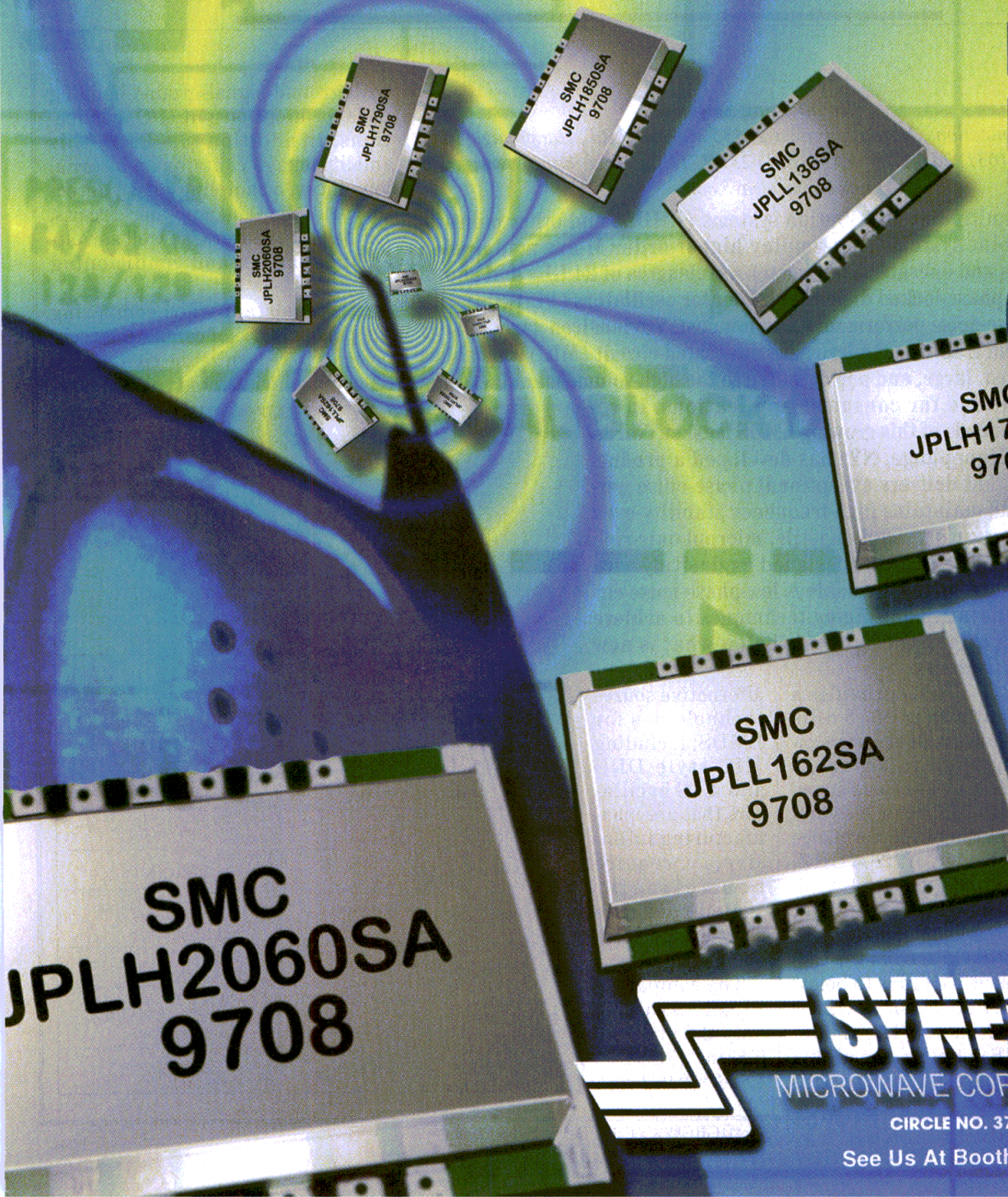
Fast switching speeds and low spurious reference sidebands are other important

features of these products. Connect these low profile, high performance synthesizers to a stable external reference source and you are ready to go.

For additional information, contact Synergy's Sales and Applications Team:

Synergy Microwave Corporation
201 McLean Boulevard, Paterson, NJ 07504
Phone: (973) 881-8800 **Fax:** (973) 881-8361
E-mail: sales@synergymw.com
World Wide Web: www.synergymw.com

SYNTHESIZERS



SYNERGY
MICROWAVE CORPORATION

CIRCLE NO. 373

See Us At Booth #506

Phase-Locked DRO Achieves Low Noise And Cost At 26 GHz

Exclusive use of surface-mount components in this phase-locked DRO yields typical phase-noise performance of -114 dBc at 10 kHz from the carrier.

Engineering Staff

L-3 Communications, Narda Microwave, 435 Moreland Rd., Hauppauge, NY 11788; (631) 231-1700, FAX: (631) 231-1711, Internet: <http://www.nardamicrowave.com>.

LOCAL multipoint distribution systems (LMDS) and other point-to-multipoint systems that employ higher-order M-ary modulation schemes and operate at millimeter wavelengths of 24 GHz and above, require phase-locked dielectric resonator oscillators (PLDROs) with superior phase-noise performance and low cost. Yttrium-iron-garnet (YIG) oscillators and traditional microwave-integrated-circuit (MIC) assemblies are high in cost, large, and poorly suited to the high-volume manufacturing processes needed for consumer applications. In response to the needs of this growing LMDS market, Narda Microwave (Hauppauge, NY) has developed a production PLDRO that delivers exceptional phase-noise performance, and maintains high-frequency stability even when in long-term service in hostile, microphonic-rich environments. The PLDRO, designed exclusively with surface-mount technology, combines low-phase-noise circuitry and innovative packaging techniques to achieve outstanding performance at costs below what is now commercially available.

The PLDRO (Fig. 1) provides a nominal output power of +5 dBm with ± 2 -dB flatness over its specified operating temperature range and into a 50- Ω load. It boasts spurious content of -75 dBc or less and harmonic/subharmonic performance of -40 dBc or better. At 26.4 GHz, the synthesizer's phase noise is typically better than -114 dBc/Hz offset 10 kHz from the carrier, and -112 dBc/Hz offset 100 kHz from the carrier. The phase noise drops to below -132 dBc/Hz for offsets of 1 MHz or greater (Fig. 2, table). The single-sideband (SSB) phase noise of this oscillator compares favorably with

alternative source technologies for LMDS, including MIC-style DRO and YIG oscillators that are manufacturing intensive, require hermetically sealed packages that are heavier and more costly.

The company's PLDRO measures only $2.2 \times 1.9 \times 0.8$ in. ($5.588 \times 4.826 \times 2.032$ cm),

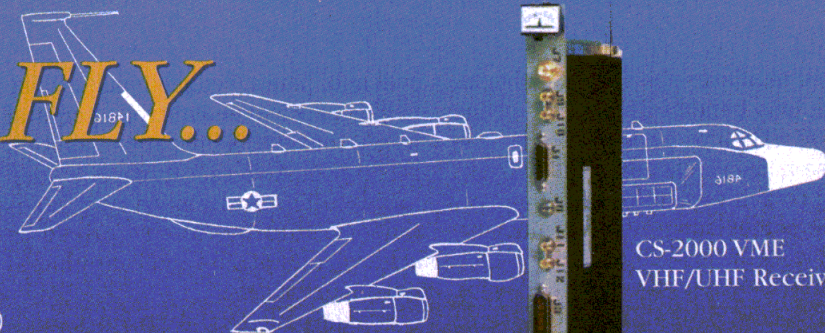
with ground-signal-ground bonding pads for input/output (I/O) connections. In addition to a DRO, this small package contains an internal loop filter, a sampling phase detector, multiplier and amplifier circuits, RF bandpass filters, as well as voltage regulation and conditioning (Fig. 3).

It is important when comparing the performance of competing technologies to recognize the significance of loop bandwidth. In typical phase-

The LMDS DRO at a glance

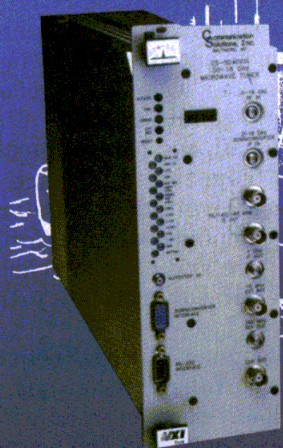
Parameter	Specification
Frequency	26.4 GHz
Nominal output power	+5 dBm
Spurious products	-75 dBc
Harmonics/subharmonics	-40 dBc
Phase noise	
Offset 1 kHz	-80 dBc/Hz
Offset 10 kHz	-105 dBc/Hz
Offset 100 kHz	-105 dBc/Hz
Offset 1 MHz	-115 dBc/Hz
Offset >1 MHz	-125 dBc/Hz
Frequency stability	Same as system reference
Shock test	0.5 J
Power supply	+8 VDC, 250 mA (max.)
Operating temperature range	-40 to +75°C

Does Your System **FLY...**



CS-2000 VME
VHF/UHF Receiver

FLOAT...



CS-5040 VXI
Microwave Tuner

or **ROLL?**



CS-5020C
Microwave Receiver

Then Look to COM-SOL for All Your Surveillance Equipment Requirements!

- Tuners and Receivers 5 kHz to 40 GHz
- Millimeter Wave Downconverters
- IF-to-Baseband Converters and Digitizers with Snap-Shot
- Custom Products - QRC Capability
- RF/IF Display Digitizers
- Demodulators and Multicouplers
- Up/Down Frequency Translators 20 MHz to 60 GHz
- Rack Mount, VXI, VME

**Communication
Solutions, Inc.**

(410) 344-9000 Fax (410) 344-1790 E-mail sales@comsol-inc.com

Visit our Web Site <http://www.comsol-inc.com> for the full COM-COL Story and New Product Announcements

PLDROs

locked oscillator specification sheets, large loop bandwidths, on the order of 500 kHz and exceptionally low phase-noise reference standards are used to achieve impressive phase-noise performance. Unfortunately, the prices of these high-performance standards are well beyond present LMDS cost objectives. Practical LMDS applications must utilize low

cost and, hence, reduced phase-noise performance oven-controlled crystal oscillators (OCXOs) for the system reference. As a result, narrow loop bandwidths and very-low phase-noise oscillators are required to achieve acceptable system phase-noise performance.

Narda's PLDRO features a loop-filter bandwidth of approximately 50

kHz to achieve an optimal balance between close-in phase noise and robust microphonic performance. In LMDS customer-premise equipment, microphonics (mechanically induced frequency deviations) are a major concern. Typical installations require the equipment to be mounted outdoors on an antenna mast, where it is exposed to a wide variety of environmental conditions, including wind, rain, hail, and low-frequency vibration from thunder. Each of these elements will induce vibrations that can be amplified within the system enclosure and produce variations in oscillator frequency and phase.

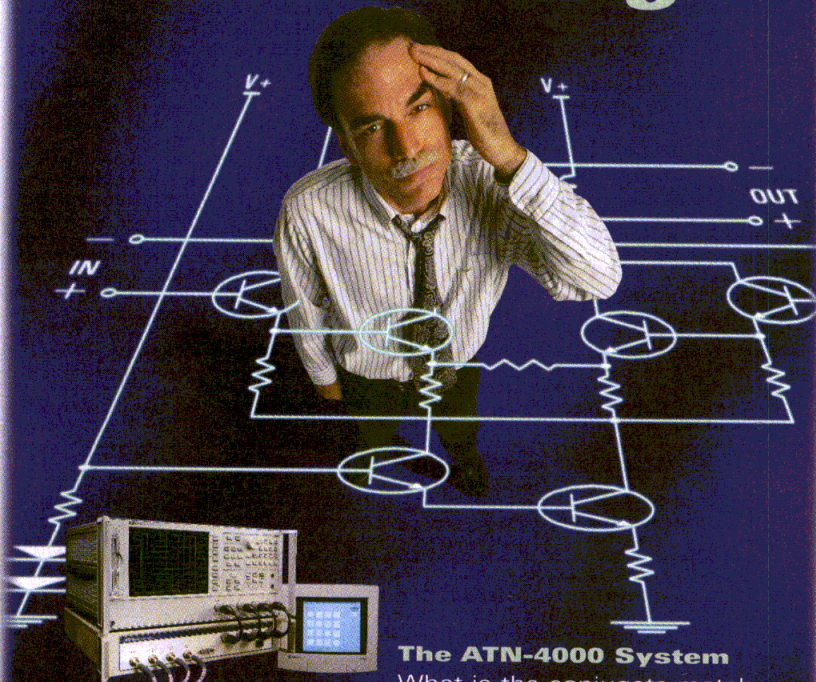
Narda designed its PLDRO to be placed on rooftops or other microphonic-rich environments and withstand significant impact from either mechanical or weather-related phenomena. The PLDRO undergoes extensive shock testing and experiences an instantaneous frequency deviation of only ± 500 Hz with a direct 0.5 Joule impact. In fact, the unit remains phase-locked even during a direct 1J impact.

The PLDRO employs an active loop filter with integral aided acquisition circuitry and a transistor-transistor-logic (TTL) window comparator to indicate phase-locked status.



1. This phase-locked dielectric resonator oscillator (PLDRO) offers stable signals at 26.4 GHz for LMDS applications. It is rugged enough to operate capably in outdoor environments with minimal power consumption.

Take the guesswork out of differential circuit design



The ATN-4000 System

What is the conjugate match of your differential 2-port device? How much common mode rejection does it have? How much of the differential input signal is being converted to common mode? If the answers to these types of questions have been eluding you, check out the new ATN-4000 Multiport S-parameter Test System at www.atnmicrowave.com. The answers have never been so easy to find.

atnmicrowave

Tools for Advanced Products



Agilent Technologies
Innovating the HP Way

Channel Partner

101 Billerica Avenue, Building 4, North Billerica, MA 01862-1256 USA
877-ATN-TOOLS • 978-667-4200 • Fax 978-667-8548 • www.atnmicrowave.com

CIRCLE NO. 433 or visit www.mwrf.com

FOUR WIRELESS FORMATS

WCDMA



CDMA

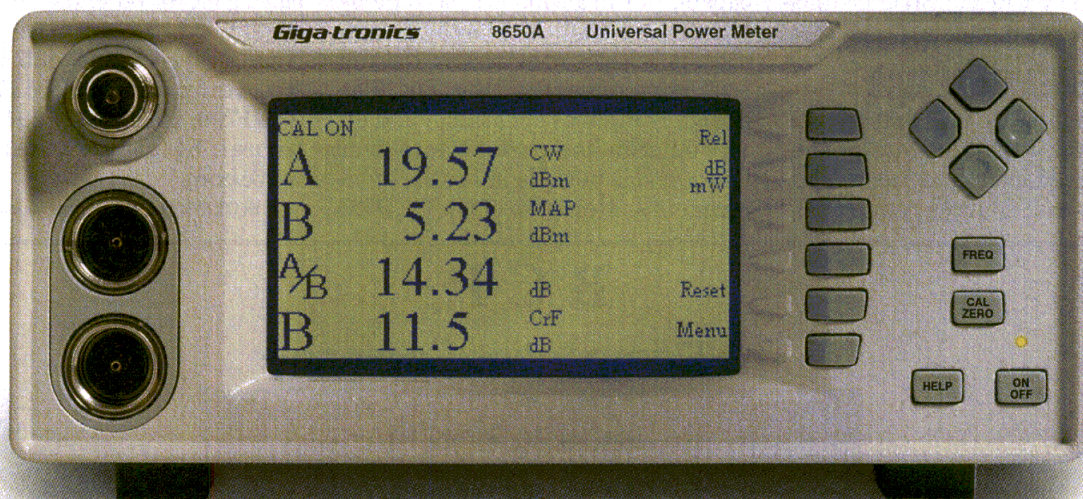


GSM



TDMA

ONE PERFECT POWER METER



The Giga-tronics 8650A Series Universal Power Meter Delivers Fast, Accurate Power Measurements for Development and Production Environments.

Use a single sensor to *measure*:

- **WIDEBAND CDMA** signals.
- The **AVERAGE POWER** of **TDMA**, **GSM** and **CDMA** signals over an 80 dB dynamic range.
- **CW POWER** over a 90 dB dynamic range.

Change sensors to *measure* the **PEAK POWER** of a pulse-modulated signal with a risetime as narrow as 100 ns.

Accelerate production with GPIB speeds **over 26,000 rdgs/sec** for CW signals and **over 800 rdgs/sec** for modulated signals.

Maximize modulated measurement speed with random sampling rates of 2.5 to 5 MHz.

Evaluate communications system efficiency with time saving capabilities such as:

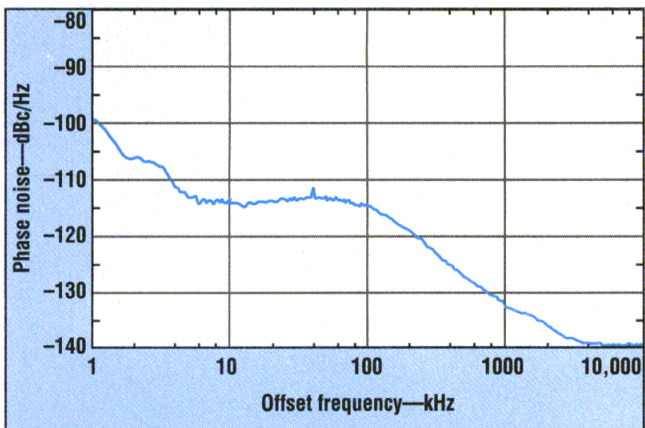
- Automatic time gating.
- Direct crest factor measurement.
- Statistical power measurement analysis.

For more information, call **1-800-726-GIGA (4442)**, or visit our web site at **www.gigatronics.com**.

Giga-tronics

Giga-tronics Incorporated ■ 4650 Norris Canyon Road ■ San Ramon, California USA 94583 ■ Telephone: 925-328-4650 ■ Telefax: 925-328-4700

PLDROs



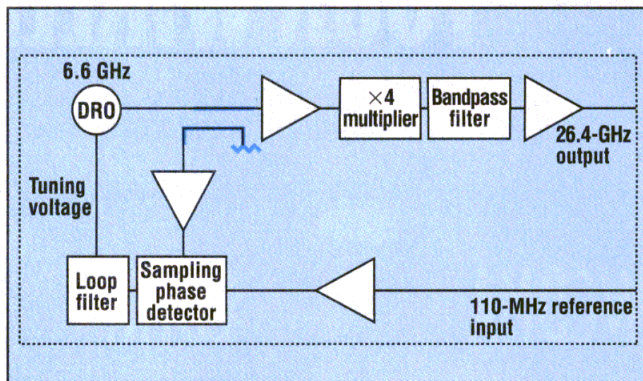
2. The low phase noise of the 26.4-GHz PLDRO can be traced to the use of low-noise SMT active devices and a high-Q dielectric resonator operating at 6.6 GHz.

The synthesizer has sufficient tuning bandwidth to remain phase-locked for the many years an LMDS installation may be left in the field.

REPEATABLE DRO

Narda's new PLDRO addresses the need for superior, low-phase-noise, reduced microphonic susceptibility, low-cost sources required by

the latest digital microwave radios. The LMDS PLDRO provides these capabilities in a compact package by eliminating traditional hybrid techniques (chip and wire) and using SMT components throughout. The design is highly repeatable, and offers outstanding performance over long service periods in hostile environments. Members of the PLDRO



3. This block diagram shows the basic architecture of the 26.4-GHz PLDRO, which is based on a 6.6-GHz dielectric resonator with two stages of frequency doubling to reach the 26.4-GHz output frequency.

family may be configured to operate from 6 to 30 GHz for use in systems employing higher-order digital modulation schemes. **L-3 Communications, Narda Microwave, 435 Moreland Rd., Hauppauge, NY 11788; (631) 231-1700, FAX: (631) 231-1711, Internet: <http://www.nardamicrowave.com>.**

CIRCLE NO. 53 or visit www.mwrf.com

B C P

The Component Company

Attenuators

Frequency Ranges

DC - 18 GHz

Power Ratings

.5 - 1,000 Watts

dB Rating

01, 02, 03, 06, 10, 20, 30

Connectors

BNC, IEC 7/16, N Type, SMA, TNC



Plus application specific designs for your demanding requirements.

B C P

10950 72nd Street N., Suite 107
Largo, FL 33777-1527

Phone: 727-547-8826 Fax: 727-547-0806

www.birdfla.com E-mail: sales@birdfla.com

BCP is a Division of Bird Technologies Group

CIRCLE NO. 405 or visit www.mwrf.com

MICROWAVES & RF ■ JUNE 2000

Loads

Frequency Ranges

DC - 6 GHz

Power Ratings

2 - 1,000 Watts

Connectors

BNC, IEC 7/16, N Type, SMA, TNC

Divider / Combiners

Frequency Ranges

460 - 2,000 MHz

Power Ratings

up to 150 Watts

Connectors

SMA, N Type



BROADBAND DC BLOCK

1MHz to 20GHz
Low Loss,
Resonance Free

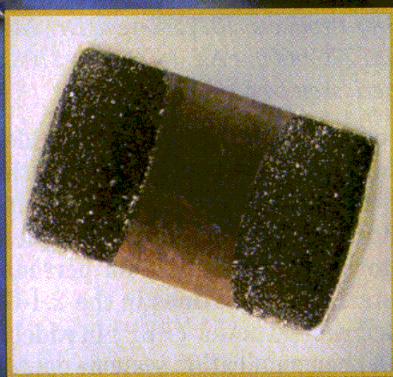
Quality
Choice
Reliability
Performance

Applications

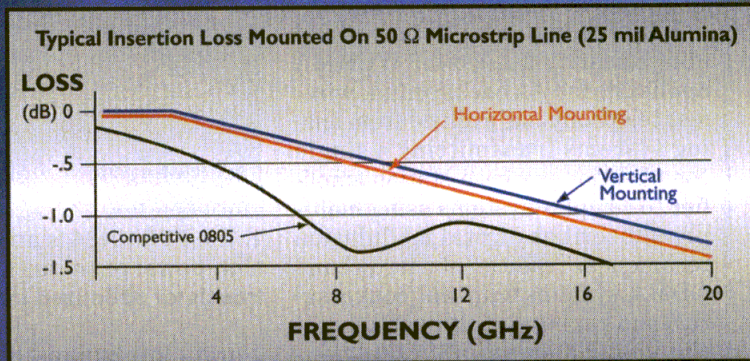
- Broadband fiber optic links
- LAN'S
- Broadband and RF/Microwave modules
- Broadband high isolation decoupling
- Broadband instrumentation and test equipment

Benefits

- Resonance free DC blocking from 1MHz to 20GHz
- Less than .25db loss @ 6GHz (typical)
- Surface mountable 0805 case size
25mil height for edge mounting on
25mil microstrip
- Now available in C06 size!

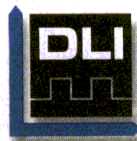


Performance Curve



Visit us on the web...

www.dilabs.com



**DIELECTRIC
LABORATORIES**

A DOVER TECHNOLOGIES COMPANY

Call The Solutions Experts
At Dielectric Labs

2777 Route 20 East, Cazenovia, NY 13035

Ph: 315-655-8710 • Fax: 315-655-8179

CIRCLE NO. 395

LDMOS Device Powers WCDMA Amplifier

This rugged gold-metallized LDMOS transistor delivers better than 100-W PEP output power for WCDMA base-station amplifiers operating in the 2.1-GHz PCS band.

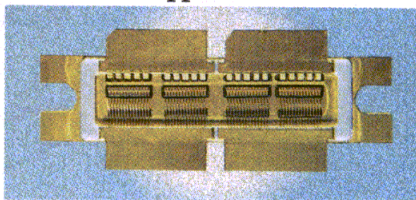
Tim Ballard

Senior RF Design Engineer

Ericsson Microelectronics, RF Power Products, 18275 Serene Dr., Morgan Hill, CA 95037; (877) GOLDMOS, (408) 776-0600, FAX: (408) 779-3108, Internet: <http://www.ericsson.com/rfpower>.

POWER transistors based on laterally-diffused-metal-oxide-semiconductor (LDMOS) technology offer high output levels with good linearity and simple biasing requirements. The PTF 10134 from Ericsson Microelectronics (Morgan Hill, CA) is an example of a gold (Au)-metallized LDMOS transistor that is well-suited for personal-communications-services (PCS) base-station applications in the 2.1-GHz band. The transistor offers 100-W peak envelope power (PEP) in wideband-code-division-multiple-access (WCDMA) communication systems operating from 2110 to 2170 MHz, with 10-dB typical power gain when biased under Class AB conditions with a +28-VDC supply. To demonstrate the performance of the device, a pair were incorporated into a pull-pull amplifier configuration to evaluate efficiency and linearity in PCS WCDMA applications.

Why are high output power and good linearity needed for WCDMA applications? As background, wireless telephony has evolved from analog systems transmitting a single conversation per base-station amplifier to complex systems using multiple-subscriber digital modulation techniques. Traditional narrowband CDMA systems transmit conversation and paging signals over a single channel. Emerging WCDMA networks will support a wider range of wireless digital services, such as Internet/intranet and other Internet-provider (IP)-based applications, video, high-speed data communications and interactive services. The information density of these more complex signals requires higher degrees of amplifier linearity to meet the necessary adjacent-channel-power-ratio (ACPR) specifications.



1. The PTF 10134 is an Au-metallized high-power push-pull LDMOS transistor optimized for WCDMA.

During low-cumulative probability distributions (CPRs), WCDMA waveforms have high peak-to-average power ratios. At high CPRs, WCDMA waveforms have lower peak-to-average power ratios, requiring amplifiers to operate significantly below saturation. As a result, amplifiers for WCDMA and other "spectrally efficient" modulation systems have significantly higher intermodulation-distortion (IMD) re-

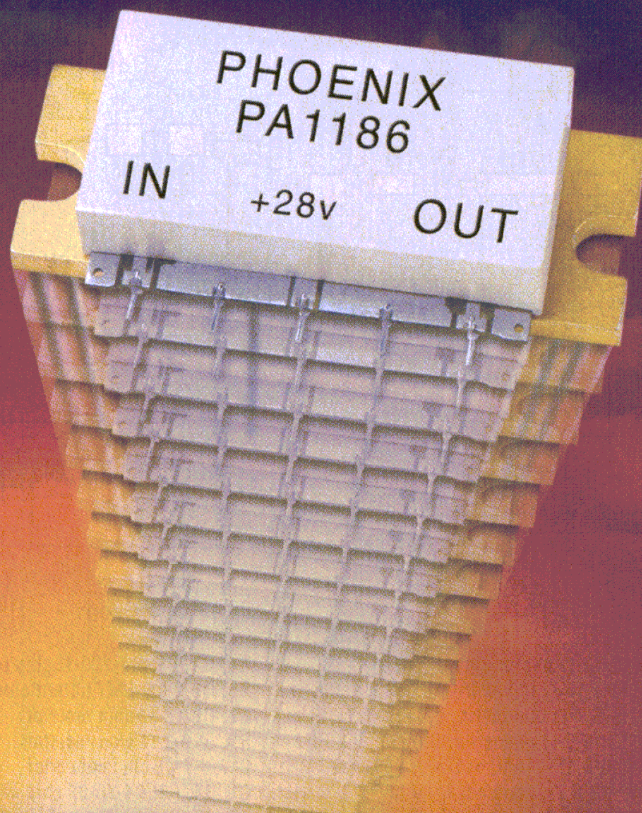
quirements for their active devices.

Most first-generation cellular base-station amplifiers used silicon (Si) bipolar power transistors. RF-transistor technology has improved over the years in terms of gain, output power, efficiency, and reliability. Linearity, however, is limited by the fundamental characteristics of bipolar transistors. Bipolars have two significant linearity problems: high-order IMD and low-level crossover distortion. Crossover distortion can be improved by changing from Class AB to Class A bias conditions. This, however, reduces efficiency and peak power when compared to Class AB bias.

Metal-oxide-semiconductor field-effect transistors (MOSFETs) have lower high-order IMD than bipolar transistors. Being majority-carrier devices, they do not require the ballasting that stabilizes minority-carrier bipolar devices. Combined, these MOSFET traits produce superior IMD at reduced output power. Additionally, thermally stable FET cells combine better than bipolar-transistor cells. This makes it more feasible to scale an active area when designing high-output-power components. Recently introduced LDMOS transistors have raised the operating frequency of Si power FETs. LDMOS devices incorporate a "p+ sinker" to connect the source terminal to the backside of the semiconductor material. With this structure, chips may be directly attached to metal flanges, improving grounding and reducing thermal resistance; it also eliminates

Introducing High Power Linear Power Amplifier Modules

NEW!
+28volt single supply
GaAs FET
rugged modules



6 Watt Wireless Linear Power Amplifiers

Typical performance @ +25° C

Parameter	PA1186	PA1166	PA1182
Frequency (MHz.)	800-960	1930-1990	2300-2400
Gain (dB.)	29.0	26.0	23.0
Pout @ 1 dB. comp. (dBm.)	38.0	38.0	37.5
Noise Figure (dB.)	2.4	2.7	3.0
ACPR (30kHz BW)*	-50.0	-54.0	-47.0
VSWR (Input/Output)	1.5:1/2:1	1.5:1/2:1	1.5:1/2:1
IP3 (two tone)**	+56.0	+54.0	+53.0
Supply Required	+28/1000	+28/1000	+28/1000
* $\pm 850\text{kHz}$ from f_c at power level of 30 dBm. (IS-95)			
** IP3 measured with 2 tones @ +25dBm. per tone			

In today's competitive wireless environment "Time to Market" is a very crucial factor for the success of a new product.

For Cellular, PCS, and WLL cell sites, Stellex Phoenix Microwave offers the largest selection of linear amplifier modules to accelerate your multi-carrier power amplifier designs.

With our *unmatched performance and delivery* you not only reduce your design time but also enhance your system's capability.

In addition, our application's staff is ready to develop new cost effective linear amplifier modules customized to your requirements.

So from your initial design concept to high volume production, make Stellex Phoenix Microwave your linear amplifier module partner.

Call today: 215-723-6011 or e-mail us at info@phnixmw.com



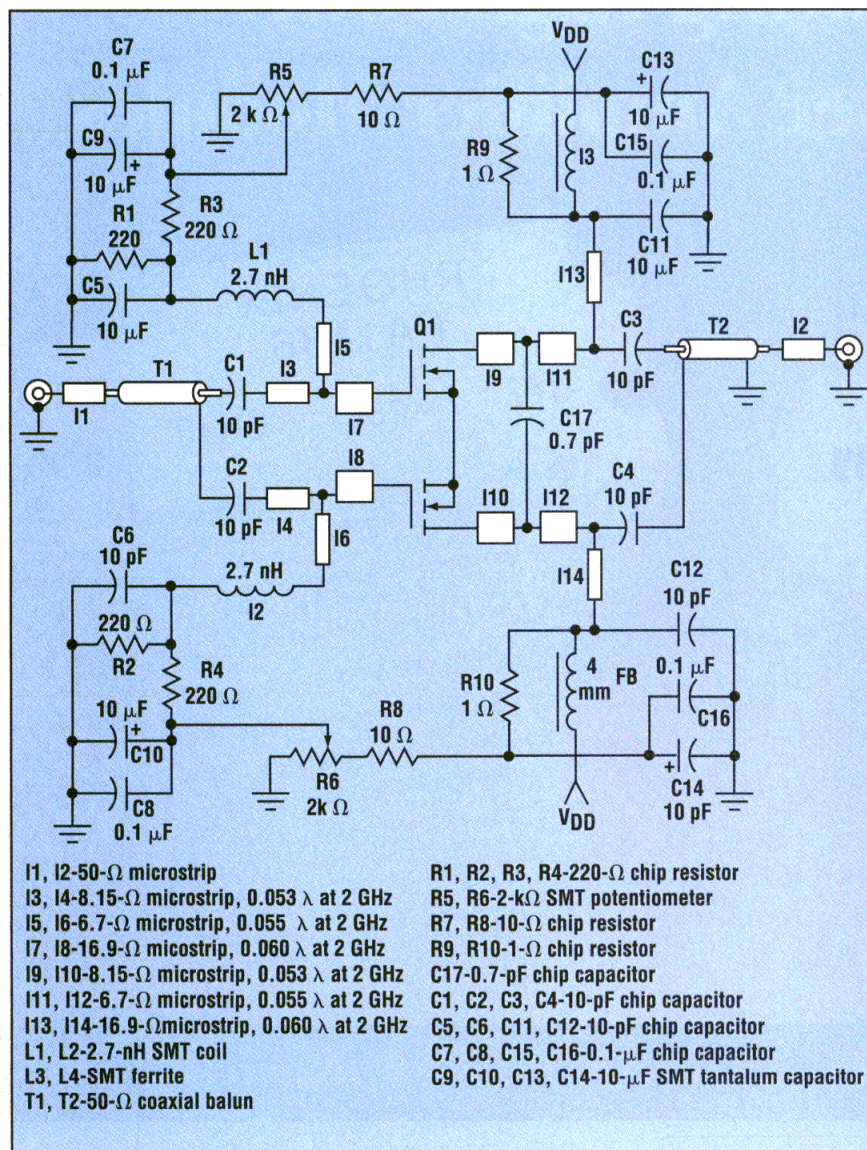
CIRCLE NO. 247

Stellex Phoenix Microwave 100 Emlen Way Telford, PA 18969 Website: www.stellexms.com

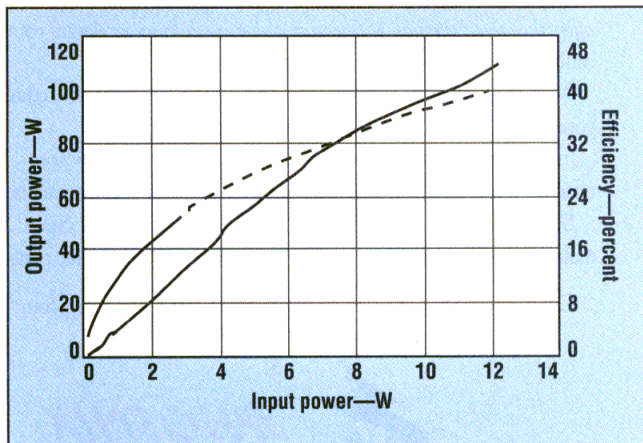
See Us At Booth #333



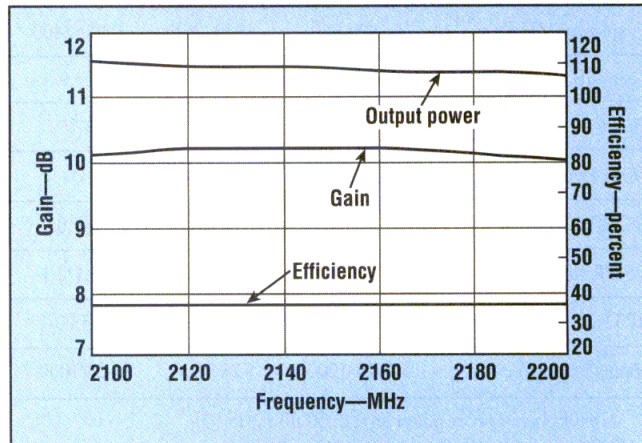
LDMOS Transistor



2. The high-power LDMOS transistor is connected in a push-pull configuration in this test circuit optimized for use from 2110 to 2170 MHz.



3. Measurements of output power versus input power were made at 2170 MHz with quiescent drain current of 1.3 A and supply voltage of +28 VDC.



4. Measurements of output power, gain, and efficiency were made across the operating frequency range with bias of 1.3 A at +28 VDC.

the need for source interconnects, and reduces parasitic-source inductance. LDMOS technology can produce RF power transistors with high gain, high efficiency, low thermal resistance, and superior IMD in wireless radio systems.

The PTF 10134 is an enhancement-mode LDMOS device that has been designed to provide all the benefits of LDMOS technology, using a proven high-volume semiconductor process with well-established packaging techniques (Fig. 1). Structurally, the transistor combines four active chips assembled in a push-pull configuration. Each chip contains 28 cells having 60 gates of 0.8-μm length. Input and output ports are internally matched (to 50 Ω) to optimize performance within the WCDMA band. Impedance matching consists of bond-wire inductors and MOS capacitors configured as a lowpass impedance-matching transformer on the input port, and a shunt-inductor (L) network (shunt inductor, series-blocking capacitor) on the output port.

All Ericsson LDMOS products employ full Au metallization. Developed in the 1970s, Au metallization has been used in place of less-reliable aluminum (Al) on microwave power chips to minimize device failures due to metal migration. All Ericsson products use Au wire interconnects to reduce wire temperature and eliminate wire fatigue occurring in systems that amplify time-varying waveforms. Ericsson's all-Au system eliminates intermetallic failures as-

GET MORE IN...



Foundry Services Your high-volume GaAs requirements will fit in our foundry. We offer processing solutions for all your chip needs, from prototyping to production. You design it, we'll build it. Or bring us your specifications and we'll provide end-to-end design, manufacturing and test. Our flexible foundry supports both HBT and HEMT manufacturing. Plus, our GaAs production line hosts the industry's largest MBE capability.

MMIC Chips Pack more features into your products with TRW's compact GaAs MMICs. Smaller chips allow you to squeeze more capability in less space.

No real animals were used in the production of this advertisement.

© 2000 TRW Inc.

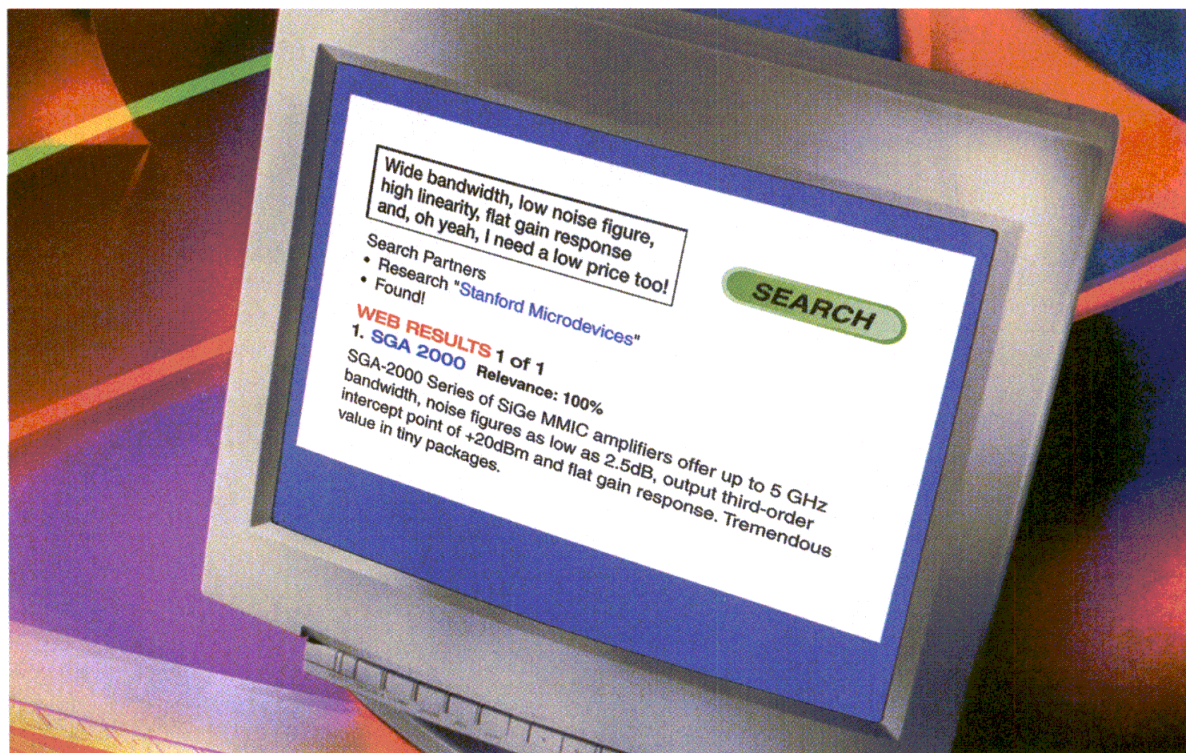
Our HBT and HEMT products offer the highest performance available anywhere. Our devices have a record of reliability proven by more than 4 million hours of lifetime testing and real-world experience.

Big Ideas We offer heavyweight solutions for your next generation products. From broadband wireless to high-speed digital, fiber-optic and photonics applications.

TRW

www.trw.com/telecom
ISO 9001 Registered

Still searching for the right amplifier for your latest design?



Successful searches end up at www.stanfordmicro.com

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

SGA-2000 product family offers wideband operation of up to 5 GHz, high output linearity, flat gain response and low noise figure with very low power consumption. These devices are available in industry standard SOT-363 and 85mil plastic packages from stock to eight weeks.

www.stanfordmicro.com
Make us your home page!

SPECIFICATION MATRIX

	SGA-2163 SGA-2186	SGA-2263 SGA-2286	SGA-2363 SGA-2386	SGA-2463 SGA-2486
Frequency (GHz)	DC-5.0	DC-3.5	DC-2.8	DC-2.0
Gain (dB)	10.5	15.0	17.4	19.6
TOIP (dBm)	20.0	20.0	20.0	20.0
P1dB (dBm)	7.0	7.0	7.0	7.0
N.F. (dB)	4.1	3.2	2.9	2.5
Supply Voltage (Vdc)	2.2	2.2	2.7	2.7
Supply Current (mA)	20	20	20	20

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

SiGe HBT MMIC

features include:

- Cascadable 50 Ω
- Single voltage supply
- High output intercept
- Low current draw
- Low noise figure



86 package



SOT-363 package



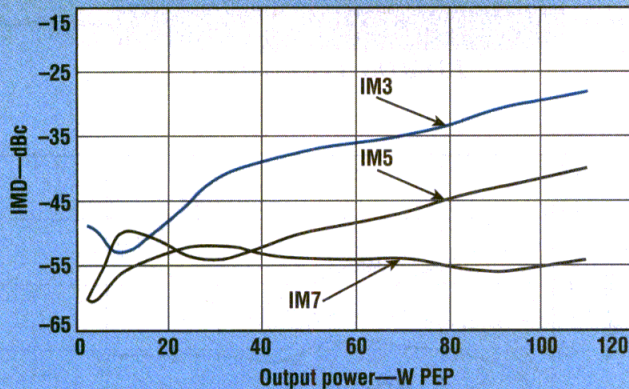
We Deliver RF Innovation

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

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

©2000 Stanford Microdevices. All company and/or product names are trademarks and/or registered trademarks of their respective owners.

LDMOS Transistor



5. The third-, fifth-, and seventh-order IMD products were measured with tones at 2169 and 2170 MHz and bias of 1.3 A at +28 VDC.

sociated with mixed-metal systems.

A push-pull test circuit was designed to cover 2110 to 2170 MHz using 1:1 compensated baluns at the PTF 10134's input and output ports. A cascaded input and tapered output are used as matching networks. Matching networks were designed to optimally transform the balanced source- and load-to-device impedances determined through point-by-point load-pull characterization using a manual impedance tuning system and a vector network analyzer (VNA). Matching networks combine distributed and lumped components in a lowpass configuration (Fig. 2).

The circuit was fabricated on a substrate with 0.028-in. (0.071-cm) dielectric thickness and having a dielectric constant of 4.0. The layout (available upon request from the author) illustrates the simplicity of LDMOS circuitry.

Biasing an FET is much simpler than biasing a bipolar transistor because FETs do not exhibit the high-current thermal runaway effect of bipolar transistors, where the gain (and current consumption) increases with increasing temperature. For the PTF 10134, the output-bias circuitry consists of a bypassed RF choke, similar to that used in bipolar circuits. Gate bias can consist of a simple resistive divider connected between the drain supply and ground.¹ A more-complex compensation network improves LDMOS linearity over temperature.^{2,3}

The prototype amplifier circuit was evaluated with a +28-VDC voltage supply and typical drain current totaling 1.30 A (650-mA current for each side of the PTF 10134 transis-

tor). Figure 3 shows the output power versus input-power characteristics of the test amplifier. The typical CW output power at 1-dB compression is 110 W. Figure 4

shows small-signal gain and efficiency at 1-dB compression, measured in a test fixture optimized from 2110 to 2170 MHz.

Figure 5 shows two-tone third-, fifth-, and seventh-order IMD versus output power. Note that, although not completely monotonic, the IMD generally decreases continually as the output decreases. Bipolar tran-

SPINNER

the Ultimate Coaxial Connectors



Field Installable Connectors

- Cut and Fit for N and 7-16 in Plug and Socket Configurations
- For Corrugated Cable Sizes to 1 5/8"
- Tools for Easy, Reliable Installation

Adapters

- Rugged/Reliable "Quick mate/ Demate" Test Adapters
- Intra-Series
- Between Series

Cable & Panel Mount Connectors

- Originators of the 7-16 Interface
- Silver Plated Inner/Outer Conductors
- Designed for Superior (-165 dBc) Intermodulation Performance
- Bulkhead and 4 Hole Panel Mount Types
- Connectors for Flexible & Semi-Rigid Cable Types

Send for complete specifications and product catalog.



6611 Bay Circle, Suite 100, Norcross, GA 30071 • Tel: 770-263-6326 • Fax: 770-263-6329
www.spinnersna.com • e-mail: sales@spinnersna.com

CIRCLE NO. 416 or visit www.mwrf.com

Model 9640 Dual HF Receiver

Frequency Range — 0.56 to 32 MHz

Instantaneous Bandwidth — 10 MHz

Noise Figure — 10 dB Maximum

Gain — 48 dB ± 2 dB

Synthesizer Control — RS-232C Interface

Synthesizer Tuning Speed — 100 μ s Maximum

Frequency Synchronous or Independent Operation



Interad Ltd.

8020 Queenair Drive • Gaithersburg, MD 20879

Phone: 301-948-7172 • Fax: 301-977-7559

E-mail: interad@pop.erols.com

CIRCLE NO. 410 or visit www.mwrf.com

Quasar Leaders in Microwave technology

For Microwave point to point radio, LMDS, UMTS & Satellite Communications

Quasar has developed a family of microwave waveguide components for communications applications where precision, quality and reliability are paramount.

- Directional Couplers, Splitters and Combiners
- Filters and Diplexers
- Power Combiners

Quasar can combine these products into single integrated assemblies which are ideally suited to "Hot stand by" or 1+1 applications this eliminates the need for flexible waveguide. Designs and prototypes for specific customer requirements can be made within weeks from Quasar's high quality factory in the UK. Whether you are designing the next point to point radio or a satellite transmitter/receiver Quasar can help you. **Call us today or take a look at our website.**



Quasar Microwave Technology Limited

Battle Road, Heathfield, Newton Abbot,
Devon TQ12 6XU, England

Tel: +44 (0)1626 834222

Fax: +44 (0)1626 832994

Email: sales@qmtl.com



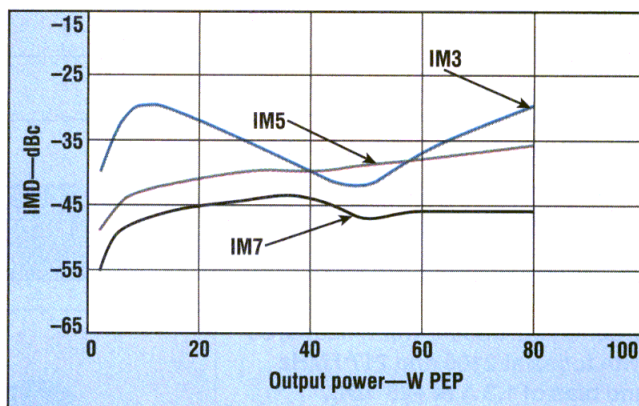
See our NEW WEBSITE www.qmtl.com

CIRCLE NO. 420 or visit www.mwrf.com

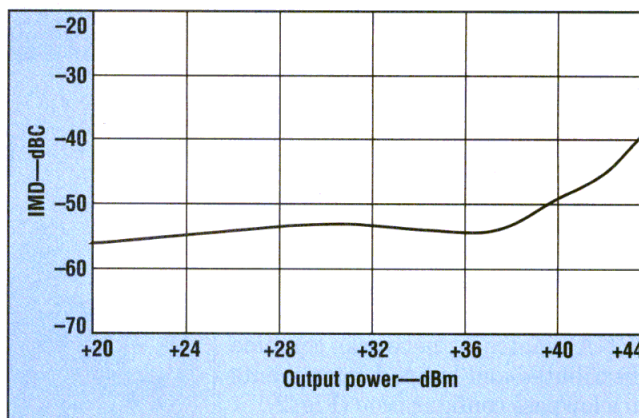


PRODUCT TECHNOLOGY

LDMOS Transistor



6. The typical third-, fifth-, and seventh-order IMD products for an Si bipolar transistor are shown for comparison purposes.



7. The ACPR performance of the PTF 10134 in a broadband circuit is shown as a function of WCDMA output power at 2130 MHz and bias of 1.3 A at +28 VDC.

sistors tend to have a noticeable "sweet spot," an output range corresponding to minimum distortion. This is mostly due to the more linear transfer function of LDMOS devices compared to bipolars. Figure 6 shows comparable two-tone third-, fifth-, and seventh-order IMD performance for a high-power Si bipolar transistor.

Testing on the PTF 10134 circuit was performed with a WCDMA spectral mask in a broadband circuit with a 15 DTCH signal. Figure 7 displays the higher of the two values of ACPR at 4.096-MHz offsets, clearly showing the suitability of LDMOS for complex waveforms.

Ericsson offers a wide range of bipolar and GOLD-MOS[™] Au-metallized LDMOS transistors for wireless communications and television-broadcast applications. **Ericsson Microelectronics, RF Power Products, Morgan Hill, CA 95037; (877) GOLDMOS, (408) 776-0600, FAX: (408) 779-3108, Internet: <http://www.ericsson.com/rfpower>.**

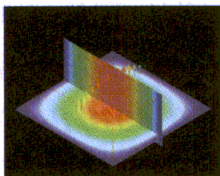
CIRCLE NO. 54 or visit www.mwrf.com

References

1. Scott Porro, "FETs Address Linearity Challenge," *RF Power Products Data Book 1998/1999*, Ericsson Microelectronics, Morgan Hill, CA.
2. Cindy Blair, "Ericsson's High Power LDMOS Breakthrough," *Applied Microwaves & Wireless*, October 1998.
3. Cindy Blair, "Biasing LDMOS FETs for Linear Operation," *RF Power Products Data Book 2000*, Ericsson Microelectronics, Morgan Hill, CA.

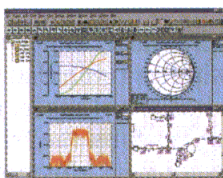
287 specs. 23 designers. 4 departments. 1 goal.

...is everybody on the same page?



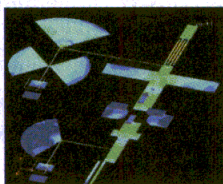
Ansoft HFSS

3D electromagnetic
structure simulation



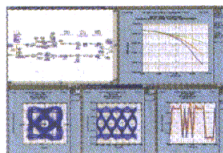
Harmonica

linear & nonlinear
circuit simulation



Ensemble

planar electromagnetic
field simulator



Symphony

wireless & wired
system simulation

Ansoft's Serenade Design Environment

...delivering system, circuit, electromagnetic simulation, synthesis, and physical design in a single software suite. Streamline your product development process using integrated schematic capture, simulation, layout, IC package modeling, and links to third-party tools from companies such as Cadence®, Mentor Graphics and EEsof.

Handshaking between modules allows engineers to focus on critical components at any stage of development. Each simulator can be used as a powerful, stand-alone tool, or in concert with others for end-to-end high-frequency design. The Serenade Design Environment is built on Ansoft's core electromagnetics technology; and offers accuracy, an easy-to-use Windows® interface, advanced design utilities, and superior value.

For a free evaluation copy of any of the tools in Ansoft's Serenade Design Environment call 412-261-3200 or send e-mail to info@ansoft.com.

Interoperate



high performance EDA

www.ansoft.com

Integrated RF Synthesizer Conserves Space And Power

This RF synthesizer can generate frequencies up to 2.6 GHz, while reducing the number of components required to implement a complete synthesizer solution.

PETER STAVENICK

Managing Editor

FREQUENCY synthesizers are playing an increasingly important role in the growth of the wireless industry. The wireless revolution has created a need for synthesizers that consume less board space, are less expensive than their predecessors, and can perform the frequency synthesis function in wireless communications equipment effectively. The single-chip Si4136 industrial-scientific-medical (ISM) RF synthesizer from Silicon Laboratories, Inc. (Austin, TX) reduces the number of external components required, saving up to 60 percent of board space and cutting power consumption. It operates across the 2.0-to-2.6-GHz range and is suitable for IEEE 802.11-standard wireless local-area networks (WLANs), wireless modems, wireless headsets, cordless phones, and security systems. The Si4136 performs RF synthesis in two bands—2.3 to 2.6 GHz and 2.0 MHz to 2.4 GHz, as well as intermediate-frequency (IF) synthesis from 62.5 MHz to 1.0 GHz.

The Si4136 consists of three complete phase-locked loops (PLLs) with integrated voltage-controlled oscillators (VCOs), loop filters, as well as

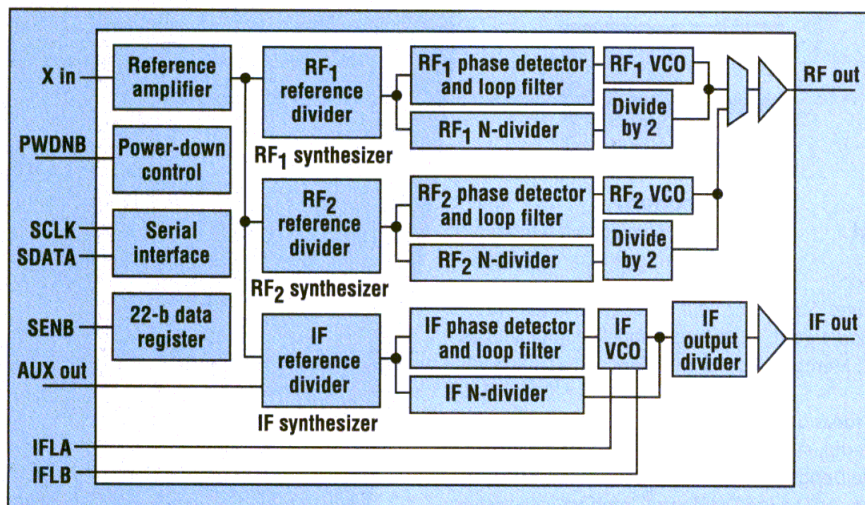
reference and VCO dividers. Divider and power-down settings are programmable through a three-wire serial interface (see figure). Each RF

VCO is optimized over a particular frequency range. The RF₁ VCO operates from 2.3 to 2.6 GHz while the RF₂ VCO operates between the 2.0-to-2.4-GHz frequency range. The IF output can range from 62.5 to 1000 MHz. With 5- μ A standby current at +3 VDC, the Si4136 offers 15.7-mA typical supply current at +3.6 VDC. It operates over a supply-voltage range of +3.0 to +3.6 VDC.

The RF₁ output phase noise at 2.4 GHz is -131 dBc/Hz offset 1 MHz from the carrier while the RF₁ integrated phase-error output at 2.4 GHz is 1.5 deg. root mean square (RMS) from 100 Hz to 100 kHz. RF₂ phase-noise output at 2.1 GHz is -131 dBc/Hz offset 1 MHz from the carrier and the RF₂ integrated phase-error output at 2.1 GHz is 1.2 deg. RMS from 100 Hz to 100 kHz.

The PLL architecture that is used in the Si4136 produces transient responses that are comparable in speed to fractional-N architectures without suffering the high phase noise or spurious modulation effects often associated with those designs. The IF PLL can tune ± 5 percent from the center frequency of the VCO. The IF center frequency is established with the value of an external inductance that is connected to the VCO. P&A: \$7.00 (10,000 qty.); evaluation board (Si4136-EVB), \$150. **Silicon Laboratories, Inc.**, 4635 Boston Lane, Austin, TX 78735; (877) 444-3032, FAX: (512) 416-9669, Internet: <http://www.silabs.com>.

CIRCLE NO. 55 or visit www.mwrf.com



The Si4136 monolithic IC includes three VCOs, loop filters, reference and VCO dividers, as well as phase detectors.

Contactless Phase Shifters:

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

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

■ Standard Connectorized CPS



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

■ Miniature CPS



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



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

CIRCLE NO. 374



GaAs FETs Offer Improved Specifications

Higher-performance data-communications systems require power GaAs FETs that provide upgraded linearity and greater gain.

GENE HEFTMAN

Senior Editor

ESCALATING data rates emerging in satellite and terrestrial communications are creating a need for gallium-arsenide (GaAs) power field-effect transistors (FETs) that deliver higher gain and better linearity than their predecessors. This has prompted Toshiba America Electronic Components, Inc. (Irvine, CA) to introduce a series of matched C-band GaAs FETs that deliver a 2-dB improvement in linearity and 1-dB higher gain than the company's existing line.

The TIM5964-xUL series achieves better gain and linearity performance over the original TIM5964 family based on refinements to the company's GaAs metal-semiconductor FET (MESFET) process technologies. Contributing to the enhanced performance are ion-implantation technology—which provides abrupt carrier concentration profiles and high carrier density—as well as a via-hole structure that reduces source inductance. In addition, the UL series has a new device structure using a plated heat sink at the source contact.

Another UL series change over the original family is the addition of three power ratings, 6, 12, and 25 W

(these are the -4UL, -12UL, and -25UL in the table) plus the 4-, 8-, and 16-W devices. The original family has FETs with power ratings of 30, 35, 45, and 60 W. The 60-W device is the highest power rating for a C-band GaAs FET (5.9-to-6.4-GHz range).

All UL series FETs have a typical gain of 10 at the 1-dB compression point (G1dB) compared with values that range from 7 to 9 for the TIM5964 types. Output power at the 1-dB compression point (P1dB in dBm) varies with a device's power rating as seen in the table, but in general, is approximately +0.5 dBm better (typical) than that of the original family. The new series also offers better third-order intermodulation-

distortion (IM3) specifications than the originals. IM3 is rated at -47 dBc for an output power of +25.5 dBm. The same specification for the original family is -45 dBc.

Also on the UL series of data sheets is a power-added-efficiency (PAE) specification η_{add} . The typical values vary between 36 and 40, depending on the device. Another benefit of the UL series compared to the original family is that they draw a smaller drain-to-source current (I_{DS}) for the same input power (P_{in}).

Typical applications for TIM5964-xUL FETs are in solid-state power amplifiers (PAs) for satellite earth-station communication transmitters and very-small aperture terminals (VSAT). The FETs also target other wireless communications systems as well as point-to-point radio applications. In all of these areas, the trend is away from voice-oriented communications and toward data.

Engineering samples of the UL series are available now and production quantities will be available in September. The series will also be developed to cover the X- and Ku-

band frequency ranges in the future. **Toshiba America Electronic Components, Inc., 9775 Toledo Way, Irvine, CA 92168; (949) 455-2000, FAX: (949) 859-3963, e-mail: toshiaki.nakamura@taec.toshiba.com.**

CIRCLE NO. 56 or visit
www.mwrf.com

TIM5964-xUL C-band GaAs FET series

Parts number	G1dB (dB) (typical)	P1dB (dBm) (typical)	I_{DS} (A) (typical)	η_{add} (percentage) (typical)	IM3 (dBc) at SCL (dBm)	$R_{th(c-c)}$ ($^{\circ}$ C/W) (typical)
TIM5964-4UL	10	36.5	1.1	37	-47 at 25.5	4.5
TIM5964-6UL	10	38.5	1.6	40	-47 at 25.5	4.0
TIM5964-8UL	10	39.5	2.2	36	-47 at 25.5	2.5
TIM5964-12UL	10	41.5	3.2	40	-47 at 25.5	2.0
TIM5964-16UL	10	42.5	4.4	36	-47 at 25.5	1.5
TIM5964-25UL	10	44.5	6.8	37	-47 at 25.5	1.3



SV MICROWAVE™

RF Connectors • Cable Assemblies • Resistive Products

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

SV MICROWAVE™

Commercial Products Group

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

www.svmicrowave.com

MICROWAVES & RF DIRECT CONNECTION ADS

TO ADVERTISE CALL JOANNE REPPAS (201) 666-6698

Microwaves & RF

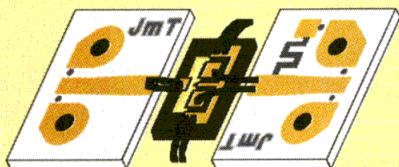
New and Current
Products Presented
By The Manufacturer

DIRECT CONNECTION ADS

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

To Advertise Call Joanne Reppas (201) 666-6698

ProbePoint™ CPW-μStrip Adapter Substrates



- Precision CPW to μStrip Adapter Substrates •
- Companion Calibration substrates and standards •
- Accurate Electrical Data to Frequencies greater than 50 GHz •

- 5, 10, & 15 mil thickness •
- Compatible with 40GHz+ probes •



JmicroTechnology
3744 NW Bluegrass Pl
Portland, OR 97229
(503) 614-9509
(503) 531-9325 (FAX)
www.jmicrotechnology.com

Test Tooling for the Unstable

J MICROTECHNOLOGY

CIRCLE 555

A Better Way to
Communicate

VDMOS
&
LDMOS

RF Power
Transistors

From
Polyfet



polyfet rf devices

Contact / View us on the WEB at
<http://www.polyfet.com>

YOUR
POWER
MOSFET
PEOPLE

1110 Avenida Acaso, Camarillo, CA 93012
TEL (805) 484-4210 FAX (805) 484-3393

POLYFET RF DEVICES

CIRCLE 560

500

500 MSPS ACQUISITION RATE

500 MHz BANDWIDTH

500 MB/s HIGH-SPEED BUS



PDA500 DIGITIZER



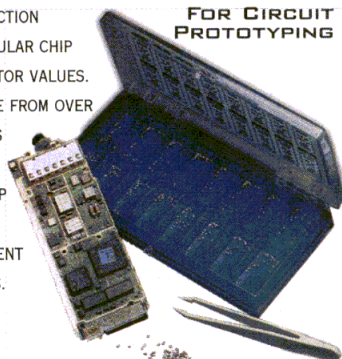
(909) 734-3001
WWW.SIGNATEC.COM

SIGNATEC

CIRCLE 561

NEW ATC MLC DESIGN KITS

A SELECTION
OF POPULAR CHIP
CAPACITOR VALUES.
CHOOSE FROM OVER
25 KITS
EACH
WITH UP
TO 16
DIFFERENT
VALUES.



**american
technical
ceramics**

to learn more

Click here
www.atceramics.com



New e-commerce package

AMERICAN TECHNICAL CERAMICS CIRCLE 551

Filters to 50 GHz

- Waveguide
- Stripline/Microstrip
- Transmission Line
- Miniature/Subminiature
- Lumped Constant.

For more information, ask for
our RF Catalog.

ME

MICROWAVE FILTER COMPANY

6743 KINNE STREET, E. SYRACUSE, NY 13057

315-438-4700 • 800-448-1666 • FAX: 315-463-1467

E-MAIL: mfcsales@microwavefilter.com

<http://www.microwavefilter.com>

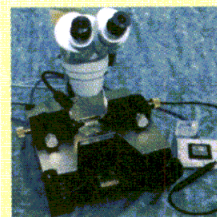
MICROWAVE FILTER CO.

CIRCLE 558

MICROWAVES & RF • JUNE 2000

Microwave Test Fixture

**Easily
Configurable
High
Thru-put**



A compact, full featured, user configurable, manually operated test fixture
with rapid load/unload capability. Useful for production measurements of
thin film and packaged microwave components with NIST traceability.

- Benchtop Size (<1ft³) • Vacuum chuck • X-Y-Z probe positioners •
- Top Plate Z-lift • Locking Stage • Integral Vacuum Accessory Manifold •
- 7X-40X Stereo Zoom Microscope • Adjustable Halogen Illuminator •
- Vacuum Accessories • Compatible with 40GHz+ probes •

Standard and custom chuck plates for testing

MICROSTRIP PACKAGES



JmicroTechnology

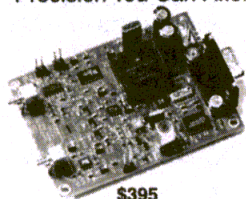
3744 NW Bluegrass Pl
Portland, OR 97229
(503) 614-9509
(503) 531-9325 (FAX)
www.jmicrotechnology.com

The Standard for Test Correlation

J MICROTECHNOLOGY

CIRCLE 557

Rb Standards & DDS Synthesizers "Precision You Can Afford"



\$395

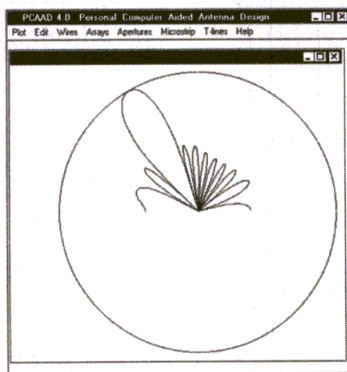
- **Atomic Frequency Standards**
1450A Rubidium+DDS Synthesizer (Rack)
2950AR Rubidium Standard (Bench)
- **Modular and PC-based Synthesizers**
DDS6m (shown) 40MHz RS232 Controlled
DDS5m Locks to Standards RS232 & Switch
DDS3pc & DDS4pc PC ISA-bus to 34 MHz
- **Bench Top Synthesizers**
2910A Series 1μHz steps to 48MHz

Novatech Instruments, Inc.
206-301-8986 (v) , 206-363-4367 (fax)
Specs & prices: www.eskimo.com/~ntsales

NOVATECH INSTRUMENTS, INC. CIRCLE 559

PCAAD 4.0 Personal Computer Aided Antenna Design 32 bit Software for Windows

The latest version of this popular general purpose antenna design and analysis software is now available.



Cost: \$390. For more information, contact:
Antenna Design Associates, Inc.
55 Teawaddle Hill Road, Leverett, MA 01002
Phone/Fax: 413-548-9919

ANTENNA DESIGN ASSOC. CIRCLE 552



Personal Probe Station

**Very Low Cost
High Function**

A compact full featured, modestly priced, manually operated probe station developed for engineers and scientists.

Measure Microwave, RF and DC parameters of Semiconductor Devices, Packages and Assemblies with NIST traceability.

- Benchtop Size (11" x 11") • Vacuum chuck • X-Y-Z stage
- X-Y-Z probe positioners • Top Plate Z-lift • Vacuum Accessory Manifold
- 7X-40X Stereo Zoom Microscope • Adjustable Halogen Illuminator
- Vacuum Accessories • Compatible with 40GHz probes
- Accessories for Thermal Chucks and Probe Cards
- Test wafers, microstrip packages and surface mount components



J microTechnology
3744 NW Blugrove Pl
Portland, OR 97229
(503) 614-9509
(503) 531-9325 (FAX)
www.jmicrotechnology.com

A Probe Station On Every Bench

J MICROTECHNOLOGY CIRCLE 556



BORON NITRIDE

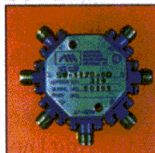
Lowest dielectric/highest thermal conductivity combination available in any material, for hot, high-power requirements and MW transparency. Easily machinable into complex waveguide shapes.

Carborundum Boron Nitride
Amherst, NY 14228
Phone: (716) 691-2052
URL: www.carbobjn.com

CARBORUNDUM CORP. CIRCLE 554

40MHz TO 18GHz HIGH ISOLATION, RADIAL SP6T & SP7T, PIN DIODE SWITCHES

- HIGH ISOLATION
- ULTRA-BROADBAND
- LOW INSERTION LOSS
- LOW PROFILE RADIAL DESIGN



AMC MODEL Nos:
SWN-1170-6DT-00418 & SWN-1170-7DT-00418

SPECIFICATIONS:

• FREQUENCY RANGE	: 0.04 TO 18.0 GHz MAX. 20 dB TO 18.0 GHz AVAILABLE
• INSERTION LOSS	: 1.0 dB MAX. (ABSORPTIVE) (+0.40 dB LOSS FOR REFLECTIVE MODELS)
• ISOLATION	: 65 dB MIN. (TYPICAL)
• VSWR	: 2.0:1
• SWITCHING SPEED	: ≤ 25 nS RISE/FALL MAX. ≤ 250 nS ON/OFF MAX. FASTER SWITCHING SPEEDS AVAILABLE
• CONTROL	: TTL COMPATIBLE REMOTE CONTROL. OPTIONS AVAILABLE
• DC POWER SUPPLY	: ± 5VDC @ +280mA, -35mA MAX.
• SIZE	: 1.25" (DIAMETER) X 0.30" (HEIGHT)
• WEIGHT	: < 3.0 oz.

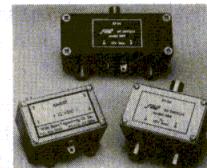
OTHER MODELS AVAILABLE FROM SP6T TO SP16T, BOTH ABSORPTIVE AND REFLECTIVE.



"In Pursuit of Excellence Through Engineering"
AMERICAN MICROWAVE CORPORATION
7311-G GROVE ROAD
FREDERICK, MD 21704
TEL: 301-662-4700, FAX: 301-662-4938

AMERICAN MICROWAVE CORP. CIRCLE 550

SOLID STATE SWITCH



Ultra wide band PIN diode solid state switches for transferring both low and high level signals with negligible distortion, high isolation and minimum loss.

PIN DIODE TRANSFER SWITCH

Switches for lower level applications. Available in transfer and SPDT configurations.

Both types available for 1-500 MHz and 1-1000 MHz operations.

WIDE BAND ENGINEERING CO. INC.

P.O. Box 21652, Phoenix, AZ 85036
Phone & Fax (602) 254-1570

WIDE BAND ENGINEERING CIRCLE 562

New and Current Products Presented By The Manufacturer

Microwaves & RF

*For further information,
circle the appropriate
number on the
Reader Service Card.*

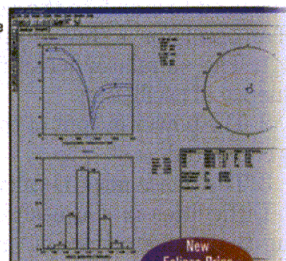
**DIRECT
CONNECTION
ADS**

**To advertise, Call Joanne Reppas at
(201) 666-6698, Fax (201) 666-0557**

Eclipse 5 for Windows 95/98/NT4

CIRCUIT-LEVEL DESIGN

- Lightning-fast 32-bit performance
- Comprehensive element library
- Optimization
- Monte Carlo/Yield analysis
- Multiple design versions within a single project
- Stability/constant-gain circles
- User-defined variables/expressions
- Flexible sweep capabilities



New
Eclipse Price
\$695



Arden Technologies, Inc.

PO Box 286 • Forest, VA 24551

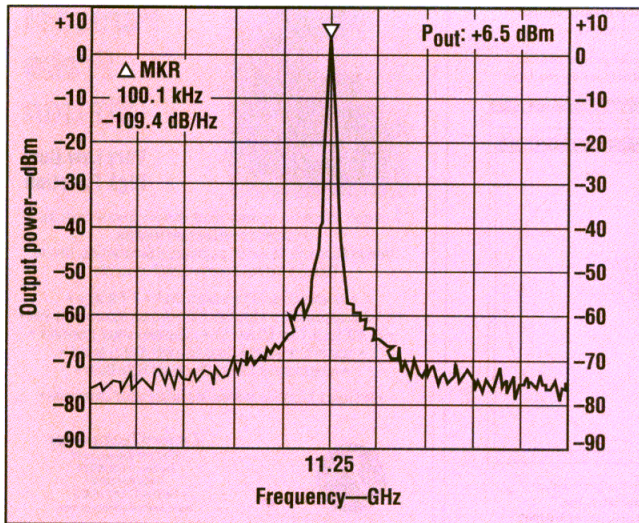
Sales: 804/525-6837 or 888/535-6837 (US only)

Fax: 804/525-5376 • E-mail: sales@ardentech.com

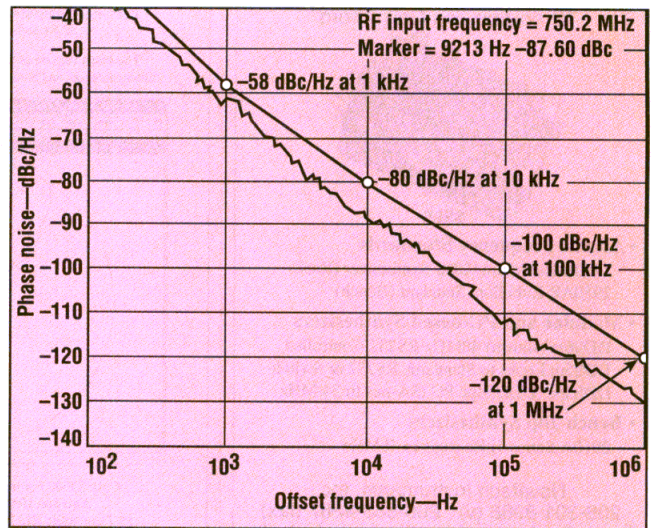
FREE fully functional demos at <http://www.ardentech.com>

ARDEN TECHNOLOGIES, INC. CIRCLE 553

Ku-Band DRO



10. The measured performance of the 11.25-GHz DRO shows good spurious performance.



11. The measured phase-noise performance of the 11.25-GHz DRO exceeds the minimum requirements.

(continued from p. 89)

$= 1/S_{11}$ and that the phase relation is equal to 0 deg. at f_0 . These two relations are easily seen in Fig. 5, where clearly both reflection coefficients have a 0-deg. phase relation and the magnitude relation is respected under small-signal conditions. As signal builds-up, $|S_{11}|$ will decrease and $1/S_{11}$ (M1 in Fig. 5) and the resonator's reflection (M2 in Fig. 5) will merge at the desired frequency at steady state.

After tuning the matching circuit and determining the proper resonator model, the nonlinear model can be substituted for the *.s2p file and used to simulate and optimize the phase noise and power performance of the circuit. Note that accurate and complete modeling of the biasing network is needed at this point to ensure the model will more closely predict the actual circuit.

The Libra simulator from Agilent Technologies (formerly HP-EEsof) was used to simulate the performance of an oscillator in three steps:

1. The simulator looks for the frequency of oscillation.
2. The power output of the oscillator is computed.
3. The phase noise is calculated.

Difficulties in successfully simulating the oscillator circuit are typically encountered in steps 1 and 2. It is more likely that problems will be encountered in step 2 and the simulator will be unable to converge on the oscillator's output power. If this problem is encountered, the following steps may

help convergence problems:

1. Change the Q of the resonator circuit by varying the R of the parallel RLC.
2. Vary the coupling of the resonator by varying the N of the transformer.
3. Vary the source and drain stub lengths.

Using a detailed schematic diagram (available from the author or from the full application note), the simulator predicted the results shown in Figs. 7 and 8. Compared to the measured performance of Table 1, it can be seen that the simulation was useful in predicting actual circuit behavior.

Upon achieving satisfactory results with the simulation and choosing the appropriate circuit values for the different components, a prototype board was constructed and tested for compliance with the proposed specifications. When turned on, the DRO exhibited a lower-than-expected output power (+2 dBm) and the tuning range (via the tuning screw) was less than the preferred 100-MHz minimum, even after optimizing the puck placement. This was due to the non-optimal length of the two tuning stubs (source and drain). Decreasing the length of the drain stub by approximately 20 mils brought the oscillator's center frequency back to 11.25 GHz, slightly increased the output power and provided the required tuning range. Decreasing the source stub granted the expected output power (+6.5 dBm).

Once basic oscillation conditions

were reached, and the two start-up conditions (slow with a power supply and fast by clipping the supply on) were verified, the phase-noise performance was investigated and the puck placement optimized. Although it usually is a time-consuming and tedious activity, it is also fairly straightforward. The puck is first moved along the 50- Ω transmission line to optimize output power, fairly close to the line (to provide a strong coupling).

Once that location is defined, the puck will be moved to that place of reference, either closer to or away from the line. This will reduce the output power, but increase the loaded Q of the DRO and dramatically improve phase noise. Figure 9 presents the layout of the DRO that was tested, and Figs. 10 and 11 present the measured output power and phase-noise performance that was achieved. As can be reviewed in Table 1, these results matched the simulated performance quite well and meet all of the design's specifications. ••

For further reading

Roger Muat, "Choosing Devices For Quiet Oscillators," *Microwaves & RF*, August 1984.

"Converting GaAs FET Models For Different Nonlinear Simulators," California Eastern Laboratories, Santa Clara, CA, Application Note AN1023.

"Designing VCOs And Buffers Using The UPA Family Of Dual Transistors," California Eastern Laboratories, Santa Clara, CA, Application Note AN1034.

J.S. Sun, L. Wu, and C.C. Wei, "Network Analysis Simplifies The Design Of Microwave DROs," *Microwaves & RF*, May 1990.

"An Introduction To Dielectric Resonators," Trans-Tech, Application Note 821.

D.B. Leeson, "A Simple Model Of Feedback Oscillator Noise Spectrum," *Proceedings of the IEEE*, Vol. 54, February 1966, p. 329.

"1/f Noise Characteristics Influencing Phase Noise," California Eastern Laboratories, Santa Clara, CA, Application Note AN1026.
Randall W. Rhea, *Oscillator Design And Computer Simulation*, Nobel Publishing, Stone Mountain, GA, 1995.

AMPS
 CDMA
 CDPD
 DAMPS
 DCS1800
 ECM
 EDGE
 EW
 GEO
 GPRS
 GPS
 GSM900
 HFC
 IFF
 LEO
 LMDS
 LMR
 MMDS
 NPCS
 PCS
 PCS1900
 RADAR
 RFID
 RLL
 SMR
 TDMA
 TETRA
 UMTS
 WAP
 WBA
 WCDMA
 WLAN
 WLL
 WWAN

**Over 400
customers.**

**9,200 part
numbers.**

**6,725,000
solutions
shipped.**

Creating RF and Microwave solutions since 1953.

What can we do for you?

VARI-L

We Have A Part In Your Future

CIRCLE NO. 252

4895 Peoria Street
 Denver, Colorado 80239
 ☎ 303.371.1560
 fax 303.371.0845
 e-mail: sales@vari-l.com

OUR
 PRODUCTS
 INCLUDE:

PLL Synthesizer Modules

Wideband RF Transformers

Couplers

ISO 9001 Certified

Special Integrated Assemblies

Voltage Controlled Oscillators

Double Balanced Mixers

Power Dividers/Combiners

IQ Modulators/Demodulators

PROUDLY MADE IN THE USA



Contact the Vari-L Sales Department for your special microwave and RF component assembly needs.

Vari-L Company, Inc.

www.vari-l.com

LNA serves multiple systems

Model MAX2374 is a miniature low-noise amplifier (LNA) in an ultra-chip-scale package (UCSP). It is intended for code-division-multiple-access (CDMA) applications but can be used in Personal Digital Cellular (PDC), Global System For Mobile Communications (GSM), and enhanced data for GSM (EDGE) applications. The device has 15-dB typical high gain at a supply current of 9 mA. In low-gain mode, the gain is reduced by 1 dB with a reduction in supply current to 4.5 mA. The part is packaged in the UCSP, significantly reducing the required printed-circuit-board (PCB) area. The chip measures only 1.0×1.5 mm and occupies only 40 percent of the area of a 6-pin SC70 package. P&A: \$0.49 (300,000 qty.). **Maxim Integrated Products, 120 San Gabriel Dr., Sunnyvale, CA 94086; (408) 737-7600, FAX: (408) 737-7194, Internet: <http://www.maxim-ic.com>.**

CIRCLE NO. 62 or visit www.mwrf.com

Signal monitor checks satcom quality

The model P9116 satcom signal monitor is a 1.6-GHz spectrum analyzer for local or remote monitoring of C-, X-, or Ku-band downlink signals. Its 0.5 parts-per-million (PPM) frequency accuracy is achieved by locking the fully synthesized local oscillator (LO) to each point in a sweep. This is performed in small steps so that every frequency point that the instrument displays is the equivalent of the reference oscillator. The unit possesses a frequency resolution of 2 Hz and a synthesizer step time of <150 μ s, with an absolute level accuracy of ± 0.5 dB over the -120- to +20-dBm amplitude range. In a remote-monitoring application, located at any designated ground station, the analyzer simulates a server and can be accessed and controlled from any "client-designated" personal computer (PC) or laptop through an RS-232 modem, Ethernet local-area network (LAN), or the Internet. This enables data processing, storage, display, transfer, or printing from anywhere in the world using normal PC techniques. **Morrow Technologies Corp., 2300 Tall**

Pines Dr., Largo, FL 33771; (727) 531-4000, FAX: (727) 531-3531, Internet: <http://www.morrow-corp.com>.

CIRCLE NO. 63 or visit www.mwrf.com

IDPs reach 2.5 Gb/s

The first 2.5-Gb/s integrated detector and preamplifiers (IDPs) have been introduced. Operating from a single +3.3-VDC supply, the models AMT8300T46F/L and AMT8400T46F/L provide high-speed data handling for 800- and 1300-nm fiber applications. They detect fiber-optic signals and convert them to electrical signals, and enable small-form-factor transceivers for high-speed 2X fiber channel and emerging 2.5-Gb/s Infiniband fiber-optic networks. Using automatic gain control (AGC), the AMT8300 offers a minimum sensitivity of -20 dBm and an optical overload of better than 0 dBm for 850-nm applications. The AMT8400 features a minimum sensitivity of -23 dBm and an optical overload of better than 0 dBm for 1300-nm systems. The units offer a bandwidth of 1800 MHz and a wide dynamic range that supports greater flexibility in system designs and applications. The wide dynamic range enables designers to expand the transmission distance of fiber links and provides additional margin in the overall receiver design, supporting greater flexibility in the selection of subsequent components in the receive (Rx) chain. **ANADIGICS, 35 Technology Dr., Warren, NJ 07059; (908) 668-5000, FAX: (908) 668-5132, Internet: <http://www.anadigics.com>.**

CIRCLE NO. 64 or visit www.mwrf.com

Features enhance channel emulator

The model 4500 FLEX5 RF channel emulator has been enhanced with the addition of a new dynamic channel-modeling feature. The FLEX5's third-generation (3G), power-delay-profile (3GPDP) emulation mode is programmable to provide a wide range of time-varying RF channel profiles, exceeding the requirements outlined in code-division-multiple-access (CDMA) 2000 and wideband-code-division-multiple-access (WCDMA)

test specification. The unit's new feature implements moving-propagation and birth-death channel models per 3G specifications designed to evaluate key receiver performance metrics by emulating temporal variations in the propagation channel by changing delay-spread characteristics versus time. The FLEX5 allows predefined 3G channel models to be recalled with the touch of a button. It provides the ability to move beyond the two-path dynamic models that are defined in minimum performance standards by permitting the independent variation of all of its paths over time. When used in conjunction with the TAS4600A noise and interference emulator, it can deliver accurate co- and adjacent-channel interference conditions to ensure precise receiver performance characterization. Together, the TAS4500 and TAS4600 comprise WCDMA-LAB, a system for WCDMA receiver testing. **Telecom Analysis Systems, Inc., 34 Industrial Way East, Eatontown, NJ 07724; (732) 544-8700, FAX: (732) 544-8347, e-mail: sales@taskit.com, Internet: <http://www.taskit.com>.**

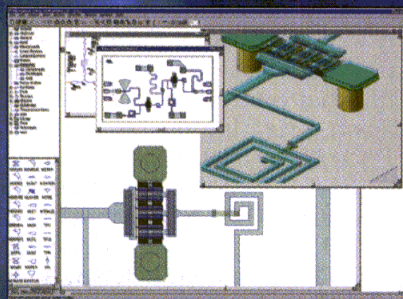
CIRCLE NO. 65 or visit www.mwrf.com

Yagi antennas span 806 to 960 MHz

Models ASP-998 and ASPG998 are Yagi antennas that operate across the 806-to-894- and 890-to-960-MHz frequency ranges, respectively. Both of the models have 8-dBd minimum (10-dBi typical) gain with a typical VSWR of 1.5:1. The ASP-998 Yagi antenna has a front-to-back ratio of greater than 11 dB with a 42-to-51-deg. E-plane and a 53-to-68-deg. H-plane beamwidth. The ASPG998 has a front-to-back ratio of greater than 10 dB with a 44-to-50-deg. E-plane and a 55-to-64-deg. H-plane beamwidth. Both antennas weigh 1.2 lb. (0.54 kg) with a length that consists of 23.2 in. (58.9 cm). The antennas are vertically polarized with a maximum power rating of 125 W. P&A: \$98.50. **Antenna Specialists, 30500 Bruce Industrial Parkway, Cleveland, OH 44139; (440) 349-8400, FAX: (440) 349-7430, Internet: <http://www.antenna.com>.**

CIRCLE NO. 66 or visit www.mwrf.com

To design better phones, use better software.



Download a fully-functional 30-day trial (just 20MB)
at www.mwoffice.com and start designing today.

You can't build tomorrow's technology with yesterday's software. Microwave Office™ 2000 is the high-frequency design suite that bridges the gap between old and new. Our schematic data translators import existing Agilent EEsof Series IV or ADS designs. From there, you have access to the ultimate microwave layout solution, statistical design capabilities, real-time tuning, yield optimization, MMIC foundry support, and new EM-based discontinuity models for precise simulations to millimeterwave frequencies and beyond. For details, visit www.mwoffice.com or call Applied Wave Research at 310-726-3000.



Hybrid aims at PCS and DCS

The model QHD-2H-1.9G Multi-Mix[®] quadrature hybrid is designed specifically for personal-communication-services (PCS) and digital-communications-systems (DCS) applications. It measures $0.56 \times 0.35 \times 0.075$ in. ($1.42 \times 0.89 \times 0.19$ cm) and has a frequency range of 1.7 to 2.0 GHz. The device features an insertion loss of less than 0.3 dB, a voltage-standing-wave ratio (VSWR) of better than 1.181:1, and an isolation of greater than 23 dB. Accurate phase and amplitude balance is less than ± 2 deg. and ± 0.25 dB, respectively, which makes the QHD-2H-1.9G ideal for applications involving in-phase/quadrature (I/Q) networks, power amplifiers (PAs), as well as signal distribution and processing with power requirements up to 100 W. The Multi-Mix QHD series is an easy-to-install, surface-mount device (SMD) designed for the full spectrum of wireless applications. The high-stability, ceramic-filled PTFE dielectrics used in these components are compatible with common substrates such as FR-4, G-10, and polyimide. The wrap-around ground plane provides electromagnetic (EM) shielding. The series is available on tape and reel. **Merrimac Industries, 41 Fairfield Pl., West Caldwell, NJ 07006; (888) 434-6636, FAX: (973) 882-5990, e-mail: MMFM@merrimacind.com, Internet: http://www.multimix.com.**

CIRCLE NO. 67 or visit www.mwrf.com

Diplexers suit LMDS

A range of WR28 (WG22) precision diplexers is suited to current point-to-multipoint telecommunication applications such as local multipoint-distribution services (LMDS). Spanning 26 to 40 GHz the diplexers are available in H- and E-plane geometries. Electrical and mechanical customizations are available to include non-standard flange configurations, fixing brackets, and heat sinks. The design uses the millimeter-wave precision-casting process, enabling complex multipart assemblies to be produced as one precision component, reducing parts count, weight, and assembly time. **Mirco Metalsmiths Ltd., Thorn-**

ton Road Ind. Est., Pickering, N. Yorks. YO187JB, United Kingdom; +44 (0) 1751 475058, FAX: +44 (0) 1751 476364, e-mail: micromarketing@dial.pipex.com, Internet: http://www.micrometal.co.uk.

CIRCLE NO. 68 or visit www.mwrf.com

Synthesizer tunes mobile satellite band

Model 310-010029-001 is a 1710-to-1990-MHz phase-locked-loop (PLL) synthesizer that tunes in 100-kHz steps. It delivers typically 1 ± 2 -dBm output power with better than -66-dBc spurious performance. The frequency stability is ± 2.5 PPM and the phase noise is less than -75 dBc/Hz at 10 kHz from the carrier. P&A: \$700 and up (depending on options). **Praxsym, Inc., P.O. Box 369, 120 South Third St., Fisher, IL 61843; (217) 987-1744, FAX: (217) 897-6388, Internet: http://www.praxsym.com.**

CIRCLE NO. 69 or visit www.mwrf.com

Upconverter MMIC serves CDMA and AMPS

Model HPMX-7201 is a dual-band, dual-mode upconverter monolithic microwave integrated circuit (MMIC) designed for use in dual-mode, mobile-phone handsets, combining 1900-MHz digital personal-communications-services (PCS), code-division-multiple-access (CDMA), and 800-MHz Advanced Mobile Phone Service (AMPS) capabilities. It has a maximum frequency of 40 GHz and operates from +3 VDC nominal (+2.27 to +3.30 VDC), making it ideal for use with a single-cell, lithium-ion (Li-ion) battery. The PCS CDMA transmit chain provides typical adjacent-channel power rejection of -59 dBc/30 kHz at $P_{out} = +11$ dBm and a low-noise floor for compliance with Telecommunication Industries Association (TIA) standard TIA98-C. The CDMA driver has a high output power (up to +10 dBm) to permit it to directly drive handset power amplifiers (PAs), and incorporates a switch on the output to support split-band filtering. The driver is adaptively biased to reduce current consumption and extend battery life. Drivers can be directly powered from the battery. A power-down function

typically reduces the supply current to 1 μ A to support gated operation and eliminate the need for a power-supply switch. **Agilent Technologies, Inc., 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052; (800) 452-4844, Internet: http://www.agilent.com.**

CIRCLE NO. 70 or visit www.mwrf.com

Varactor targets +3-VDC platforms

The model SMV1763-079 silicon (Si) hyperabrupt junction tuning varactor diode is designed specifically for +3-VDC platforms. The hyperabrupt junction tuning varactor features a high capacitance ratio at low reverse voltage, making it suitable for low-phase-noise, voltage-controlled oscillators (VCOs) in wireless systems to 2.5 GHz and beyond. The varactor is designed for high-volume, low-cost battery-powered applications. **Alpha Industries, Inc., 20 Sylvan Rd., Woburn, MA 01801; (781) 935-5150, FAX: (617) 824-4579, Internet: http://www.alphaind.com.**

CIRCLE NO. 71 or visit www.mwrf.com

Amplifier powers Bluetooth designs

Model MAX2240 is a power-amplifier (PA) integrated circuit (IC) designed specifically for applications from 2.4 to 2.5 GHz. The IC operates from a +2.7- to +5-VDC single-supply voltage and generates a nominal +20-dBm (100 mW) output power in the highest power mode with a typical current consumption of 105 mA. The PA is compliant with Bluetooth, HomeRF, and 802.11 wireless local-area-network (WLAN) standards, as well as other frequency-shift-keying (FSK) modulation systems. The PA includes a digital power-control circuit in order to greatly simplify control of the output power. Four digitally controlled output-power levels are provided from +3 to +20 dBm. A digital input controls the active or shutdown operating modes of the PA. P&A: \$1.75 (1000 qty.). **Maxim Integrated Products, 120 San Gabriel Dr., Sunnyvale, CA 94086; (408) 737-7600, FAX: (408) 737-7194, Internet: http://www.maxim-ic.com.**

CIRCLE NO. 72 or visit www.mwrf.com

MILLIMETERWAVE MMICs!

OFF-THE-SHELF!...



from Hittite Microwave

CONVERTER/MIXERS FEATURE:

- ▶ SUB-HARMONIC (x2) LO INPUT
- ▶ INTEGRATED LO AND IF AMPLIFIERS
- ▶ 1.3 x 1.3 mm OR

AMPLIFIERS FEATURE:

- ▶ BROAD BANDWIDTH
- ▶ STABLE GAIN VS. TEMPERATURE
- ▶ +3V SUPPLY

For applications in the emerging market for LMDS, PT-PT, & SATCOM Ka-band communication systems, Hittite Microwave introduces a family of 5 new millimeterwave MMICs.

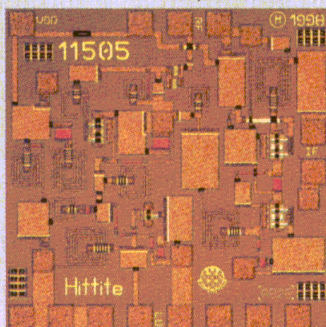
Production qualified PHEMT and MESFET processes are utilized. We offer commercial level die products, 100% RF tested & visually inspected, as well as military and space level screening.

Millimeterwave products are available now in sample or production quantities from our stock!

HMC265

20 - 32 GHz DOWNCONVERTER

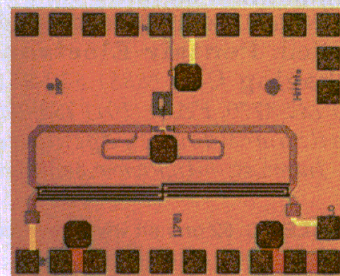
- 13 dB GAIN
- 35 dB 2LO/RF ISOLATION



HMC259

28 - 40 GHz MIXER

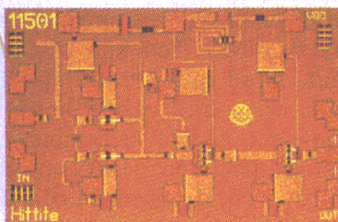
- 1.24 mm x 1.55 mm
- 50 dB 2LO/RF ISOLATION



HMC261

20 - 40 GHz DISTRIBUTED AMPLIFIER

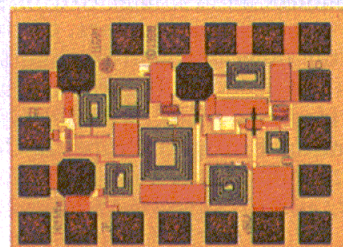
- 14 dB GAIN
- +3 V @ 75 mA



HMC258

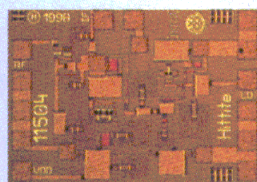
14 - 21 GHz UP/DOWNCONVERTER

- 0 dBm LO INPUT
- 40 dB 2LO/RF ISOLATION



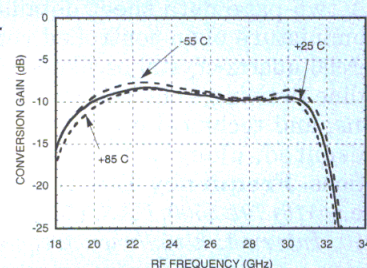
HMC264

20 - 32 GHz
UP/DOWNCONVERTER



FEATURES:

- ▶ INTEGRATED LO AMPLIFIER:
-4 dBm LO INPUT
- ▶ SUB-HARMONICALLY
PUMPED (x2) LO
- ▶ HIGH 2LO/RF ISOLATION:
>35 dB
- ▶ SMALL SIZE:
0.97mm x 1.32mm



PRODUCT SPECIFICATIONS ARE GUARANTEED, -55 °C TO +85 °C...

Hittite
MICROWAVE CORPORATION



www.hittite.com

PHONE: 978 250 3343 ▶ FAX: 978 250 3373

12 Elizabeth Drive, Chelmsford, MA 01824 USA

CIRCLE NO. 394



Request
Our 1999
Catalog/CD!



Packaging technologies

The latest electronic enclosure and packaging technologies, products, and trends are detailed in a 20-page brochure. Enclosure specifications, precision stamping, outdoor enclosures, other applications, and input/output (I/O) interconnection methodology for VME board and chassis designers are covered. A new products and literature section is also included. **Pentair Electronic Packaging Co.;** (888) 550-9543, (401) 732-3770, FAX: (401) 738-7988, e-mail: gmceldowney@pentairep.com, Internet: <http://www.pentairep.com>.

CIRCLE NO. 62 or visit www.mwrf.com

ADSL technology

An 11-page application note (no. 72) provides an overview of asymmetric-digital-subscriber-line (ADSL) technology for installing, operating, and maintaining ADSL lines and equipment. Measurement techniques for U-C and U-R interface electrical parameters, testing splitter functions, and transmitter tests are included. Descriptions are provided. **Wavetek Wandel Goltermann Eningen GmbH & Co.;** +49 7121 86-1616, FAX: +49 7121 86-1333, e-mail: info@wvgsolutions.com, Internet: <http://www.wvg solutions.com>.

CIRCLE NO. 63 or visit www.mwrf.com

Quartz-crystal oscillator

A two-page data sheet details a subminiature oven-controlled commercial quartz-crystal oscillator. An outline drawing, complete specifications, and technical highlights are presented, along with available options. **Frequency Electronics, Inc.;** (516) 794-4500, FAX: (516) 794-4340, Internet: <http://www.fregelec.com>.

CIRCLE NO. 64 or visit www.mwrf.com

Chemical milling

A media kit containing two brochures and an information sheet illustrates the chemical milling process. Benefits, frequently asked questions, as well as dimensions and tolerances are explained. Sheet-metal stamping is also discussed, along with custom RF shields that

are produced using the photochemical milling process. **Precision Photo-Fab, Inc.;** (800) 875-1093, (716) 821-9393, FAX: (716) 821-9399, e-mail: ppfi@aol.com, Internet: <http://www.precisionphotofab.com>.

CIRCLE NO. 65 or visit www.mwrf.com

Cable assemblies

A 60-page catalog features a line of cable assemblies and adapters. Standard flexible and semirigid cable assemblies, coaxial adapters, isolators, circulators, detectors, limiters, attenuators, terminations, phase-adjustable adapters, and connectors are featured. The catalog tabulates approximately 3000 standard-cable assemblies in 12-in. (30.48-cm) increments up to 72 in. (182.88 cm). **Microwave Distributors Co.;** (800) 637-4353, (631) 234-3434, FAX: (631) 234-3913, Internet: <http://www.microwavedistributors.com/mi disco>.

CIRCLE NO. 66 or visit www.mwrf.com

Test equipment

A 300-page catalog contains information on products from a variety of manufacturers. Tool kits, test equipment, hand, power and specialty tools, wire and cable, soldering equipment, as well as computer and local-area-network (LAN) products are covered. **Jensen Tools, Inc.;** (800) 426-1194, (602) 453-3169, FAX: (800) 366-9662, (602) 438-1690, e-mail: jensen@stanleyworks.com, Internet: <http://www.jensentools.com>.

CIRCLE NO. 67 or visit www.mwrf.com

Wireless design

A brochure discusses a software package that offers a set of planning tools for wireless communication systems applications. Multiple map displays, support for Windows™ printer/plotter device drivers, clipboard support, and toolbars are highlighted. **EDX Engineering, Inc.;** (541) 345-0019, FAX: (541) 345-8145, e-mail: info@edx.com, Internet: <http://www.edx.com>.

CIRCLE NO. 68 or visit www.mwrf.com

Process cleaning

A four-page brochure details power generators for wet process cleaning. Generator features are

included. Power and frequency range, generator and operator controls, footprint choices, RF output channels, and an operating protocol are specified. **Lambda RF Systems;** (408) 653-1675, FAX: (408) 653-1660, e-mail: bruce_chinich@Lambdaaa.com, Internet: <http://www.lambdarfsystems.com>.

CIRCLE NO. 69 or visit www.mwrf.com

Power dividers

A 152-page catalog details power dividers, directional couplers, high-power dual directional couplers, as well as 90- and 180-deg. hybrids. Waveguide adapters; coaxial terminations; low-, medium-, and high-power waveguide terminations; coaxial attenuators; continuously variable attenuators; as well as interdigital and bandpass filters are also offered. **Microwave Communications Laboratories, Inc.;** (727) 344-MCLI, (727) 344-6254, Internet: <http://www.MCLI.com>.

CIRCLE NO. 70 or visit www.mwrf.com

DC-to-DC converters

A design guide provides information on a family of second-generation DC-to-DC converter modules. Design considerations, test-and-measurement methods, as well as filtering and transient protection are discussed. Mechanical specifications, as well as mounting and thermal management data are presented. Control function information is provided, along with soldering guidelines. **Vicor Corp.;** (800) 735-6200, e-mail: vicorex@vicr.com, Internet: <http://www.vicr.com>.

CIRCLE NO. 71 or visit www.mwrf.com

Epoxy systems

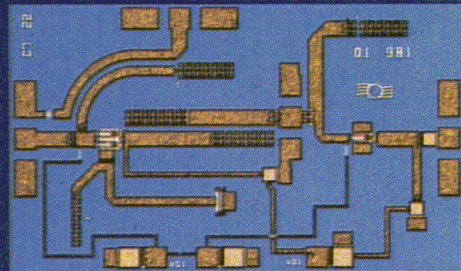
A technical bulletin presents a line of epoxy systems. Ultra-high temperature systems—consisting of both filled and unfilled systems for applications as high as 600°F, high-temperature general-purpose systems, as well as high-temperature maintenance-and-repair systems are covered. Specifications are also provided. **Aremco Products, Inc.;** (914) 268-0039, FAX: (914) 268-0041, e-mail: aremco@aremco.com, Internet: <http://www.aremco.com>.

CIRCLE NO. 72 or visit www.mwrf.com

WITH A LITTLE *TLC* ...

TLC "O" MMIC Chip

The Worlds Most Versatile
MMIC Chip



- 2 to 79 GHz Operation
- MULTIPLIER, VCO, ILO, DRO, MIXER, AMP
 - $> 16 \text{ dBm @ } 38 \text{ GHz}$
 - $8 \text{ dBm @ } 77 \text{ GHz}$
 - $-100 \text{ dBc/Hz @ } 100 \text{ KHz @ } 77 \text{ GHz}$

The TLC "O" chip is a general purpose MMIC oscillator with an output buffer amplifier. The center frequency is voltage and mechanically tunable by plucking airbridges. Versatile option allows for higher Q restoration, injection locking, harmonic multiplication, sub-harmonic mix up and down.

The versatility of the TLCO01981 "O" chip oscillator makes it an excellent candidate for use in radar or communication systems from 2 to 79 GHz.

Patents Pending

... YOUR PRODUCT COMES TO LIFE



TLC PRECISION WAFER TECHNOLOGY, INC.
1618 WEST RIVER ROAD N.
MINNEAPOLIS, MN 55411
(612) 341-2795 FAX (612) 341-2799
Web: www.tlcprecision.com
E-mail: sales@tlcprecision.com

OUR MISSION IS TO GIVE OUR CUSTOMERS A COMPETITIVE ADVANTAGE!



Wireless Symposium

Portable by Design

WHERE THE WIRELESS FUTURE GETS BUILT

2nd Annual Engineering Technology Conference & Showcase at PCIA GlobalXChange

September 27th - 29th, 2000
McCormick Place
Chicago, IL

PCIA
GLOBAL
XCHANGE™

Partners for a Global Marketplace

For the second consecutive year, Wireless/Portable will present a leading technical conference and showcase for electronics engineers and designers at PCIA GlobalXChange (formerly the Personal Communications Showcase). Discover the engineering solutions that will keep you up with demanding schedules. See the latest technology at the wireless industry's "must-attend" event. This year, PCIA GlobalXChange will feature traditional wireless companies as well as the Internet and computing players positioning themselves for global wireless convergence.

Leading Technology Forum

Wireless/Portable in conjunction with Besser Associates consistently delivers high-level technical presentations led by the industry's brightest talent. For the second consecutive year, Wireless/Portable will focus more than 50 sessions on wireless technologies, infrastructure solutions, and support solutions in:

- Bluetooth/Wireless LAN's
- Broadband Wireless
- ESMR/SMR
- Fixed Wireless
- Satellite and Mobile Computing
- And More!!!

Focused Showcase

Don't miss the Wireless/Portable showcase on the show floor. You will discover the top vendors in electronics engineering and design offering the latest in hardware, software, services, and test equipment!

Wireless/Portable is sponsored by:

**EMBEDDED
SYSTEMS
DEVELOPMENT**

ELECTRONIC DESIGN
TECHNOLOGY INFLUENCING PRODUCT SOLUTIONS

EE new products for prototype design
Product News

Microwaves & RF

**WIRELESS
SYSTEMS DESIGN**

Conference Director



Free Admission

to the show floor with your
paid conference Registration
(\$100 Value)

Save up to 40%

Register for a conference package
online before July 28th using code
MRF2 and receive 40% off
the on-site prices.

Log on to www.WirelessPortable.com
for detailed session descriptions,
registration information, and more.
Call 1-888-WireReg to receive
a conference brochure.

**Don't delay,
seating is limited!**

When you need Clarity and Power



Stanford Microdevices is the clear choice.

When clarity and power matter most, Stanford Microdevices delivers.

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

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

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

www.stanfordmicro.com
Make us your home page!

SPECIFICATION MATRIX

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

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

SiGe HBT MMIC features include:

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



SOT-89 package



86 package

**STANFORD
MICRODEVICES**

We Deliver RF Innovation

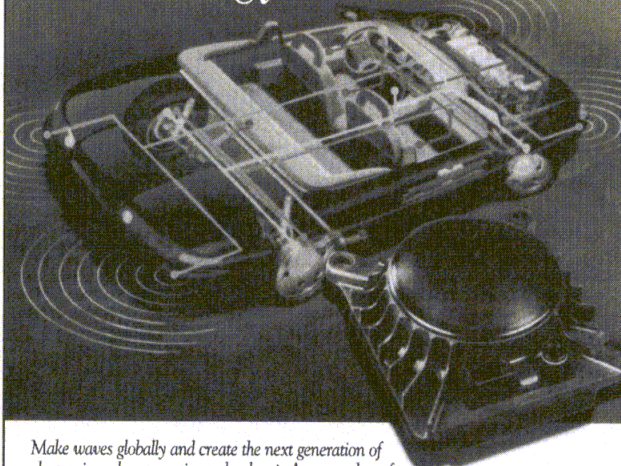
1-800-764-6642 U.S. Toll-Free

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

©2000 Stanford Microdevices. All company and/or product names are trademarks and/or registered trademarks of their respective owners.

MICROWAVES & RF ENGINEERING CAREERS

Technology that hits home



Make waves globally and create the next generation of electronic and automotive technology! As a member of our team, you'll enjoy the resources of Tyco International Ltd, our parent company. You'll have the opportunity to sharpen your skills, advance your career, and integrate new wireless sensor technologies into automobiles. The electronics share in tomorrow's vehicles will surpass everything that's come before it — and will demand unique expertise in electronic and automotive technology. Are you ready for the challenge? Make waves with M/A-COM.

Sr. Quality Assurance Engineer - Automotive

Lowell, MA - Job Code: FD-99-195CBA

Implement, improve and maintain our Automotive Quality System (QS9000/ VDA 6.1) activities, such as APQP, 8-D corrective action, PPAP, etc. for various automotive programs. Provide internal engineering and production support, reliability engineering, supplier development/ control and interface with customers on quality. Requires BSME/EE, minimum of 6 years experience, and strong electronics experience, preferably RF. Solid automotive background with an understanding of industry quality requirements is essential. Quality system implementation experience preferred.

Software Engineer

Lowell, MA - Job Code: DBC-99-AU011D

Openings for Staff and Sr. Software Engineers. Develop radar signal processing algorithms for automotive radar. Background in high level C programming essential. Some Windows and/or UNIX programming experience useful. Experience in the following areas a plus: embedded systems, OSEK, RTOS, DSP, radar, tracking filters, CAN, automotive industry software standards. Domestic/ International travel may be required.

Sr. RF Electrical Engineer

Lowell, MA - Job Code: DBC-00-272-CBD

Design/develop millimeter wave circuits for high volume automotive applications. Requires BSEE with 5 years experience or MSEE with 3 years experience. Oscillator, mixer, high speed switch, and/or antenna design experience required. Experienced with simulation, analysis, and layout tools (i.e. ADS, HFSS, SONNET, ME-10, Mentor). Radar and/or communication system experience desired. Domestic/ International travel may be required.

Sr. Mechanical Engineer

Lowell, MA - Job Code: DBC-00-271-CBD

Design/develop electronic packaging for high volume automotive applications. Requires BSEE with 5 years experience or MSEE with 3 years experience. Experience with high volume design and manufacturing techniques desired. Familiarity with CAD design tools required (i.e. ME-10, Solid Designer). Automotive experience and familiarity with VDA and/or QS9000 quality systems desired. Domestic/ International travel may be required.

We will provide relocation assistance.

M/A-COM is celebrating its 50th anniversary this year.

If interested please forward your resume to: M/A-COM, Attn: Employment Department, 1011 Pawtucket Boulevard, Lowell, MA 01854; Fax: 978-442-4443.

E-mail responses may be sent to: macom_careers@tycoelectronics.com

An Equal Opportunity/
Affirmative Action Employer

tyco
Electronics

M/A-COM

For more information, please visit our website at:

www.macom.com

RATES

Effective January 1, 2000

\$205 per column inch

Commissionable to agencies

DEADLINES

Space reservation: 5th of month preceding issue date

Ad material to: Penton publishing, Classified

Dept., 611 Route 46 West,
Hasbrouck Heights, NJ 07604

SALES STAFF

Call Customer Service

Department

(201) 393-6083

Fax (201) 393-0410

RF Job Network™

Jobs for RF/Wireless/Microwave Engineers

www.rfjn.com

Free to Job-Seekers / \$100 for Employers



If you
would
like to
place an
ad in the

**Classified Section
of Microwaves & RF!**

Customer Service
Department at...

• PH 201-393-6243

• FAX 201-393-6200

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

Advertiser Website, E-Mail Address Page

A			
Agilent Technologies	www.agilent.com	Inside Front Cover, 27, 43, 53, 99, 109, 125	
American Microwave Corp.	www.amwave.com, e-mail: amcpm@aol.com	57, 163	
American Technical Ceramics	www.atceramics.com, e-mail: sales@atceramics.com	45, 162	
AML Communications	www.aml.com, e-mail: sales@aml.com	107	
Analog Devices	www.analog.com/fastacts	9	
Anaren Microwave, Inc.	www.anaren.com	19, Back Cover	
Anritsu Co.	www.anritsu.com	8	
Ansoft Corp.	www.ansoft.com, e-mail: info@ansoft.com	87, 135, 157	
Antenna Design Assoc.		163	
Applied Wave Research	www.mwoffice.com	167	
Ardent Technologies	www.ardentech.com, e-mail: sales@ardentech.com	163	
ARRA, Inc.	www.ara.com	Inside Back Cover	
ATN Microwave, Inc.	www.atnmicrowave.com	146	
Avnet-MTS	www.em.avnet.com	37, 39	
Avtech ElectroSystems Ltd.	www.avtechpulse.com, e-mail: info@avtechpulse.com	18	
B			
Bird Component Products	www.birdfla.com, e-mail: sales@birdfla.com	148	
C			
California Eastern Labs	www.cel.com	4	
Carborundum Corp.	www.carb.com	163	
Chin Nan Precision Electronics	www.chinnan.com, e-mail: market@chinnan.com.tw	92	
Communications Solutions, Inc.	www.comsol-inc.com, e-mail: sales@comsol-inc.com	145	
Continental Microwave & Tool	www.contmicro.com, e-mail: sales@contmicro.com	35	
Cougar Components	www.cougarcorp.com, e-mail: cougar.amps4@cougarcorp.com	76	
CTT, Inc.	www.cttinc.com	41	
D			
Dielectric Laboratories	www.dilabs.com, e-mail: sales@dilabs.com	149	
Digi-Key	www.digkey.com	6	
Dupont	www.dupont.com/mcm	51	
E			
Eagleware	www.eagleware.com, e-mail: eagleware@eagleware.com	118	
EE Product News Online	www.eepn.com	128	
Elanix, Inc.	www.elanix.com	117	
Ericsson RF Power Products	www.ericsson.com/rfpower, e-mail: rfpower@ericsson.com	32-33, 32AB	
EIC Corp. - Excellence In Communications	www.eicorp.com, e-mail: sales@eicorp.com	60	
G			
General Microwave	www.generalmicrowave.com	83	
Giga-tronics, Inc.	www.gigatronics.com	147	
H			
H.C. Protek	www.hcprotek.com, e-mail: hcprotek@hcprotek.com	128AB	
Herley MDI	www.herleymfg.com	141	
Hitachi Metals America, Inc.	www.hitachimetals.com	102	
Hittite Microwave	www.hittite.com	169	
I			
Infinicon Technologies	www.infinicon.com	95, 139	
Inmet Corp.	www.inmetcorp.com	66	
Interad Ltd.	e-mail: interad@pop.erois.com	156	
Internet Device Builder	www.idvbuilder.com	62*	
J			
J Microtechnology	www.jmicrotechnology.com	162, 163	
JCA Technology	www.jcatech.com, e-mail: jca@jcatech.com	2	
JFW Industries, Inc.	www.jfwindustries.com, e-mail: sales@jfwindustries.com	36	
Johanson Manufacturing Co.	www.johansonmfg.com	137	
Johnson Components, Inc.	www.johnsoncomp.com	10	
K			
K&L Microwave	www.klmicrowave.com, e-mail: klsales@klmicrowave.com	21	
Kalmus Engineering	www.kalmus.com	88	
KMW USA, Inc.	www.kmwinc.com	100, 130, 159	
Korea Sangshin Electric Co. Ltd.	www.koreasangshin.com, e-mail: ksebz@komet.net	70	
Krytar, Inc.	www.krytar.com	84	
L			
LPKF Laser & Electronics	www.lpkfcdacm.com, e-mail: info@lpkfcdacm.com	105	
M			
M/A-COM Microelectronics	www.macom.com	16, 49	
Maury Microwave, Inc.	www.maurymw.com, e-mail: maury@maurymw.com	38	
Maxim Integrated Products	www.maxim-ic.com, e-mail: appsthesupport@cmil.mxim.com	73, 75, 77, 79	
MDL	www.micro-dev-labs.com, e-mail: mdsales@micro-dev-labs.com	136	
Microtronics/Test Equipment	www.microtronics.com	12	
Microwave Communications Labs, Inc.	www.mcl.com	17	
Microwave Filter Co., Inc.	www.microwavefilter.com, e-mail: mfcsales@microwavefilter.com	162	
Microwave Solutions, Inc.	www.microwavesolutions.com, e-mail: sales@microwavesolutions.com	134	
MITEQ, Inc.	www.miteq.com	1, 68-69	

Advertiser Website, E-Mail Address Page

N			
Modular Components National	www.mcn-mmmp.com, e-mail: sales@mcn-mmmp.com	48	
MTI-Millren Technologies	www.mti-millren.com	101, 111	
O			
National Semiconductor	www.national.com	28	
Nexyn Corp.	www.nexyn.com	89	
Noise Corn, Inc.	www.noise.com, e-mail: info@noise.com	96AB	
Novatech Instruments, Inc.	www.eskimo.com/~ntsales	163	
P			
ON Semiconductor	www.onsemi.com/broadband-ecl	14-15	
Optotek Ltd.	www.optotek.com, e-mail: sales@optotek.com	127	
Q			
Planar Electronics Technology		61	
Planar Filter Co.		63	
Planar Monolithic Industries		59	
Phoenix Microwave Corp.	www.stellexms.com, e-mail: info@phnixmw.com	151	
Point Nine Technologies	www.rfmstet.com	34	
PoleZero Corp.	www.polezero.com	101	
Polyfet RF Devices	www.polyfet.com	162	
Precision Photo-Fab, Inc.	www.precisionphotofab.com, e-mail: ppfi@aol.com	18	
R			
Q-Bit Corp.	www.remecq-bit.com, e-mail: sales@remecq-bit.com	121	
Q-Tech Corp.	www.q-tech.com	40	
Quasar Microwave Technology	www.qmtl.com, e-mail: sales@qmtl.com	156	
Questlink Technology, Inc.	www.questlink.com	103	
Quinstar Technology, Inc.	www.quinstar.com, e-mail: sales@quinstar.com	50	
S			
RF Micro Devices	www.rfmd.com	90-91	
RF Power Components, Inc.	www.rfpower.com	Back Cover	
Richardson Electronics	www.rpower.com, e-mail: ssc@rell.com	11	
T			
Sawtek, Inc.	www.sawtek.com, e-mail: sales@sawtek.com	44	
Signatec	www.signatec.com	162	
Sonnet Software, Inc.	www.sonnetusa.com, e-mail: info@sonnetusa.com	115	
Spectrum Elektrotechnik GmbH	e-mail: specelek@compuserve.com	62**	
Spinner North America	www.spinerna.com, e-mail: sales@spinerna.com	155	
Sprague-Goodman Electronics	www.spraguegoodman.com, e-mail: info@spraguegoodman.com	67	
Stanford Microdevices	www.stanfordmicro.com	58, 112, 154, 173	
Stellex Microwave Systems	www.stellexms.com, e-mail: sales@stellexms.com	24	
Storm Products, Inc.	www.stormproducts.com	46	
SV Microwave	www.svmicro.com, e-mail: sales@svmico.com	161	
Synergy Microwave	www.synergymw.com, e-mail: sales@synergymw.com	81, 123, 143	
U			
Ultratrol Cyclonectics, Inc.	www.tci-ant.com, e-mail: techtrol@paonline.com	102	
Tegam, Inc.	www.tegam.com, e-mail: sales@tegam.com	66	
Tektronix Corporate Advtg.	www.tektronix.com/3G	133	
Telecom Analysis Systems	www.taskit.com, e-mail: sales@taskit.com	3	
TLC Precision Wafer	www.tlcprecision.com, e-mail: sales@tlcprecision.com	171	
TestMart	www.testmart.com	22	
TFW Space & Electronics	www.tfw.com/telecom	153	
TTE, Inc.	www.tte.com, e-mail: sts@tte.com	13	
V			
Ultra RF	www.ultraf.com, e-mail: info@ultraf.com	30	
W			
Vari-L Company, Inc.	www.vari-l.com	165	
Voltronics Corp.	www.voltronicscorp.com, e-mail: info@voltronicscorp.com	64, 64AB	
X			
W.L. Gore & Associates, Inc.	www.gore.com	104	
Watkins Johnson Co.	www.wj.com	20	
WaveLine, Inc.	www.wavelineinc.com	138	
Weinschel Corp.	www.weinschel.com	7	
Wide Band Engineering	www.wbecoinc.com, e-mail: wideband@wbecoinc.com	163	
Wireless Symposium/Portable By Design	www.wirelessportable.com	172	
Y			
Xpedition Design Systems, Inc.	www.xpedition.com, e-mail: info@xpedition.com	82	
Z			
Zeland Software, Inc.	www.zeland.com, e-mail: zeland@zeland.com	120	
Zeta Labs	www.zeta-sni.com, e-mail: zeta@zeta-sni.com	54	

*Domestic Edition only
**International Edition only

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

MARKETING AND ADVERTISING STAFF

GROUP PUBLISHER
Craig Roth
(201) 393-6293
e-mail: crr@penton.com

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

EXHIBIT SALES REP, ELECTRONICS
Todd Cusumano
(212) 547-1841, FAX: (212) 949-8981
e-mail: tcusumano@penton.com

RECRUITMENT ADVERTISING
Carl Customer Service Dept.
(201) 393-6243
FAX: (201) 393-6243

NORTHERN CA, NORTHWEST
Gene Roberts
Regional Sales Manager
Penton Media, Inc.
611 Route 840 West
Hawthorne Heights, NJ 07040
(908) 441-0550
e-mail: groberts@penton.com

NEW YORK, NEW ENGLAND, MIDWEST, MID-ATLANTIC, CANADA
Paul Borman
Regional Sales Manager
Penton Media, Inc.
611 Route 840 West
Hawthorne Heights, NJ 07040
(908) 704-2496
e-mail: pborman@penton.com

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

MIDWEST, MID-ATLANTIC
Paul Borman
Regional Sales Manager
Penton Media, Inc.
611 Route 840 West
Hawthorne Heights, NJ 07040
(908) 441-0550
e-mail: pborman@penton.com

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

ISRAEL
Igael Ezer, General Manager
BSP Marketing Group
2 Habonim Street
Ramat Gan, Israel 52462
Phone: 011-972-3-612246
011-972-3-612248
FAX: 011-972-3-612249

TAIWAN, R.O.C.
Charles C.Y. Liu, President
Two-Way Communications Co. Ltd.
11F/1, No. 421
Sung Shun Road
Taipei 110, Taiwan, R.O.C.
Phone: 886-2-727-7799
FAX: 886-2-725-3686

INDIA
Shivaji Bhattacharya
Information & Education Services
1st Floor, 30/8, Bar Saral Village,
Near U.T. Hou. Khola, Behind
South Indian Temple
New Delhi, 110016 India
FAX: 001-91-11-6871615

ITALY
Claudio Cetrighi
Via Nappa Torloni 19/c
1-22100 Como - Italy
Phone: 39-31-261487
FAX: 39-31-261380

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

SPAIN
Luis Andrade, Miguel Estebar
España
Publicidad Internacional
Secuiteria 143-38
08011 Barcelona, Spain
Phone: 011-34-93-323-3031
FAX: 011-34-93-453-2977

SCANDINAVIA
Paul Bonett
J.P.M. Hartwood
Hallmark House
26 Downham Road
Ramsden Heath
Bilbercy, Essex
CM11 1PV
United Kingdom
Phone: 44-1268-711-560
FAX: 44-1268-711-567

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

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

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

PORTUGAL
Paulo Andrade
Imitudo Publicidade
Internacional, LDA
Av. Eng. Duarte Pacheco
Empreendimento das
Amoreiras-Torre 2
1070 Lisboa, Portugal
Phone: 351-1-3883176
FAX: 351-1-3883283

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

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

KOREA
BSKOM
Jo Young Sang
Rm. 821, Midco Bldg. 145
Dan Ju-Dong
Chongno-Gu
Seoul 150-971, Korea
Phone: (02) 9797840
FAX: (02) 9736662

Like what
you see?
Need more
information?
Do you want
it now?

www.mwrf.com



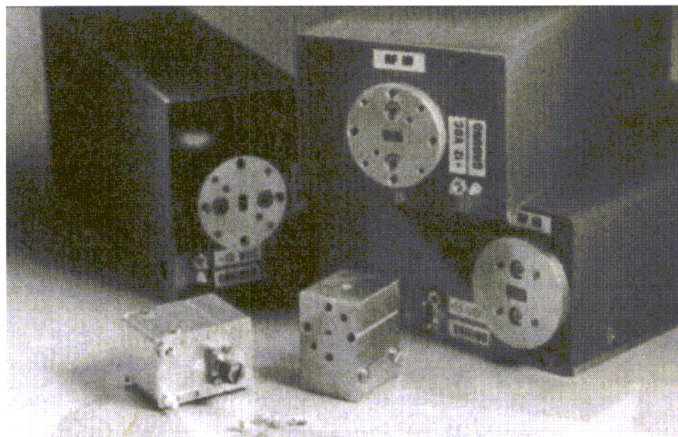
Visit the
Microwaves & RF
website at:

www.mwrf.com and click the
instant inquiry button to request
information seen in this issue or
visit the manufacturers links for
direct access to all *Microwaves & RF* advertisers.

**Microwaves
& RF**

 **Penton**

611 Rte. 46 West,
Hasbrouck Heights, NJ 07604



Just over 15 years ago, Varian Associates (Palo Alto, CA) introduced a millimeter-wave amplifier for satellite-communications use at 44 GHz. Based on indium-phosphide (InP) Gunn diodes, the amplifier delivered 100-mW output power with 30-dB small-signal gain and 15-dB noise figure.

Microwaves & RF July Editorial Preview

Issue Theme: Fiber-Optics Technology

News

Fiber-optic technology has often been viewed as an alternative to RF technology. Increasingly, RF designers are viewing fiber optics as a companion technology. Already, device manufacturers are looking ahead to rates of 40 Gb/s. This technology is already well-entrenched in portions of wireless systems, with many high-speed applications on the way.

Design Features

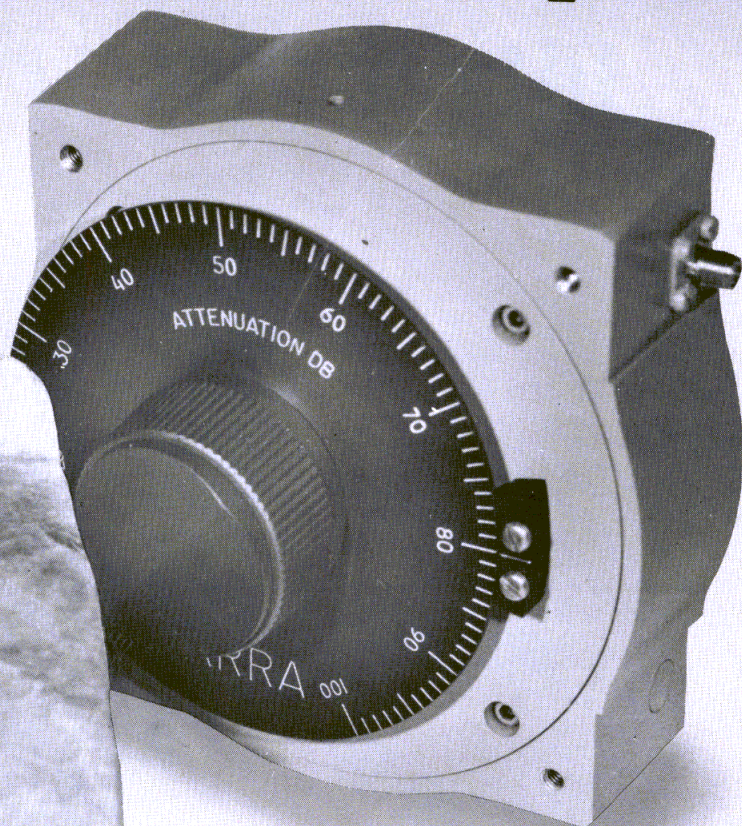
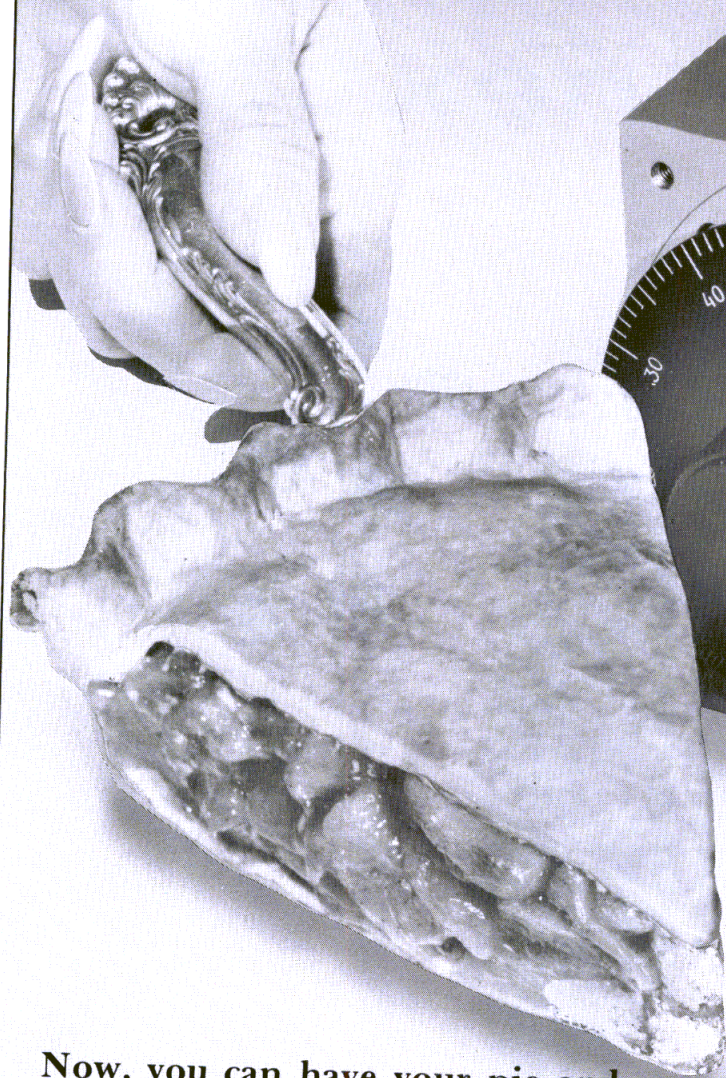
Several of July's contributed articles are devoted to noise analysis. In one, authors from France explain how a powerful system-level software simulator can be used in order

to predict the noise power ratio (NPR) of RF and wireless modules. In another, a world-renowned author in frequency-synthesizer design reviews recent advances in linear voltage-controlled-oscillator (VCO) calculations and design.

Product Technology

July's Product Technology section features several components that are aimed at high-power solutions, including a four-port drop-in circulator for personal-communications-services (PCS) applications and a line of high-power transistors designed for pulsed avionics applications.

Get a piece of the ARRA pie...



100 dB Variable Attenuators

Now, you can have your pie and eat it too! Only from **ARRA!** Four models that cover the 500 to 8000 MHz frequency range! Available in lower attenuation ranges. *Customerized to your requirements with little or no additional charge.* Top performance. Super dial accuracy.

- Direct reading dial
- Extremely high reliability
- Non-contacting movable parts (our special recipe)
- High power version available (up to 200 W)
- Usage will not change calibration
- Attenuation will not vary with temperature
- Excellent phase characteristics
- Type N standard SMA connectors available

Applications include:

- TACAN • DME/IFF • Lab standards • Altimeter
- Or any other requirements needing high attenuation and accurate dial reading.

Visit our website at www.arra.com

100 dB Attenuators Mmmm....		
Freq Range	Atten vs Freq dB	Model #
500 - 1000 MHz	1.5	2952 - 100
900 - 1300 MHz	0.75	2-3952 - 100
1000 - 2000 MHz	1.5	3952 - 100X
2000 - 4000 MHz	1.5	4952 - 100 X
4000 - 8000 MHz	1.5	5952 - 100X
Insertion loss - 6 dB		
VSWR - 1.5		
Power - 15 cw		
Temperature -30 to +120 C		

Some of the best attenuator recipes you can find are cooking at **ARRA** right now! Send for your copy today and get a piece of the **ARRA** pie.

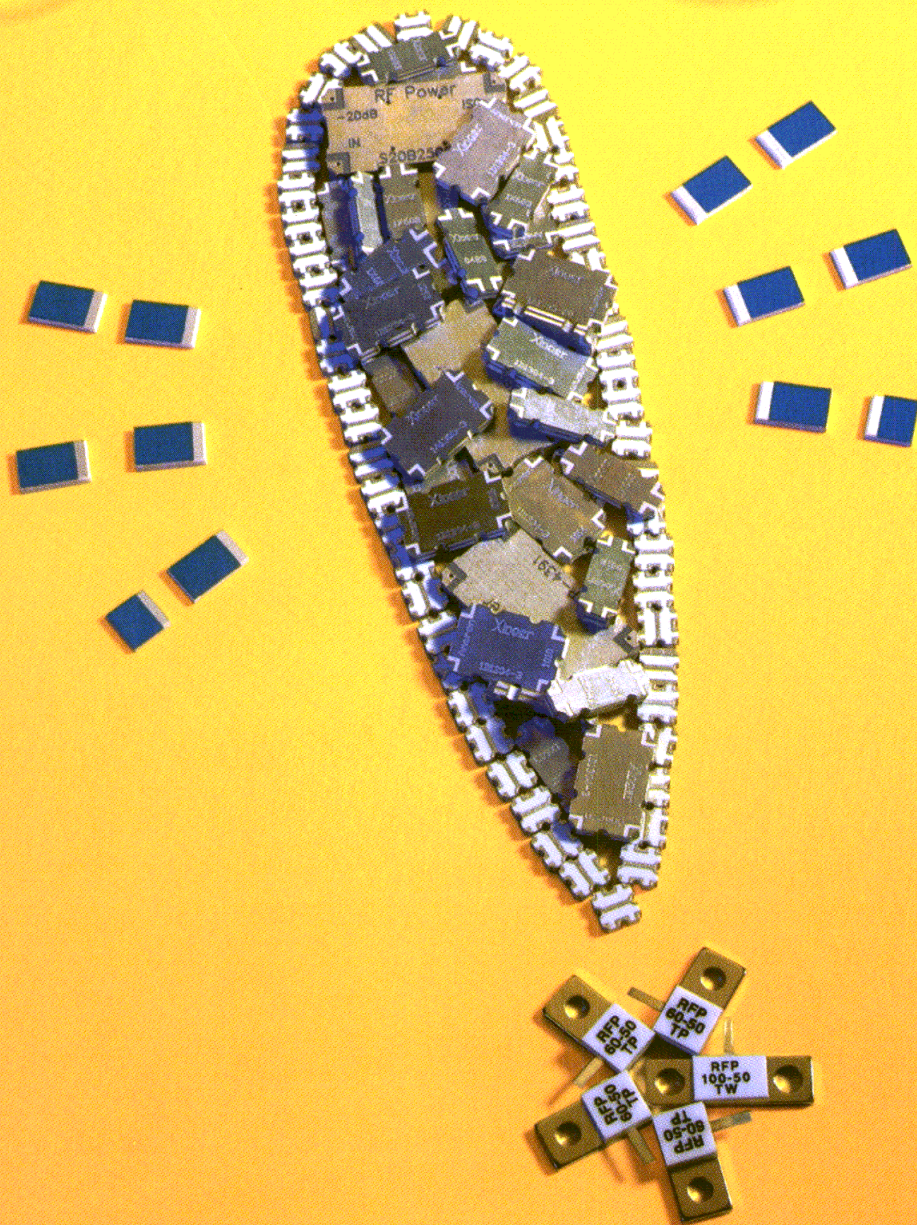
... the last word in variable attenuators

ARRA INC.

ANTENNA & RADOME RESEARCH ASSOCIATES

15 Harold Court, Bay Shore, N.Y. 11706 • 631-231-8400

What's next?



Anaren is proud to announce the acquisition of RF Power Components, Inc., to complement our current microwave component manufacturing and design capabilities. We welcome RF Power's management, engineers, employees, and customers to the Anaren family and look forward to providing our joint clients worldwide with new opportunities and ideas.

www.anaren.com

ISO 9001 certified

Anaren

What'll we think of next?™