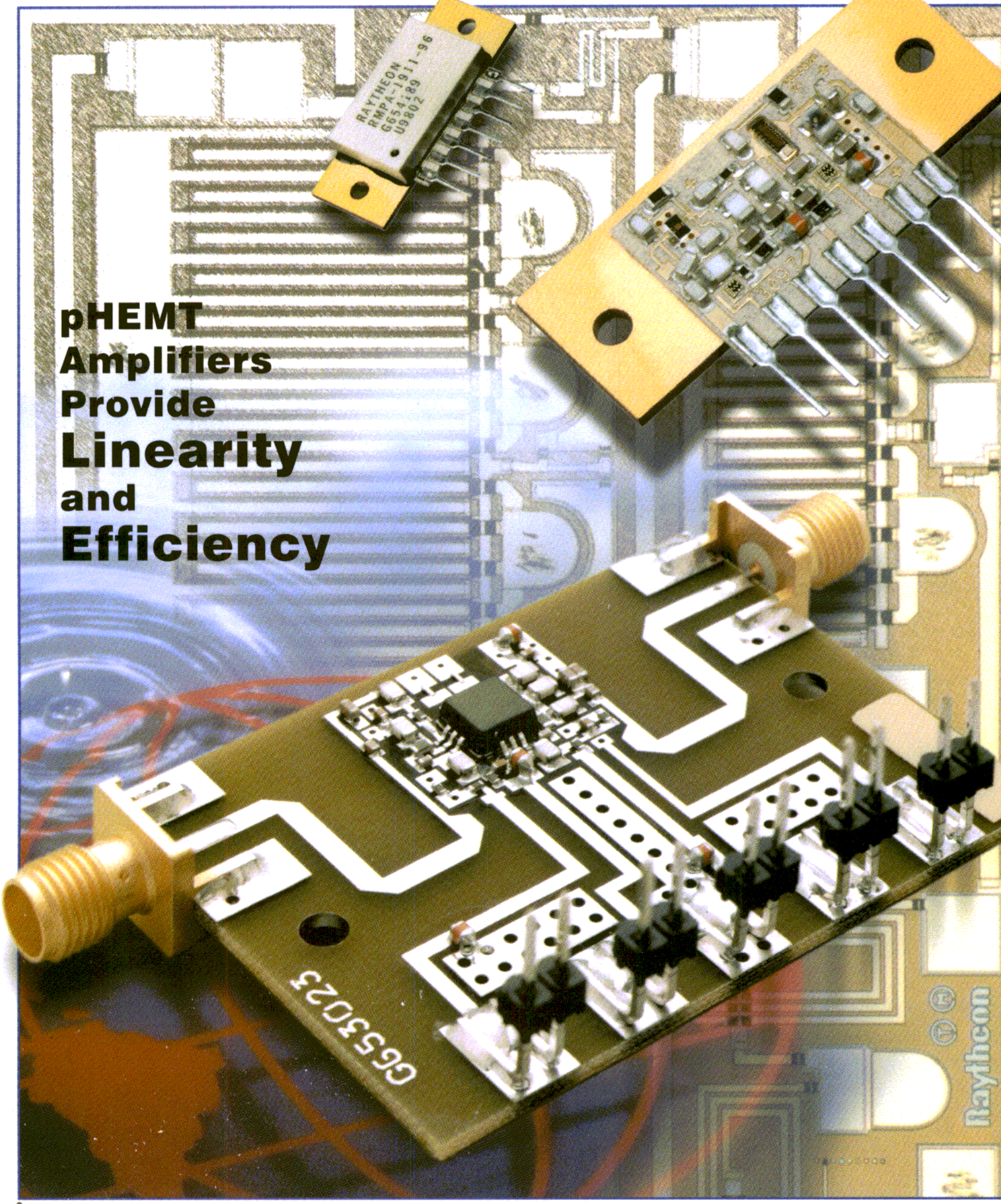
January 1999

Applied MICROWAVE & WIRELESS



Wireless Systems

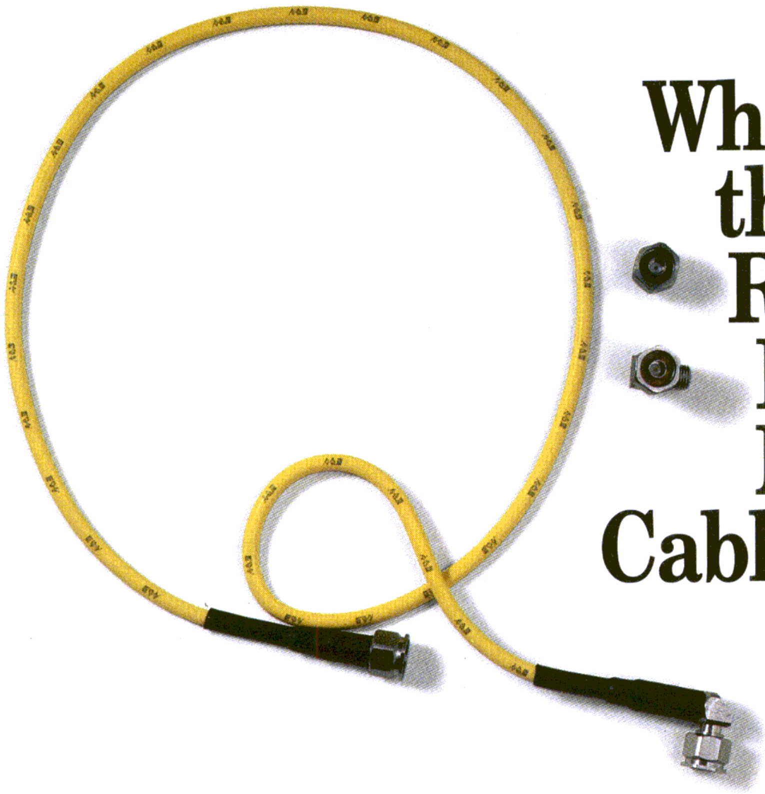
A Half-Wave Hula Hoop Antenna for GSM Mobile Applications

Design Ideas

Gated Oscillator has Adjustable On and Off Times

Conference Preview

The 1999 Wireless Symposium



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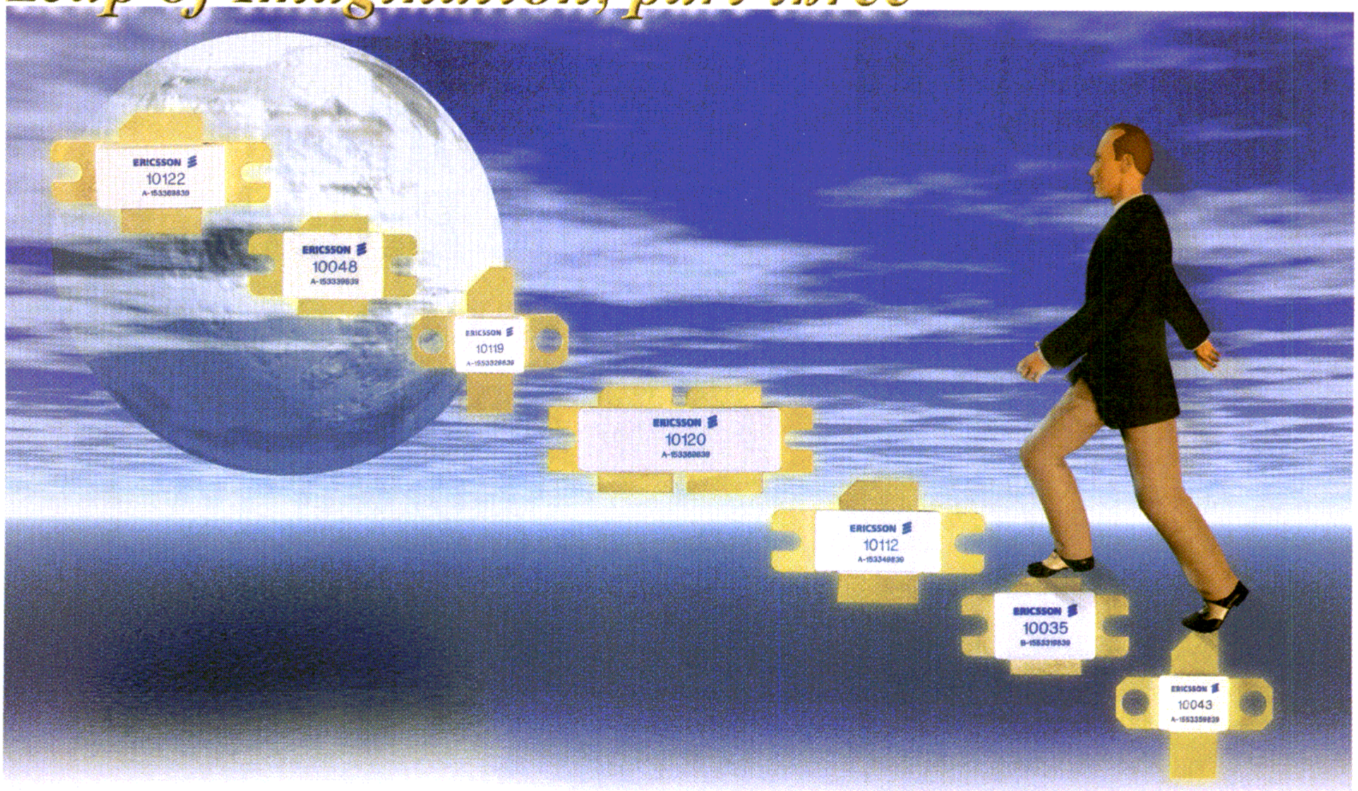
Leap of Imagination, part three



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	PTF 10112	60 W	12 dB
1.9 – 2.0 GHz	PTF 10035	30 W	12.5 dB
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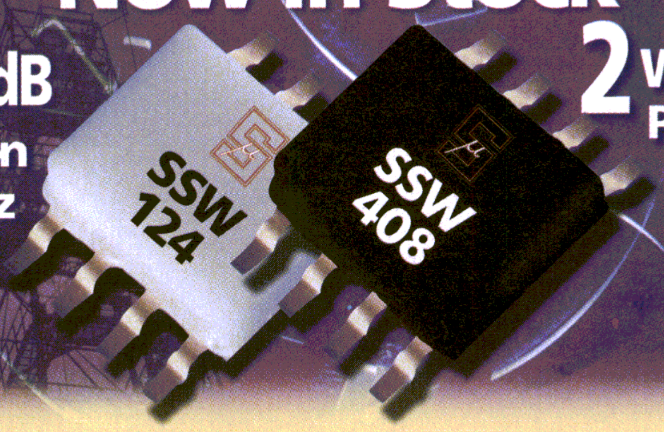

2 watts P1dB

Part Number	n pole n throw	Type	Bandwidth (GHz)	Insertion Loss (dB)	Isolation 2GHz (dB)	P1dB (dBm)	TOIP (dBm)	Package Style
SSW-107	SPDT	Terminated	DC-4	0.8	30	+26	+45	SSOP-8
SSW-108	SPDT	Terminated	DC-4	0.8	30	+26	+45	SOP-8
SSW-124	SPDT	Terminated	DC-6	0.7	42	+26	+45	Ceramic-8
SSW-207	SPDT	Reflective	DC-4	0.8	30	+26	+45	SSOP-8
SSW-208	SPDT	Reflective	DC-4	0.8	30	+26	+45	SOP-8
SSW-224	SPDT	Reflective	DC-6	0.7	40	+26	+45	Ceramic-8
SSW-307	SPDT	Reflective	DC-3	0.6	22	+31	+50	SSOP-8
SSW-308	SPDT	Reflective	DC-3	0.6	22	+31	+50	SOP-8
SSW-363	SPDT	Reflective	DC-3	0.6	22	+31	+50	SOT-363
SSW-407	SPDT	Terminated	DC-4	0.9	22	+36	+55	SSOP-8
SSW-408	SPDT	Terminated	DC-4	0.9	22	+36	+55	SOP-8
SSW-424	SPDT	Terminated	DC-6	0.7	22	+36	+55	Ceramic-8
SSW-507	SPST	Terminated	DC-4	0.9	30	+25	+44	SSOP-8
SSW-508	SPST	Terminated	DC-4	0.9	30	+25	+44	SOP-8
SSW-524	SPST	Terminated	DC-8	0.8	40	+25	+44	Ceramic-8

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January 1999
Vol. 11 No. 1

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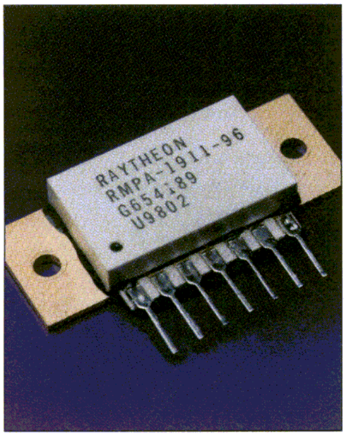
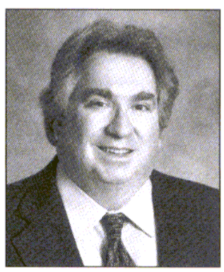


January 1999
Vol. 11 No. 1

Applied MICROWAVE & WIRELESS

PRODUCTS & TECHNOLOGIES

GUEST EDITORIAL



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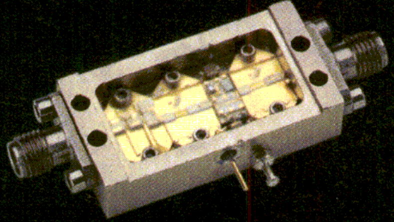
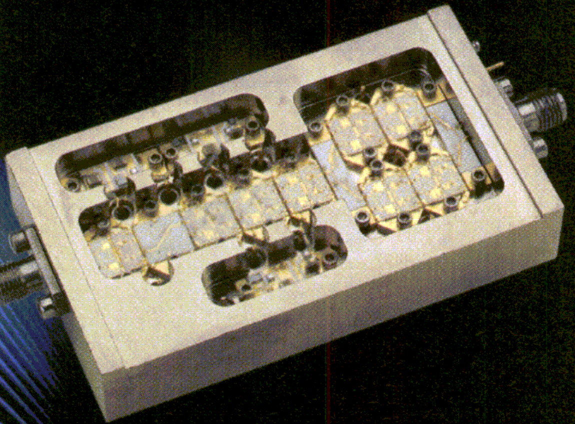


ULTRA BROAD BAND

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

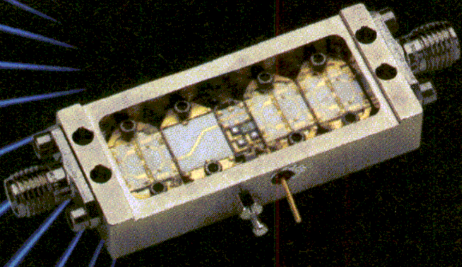


MULTI OCTAVE AMPLIFIERS

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

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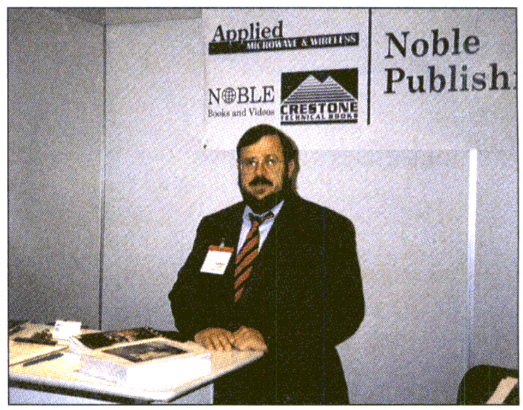
Editorial

Pursue New Ideas, but Don't Forget the Past

By Gary A. Breed
Publisher

This is the first issue of the monthly *Applied Microwave & Wireless*! As a mainstream publication for RF and microwave technology, we are excited to be involved in the myriad of new ideas yet to be pursued in wireless communications, navigation, telemetry and control. We are pleased to have your support as we continue to grow with the industry.



One of our goals is to be ready for the "next application," the technology that our readers will be working on in the near future. Yet, despite this view to the future, we will do our best not to forget how technology has developed to reach today's level of achievement.

There is a real danger that "old" ideas will be forgotten as engineers direct their efforts toward learning new techniques in areas like spectrally-efficient modulation, adaptive antennas and low cost mm-wave techniques. The potential for lost knowledge increases as older engineers retire, taking with them the accumulated wisdom of decades of design experience. While some companies have a program of using senior engineers as mentors to the younger staff, unfortunately, this is not the norm.

If you doubt the importance of my concern, here is an example of old technology coming around again: In the early 1950s, single-sideband was an important development in voice communications. Early methods included the phase-shift method, with major contributions by Norgaard and Bedrosian. In the 1960s, advances in narrowband IF filters resulted in the virtual disappearance of the phasing method. Today, digital transmission employs I and Q modulation and demodulation, which is *exactly* the same technique as phasing method SSB. You can bet that a lot of young engineers have been studying papers published in the "old" IRE Transactions!

For our part, we will continue to include tutorial articles among the more advanced topics. Some of these will be quite fundamental, targeted at engineers with only a little experience. Other articles will revisit established technology to be sure it doesn't get lost.

One of my own strong beliefs is that nothing you learn ever goes to waste! Information that now seems trivial, unimportant or obsolete will be needed sometime in the future. The key is being able to remember past information when you need it. We'll try to help you with that part, just as we help you learn the newest techniques. ■

Letters

LNA feedback article comment

Editor:

In the article "LNA Design Using Series Feedback to Achieve Simultaneous Low Input VSWR and Low Noise" (October 1998 issue, pg. 26), one should note that while the added series feedback inductance helps to improve the input match and stability in the 1900 MHz band, the circuit is still potentially unstable at the lower (below 1 GHz) and higher (above 8 GHz) frequencies. At the low RF frequencies where the device is potentially unstable, the small emitter inductor does not help much. At the higher frequencies, the inductor actually creates a *positive* feedback that could lead to problems! To prevent possible unwanted oscillation, a frequency-dependent stabilizing network should be added to care of out-of-band instability.

We should remember that $k<1$ is only a necessary, but not sufficient condition to test for stability. A second condition, such as $|s_{11}s_{22}-s_{21}s_{12}|<1$, must also be satisfied to assure unconditional stability. A more convenient single test is provided by the μ-factor computation (M. L. Edwards and J. H. Sinsky, "A Single Stability Parameter for Linear 2-Port Circuits," *IEEE MTT Transactions*, Dec. 1992).

Les Besser
Besser Associates.

Clarifications on capacitive-coupled filters

Editor:

The article "RF Capacitive-Coupled Filters" by GlenVar Rosenbaum (October 1998 issue) attracted my attention because of the author's good insight and practical approach. However, I found a few possible errors that I thought were worthwhile to mention:

1. The coefficients of q1, q3, k12 and k23 as given in the article are not the same as listed in [1] and [2] (below). Table 5-5 in [1] on page 5-20 gives: q1 = q3 = 1.433, k12 = k23 = 0.662 for a 0.1 dB, n = 3, Chebyshev filter. Table 2 in [2] on page 8-24 gives: q1 = q3 = 1.43, k12 = k23 = 0.665 for a 0.1 dB, n = 3 Chebyshev filter. This raises some doubt of the validity of other calculation given by Mr. Rosenbaum.

[*Mr. Rosenbaum's response: The example uses ripple passband coefficients, not –3 dB coefficients that are in these "standard" tables. See pp. 76 and 78 in the article and Ref. 3*]

2. There is a typo on page 78. The two bottom left formulae should have Cs instead of C3. [*Yes, this should be changed*]

3. I think that the listing in the C++ program should have k[0] = 0 and k[n] = 0 instead of c[0] = 0 and c[n] = 0. [*No, the listing is correct*]

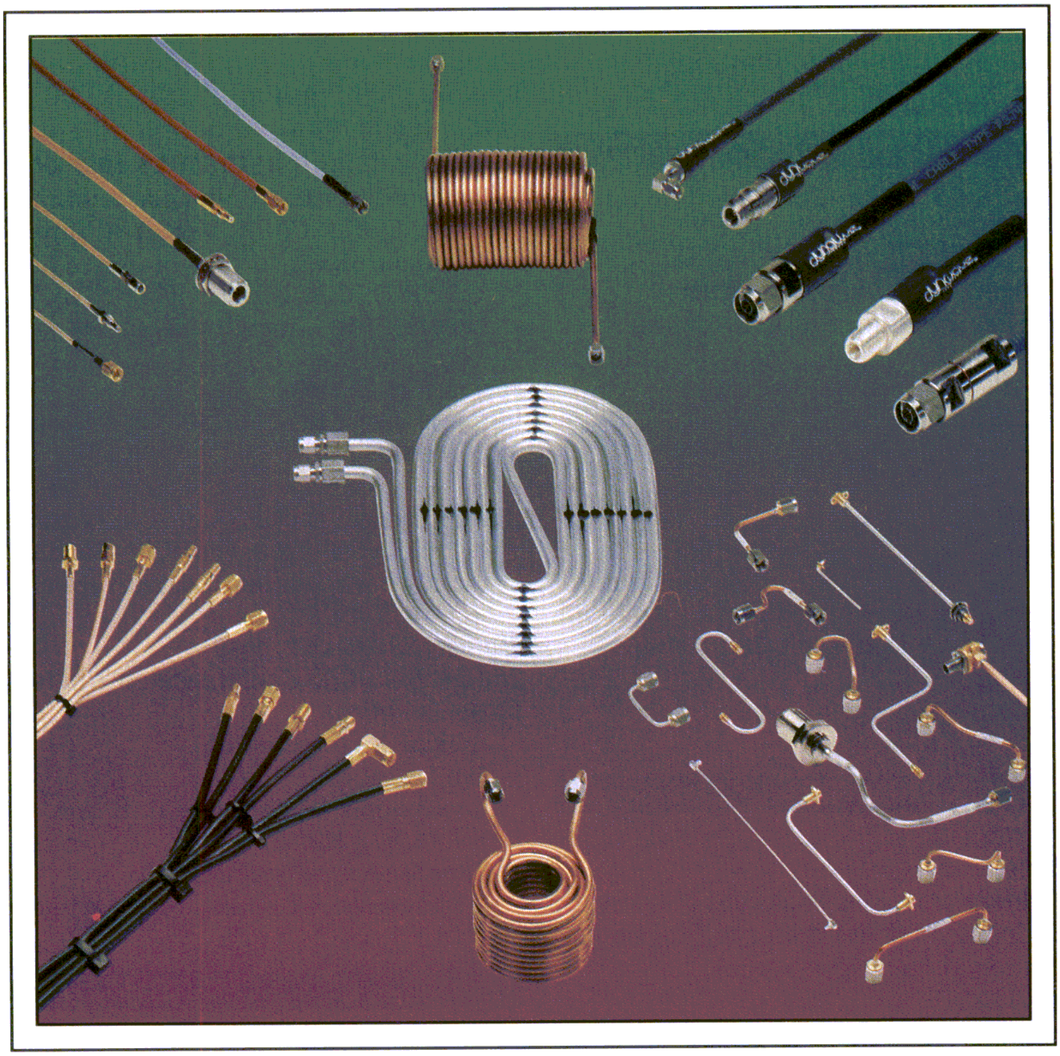
4. The Q = 35.7 given in the author's example is not set by the inductors, but is a loaded Q of resonators 1 and 3. The loaded Q is due to the effect of the source resistance Rs and the load resistance Rl. The Q of resonator 2 is assumed equal to infinity. [*The "Q1 and Q3" in the article are more general Q factors defined to be functions of ripple and center frequency divided by the passband, not component unloaded or loaded Q, which are other important factors, as noted in the article*]

I want to express my gratitude to Mr. Rosenbaum for sharing his knowledge.

Roger Olin
Vectron Laboratories

[1] A. Williams, *Electronic Filter Design Handbook*, McGraw-Hill.
[2] *Reference Data for Radio Engineers*, Howard W. Sams & Co.

Send letters to: Editor, *Applied Microwave & Wireless*, 4772 Stone Drive, Tucker, GA 30084; fax: 770-939-0157; e-mail: amw@amwireless.com.



Calendar

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February 17-19, 1999
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February 22-25, 1999
INTER COMM '99 —
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Tel: (781) 762-6279; Fax: (781) 255-9211
Internet: http://www.intercomm99.com

February 22-26, 1999
Wireless Symposium/Portable by Design Conference and Exhibition
San Jose Convention Center, San Jose, CA
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Tel: (201) 393-6256; Fax: (201) 393-6297
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February 28-March 2, 1999
2nd Annual UCSD Conference on Wireless Communications
Holiday Inn on the Bay,
San Diego, CA
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Internet: http://www.mtesz.hu/tagegy/diamond

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1999 IEEE Emerging Technologies Symposium on Wireless Communications and Systems
Clarion Hotel, Richardson, TX
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April 12-16, 1999
12th European Frequency and Time Forum and 1999 IEEE International Frequency Control Symposium
Besancon, France
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E-mail: isabelle.bourgon@ens2m.fr
Internet: http://www.ens2m.fr/eftf
http://www.ieee.org/uffc/fc

April 19-22, 1999
GaAs MANTECH — 1999 International Conference on Gallium-Arsenide Manufacturing Technology
Vancouver, British Columbia, Canada
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E-mail: info@GaAsMantech.org
Internet: http://www.gaasmantech.org

April 28-30, 1999
IWCE '99 — 23rd Annual International Wireless Communications Expo
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MAY – JUNE

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Internet: http://radio.stu.neva.ru/complex/icarsm99.html

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June 2-4, 1999
1999 Virginia Tech Symposium on Wireless Personal Communications
Virginia Tech, Blacksburg, VA
Information: Jenny Frank
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HBT IC Technology for Communications Applications
Los Angeles, CA . . . . February 18-20, 1999
Information: UCLA Extension, Short Course Program Office, Tel: (310) 825-3344; Fax: (310) 206-2815.

Whiting School of Engineering
Johns Hopkins Universeity
Digital Signal Processing (DSP) —
Principles, Architectures, and System Applications
Washington, D.C. . . . . . . January 18-20, 1999
Understanding ATM Technology and Design
Washington, D.C. . . . . . . January 25-27, 1999
Radiowave Propagation Channel Engineering for Personal Communications, PCS
RTP, NC . . . . February 1-3, 1999
Principles of Telecommunications
Washington, D.C. . . . . . . March 8-10, 1999
GSM Systems Operation and Technology
Washington, D.C. . . . . . . March 15-17, 1999
Wireless Digital Communications Systems: Specification, Test, Components, and Evaluation
RTP, NC . . . . March 22-24, 1999
Wireless and Personal Communications Systems
RTP, NC . . . . March 29-31, 1999
Information: Anita Hellstrom, Program Coordinator, Tel: (800) 683-7267; Fax: (301) 871-9608; E-mail: info.oei@apl.jhu.edu; Internet: http://www.jhu-oei.com/

Northeast Consortium for Engineering Education
Antennas: Principles, Design, and Measurements
San Diego, CA . . . . March 9-12, 1999
Orlando, FL . . . . May 17-20, 1999
Colorado Springs, CO . . . August 16-19, 1999
Information: Kelly Brown, Tel: (407) 892-6146; Fax: (407) 892-6146; E-mail: stcloudofl@aol.com; Internet: http://www.usit.com/antenna

Besser Associates
Wireless RF System Design
Mountain View, CA . . . . . January 11-15, 1999
Frequency Synthesis and Phase-locked Loop Design
Mountain View, CA . . . . . January 21-22, 1999

Applied RF Techniques I
Mountain View, CA . . . . .January 25-29, 1999
Practical Wireless RF Component and System Measurements
Mountain View, CA . . . . .February 1-5, 1999
RF Transceiver Design
Mountain View, CA . . . . .February 8-11, 1999
Signal Integrity of High-speed Digital Design
Mountain View, CA . . . . .February 18-19, 1999
RFIC Design
Mountain View, CA . . . . .February 22-26, 1999
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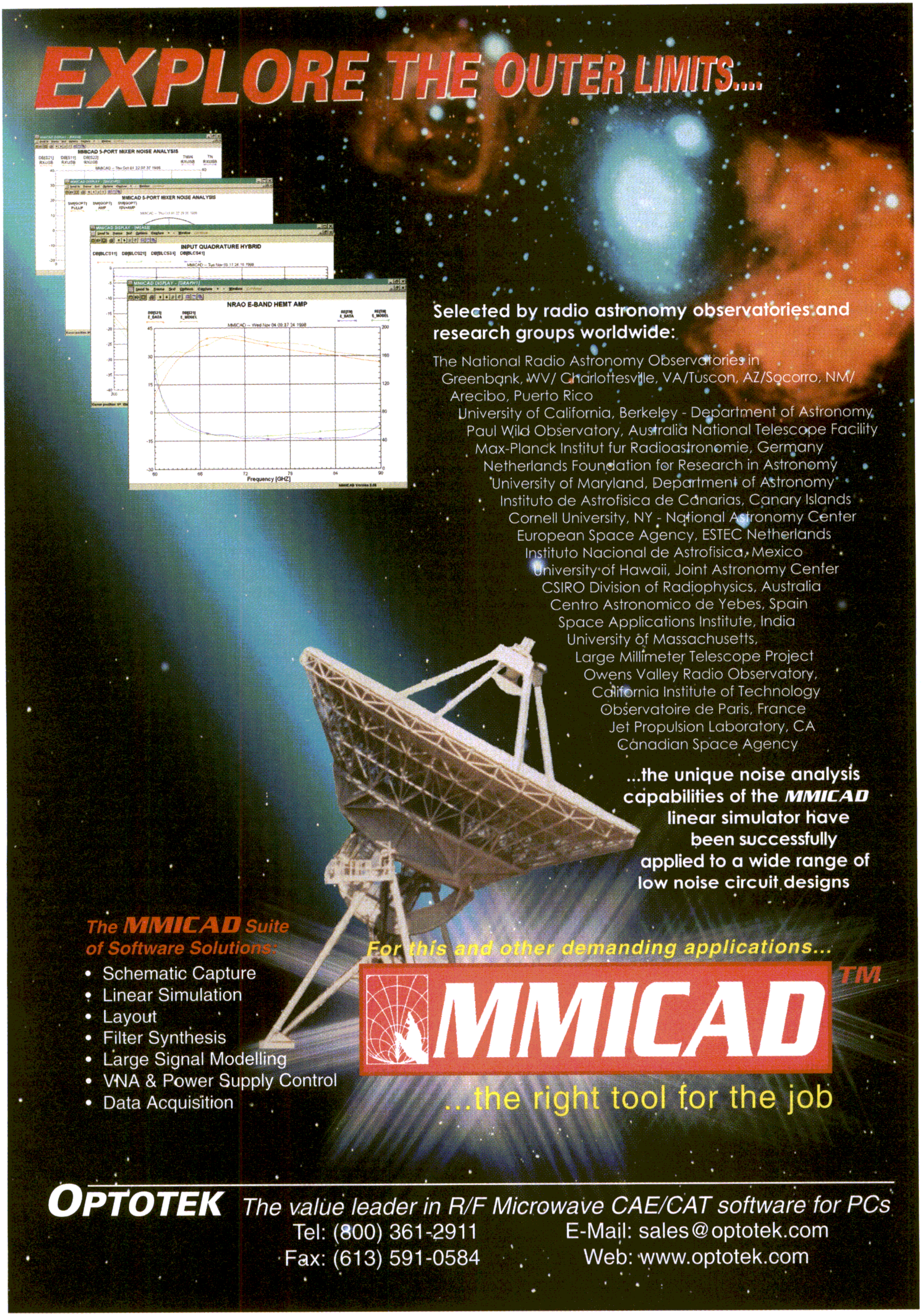
Mountain View, CA . . . . .March 1-2, 1999
Wireless Handsets: Architecture and Frequency Planning
Mountain View, CA . . . . .March 3-5, 1999
RF and Wireless Made Simple
Mountain View, CA . . . . .March 8-9, 1998
DSP Made Simple
Mountain View, CA . . . . .March 10-12, 1999
Behavioral Modeling
Mountain View, CA . . . . .March 15-17, 1999
Multitone Amplifier Design
Mountain View, CA . . . . .March 29, 1999
RF Power Amplifiers: Operation and Use
Mountain View, CA . . . . .March 30, 1999
Information: Annie Wong, Tel: (415) 949-3300; Fax: (415) 949-4400; E-mail: info@bessercourse.com; Internet: http://www.bessercourse.com/

University of Missouri-Rolla
Grounding & Shielding Electronic Systems — How to Diagnose and Solve Electrical Noise Problems
Phoeniz, AZ . . . . .February 8-9, 1999
San Diego, CA . . . . .March 8-9, 1999
San Jose, CA . . . . .April 28-29, 1999
Toronto, Canada . . . . . . .May 18-19, 1999
Ottawa, Canada . . . . . . .May 25-26, 1999
Circuit Board Layout to Reduce Noise Emission and Susceptibility
Phoenix, AZ . . . . .February 10, 1999
San Diego, CA . . . . .March 10, 1999
San Jose, CA . . . . .April 30, 1999
Toronto, Canada . . . . . . .May 20, 1999
Ottawa, Canada . . . . . . .May 27, 1999
Information: Buddy Poe, Tel: (573) 341-6061; Fax: (573) 341-4992; E-mail: buddyp@umr.edu; Internet: http://www.umr.edu/~conted/ee.html



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Netherlands Foundation for Research in Astronomy
University of Maryland, Department of Astronomy
Instituto de Astrofisica de Canarias, Canary Islands
Cornell University, NY - National Astronomy Center
European Space Agency, ESTEC Netherlands
Instituto Nacional de Astrofisica, Mexico
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Circle 12

CALLS FOR PAPERS

1999 IEEE AP-S International Symposium and USNC/URSI National Radio Science Meeting

July 1-16, 1999 — Orlando, Florida

Suggested topics: Electromagnetic Metrology, Fields and Waves, Electronics and Photonics, Propagation, and Electromagnetics in Biology and Medicine. A complete list of conference topics, including topic numbers, is available at the address below, or on the conference's website (URL below).

Summaries or abstracts may be submitted by mail or e-mail. They must be in English and include the topic number provided in the conference topic list. Submissions must include the complete mailing address, telephone number, e-mail address, and fax number of the presenting author.

For complete submission information:
Parveen Wahid
1999 TPC Co-Chair
Dept. of Electrical and Computer Engineering
University of Central Florida
4000 Central Florida Boulevard
Orlando, FL 32817
E-mail: eetpc99@mail.ucf.edu
Internet: http://www-ece.engr.ucf.edu/apursi99

Deadline: January 8, 1999

PIMRC'99 — 10th International Symposium on Personal, Indoor and Mobile Radio Communications

September 12-15, 1999 — Osaka, Japan

Suggested topics: Wireless Propagation/Channel Modeling; Antenna and RF subsystems; Adaptive Traffic and Access Control Protocol; Radio Resource Management; Dynamic Channel Assignment; Coding and Modulation; Acquisition and Synchronization; Spread Spectrum; Adaptive Array; Signal Processing for Wireless Communications; Software Radio; Ranging, Positioning; Novel network and switching architectures; EMC/EMI; Wireless ATM, LAN, WMAN, WLL/FWA; Intelligent Transportation System; Optical Wireless Communications; Satellite Communications; and Chip sets for wireless applications.

Submit five copies of the paper, in English and no more than 3,000 words, with name(s), affiliation and full contact information for the author(s) on the title page. Please indicate the technical area with key words from the above list or other words describing the topic.

American continent submissions should be sent to:
Professor K. Pahlavan
Electrical and Computer Engineering Department
Worchester Polytechnic Institute
Worchester, MA 01609
Fax: (508) 831-5491
E-mail: kaveh@ece.wip.edu
Internet: http://pimrc99.kuee.kyoto-u.ac.jp

(In Europe, the Middle East and Africa, contact Professor A.H. Aghvami at h.aghvami@kcl.ac.uk. In the Pacific and Asia, contact Professor R. Kohno at kohno@kohnolab.dnj.ynu.ac.jp.)

Deadline: February 2, 1999

ICEAA '99 — International Conference on Electromagnetics in Advanced Applications

September 13-17, 1999 — Torino, Italy

Suggested topics: Electromagnetic measurements, modeling of devices and circuits, packaging and properties of materials, Electromagnetics in wireless communications, EMC/EMP, Finite methods, Frequency selective surfaces, Integral equation methods, Inverse scattering and remote sensing, Microwave antennas, Optoelectronics and photonics, Plasma and plasma-wave interaction, Phase and adaptive relays, Printed and conformal antennas, Radar Cross Section and asymptotic techniques, Radar imaging, Radomes, Random and nonlinear electromagnetics, and Technologies for mm- and sub-mm-waves.

Authors should submit four copies of a one-page abstract, in English, along with a cover letter containing the author's full mailing address, telephone and fax numbers, and e-mail address.

Send to:
COREP — ICEAA 99
Politecnico di Torino
Corso Duca degli Abruzzi 24
10129 Torino, Italy
Internet: http://www.polito.it/iceaa99

Deadline: February 26, 1999

COST 259 Workshop — "Spatial Channel Models and Adaptive Antennas"

April 20-21, 1999 — Vienna, Austria

Topics: Adaptive antennas and spatial channel measurements and modeling.

Authors should send papers in English, not longer than eight pages, including full contact information for all authors (name, address, e-mail, phone and fax numbers). Papers may be submitted by mail or electronically in Word for Windows (*.doc), Adobe Postscript (*.ps), or Adobe Acrobat (*.pdf) format. Detailed instructions are available on the workshop's web site (URL below).

Submit papers to:
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Institute of Communications and
Radio-Frequency Engineering / Secretary
Gußhausstrass 25/389
A-1040 Wein Austria
Tel: +43 1 58801-38901 or -38948
E-mail: cost_ws@mobile.nt.tuwien.ac.at
Internet: http://www.nt.tuwien.ac.at/mobile/research/COST259_Workshop/

Deadline: March 12, 1999

Circle 37

BRIEFS

• Andrew Corporation has begun production at a new factory in the China-Singapore Suzhou Industrial Park. The 5,000-square-meter facility manufactures coaxial cables and base station antennas for the wireless communications market in China.

• IFR Americas Inc. has redesigned its web site to reflect the company's recent acquisition of Marconi Instruments. The new site, http://www.ifrinternational.com, includes an online catalog, product index, data sheets, sales information and company and product news.

• Noise Com Inc. has completed a web site redesign to improve navigation and offer more information. The site, http://www.noisecom.com, offers technical specifications, application notes, news and other features.

• Ecliptek Corporation has added a "chipset to part number" cross reference to its web site, http://www.ecliptek.com, as a guide to specifying and ordering crystals and oscillators for chipset designs.

• Photofabrication Engineering Inc. has expanded its web site, http://www.photofabrication.com, to include divisional information, a company profile and a description of the etching process.

• Hewlett-Packard Company has announced a new web site and other programs to help test-and-measurement customers deal with Year 2000 issues. The site, http://www.hp.com/go/tm-year2000, will allow customers to determine if their HP products are Y2K compliant or will need upgrading.

• Andrew Corporation's web site, http://www.andrew.com, now offers a Fax-On-Line service that allows customers to receive product and technical information by fax. Users may select from more than 2,500 documents covering the company's complete line of products and services.

Military warning system upgraded with newest ICs

ATLANTA, GA — As part of an ongoing effort to improve military aircraft performance, engineers at the Georgia Institute of Technology's Research Institute (GTRI) have redesigned a vital component of a widely used radar warning system, making it more dependable and easier to maintain.

The GTRI team recently finished revamping the display unit found on the ALR-69 Radar Warning Receiver (RWR), a system used on 2,000 US and 1,000 foreign aircraft. The refurbished display unit has all-new electronics that improve its predicted reliability by more than 500 percent, researchers say.

"In layman's terms, the ALR-69 is the military version of a Fuzzbuster (consumer radar-warning device)," said Michael J. Willis, a senior research engineer with GTRI's Electronic Systems Laboratory. "It lets pilots know when an enemy has a radar pointed at them, so they can take evasive action."

Many of the improvements in the system can be attributed to the better capabilities, features and reliability of today's electronics, Willis said. The new model has no adjustable components, better fault diagnostics and built-in test capability.

"Twenty or 30 years ago the electronics of that day didn't have the features and capabilities that we have today because of newer integrated circuits," he said. "The reliability improvements are more a function of improved electrical performance and integrated circuit performance than any special mechanical changes."

GTRI has worked on both hardware and software aspects of the complex system, which includes radio-frequency, microwave, analog, digital and other kinds of circuits.

Display replaces CRT with flat-panel screen

Because any warning device like the ALR-69 is useless if it cannot relay a warning signal, the dependability of the system's display hardware is critical. In place of the old model's oblong 3-inch by 9-inch cathode ray tube (CRT), the new system uses a flat-panel electro-luminescent screen – chosen because of its relatively low power requirement – and three printed circuit cards.

The new model's container is identical in size and shape to the old model, allowing plug-in unit-swapping in the field. The only visible difference between the two designs is the new model's amber monochrome screen, a departure from the green used by the old model. The new display unit offers higher brightness, night vision compatibility, sunlight readability and is fully compatible with the rest of the system.

The new system also has a predicted reliability of some 14,000 hours, versus an actual reliability of about 2,500 hours on the old CRT-based model.

The U.S. military uses the ALR-69 on the B-52 bomber; A-10 and F-16 fighters; MH-53J and H-60 helicopters, and C-130 and C-141 cargo planes.

The redesigned display unit is now undergoing extensive electrical, environmental and field testing. If all goes well, the new model should begin service around the world within two years.

A technical article describing the work was published in the Georgia Tech Research Institute Journal of Technology, available on the Internet at http://www.gtri.gatech.edu/job/Coker/coker.htm

BUSINESS AND FINANCE

Midway to install wireless network for school districts

Midway Electronics of San Diego, CA, has received a contract from a consortium of four school districts in Venango County, Pennsylvania, to install a wireless wide area network. The $394,000 project is being funded through a "Link to Learn" initiative sponsored by Pennsylvania Governor Tom Ridge.

The system, which will use wireless bridges and routers provided by Solectek Corp., will link schools in the Cranberry, Franklin, Oil City and Valley Grove districts, providing shared Internet access and resources among the four districts.

Midway is a provider of two-way microwave system design and installation services.

Motorola CIG wins new contracts, launches new system

Motorola's Cellular Infrastructure Group (CIG) has announced three contracts worth a combined $55 million to upgrade cellular systems in China and Singapore, as well as the launch of a new CDMA network in West Virginia.

Under a contract with M1's Personal Communications Services (PCS) in Singapore, Motorola CIG will upgrade the CDMA (Code Division Multiple Access) digital cellular network in Singapore. Two contracts with China United Telecommunications Corporation (China Unicom) provide for expansion of GSM (Global System for Mobile) networks in China's Fujian and Shandong provinces.

The West Virginia system, run by Intelos, is a $38 million CDMA digital wireless PCS network operating along a corridor between Charleston and Huntington. The system has been scheduled for expansion early in 1999.

Motorola, based in Schaumburg, IL, is a leading provider of wireless communications semiconductors and electronics systems, components and services.

Richardson announces acquisition, signs distribution agreements

LaFox, IL-based Richardson Electronics Ltd. has acquired Sahabsa S.A., a broadcast transmitter and component distributor based in Mexico. Sahabsa will be renamed Sahabsa Electronics SA de CV and will serve as Richardson's broadcast division in Mexico.

Richardson will merge its Mexico City operation with Sahabsa's, and the new division will provide sales, design, installation and distribution services in Mexico.

Richardson's Solid State & Components Group has also announced new agreements with GHz Technology, based in Santa Clara, CA, and PolyPhaser Corporation, a subsidiary of Smith Industries plc of London, to distribute the companies' products worldwide.

Richardson is a specialized international distributor of electronic components, equipment and assemblies for industrial, communications, medical and scientific applications.

Bliley Electric sold to Pennsylvania businessman

Bliley Electric Company and its subsidiary, Sunburst Electronics, have been purchased by Roger W. Richards, a business attorney based in Erie, PA. Terms were not disclosed.

Bliley is an established manufacturer of custom crystal oscillators and quartz crystals.

Bell Labs, German researchers produce electrical images

Scientists at Bell Labs and Germany's Institute for Semiconductor Physics have produced the first microscopic images of electrical forces inside a transistor.

The research, presented in December at the IEEE International Electron Devices Meeting, may lead to improved software to design today's increasingly smaller transistors by eliminating some of the need for trial-and-error.

Studying boron in state-of-the-art 0.18-micron transistors, the researchers were able to receive images of the source and drain regions of the transistor. Electrons flow between these regions, and adding specific amounts of impurities to them can alter the electron flow – and thus, the transistor's performance.

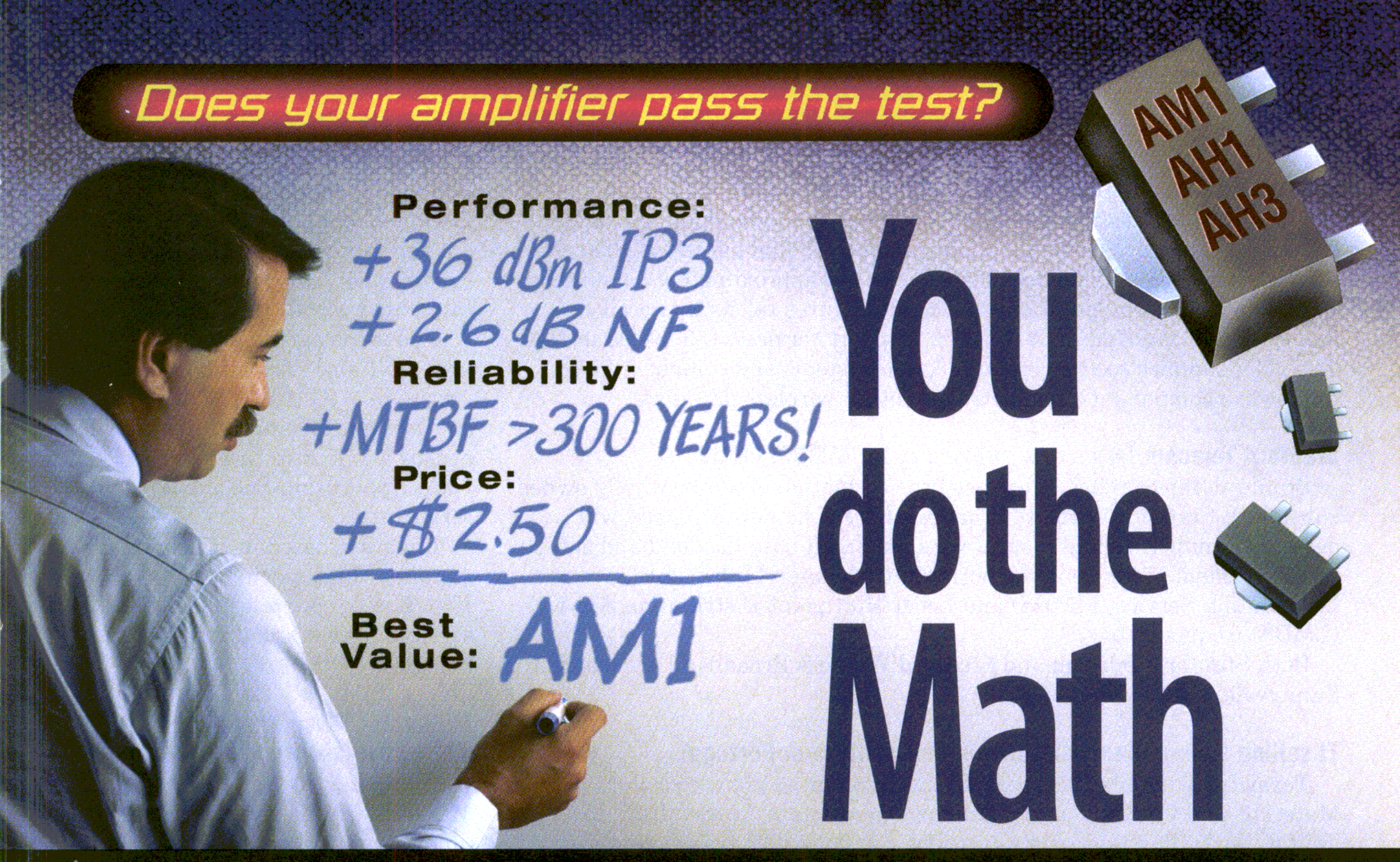
Bell Labs is the research and development arm of Lucent Technologies, headquartered in Murray Hill, NJ. The Institute for Semiconductor Physics is a publically funded research and development institution located in Frankfurt, Germany.

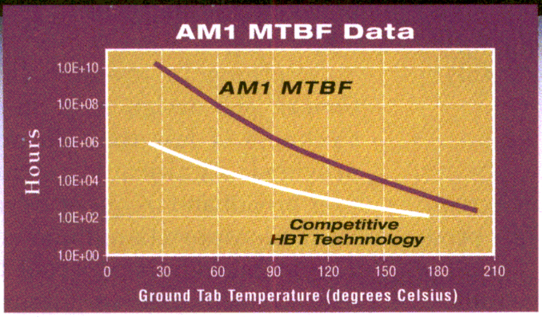
Xilinx to offer computer-based training on Verilog HDL

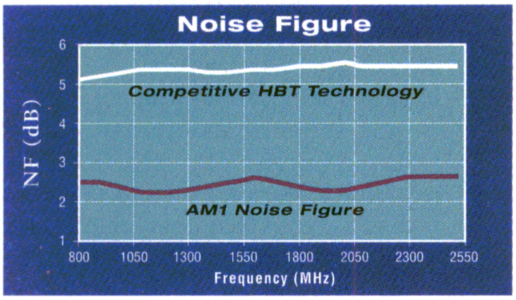
Xilinx Inc. has introduced a computer-based training course, the Verilog CBT course, as a new educational method for the Verilog hardware description language (HDL).

The course teaches writing, synthesizing and simulating in Verilog HDL for Xilinx devices. It is based on a three-day class offered in the traditional classroom format but has been converted into a computerized, self-study program. The program is available through Xilinx distributors or directly from the company. Information is available on the company's web site (http://www.xilinx.com).

Based in San Jose, CA, Xilinx provides advanced integrated circuits, software design tools and field engineering support.







WJ's AM1 adds up to superior performance and reliability.

The combination of high IP3 and low noise figure at a low DC bias makes the AM1 the amplifier of choice for today's designer of multisignal wireless systems. Drawing only 75 mAmps, the AM1 boasts IP3 of +36dBm across the entire 250-3000 MHz band. Add the low 2.6 dB NF with the high IP3 and great price, and you have an extremely versatile amplifier to use in multiple locations, reducing your overall part count.

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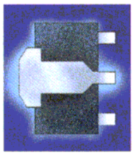
The AM1's superior electrical and thermal design ensures long term reliability at high temperatures. At 80°C, MTBF performance of the AM1 is 7 million hours.



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AH3	50-450	40	21	2.8	150

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Circle 60

BUSINESS AND FINANCE

L-3 to purchase Microdyne in $90 million transaction

L-3 Communications has signed an agreement to acquire Microdyne Corporation by purchasing all outstanding stock and assuming the company's existing debt. The transaction is worth approximately $90 million.

Alexandria, VA-based Microdyne manufactures telemetry receivers, secure communications and technical support services. L-3, based in New York, NY, supplies secure communication systems and components, microwave components, telemetry and other wireless products.

Stanford Telecom forms new subsidiary for MMDS, LMDS

Stanford Telecom has announced the formation of a new wholly owned subsidiary, Stanford Wireless Broadband Inc. The new company will design, manufacture and market wireless broad base headend and subscriber modem products using both Multi-channel, Multipoint Distribution Service (MMDS) and Local Multipoint Distribution Service (LMDS) frequency bands.

Both Stanford Telecom and Stanford Wireless Broadband are based in Sunnyvale, CA.

TI selling Italian plant, dissolving joint venture in Portugal

Texas Instruments Incorporated has announced plans to sell its Materials and Controls manufacturing operation in Aversa, Italy, to Telital, the Italian telecommunications company. The transaction was expected to be complete by the end of 1998

TI will also end a joint venture with Samsung, Electronica (Portugal), Lda., in Porto, Portugal. The shutdown of the semiconductor assembly operation there is expected to be complete by March 31.

RF Monolithics announces distribution agreement with Insight

RF Monolithics, based in Dallas, TX, has signed a distribution agreement for Insight Electronics of San Diego, CA, to distribute RFM's products through Insight's 50 offices in North and South America.

RFM is a manufacturer of low-power components, short range radio systems, frequency control modules and filters.

P-Com receives more than $6.5 million in radio system orders

P-Com Inc., based in Campbell, CA, has received purchase orders from a PCS provider in the United Kingdom for the supply of digital millimeter wave radio systems. The orders are valued in excess of $6.5 million.

The systems are being used as part of a nationwide mobile network rollout in the UK. The network provider has previously purchased radio systems from P-Com.

P-Com develops and manufactures network access systems for wireless telecommunications markets, including point-to-point, spread spectrum and point-to-multipoint links.

DSP Communications to acquire Canada's Isotel Research

Cupertino, CA-based DSP Communications Inc. has announced an agreement to purchase Isotel Research Ltd. of Calgary, Canada. The transaction's value was not disclosed.

DSPC is a developer of chip sets and products for cellular, personal communication services (PCS) and wireless local loop (WLL) markets. Isotel develops call processing software for the digital cellular and personal communications markets.

TriQuint, Boeing team up for GaAs IC services

TriQuint Semiconductor and The Boeing Company have announced an agreement to combine their capabilities to develop turn-key integrated circuit (IC) services.

Under the agreement, the companies will use TriQuint's Gallium Arsenide (GaAs) IC Foundry Services and Boeing's third party IC design services to provide turn-key GaAs Application-Specific IC (ASIC) services.

TriQuint, based in Hillsboro, OR, supplies high-performance GaAs ICs. Boeing provides ASIC design services over a broad range of technologies.

Millimeter Wave announces microwave absorber breakthrough

Millimeter Wave Technology of Marietta, GA, has made recent technology breakthroughs in almost paper-thin microwave absorber materials.

According to inventor Floyd C. Cooper, one design with an overall thickness of less than 65 mils has provided significant attenuation over broadband frequencies ranging from microwave to millimeter wave. The technology is expected to find uses in such areas as antenna coupling and multipathing.

Washington Laboratories expands test capabilities

Washington Laboratories Ltd. of Gaithersburg, MD, has recently expanded its test capabilities to measure radio frequency millimeter wave frequencies up to 220 GHz.

Washington Labs specializes in EMC and safety testing and design consulting. ■

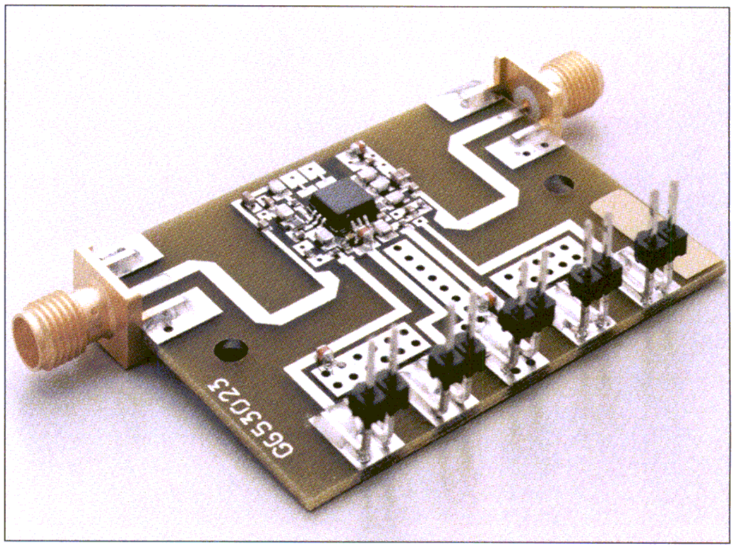
Companies, organizations and institutions may submit information for our News section to: Shannon O'Connor, Managing Editor, *Applied Microwave & Wireless*, 4772 Stone Drive, Tucker, GA; 770-939-0157 (fax); amw@amwireless.com (e-mail).

pHEMT MMIC Power Amplifiers for Base Stations and Adaptive Arrays

GaAs technology is used in a family of amplifiers for wireless applications requiring good gain, efficiency and linearity

Raymond S. Pengelly, Robert B. Binder, James R. Griffiths, Michael Virostko and Michael McPartlin
Raytheon Microelectronics

MMICs based on pseudomorphic HEMTs (pHEMTs) have been in volume production at Raytheon Microelectronics for several years. Applications include low-noise and power amplifiers from UHF through millimeter-wave. The largest single application for pHEMT technology is in power amplifiers for cellular and personal communication system mobile handsets. These power amplifiers presently operate in the voltage ranges of 3 to 7.5 volts depending on the generation of the platform. CDMA and TDMA phones require linear amplifiers where the maximum operating output power is typically backed-off 3 dB from saturated output power. Analog and GSM phones normally operate with power amplifiers that are much closer to their saturated output powers. The pHEMTs used in these designs have gate-to-drain breakdown voltages ranging from 14 to greater than 20 volts depending on the materials and gate-recess technologies used in their fabrication. A good rule-of-thumb for power amplifiers being driven to saturation is that the breakdown voltage should be 3 times the nominal operating voltage, e.g. a 4.8 volt PA requires a minimum breakdown voltage of 14.4 volts.



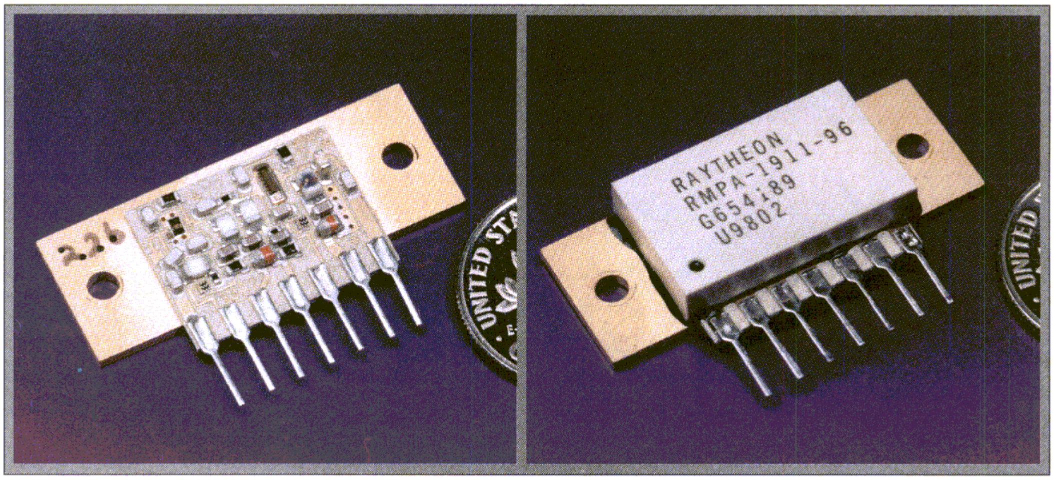
▲ **Figure 1. This pHEMT amplifier is shown in the PMBG-12 air cavity plastic metal base package.**

pHEMT power amplifiers operating in the cellular and PCS bands for reverse link applications (handset to base station) show excellent linearities and power added efficiencies (PAE), typically >65 percent PAE for saturated power and 40 percent for linear power (e.g. CDMA). Power amplifiers designed for forward link, multi-carrier (base station to handset) applications are normally operated with their output stages operating close to Class A. Efficiencies are in the 15 to 30 percent range for such amplifiers because of the much higher linearity and IMD requirements that require further power output back-off. For example, forward link CDMA uses QPSK modulation whereas reverse link uses OQPSK with a 6 dB higher peak-to-average power ratio in the former case. All the results in this article are for amplifiers that are unconditionally stable over specified source and load impedances and temperature ranges.

Output power as a function of operating voltage

The output power of a power amplifier is directly related to the square of the operating

voltage. Thus, an amplifier such as the RMPA1902-53, designed for 29 dBm linear output power under 1900 MHz CDMA operation at 3.5 volt should have a linear output power of greater than 34 dBm at 6.5 volts if the power output is not limited by incorrect output stage load impedances. Measurements confirm this relationship to be true. For linear operation where the amplifier will be typically backed off by between 3 and 6 dB the breakdown voltage of the transistors needs to be typically 2 times the operating voltage plus gate voltage, e.g. an 8 volt PA requires a minimum breakdown voltage of 16 + 1 = 17 volts.



▲ **Figure 2. The RMPA1911-96 35 dBm power amplifier is shown with the cover off (left) and in packaged form (right).**

Thermal considerations

It is important to consider the impact of total thermal resistance between the top surface of the GaAs die and the heat sink for power amplifier MMICs that were originally designed to operate at lower voltages. For example, the RMPA1902-53 amplifier was designed to operate nominally at 3.5 volts with a dissipated power of 1.5 watts at its full RF output power of 29 dBm. The GaAs die is silver epoxied into the PMBG-12 air-cavity plastic package with a measured thermal resistance of 17 deg C/watt. The PMBG-12 package (Figure 1) has a copper base for heat sinking.

The channel temperature rise above the package base temperature is about 25° C for that dissipated power. For a maximum operating temperature of 90° C the pHEMT channel is running at 115° C, well below the 150° C normally considered "safe" for long lifetime (i.e. at least 10 years). At 6.5 volts operating voltage the RMBA19500-53 (a derivative of the RMPA1902-53 using an additional heat-spreader between the GaAs die and the package metal base) has a dissipated power of 4.7 watts when delivering 2 watts linear RF power. The thermal resistance of this approach is 9° C/watt. For a PMBG-12 packaged MMIC soldered to the top surface of a PCB, whereby multiple via holes are used for thermal sinking as well as RF grounding, the channel temperature at a 90° C baseplate temperature is calculated to be 168° C. [90 + (4.7 × 9) + 36 (temperature rise through board)]. Mounting the packaged amplifier directly to a metal heat sink through the PCB results in a transistor channel temperature of <135° C at a 90° C heat-sink temperature. This is, therefore, the recommended mounting approach.

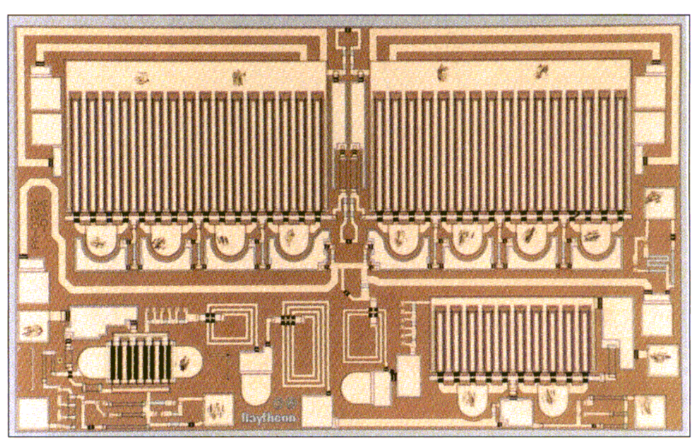
Typical pHEMT MMIC amplifier realization — Amplifier electrical design

Discrete and MMIC pHEMT amplifiers have been designed at Raytheon Microelectronics both for handset and base-station applications.

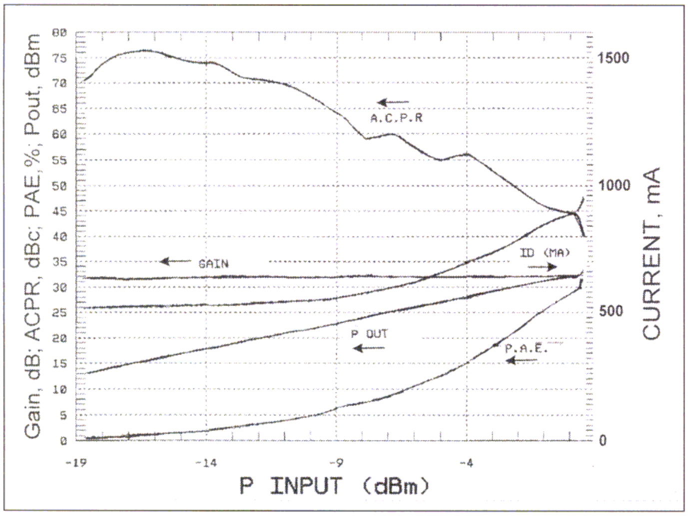
Figure 2 shows a photograph of a two-stage 35 dBm amplifier (RMPA1911-96) operating in the US PCS band This chip-on-board design using discrete pHEMTs has 27 dB gain and 30 percent PAE (under CDMA forward link operation) operating from an 8 volt rail. This amplifier has been used as a "building block" for higher power amplifiers as described later in this article.

Figure 3 shows a photograph of the MMIC used in a three-stage 33 dBm amplifier operating in the U.S. PCS band (RMBA19500-53). This air-cavity plastic packaged MMIC design has 30 dB gain and 30 percent PAE (under CDMA forward link operation) operating from a 6 volt rail. Again, this amplifier has been used as a "building block" for higher power amplifiers as described later in this article.

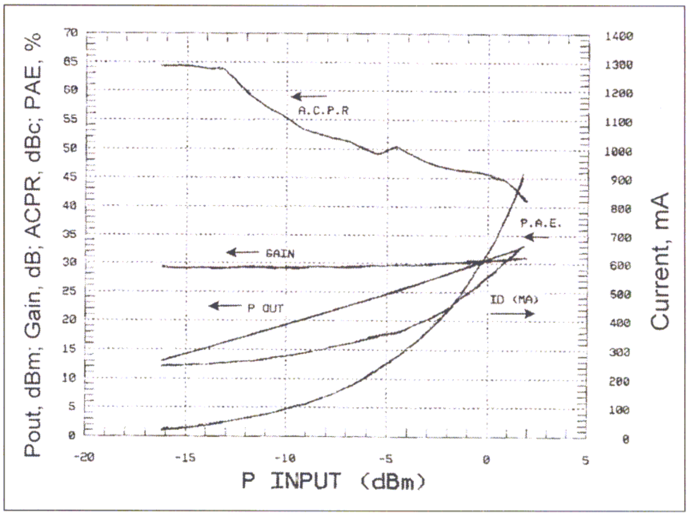
The design of these power amplifiers is primarily aimed at minimizing nonlinear effects and maximizing



▲ **Figure 3. 33 dBm linear power amplifier MMIC.**



▲ **Figure 4. Performance parameters of RMBA19500-53.**



▲ **Figure 5. Performance parameters of RMBA09500-53.**

efficiencies over different operating conditions determined by the system into which the amplifier is placed. An extreme example of this is that the biasing and load-line conditions for a "super-linear" amplifier requiring <–60 dBc IMD products will be different than the conditions required for an amplifier used in a TDMA application (Class A bias in the former case and Class A/B bias in the latter case). Generally, however, the design approaches follow similar paths. The main sources of spectral regrowth in pHEMT amplifiers are AM to AM distortion resulting from nonlinear transconductance, AM to PM distortion resulting from nonlinear gate-to-source capacitance, and distortion caused by waveform clipping at the gates and saturation and breakdown effects at the drains. The design issues that are addressed to minimize spectral regrowth are optimum fundamental frequency drain loading on all amplifier stages (but particularly the output stages), harmonic gate and drain loading and pre-distortion of the waveform through the amplifier. Pre-distortion is essential for linear operation as careful attention has to be paid to quiescent bias currents and transistor sizing to allow acceptable operation over temperature and maximization of power added efficiency.

Load-pull measurements of a range of transistor peripheries are required to determine the optimum pHEMT device sizes. The input and output of the transistors are tuned at specific bias currents. Contours of ACPR, output power, power gain, and PAE are plotted as a function of source and load conditions using automated systems such as ATN, Maury and Focus. Careful measurements result in the designer being able to choose a small impedance region where the chosen device has a "sweet spot" for best ACPR and PAE. Optimum efficiency is just as important in base station applications as in handset operation because significant reduction in "ancillary" equipment such as cooling fans and power supplies can result, making the amplifiers physically smaller and lower cost.

Base station driver amplifiers and phone PAs have critical requirements for stability. Stabilization techniques are required at the FET, MMIC, package and board levels. Peak performances (PAE, ACPR and Gain) are compromised when stabilization is added. Raytheon's amplifiers are tested into 10:1 load VSWRs over temperature with no RF as well as under small signal and compressed power levels.

Results under linear and nonlinear conditions

Figure 4 shows the P_{OUT} versus P_{IN} for the RMBA19500-53 operating under forward link CDMA conditions at 1900 MHz. Also shown is the PAE of the amplifier as well as the ACPR1 in dBc over a 19 dB dynamic range.

Figure 5 shows the P_{OUT} versus P_{IN} for the RMBA09500-53 operating under forward link CDMA conditions at 870 MHz. The PAE as well as the ACPR1 of the amplifier are shown over a 19 dB dynamic range.

These amplifiers provide 32 to 33 dBm of output power to the IS-95 forward link specification on ACPR. They are attractive as building blocks for driver and power amplifier applications as they are physically small (approximately 250 mil square package) and are competitively priced.

Differences between single carrier, multi-carrier, reverse link and forward link applications

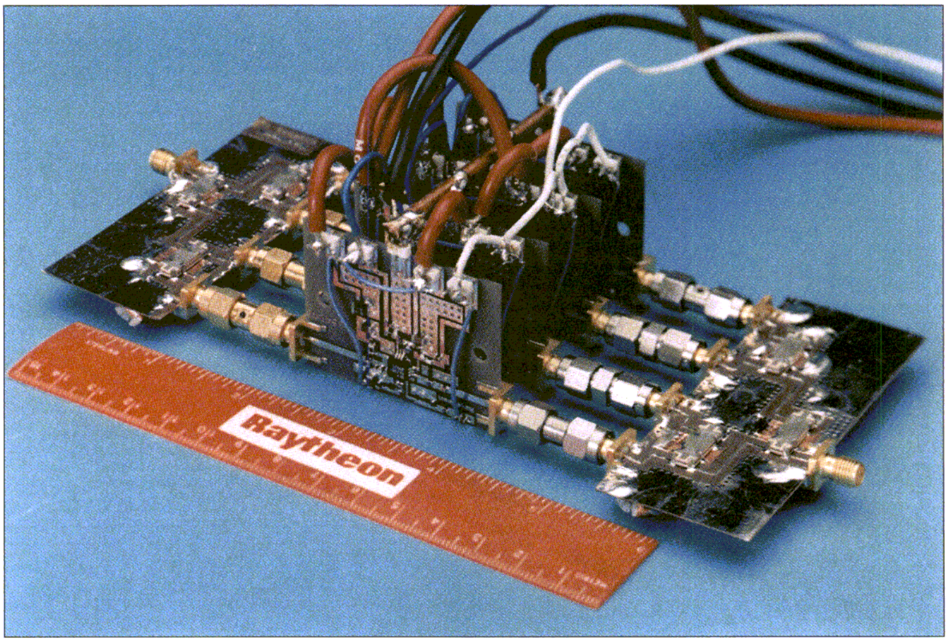
There are two basic types of cellular systems – analog and digital. These systems require different types of base-station PAs.

Analog cellular systems include AMPS in the USA, ETACS/NMT in Europe and NTACS in Japan. Analog systems use Frequency Division Multiple Access (FDMA) and the power amplifiers that are required

Circle 35

operate in saturated mode with efficiencies as high as 60 to 70 percent. These power amplifiers must maintain harmonics below certain values depending on system requirements (e.g. –70 dBc). This perofrmance is achieved using harmonic terminations and filters.

Digital cellular systems include IS-54 TDMA in the USA which employs π/4 DQPSK modulation, GSM in Europe using GMSK and PDC in Japan using π/4 DQPSK modulation. In addition IS-95 CDMA has become popular in the USA, Hong Kong and Korea where OQPSK is used in the handsets and QPSK in the base-stations. Unlike GSM that employs constant envelope waveforms, the other digital standards have peak-to-average power envelope fluctuations that require linear power amplifiers to avoid spectral regrowth. This spectral regrowth may be defined by adjacent channel power ratio (ACPR) or an absolute spurious emission power level.



▲ **Figure 6. RMBA19520 power amplifier.**

ACPR = Adjacent Channel Power in dBm – Transmit Channel Power in dBm

For IS-54 and IS-136 TDMA operation: Channel Bandwidth = 24 kHz and Channel Spacing = 30 KHz. The spectral splatter is determined by the ACPR1 (Adjacent Channel) being ≤–30 dBc and the ACPR2 (Alternate Channel or next Adjacent Channel) being ≤–48 dBc.

For IS-95 and IS-98 the relevant linearity requirements are an ACPR1 of ≤–42 dBc at 885 kHz offset with a channel bandwidth of 1.23 MHz and an ACPR2 of ≤–54 dBc at 1.98 MHz offset.

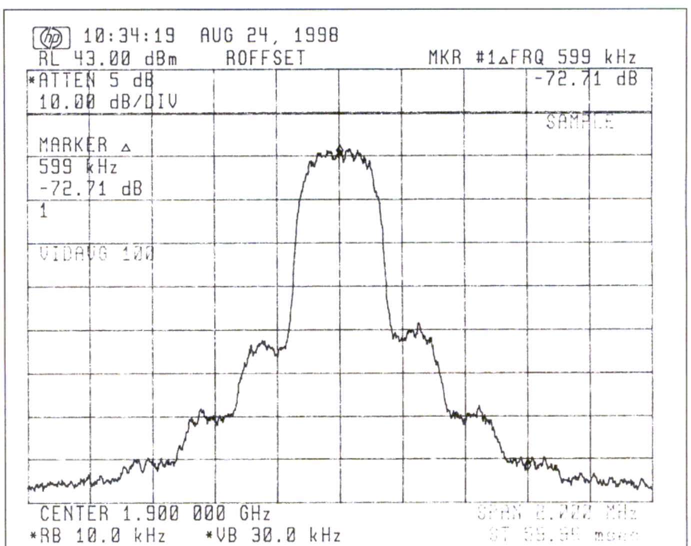
Base station splatter and emission level requirements resulting from multi-carrier transmissions result in more severe PA design requirements. In addition certain standards, such as CDMA, require more linearity in the base-station (forward link) PAs than in the handset (reverse link) PAs. In the CDMA case this is because the forward link modulation is QPSK with a 10 dB peak-to-average power envelope while the reverse link modulation is OQPSK with a 3 dB peak-to-average envelope.

Advantages of using pHEMT amplifiers in medium power linear applications

pHEMTs consistently show greater efficiencies than bipolar transistors and some MESFETs for highly linear applications e.g. 15 to 20 percent PAE compared to 5 percent under backed off power operation. pHEMTs, operating at voltages below 10 volts, are ideal for "low power" base-station and antenna array applications such as microcell, wireless local loop (WLL), "smart antennas" etc.. Such pHEMT amplifiers operating from 1 to >10 watts linear output power also find applications as driver amplifiers in macrocell sites.

Using pHEMT MMICs in higher power applications — Power combining

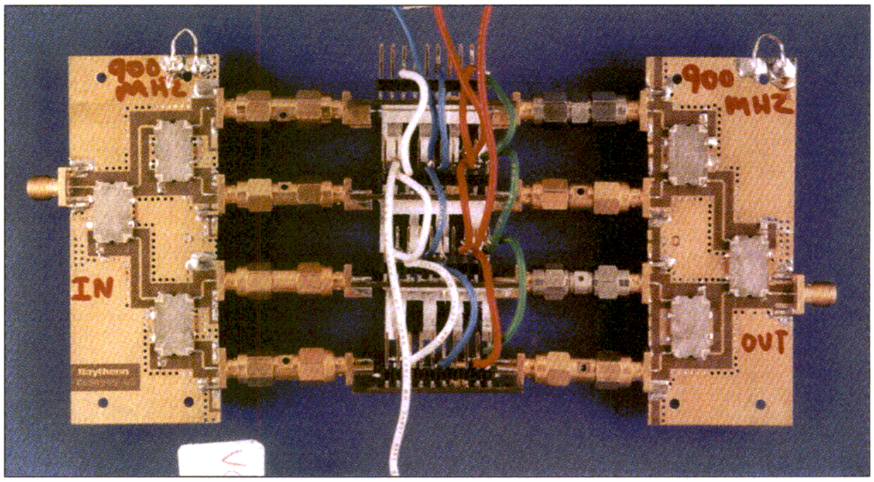
A number of discrete and MMIC-based amplifiers such as the RMBA09500-53, RMBA19500-53, RMPA1911-96 and RMPA2450-53 products have been used in higher power amplifiers by combining two, three and four units. All of these amplifiers have been



▲ **Figure 7. PHS emission level test at 5 watts output power.**

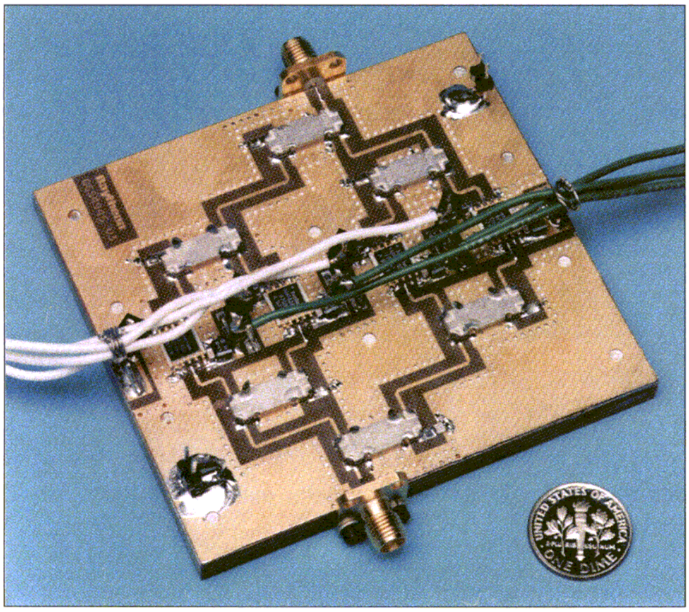
designed to operate from single drain and gate voltages (usually 6.5 or 8 volts on the drains and –3.5 volts on the gates).

Figure 6 shows the RMBA19520 consisting of four RMBA19500-53s operated at 6.5 volts. This amplifier has been used in a Japanese PHS rural microcell application, providing an output power of 5 watts, and an absolute emission level of 400 nanowatts at a 600 kHz offset (Figure 7). The same amplifier provides an output power of 6 watts under CDMA operation at an ACPR1 of 49 dBc under different biasing conditions. The overall PAE of the RMBA19520 is between 20 and 30 percent depending on mode of operation and biasing.

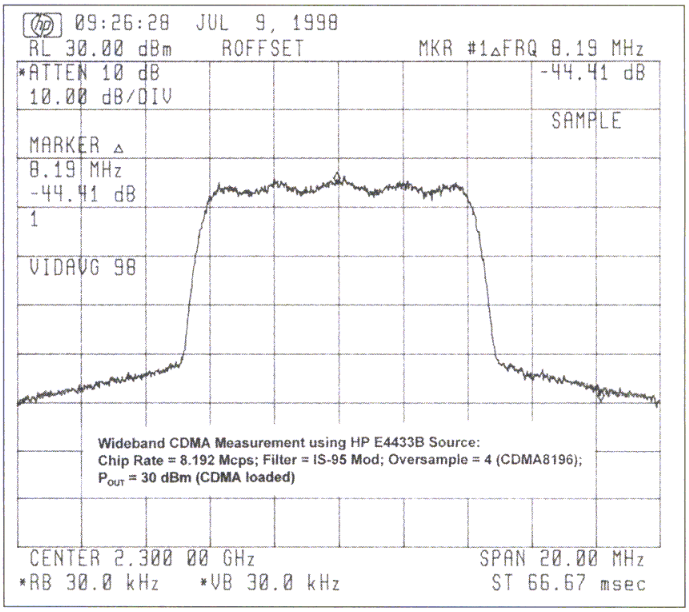


▲ **Figure 8. Photograph of the RMBA09520 cellular power amplifier.**

Figure 8 shows the RMBA09520 consisting of four RMBA09500-53s operated at 6.5 volts. This amplifier delivers 41.5 dBm saturated output power in Analog mode. For example the IMD of this amplifier is <–35 dBc at 10 watts output power at a PAE of 31 percent. Under digital modulation the amplifier delivers an output power of 38 dBm with a PAE of 29 percent with 45 dBc ACPR1 at 1.25 MHz offset for 1.23 Mbps forward link CDMA. The same amplifier, under different biasing conditions, provides 39 dBm output power at <–30 dBc ACPR1 and <–48 dBc ACPR2 at 30 and 60 kHz offsets for NADC TDMA with an overall PAE of 32 percent. Under GMSK modulation for 270



▲ **Figure 9. The RMBA23610 power amplifier.**



▲ **Figure 10. Wideband CDMA ACPR performance of the RMBA23610 at an output power of 1.25 watts.**

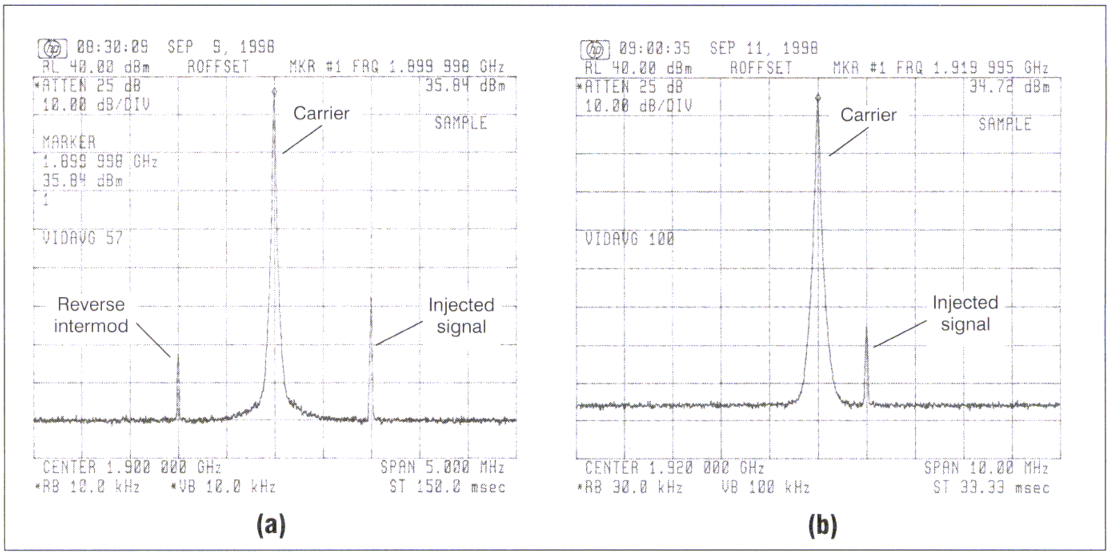
kbps the amplifier delivers 39 dBm output power at <–30 dBc and <–60 dBc emissions at 200 and 400 kHz offsets respectively.

Figure 9 shows a third power amplifier example using four RMPA2450-53 MMIC amplifiers. This amplifier is designed to be used under W-CDMA modulation at 8.2 Mcps for WLL applications at 2.3 MHz. The amplifier delivers 1.25 watts of linear power at an ACPR1 of –58 dBc. Figure 10 shows a wideband CDMA measurement using an HP E4433B digital modulation source. The four amplifiers are combined using Anaren Xinger surface mount couplers, are operated from 7 volts and have an overall PAE of 12 percent.

Table 1 and the accompanying notes provide a summary of various performance parameters for a number of pHEMT-based base-station power amplifiers available from Raytheon Microelectronics

Reverse intermodulation

One of the strictest emission level requirements in base-station system specifications is the so-called reverse intermodulation level. For example, for the 1900 MHz GSM requirement the reverse intermodulation level is an absolute power level at the power amplifier output of –70 dBm. In this case the reverse intermodulation product is defined as the resultant intermodulation signal produced when a + 4dBm single-tone signal is injected into the output of the power amplifier under full output power of 36 dBm. This measurement simulates the condition whereby a transmitter "receives" an adjacent channel signal from another nearby base-station. In order to prevent such signals being generated power amplifiers require "linear" isolators to be placed between the amplifier and the filters preceding the antenna. The lower the intrinsic



▲ **Figure 11. Reverse intermodulation: (a) without, and (b) with output isolator in a RMBA 19620 power amplifier.**

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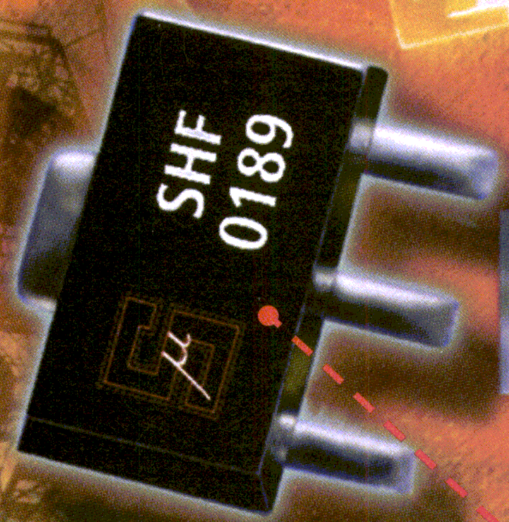
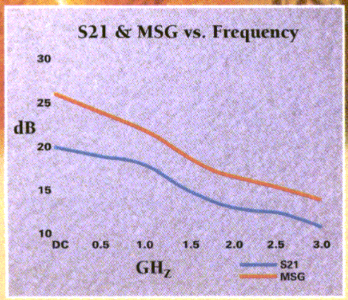
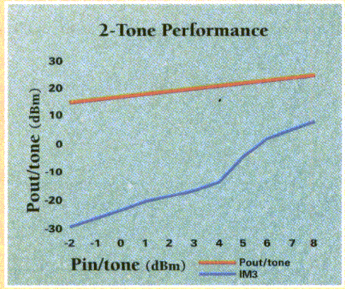
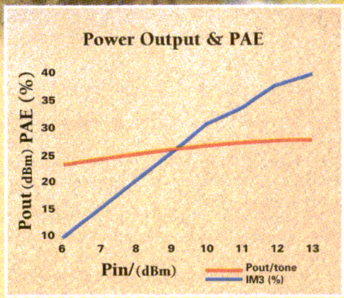


P1: +27dBm **IP3: +40dBm**







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The new SHF-0189 is a high performance A/GaAs/GaAs heterostructure FET in plastic SOT089 packaging. HFET technology increases breakdown voltage for high drain voltage operation and also minimizes Schottky leakage current for high efficiency and linearity.

This half-watt HFET can be used in both analog and digital wireless applications including cellular, PCS, CDPD, wireless data and pagers.

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Part Number & Frequency	V_{DD} volts	P_{OUT} GSM dBm	P_{OUT} CDMA dBm	P_{OUT} TDMA dBm	P_{OUT} PHS dBm	P_{OUT} IMD dBm	Gain dB (S.S)	PAE % CDMA	P_{1dB} dBm CDMA	OIP_3 dBm CDMA	I/P & O/P VSWR	Noise Figure dB	Harmonics dBc (CW)
RMBA09500-53 840 to 900 MHz	6.5	34	31	34			30	30	34	44	2:1	5	- 30
RMBA09510 840 to 900 MHz	6.5	37	34	37			30	30	37	47	1.5:1	5.25	- 35
RMBA09520 840 to 900 MHz	6.5	39	38	40		40(b)	30	29	40	50	1.5:1	5.5	- 40
RMBA19500-53 1900 MHz	6.5		33	32	32		30	30	33.5	41	2:1	6	- 30
RMBA19510 1900 MHz	6.5		35	34	34		30	26	38	46	1.5:1	6.5	- 35
RMBA19520 1900 MHz	6.5		37	37	37	38(a) 27(b)	29	19	40	48	1.5:1	7	- 40
RMPA1911-96 1900 MHz	8		33	34		34(a) 21(b)	27	27	34	44	2:1	5	- 30
RMBA19600 1900 MHz	8					22(b)	27	24	35	45	2:1	6	- 30
RMBA19610 1900 MHz	8		35	36	34	36(a) 23(b)	27	11	36	45	1.5:1	5.5	- 35
RMBA19620 1900 MHz	8		36	37	37	37(a) 24(b)	26	14	39	48	1.5:1	6	- 40
RMPA2450-53 2300 MHz	7		25					12	27	37	2:1	5.5	- 30
RMPA2311-96 2300 MHz	8		30					12	32	42	2:1	5.5	- 30
RMBA23610 2300 MHz	7		31				30	12	33	43	1.5:1	6	- 40

Notes

1. The linearity parameters are not necessarily available simultaneously. The amplifiers are biased for optimum performance for each type of modulation scheme or linearity requirement. POUT is linear output power to meet one or more of the following specifications:
GSM: 270.8 kHz symbol rate; Forward Link; GMSK modulation; @ 200 kHz offset ACPR1 = 35 dBc; @ 400 KHz offset ACPR2 = 65 dBc
CDMA: 1.23 MHz symbol rate; Forward Link; 9 Channels
@ 1.23 MHz offset in 30 kHz integration bandwidth ACPR1 = 46 dBc; @ 2.5 MHz offset in 30 kHz integration bandwidth ACPR2 = 64 dBc
TDMA: NADC with 48.6 kHz symbol rate; @ 30 kHz offset ACPR1 = 30 dBc; @ 60 kHz offset ACPR2 = 48 dBc
PHS: Relative emission level of –70 dBc at Bit Rate of 384 kbps at offset frequency of 600 kHz
IMD: (a) Third Order Two Tone Rejection >30 dBc; (b) Third Order Two Tone Rejection >60 dBc; This parameter does not refer to reverse IMD
2. Baseplate Operating Temperature Range: 0° C to +50° C. These amplifiers do not contain temperature compensation unless specified by the customer. Gain change with temperature is approximately 0.02 dB per °C
3. Non-operating Temperature: -40° C to + 85° C; Humidity without condensation: 95% relative; Altitude: 10,000 feet
4. Outlines are to customer requirements; normally consist of either machined enclosures with gasket seals, SMA Female or Type N Female connectors, EMI/RF filters or tab leaded modules
5. Single Power Supply. Maximum supply without damage: 10 volts
6. Load Mismatch sustainable without damage: 3.0:1

Packages
Type 53 is a 12 lead "quad" plastic package with metal base; Type 96 is a 7 "edge" leaded package with flange.

▲ **Table 1. Summary of performance parameters of pHEMT-based base station power amplifiers.**

Temp. Deg. C	Small Signal Gain, dB	Large Signal Gain, dB	Quiescent Current, mA	RF Loaded Current, mA	ACPR1, dBc
-38	26	25.9	1800	2500	46.2
-30	26	25.7	1730	2520	45.6
-20	25.9	25.6	1660	2560	45.1
-10	25.6	25.4	1570	2630	46.5
0	25.4	25.1	1580	2700	45.1
10	25.1	24.8	1430	2773	46.6
20	24.9	24.7	1410	2780	45.0
30	24.7	24.4	1410	2850	45.0
40	24.7	24.2	1370	2900	45.0
50	24.4	24.0	1360	2950	44.0
60	24.2	23.8	1290	3000	44.5
70	24.0	23.5	1330	3070	44.3
80	23.5	23.2	1340	3130	44.2

▲ **Table 2. Variation in performance of the RMBA 19620 as a function of temperature.**

reverse intermodulation of the power amplifier the less stringent the requirements placed on the "linear" isolators (isolators chosen specifically to exhibit very small nonlinear effects). Figure 11 shows the reverse intermodulation of the RMPA19620 that results from using a standard isolator compared to no isolator. With the isolator connected the reverse intermodulation level is <–115 dBc (or –79 dBm) compared to –96 dBc (or –60 dBm) without the isolator.

Typical amplifier performance versus temperature

The amplifiers described above do not feature temperature compensation. In many cases temperature compensation is not required because the intrinsic variation in gain etc. of the amplifiers using pHEMTs is acceptably small. Table 2 shows the typical parameters of the RMBA19620 1900 MHz amplifier as a function of temperature. The ACPR1 figures refer to 9 channel forward link CDMA conditions with QPSK modulation. The measurements were performed by setting the output power to 36 dBm by adjusting input RF power at each temperature and recording the parameters that are tabulated. The amplifier quiescent current was set to a nominal value at 20° C only. The measured temperature coefficient of gain over –38° to + 80° C. is 0.02 dB per °C.

Conclusions

pHEMT transistors have been used effectively in a range of power amplifiers for cellular and PCS base-station applications. These amplifiers, having linear output powers in the range of 1 to 10 watts, show excellent efficiencies when compared to BJT and MESFET based products.

Low operating voltages coupled with relatively high efficiencies result in simplified construction and installation of the amplifiers. This makes them suitable for masthead applications where convection cooling is sufficient to maintain the amplifiers below safe operating temperatures. A number of examples of such amplifiers have been described in this article together with typical data for a range of constant envelope and linear modulation conditions. ■

Author information

Raymond S. Pengelly, Robert B. Binder, James R. Griffiths, Michael Virostko, Michael McPartlin are with Raytheon Microelectronics, 362 Lowell Street, Andover, MA 01810. They can be reached by telephone at: 978-470-9715, by fax at: 978-470-9452, or by e-mail at: Raymond_S_Pengelly@me.raytheon.com. Further information can be obtained from the Raytheon Web site: www.raytheon.com/micro.

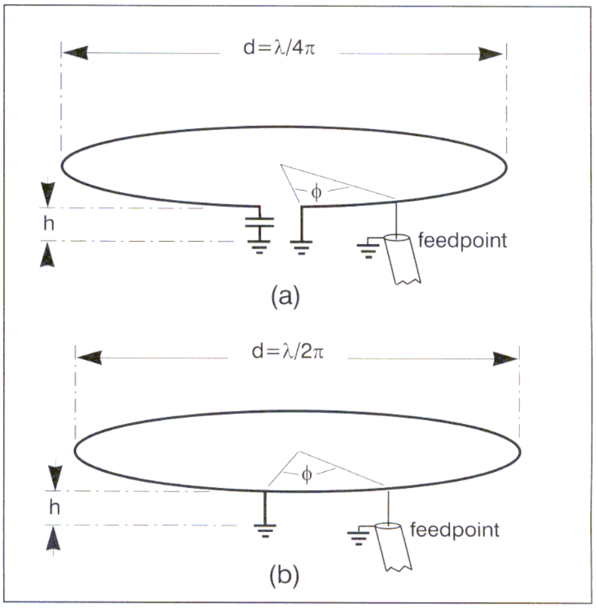
A Half-Wave Hula-Hoop Antenna for GSM Mobile Applications

Here is a low-profile antenna option for applications requiring low visibility, durability and a uniform radiation pattern

V. Stoiljkovic, A. D. Spencer and G. Wilson
Centurion International, Inc.

This article describes an investigation into the input impedance bandwidth and radiation characteristics of a half-wave hula-hoop antenna. The antenna is designed to work in the GSM frequency band of 860-960 MHz. Theoretical and experimental results are presented, showing the antenna's capability of producing nearly isotropic radiation patterns. The basic antenna structure is metallic and does not involve any dielectric materials, enabling an inexpensive and easy-to-construct low-profile antenna design.

Low-profile antennas have been used in specialized and covert applications in Professional Mobile Radio (PMR) for many years. They were initially designed to satisfy the need for almost indestructible antennas. The aesthetic appeal of low-profile designs and their durability are their main marketing advantages. On the other hand, GSM is increasingly employed in mobile location services, especially tracking and remote services. Tracking services, for example, are used to locate and monitor cargoes, and remote services are used for long-distance control of vehicle functions, etc. most of these applications require robust low-profile antennas with an omni-directional radiation pattern. This article introduces one such design, which is inexpensive to produce and has good RF performance.



▲ **Figure 1. Hula-hoop antennas: (a) the quarter-wave loop, and (b) the half-wave loop.**

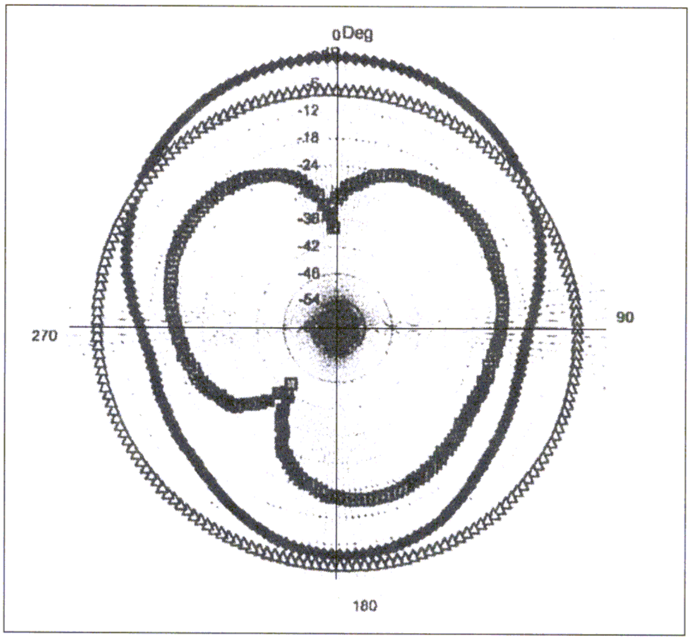
Structure of the antenna

The hula-hoop antenna, also known as a directional-discontinuity ring-radiator (DDRR) gained a lot of attention in the early 1960s [1-3]. The original version consists of a quarter-wavelength long piece of wire bent into a circular shape over a conductive ground plane, as illustrated in Figure 1a. The position of the loop is parallel and close to the ground plane. The loop is driven at one of its ends and open at the other. The antenna resonant frequency can be lowered by capacitive tuning at the open end. The basic idea of this design is to replace a quarter-wave monopole antenna with a shorter but wider radiating structure with similar electrical characteristics. The quarter-wave DDRR has, however, been proven to have the input impedance bandwidth of only one to two percent [4].

In order to increase the input impedance bandwidth, a closed half-wave loop structure has been proposed (Figure 1b) [4]. A half-wavelength long piece of wire is bent into a circle and short-circuited to a ground plane at one point.

Loop Diameter (mm)	Loop Height (mm)	Resonant Frequency (MHz)	Bandwidth (MHz)
50	30	1050	90
50	35	975	85
50	40	910	70
50	45	855	60
60	25	1040	120
60	30	960	105
60	35	900	80
60	40	840	70
60	45	795	65
70	25	940	50
70	30	880	65
70	35	825	70
70	40	775	60
70	45	735	60
80	25	870	45
80	30	760	50
80	35	760	55
80	40	720	60
80	45	685	60

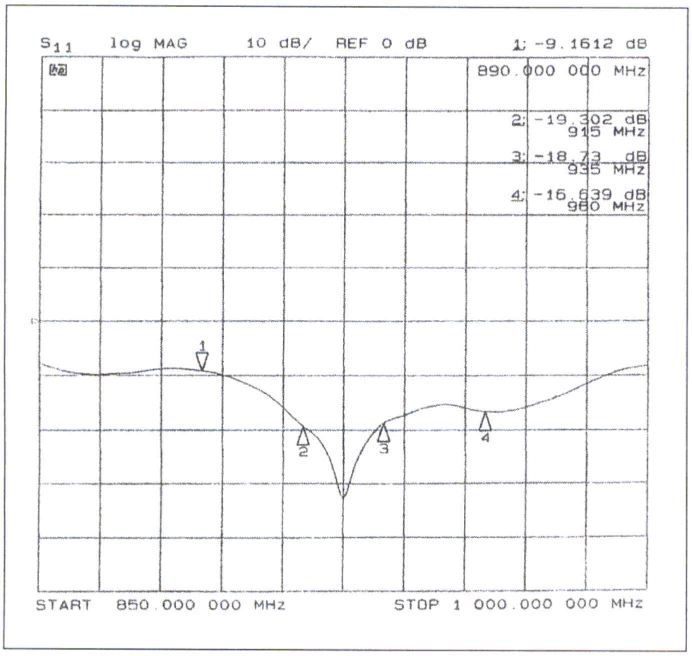
▲ **Table 1. Antenna resonant frequency and bandwidth as a function of loop diameter and height.**



▲ **Figure 3. Radiation pattern (azimuth) at 925 MHz. Triangles are vertical polarization, squares are horizontal polarization and diamonds are the reference horn antenna.**

The antenna is fed by a coaxial cable at another point. The position of the feed point is usually 100° to 140° away from the short-circuit point. By changing the original quarter-wave long, open hula-hoop design into a half-wave long closed-loop design, a noticeable improvement in the input bandwidth can be achieved.

The antenna was modeled using WIPL [5]. Initial numerical results showed that the antenna impedance



▲ **Figure 2. Measured antenna input reflection coefficient *vs.* frequency.**

bandwidth was strongly dependent on the size of the ground plane. For practical reasons, the ground plane was chosen to be circular with a diameter of 240 mm.

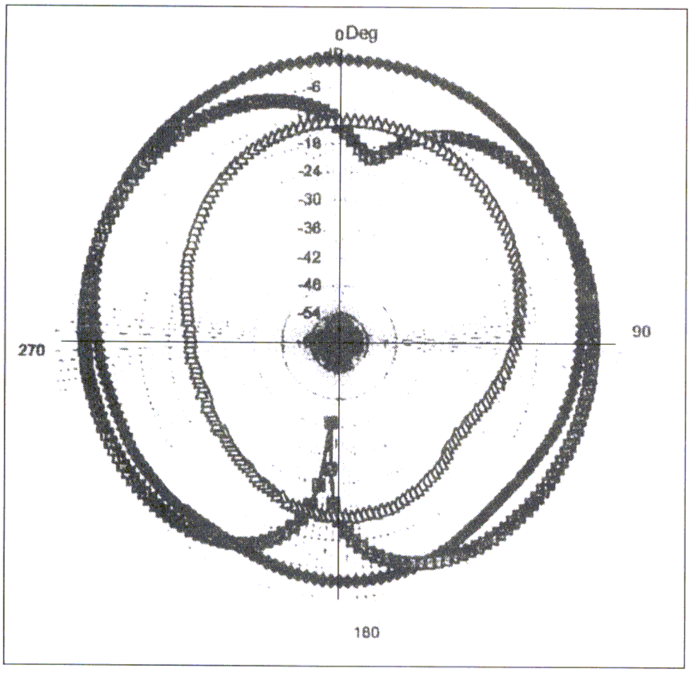
The loop diameter and its height above the ground plane were then changed and the antenna resonant frequency and input impedance bandwidth were calculated. The numerical results are shown in Table 1. As expected, the resonant frequency decreases with an increase of both loop diameter and its height above the ground plane.

In order to cover the whole of the GSM band (890-960 MHz), the loop diameter was chosen to be 60 mm and its height was chosen to be somewhere between 30 and 35 mm. The final value for the height was to determined experimentally.

Antenna electrical characteristics

A prototype antenna was built and tested. the antenna's input reflection coefficient as a function of frequency is shown in Figure 2. The bandwidth (–10 dB) is about 90 MHz.

The antenna radiation patterns in the azimuth and elevation planes are shown in Figures 3 and 4, respectively. The antenna has an almost omni-directional radiation pattern. The peak gain is 0.2 dBi in the azimuth plane and 2.0 dBi in the elevation plane. The gain was measured using a double-ridged horn as a reference antenna. The horn peak gain was 6.3 dBi. The fair amount of cross-polarization in the elevation plane is considered to be beneficial for applications involving multipath fading.



▲ **Figure 4. Radiation pattern (elevation) at 925 MHz. Triangles are vertical polarization, squares are horizontal polarization and diamonds are the reference horn antenna.**

Conclusion

A half-wave hula-hoop antenna has been described. The antenna operation was analyzed both theoretically and experimentally. It has been shown that the antenna has an almost omni-directional radiation pattern. The antenna also has a low profile and is inexpensive and easy to manufacture. The design presented here is suitable for GSM applications. ■

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Author Information

Vladimir Stoiljkovic is Lead Engineer, and A. D. Spencer and G. Wilson are members of the engineering staff at Centurion International, Inc., 2A, Alton Business Park, Gatehouse Way, Aylesbury, Buckinghamshire, HP 19 3XU, UK; by fax at +44 1296 339 808; or by e-mail at: vladimirs@centurion-int.co.uk

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ULTRAFAST WIDEBAND MICROWAVE

LOGARITHMIC AMPLIFIERS

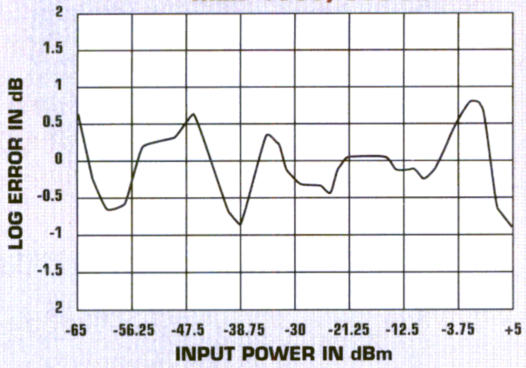
FEATURES

- Fast Recovery Time
- Low Output Noise for Increased Accuracy
- Improved Sensitivity Through Low Noise Figure Input Stages
- Custom Electrical Performance Available

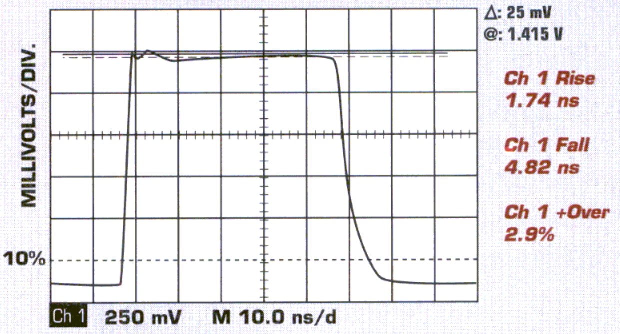
ELECTRICAL SPECIFICATIONS

Model Number	Center Frequency (MHz)	Operational Bandwidth (MHz, Min.)	Dynamic Range (dB, Min.)	TSS (dBm, Max.)	Log Linearity (±dB, Max.)	Video Flatness (±dB, Max.)	Rise Time (ns, Max.)	Recovery Time (ns, Max.)
MLIF-500/100-70	500	100	-70 to 0	-74	1	1.0	5	23
MLIF-750/500-60	750	500	-60 to 0	-67	1	1.5	2	12
MLIF-1000/300-60	1000	300	-60 to 0	-68	1	0.75	2	12
MLIF-1000/500-70	1000	500	-65 to +5	-72	1	2.0	5	25
MLIF-1500/500-60	1500	500	-60 to 0	-66	1	1.0	1.7	12
MLIF-1575/200-50	1575	200	-45 to +5	-53	1	1.0	1.5	10

LOG LINEARITY
MLIF-1000/500-70



PULSE RESPONSE
MLIF-1000/300-60



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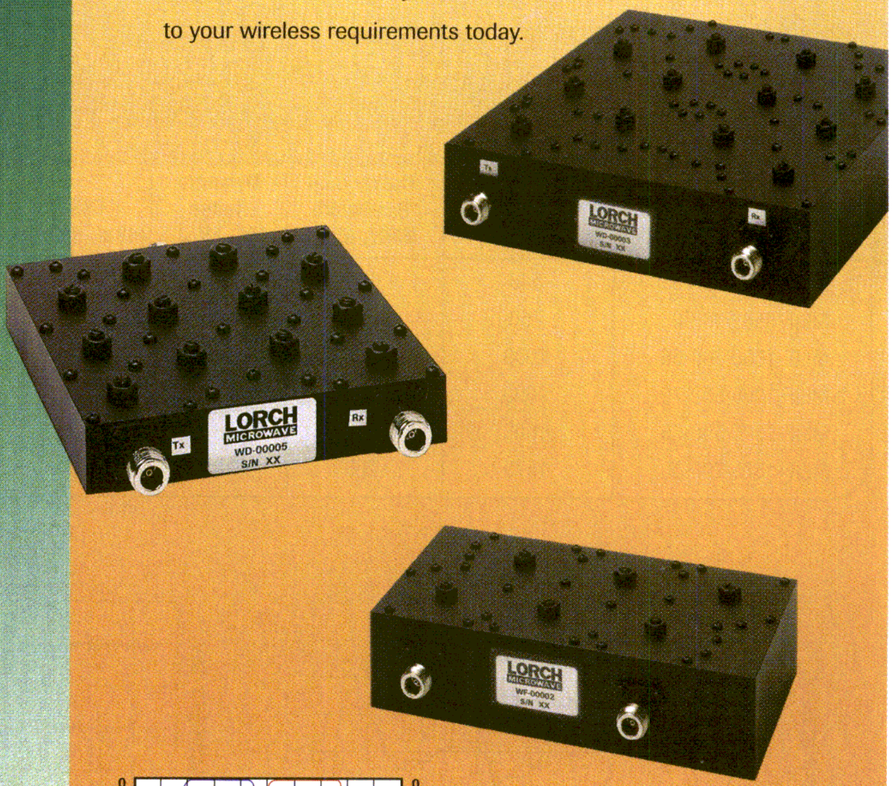

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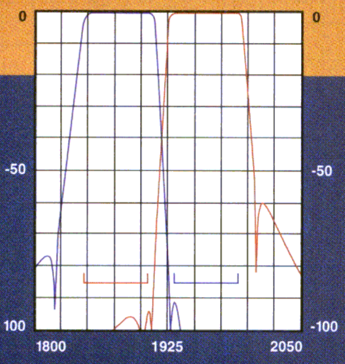

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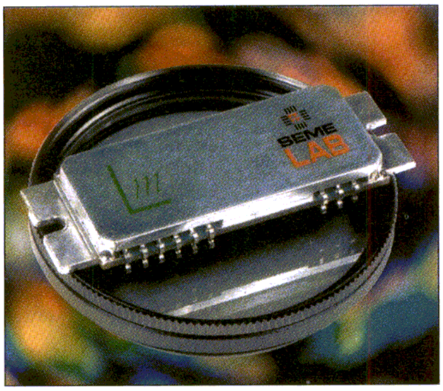
AMPLIFIERS

Linear amplifier modules

Semelab has started production of new RF power amplifier modules for linear modulation architectures used in Private Mobile Radio

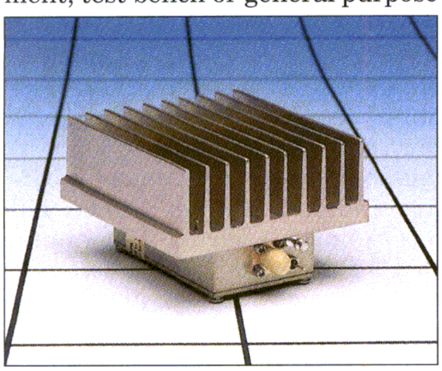


(PMR), Public Access Mobile Radio (PAMR) and Terrestrial Trunk Radio (TETRA). Power output of the modules is 5.5 watts using a 7.2 volt supply. Wide temperature operation and rugged, compact construction are additional features. Models are available for the 220 MHz and 150-170 MHz bands. Additional modules are in development.

Semelab plc
Circle #159

1-500 MHz amplifier

RF Gain, Ltd. now offers a wideband amplifier for laboratory equipment, test bench or general purpose

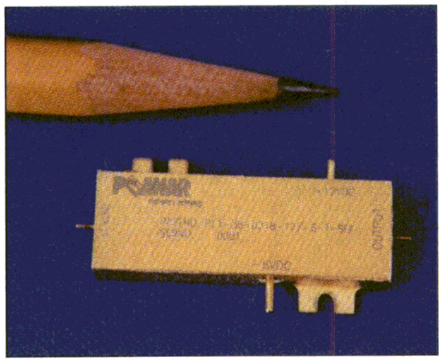


applications. The RFGA0105-01 operates over 1-500 MHz with an output power of 1 watt at 1 dB compression, or 2 watts CW. The third order intercept point is +40 dBm, small signal gain is 30 dB, and the unit features high linearity, low spurious, noise and harmonics. The amplifier is designed around high reliability gold metalized transistors. The RFGA0105-01 is currently available from stock.

RF Gain, Ltd.
Circle #160

Amplifier covers 2-18 GHz

Planar Electronics Technology has introduced the PE1-38-0218-12/-7-T-SFF, with temperature com-

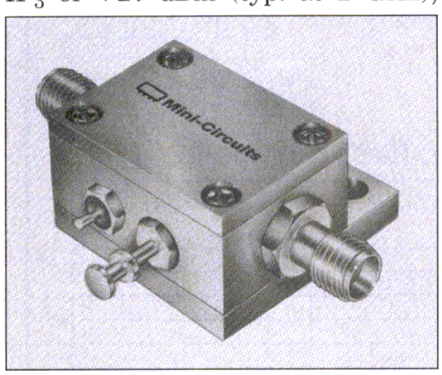


pensation for operation over 2-18 GHz with 38 dB gain. Gain variation is just ±3 dB over a temperature range of –55 to +85°C. The PE1 series can be used in microstrip or connectorized applications, and measures 1.08 × 0.56 × 0.195 inches.

Planar Electronics Technology
Circle #161

Low power wideband unit

Mini-Circuits offers the ZJL-7G, a connectorized amplifier with an IP_3 of +27 dBm (typ. at 2 GHz),

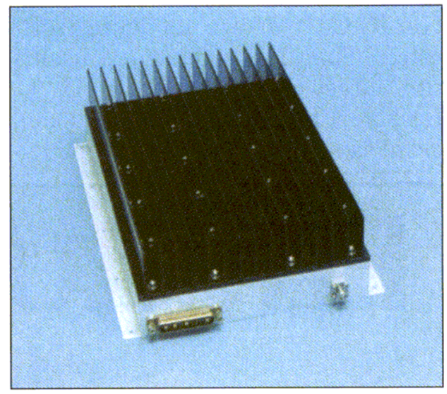


gain of 10.2 dB (±1.2 dB) and a typical P_{1dB} of +12.4 dBm. The frequency range covered by the unit is 20-7000 MHz. Pricing of the ZJL-7G wideband amplifier is $99.95 each in 1-9 quantities.

Mini-Circuits
Circle #162

50 watts for PCS GSM

Chesapeake Microwave Technologies' 50 watt GSM amplifier offers 45 dB of gain and a minimum of 50 watts output power in a single assembly. The unit operates in the

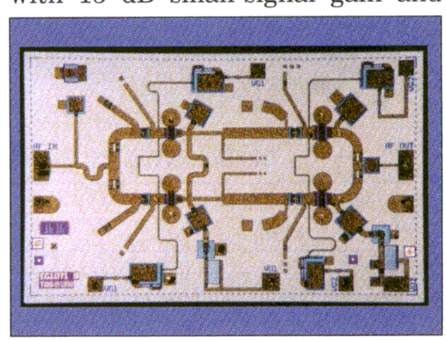


1930-1990 MHz PCS band, using GaAs FETs in class AB linear operation. A DCS model is also available. It is packaged in a 8.0 × 4.0 × 1.5 inch case with an integral heat sink. Power requirements are +15 volts at 9.5 amperes.

Chesapeake Microwave Technology
Circle #163

38 GHz amplifier MMIC

TriQuint Semiconductor has introduced a 36 to 40 GHz pHEMT MMIC power amplifier for mm-wave applications in point-to-point and point-to-multipoint digital radio systems. The TGA1071-EPU is a two-stage monolithic amplifier with 15 dB small-signal gain and

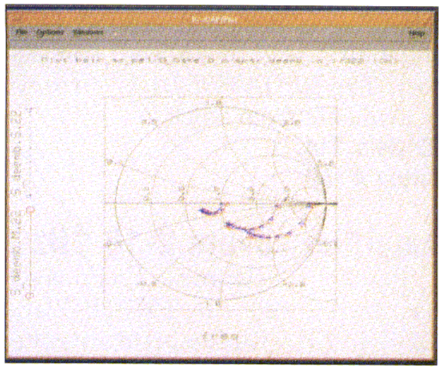


150 mW power output when biased at 120 mA from a 5 volt supply. The device is available in chip form with a physical size of 3.4 × 2.1 × 0.10 mm. Bond pad and backside metal is gold plated. Pricing is $56 each in quantities of 1000.

TriQuint Semiconductor
Circle #164

SOFTWARE

Modeling enhancement for MOS/CMOS ICs

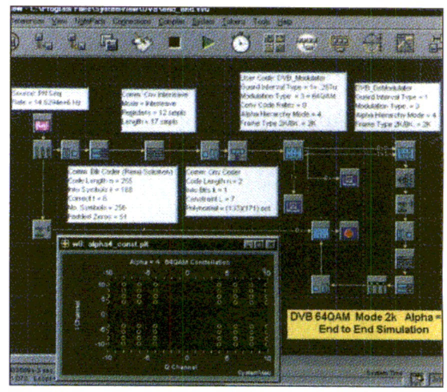


HP EEsof has added new parameter extraction capabilities to its HP IC-CAP device modeling software. The new package contains the latest release of the U. C. Berkeley BSIM3v3.2 MOS model, extraction templates and a modeling toolkit. The package offers a fast and accurate solution for modeling MOS/CMOS ICs in high-frequency applications such as wireless communications. Parameters modeled include DC I-V, capacitance models, temperature behavior, noise effects and high-frequency modeling. The HP BSIM3v3 modeling package is $15,000 and is available as part of HP IC-CAP Version 5.2 for UNIX® system platforms from HP and Sun.

Hewlett-Packard Company
HP EEsof Division
Circle #165

Digital video broadcast system-level simulation

Elanix has added support for Digital Video Broadcasting (DVB) applications for the SystemView by Elanix simulator. The DVB library enables developers of applications conforming to the European Telecommunications Standard



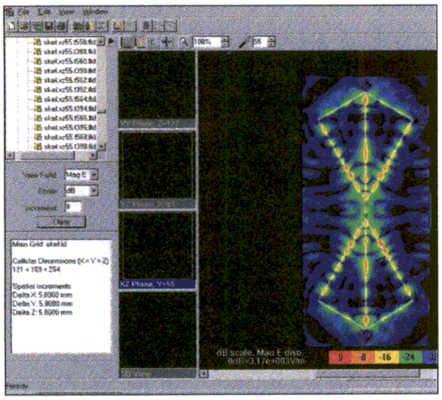
(ETS) 300 744 to rapidly analyze different design approaches. The library enable simulation of baseline transmission systems, supporting specifications for channel coding and modulation. Functional blocks include signal generators, the shortened Reed-Solomon encoder, convolutional interleaver, punctures convolutional encoder and the DVB modulator/demodulators. The modulators can be used as a single token, or broken down into constituent components. The DVB library costs $1,995 and is now available.

Elanix Inc.
Circle #166

Products

FDTD EM analysis released for Windows®

Remcom announces the release of version 5.0 of XFDTD for Windows 95/98/NT, complementing its existing UNIX products. Key features of XFDTD include steady state and transient analysis, S

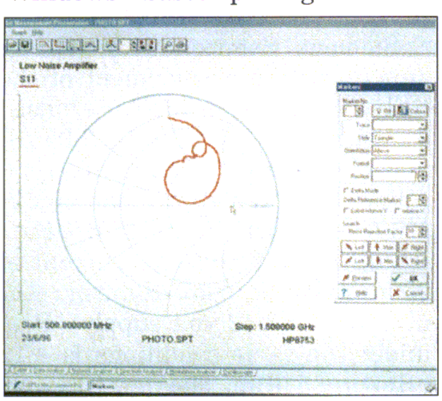


parameters, complex media and specific absorption rate (SAR) for biomedical applications. The product allows its users to perform complex analysis for many applications in antennas, cell phone design, EMC, propagation, biomedical technology and radar cross section. The main module is priced at $12,000.

Remcom Inc.
Circle #167

Test data presentation and analysis software

P & H Technology Consultants has introduced SoftPlot, a Windows®-based package for the

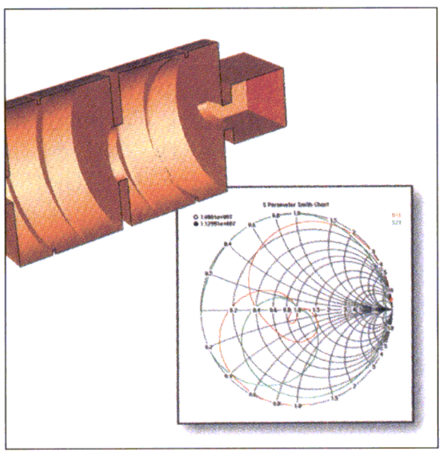


capture, display and formatting of measurement data from spectrum or network analyzers, oscilloscopes, etc., which can then be embedded in documents, presentations and spreadsheets. SoftPlot is targeted at RF and microwave engineers, using integral GPIB drivers for connection to the test instrumentation. Once captured, data can be displayed as needed as VSWR, log magnitude, Smith chart, real and imaginary or polar plots. Markers, test limits, trace math and text annotation are also included. Pricing of SoftPlot is £390 (+VAT as required). A National Instruments GPIB card, or equivalent, is required.

P & H Technology Consultants
Circle #168

EM field simulator for microwave circuits

CST MicroWave Studio is a high-frequency electromagnetic field simulator, featuring a user-friendly



graphical interface and fast, accurate calculation of S parameters for waveguide filters and couplers, dielectric filters, directional couplers, microstrip lines and other microwave circuits. A full set of display and calculation features is included. The software incorporates the company's Perfect Boundary Approximation technique for accurate modeling of curved surfaces, which maintaining the high performance of the FI-method in the time domain. *CST MicroWave Studio* is based on the ACIS 3D solid modeling kernel, which enables 3D interoperability with other ACIS-enabled applications such as AutoCAD.

CST – Computer Simulation Technology
Circle #169

Products

SEMICONDUCTORS

30 watt GaAs MESFET for Wireless Local Loop

California Eastern Labs has announced the availability of the NEC S-Band GaAs MESFET, the NEZ3436-30E. The device features high output power, low distortion and high linear gain in the 3.4 to 3.6 GHz frequency band. The NEZ3436-30E provides 30 watts

output power, 10.0 dB linear gain and –45 dBc third-order intermodulation products at 33 dBm SCL. Power added efficiency is 37 percent, and the device is intended for Class A or AB operation. Internal matching to 50 ohms is provided. The NEZ3436-30E comprises two chips with 0.9 μm tungsten silicide gate structure, silicon dioxide passivation, and is sealed in a rugged hermetic package. Price of the device is $265 in 100-piece quantity.

California Eastern Laboratories
Circle #170

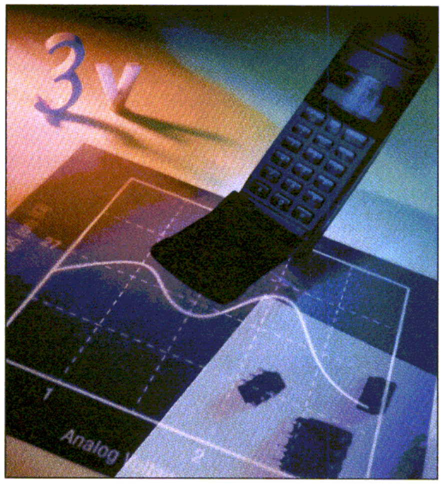
DECT baseband processors

VLSI Technology has announced the VEGA+™ family of baseband processors for cost-sensitive DECT applications. Features include 128 kbytes program memory, RISC processor, digital answering machine functionality, caller ID detection, DTMF detection and other calling functions. Pricing is below $5 in 1 million quantities, and is part of a sub-$25 reference design.

VLSI Technology
Circle #171

Low voltage analog switch

Vishay Siliconix has two new analog switches offering high performance at voltages a slow as 2.7 V. The single-pole, double-throw DG9431 and DG9461 provide signal routing and signal source selec-

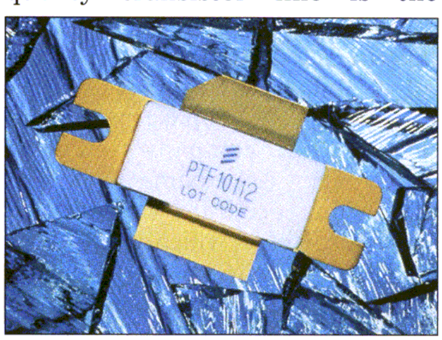


tion in applications like cellular phones, portable communications equipment, test instruments and notebook computers. Typical on resistance for the DG9431 is 30 ohms, or 50 ohms for the DG9461. Typical turn on/turn off times are 50/20 ns in 3 volt applications. In 1000-piece quantities, pricing is $0.90 for the DG9431 and $0.80 for the DG9461.

Vishay Siliconix
Circle #172

High power for PCS

The latest addition to Ericsson Component's high power, high frequency transistor line is the

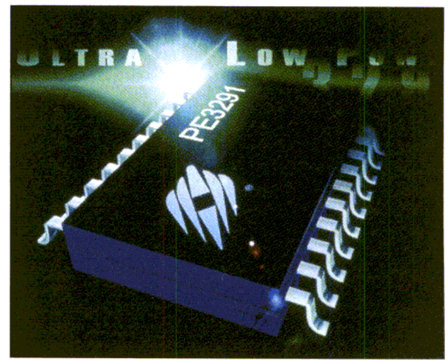


PTF10112. The transistor operates in the 1.93 to 1.99 GHz PCS band, providing 60 watts P_{1dB} with a typical power gain of 12 dB. Gain flatness is ±0.2 dB over the band, and Class AB two-tone third-order IM D is –40 dBc at 25 watts power output. The gold-metalized LDMOS device operates from a 28 VDC supply with a 65 volt minimum drain-source breakdown voltage.

Ericsson Components
Circle #173

PLL cuts noise, spurs and power consumption

Peregrine Semiconductor Corp. offers the PE3291, a PLL designed for two-way pagers, CDMA and



wireless meter reading products. The new PLL is a 1 GHz dual fractional-N synthesizer IC with low noise and spur performance. Low voltage operation (as low as 1 V for the prescaler) conserves power in battery-operated equipment. The PE3291 is priced at $1.95 in 100k quantities. A full evaluation kit and manual is available.

Peregrine Semiconductor
Circle #174

45 GHz f_T silicon bipolar low-noise transistor

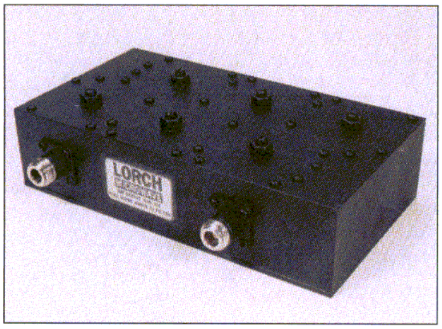
Siemens Semiconductor Group announces the development of the BFP 520, a silicon bipolar transistor with an f_T of 45 GHz, 0.95 dB noise figure at 1.8 GHz, and a typical power gain of more than 20 dB. Minimum noise figure at 6 GHz i 1.8 dB. With a collector current of 20 mA, IP_3 is +25 dBm, or +17 dBm at 7 mA (2 volt supply). P_{1dB} under the same conditions is +12 dBm or +5 dBm. The new BFP 520 launches the SIEGFET® 45 family, surpassing the performance of the earlier SIEGFET 25 devices.

Siemens Semiconductors
Circle #175

SIGNAL PROCESSING

AMPS transmit filter

Lorch Microwave offers the WD-00003, a full band AMPS transmit filter, with a passband insertion

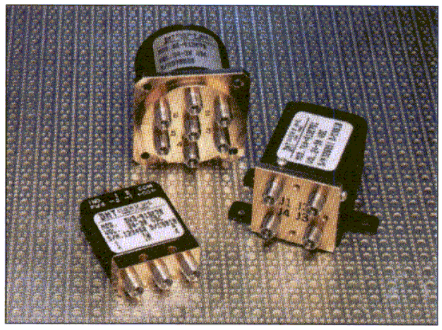


loss of less than 0.5 dB and ripple less than 0.25 dB. The filter exhibits receive band rejection of greater than 80 dB. The filter operates over –20 to +70° C at 5 kW PIP, 2.5 kW PEP.

Lorch Microwave
Circle #176

Coaxial switch operates up to 40 GHz

DMT announces a DC-40 GHz coaxial switch to meet market demand for higher frequency testing. SPDT, multiposition and trans-

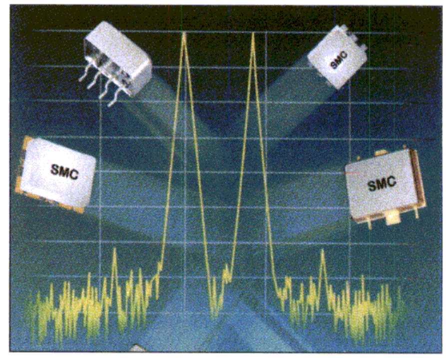


fer configurations are available. Over the DC-40 GHz range, maximum VSWR is 1.9:1, insertion loss is 0.8 dB and power handling is 10 watts. Isolation between ports is 50 dB, minimum.

DMT
Circle #177

Mixer line adds high IP3 triple balanced model

Synergy Microwave complements its extensive mixer line with the SMDHI series of triple balanced



mixers, with +17 dBm LO level and a guaranteed input IP_3 of +30 dBm. Models are available optimized for specific frequency bands for cellular and PCS, suitable for both CDMA and TDMA signals.

Synergy Microwave Corp.
Circle #178

Guidelines for submitting New Product press releases:

1. Press releases should include a concise, but complete technical description of the product.
2. Include price information.
3. Be sure to include contact information for: (a) editorial follow-up, (b) reader service response delivery, and (c) direct reader contact.
4. Photography should be either color print or color slide. Send 2-1/4 or 4×5 transparencies only if no other format is available.
5. Electronic images should be color TIFF, 300 dots-per-inch, in PC format (not MAC!). Please note — 72 dpi Web images are not acceptable for magazine publishing.
6. Please include a data sheet! New Products are handled by *real engineers* on our editorial staff, not journalism or English graduates.
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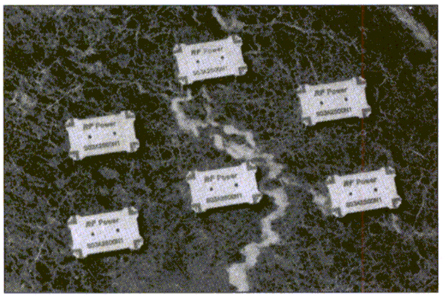
8. Send releases to the New Products Editor using the address at the bottom of the right hand column on page 8.

High power 90 degree hybrid coupler

The Coupler Components Division of RF Power Components has just released a high power 100

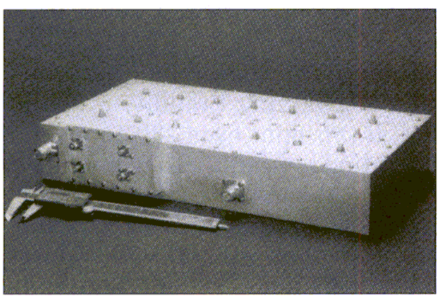


watt surface mount 90 degree coupler for the 2.0-3.0 GHz frequency range. Model S03A2500N1 provides low insertion loss (<0.3 dB) 1.2:1 VSWR and isolation of greater than 20 dB. Phase and amplitude balance is ±2 degrees and ±0.35 dB, respectively. Additional products in this line cover 400 to 3000 MHz at power ratings of 50 to 200 watts.

RF Power Components
Circle #179

"A" Band transmit filter

ClearComm Technologies' new CCTF-28 integrates a filer and directional coupler into an A Band



transmit filter assembly with high power handling (12.5 kW) and 120 dBm intermodulation performance.

ClearComm Technologies, Inc.
Circle #180

mm-wave chip mixers

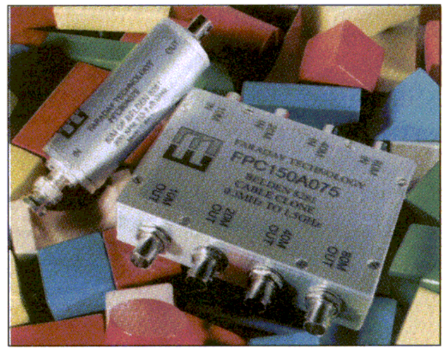
TRW offers new mixers for frequencies from 19 to 64 GHz. For example, the MBD171C is a doubly-balanced image-reject mixer for 35-45 GHz with 8 dB conversion loss and 20 dB image rejection

TRW Inc.
Circle #181

Cable simulator

Faraday Technology Ltd. offers a cable clone that can simulate cable lengths to 150 meters, to assure accurate loss vs. frequency characteristic for HDTV signals adhering to SMPTE 292 M. The simulator can substitute for actual cable when establishing system timing.

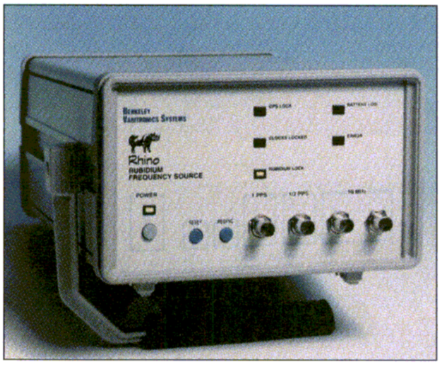
Faraday Technology Limited
Circle #182



FREQUENCY CONTROL

Rubidium frequency source

The new Rhino from Berkeley Varitronics is designed for either field or laboratory use. Outputs for

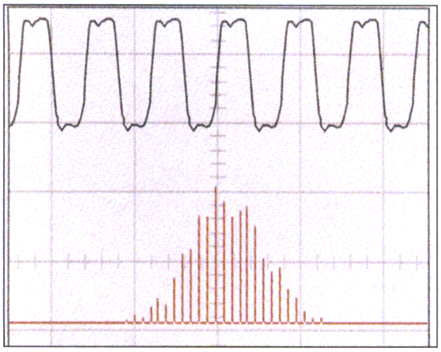


CDMA equipment include 19.6608 MHz, 1 pps, phase adjustable 1 pps and 1/2 pps synchronized to UTC. The Rhino includes eight buffered 10 MHz outputs with Rubidium standard stability, and the unit is equipped with a GPS receiver that allows locking of the unit's internal standard to UTC, even in portable operation.

Berkeley Varitronics
Circle #183

Oscillators reach high frequency without multipliers

The HK-2900 Series of quartz crystal oscillators from NEL Frequency Controls feature advanced crystal overtone technol-

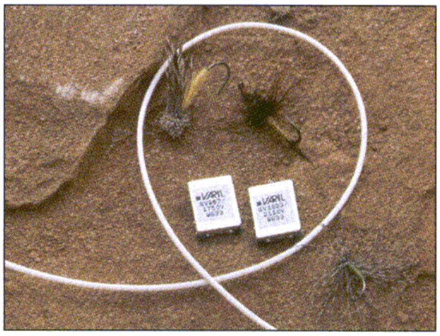


ogy to offer high frequencies without using phase locked loop techniques. Power supply noise and loop synchronization problems are thus avoided. Frequencies are available up to 600 MHz. The HK-2900 has cycle-to-cycle jitter of less than 30 ps, with frequency tolerance from ±0.01 percent, depending on customer requirements. The units are provided in a welded all-metal package.

NEL Frequency Controls
Circle #184

Dual band VCO

Vari-L model SV-967/1750V generates frequencies in band one from 954 to 980 MHz, and band two from 1720 to 1780 MHz. Both bands

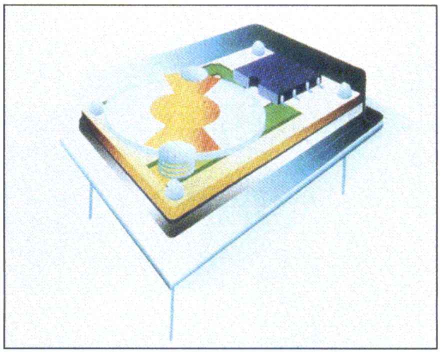


operate with a control voltage from 0.4 to 2.7 volts. The unit typically requires 6.0 mA from a 3 volt supply. Typical band one specifications include –116 dBc/Hz phase noise at 30 kHz offset and –3.0 dBm power output. For band two, the unit provides –106 dBc/Hz phase noise performance and –4.0 dBm power output. Second harmonic suppression is –10 dBc, with third harmonics at –20 dBc.

Vari-L Company, Inc.
Circle #185

VCXO targets telecom PLL applications

Ecliptek Corp. announces the EC3200 series of 3.3 volt VCXOs.

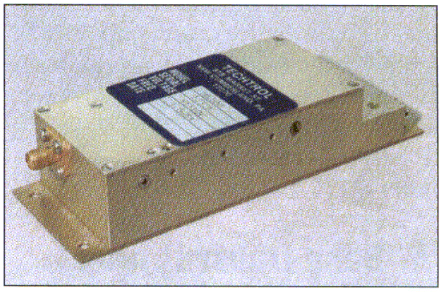


This series is suitable for phase locked loop applications in microwave, radio, video decoders, cable modems, set-top boxes, WLL handsets and other telecommunications systems. The EC3200 provides outputs ranging from 1.000 to 40.000 MHz, with stability options from a tight ±20 ppm to ±100 ppm. The VCXOs are housed in either a 14-pin of 8-pin DIP welded metal package.

Ecliptek Corporation
Circle #186

Very low phase noise microwave source

Techtrol Cyclonetics offers the M4100 Series crystal-controlled source providing fixed frequencies from 500 MHz to 2.5 GHz with low PM/AM noise and spurious. The M4100 is a solution for noise-criti-



cal transmitter and receiver designs. Phase noise is –103 dBc/Hz at 100 Hz, –127 dBc/Hz at 1 kHz and –135 dBc/Hz at 10 kHz. –135 dBc/Hz is the noise floor for a typical 1.6 GHz unit. Stability is specified at ±5 ppm over –20 to 60° C. Operation is from a +15 volt supply, drawing 115 mA and providing +13 dBm power output. Harmonics and sub-harmonics are –60 dBc; spurious rejection is –90 dBc. ±8 ppm electronic tuning for fine frequency control is an available option.

Techtrol Cyclonetics
Circle #187

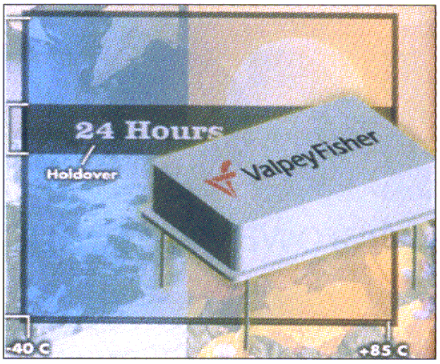
Super-low jitter VCXOs

MF Electronics announces the Series 3262 VCXOs, with super low jitter specifications (<20 ps p-p) for applications such as up-conversion to the GHz-range for ATM, SONET, gigabit ethernet and high-speed backplanes. The VCXO series offers frequency outputs up to 175 MHz, using regular crystals from 3

to 44.736 MHz, and inverted-mesa high frequency fundamental crystals from 44.736 MHz to 175 MHz. The Series 3262 VCXOs operate from a +5 volt supply and are compatible with HCMOS logic families. pulling range is from ±100 to ±200 ppm. full size and half size stainless steel DIL packages are offered, including a gull wing version for surface mounting.
MF Electronics Corp.
Circle #188

Digitally compensated crystal oscillator

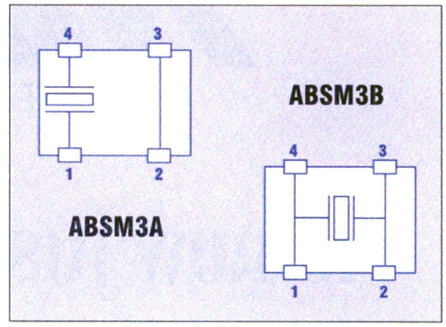
Valpey Fisher has developed the DigiXO, a digitally compensated crystal oscillator that achieves greater stability over ordinary TCXOs. Stability of the DigiXO is ±0.3 ppm and better over range of –40 to +85°, comparable to a low-end oven-controlled crystal oscillators, with much lower power consumption. Stability exceeds the ±4.6 ppm tolerance specified for



Stratum III timing for telephony, GPS and satellite modems. Phase noise is typically less than –145 dBc/Hz at 10 KHz and greater offsets. Packaging is a standard 0.8 × 0.5 × 0.35 inch 14-pin DIP. Pricing is $45 to $60 in 1000 quantities for standard products.
Valpey Fisher
Circle #189

4-pad SMT crystals

Abracon Corporation offers a new series of 4-pad microprocessor crystals (the ABSM3 series), with land pattern compatibility with popular plastic encapsulated crystals from other manufacturers. Two



crystal connection options are available, the ABSM3A and ABSM3B. Frequencies are available from 3.579 to 60.0 MHz, with fundamentals up to 40.3200 MHz.
Abracon Corporation
Circle #190

New Product information in this section is a free service for our 40,000 readers.

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Send us you comments via e-mail to:

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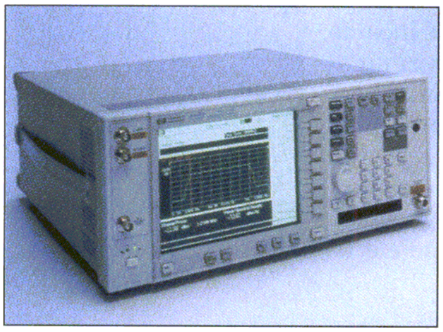
Thank you for your help!

TEST EQUIPMENT

Transmitter tester for GSM and cdmaOne

To help wireless equipment manufacturers speed production, Hewlett-Packard Company has introduced the HP E4406A VSA-series

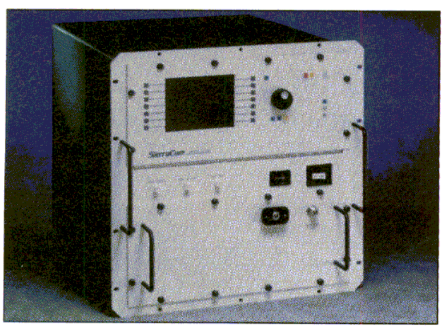


transmitter tester. The instrument offers format-specific, standards-compliant testing for GSM and cdmaOne now, W-CSMA, NADC, PDC and other formats under development. The basic HP E4406A is priced at $27,800. The GSM (Option BAH) and cdmaOne (Option BAC) measurement personalities are $3,400 each.

Hewlett-Packard Company
Circle #191

Solid state TACAN/IFF RF source replaces tube types

SierraCom offers Model 2760 for the calibration of TACAN and IFF test sets. The unit was developed



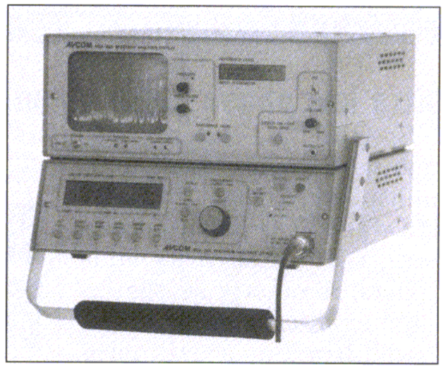
for the Air Force to replace older tube-based sources. Solid state design and a internal microcontroller permit complete control of pulse shape, frequency and amplitude for accuracy and long-term reliability.

SierraCom
Circle #192

Affordable microwave spectrum analyzer

AVCOM's latest microwave spectrum analyzer is priced at $3875, covering 50 kHz to >1 GHz with 1 kHz frequency accuracy. Seven IF bandwidths are offered, from 3 MHz to 3 kHz. Internal demodulators permit easy monitoring.

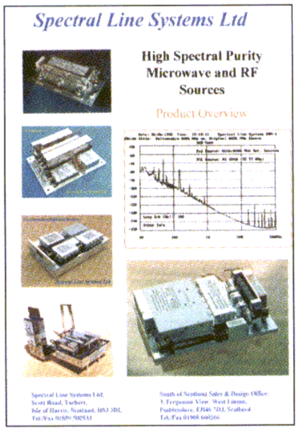
AVCOM of Virginia, Inc.
Circle #193



LITERATURE

Ultra low phase noise signal sources

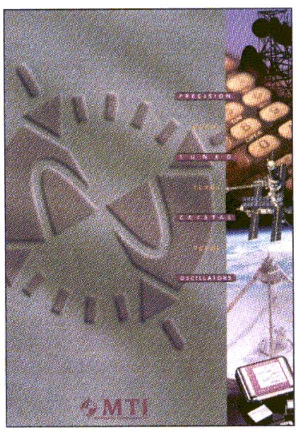
Spectral Line Systems Ltd. offers a line of specialized high performance oscillators, multiplied signal sources, VCOs and VCO-based subsystems, microwave cavity multipliers, frequency synthesizers and discriminator stabilized ultra-low phase noise microwave sources. Their brochure includes applications notes on phase noise measurement, microwave frequency agile techniques and a note on techniques for ultra-low noise synthesizers that have achieved –127 dBc/Hz phase noise at 1 kHz offset at 8.7 GHz.



Spectral Line Systems Ltd.
Circle #194

Precision tuned crystal oscillators

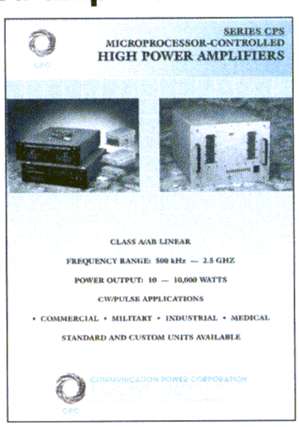
MTI-Milliren Technologies Inc. has released its latest product catalog, which includes is newly-expanded line of Precision Quartz Crystal Oscillators — TCXOs, VCXOs, OCXOs and its new ultra-stable OCXOs.. the new catalog features performance specifications, technical information and a selection guide. Basic products can be customized to meet specific requirements.



MTI-Milliren Technologies Inc.
Circle #195

Microprocessor-controlled amplifiers

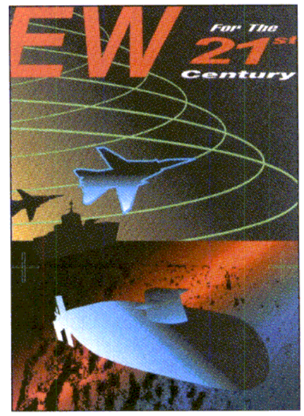
Communication Power Corporation offers a four-page brochure featuring their CPS series of microprocessor-controlled high power amplifiers. This series of linear amplifier systems cover the frequency range of 500 kHz to 2.5 GHz in discrete bands, at power levels of 10, 100, 500, 1000 and 10,000 watts power. The amplifiers feature complete control and monitoring systems.



Communication Power Corporation
Circle #196

EW systems capabilities

Wide Band Systems has published a capabilities brochure, *EW for the 21st Century*. The brochure highlights the company's signal acquisition and processing products for real time, tactical signal identification for land, sea and air defense forces. Their products include digital frequency discriminators (DFDs) and instantaneous frequency measurement (IFM) receivers used in radar warning receivers, electronic warfare and counter measures systems, and electronic intelligence systems.



Wide Band Systems
Circle #197

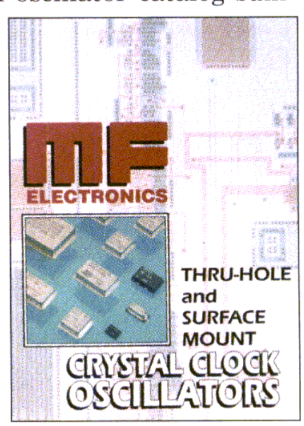
Wireless products catalog

K&L Microwave has a new Wireless Products catalog, with a company overview, power handling notes and detailed product information. The catalog presents the company's wireless system assemblies, receive multicouplers, duplexers and diplexers, receive filters, transmit combiners, transmit filters, fixed notch filters, tunable filters and ceramic filters. Complete descriptions, performance specifications and measurement plots are included for the entire product line.

K&L Microwave
Circle #198

Crystal oscillator catalog

MF Electronics' new crystal oscillator catalog summarizes specifications for their fixed frequency oscillators and VCXOs for both digital and communications applications. Featured products include low jitter oscillators for frequency multiplication and extended temperature range oscillators. The line covers 1 KHz to 400 MHz in CMOS, TTL, ECL and other logic families, including standard packages and low-height SMT models.



MF Electronics
Circle #199

Mismatch Tolerant

HIGH POWER WIDEBAND COMBINERS

1.5 - 30 MHz

Type	Power Level(s)	Insertion Loss
2-Way	3000 W	0.1 dB
2-Way	6000 W	0.25 dB
4-Way	1000 W	0.2 dB
4-Way	7000 W	0.3 dB

20 - 500 MHz

Type	Power Level(s)	Insertion Loss
2-Way	100 and 500 W	0.4 dB
2-Way	1500 W	0.5 dB
4-Way	100, 500 and 750 W	0.7 dB

20 - 100 MHz

Type	Power Level(s)	Insertion Loss
2-Way	200, 500, and 1500 W	0.3 dB
4-Way	400 W	0.4 dB
4-Way	3000 and 7000 W	0.3 dB

100 - 1000 MHz

Type	Power Level(s)	Insertion Loss
2-Way	300 W	0.5 dB
4-Way	100 W	0.6 dB
4-Way	250 and 400 W	0.8 dB

Note: All units are isolated and withstand at least one input failure at rated power.

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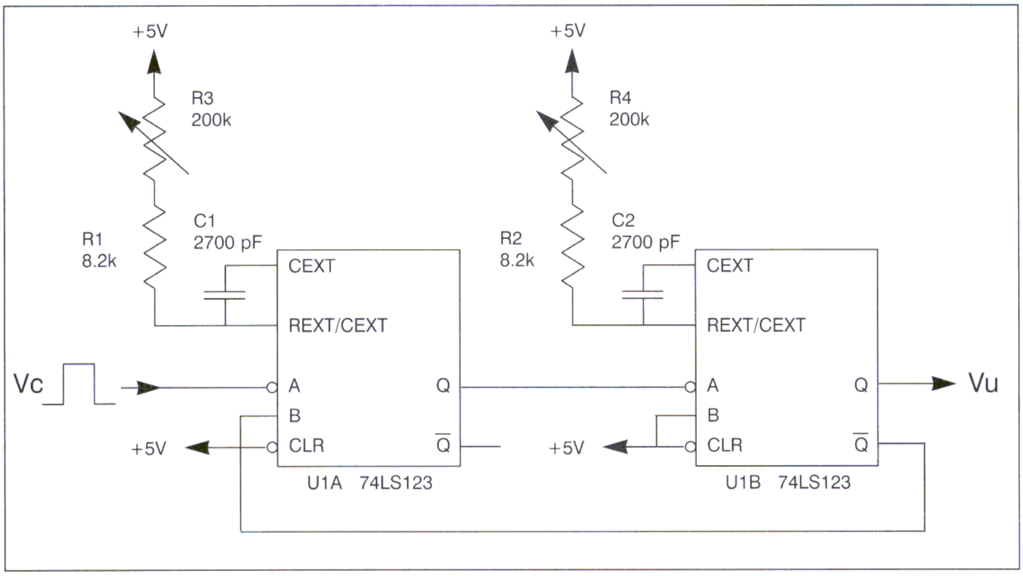
Circle 41

Gated Oscillator has Independently Variable t_{on} and t_{off}

By Alfredo Gallerani
Instituo di Radioastronomia

A clock source is a very important circuit, because it finds applications in almost any digital circuit, whether in communications, computation or system timing. Generally, clock oscillator design does not present any particular difficulty, and suitable circuits are mainly of two types: Crystal-based if frequency accuracy and stability is a necessary requirement, and some form of RC free-running multivibrator in most other cases.

The design can become quite another story if the oscillator has the following unusual requirements:



▲ **Figure 1. Circuit diagram of the gated oscillator.**

- Wide frequency range
- Variable duty cycle with t_{on} and t_{off} adjustable independently of one another
- The capability for synchronization with an external signal

The number of references available for the design of an astable multivibrator are is considerable, but rarely are the above requirements achievable in a single circuit.

One very simple solution is proposed here in Figure 1. As shown, the circuit is built with only one 74LS123, two capacitors and two resistors. This basic design assumes that a final design will combine the potentiometers' resistance values with resistors R_1 and R_2.

To analyze this circuit, let the A input of the first monostable U1A be momentarily connected to ground. U1B's positive-going output of $\overline{Q}$ triggers the B input of U1A, whose Q negative-going output triggers the A input of U1B, establishing a DC positive feedback that will always self-start the circuit.

t_{on} is determined by the time constant $(R_2+R_4) \times C_2$, and t_{off} by $(R_1+R_3) \times C_1$. For the 74LS123, the output pulse width is essentially determined by the value of the external components R_{ext} and C_{ext}:

$$t_w = k \cdot R_{ext} \cdot C_{ext}$$

where $k = 0.45$ for $C_{ext} > 1000$ pF [1].

Assuming $R_A = R_1 + R_3$ and $R_B = R_2 + R_4$, the period and the duty cycle are given by:

$$DuCy = \frac{t_{on}}{t_{on} + t_{off}} = \frac{K \cdot R_B \cdot C_2}{K \cdot R_A \cdot C_1 + K \cdot R_B \cdot C_2}$$

$$= \frac{R_B \cdot C_2}{R_A \cdot C_1 + R_B \cdot C_2}$$

If $C_1 = C_2$, then:

$$DuCy = \frac{R_B}{R_A + R_B}$$

and the circuit oscillates at the frequency:

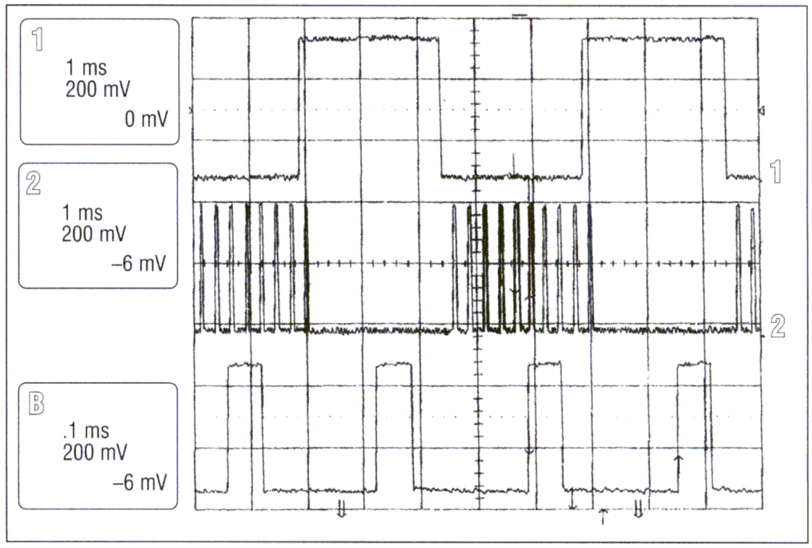
$$f = \frac{1}{t_{on} + t_{off}} = \frac{1}{K \cdot R_A \cdot C_1 + K \cdot R_B \cdot C_2}$$

In the 74LS123 operating range (5 kΩ ≤ 200 kΩ and no limits for C_{ext}) we have:

- For R_A = 5 kΩ and R_B = 200 kΩ, *DuCy* = 100%
- For R_A = 200 kΩ and R_B = 5 kΩ, *DuCy* = 0

That is, the duty cycle can change from the minimum to the maximum possible. What is more, since t_{on} and t_{off} are completely independent, it is also possible to vary frequency without affecting the duty cycle. The oscillator frequency is adjustable from approximately a few Hz to 15 MHz.

Another important property of the circuit is the fact that it can easily become a gated oscillator simply by applying to the A input of U1A a square wave vc whose frequency is less than that defined by *f*. In this case, the oscillator is gated by vc, with the oscillator output low when the gating signal is high, and free-running when the gating signal is low.



▲ **Figure 2. Waveforms of the gating signal (top), the oscillator output (center) and its expanded waveform (bottom).**

Figure 2 shows the 200 Hz gating signal, the oscillator output and its expanded waveform when R_A = 170 kΩ, R_B = 50 kΩ and C_{ext} = 2700 pF. In this case, using the above formulas we have $t_{on} \cong 60\ \mu s$, $t_{off} \cong 206\ \mu s$ and f ≅ 3741 Hz. These calculations are in good agreement with the oscilloscope waveform. ■

Reference

1. *The TTL Data Book for Design Engineers*, Texas Instruments.

Author information

Alfredo Gallerani is a research engineer in the Instituto di Radioastronomia of the National Research Council (C.N.R.), Italy. His activity involves the construction of high-speed acquisition systems for radio astronomy. He is presently responsible for development of a digital correlator for the Italian Northern Cross radio telescope. Mr. Gallerani may be reached by e-mail at: gallerani@astbol.bo.cnr.it

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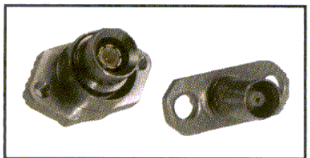
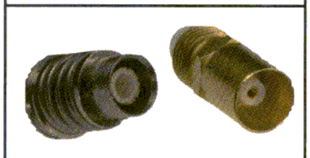


BMZ Subminiature Blindmate RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 18 Ghz	50 Ohms	Semi-Rigid Flexible	Blindmate/ Slide-on	Stainless Steel Beryllium Copper	Pass/Gold Gold

Also available: Panel mount receptacles, PC board receptacles, hermetic seal jacks, in and between series adapters.



BZ Miniature Blindmate RF Coaxial Connectors

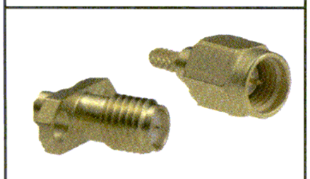
Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 12.4 Ghz	50 Ohms	Semi-Rigid Flexible	Blindmate/ Slide-on	Stainless Steel Beryllium Copper	Pass/Gold Gold

Also available: Panel mount receptacles, PC board receptacles, in and between series adapters.

BMA Miniature Blindmate RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 18 Ghz	50 Ohms	Semi-Rigid Flexible	Blindmate/ Slide-on	Stainless Steel Beryllium Copper	Pass/Gold Gold

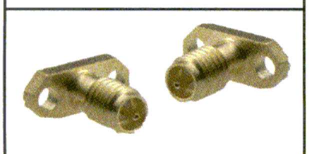
Also available: In series jack to plug adapters



SSMA Screw-on Subminiature RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 26 Ghz	50 Ohms	Semi-Rigid Flexible	Blindmate/ Slide-on	Stainless Steel Beryllium	Pass/Gold Gold

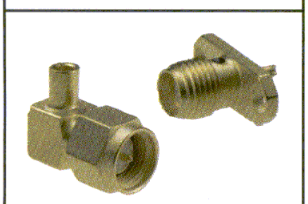
Also available: Panel mount jacks and plugs (hermetic), bulkhead mount jacks (hermetic), surface launch plugs and jacks, in and between series adapters.



HFSSMA Screw-on Subminiature RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 40 Ghz	50 Ohms	Semi-Rigid	Screw-on	Stainless Steel Beryllium	Pass/Gold Gold

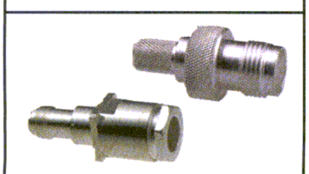
Also available: Panel mount plugs and jacks, in and between series adapters.



SMA Screw-on Miniature RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 18 Ghz	50 Ohms	Semi-Rigid Flexible	Screw-on	Stainless Steel Beryllium Copper	Pass/Gold Gold

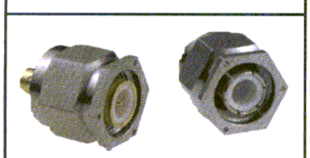
Also available: Panel mount jacks and plugs (hermetic and field replaceable), M.I.C. launcher jacks and plugs, bulkhead jacks (hermetic), surface launcher jacks and plugs, end launcher jacks, in and between series adapters, dust caps, flange mount cable receptacles, glass seals, 27 GHz versions.



TNC Small-size Screw-on RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 11 Ghz	50 Ohms	Flexible	Screw-on	Brass Beryllium Copper	Silver or Nickel Gold

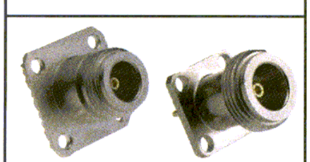
Also available: Panel mount jacks and plugs (hermetically sealed), bulkhead jacks and plugs (hermetically sealed), surface launcher jacks and plugs, end launcher jacks and plugs, in and between series adapters, dust caps.



PTNC Precision Small-size Screw-on RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 15 Ghz	50 Ohms	Flexible Semi-Rigid	Screw-on	Stainless Steel Beryllium Copper	Pass/Gold Gold

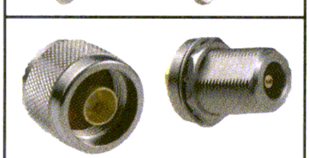
Also available: Panel mount jacks, bulkhead mount jacks, in and between series adapters, dust caps, hermetics.



TYPE N Large-size RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 11 Ghz	50 Ohms	Flexible	Screw-on	Brass Beryllium Copper	Silver or Nickel Gold

Also available: Panel mount jacks, surface end launch jacks and plugs, dust caps.



PN Precision Large-size RF Coaxial Connectors

Frequency	Impedance	Cable Type	Coupling	Body & Contact Material	Finish
DC to 12.4 Ghz	50 Ohms	Flexible Semi-Rigid	Screw-on	Stainless Steel Beryllium Copper	Pass/Gold Gold

Also available: In and between series adapters and 18 Ghz versions.

Also Available: Cable Assemblies, Attenuators, Terminations and special products.

Circle 27

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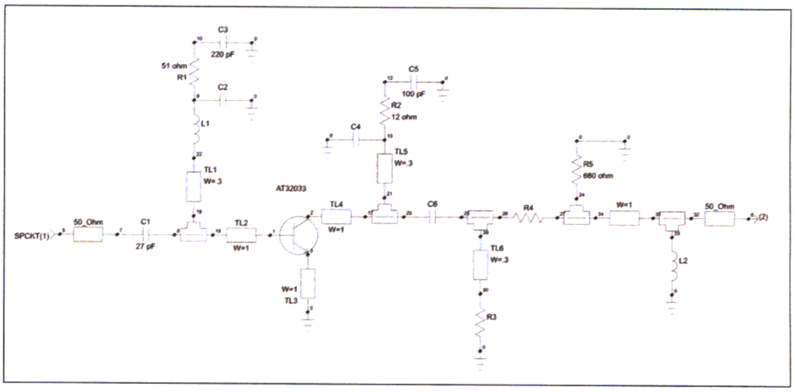
Exact Simulation of LNAs Reduces Design Cycle Time

A 900 MHz design example illustrates the methods necessary to predict actual circuit performance using computer simulation

By Sean Mercer
Motorola Canada

Simulated and measured data for 900MHz single-stage low noise amplifiers with <1.5:1 input VSWR are presented in this article. Excellent correlation is demonstrated between the simulation and measured data, and potential design and layout problems that may lead to poor circuit performance are discussed. A comparison of amplifier performance on FR4 and higher quality substrate is also given.



▲ **Accurate simulation can translate into faster design time.**

RF circuit design is still considered an iterative process in some circles. In fact many RF circuit designers accept circuit tuning or tweaking as part of the design process, often leading to multiple PCB iterations and increased design time. The ability to produce RF circuits with first time design success can provide a valuable competitive edge.

The specification of an LNA is strongly influenced by the intended application. Consideration must be given to performance, power consumption, linearity and cost. A compromise between these parameters is often necessary. Base station infrastructure applications usually have minimal power constraints so higher LNA power consumption can be tolerated to obtain better linearity. Battery powered equipment applications, however, usually demand low power operation.

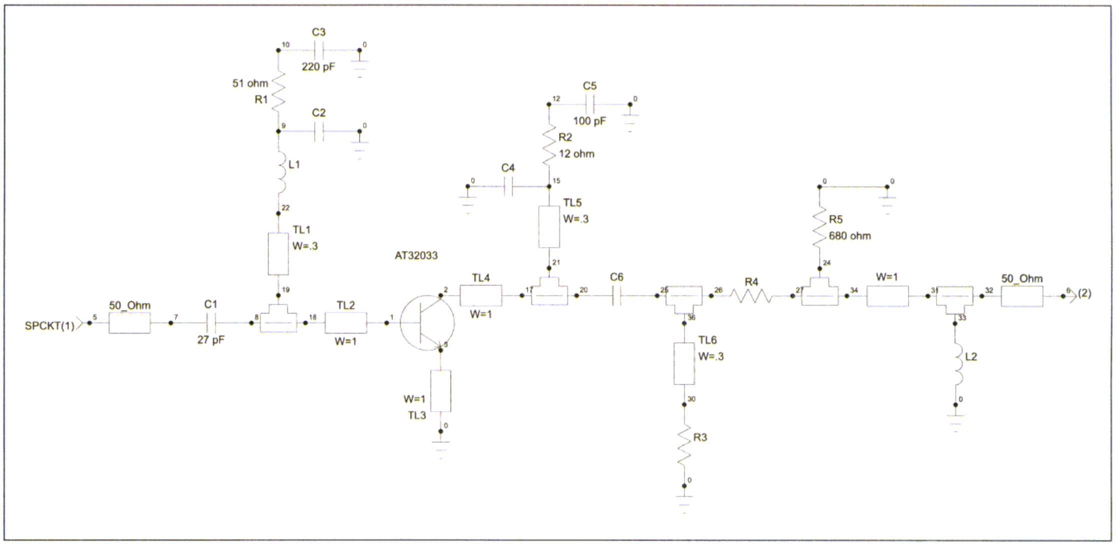
Component cost is another important consideration, usually forcing a compromise in other parameters such as noise figure and linearity. A low noise bipolar transistor is cheaper than a GaAs FET, but superior noise performance can be obtained from FET designs. Most portable wireless devices currently use silicon transistors. Component costs can be further reduced by using high impedance lines as inductive elements if real estate is available to accommodate the traces.

A transistor low noise amplifier design operating at 2.7 V, 2 mA will be presented in this article. Circuit performance on two different substrates will be compared. A high performance GaAs FET design biased for 2 V, 25 mA operation will also be presented for comparison.

Choose a device that can deliver the required noise performance. The noise figure listed on a device data-sheet is the optimum device noise figure for a 'typical' device when its input is terminated with the specified optimum noise match, Γ_{OPT}. This device noise figure does not include circuit losses, which can be high with low cost substrates such as FR4. You will obtain a poorer than specified noise figure from the device if your matching circuit presents a termination other than the optimum noise match

(Γ_{OPT}) to the device. The accurate measurement of noise figure has been detailed in the literature [1].

Bias your transistor or FET for the same operating condition as the S parameter data used in the simulation. The S parameter data is a representation of the device characteristics at a specific operating point. A different bias point for the same transistor can significantly alter the terminating impedances that should be presented to the device for optimum performance. Biasing a device at an operating point that is significantly different from that used for the S parameter data reduces the likelihood of good correlation between simulation and measured performance. If you design for unconditional stability using the S parameter data and then operate the device under different bias conditions your circuit may be unstable. Why risk this?



▲ **Figure 1. Simplified schematic of a 900 MHz transistor LNA.**

Most active devices that will be selected for use as low noise amplifiers in wireless applications will have gain, and the potential to oscillate, at frequencies much higher than the intended operating frequencies. The transistor used for two of the 900 MHz amplifiers discussed in this article has gain at 5 GHz. It is wise, and possible, to design for unconditional stability at all frequencies at which the device has gain. To this end, all microstrip discontinuities should be included in your circuit simulation. The effect of these step discontinuities will often be negligible at 900 MHz but can be significant at much higher frequencies.

Include the transistor mounting pads in your simulation. The mounting pad dimensions must be chosen to allow proper soldering of the device to the substrate. If your device has 0.5 mm wide leads, don't use a 0.3 mm line in your simulation to connect to the device. If you omit an appropriate mounting pad for the device, you will have poor correlation between your simulation and the measured circuit performance. Choose a pad topology that can be modeled with the available software tools. For these designs, Eagleware simulation and layout software was used. The circuit boards were fabricated using a T-tech Quick Circuit 5000 milling machine.

Include the mounting pads for passive components such as inductors, capacitors and resistors in your simulation. Include the step width discontinuities between the component pads and other traces in your simulation. A long microstrip line can be meandered to produce a more compact form factor. Include any bends in microstrip lines. If you follow the above design guidelines and simulate a design with unconditional stability, it is not likely that you will have any unpleasant surprises when you build your circuit.

Ideal passive components were used for the initial amplifier designs. Many passive component manufacturers provide S parameter data for their products. The ideal component models were then replaced with manufacturer's S parameter data. Microstrip component lengths were then adjusted to restore the desired performance if the component S parameter data caused a significant change to the circuit performance. Resistive loading may need to be increased if the real component data introduces a potential circuit instability ($k<1$). The manufacturer's S parameter data for the Murata GRM39 series chip capacitors, the Coilcraft 0603CS and 0805HT chip inductors and the ATC100A chip capacitors were used in the simulation of these amplifiers. All the resistors in these circuits were of the 0603 chip variety.

Be aware of the limitations of S parameter files. The S parameter data from some manufacturers is not very accurate and can lead to variations between simulated and measured performance. The manufacturer's data represents typical components. If you are using parts with a 5 percent tolerance you must expect to see some differences between simulated and measured results. Using statistical analysis, some components are only characterized over a limited frequency range. Most linear simulators will, however, extrapolate data beyond the frequency range included in the data files. If a component is characterized to 3 GHz, do not believe the results of your simulation at 5 GHz, where the accuracy of the extrapolated data is questionable. If your simulation frequency range extends beyond the available S parameter data for the passive components, you can check circuit stability by using ideal component models and include parasitic elements [2].

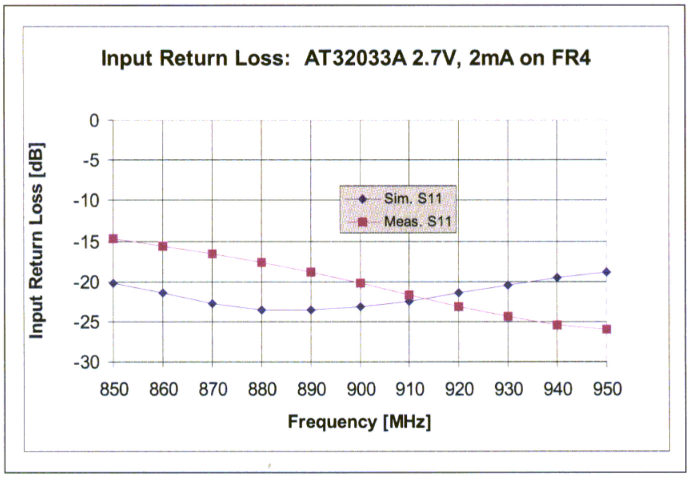
The Hewlett Packard AT32033 bipolar transistor was used for two amplifier designs, the first using 0.8 mm FR4 substrate and the other using the higher quality Taconic 60 mil RF-35 substrate. The manufacturers 2.7 V, 2 mA S parameters for this transistor were used. A simplified schematic diagram for these 900 MHz transistor low noise amplifiers is shown in Figure 1. Minor adjustments to component values and line lengths and widths were required to implement this circuit topology on the substrates with different thickness and dielectric constant. The actual base and collector bias circuits are not shown here. A Siemens BCR400 active bias chip was used to maintain the transistor's 2.7 V, 2 mA operating point. A single external resistor can be used with the BCR400 to set the transistor collector current.

For the sake of clarity the schematic in Figure 1 does not include the microstrip lines for component pads, the discontinuities due to microstrip bends or changes in line width or the effect of the via holes to ground. All of these effects were, however, included in the actual circuit simulations and are reflected in the simulated performance curves presented in this article.

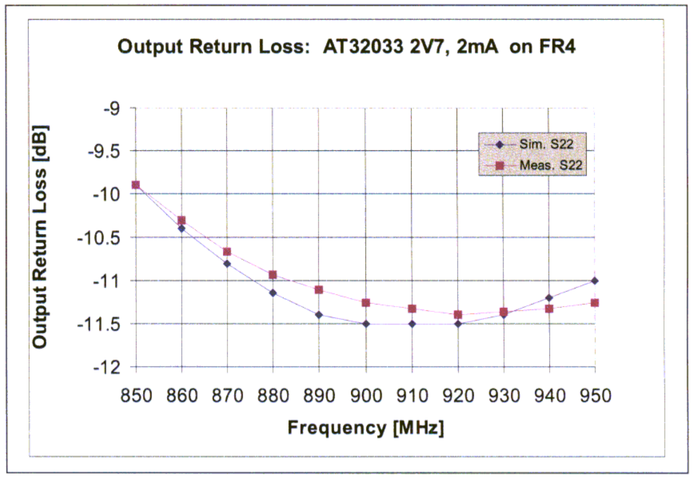
Capacitor C1 served as a DC blocking capacitor. The high impedance transmission line TL1 was connected in series with the lumped inductor L1 to provide input matching and a base bias injection point. Capacitor C2 provided low impedance at 900 MHz (close to short circuit in-band) while presenting a much higher impedance at very low (say <100 MHz) frequencies. Resistor R1 provides input loading to improve stability at very low frequencies. To avoid degrading the in-band circuit noise performance, the resistive loading at the device input is kept to a minimum. The value of C2 can, however, be selected to allow a small amount of resistive loading from R1 if this is required to improve device stability.

A small amount of inductance in the form of trace TL3 is included in series with the device emitter lead [3, 4]. This has the effect of moving the optimum noise match impedance (Γ_{OPT}) and the terminating impedance for optimum input match (S_{11}) closer together. When the device is matched for optimum noise performance, it is then also possible for the input match to be close to optimum.

The series transmission line TL4 was used as a matching element, along with series capacitor C6. Collector bias injection was via the high impedance transmission line



▲ **Figure 2a. Input return loss for the transistor LNA on FR4.**



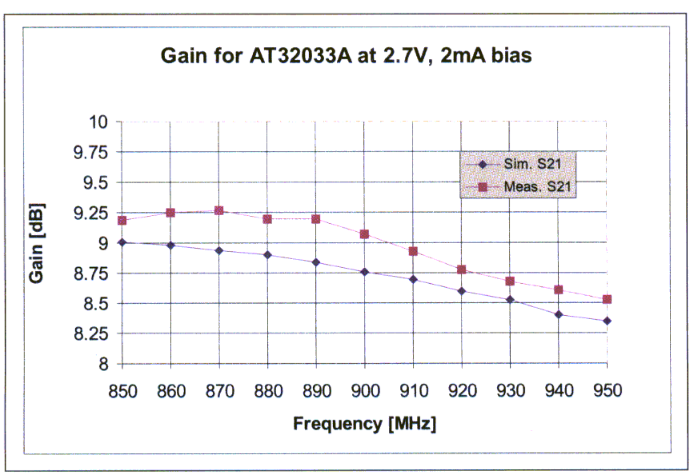
▲ **Figure 2b. Output return loss for the transistor LNA on FR4.**

TL5. There are four resistors used in the output matching circuit to ensure excellent device stability. Resistor R2 serves to enhances low frequency circuit stability. In higher current designs, the resistor must be constrained to a low value to prevent excessive power dissipation in this component. The shunt stub TL6 formed part of the output matching circuit. A small value series resistor R3 was included in this stub for enhanced amplifier stability.

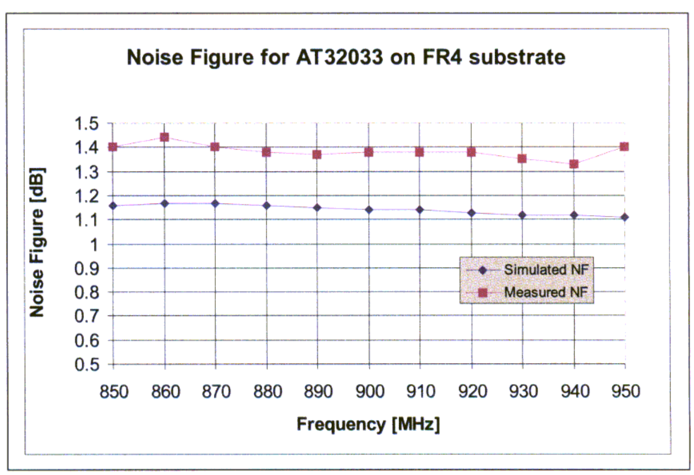
The value of the shunt resistor R5 is very high (680 ohms) and has minimal loading effect on the device while improving high frequency stability. The series resistor R4 has a low value (typically 2.2 to 6.8 ohms) to provide some circuit loading to enhance broadband amplifier stability. Although these resistors will have a very slight adverse effect on the amplifier noise figure and output compression point, this is a small price to pay for a highly stable circuit. The shunt inductor L2 formed part of the output matching network.

The amplifiers presented in this article were designed for operation over the 850 - 950 MHz frequency range. The design goal was an input VSWR of better than 1.5:1 with an output VSWR of at least 2.0:1. Unconditional stability at all frequencies at which device data was available was a requirement. The designs were optimized for minimum noise figure and maximum gain over the 850 - 950 MHz frequency range. No attempt was made to flatten the gain response of these single-stage amplifiers. Resistive feedback can be applied between the base and collector (gate and drain for a FET) of a transistor to flatten the gain response. There is usually a noise figure penalty associated with this. It is common to use this type of feedback in the latter stages of a multi-stage design to achieve a flat gain response without compromising the noise performance of the critical first stage.

The data for the LNA constructed on 0.8 mm FR4 substrate are presented in the following diagrams. The circuits presented in this article were constructed using the simulated component values, and no tuning, tweaking or component substitutions were made at all. Figure 2a shows the simulated and measured data for S_{11}. The input match was optimum at a slightly higher frequency than simulated, but the design requirement was met



▲ **Figure 3a. Gain for the transistor LNA on FR4.**

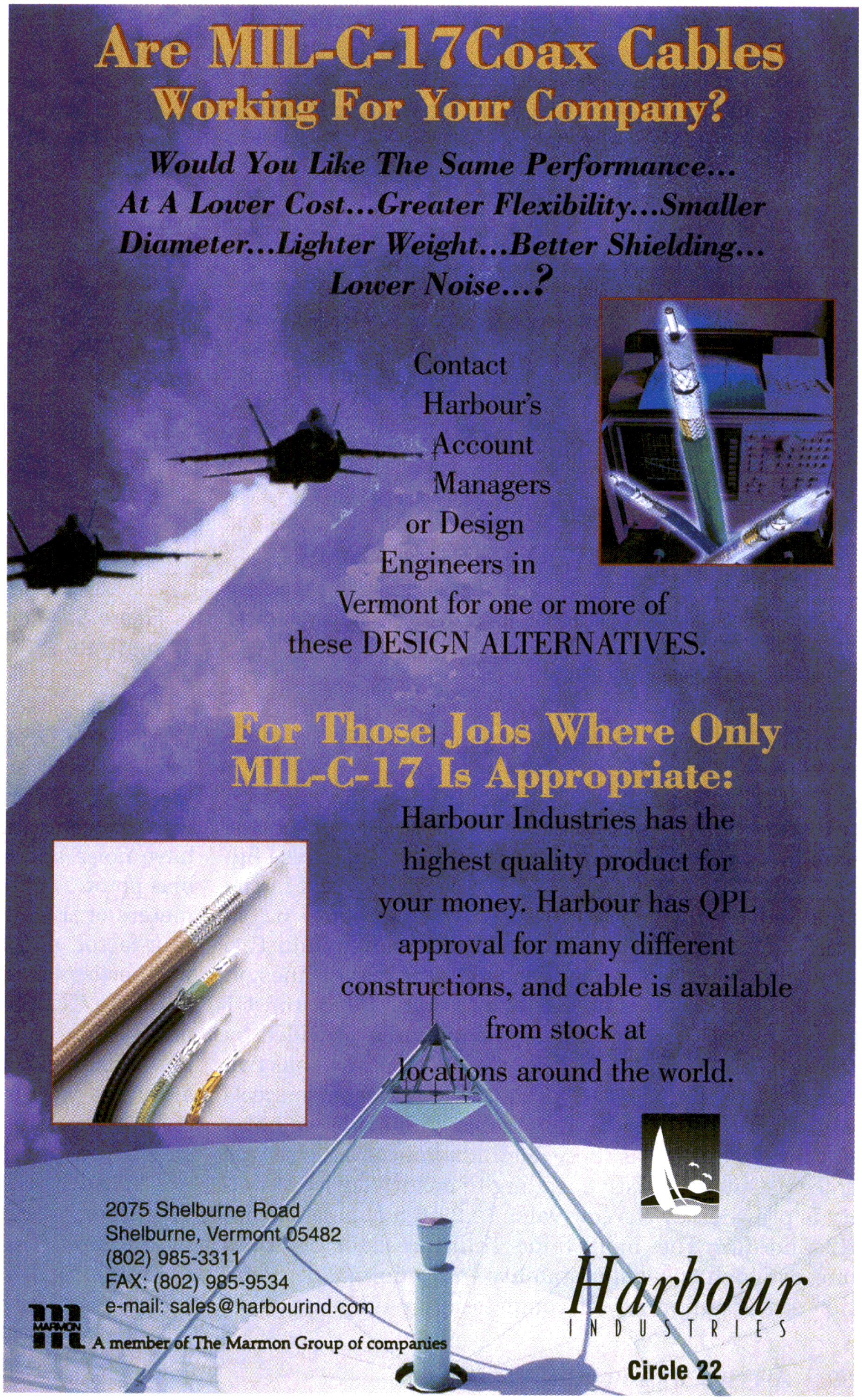


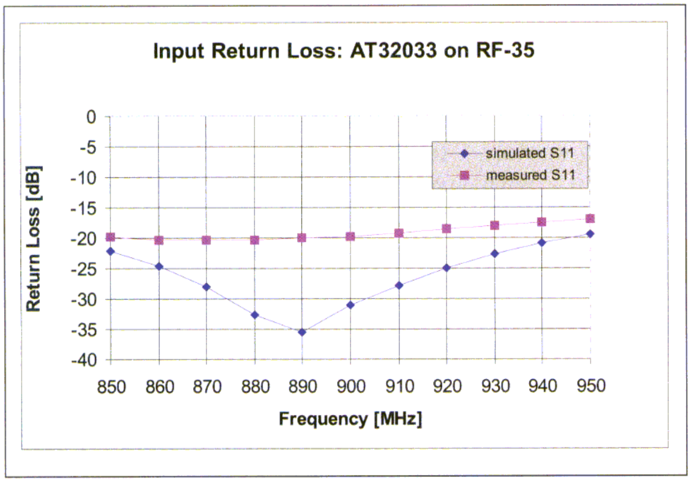
▲ **Figure 3b. Noise figure for the transistor LNA on FR4.**

without circuit adjustment. A Monte Carlo analysis indicated that the measured performance was within the limits dictated by component tolerances. The data in Figure 2b indicate that the 10 dB output return loss requirement was easily met. The actual circuit gain displayed in Figure 3a was within 0.4 dB of the simulated response. The measured amplifier noise figure shown in Figure 3b was approximately 0.4 dB worse than predicted in the simulation. This measured noise figure was not predicted by statistical analysis. The high measured noise figure value could have been due to excessive substrate loss attributed to the use of many distributed elements on the FR4 PCB.

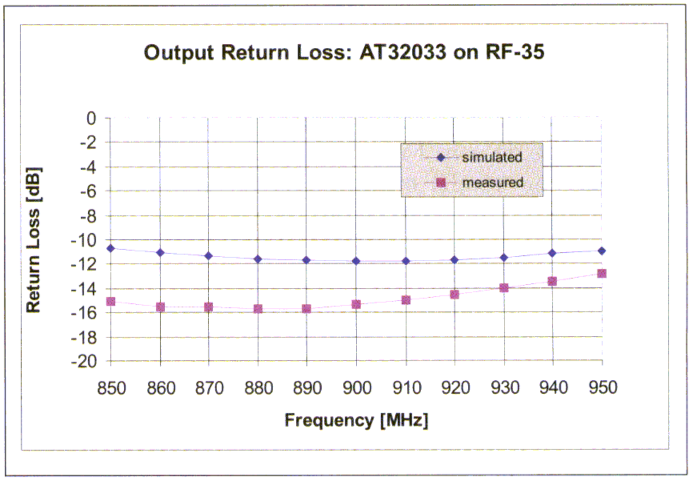
A similar amplifier circuit was fabricated on 60 mil RF-35 Taconic substrate for comparison. The circuit topology shown in Figure 1 was also used for this amplifier. The simulated and measured results for S_{11} and S_{22} are shown in Figures 4a and 4b. The design requirement for these parameters was easily met and the measured results were within the limits predicted by statistical means. The similar measured and simulated circuit gain responses are graphed in Figure 5a. The noise figure results in Figure 5b indicate that the actual circuit noise figure was within 0.2 dB of the simulated value. It can be seen from the data above that there was good correlation between simulated and measured performance for all of the above parameters. From the above data it seems that the simulated noise figure value was slightly optimistic, and the simulation was not entirely successful at predicting the noise performance on the FR4 material. The electrical parameters of FR4 are poorly controlled during manufacture. A nominal value of $\varepsilon_r = 4.7$ and loss tangent = 0.025 were used in the simulation. Substantially changing these parameters in the simulation could not, however, predict the actual measured circuit noise performance. FR4 PCB material can also exhibit anisotropy with respect to dielectric constant and this may have adversely influenced the meandered microstrip components.

The transistor was conjugately matched in the above circuits, with no attempt to provide the optimum power termination to the device output. For the FR4 design, the P_{1dB} point was measured to be –3.4 dBm with an output IP_3 of +10.3 dBm. The circuit built on RF-35 substrate had a P_{1dB} of –2.7 dBm and an IP_3 of +16 dBm. The latter IP_3 result was tested numerous times and appears to be correct. This unusually high value for IP_3 has been previously reported with this device [5] and seems to be matching circuit dependent. The design described in [5] achieved similar noise performance to the FR4 design presented here,

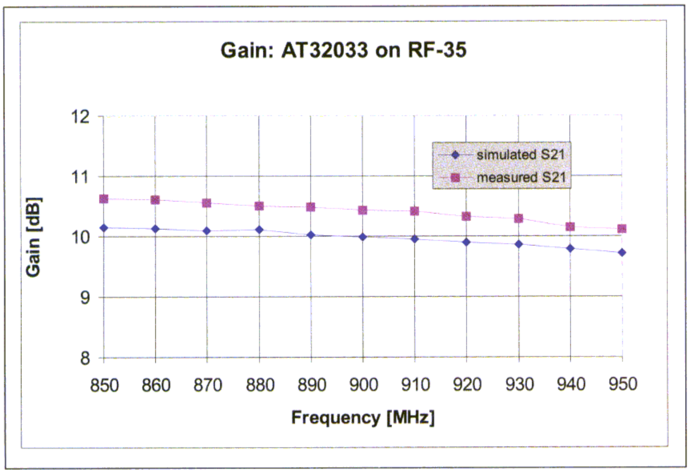




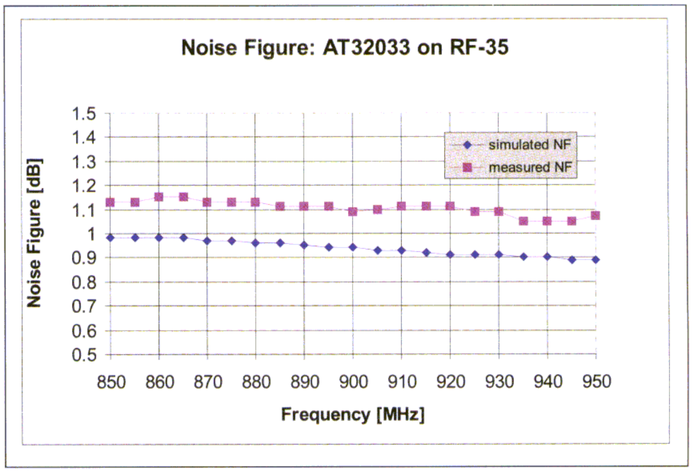
▲ **Figure 4a. Input return loss for the transistor LNA on RF-35 substrate.**



▲ **Figure 4b. Output return loss for the transistor LNA on RF-35 substrate.**



▲ **Figure 5a. Gain for the transistor LNA on RF-35 substrate.**



▲ **Figure 5b. Noise figure for the transistor LNA on RF-35 substrate.**

but with an input return loss of approximately 7.5 dB at 900 MHz.

The AT32033 has a good noise figure for a silicon transistor but a GaAs FET or HEMT is required for amplifiers with substantially better than 1 dB noise figure. The Celeritek CFB0301 GaAs FET was used in the amplifier circuit configuration shown in Figure 6. No chip inductors were used in the design and all inductive elements were implemented as high impedance lines on the 0.060 inch Taconic RF-35 material. Capacitor C1 served as a DC block with input matching provided by traces TL1 and TL2. Note that the FET package has two source leads and traces TL3 and TL4 are each connected to one of those leads. Remember to include via holes in your simulation as these add inductance to the source traces. Output resistive loading to ensure device stability is provided by the low value (2.2 - 6.8 ohm) resistors R2 and R5. The high value shunt resistor R4 does improve high frequency stability with minimal degradation of the output power compression point. Capacitors C2, C3 and traces TL5, TL6, TL7 and TL8 formed the remainder of the output matching network.

The manufacturer's 2 V, 25 mA S parameter data were used for this design. Ideally, any design should have noise and S parameter data available at the same bias point. This allows the designer to simulate all parameters of the design, including noise-figure and stability k-factor, and have confidence that the actual circuit will perform as simulated. Regrettably, the manufacturer of the CFB0301 has provided noise data and S parameter data at different bias conditions. The available manufacturers data, the 2 V, 25 mA S parameter data and the 4 V, 30 mA noise data, were used for this design.

The simulated circuit was designed for unconditional stability using the S parameter data and the amplifier was biased for 2 V, 25 mA operation to ensure stable operation. A dual supply was used for this amplifier, with a gate bias voltage of approximately –0.79 V resulting in 25 mA drain current. It was understood that there could be a discrepancy between the simulated and measured noise figure due to the different bias conditions for the noise data and the actual circuit.

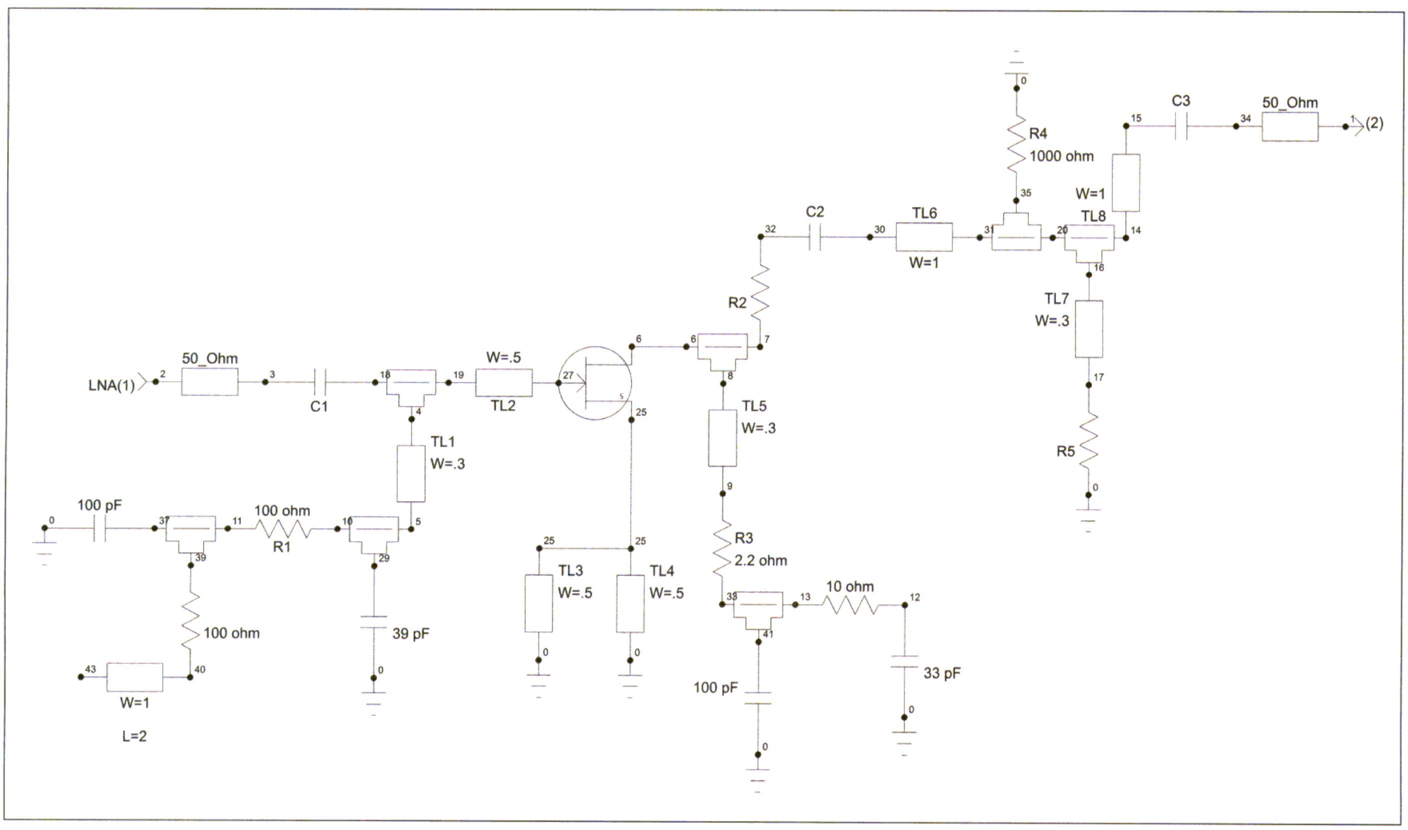
The simulated and measured input and output return loss data for this GaAs amplifier design are presented in Figures 7a and 7b. The input return loss was better than -15 dB and output return loss better than –10 dB over the 850 - 950 MHz frequency range. The output return loss response is within the limits predicted by a Monte Carlo analysis of the circuit. The amplifier gain responses recorded in Figure 8a demonstrate very good correlation between simulated and measured performance.

A plot of the amplifier noise figure is given in Figure 8b. The amplifier noise figure was measured as less than 0.46 dB over the 850 - 950MHz frequency range. This is an excellent result given that the CFB0301 device has an optimum noise figure of 0.4 dB at these frequencies. The simulated noise figure prediction varied from 0.61 dB to 0.64 dB over this frequency range. This was clearly pessimistic and is not surprising given that the noise figure prediction was based on data taken at a completely different bias condition (4 V, 30 mA). We were fortunate that the actual circuit noise figure was better than predicted. It is highly desirable to have device noise and S parameter data at the same bias point to obtain good correlation between predicted and measured performance. For interest, the circuit noise figure was recorded over a wider span and found to be <0.6 dB over the 700 - 1200MHz frequency range. All noise figure measurements presented here were measured in a screened room using an HP346A noise source and an HP8970A noise figure meter. The amplifier's output power compression point (P_{1dB}) was determined to be +13.2 dBm. The third order intercept point was found to be +25.1 dBm using a two-tone test at 900 MHz.

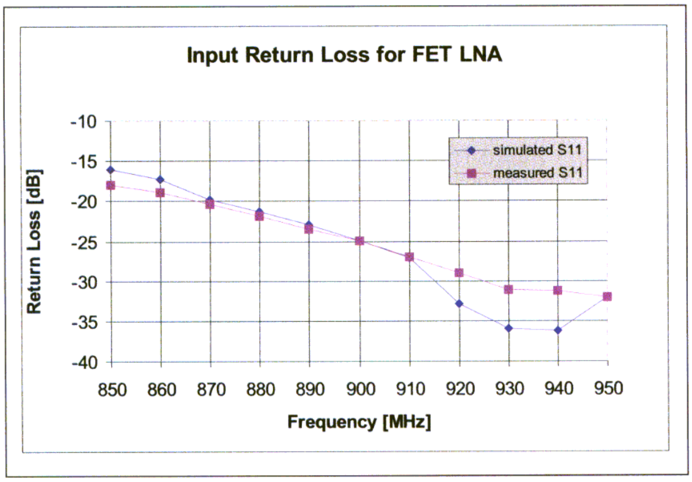
The simulated and measured performance for three different amplifiers has been compared in this presentation. By following a few simple guidelines it is possible to produce high performance LNAs without multiple design iterations:

- Choose a device that is appropriate for the intended application. Silicon transistors can be low cost but a FET can offer superior noise performance.
- The use of emitter or source feedback in the amplifier circuit allows the designer to simultaneously obtain good noise performance and a good input match.
- Avoid unintentional coupling between microstrip elements in the circuit layout.
- Resistive loading for device stabilization should be applied largely to the device output to avoiding degrading the circuit noise performance.
- Include all microstrip discontinuities, including component pads, in your circuit simulation. This will allow accurate evaluation of the amplifier's high frequency stability.

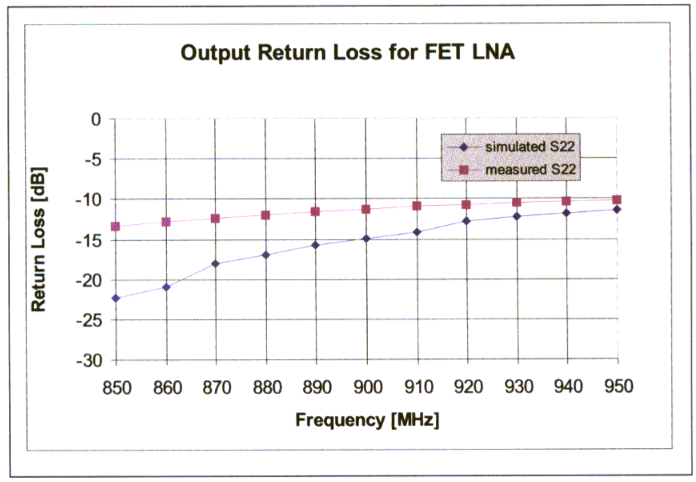
The circuit modeling techniques presented in this



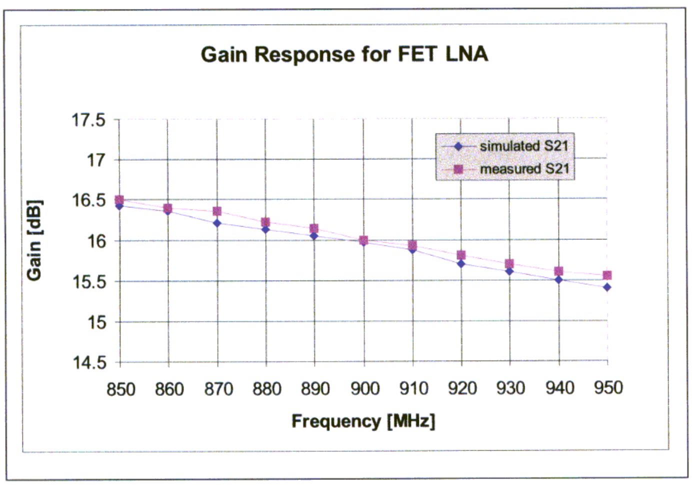
▲ **Figure 6. Simplified schematic diagram for the FET LNA.**



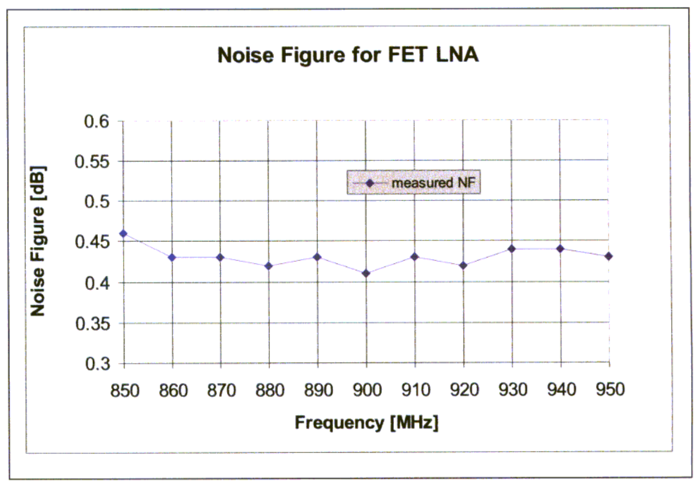
▲ **Figure 7a. Input return loss for the FET LNA.**



▲ **Figure 7b. Output return loss for the FET LNA.**



▲ **Figure 8a. Gain response for the FET LNA.**



▲ **Figure 8b. Noise figure for the FET LNA.**

article are all valid at much higher frequencies. Be aware that the effects of discontinuities and bends are greater at high frequencies where signal wavelengths are shorter. Synthesis software is available that will allow first time design success at X band and beyond [6]. Following the guidelines presented above will greatly assist in obtaining good correlation between design simulation and practical results. ■

Acknowledgement

The author thanks Mack Tan for expertly milling the circuit boards used for the amplifiers discussed in this article.

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5. "900 and 2400 MHz Amplifiers using the AT-3 series Low Noise Silicon Bipolar Transistors," Hewlett Packard Application Note 1085.
6. Information can be found at www.ampsa.com

Author Information

Sean Mercer is a Senior Staff Engineer with Motorola in Richmond, BC, Canada. He is currently involved in the design of Paging Infrastructure Products. He received a M.Sc. (Eng.) in 1987 and a Ph.D. in 1990 from the University of Cape Town, South Africa. Prior to joining Motorola, Mercer worked on a wide variety of microwave and RF projects, including HF transceiver design and numerous microwave amplifier and oscillator designs up to X band. He can be contacted via email at mercer@ipsg.mot.com or by telephone at (604) 241-6372.

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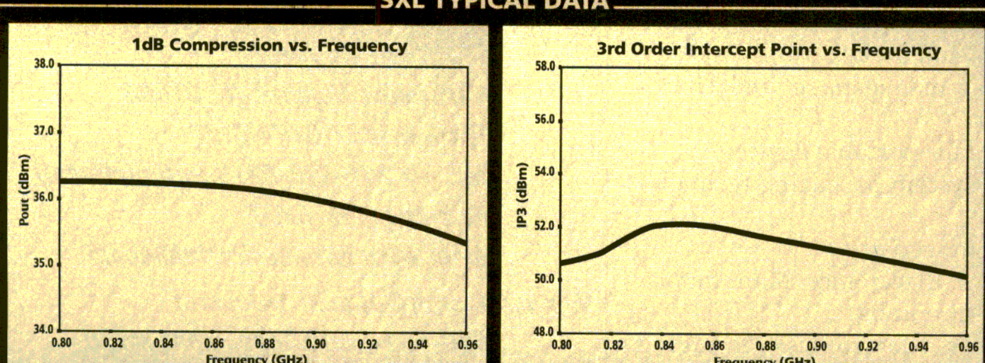

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Preview of the 1999 Wireless Symposium

Wireless products and technologies are on display at this annual conference and exhibition

The Seventh Annual Wireless Symposium and Portable by Design Conference & Exhibition will take place February 22-26 at the San Jose Convention Center in San Jose, CA. After several years of holding the event in the nearby Santa Clara Convention Center, the new venue allows for expansion of the exhibition, with up to 40 percent more room. The exhibition floor will be open on February 23-25.

The conference portion of the event will be held during the entire week of February 22-26. Conference sessions include the following wireless and portable engineering topics:

- Cellular, cordless and PCS design
- Digital communications systems
- Modulation techniques
- Wireless data transmission
- Wireless Local Area Networks (WLANs)
- Point-to-point and base station design
- High power design
- Wireless IC solutions
- Automotive and satellite systems
- Test & measurement solutions
- Embedded Internet systems
- MMITS/advanced wireless systems
- Portable system software issues
- Systems, busses and architectural issues
- Batteries, power management and charging circuits
- CPUs and DSPs for portable devices
- Mobile and RF system packaging technologies
- Infrared data connectivity
- Industry Week's Electronics Manufacturing Executive Roundtable
- IMAPS Wireless Electronics Packaging Conference

Conference organizers characterize this year's program as representing the future of wireless technology, with its "high-level technical papers with a heavy concentration on personal communications services (PCS) and wireless data systems." In addition, the program offers strong technical sessions on RF identification, satellite communications, cellular/cordless system design, integrated circuits (ICs) and spread spectrum techniques.

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Mini-tutorials and paper presentations will be held February 24-26. The following is the schedule of sessions for these presentations:

Wednesday, February 24, 1999
9:00 a.m. - 10:00 a.m.
W-CDMA and cdma2000 Basics
FCC Approvals
Infrastructure Buildout for CDMA Repeaters
CPUs and DSPs for Portable Systems I
Battery Chemistries I
Software Defined Radio
Integrated Packaging for Wireless I

11:00 a.m. - 12:00 p.m.
Next Generation Handsets
Wireless Data I
Point-to-Point and Base Station Design I
CPUs and DSPs for Portable Systems II
Battery Chemistries II
Extending Adaptive Communications
Integrated Packaging for Wireless II

1:30 p.m. - 3:00 p.m.
Cellular, Cordless and PCS Design I
Wireless Data II
Point-to-Point and Base Station Design II
CPUs and DSPs for Portable Systems III
Charging and Related Electronics I
Software Defined Radio: Hardware Perspective
Integrated Packaging for Wireless: Case Studies I

3:30 p.m. - 4:30 p.m.
Cellular, Cordless and PCS Design II
Wireless Data III
Low Cost Integrated Power Termination
CPUs and DSPs for Portable Systems IV
Charging and Related Electronics II
Software Defined Radio: Software Perspective
Integrated Packaging for Wireless: Case Studies II

Thursday, February 25, 1999
9:00 a.m. - 10:00 a.m.
120 Mbit Burst Mode QPSK Receiver
Filter Tuning in the Time Domain
High Power Design I
Battery Related Electronics
Software Defined Base Stations
Integrated Packaging for Wireless: Make it Happen I

11:00 a.m. - 12:00 p.m.
Introduction to Spread Spectrum Systems
Test & Measurement Solutions I
High Power Design II

Workshops — February 22-23, 1999

February 22

10:30 a.m. - 5:00 p.m.
RF and Wireless Made Simple
Al Scott, Besser Associates

10:30 a.m. - 5:00 p.m.
DSP Made Simple
Rick Lyons, Besser Associates

10:30 a.m. - 5:00 p.m.
RF Circuit Fundamentals,
Les Besser, Besser Associates

10:30 a.m. - 5:00 p.m.
Measuring the Wireless Transmission Spectrum
Morris Engelson, Joint Management Strategy

10:30 a.m. - 5:00 p.m.
Phase Locked Loops (PLLs) and Frequency Synthesis for Wireless Design Engineers
Eric Drucker, PLL Consultants

10:30 a.m. - 5:00 p.m.
Antennas and Propagation for Wireless Communication
Dr. Steven R. Best, Cushcraft Corp.

10:30 a.m. - 5:00 p.m.
Printed Circuit Board Suppression Techniques for EMC Compliance
Mark Montrose, Montrose Compliance Services

10:30 a.m. - 5:00 p.m.
Practical Filter Design
Randy Rhea, Eagleware Corp.

February 23

9:00 a.m. - 3:00 p.m.
RF and Wireless Made Simple, Part II
Al Scott, Besser Associates

9:00 a.m. - 3:00 p.m.
DSP Made Simple, Part II
Rick Lyons, Besser Associates

Smart Battery Systems
Software Defined Radio: The Market View
Integrated Packaging for Wireless: Make it Happen II

1:30 p.m. - 3:00 p.m.
Modulation Techniques I
Test & Measurement Solutions II
Automotive and Satellite Systems I
Portable System Software Issues I
IR for Universal Wireless Connectivity I
Making Sure the CPU tools Work for You
Introduction to EMC and the Printed Circuit Board
Nonlinear Characterization of High Power Transistors

3:30 p.m. - 4:30 p.m.
Modulation Techniques II
Test & Measurement Solutions III
Automotive and Satellite Systems II
Portable System Software Issues II
IR for Universal Wireless Connectivity II
LPGAs for Low-Power Wireless Applications
Fundamentals of Signal Integrity and EMI

Friday, February 26, 1999
9:00 a.m. - 10:00 a.m.
Digital Communications Systems
Worldwide Compliance for WLAN Devices
Automotive and Satellite Systems III
Systems, Busses and Architectural Issues I
Portable System Software Issues III

11:00 a.m. - 12:00 p.m.
Synchronization for Wireless Digital Radios
Wireless LANs for Small Business and Home
Wireless IC Solutions, Design
Systems, Busses and Architectural Issues II
Portable System Software Issues IV

1:30 p.m. - 3:00 p.m.
Digital Communication Systems I
Issues in Wideband and High Data Rate WLANs
Wireless IC Solutions I
Systems, Busses and Architectural Issues III
IrDA System Design and Test Guidelines

3:30 p.m. - 5:00 p.m.
Digital Communication Systems II
IEEE 802.11 Developments
Wireless IC Solutions II
USB Power Management Tricks, Traps and Tradeoffs
IrDa Protocol and Inter-Op Test Detail

The three-day conference registration fee is $554 in advance, $615 on-site. Contact information is given below in the "Workshops" box.

Workshops — February 22-23, 1999

9:00 a.m. - 3:00 p.m.
RF Circuit Fundamentals, Part II
Les Besser, Besser Associates

9:00 a.m. - 3:00 p.m.
Digital Modulation Workshop
Harold Walker, Pegasus Laboratory

9:00 a.m. - 3:00 p.m.
Managing the New Microwave Market
David L. Sprague, Chaparral Labs

9:00 a.m. - 3:00 p.m.
Fundamentals of CDMA
Darryl Schick, Linear Lightwave

9:00 a.m. - 12:00 p.m.
Packaging Considerations for Microdisplays in Wireless Consumer Products
Ramon M. Oliver IV, MicroDisplay

9:00 a.m. - 3:00 p.m.
Oscillator Design Principles
Randy Rhea, Eagleware Corp.

1:30 p.m. - 3:00 p.m.
Optical Design in Portable Microdisplay Products
Ramon M. Oliver IV, MicroDisplay

■ Workshop registration

Registration fees:	By Feb. 1	On-site
VIP All-Access Pass	$909	$1010
Two-day workshop	$631	$701
One-day workshop	$394	$438
Three-day conference	$554	$615

Workshop and General registration contacts:

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611 Route 46 West
Hasbrouck Heights, NJ 07604
Fax: 201-393-6297
Tel: 201-393-6213 or 888-WireReg
Web: www.WirelessPortable.com

Portable Instrument Measures Antenna System Performance

The new SITE ANALYZER™ from Bird Electronic Corporation provides antenna site measurements for cellular, data, paging, PCS, SMR/ESMR and other communication systems in the 806-2000 MHz range. The unit measures VSWR, return loss and fault location with extensive display and reporting capabilities.

The SITE ANALYZER facilitates regular measurements and performance records to evaluate system aging or to detect damaged antennas or cables. For example, a portable printer can be used to create a report that can be posted at the site, while stored data can be reviewed and archived at the main engineering office.

The unit is approximately 10-3/8 × 8-1/2 × 3-3/16 inches and weighs 4-1/2 lbs., and includes an integral color LCD display. Complete onboard measurement and storage features are complemented by a printer port, an RS-232 interface and Windows® 95/98 compatible analysis software. A lithium ion rechargeable battery pack provides 3+ hours of operation per charge, and has an easily accessible compartment for quick field replacement.

VSWR and return loss measurements are made with 42 dB directivity and 0.01 VSWR resolution. The fault location circuitry has 60 dB dynamic range and 238 data points. Immunity to on-channel interfering signals is +13 dBm for reliable measurements at active sites.

Intuitive pop-up menus contain pre-programmed frequency bands and cable types, as well as provide access to stored measurement data. Both visual and mathematical comparisons of the current measurements to stored data can be made without an external computer for instant identification of problems. Measurements include automatic date and time stamping, and flexible data labeling allows custom reports to be created.

▲ **The Bird SITE ANALYZER provides convenient and accurate portable antenna measurement, with data recording and reporting capability, printer port and an RS-232 PC interface.**

The SITE ANALYZER includes a carrying case, instruction manual, serial cable, PC Tool software, AC power supply and automotive power adapter. ■

For more information, contact:

Bird Electronic Corporation
30303 Aurora Road
Cleveland, OH 44129
Tel: 440-248-1200 ext. 2207
Fax: 440-248-5426
E-mail: sales@bird-electronic.com
Web: www.bird-electronic.com

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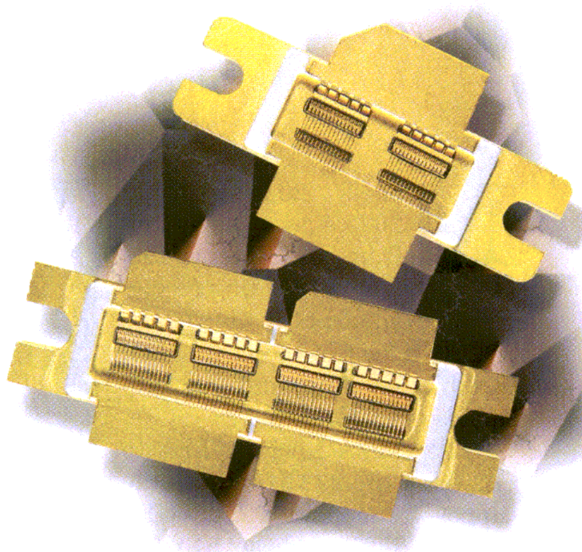

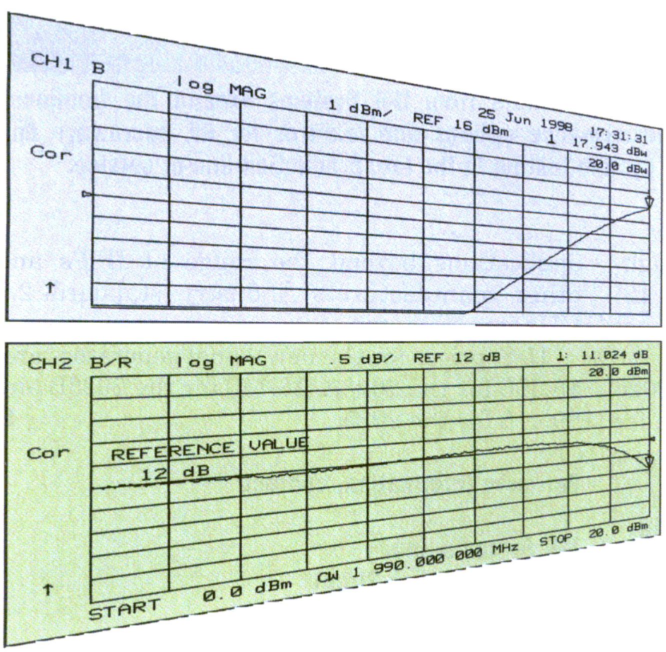

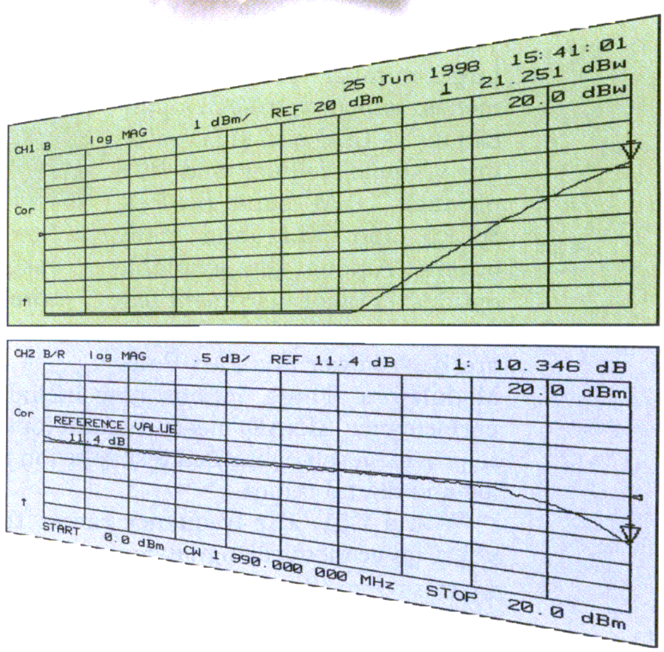

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Circle 26

New Signal Generators Feature Low Noise, Expanded Frequency Ranges

Models 2023A/B and 2025 signal generators from IFR Systems, Inc. are aimed at demanding receiver and component testing in the engineering development lab, production line and maintenance operations.

The 2023A covers 9 kHz to 1.2 GHz, the 2023B extends the upper frequency to 2.05 GHz and the 2025 reaches 2.51 GHz. The signal generators provide a large number of modulation modes, supporting such applications as LEO and MEO satellite systems, cellular and PCS products, ISM band devices, WLAN and WLL, and many others. Among the available options to tailor insrument features to a particular application are High Power and Fast Pulse Modulators. These options now include high-performance SINAD measurement (option 12) to provide a self-contained test solution for analog and digital radios.

▲ **New signal generators from IFR Systems expand the frequency range, performance options and features for RF, microwave and wireless system testing in the lab, production line or service.**

With a 2.51 GHz frequency range, the 2025 offers an economical signal generator choice for applications beyond the range of IFR's and other manufacturers' industry standard 2.0 GHz instruments.

U. S. prices for the new signal generators are: $6,366 for the 2023A, $8,143 for the 2023B and $9,415 for the 2025.

Model	Frequency	Applications
2023A	9 kHz-1.2 GHz	Cellular, SMR/ESMR VHF/UHF, General Lab
2023B	9 kHz-2.05 GHz	PCS, GPS, PHS, DECT DRB, Other L-Band
2025	9 kHz-2.51 GHz	WLAN, WLL, ISM MMDS, LEO, MEO

▲ **Summary of new IFR signal generator ranges.**

For more information, contact:

IFR Systems, Inc.
10200 West York Street
Wichita, KS 67212
Tel: 800-835-2352 (U.S.)
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Web: www.ifrinternational.com

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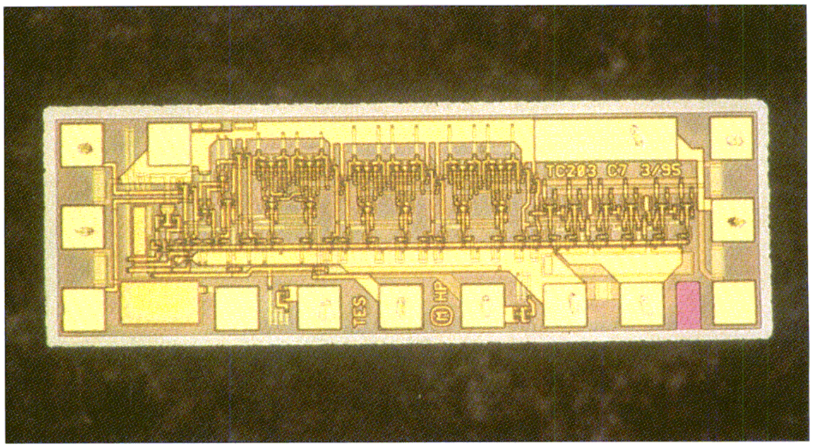
HP Introduces GaAs HBT Microwave IC Family

Eight new microwave ICs have been announced by Hewlett-Packard Company, their first products using InGaP-GaAs HBT technology. Benefits of this technology include high gain per stage, low phase noise, high linearity, uniformity and repeatability.



▲ **New microwave ICs from Hewlett-Packard use GaAs HBT technology to achieve low noise, high gain and single-supply voltage.**

HMMC-3002, -3004, -3008: 200 MHz to 16 GHz divide-by-two, divide-by-four and divide-by-eight prescalers with phase noise of –153 dBc/Hz at 100 kHz offset. On-chip pre- and post-amplifiers provide high sensitivity (–20 to +10 dBm from 1-10 GHz), 0 or +5.5 dBm output, and –75 dB output-to-input isolation.

HMMC-3022, -3024, -3028: High-efficiency divide-by-two, divide-by-four and divide-by-eight prescalers operating at half the current of the -300x series.

HMMC-5200, -5220: DC-20 GHz and DC-15 GHz Darlington-feedback amplifier chips with 50-ohm input and output match, operating from a single >4.75 volt supply. A typical device draws 44 mA and provides 9.5 dB ±1 dB gain with +12 dBm output power (P_{1dB}) at 1 GHz. Both amplifiers have a low $1/f$ noise corner at less than 20 kHz.

The InGaP-emitter HBT process used in these devices achieves f_T and f_{max} values of 65 GHz and 75 GHz, respectively. Reliability testing by HP indicates that the mean time to failure (MTTF) appears to be an order of magnitude larger than that achieved using AlGaAs-emitter HBT circuits.

These MMIC devices are available in chip form, and are priced as follows in 1,000-2,499 quantities:

HMMC-3002	$27.35
HMMC-3004	$27.35
HMMC-3008	$27.35
HMMC-3022	$27.35
HMMC-3024	$27.35
HMMC-3028	$27.35
HMMC-5200	$21.40
HMMC-5220	$15.10

For more information, contact:

Hewlett-Packard Company
Tel: 800-537-7715, ext. 10055
Web: www.hp.com/go/rf

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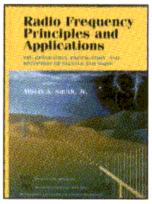
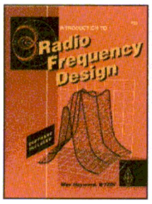
TECHNICAL BOOKS

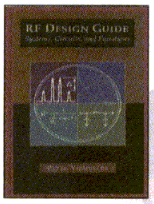
RF & microwave circuit fundamentals



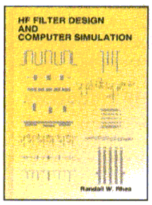
Radio Frequency Principles and Applications
Albert A. Smith, Jr.
A wealth of accessible, practical information on radio system behavior, wave propagation and system-level considerations.
IE-15 . . . . $70.00



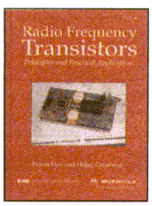
Introduction to Radio Frequency Design
Wes Hayward
A guide for practicing engineers, with special attention to the circuits that make up a radio system, with a receiver as the main example.
AR-7. $30.00



RF Design Guide
Peter Vizmuller
A design "cookbook" that covers circuit examples with sufficient theoretical background. Includes a software workbook of design examples and equations.
AH-8. $99.00

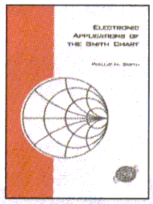


HF Filter Design and Computer Simulation
Randall W. Rhea
An excellent basic design book on LC and distributed filters; for engineers who must build filters with the desired performance.
NP-2. $59.00



Radio Frequency Transistors
Norm Dye and Helge Granberg
Solid state amplifier design from microwatts to kilowatts, from HF through UHF, is the subject of this book. A concise book based on the authors' many years of experience.
BH-1. $48.00

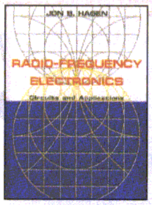
Microwave Transistor Amplifiers
Guillermo Gonzales
The classic book on network theory and Smith Chart-based design techniques for amplifiers. Complete coverage of noise, stability, matching and other necessary considerations.
PH-1. $91.00



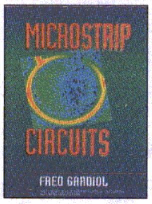
Electronic Applications of the Smith Chart
Phillip Smith
The original book by the author of the most powerful RF design tool ever developed. Learn matching and analysis using the Smith Chart.
NP-4. $59.00

Oscillator Design and Computer Simulation
Randall W. Rhea
A unified approach to oscillator design with many active device types and all the important resonator types: LC, crystal, SAW, etc.
NP-1. $64.00

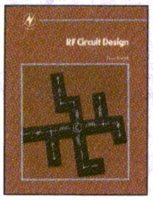
Practical Microwaves
Thomas S. Laverghetta
Lessons in the full range of microwave theory in down-to-earth language. Covers materials, components, design methods, test equipment and measurements.
PH-20. . . . . $85.00



Radio-Frequency Electronics: Circuits and Applications
Jon B. Hagen
A good introduction to radio concepts and circuits. Basic, but with enough technical depth to properly cover many RF circuits.
CU-1. $53.00



Microstrip Circuits
Fred Gardiol
A valuable overview of high-frequency distributed-element printed circuits. For engineers with interest in microwaves, antennas, and even high-speed digital design.
JW-18 . . . . $90.00



RF Circuit Design
Chris Bowick
Get started with Smith Chart-based low noise amplifier, power amplifier and oscillator design. An excellent tutorial approach to RF circuits, transmission lines and matching techniques.
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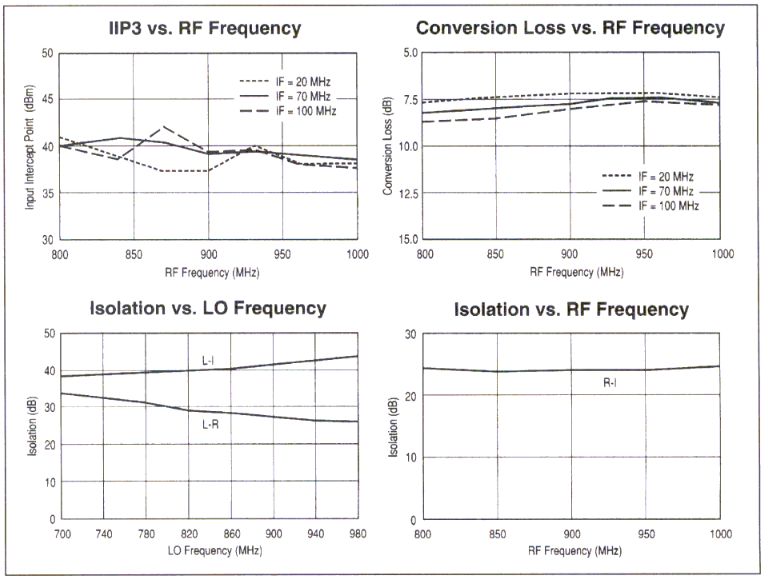
High Dynamic Range Mixers Deliver Performance for Wireless Systems

Four GaAs FET mixers from Watkins-Johnson Company offer high dynamic range performance for cellular, GSM, PCS, DECT, PHS and other wireless systems, plus CATV headend and many general-purpose frequency conversion and modulation applications.

The HMJ1 model features +39 dBm IIP_3 with +17 dBm LO drive. It covers the 80-1000 MHz cellular band with an IF in the 20-100 MHz range. No external matching is required and the mixer operates from a +3 volt supply, drawing 23 mA (typical). Plots of key operating parameters of the HMJ1 are shown in Figure 1.



▲ **Figure 1. Intercept, conversion loss and isolation performance graphs for the HMJ1 cellular-band FET mixer.**

The HMJ2 covers the 1850-1990 MHz PCS band, delivering +37 dBm IIP_3 with +17 dBm LO drive. It draws 25 mA (typical) from a 3 volt supply, and also requires no external matching.

For the 1700-1880 DCS1800 and PHS frequency range, model HMJ4 provides +36 dBm IIP_3 with +17 dBm LO drive, drawing 18 mA (typical) from a 3 volt supply. This mixer supports IFs from 50-150 MHz.

These three wireless band mixers offer 7.7-9.0 dB typical insertion loss and high port-to-port isolation.

The HMJ7 provides general purpose performance over 1000-2000 MHz for CATV headend equipment and other applications in this band. Performance specifications are +34 dBm IIP_3 with +21 dBm LO drive, 40 mA current draw from a 5 volt supply, and a 10.5 dB noise figure.

The mixers are offered in J-lead surface mount packages, 18 pins for the HMJ1, 2 and 4 and 22 pins for the HMJ7. The mixers are provided on tape and reel, 300 pieces per reel, for automated production. ■

For more information, contact:

Watkins-Johnson Company
WJ Wireless Products Group
Tel: 800-WJ1-4401
Fax: 650-813-2447
E-mail: wireless.info@wj.com
Web: www.wj.com

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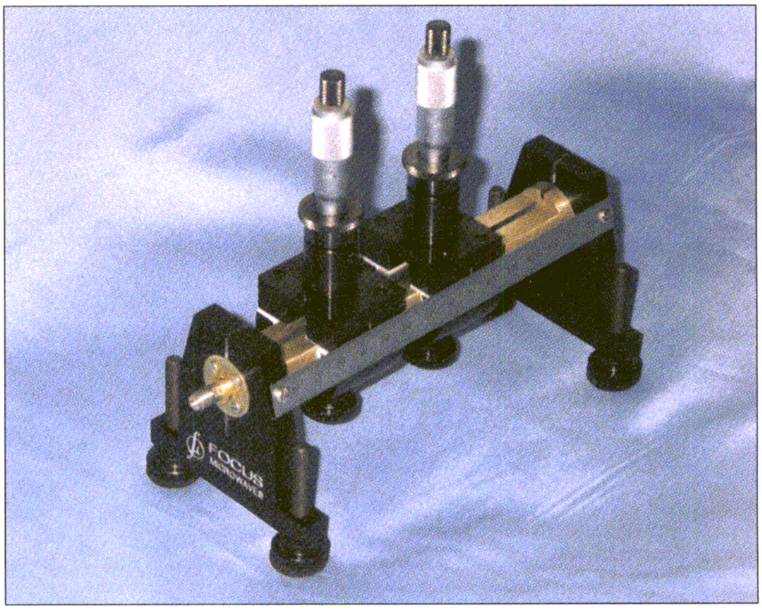
Manual Tuners Help Make Precise Load Pull and Noise Measurements

A new family of Manual Microwave Tuners MMTs) is offered by Focus Microwaves, Inc. The new tuners generate high CSWR (10~20:1) using a single probe, and more than 40:1 when the second, independently movable probe is used for prematching. The smooth sliding mechanism of the manual tuners provides high tuning stability and position accuracy, and is insensitive to vibrations and mechanical jitter. The MMTs are available from 400 MHz to 50 GHz, and can be equipped with a wide variety of connectors: GPC-7, N, 3.5, K and 2.4 mm.



▲ **Figure 1. Photo of a Microwave Manual Tuner (MMT) from Focus Microwaves.**

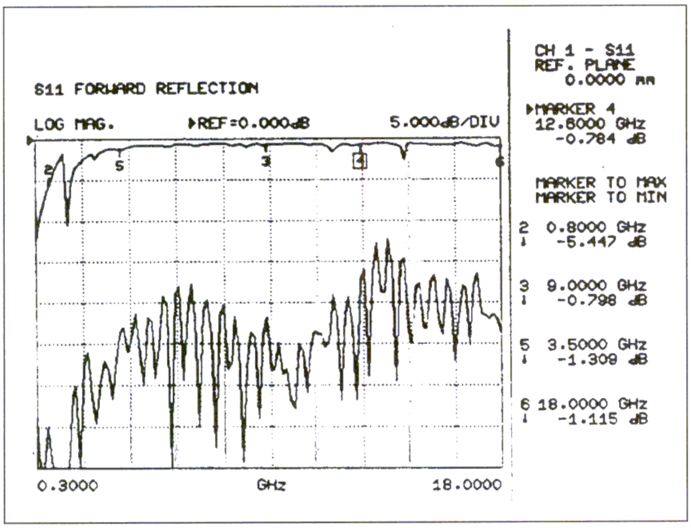
Manual Microwave Tuners (Figure 1) are designed for critical RF impedance matching operations, like load pull and noise measurements. MMTs use parallel plate airlines (slablines) and one or two sliding carriages with one vertical micrometer screw and a microwave probe (slug) each. The microwave probes and slablines are designed to generate high reflection factors over a very wide frequency band, such as 0.8 to 18 GHz with a typical VSWR of 20:1. The two independently adjustable carriages allow mutual prematching of the probes and thus selectively generate extremely high VSWR of greater than 50:1. The sliding mechanism and the probes ensure long lasting operation, high reproducibility and insensitivity to vibrations. MMTs are manufactured for frequencies from 400 MHz to over 40 GHz, using many different connector types.

Manual Microwave Tuners at a Glance

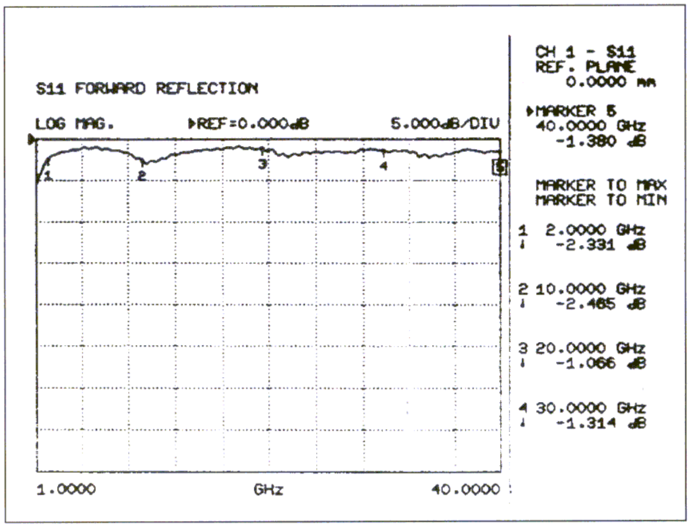
Frequency range:	0.4 to 40.0 GHz
VSWR tuning range:	1.04:1 to 20:1
Phase tuning range:	0 to 360 degrees
Instantaneous bandwidth:	up to five octaves
VSWR with prematching:	up to 50:1
Insertion loss:	0.1 to 0.9 dB
Connectors:	GPC-7, 3.5, 2.9, N, SMA, K

Tuning and repeatability

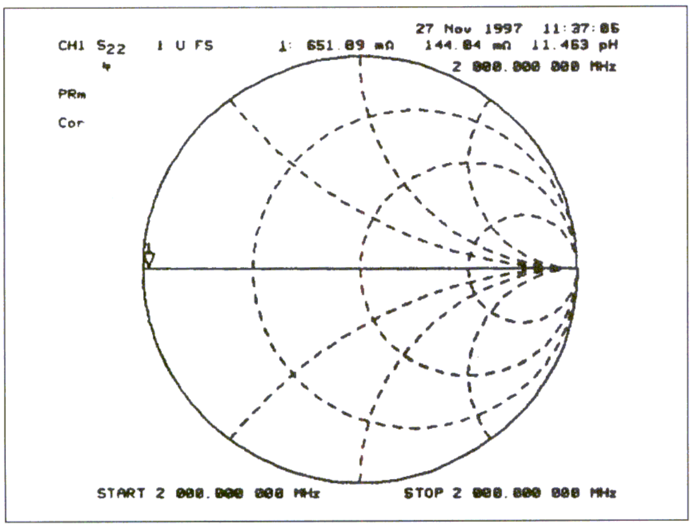
Figures 2 and 3 show the tuning capability of various MMT models with two RF probes mounted on two independent carriages. Model 1808 (Figure 2) covers 0.8 to 18 GHz, with GPC-



▲ **Figure 2.** $\Gamma_{min}/\Gamma_{max}$ **of the MMT-1808.**



▲ **Figure 2.** $\Gamma_{min}/\Gamma_{max}$ **of the MMT-4002.**



▲ **Figure 3. High Γ (Z ≈ 0.65Ω) generated using prematching capability of Manual Tuners at 2.0 GHz.**

Setting	S_{11},f_{11}	S_{12},f_{12}	S_{21},f_{21}	S_{22},f_{22}	Loss (dB)
1	0.883 –36.2	0.372 33.1	0.369 33.0	0.839 –76.1	L=2.038
2	0.883 –36.3	0.366 32.6	0.364 32.5	0.842 –76.5	L=2.151
3	0.887 –35.8	0.366 32.5	0.363 32.4	0.841 –76.8	L=2.024
4	0.884 –35.8	0.369 32.8	0.367 32.8	0.837 –76.8	L=2.059
5	0.884 –35.7	0.373 33.0	0.371 33.0	0.835 –76.7	L=1.964
6	0.891 –37.2	0.352 31.7	0.350 31.6	0.847 –76.7	L=2.229
7	0.890 –36.2	0.354 31.9	0.352 31.8	0.852 –77.2	L=2.193
8	0.887 –35.5	0.367 32.6	0.365 32.5	0.843 –77.1	L=1.987
9	0.884 –36.1	0.364 32.4	0.361 32.4	0.838 –76.9	L=2.168
10	0.883 –36.1	0.365 32.7	0.363 32.6	0.832 –76.6	L=2.178

▲ **Table 1. Repeatability of Manual Tuning using the MMT-1808 at 3 GHz.**

7 connectors, while model 4002 (Figure 3) covers 2 to 40 GHz with K connectors. Figure 4 shows the "prematched" tuning range, where one probe is used to increase the tuning range of the second one, in a narrow frequency range around 17 GHz. Table 1 summarizes tuning repeatability data. To obtain this data, the tuning probe was re-positioned manually and the network analyzer S parameters were measured via GPIB and saved in a PC file.

Conclusion

Manual Microwave Tuners (MMTs) are a reliable, low cost, yet still very accurate, tuning method for microwave load pull and noise measurements. MMTs are available from 0.4 to 50 GHz and provide very high VSWR through prematching using two horizontally and vertically independent probes. ■

For more information, contact:

Focus Microwave, Inc.
970 Montee de Liesse, Suite 308
Ville St. Laurent, Quebec H4T 1W7
Canada
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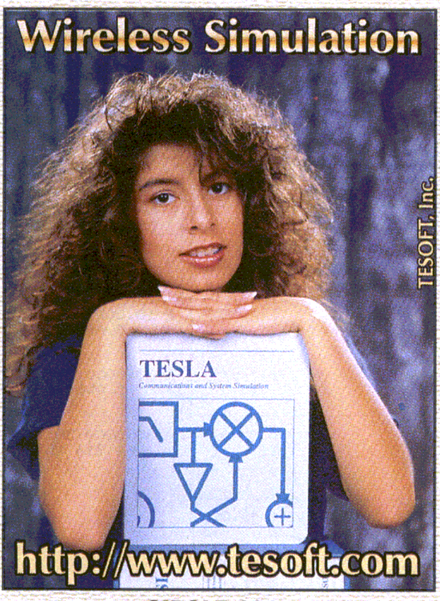

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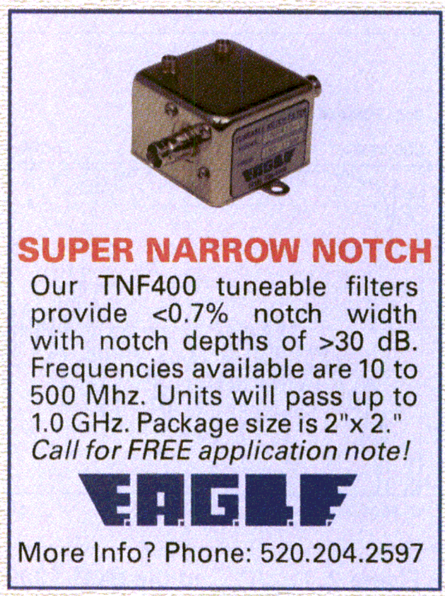
CIRCLE 102



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For more information on advertising in these two new sections, please contact Paul Beavin, Applied Microwave & Wireless, 4772 Stone Drive, Tucker, GA 30084; Tel: (770) 908-2320; Fax: (770) 939-0157.

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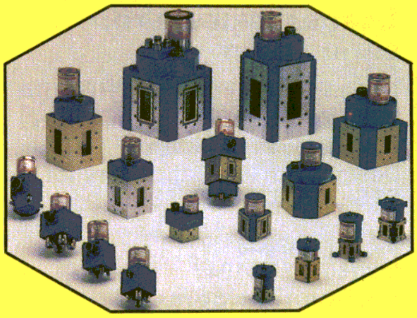

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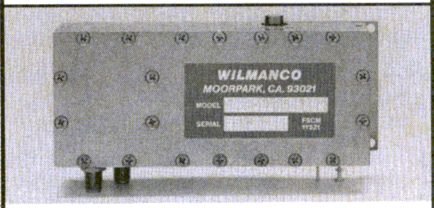

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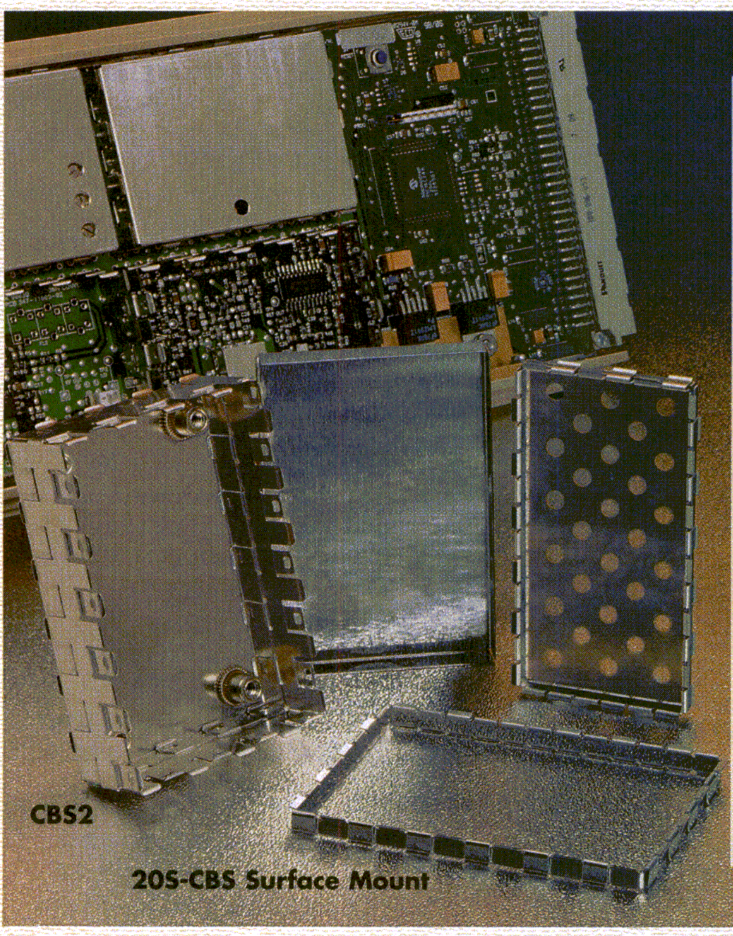

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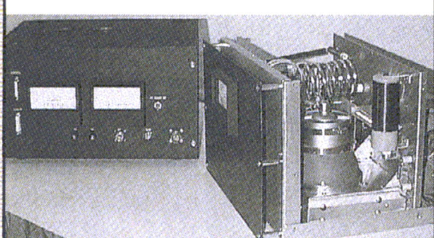

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Guest Editorial

The EPDeS initiative's goal is to streamline the portable wireless device design process. Taking a top-down approach, the group has embarked on a two to three year effort to integrate existing mechanical, thermal, and electrical EDA design tools with materials data, models, and manufacturing process, focusing on packaging and interconnect technologies. There are two primary challenges. First, we must develop the ability to transfer files seamlessly from one EDA tool to another, keeping material properties and attributes intact. Second, we need to create a "common language" to communicate materials properties, models, and manufacturing processes up and down the supply chain in a way that the EDA suppliers can "codify" into their design tools.

Another major Workshop will take place on January 24, 25, and 26 1999 where the IWPC will focus on completely different issues. Bringing together pro-active manufacturers of ground-based low-earth orbit (LEO) satellite and Local Multi-Point Distribution System terminals and their suppliers, this meeting is designed to facilitate and stimulate breakthrough thinking to meet the stringent needs of consumer-priced microwave/millimeter-wave antenna subsystems.

The workshop, entitled "Consumer-Priced Antenna Subsystems for LEO Satellite Terminals and Local Multi-Point Distribution Systems (LMDS)," will be hosted by Motorola's Ground Systems Division in Phoenix, and will include a tutorial section, entitled "Microwave/Millimeter Wave Antenna Fundamentals for Non-Antenna Experts," presented by IWPC's Technical Director, Rene Douville, a 30 year veteran and expert in this industry.

Currently, the IWPC is inviting companies that want to take a proactive role in shaping these designs of the future to join the consortium. For more information on the IWPC, its resources, and membership, visit our web site at http://www.iwpc.org. ■

Bridging the Wireless Packaging Knowledge Gap

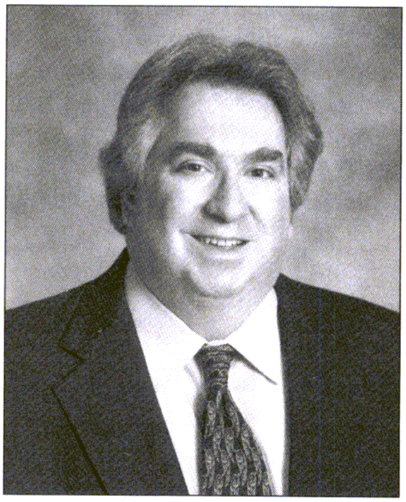
By Don Brown
International Wireless Packaging Consortium

Getting product to market and reducing cost are not just important goals for wireless component and system manufacturers, they are essential for success in this intensely competitive market. Although achieving these goals requires close cooperation between manufacturers and their suppliers, it is difficult for such synergy to develop. The International Wireless Packaging Consortium (IWPC™) was recently created to provide just such an opportunity, and it is already receiving broad support.

The IWPC's mission is to reduce costs and time to market for all types of wireless products from RFID tags to satellites, focusing on all levels of packaging and interconnection from individual device packaging to systems packaging.

Members of the IWPC represent both OEMs and their suppliers, from the largest mobile phone manufacturers, to material suppliers, manufacturing and assembly houses, and electronic design automation (EDA) developers from around the world. After 100's of face-to-face meetings with industry leaders, I helped to found the IWPC because I discovered a wide knowledge gap between the OEMs and suppliers in the wireless manufacturing industry and a hunger to bridge that gap.

I would often mention a new packaging technology to an OEM engineering manager that might solve some design issue, and the manager would have never heard of it. This was because there were limited opportunities and very little time for OEM designers and their suppliers to sit down and share their technology roadmaps to find solutions for engineering needs.



Don Brown is the founder and director of the IWPC. He has spent more than 20 years in the industry consulting on issues such as integrated packaging for the wireless/RF industry, surface mount technology, advanced electronic packaging and assembly, and worldwide technology trends. He is a member of the IEEE and IMAPS, and holds a BS in Mechanical Engineering from Penn State University, an MS in Mechanical, Aerospace, and Biomedical Engineering from the University of Delaware, and has been awarded three US patents. He can be reached at the International Wireless Packaging Consortium, 1745 Appaloosa Rd., Warrington, PA 18976; (215) 491-2113; e-mail: donbrown@iwpc.org

Ironically, even though reducing time-to-market is so important, the effort required just to maintain the status quo is robbing the industry of the time required to achieve it.

IWPC services

The IWPC steps into that knowledge gap and provides members with interactive technical workshops and tutorials as well as numerous other services. For instance, we conduct more than 100 face-to-face interviews worldwide per year with selected companies and report on the conclusions. The goal of these interviews is to identify the current and future needs of wireless and RF OEMs and the capabilities of advanced thinking suppliers.

IWPC also attends and reports on relevant national and international technical conferences, and maintains a wireless and RF packaging "keyword index service" for its members on the IWPC web site (http://www.iwpc.org) that contains listings (more than 6,000 documents to date and counting) for many major technical proceedings, trade newspapers, magazines, and other media.

Upcoming events

The IWPC organizes interactive technical workshops on key issues faced by its members. The latest, which launched the Electronic Product Design System (EPDeS) Initiative at the Nokia Research Center in Helsinki, Finland, was held this past October. The next EPDeS workshop is scheduled for February 26 and 27, 1999 and will feature input from Qualcomm in San Diego, CA and many other companies interested in moving this effort forward.

(continued on pg. 103)

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