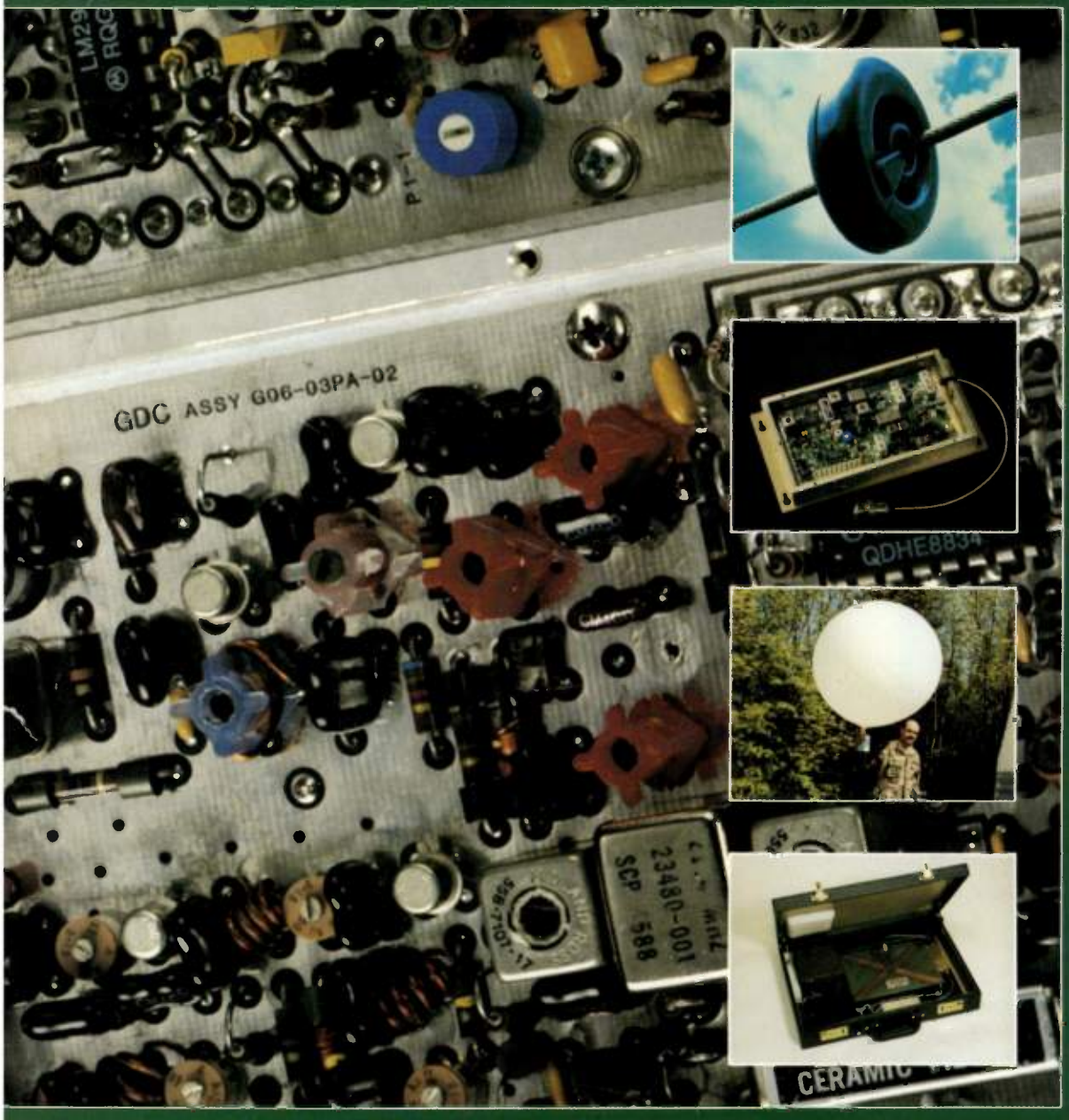
RF design

engineering principles and practices

November 1991



RF Expo East—Official Show Issue

Cover Story
New RF Applications

Featured Technology
Simple IC Circuits

NARDALERT™. Your personal warning for microwave radiation.

NARDALERT is the first commercially available personal monitor that detects potentially hazardous microwave environments. There's nothing else like it on the market.

It's pocket sized and hands free, and provides continuous coverage over the 2-18 GHz range.

You simply wear it on your person. The moment it's exposed to the preset threshold level, you get an audible and visual alarm – a beep and an LED flash. The unit even comes with an earplug for times you might have to work in noisy areas.

NARDALERT is fail-safe.

It incorporates a critical design that allows its sensitive electronic circuitry to operate correctly while surrounded by high level RF radiation. So there are no false alarms – inside or outside the specified frequency range.

NARDALERT also includes built-in test circuitry that verifies operation each time the unit is turned on. It also has a low battery warning signal.

Alarm sensitivity is preset to a 1 or 5 mW/cm² level. Frequency sensitivity is ± 1.5 dB. Half power beam width exceeds 120°, vertical and horizontal.

For more information and a free power density conversion calculator, call or write Loral Microwave-Narda, 435 Moreland Road, Hauppauge, New York 11788. Tel: (516) 231-1700. Fax: (516) 231-1711.

IDEAL FOR ANY MICROWAVE ENVIRONMENT.

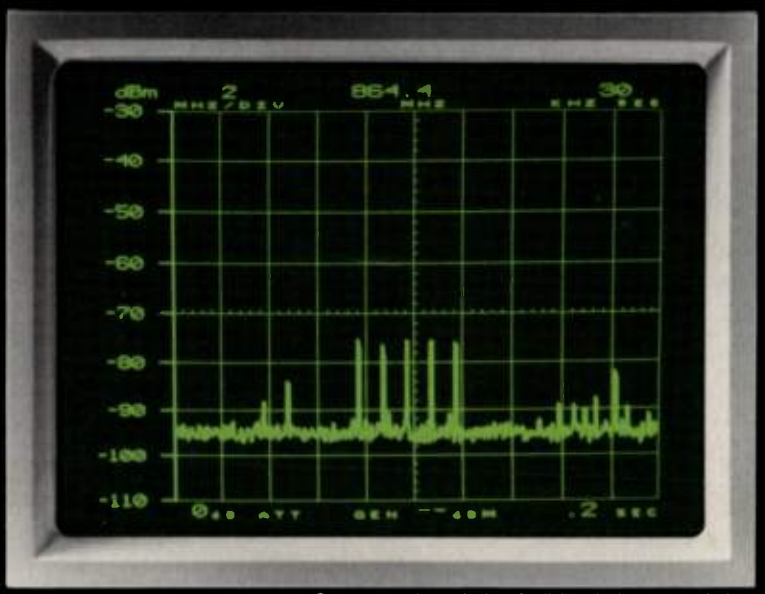
- Flight line
- Repair facilities for
  - EW
  - Radar
  - Avionics
- Repeater stations
- Satellite uplinks
- Shelters (microwaves)
- Shipboard

Visa and MasterCard accepted.

LORAL
Microwave-Narda

INFO/CARD 1
Please see us at RF Expo East, Booth #518.

If you're not using a spectrum analyzer...



Spectrum analyzer display of cellular telephone transmissions.

maybe it's time to take a closer look.

ifr

Spectrum Analyzers

A-7550—10 kHz to 1.0 GHz

A-8000—10 kHz to 2.6 GHz

You can't hear them or see them, but there are probably thousands of electromagnetic signals being transmitted through the air around you at this very moment.

Many of these signals originate from radio and television transmission. However, many other signals are emitted from computers, CRT display terminals, and other electrical devices.

Each of these signals can be a potential source of harmful interference to sensitive electrical equipment or critical systems you are operating.

The IFR A-7550 and A-8000 Spectrum Analyzers provide a full set of features to speed the identification and measurement of signals over a wide frequency range.

Optional built-in features including a rechargeable battery, tracking generator, sensitive AM/FM/SSB receiver, IEEE-488 interface, RS-232 interface, and quasi-peak detector allow either instrument to be configured to your unique testing requirements at a surprisingly affordable price.

For more information or a demonstration of the A-7550 or the A-8000, contact your local IFR representative or call IFR at (316) 522-4981.

ifr

IFR SYSTEMS, INC.
10200 West York Street
Wichita, Kansas 67215-8935 U.S.A.
FAX 316/524-2623

INFO/CARD 2

Please see us at RF Expo East, Booth #604.

GaAs Pains?

Call DAICO!

SELECTION CHART

Part No.	Type	Freq/MHz	IL/dB*	Iso/dB*	Sw. Speed/ nSec**	Package	Control
DSO841	SPST	10-200	1.7	70	7.0	14 Pin DIP	TTL
DSO699	SPST	5-1500	1.0	48	23.0	TO-8	TTL
DSO990	SPST	10-2000	1.5	62	25.0	14 Pin DIP	TTL
DSO850	SP2T	DC-2000	0.4	47	5.0	TO-5	0/-7
DSO813	SP2T	DC-2000	0.7	40	140.0	TO-5	TTL
DSO812	SP2T	10-1000	0.5	54	50.0	TO-8	TTL
DSO860	SP2T	10-1000	0.5	47	50.0	.380 sq	TTL
DSO602	SP2T	5-4000	1.3	65	26.0	14 Pin DIP	TTL
DSO842	SP2T	5-1500	1.0	75	50.0	14 Pin DIP	TTL
DSO864	SP4T	5-2000	1.3	49	28.0	16 Pin DIP	TTL
DSO874	SP4T	DC-2000	2.2	60	55.0	14 Pin DIP	TTL
DSO838	SP8T	5-1000	2.2	40	40.0	24 Pin DIP	TTL
DSO918	SP16T	DC-4000	3.8	30	150	58 Pin DIP	TTL

*Typical performance measures, mid-band.
**50% TTL to 10%/90% RF

Does your switch supplier give you GaAs pains?...Call DAICO.

DAICO remedies GaAs pains fast with 20 high performance GaAs switches available directly from stock. In fact, we have a total of 64 different models of GaAs switches, digital attenuators and VCA's in stock guaranteed to alleviate your GaAs pains.

So get rid of your GaAs pains fast...call DAICO for technical assistance and our 1991 Catalog at (213) 631-1143.

DAICO INDUSTRIES, INC.
2453 East Del Amo Blvd., Compton, CA 90220
Telephone (213) 631-1143 • FAX (213) 631-8078

INFO/CARD 3

RF design

contents

November 1991

featured technology

cover story

emc corner

design awards

departments

R.F. DESIGN (ISSN: 0163-321X USPS: 453-490) is published monthly plus one extra issue in September. November 1991. Vol. 14, No. 12. Copyright 1991 by Cardiff Publishing Company, a subsidiary of Argus Press Holdings, Inc., 6300 S. Syracuse Way, Suite 650, Englewood, CO 80111 (303) 220-0600. Contents may not be reproduced in any form without written permission. Second-Class Postage paid at Englewood, CO and at additional mailing offices. Subscription office: *RF Design*, P.O. Box 1077, Skokie, IL 60076. Domestic subscriptions are sent free to qualified individuals responsible for the design and development of communications equipment. Other subscriptions are: $38 per year in the United States; $48 per year in Canada and Mexico; $52 (surface mail) per year for foreign countries. Additional cost for first class mailing. Payment must be made in U.S. funds and accompany request. If available, single copies and back issues are $5.00 each (in the U.S.) This publication is available on microfilm/fiche from University Microfilms International, 300 Zeeb Road, Ann Arbor, MI 48106 USA (312) 761-4700.

SUBSCRIPTION INQUIRIES: (708) 647-0756.

POSTMASTER & SUBSCRIBERS: Please send address changes to R.F. Design, P.O. Box 1077, Skokie, IL 60076.

Expense or Investment?

By Gary A. Breed
Editor

This column is written for those of you who couldn't go to RF Expo East. Maybe someone in management or accounting decided it cost too much, or perhaps your position isn't senior enough to get "perks" like travel, fun and sun. Somewhere, a decision was made that trade shows and engineering conferences are expenses, not investments that pay dividends for a long time. Too bad!

I know of two patents that were inspired by technical papers and discussions with fellow engineers at an RF Expo, and I know of other successful products that were conceived in the same manner. There are dozens of stories from both engineers and exhibiting companies about finding exactly the right supplier of hardware or software, saving money in manufacturing, achieving performance goals, or even making the product possible at all!

Junior engineers have jump-started their careers with our short courses, technical sessions, and first-hand examination of key RF products. A few days of highly concentrated RF engineering is enough to make an engineer of any age see new possibilities. It's an atmosphere that isn't duplicated anywhere.

What did you miss this year? Plenty, if you work for one of the many companies in the business of (or trying to get into) personal communications or consumer wireless systems. More than a dozen papers covered topics directly related to these active technology areas! And this doesn't include excellent presentations on broader topics like receiver performance, power amplifiers, testing, low noise amplifier design, or design software.

If you didn't attend RF Expo East, you also missed an opportunity to take our short courses on RF Fundamentals, Filters and Matching Networks, and Oscillator Design. Instructors Les Besser and Randy Rhea receive consistent praise from students in these classes, some of whom have returned several times just to stay sharp.

You also didn't get to visit with the representatives of 100 key RF suppliers. You can read catalogs and collect data sheets, but there is nothing like a hands-on demonstration for test equipment and design software, or a live test setup of an oscillator, mixer, modulator or synthesizer module. You also passed up the opportunity to talk privately with design, applications, or manufacturing engineers about capacitors, inductors, transistors and ICs. (Yes, our exhibiting companies bring lots of technical personnel, not just salesmen!)

Fortunately, there are plenty of companies who realize the importance of keeping up with technology. They allow their engineers to proudly present technical papers on recent developments. They support their staff by making educational opportunities available. They get the advantage of first-hand information from current or prospective suppliers. But most of all, they get enthusiastic, productive engineers when those men and women return from RF Expo East full of new ideas.

THE NCI FILES

Case study No. 1:

AN ULTRA-STABLE DTO/SYNTHESIZER

NCI takes the toughest challenges in frequency control. And we deliver solutions — fast.

A case in point:

NCI was asked to design an extremely stable digitally tuned oscillator (DTO) that could handle modulation from DC to 10 MHz with deviations up to ±250 MHz. High stability and pinpoint accuracy were critical. The unit would also operate as a synthesizer with 1 MHz resolution and narrowband FM deviation. And it had to be small.

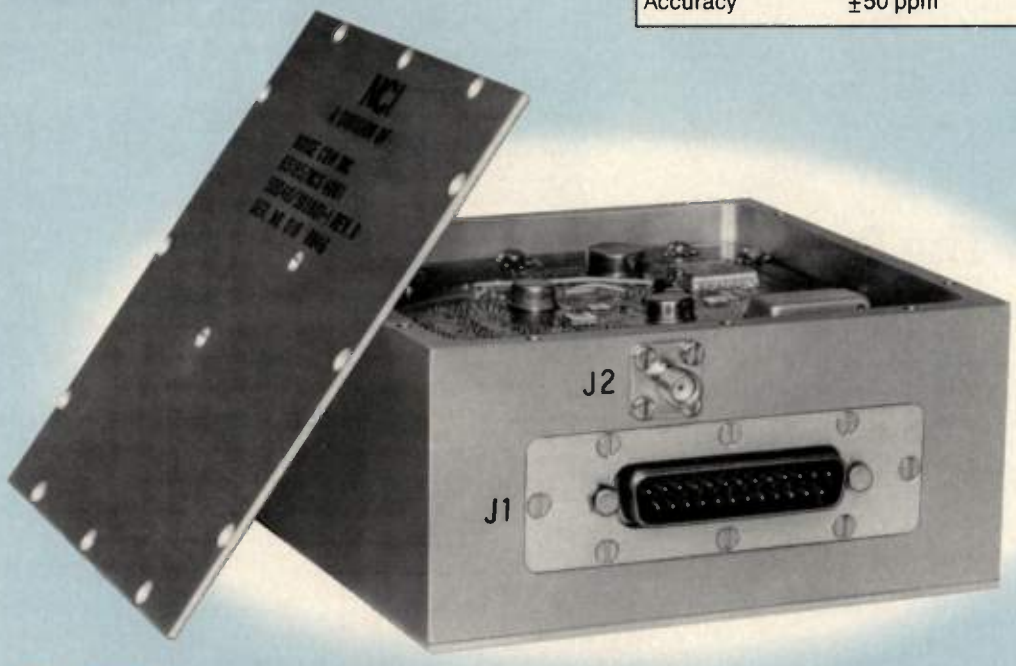
NCI designed the synthesizer/DTO in 2 weeks and produced a prototype in 8 weeks. Performance of the production units exceeds the customer's specification in every area.

The synthesizer/DTO utilizes a PROM and D/A converter to achieve excellent linearity and resolution. The tuning command is simple — the output frequency equals the input word. Proprietary temperature compensation circuitry unconditionally maintains stability.

It's what you'd expect from the innovators at NCI, a veteran design team that will produce results from your toughest challenges. We build enormous capability into very small enclosures, with power consumption generally one-fifth of open and closed loop DTOs and synthesizers from other manufacturers.

Give NCI's design innovators your toughest specifications. We'll give you solutions, fast. Call (201) 261-8797, and ask for Gary Simonyan.

Parameter	What they needed	What NCI delivered
GENERAL		
Frequency coverage	2 to 4 GHz	2 to 4 GHz
Output power	0 dBm	+4 dBm
Flatness	±1.5 dB	±1 dB
Power consumption	41 W maximum	8 W typical
Size		4 in. × 4 in. × 4 in.
Environmental	−35 to +70 C, 10,000 ft., 12 G shock. Vibration and humidity to MIL-STD 810D	
DTO		
Stability	±0.2%	±0.04%
Accuracy	±100 MHz	±1 MHz
Settling time	1 s	200 ms
SYNTHESIZER 1 MHz resolution, 10 Hz to 1 MHz modulation		
Stability	±0.03%	50 ppm
Accuracy	±50 ppm	±10 ppm



NCI

The Force In Frequency Control

E. 49 Midland Avenue, Paramus, New Jersey 07652
(201) 261-8797 • FAX: (201)-261-8339 • TWX: 910-380-8198

A DIVISION OF NOISE COM, INC.

INFO/CARD 5

RF design

a Cardiff publication Established 1978

Main Office:
6300 S. Syracuse Way, Suite 650
Englewood, CO 80111 • (303) 220-0600
Fax: (303) 773-9716

Publisher
Kathryn Walsh

Editor
Gary A. Breed

Associate Editor
Liane Pomfret

Consulting Editor
Andy Przedpelski

Associate Sales Manager
Bill Pettit

Account Executive
Maryanne Averill
Main Office

Account Executive
Cindy Wieland
Main Office

Editorial Review Board
Alex Burwasser
Doug DeMaw
Dave Krautheimer
James W. Mize, Jr.
Robert J. Zavrel, Jr.
Ed Oxner
Andy Przedpelski
Jeff Schoenwald
Raymond Sicotte

Advertising Services
Tisha Boberschmidt Hill

Secretary
Theresa Maier

Convention Manager
Kristin Hohn

Registration Coordinator
Dawn Keith

Exhibits Coordinator
Barb Binge

Trade Show Account Executive
LeAnn Nowacki

Associate Production Managers
Matt Park
Maurice Lydick

Artists
Kim Austin
Joyce Fields
Brad Fuller
Paul Rivera
Sheri Ryder

Composition
Mike C. Moore
Marcie Tichenor

Creative Director
Bob Stewart

Published by

CARDIFF PUBLISHING COMPANY, INC.

BPA

President
Robert A. Searle

Vice President — Production
Cherryl Greenman

Vice President — Convention Management
Kathy Kriner

Treasurer
Jennifer Burger

Circulation Director
Patricia Shapiro

Credit Manager
Patti McManness

Please address subscription inquiries to:
RF Design
P.O. Box 1077, Skokie, IL 60076-9931
Postmaster: send form 3579
to the above address.

NOISE/COM

"NOISE IS OUR ONLY BUSINESS"

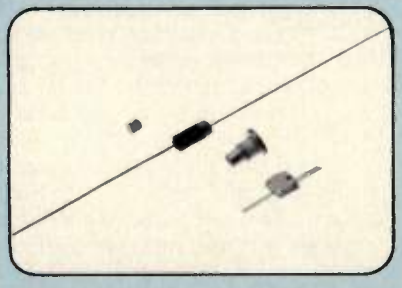
Broad Band Noise Sources

For Space, Military and Commercial Applications

DC-50 GHz

Chips and Diodes

•Glass •Ceramic •Beam-Lead
•Hermetically Sealed •MIL-STD-202
•Audio •VHF •UHF •RF •MW •MM

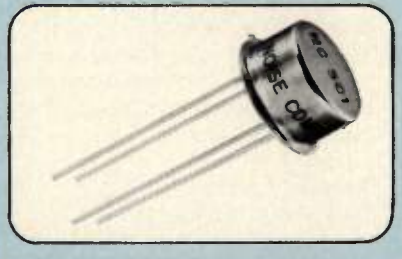


TYPICAL STANDARD MODELS	
NC 100 Series	up to 3 MHz
NC 200 Series	up to 500 MHz
NC 300 Series	up to 11 GHz
NC 400 Series	up to 50 GHz

ALL ARE IN STOCK

Drop In Modules For Bite

Self energized in TO-8
Ideal for self testing of receivers
50 ohms, 30 dB ENR min,
35 dB ENR typ.

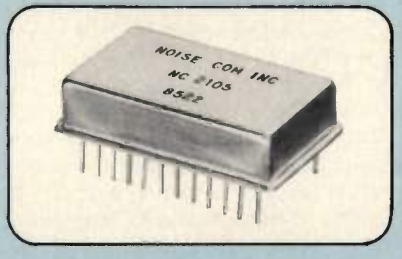


TYPICAL STANDARD MODELS	
NC 501	up to 500 MHz
NC 502	up to 1 GHz
NC 503	up to 2 GHz
NC 504	up to 3 GHz
NC 505	up to 4 GHz
NC 506	up to 5 GHz

ALL ARE IN STOCK

Broad Band Amplified Modules

PLUG-IN, DUAL-IN-LINE
24 or 14 PIN, 150mv out



TYPICAL STANDARD MODELS	
NC 2101	up to 20 kHz
NC 2102	up to 100 kHz
NC 2103	up to 500 kHz
NC 2104	up to 1 MHz
NC 2105	up to 10 MHz
NC 2106	up to 20 MHz
NC 2201	up to 100 MHz
NC 2301	up to 300 MHz

MOST ARE IN STOCK

HIGH-OUTPUT:
+ 10 dBM, 50 ohms
SMA or BNC output

TYPICAL STANDARD MODELS	
NC 1101A	up to 20 kHz
NC 1107A	up to 100 MHz
NC 1108A	up to 500 MHz
NC 1109A	up to 1 GHz
NC 1110A	up to 1.5 GHz

Other frequency ranges
and output levels available
MOST ARE IN STOCK

Broad Band Precision, Calibrated Coaxial

SMA, N, TNC Output
Connectors

TYPICAL STANDARD MODELS	
NC 3100 Series	up to 18 GHz 15.5 dB ENR, noise figure meter compatible
NC 3200 Series	up to 18 GHz 30-35 dB ENR, high noise output

NOISE/COM

"NOISE IS OUR ONLY BUSINESS"

NOISE COM, INC.
E. 49 Midland Ave.
Paramus, NJ 07652
PHONE (201) 261-8797
FAX (201) 261-8339
TWX 910-380-8198

INFO/CARD 8

RF letters

Letters should be addressed to: Editor, *RF Design*, 6300 S. Syracuse Way, Suite 650, Englewood, CO 80111.

RF Education Comments

Editor:

I am in an RF engineering position with the Air Force, and an electrical engineering student at Wright State University. I enjoyed your editorial in the August issue concerning "Education and RF Engineering." I agree that students receive little information about this field as a career. I chose to pursue radio-electronics early in life, due to my ham radio hobby and an electrical engineer I knew when I was a boy. He showed me examples of his work at the GM Tech Center in Detroit and I was hooked!

The engineering school dean here at Wright State has assured me that the courses available can easily lock-in a student considering RF engineering. Also, I would guess that many of us students get swayed by our teachers' experience as engineers. If a course instructor was an instrument engineer, he'll share that experience with his class. If RF engineers, wherever they are, would do the same, it would help prospective engineers with that career path.

Maybe you should offer your magazine to educators as well as professionals. I'm sure many would subscribe.

John J. Parrish, Jr.
Dayton, Ohio

Circuit Decoupling

Editor:

With reference to Bernard Cooperstein's article concerning EMC techniques for PCBs (June 1991), the use of two capacitors for supply decoupling of ICs or any other circuit block is a fraught technique. An impedance analysis of the equivalent circuit which includes all the series inductances will reveal resonances which may be significant and degrade performance at some frequencies. Murphy's Law applies, and a crosstalk, instability or lumpy frequency response problem may have an obscure solution found in the supply decoupling.

John Salter
British Broadcasting Corporation

The conventional wisdom that dictates multiple bypass capacitors is still accepted where bypassing must cover DC to many MHz, but the use of surface mount components has significantly reduced the practice. Engineers can use high-value SMT capacitors and still avoid unwanted resonances. — Editor

Is *Inefficiency* a Better Term?

Editor:

Traditionally, power amplifiers and power converters have been evaluated on the criterion of efficiency, $\eta = P_{out}/P_{in}$. This has been satisfactory for equipment of moderate efficiency, e.g, n < 80 percent, but for high-efficiency power amplifiers and power converters, this criterion misses an important characteristic: power dissipation is small in relation to power output or input. That characteristic allows the use of compact construction and small heat sinks. However, a small difference in efficiency between two alternative designs can make a large difference in power dissipation. This, in turn, makes a large difference in the heat-removal requirement, usually critical in military, portable, land mobile and aircraft usage.

For such applications, a more appropriate evaluation criterion is inefficiency, defined as $P_{dissipated}/P_{output}$, and related to efficiency η by:

$$\text{Inefficiency} \equiv \eta' = 1/\eta - 1$$

This expresses directly the power dissipated, normalized to the output power. Output power is a better normalizing parameter than input, since nearly all equipment is specified to provide a particular output power. The input power simply becomes whatever is necessary to achieve that output.

As an example, consider two designs having "almost the same efficiency" of 85 and 90 percent. This apparently small difference yields inefficiencies which are drastically different: 17.6 and 11.1 percent, respectively. There is a factor of 1.6 in the heat-removal requirements for these two designs, although they differ by "only" 5 percent in efficiency!

Nathan O. Sokal
Design Automation, Inc.

NOISE/COM

"NOISE IS OUR ONLY BUSINESS"

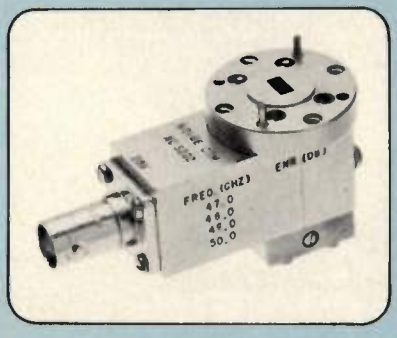
Broad Band Noise Sources

For Space, Military and Commercial Applications

DC-50 GHz

Broad Band Precision, Calibrated Waveguide

W/R-22,-28,-42



TYPICAL STANDARD MODELS	
NC 5100 Series	up to 50 GHz 15.5 dB ENR, noise figure meter compatible
NC 5200 Series	up to 50 GHz 21-25 dB ENR, high noise output
NC 5300 Series	up to 50 GHz 21-25 dB ENR, high noise output

For More Information And Quick Response Call:

GARY SIMONYAN at 201-261-8797

Broad Band Instruments

115V or 230V Standard
Bench Type or Rack Mounted

MANUALLY CONTROLLED
+ 10 dBM Output

TYPICAL STANDARD MODELS	
NC 6101	up to 20 kHz
NC 6107	up to 100 MHz
NC 6108	up to 500 MHz
NC 6109	up to 1 GHz
NC 6110	up to 1.5 GHz
NC 6111	up to 2 GHz
NC 6218	up to 18 GHz

Other standard models available
MOST ARE IN STOCK

PROGRAMMABLE
IEEE-488 (GPIB), MATE (CIIL)
RS232, etc. + 10 dBM Output

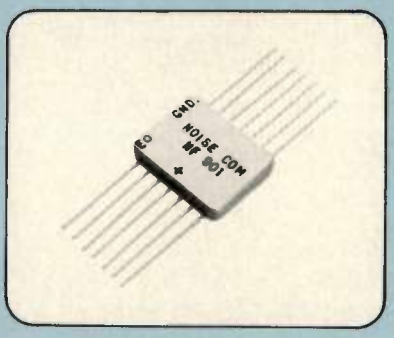
TYPICAL STANDARD MODELS	
NC 7101	up to 20 kHz
NC 7107	up to 100 MHz
NC 7108	up to 500 MHz
NC 7109	up to 1 GHz
NC 7110	up to 1.5 GHz
NC 7111	up to 2 GHz
NC 7218	up to 18 GHz

OPTIONAL: Remote variable filters, signal input combiner, 75 ohms output, marker input.
Other standard models available
MOST ARE IN STOCK

Custom & Hi Rel Products

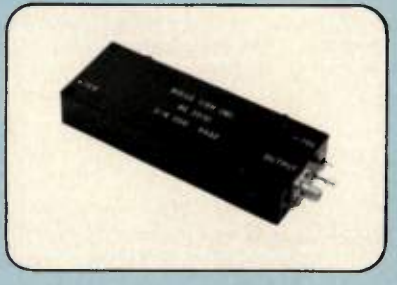
HYBRID FOR SPACE QUALIFIED AMPLIFIED MODULES

10 Hz to 10 MHz, 7 GHz, 9 GHz, 14 GHz etc. Small size and weight



DC COUPLED AMPLIFIED MODULES

- 1 volt output into 50 ohms
- DC-100 kHz
- Low offset voltage
- Compact
- DC-4 MHz



NOISE/COM

"NOISE IS OUR ONLY BUSINESS"

NOISE COM, INC.
E. 49 Midland Ave.
Paramus, NJ 07652

PHONE (201) 261-8797
FAX (201) 261-8339
TWX 910-380-8198

INFO/CARD 10

NEW from KALMUS...

Model 710FC

- ★ 10 Watts Output
- ★ 1-1000 MHz Broadband
- ★ 40 dB Gain
- ★ 10 dB Gain Adjust
- ★ Only 16 Pounds
- ★ MOS-FET Efficiency
- ★ 19" Rack Adapters Included

UP TO

200W/1000MHz LINEAR RF AMPLIFIER SYSTEMS

MODEL	POWER OUT	FREQUENCY RANGE	GAIN	SIZE (CM)	WEIGHT	AC LINE	U.S. PRICE $
700LC	1.5W CW	.003-1000 MHz	33dB	25x28x13	3.3kg	100-240V	$ 1,695
704FC	4W CW	.5-1000 MHz	33dB	23x18x09	2.8kg	100-240V	$ 2,195
706FC	6W CW	.5-1000 MHz	36dB	25x28x13	3.3kg	100-240V	$ 3,195
410LC	10W CW	.006-400 MHz	43dB	30x35x13	4.5kg	100-240V	$ 4,600
710FC	10W CW	1-1000 MHz	40dB	30x35x13	7.3kg	100-240V	$ 6,695
727LC	10W CW	.006-1000 MHz	43dB	48x46x13	8.5kg	100-240V	$ 7,750
711FC	15W CW	400-1000 MHz	40dB	30x35x13	5.5kg	100-240V	$ 3,620
720FC	25W CW	400-1000 MHz	40dB	48x46x13	8.6kg	100-240V	$ 5,995
712FC	25W CW	200-1000 MHz	40dB	48x46x13	8.8kg	100-240V	$ 7,350
737LC	25W CW	.01-1000 MHz	45dB	48x46x13	10.5kg	100-240V	$ 9,995
747LC	50W CW	.01-1000 MHz	47dB	48x46x26	26.5kg	100-240V	$22,500
707FC	50W CW	450-1000 MHz	47dB	48x46x13	13.0kg	100-240V	$ 9,995
709FC	100W CW	500-1000 MHz	48dB	44x48x18	22.5kg	100-240V	$19,990
722FC	200W CW	500-1000 MHz	50dB	44x18x31	41.5kg	100-240V	$31,900

Note: Models 727LC, 737LC and 747LC consist of two bands with one common input and output connector, switched with coaxial transfer relay, manually, or by remote. Switching speed 5 milliseconds.

MODEL 704FC

MODEL 707FC

21820 87TH SE
WOODINVILLE, WA 98072

KALMUS
Engineering International, Ltd., U.S.A.

(206) 485-9000
FAX: (206) 486-9657

INFO/CARD 11

RF calendar

November

14-15 **NIST Symposium on Science, Technology and Competitiveness**
Gaithersburg, MD
Information: Karl Kessler, A505 Administration Bldg., NIST, Gaithersburg, MD 20899. Tel: (301) 975-3089.

19-21 **Wescon '91**
San Francisco, CA
Information: Wescon/91, 8110 Airport Blvd., Los Angeles, CA 90045. Tel: (800) 877-2668. Fax: (213) 641-5117.

December

2-5 **Globecom '91**
Phoenix, AZ
Information: Globecom '91 Registration, c/o Frank Young, PO Box 40495, Phoenix, AZ 85067-0495. Tel: (602) 266-1991. Fax: (602) 235-5829.

3-5 **Technology 2001**
San Jose, CA
Information: Justina Cardillo or Joseph Pramberger, NASA Tech Briefs. Tel: (212) 490-3999.

5-6 **ARFTG**
San Diego, CA
Information: ARFTG, c/o Henry Burger, 1061 E. Frost Drive, Tempe, AZ 85282. Tel: (602) 839-6933.

8-11 **IEEE Ultrasonics Symposium**
Orlando, FL
Information: LRW Associates, 1218 Balfour Drive, Arnold MD 21012. Tel: (301) 647-1591.

8-11 **1991 IEEE International Electron Devices Meeting**
Washington, D.C.
Information: Melissa Widerkehr, Courtesy Associates, 655 15th Street, NW, Suite 300, Washington, DC 20005. Tel: (202) 347-5900.

9-12 **Sixth International Conference on Mobile Radio and Personal Communications**
University of Warwick, United Kingdom
Information: MRPC 91 Secretariat, IEE Conference Services, Savoy Place, London WC2R 0BL, UK. Tel: (44) 071-240-1871 ext. 222. Fax: (44) 071-240-7735.

January

13-16 **ATE & Instrumentation Conference**
Anaheim, CA
Information: Miller Freeman Expositions, 1050 Commonwealth Ave., Boston, MA 02215-1135. Tel: (800) 223-7126. Fax: (617) 232-0854.

27-31 **Communications Networks '92**
Washington, D.C.
Information: World Expo Corp., Barbara Inglese, PO Box 9107, 111 Speen Street, Framingham, MA 01701-9107. Tel: (800) 545-EXPO. Fax: (508) 872-8237.

RF courses

Far-Field, Anechoic Chamber, Compact and Near-Field Antenna Measurements
December 3-6, 1991, Atlanta, GA
Phased-Array Antenna Design
December 3-6, 1991, Atlanta, GA
Information: Education Extension, Georgia Institute of Technology. Tel: (404) 894-2547.

Frequency Hopping Signals and Systems
November 18-20, 1991, Washington, DC
Electromagnetic Interference and Control
November 18-22, 1991, Washington, DC
Communications Satellite Systems
December 2-5, 1991, Washington, DC
Modern Radar System Analysis
December 2-6, 1991, San Diego, CA
Principles of High Frequency Radio Communications for Operators and Managers
December 3-6, 1991, Washington, DC
Digital Transmission Systems
December 9-12, 1991, Washington, DC
Spread Spectrum Communications Systems
December 9-13, 1991, Colorado Springs, CO
New HF Communications Technology: Advanced Techniques
December 9-13, 1991, Washington, DC
Grounding, Bonding, Shielding and Transient Protection
December 10-13, 1991, San Diego, CA
Information: The George Washington University, Continuing Engineering Education, Merril A. Ferber. Tel: (202) 994-8522 or (800) 424-9773.

Microstrip Transmission Line Design
November 19-22, 1991, Bethesda, MD
Modern Microwave Techniques
December 10-13, 1991, Bethesda, MD
Radar Cross-Section Measurement Techniques
December 10-13, 1991, Scottsdale, AZ
Information: Technology Service Corporation. Tel: (800) 638-2628, (301) 565-2970. Fax: (301) 565-0673.

Pulsed EMI
November 13-14, 1991, Columbus, OH
Information: Keytek. Tel: (508) 658-0880.

Seminar on ELF and VLF Magnetic Fields
November 20-21, 1991, Orlando, FL
Information Frances George, Ergonomics, Inc. Tel: (215) 357-5124. Fax: (215) 364-7582.

Field Programmable Gate Arrays
November 19, 1991, San Diego, CA
November 20, 1991, Irvine, CA
November 21, 1991, Torrance, CA
Digital Signal Processing Control Seminar
November 15, 1991, Rochester, NY
Information: Texas Instruments. Tel: (800) 336-5236.

EC 92, Its Effect on the American Electronics Industry
December 12, 1991, San Jose, CA
Information: Rockford Engineering Services, Julia Gbadebo. Tel: (800) 848-3781. Fax: (510) 862-9013.

Seminar in EMI Software (EMCAD1)
December 4-5, 1991, Mariposa, CA
Information: CKC Laboratories, Registrar. Tel: (209) 966-5240. Fax: (209) 742-6133.

ESD Design and Testing
January 23, 1992, Novi, MI
Information: S.E. Michigan IEEE EMC Society. Tel: (313) 597-3950 or Jastech. Tel: (313) 553-4734.

Understanding Data Communications
November 18-19, 1991, Denver, CO
December 12-13, 1991, Indianapolis, IN
December 16-17, 1991, Boston, MA
Information: Quest. Tel: (908) 251-3217. Fax: (908) 251-0638.

The VXIbus Seminar 1 Day Overview
November 19, 1991, Raleigh, NC
November 21, 1991, Richmond, VA
Information: Testech, Ltd. Tel: (708) 554-1222.

Improving the Software Testing Process
November 14-15, 1991, Denver, CO
November 21-22, 1991, Dallas, TX
December 2-3, 1991, Phoenix, AZ
December 2-3, 1991, St. Louis, MO
December 5-6, 1991, Atlanta, GA
December 16-17, 1991, Boston, MA
December 19-20, 1991, Detroit, MI
Information: Data-Tech Institute. Tel: (201) 478-5400. Fax: (201) 478-4418.

RF/MW Circuit Design: Linear/Nonlinear
November 11-15, 1991, Germany
RF/MW Component Modeling
November 13-15, 1991, Germany
Information: CEI-Europe/Elsevier, Mrs. Tina Persson, Box 910, S-612 01 Finspong, Sweden. Tel: +46 (0) 122-17570. Fax: +46 (0) 122-14347.

DSP Without Tears
December 16-18, 1991, San Jose, CA
Information: Right Brain Technologies. Tel: (404) 420-3834. Fax: (404) 967-1672.

Introduction to Telecommunications
December 10-13, 1991, Washington, DC
December 10-13, 1991, San Francisco, CA
Digital Signal Processing: Techniques & Applications
November 19-22, 1991, Los Angeles, CA
December 3-6, 1991, Washington, DC
Information: Learning Tree International. Tel: (800) 421-8166, (703) 893-3555, (203) 417-8888.

Worst Case Circuit Analysis
December 9-10, 1991, Los Angeles, CA
Information: Design & Evaluation. Tel: (609) 228-3800.

New 1 MFd Capacitor Now Available From ATC

100 kHz to 100 MHz Operation

FEATURES:

- Low inductance / high self resonance
- Low ESR (less than 0.1 ohm from 100 kHz to 100 MHz)
- Reduces RFI at source
- Rugged ATC construction
- High reliability

TYPICAL APPLICATIONS:

- Power supply switching transient filter
- Wideband RF transistor emitter or source bypass
- Wideband RF supply line bypass
- Remove spikes from high clock rate computer DC supply line
- Tuning capacitor for resonant power supplies
- Wideband RF circuit DC block

SPECIFICATIONS:

Dissipation factor (DF): 2.5% maximum at 1 kHz
Operating Temperature Range: -55°C to +125°C
Capacitance Change with Temperature (TC): less than ±15%
Insulation Resistance (IR): 1000 megohms min. (25°C) at rated WVDC
100 megohms min. (125°C) at rated WVDC
WVDC: 300 for .01 MFd; 100 for 1.0 MFd
Dielectric Withstanding Voltage: 2x rated voltage for 5 seconds
Capacity Tolerance: ±20% (Tighter tolerances are available, consult factory)
Termination: Nickel barrier solder coated "pellet" (over silver termination)
Capacity Values: .01 to 1.0 MFd
Mechanical Dimensions: Length .225 ±.020; Width .250 ± .020; Height .165 max (.150 typical)

Call our APPLICATIONS HOTLINE

(516) 547-5708

american technical ceramics CORP.
one norden lane, huntington station, n.y. 11746-2102 usa
phone 516-547-5700 • telex 825707 • fax 516-547-5748

INFO/CARD 14
Please see us at RF Expo East, Booth #608.

Chemists Develop New Carbon Molecules

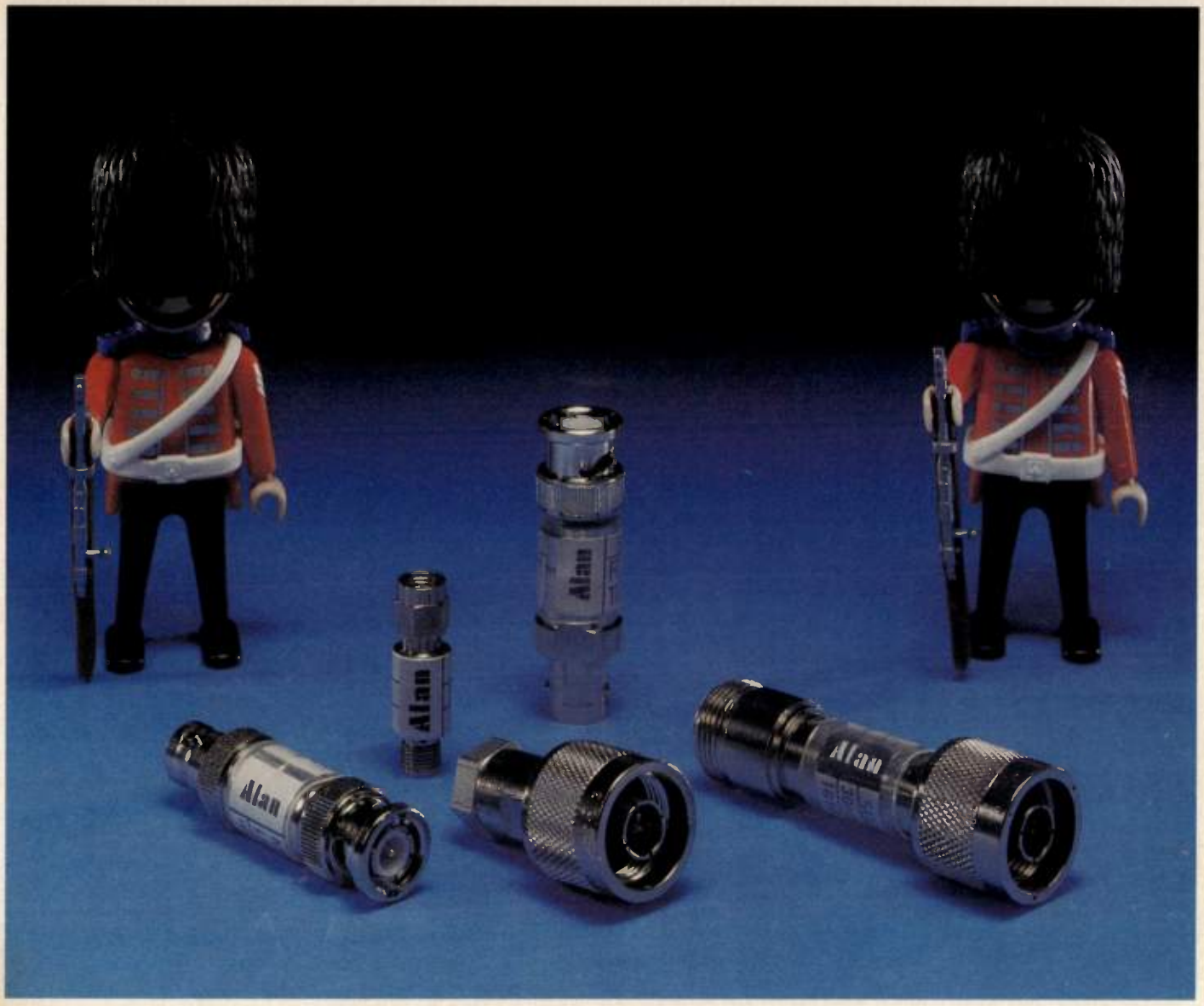
The October 1991 issue of *Scientific American* reported on a new family of stable carbon compounds, called fullerenes, that offer promise as semiconductors and superconductors. These three-dimensional molecules contain familiar hexagon and pentagon arrangements of carbon atoms, but unlike the flat layers found in graphite or diamond, they enclose a nearly-spherical space. Because this is the same architectural principal as the geodesic dome invented by R. Buckminster Fuller, the chemists at Rice University who predicted their existence named them fullerenes.

Although these molecules can be formed from 32 to 100s of carbon atoms, C_{60} appears to be the most stable and easily reproduced form of fullerene due to its perfect symmetry (exactly like that of a soccer ball). This particular molecule has been dubbed buckminsterfullerene, or "buckyball" for short. C_{60} has been found to be a direct band-gap semiconductor like gallium arsenide, but with freer spin characteristics like amorphous silicon. The material becomes superconductive at 18 Kelvins.

The spherical shape and hollow interior allow chemical researchers to enclose other atoms inside the structure, or to create crystals with "doping" atoms located in the spaces between adjacent molecules. A team at AT&T Bell Laboratories found that C_{60} with three potassium atoms per molecule created a metallic compound that can be grown on GaAs or pure C_{60} substrates. A material doped with rubidium and thallium achieved superconductivity at 43 Kelvins in experiments at Allied-Signal, Inc. British researchers have reported the creation of fully fluorinated buckyballs, which, because of their nearly perfect spherical shape, could turn out to be the world's best lubricants.

First postulated in 1985, the existence of fullerenes was confirmed in May 1990. Fortunately, these compounds are easily and cheaply produced in the lab, requiring only a carbon vapor source (arc electrodes or heated graphite) and low-pressure jet of helium. This will allow a great number of researchers to examine their properties. This potentially cheap new material, with its three-dimensional symmetry, may have benefits for both microelectronics and superconducting electronics.

Radio Amateurs Help Defend Russian Parliament Against Coup — When conspirators attempted to overthrow the government of the USSR on August 19, Soviet amateur radio operators were at the Russian Parliament building within hours. Peter Strezev, UA3AOC, ignored a nighttime curfew and took his handheld VHF radio into the building to help feed information to Boris Yeltsin's supporters in Moscow. Other amateurs brought an HF transceiver and a roll of antenna wire through the barricade of tanks and troops to set up emergency station R3A. Early attempts at communi-



Fixed Sentries

Alan precision SP and MP fixed attenuators handle 2 watts average power and up to 750 watts peak power. These accurate, quiet components offer low VSWR and operate over -55 to +125°C. Select from a wide choice of attenuation values, broadband frequency coverage, connector options and **MIL-Qualified** models. Key accessories include Z Series impedance matching pads and F and T Series terminations.

For more information on how our products can help guard your equipment call us today, toll free.

Alan Industries, Inc.
745 Greenway Drive, P.O. Box 1203, Columbus, Indiana 47202
Phone: 812-372-8869 **CALL TOLL FREE: 800-423-5190**
FAX: 812-372-5909

Alan

Manufacturers of...

Attenuators: Programmable • Rotary • Manual Switch • Fixed • Continuously Variable
Accessories: Loads • Dividers • Terminations • RF Fuses • Bridges

INFO/CARD 15
Please see us at RF Expo East, Booth #417.

At last: A complete GPS station clock under $10,000

Everything you want in a GPS station clock, in one neat box:

- **GPS receiver**
- **Disciplined standard**
- **Multiple output timing signal generator, and much, much more.**

What do you expect from a company with more than 30 years of production and field experience in the timing business? You'd expect a one-unit master timing station, capable of tracking six satellites simultaneously — even while moving at 1,000 miles per hour — all inside a 3½ inch rack-mount chassis.

That's the **Model 8810** — a mature product, value-engineered and time-tested, just like the ones we've been providing to NASA and DoD for decades. And there's so much built into this unit, it's hard to describe. Just review the features listed below:

- Automatically determines geographical coordinates — no need to enter position anywhere on earth
- Automatic multi-satellite acquisition
- Time accuracy maintained with platform velocities to over 1,000 mph
- Outputs position data whether stationary or moving
- Multiple time code and rate output options
- User friendly, menu-prompted setup
- 20-key keypad and 4-line, 40 character display allows complete operation, checkout, and status acquisition without ancillary equipment
- Nonvolatile memory stores setup and data indefinitely
- Accurate to within 100 ns worldwide, 24 hours a day
- RS-232 remote control and time output (optional IEEE-488 output)
- RS-232 printer port
- Displays time, position, and REF-UTC/GPS
- Time display is keypad-selectable to UTC, GPS, or local time
- 115/230 VAC with optional 24 VDC backup
- Antenna with 50′ coax cable included
- Built-in test routines
- Fully modularized
- GPS receiver is drop-in replaceable
- Workmanship standards to MIL-STD-454
- Three-year limited warranty
- Plus, a host of desirable options

That's the **Model 8810,** from TRAK Systems. And at this price, there's nothing else like it on the market. So why pay more, and install boxes of equipment, when you can have it all in one neat unit?

For free literature, or more information, contact us at:

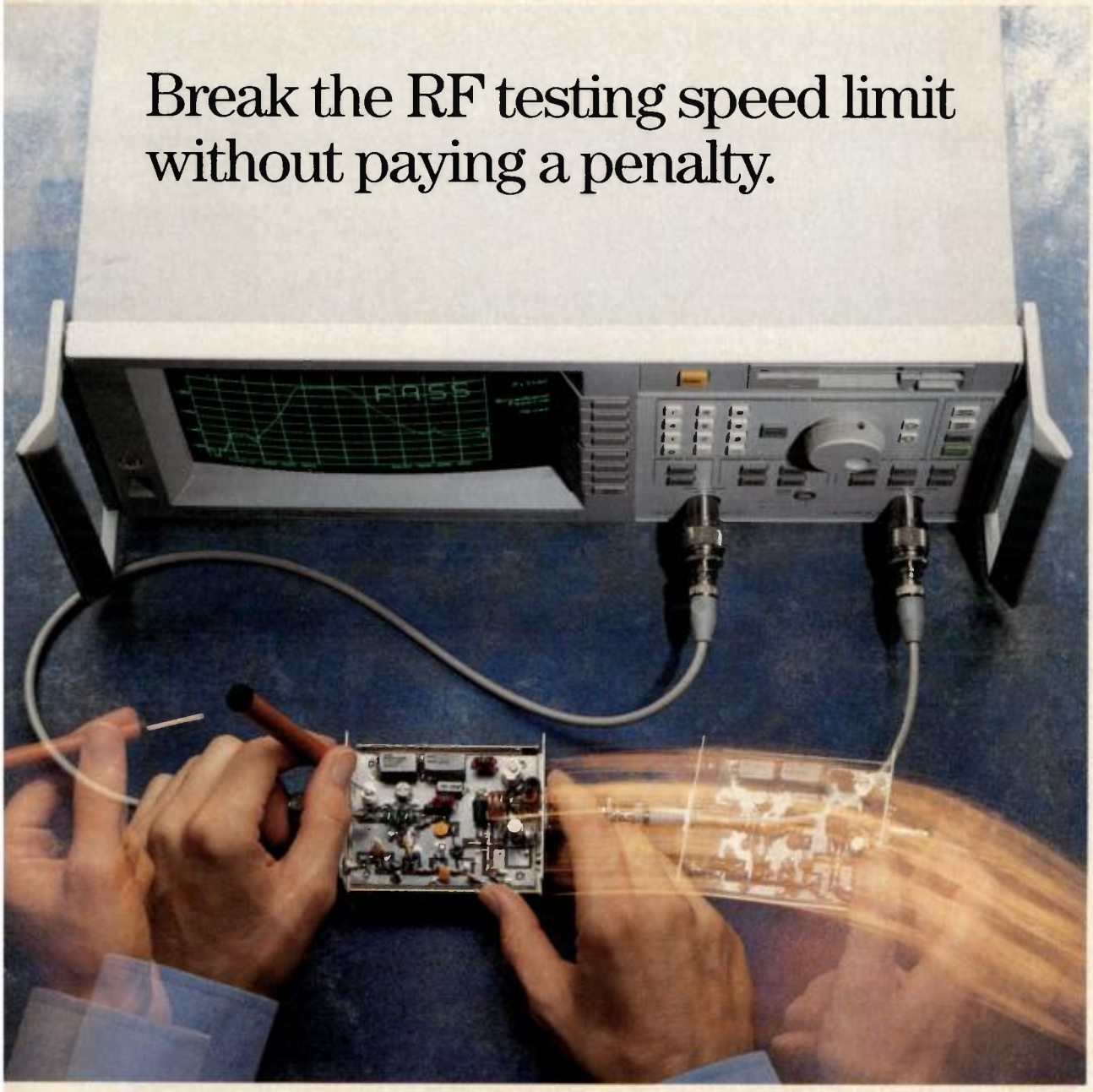
TRAK SYSTEMS DIVISION
4726 Eisenhower Blvd.
Tampa, Florida 33634-6391
Phone: (813) 884-1411, extension 248
TLX: 52-827
FAX: (813) 886-2794

TRAK SYSTEMS
DIVISION OF **TRAK MICROWAVE CORP.**

INFO/CARD 53

Please see us at RF Expo East, Booths #321, 323.

Break the RF testing speed limit without paying a penalty.



The new HP 8711A makes faster RF testing affordable.

To beat the competition in RF manufacturing, you have to get products tested and out the door faster, while keeping costs down. And with the new HP 8711A network analyzer you can do just that.

The HP 8711A brings fast trace update and synthesized accuracy together for the first time. So you can tune in "real-time" from 300 kHz to 1300 MHz—without frequency drift.

Selectable broadband/narrow-band measurement modes let you test conversion loss of frequency translators and mixers. And make high dynamic range (90dB) measurements on filters and switches. All with the same instrument. You don't even need a computer. Built-in automation lets you race through tests without one.

As for cost control, the HP 8711A is just $13,500.* At that price, the only penalty is not having one.

So, move fast. If you'd like more information on the HP 8711A, call **1-800-452-4844.** Ask for **Ext. 2518**, and we'll send you a free video and brochure that show how you can afford to go a lot faster.

There is a better way.

HEWLETT PACKARD

*U.S. Price only.

INFO/CARD 17

Please see us at RF Expo East, Booths #309, 311, 410, 412.

Peter Strezev operates amateur radio station R3A from the Russian Parliament building during the August coup. Photo was sent by Gene Shablygin to Dick Erhorn of ETO.

cations were hindered by KGB jamming, a problem which was solved when two amateurs again crossed the tank lines to bring an Alpha 76A amplifier to the station.

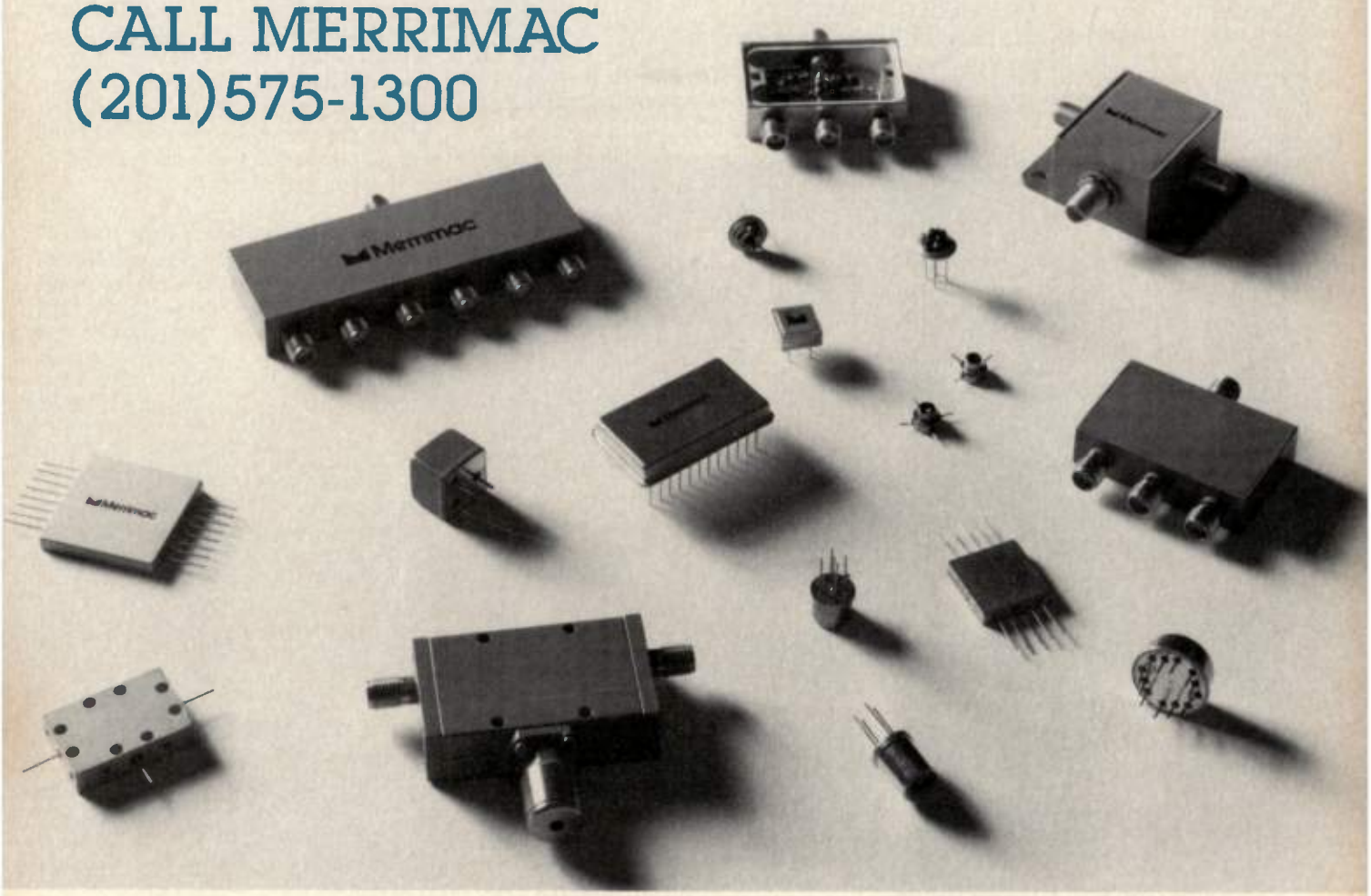
Erhorn Technological Operations (ETO), manufacturer of the Alpha 76A, was honored when president Dick Erhorn received a FAX from the R3A operators on Thursday, August 22, as President Gorbachev was returning to Moscow after the coup's failure. The R3A station with Yeltsin and other prominent Russians at the microphone was shown on both CNN and ABC-TV news reports.

Call for Papers — The second Virginia Tech Symposium on Wireless Personal Communications is slated to be held June 17-19, 1992 in Blacksburg, Virginia. Interested parties are invited to submit a paper for presentation at the symposium. A 500-word abstract should be sent to Ted Rappaport, MPRG, Bradley Department of Electrical Engineering, Virginia Tech, Blacksburg, VA 24061-0111 by November 15.

IEEE Announces Fellowship Program — The IEEE has formed a new program designated the IEEE-USA's

Common Problem:
SPECS CALL FOR CUSTOM DESIGN – DEADLINES CALL FOR OFF-THE-SHELF

Simple Solution:
CALL MERRIMAC (201)575-1300



Our Stock is Anything but Common!

Double Balanced Mixers
Image Reject Mixers
Biphase Modulators
Frequency Doublers
Quadraphase Modulators
Vector Modulators
Single Sideband Modulators
Phase Modulators
I & Q Phase Detectors
Frequency Discriminators
Phase Comparators

Analog Phase Shifters
Digital Phase Shifters
Precision Phase Resolvers
0° Power Dividers
2, 3, 4, 5, 6, 8 & 12 ways
90° Power Dividers
Quadrature Hybrids

180° Power Dividers
Hybrid Junctions
Quadrature Couplers
Filmbrid Couplers
Directional Couplers
Bidirectional Couplers
Complex Phasing Networks
Digital Attenuators
Analog Attenuators
Balanced Switches
Amplifiers & Isolators

Merrimac

41 Fairfield Place, West Caldwell, NJ 07006
Tel: (201) 575-1300 / Fax: (201) 575-0531

INFO/CARD 19
Please see us at RF Expo East, Booths #503, 505.

Technology Administration Fellowship program, designed to identify opportunities and actions that will strengthen the U.S. competitiveness position in critical technologies, especially manufacturing technology. Two fellows have been appointed by the electrical engineering group to work for a period of one year with the U.S. Under Secretary of Commerce for Technology. The Technology Administration Fellows will act as Special Assistants to the Under Secretary for Technology in conducting studies, drafting testimonies, critiquing short and long-range strategies, and providing independent expertise.

Trade Surplus for First Half of 1991 — The EIA recently announced that U.S. exports of electronics products reached nearly $36 billion for the first half of 1991, representing a growth rate of 8.3 percent over last year's exports. According to the report, there is a current positive trade balance of $389 million.

Antenna Measurement Services Expanded — NIST has expanded their antenna measurement services above 30 GHZ in response to requests from industry and other government agencies. The swept frequency gain measurement service now includes the 33-50 GHz band and covers 1-50 GHz with gain values with an accuracy of ±0.3 dB or better for this frequency range. NIST has the capability to measure fixed frequency gain and polarization for 33-65 GHz and to measure antenna patterns for 33-50 GHz. Paper no. 36-91 outlines the high frequency antenna measurement services and is available from Jo Emery, Div. 104, NIST, Boulder, CO 80303.

Electromagnetic Signal Processor Patented — Researchers with the Texas Engineering Experiment Station have developed a new electromagnetic signal processor for use in microwave radar systems, high-speed signal processing, phased array systems, measurement systems, electronic warfare systems, optic-microwave links and microwave communications systems. The constructed device uses a circular ring resonator distributive electromagnetic signal processor. In addition, the structures can be easily and economically mass-produced; individual signal processors may be capable of performing a multiplicity of functions; the ring structures of the design provide improved

900MHz

Cellular base station solutions.

New and complete line of linear amplifiers to the rescue.

Only RF experts like Motorola could package cost effective standard and custom designs to meet cellular base station and many other applications such as linear accelerators, microwave heating or excitors for TV transmitters/translators.

For example, Motorola PA series of Class A and AB amplifier modules incorporate microstrip technology and high performance gold metallized push-pull transistors rugged enough to withstand an infinite VSWR load with no damage.

These complete broadband linear amplifier modules are RFI shielded and housed in aluminum cases.

Motorola's CA Series hybrid high-frequency amplifiers are designed for applications in 50 OHM systems that need wide bandwidth (such as cellular base stations), low noise and low distortion.

Push-pull circuit design provides excellent second order distortion and gain stability over a wide temperature range and linear operation.

These thin film CA hybrids utilize all gold metallization process, are designed specifically for high reliability and are available in standard CA or short heat sink package.

PART NUMBER	LOW PROFILE EQUIVALENT	SUPPLY VOLTAGE	BANDWIDTH (MHz)	GAIN (dB)	POWER OUT AT 1dB (W)	NOISE FIGURE AT 1GHz (dB)	3rd ORDER INTERCEPT (dbm)
PA900-19-100L	N/A	24	865 - 900	19	100*	9.0	N/A**
PA900-19-60L	N/A	24	865 - 900	19	60*	9.0	N/A**
PA900-45-10LGC	N/A	24	865 - 900	45	10	8.5	50
CA4800C	CA4800C,S	24	10 - 1000	17	.400	7.5	38
CA4812C	CA4812C,S	12	10 - 1000	17	.400	7.5	38
CA4815C	CA4815C,S	15	10 - 1000	17	.400	7.5	38
CA4900	CA4900S	24	10 - 1200	17	.400	7.5	38
CA4912	CA4912S	12	10 - 1200	17	.400	7.5	38
CA4915	CA4915S	15	10 - 1200	17	.400	7.5	38
CA5800C	CA5800C,S	28	10 - 1000	15	1.000	8.5	41
CA5815C	CA5815C,S	15	10 - 1000	15	1.000	8.5	41
CA5900	CA5900S	28	10 - 1200	15	1.000	8.5	41
CA5915	CA5915S	15	10 - 1200	15	1.000	8.5	41

* PEP ** CLASS AB

Call for assistance.

Call Motorola at (800)521-6274 today for the best design insurance. Application engineers are ready to help. For literature call (800)441-2447.

See us at Booth #203, RF Expo East, Orlando, Florida

MOTOROLA

INFO/CARD 22

Please see us at RF Expo East, Booths #203, 205, 304, 306.

impedance characteristics when compared to the linear structure of known devices, the device is smaller and provides higher gain and power output than conventional amplifiers; and the device can be easily matched to an external circuit.

New DSP Chip Developed — A digital signal processing chip capable of performing 250 million multiplications and additions per second, has been developed by researchers at the IFI Institute of Advanced Microelectronics at Queen's University in Northern Ireland. The new device, a CMOS Infinite Impulse Response filter can be used in such applications as communications systems, HDTV, aerospace and radar. The device uses a "redundant number systems" technique to increase actual operating speed, which helps break a previously assumed speed barrier in operation. In addition the new chip can be directly interfaced with conventional digital ICs, and the internal circuitry is no more complex than that based on conventional arithmetic.

Electrically Conductive Adhesive for High Clock Rates — Researchers at the Mayo Foundation and 3M's Electronic Materials Application Laboratory have demonstrated clock rates of 1 GHz in an unpackaged and unbumped GaAs IC, flip-chip bonded to a test substrate. The new flip-chip technique uses an adhesive that is electrically conductive only in the vertical (or "z") axis. A clean, low-resistance interconnect is achieved between the pads on the chip and corresponding pads on the substrate. Complete electrical isolation is maintained between adjacent pads.

CAL Signs Antenna Contract — CAL Corporation has signed a contract with Telesat Mobile Inc. to provide magnetically mounted passenger vehicle satellite antennas (the MET-140B), for use in TMI's Mobile Earth Terminal System. The antenna is used for both L-band satellite data communications and for receiving position signals from Loran C/GPS networks. Other terms of the contract were not released.

Hughes Wins Turkish Satellite Contract — Hughes Aircraft Company recently signed a contract to provide traveling wave tube amplifiers for Turkey's communications satellite program. The contract, valued at $6 million, was awarded by Alcatel Espace, which will integrate the amplifiers into the payload. It calls for Hughes to supply 55-Watt Ku-band amplifiers for downlink communications for two Turksat spacecraft.

Cirrus Logic Acquires Crystal Semiconductor — Cirrus Logic Inc. and Crystal Semiconductor Corp recently announced that they have signed a definitive agreement for merger. Crystal Semiconductor will become a wholly owned subsidiary of Cirrus Logic. The merger is structured as a tax-free reorganization and will be accounted for as a pooling of interests. Other terms of the agreement were not disclosed.

WAVETEK COMPONENTS DELIVER

More than 20 years in the design and manufacture of high performance attenuators and filters has led us to one important conclusion: There is no such thing as an unimportant component.

Every RF and microwave component we make has the same dedication to quality and workmanship that our highest Military Standard products do. We know that not just *something* but *someone* depends on our products.

Not only do we design our components to exceed specified performance characteristics, we build them that way. Wavetek production processes are qualified to MIL-T-45208, with documented quality processes and procedures.

Quality, reliability, performance and expeditious delivery are the cornerstones of all Wavetek components: miniature passive filters from 500 KHz to 4 GHz, programmable attenuators from DC to 3 GHz, standard and custom products.

Today Wavetek filters and attenuators serve in a wide array of demanding applications in aerospace, defense, communications, and test equipment industries. These industries count on us. So can you. Because we build every component knowing someone important relies on it.

Find out how Wavetek RF and microwave components can deliver for you. Call 1-800-851-1202 today and request our free *Wavetek RF & Microwave Components Catalog.* Experience Wavetek delivery.

INFO/CARD 24

Please see us at RF Expo East, Booths #116, 118.

WAVETEK®

Courting the Consumer Market

By Gary A. Breed
Editor

The manufacture of consumer electronic equipment has gained new attention in anticipation of lasting reductions in budgets for military hardware. Along with commercial and industrial RF applications, consumer equipment has gotten new attention in recent months.

A serious question that must be answered to the satisfaction of each RF component, test instrument, or subsystem manufacturer concerns the state of end product production. Can renewed interest and effort in manufacturing consumer products in this country catch up with the long experience of Pacific Rim countries? In simpler terms, is there a market here in the U.S., or must a marketing plan be tailored to customers in other countries?

One more question, even more fundamental, is whether the consumer market is growing enough to generate more RF business. A company pursuing this market will have a much harder time displacing existing suppliers than it will have selling into new applications. While it is nearly unanimous that the *potential* for rapid growth exists, the most promising new consumer products are not yet in the pipeline.

Existing Markets

At the top of the list of current RF consumer markets is cellular telephones. Although products like large-screen television sets and personal computers are much larger parts of U.S. electronics manufacturing, the cellular market represents an RF-specific application with possibilities for growth or adaptation into new areas using similar technology. Companies making power transistors, integrated circuits and MMICs, signal processing components, filters, inductors and capacitors continue to pursue the market with vigor.

The cable television and television receiver industry is well-established, and a significant part of U.S. business. Small-signal transistors, frequency synthesizer ICs, RF and IF ICs, filters, varactor diodes, inductors, connectors, and many other RF components have big customers for their products. However, there is little room for the entry of new companies into these markets, since they are mainly served by large component manufacturers. A company seeking a shift away from military products, or a small company seeking diversification of its customer base may find it very difficult to make any headway in these markets.

New Markets

The anticipated extension of cellular-type personal communications has many RF companies excited. Once regulatory matters are settled, there is great optimism that consumers will flock to new technology. It is expected that some kind of mid-level personal communications system will be approved in the U.S. Whether it is similar to the U.K.'s Personal Communications Network (PCN), a microcell system, or simply a "souped-up" cordless telephone with lots of new capabilities, most analysts believe that a significant new RF market will be created.

Until recently, the advent of High Definition Television (HDTV) was heralded as the "savior" of the U.S. consumer electronics industry. Now, with broadcast standards for HDTV still under debate, delays may have allowed the traditional foreign competition to get a head start. Even if the U.S. broadcast standard is drastically different from any other, foreign TV makers will already have experience in HDTV display technology, the most important part of the system.

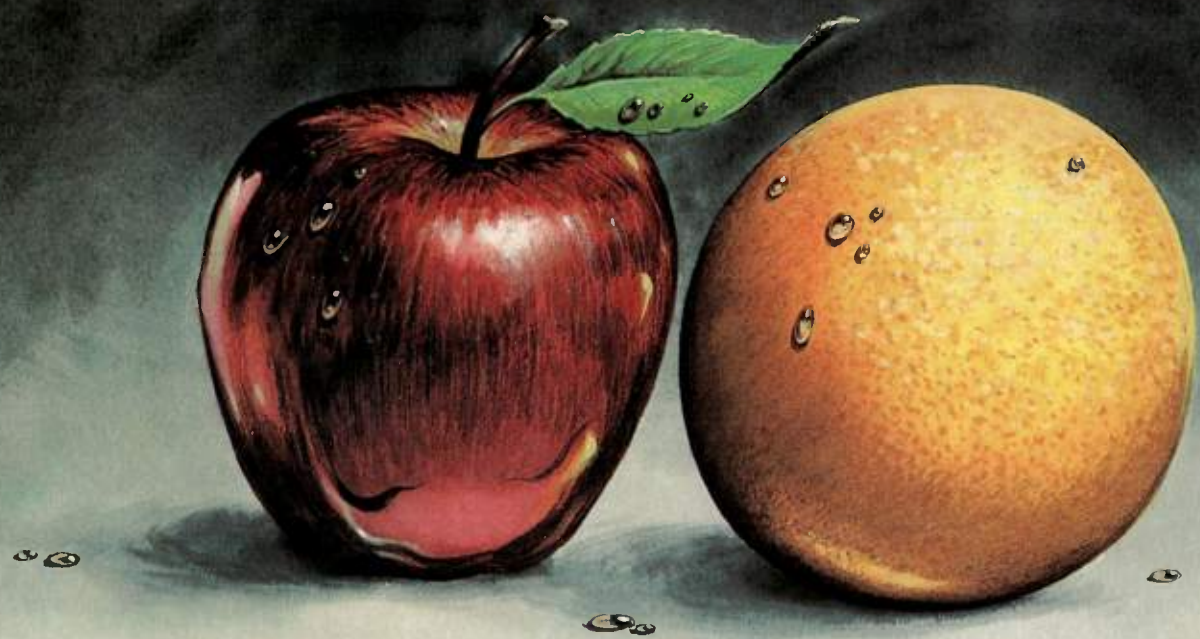
Unlicensed devices operating under FCC Part 15 are being investigated at a frantic pace right now, particularly the new spread-spectrum allocations. The potential for more reliable performance and greater range than was previously allowed has RF engineers working long hours in entrepreneurial efforts. In-home "broadcasting" to distribute video or Compact Disc (CD) audio throughout the house is one area with products already on the market, both domestic and imported. Home security systems with wireless interconnections offer flexibility and easy installation, and represent a new market with great potential.

The personal computer boom offers some interesting new RF applications. Most exciting is the Personal Computer Network (PC-Net) proposed by Apple Computer, which has petitioned the FCC for spectrum allocation. This L-band system would be used to provide wireless interconnection between computers and their peripheral devices. The logic behind it certainly makes sense. First, the various cords can be a mechanical mess, getting in the way. Also, these cables are the main source of radiated emissions; if the digital signals can be contained inside the enclosures, regulatory compliance would be simpler. A narrowband RF link offers few EMI problems compared to broadband digital RF noise. Finally, with battery powered laptop computers, why should we worry about plugging things together just to get a printout or use a better monitor?

The industry consensus is that consumer electronics will continue to grow, perhaps very rapidly. Whether experienced offshore manufacturers will remain dominant is the major question. For some RF component manufacturers, it doesn't matter — they will rely on foreign markets if necessary. For others, a resurgence in U.S. electronics manufacturing will be necessary to make consumer products viable markets for their products. ***RF***

For reprints of this report, contact Cardiff Publishing Company at (303) 220-0600. Ask for the Circulation Department.

EVERYONE'S DEFINITION OF HIGH POWER RF AND MICROWAVE AMPLIFIERS IS NOT THE SAME.



To some, one watt represents high power. To others, it takes a good deal more.

However, whatever *your* definition is, we build it. From a single watt, up to a 100 watt amplifier; and any increment of power in between.

In addition, if one of our standard models doesn't meet the need exactly, we can design one that does. With not only the output power, but also the form factor, frequency/bandwidth, class of operation, and other options.

All Trontech assemblers are also certified to MIL-S-45743E — and products can be supplied to the new workmanship standard, DOD-STD-2000.

So when your specs call for a high power commercial or military amplifier, whether it be cellular radio, EW, communications, avionics, GPS, active decoy or any other system, specify the source that offers real choice. Along with quality, performance, and a proven track record with most of the major primes: Trontech! Your system is sure to benefit from the fruits of our labor.

STANDARD HIGH POWER RF AND MICROWAVE AMPLIFIERS

Model Number	Frequency Response (MHz) Min.	Max.	PO @ 1dBc (dBm) Min.	Intercept Point 3rd Order (dBm) Min.	Typ.	SS Gain (dB) Min.	Flatness (dB) Max.	VSWR (In)	VSWR (Out)	VDC
P316A	311	321	50 100 w	Class C		40	±1.5	2:1	2:1	110 VAC
P500A-3	0.1	500	30 1 w	40	42	33	±1	2:1	2:1	+24
P500L-3	2	500	37 5 w	47	49	30	±1.5	2:1	2:1	220 VAC
P894-40	869	894	42 16 w	52	54	35	±1	1.5:1	2:1	+15
PF880-39	869	896	39 8 w	49	51	40	± .5	2:1	2:1	+24
P928M-40	902	928	40 10 w	50	52	40	±1	2:1	2:1	+15
PIGA-36	500	1000	36 4 w	46	48	40	±1	2:1	2:1	+24
PIGA-40	500	1000	40 10 w	50	52	44	±1	2:1	2:1	+24
P1400M-37	400	1400	37 5 w	47	49	20	±1	2:1	2:1	+24
PF19GA-40	1700	1900	40 10 w	50	52	30	±1	2:1	2:1	+24
PF19GA-43	1700	1900	43 20 w	53	55	35	±1	2:1	2:1	+15
P2GF-1	1	2000	30 1 w	40	42	32	±1	2:1	2:1	+15
P1020-40	1000	2000	40 10 w	50	52	27	±1	2:1	2:1	+24
P1020-43-PS	1000	2000	43 20 w	53	55	33	±1.25	2:1	2:1	110 VAC
PF2GA-40	1800	2000	40 10 w	50	52	35	±1	2:1	2:1	+24
P2450M-46-PS	2445	2455	46 40 w	56	58	36	± .5	2:1	2:1	110 VAC
P25GA-40-1	2100	2600	40 10 w	50	52	30	±1	2:1	2:1	+24
P35GA	3000	3500	33 2 w	43	45	30	±1	1.5:1	1.5:1	+15
P42GA	500	4200	30 1 w	40	42	40	±1.5	2:1	2:1	+20

DELIVERIES TO YOUR SCHEDULE/PROMPT RESPONSE TO INQUIRIES

REQUEST LITERATURE ON COMPLETE LINE

TRONTECH INC.

38 Industrial Way East, Suite #1, Building #2, Eatontown, New Jersey 07724 • (908)542-1133 • FAX (908)542-1118

SW-449

INFO/CARD 25

Please see us at RF Expo East, Booth #614.

WRH

NOW AVAILABLE FROM AMPLIFONIX

LOW COST SWITCHES

WITH INTERNAL TTL DRIVERS

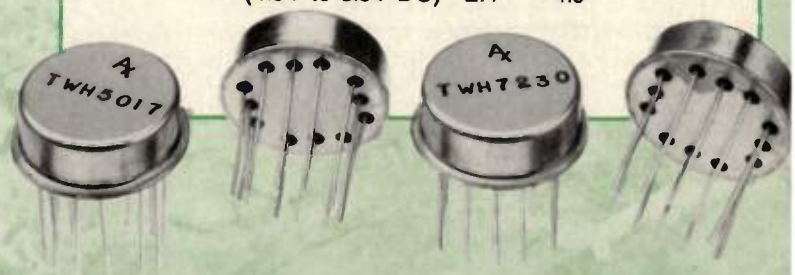
SP2T, SP3T, SP4T & SP5T FROM $39.00

- Min/Max Specifications Guaranteed Over −55° to +100°C.
- Hermetically Sealed TO-8B Package.
- Switches Reflective in Off State.
- Lower Cost, Reduced Isolation Units Available.
- Delivery From Stock.
- Screening to Tables of MIL-STD-883 Available.
- Call or write for Amplifonix' Catalogue listing our Complete Line of PIN Diode and GaAs MMIC Switches.

SPECIFICATIONS

SP2T P/N TWH7230 Price (10-24) $39.00	**SP4T** P/N TWH7425 Price (10-24) $59.00
SP3T P/N TWH5016 Price (10-24) $49.00	**SP5T** P/N TWH5017 Price (10-24) $69.00

Freq Range (MHz)	10-3000	
Insertion Loss (dB)	**TYP**	**MAX**
10-100 MHz	1.0	1.5
100-1500 MHz	1.2	1.6
1500-3000 MHz	1.4	2.4
Isolation (dB)	**TYP**	**MIN**
10-100 MHz	70	60
100-1500 MHz	45	35
1500-3000 MHz	35	30
1 dB Compression (dBm)	**TYP**	**MIN**
10-100 MHz	18	8
100-1500 MHz	27	20
1500-3000 MHz	30	29
VSWR (ON)	**TYP**	**MAX**
	1.3:1	1.6:1
Switching Time (μSec)	**TYP**	**MAX**
(50% TTL to 90% RF)	2.0	3.0
Bias (mA)	**TYP**	**MAX**
(4.5V to 5.5V DC)	2.4	4.0



Amplifonix

2707 Black Lake Place • Philadelphia, PA 19154 • Phone: 215-464-4000 • FAX: 215-464-4001

INFO/CARD 26

A Low Cost UHF AM Receiver

By Robert Friday and
John Neder
Metricom, Inc.

The origins of the low cost UHF AM receiver shown in Figure 1a come from the frustrations of trying to control a stereo system with an infrared controller from the second floor of a home. After trying IR reflectors and amplifiers, I resigned myself to walking downstairs to control the stereo. Each trip down the stairs, I wondered why the majority of controllers are based on infrared technology and not some other technology such as garage door openers. If a garage door can be opened from around the block, a stereo should be able to be turned off from the second floor of a house.

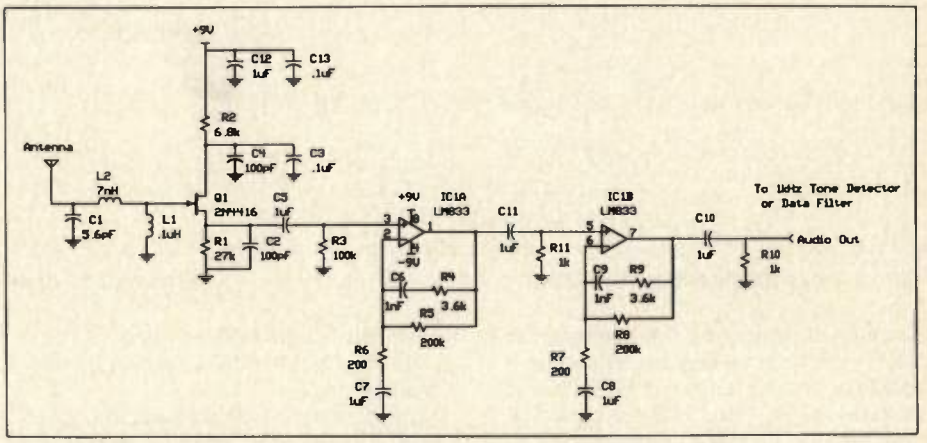


Figure 1a. Schematic of a low cost UHF AM receiver.

Some of the reasons why IR controllers are so prevalent might include: IR receivers are smaller and less costly to build than a UHF receiver; FCC regulations do not limit the power of IR controllers; and the characteristics of IR frequencies in a cluttered environment such as a house are more predictable than UHF frequencies.

After working with UHF devices employing FM modulation techniques for the last three years, I have been rather impressed at the performance of these devices in the indoor environment and thought it would be interesting to see if the first two reasons could be overcome for an indoor UHF AM communication link.

The FCC Regulations and Range Analysis

The low cost UHF AM receiver discussed in this paper is designed to be used with a low power transmitter operated under Part 15 of the FCC rules. The emphasis of the design was to minimize the cost to performance ratio for a short range UHF communication link. Combining the receiver discussed in this article with a low power, Part 15 transmitter would provide a short range communication link on the order of 50 feet. Possible uses of such a link are remote control functions (VCRs, TV, automobile locks) and low speed (1200 baud) digital communication links.

Operation of the transmitter under paragraph 15.249 of the FCC rules would allow for emissions of 50 mV/meter (using quasi-peak detector measurements) at a distance of three meters in the 902-928 MHz band. Using the equation:

$$E = \frac{\sqrt{30\ W_{rad}}}{d} \qquad (1)$$

E = the RMS value of the electric field ($V\ m^{-1}$)
W_{rad} = The power radiated by an isotropic point source (W)
d = The distance between the point source and where the electric field measurement is made (M).

It can be calculated that a .75 milliwatt (−1.25 dBm) isotropic transmitter is allowed under the rules. Such a transmitter coupled with a −62 dBm receiver would provide for a 60 dB line sight path loss. Assuming zero dBi gain for both the receiving and transmitting antennas and using the equation:

$$W_{rec} = W_{rad}\left[\frac{\lambda}{4\pi d}\right]^2 \qquad (2)$$

W_{rec} = Power delivered to the load at the receiving antenna
W_{rad} = Power radiated at the transmitting antenna
d = Distance between the transmitting and receiving antennas.

A line of sight communication path of 22.5 M (73 feet) is possible.

Overview of the Block Diagram

The block diagram in Figure 1b shows a basic AM receiver. The goal of the circuit presented in this paper was to implement this block diagram for under two dollars and achieve sensitivity performance exceeding −60 dBm. The antenna and filter blocks were implemented using a microstrip patch antenna. The advantages of the microstrip patch antenna is that it has inherent selectivity (bandwidth .5 percent to 3

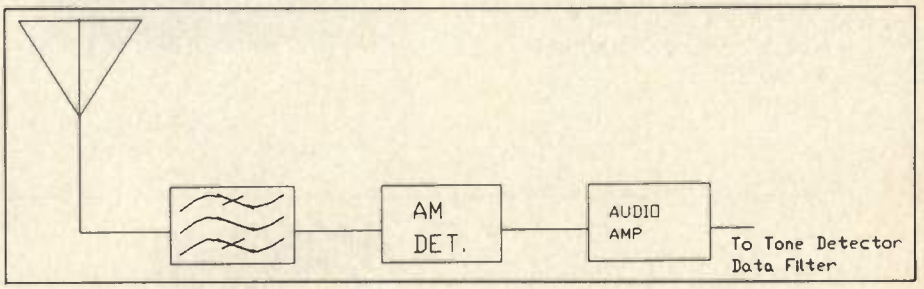
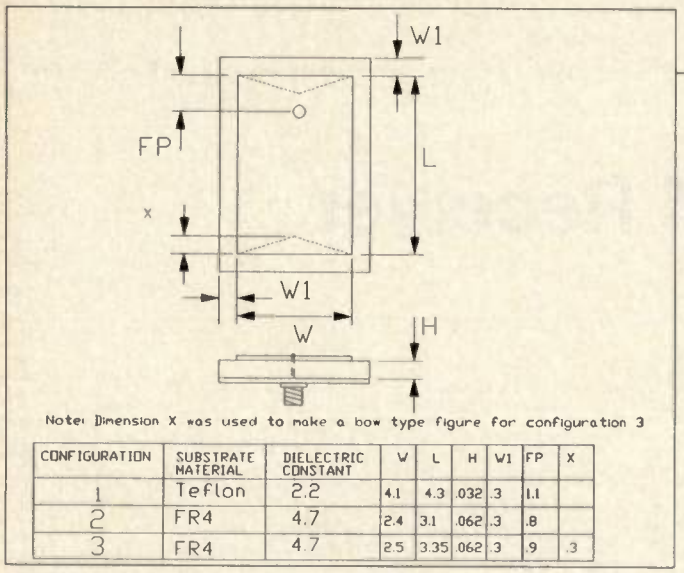


Figure 1b. Block diagram.



Note: Dimension X was used to make a bow type figure for configuration 3

CONFIGURATION	SUBSTRATE MATERIAL	DIELECTRIC CONSTANT	W	L	H	W1	FP	X
1	Teflon	2.2	4.1	4.3	.032	.3	1.1	
2	FR4	4.7	2.4	3.1	.062	.3	.8	
3	FR4	4.7	2.5	3.35	.062	.3	.9	.3

Figure 2a. Antenna configurations.

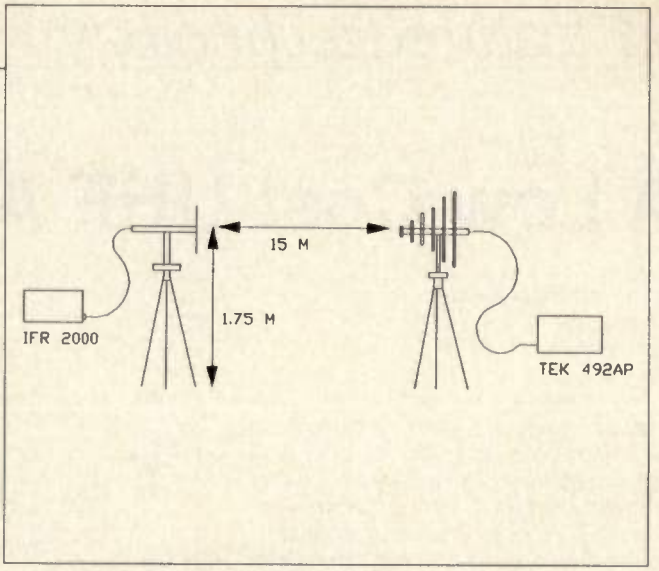


Figure 2b. Antenna test setup.

percent) and is very inexpensive to implement. It can easily be etched on a standard printed circuit board and is relatively small. Experimental data was collected for patch antennas built on both PTFE and FR4 as a substrate. Although the FR4 version was not as efficient as its PTFE counterpart, it was decided to trade performance for cost in this case and use FR4 epoxy glass for the substrate.

The detector block was implemented using an infinite source impedance detector based on an N channel JFET. This structure was chosen over the more common super-regenerative and direct conversion structures found in most garage door openers for cost reasons. Using such a detector with 50 uA of bias current, a receiver sensitivity (12 dB SINAD for a 1 kHz tone) of −62 dBm was achieved. It is speculated that the sensitivity could be improved upon with more research and experimentation.

Finally, an Alternative....

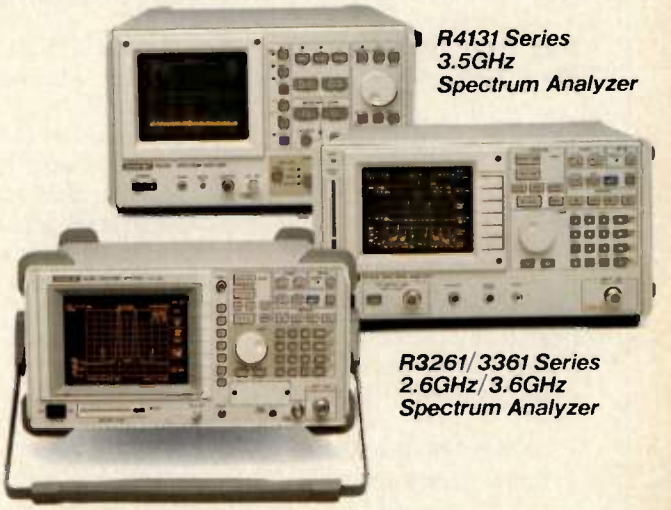
High-performance Spectrum Analyzers.

26.5GHz

NEW

R3271
Spectrum Analyzer

Portable Spectrum Analyzer Family



R4131 Series
3.5GHz
Spectrum Analyzer

R3261/3361 Series
2.6GHz/3.6GHz
Spectrum Analyzer

The Advantest R3271 Portable Spectrum Analyzer with wide 10Hz to 3MHz IF filter is capable of continuous repetitive sweep and measurements from 100Hz to 26.5GHz. An 8-point multi-marker and list display functions simplify spurious measurements and low-signal response measurement. The high-speed 5μs/div sweep and digital readout make it the optimum choice for mobile communications research and development.

NEW *R3265*
8GHz Spectrum Analyzer

New visions in test instrumentation

ADVANTEST®

ADVANTEST CORPORATION Shinjuku-NS Building, 4-1, Nishi-Shinjuku 2-Chome, Shinjuku-ku, Tokyo 163, Japan Tel.(03)3342-7500 Fax.(03)3342-7410

Advantest America, Inc. 300 Knightsbridge Parkway, Lincolnshire, IL 60069, U.S.A. Tel.(708)634-2552 Fax.(708)634-2872

Advantest UK Limited CI Tower, St.Georges Square, High Street, New Malden, Surrey, KT3 4HH, U.K. Tel.(081)336-1606 Fax.(081)336-1657

Advantest (Singapore) Pte.Ltd. 150 Beach Road, #01-00 Gateway West Singapore 0718 Tel.299-4268 Fax.299-4226

INFO/CARD 28

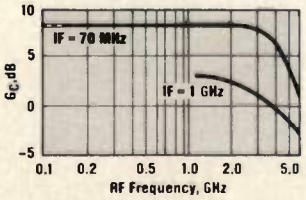
Please see us at RF Expo East, Booths #110, 112.

AVANTEK 5 GHz ACTIVE SMT MIXERS WILL BRING YOUR SYSTEM DESIGN TO LIFE

And Bring A Little Fun Back To Designing

Avantek's new IAM-81008 silicon MagIC™ MMIC is the Gilbert cell active mixer/amp that will keep your parts count low, increase your circuit yield and become the design-in standard for all your communication circuits. In an SO-8 plastic SMD package, it's a complete frequency conversion device that costs only $3.40 in 25,000 piece quantities. Made with Avantek's advanced 10 GHz f_T ISOSAT™ process for more consistent performance than passive diode/balun devices. It requires as little as –5 dBm LO drive, and provides up to 6 dB RF and IF conversion gain from 50 MHz to 5 GHz, with high isolation and broad load-insensitivity—all from a single 5V supply.

IAM-81008 RF to IF Conversion Gain vs. Frequency

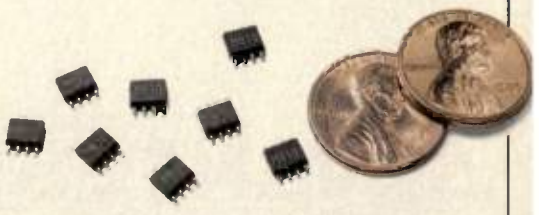


Upconverter, Downconverter, Multiplier, Phase Detector, Modulator, or Demodulator...

The versatile IAM-81008 is perfect for pocket transceivers, portable telephones, or spread spectrum terminals, MSAT and GPS receivers—it's *the mixer* for all your communications circuit designs. And it's available in tape and reel for high volume SMT manufacturing.

Avantek Delivers Today

Call your Avantek distributor or 1 (800) AVANTEK for your free mixer design kit, and see if this mixer/amp doesn't make you smile.



AVANTEK

INFO/CARD 29

Please see us at RF Expo East, Booth #606.

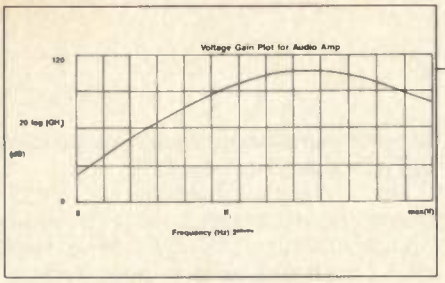


Figure 3. Voltage gain

The audio amp block was implemented in the prototype using an LM833 dual op amp with feedback networks to provide approximately 110 dB of gain at 1 kHz and a limited amount of selectivity. In the final version, a low cost op amp such as the LF353 would probably be used.

Antenna and Filter Blocks

The antenna and filter block functions were combined into the microstrip patch antenna, Figure 2a. The design equations used for the antenna were:

$$L = 0.49\left[\frac{\lambda}{\sqrt{E_r}}\right] \quad (3)$$

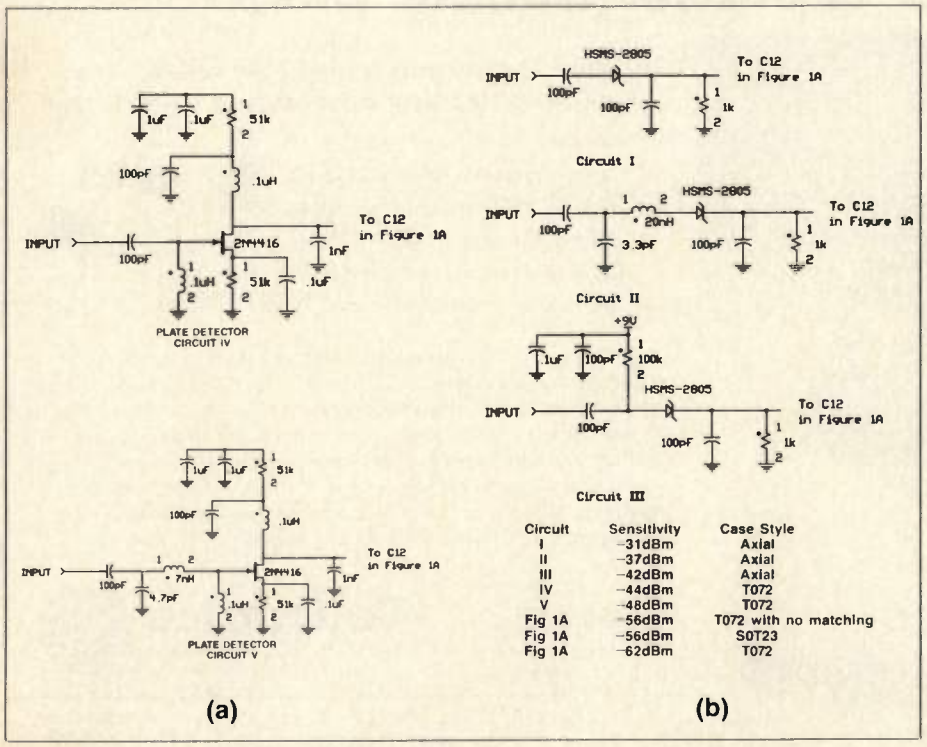
$$R_{in} = (-.5\ \beta_1 + 72.5) \quad (4)$$

$$BW = 4f^2\left[\frac{H}{.032}\right] \quad (5)$$

10 degrees $< \beta_1 <$ 70 degrees

E_r = Dielectric constant
L = Length of the patch
f = Frequency of operation
H = Thickness of the substrate
β_1 = Distance of the feed point from the end of the patch measured in electrical length

From examining the design equations it can generally be said that the length of the antenna determines the frequency of operation, the location of the feed point determines the input impedance and the thickness of the substrate determines the bandwidth (Figure 2b). The efficiency of such an antenna is dependent on factors such as the dielectric constant, loss tangent, the conductor losses, the reflected power, and the cross polarization loss. Efficiencies of 95-99 percent have been reported for patches using air as a substrate and 10 percent for patches using glass epoxy (1). Our experimental results confirmed that the PTFE patch was more efficient than its FR4 counterpart. The results show that a 4 dB loss in antenna gain is suffered in choosing the FR4 patch over the PTFE patch. It was decided, however, to use the FR4 version for cost reasons. The PTFE material cost is approximately six times that of standard FR4. Additionally, PTFE is more costly



Circuit	Sensitivity	Case Style
I	−31dBm	Axial
II	−37dBm	Axial
III	−42dBm	Axial
IV	−44dBm	T072
V	−48dBm	T072
Fig 1A	−56dBm	T072 with no matching
Fig 1A	−56dBm	SOT23
Fig 1A	−62dBm	T072

Figure 4. Experimental results.

to process. The experimental results also show a bandwidth of 24 MHz (3 percent) for the FR4 patch antenna built on 0.062" substrate versus 11 MHz for the antenna built on 0.031" thick PTFE. Since the patch configuration has a very narrow bandwidth, the electrical length of the patch is critical in determining the frequency of operation and would most likely have to be adjusted using either a laser or variable cap during some phase of its assembly.

The AM Detector Block

The AM detector block was implemented using an infinite source impedance detector. This type of detector was chosen over a diode detector because the amplifying action of the JFET provides better sensitivity performance. The infinite source impedance detector also does not load the input tuning stages thus allowing the antenna to independently determine the selectivity of the receiver. The theory of operation of the detector is to bias the JFET so that it is operated very near the cut off point. This is easily accomplished using a simple self biasing configuration as shown in the schematic in Figure 1a. The application of a signal then causes the average drain current to increase which is then rectified by the source resistor and capacitor (2). The JFET then basically acts as a diode with gain at 915 MHz and a low turn on voltage. Various detector configurations based on JFETs and diodes shown in Figure 4a were investigated and the experimental results are shown in Figure 4b. Sensitivity measurements were based on a 12 dB SINAD for a 1 kHz tone which was felt to be adequate for a tone detector. The experimental results were obtained using an HP8903A audio analyzer and a Fluke 6060B signal generator with 90 percent AM modulation. Experimental results showed that matching the input impedance of the detector to that of the antenna in general provided a 3 to 6 dB improvement in performance. So as to avoid an adjustment step during assembly and lower cost, the inductors L2 and L1 shown in the prototype circuit would eventually be incorporated into the PCB.

The experimental results and prototype circuit presented in this paper show the potential for a UHF AM receiver with low to moderate performance having a cost of materials for under two dollars. Further work needs to be done in the area of characterizing the performance of an UHF AM link in an indoor environment, additional temperature characterization and improved sensitivity of the detector are needed. ***RF***

References

1. Richard Johnson, Henry Jasik, *Antenna Engineering Handbook*, McGraw-Hill, New York, pp. 7-13 to 7-14.
2. ARRL, *The Radio Amateur's Handbook*, 1982, ARRL, Connecticut, p. 8-4.

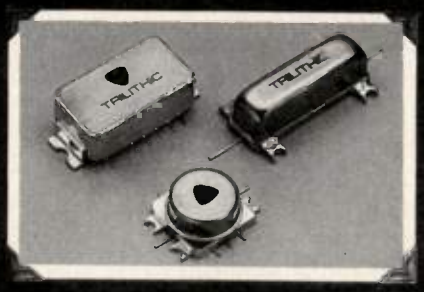
About the Authors

Robert J. Friday is an RF Design Engineer and John Neder is an RF Technician for Metricom, Inc., 2605 Nodder Blvd., Campbell, CA 95008. Tel: (408) 370-1818.

Trilithic Family Album

From our industry leading surface mount filters to our time-proven rotary and fixed pad attenuators, Trilithic is your source for a complete family of RF and microwave components. Our strict quality assurance standards apply to all product lines, whether your application is for high reliability military or field-tough commercial items. In addition, Trilithic's high stock volume ensures competitive pricing and availability, so call us toll-free at 800-344-2412, and get acquainted with our family.

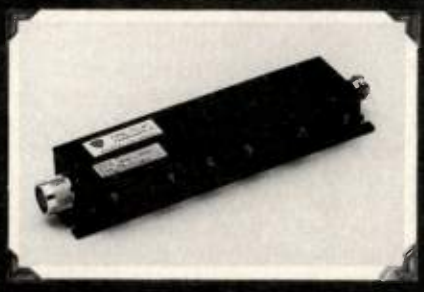
Miniature filters



Surface mount filters

Tubular filters

Waveguide filters

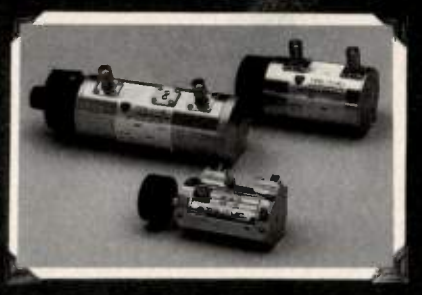


Cavity filters

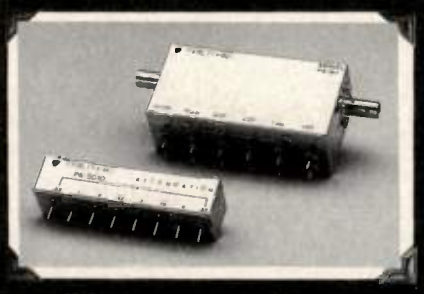
Tunable filters

Coaxial attenuators

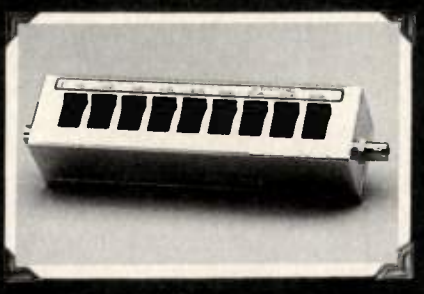
Pushbutton attenuators



Rotary step attenuators



Programmable step attenuators



Switch attenuators

Microwave coaxial attenuators

TRILITHIC

9202 East 33rd Street • Indianapolis, IN 46236
Phone: 317-895-3600 1-800-344-2412 FAX: 317-895-3613

INFO/CARD 31

Please see us at RF Expo East, Booth #208.

WRH

A Simple, Low Cost Microwave LAN Link

By Peter Minett
GEC Plessey Semiconductors

Here is a design idea for a very low cost microwave data link. The requirements of the IF amplifier are quite severe as it must cope with at least 40 dB of signal variation due to variations in atmospheric attenuation. It must also have a rise and fall time better than 25 ns to avoid the corruption of data. Finally, it must be inexpensive, since this is a low cost link!

Conventional design solutions for IF systems using AGC amplifiers, either in integrated or using discrete transistors, can be difficult to design and often require set up adjustment. A simple solution to the problem is to use a logarithmic/limiting amplifier as a straight limiting amplifier.

These devices have been available as costly hybrid or board level products for many years but a new device from GEC Plessey Semiconductors, the SL3522, gives a 60 dB limiting amplifier with a frequency response from 100 to 600 MHz. The IF chosen for this application is 140 MHz, well within this range. In addition, the rise and fall times are both better than 25 nS. This device is supplied in a miniature ceramic surface mount package, 0.7 inches long. It is shown in Figure 2 in use as a limiting amplifier (as opposed to its more usual configuration as a successive detection logarithmic amplifier).

Output is 0 dBm differential into a 50 ohm load. It is also internally terminated into 50 ohms. The device has a chip decoupling capacitor for good RF stability and operates from a single 5 V supply rail. It uses less than one watt with a powerdown facility in the final stage.

The System

Figure 1 is an outline of a simple, cost effective 10 GHz (10 Mbit) link between to Ethernet LANs. The various system blocks can be readily purchased from a number of different suppliers, and are not described in detail here. With careful selection of components and with modest requirements for system performance, this link can be implemented at a very low cost. ***RF***

About the Author

Peter Minett is a product manager in the Personal Communications Division of GEC Plessey Semiconductors. He may be reached at Cheney Manor, Swindon, Wiltshire, UK SN2 2QW. Tel: (44) 793 51-8000. Information can be obtained from GEC Plessey Semiconductors, 1500 Green Hills Road, Scotts Valley, CA 95066. Tel: (408) 438-2900.

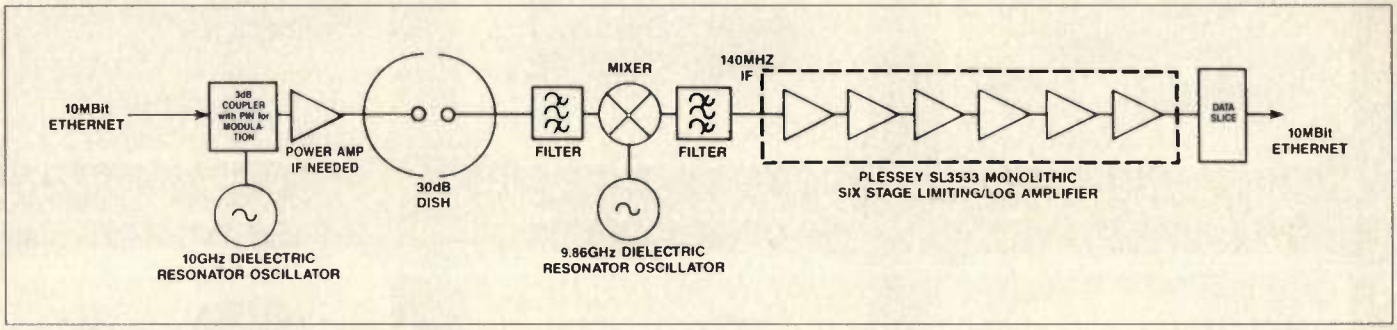


Figure 1. A low cost microwave link.

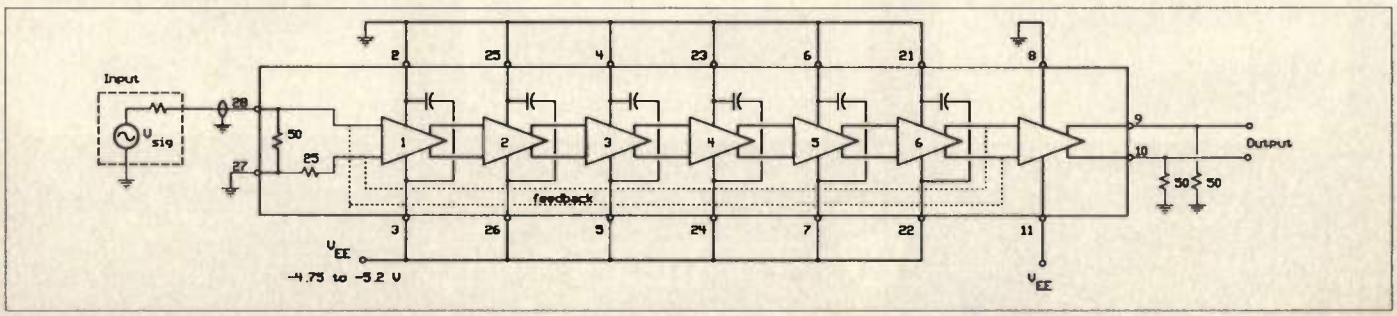
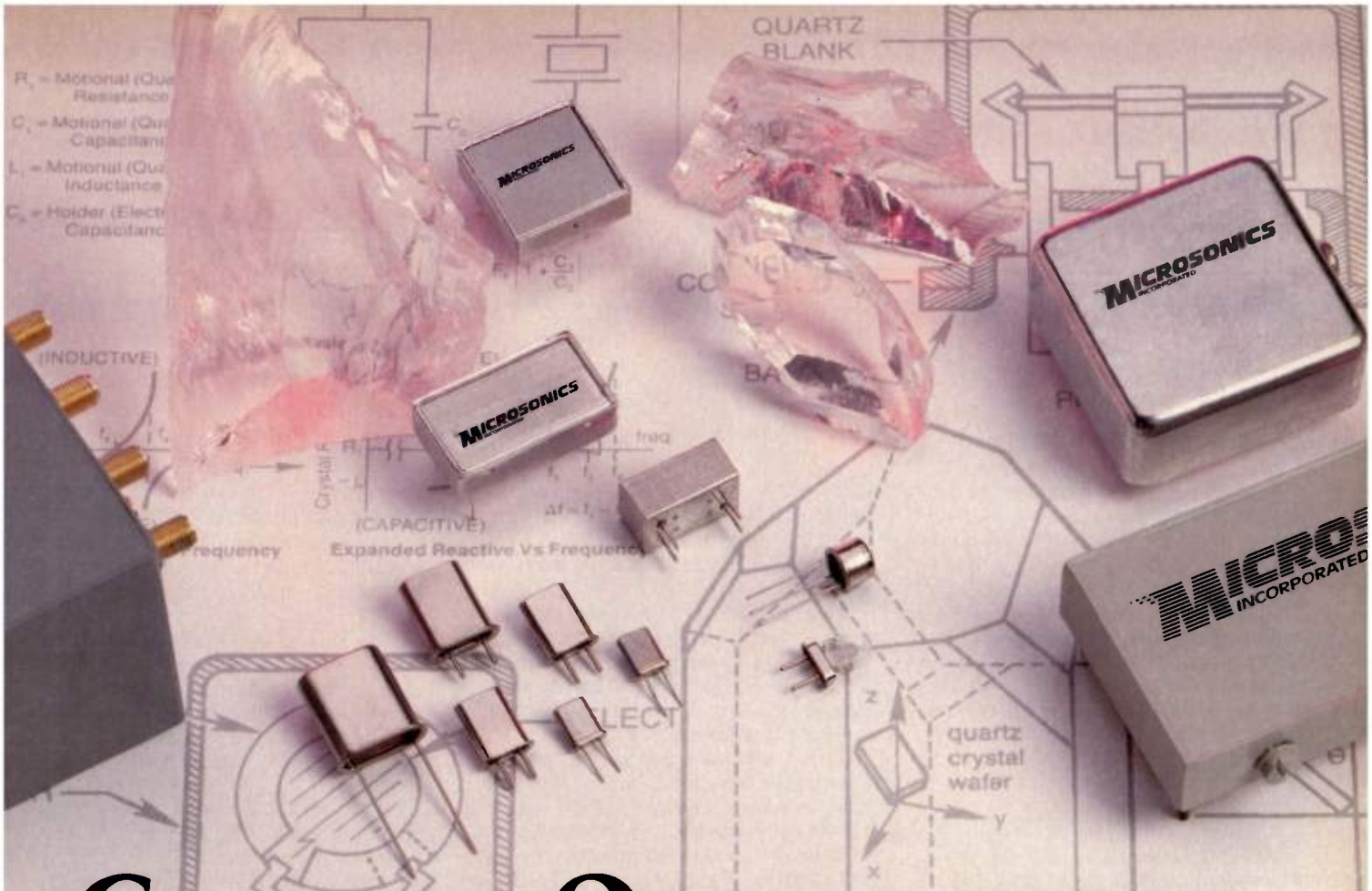


Figure 2. In use as a limiting amplifier.



CRYSTAL OSCILLATORS, FILTERS and DELAY LINES

Microsonics, Inc. a subsidiary of Signal Technology Corporation, has supplied high reliability crystal oscillators, filters and delay lines, for more than 30 years.

Our in-house crystal design and manufacturing facility ensures low phase noise and excellent long term stability in all our crystal oscillator products (TCXO and VCXO's) from 1 KHz to 1000 MHz.

Our crystal and LC filters feature low insertion losses and are available in a number of configurations, including narrow and wide bandwidths, from 10 KHz to 200 MHz. Designs are available to meet specific requirements for group delay equalization, amplitude, phase tracking, and time domain response.

Using glass and quartz as a medium, we offer the video, military, and avionics industries a wide range of delay lines from 0.25 µs to 5000 µs. Features include: Wide bandwidths, excellent phase characteristics, temperature stability, small sizes, and low power consumption.

30 years of experience with the ability, and dedication to provide real solutions to customer requirements today, and tomorrow.

Microsonics, Your source for Crystal Oscillators, Filters, and Delay Lines in the 90's.

Call today for more information.

MICROSONICS
INCORPORATED

A Subsidiary of Signal Technology Corporation

60 Winter Street Weymouth, MA 02188-3336
(617) 337-4200 FAX (617) 337-4200

INFO/CARD 113

Please see us at RF Expo East, Booths #722, 724.

A Two-Chip Solution for Audio Processing

By Alvin K. Wong
Signetics

The demand for portable, battery-powered telecommunications products has expanded significantly in recent years. This demand is being driven by the convergence of several trends, ranging from the availability of more channels for public use to the development of cost-effective manufacturing processes and the adoption of protocol standards worldwide. One of the most important of these trends is the evolution of highly integrated, low-power components that can be used in a wide range of products.

A critical element in the design of telecommunications products is audio processing. To achieve the desired audio performance while minimizing product size, weight and cost, the designer needs to be aware of important issues to be addressed and alternative solutions. These issues are common to applications such as cellular radio, high-performance cordless telephones and intercom systems, as well as hand-held, base or mobile two-way communications equipment.

This article defines audio processing, and describes a dual chipset solution that addresses the complex problems of today's portable applications.

What Audio Processing Involves

Audio processing involves all the steps between one person's speaking into a transmitter and another's hearing the message at a receiver. The main objective of the system is to maintain voice quality in the presence of noise and other distortion factors. The major problems in processing audio correctly are listed below.

First, the audio processor has to accommodate a range of speaking voices. Soft voices have to be heard as easily as loud ones, and high-pitched as well as low.

Second, voice signals can bleed into adjacent channels and cause interference if they deviate too widely from their assigned bandwidths. System output should be less than 12 kHz for maximum frequency deviation regardless of the input signal.

Third, background noise needs to be suppressed when no voice signal is present. This is particularly important for products normally used in a noisy environment, such as car phones.

Lastly, in the process of maintaining voice quality, the audio processor must not turn on too slowly or too rapidly, since it can cut off or distort the first syllable transmitted.

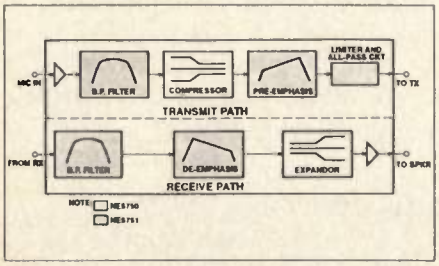


Figure 1. Key functions of the NE5750 and NE5751 that contribute to improving the S/N ratio and sensitivity in the system.

The Two-Chip APROC Solution

The audio problems listed above can be readily handled while maintaining the desired voice quality from transmission through reception using compression/ expansion and pre-emphasis/ de-emphasis techniques. Signetics' two-chip audio processor, called APROC (Audio PROcessor Chipset), provides an efficient solution to these problems. The key elements of this solution are detailed in Figure 1.

To accommodate the variability in voice quality, the APROC uses a series of filters in conjunction with companding and pre-/de-emphasis. During transmission, the voice signal from the microphone first goes through a programmable gain preamplifier and is screened through a bandpass filter. Once the noise has been filtered out, the signal is processed by a compressor that attenuates loud voices and amplifies soft ones.

Next, a pre-emphasis filter is used to boost upper voice frequencies before their voltage amplitudes are restricted

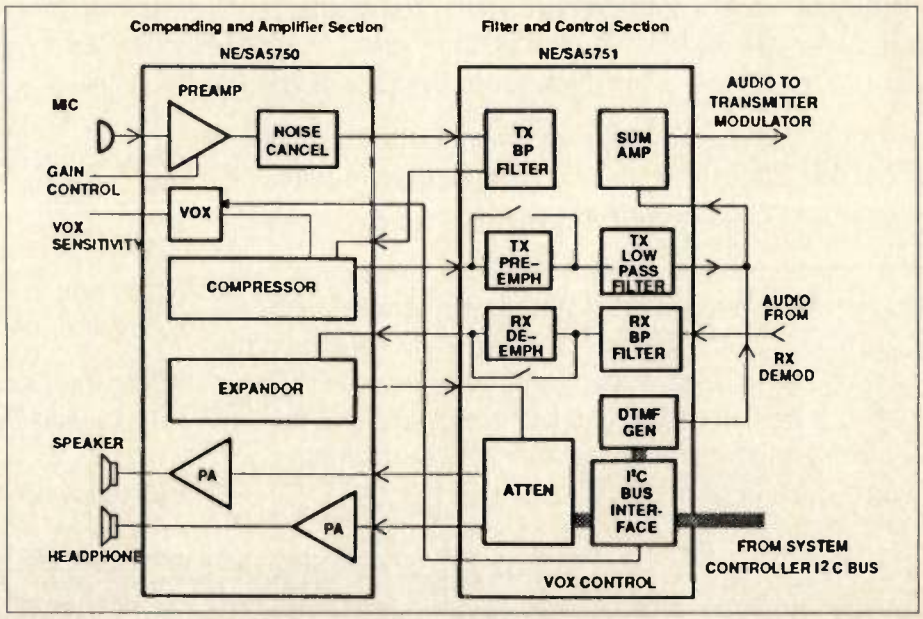


Figure 2. Typical configuration of audio processor (APROC) system chipset.

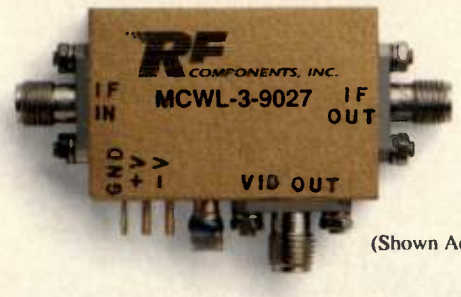
Log Amplifiers

MCWL-3-9027
Guaranteed Specifications*

Frequency Range	20 to 100 MHz
Dynamic Range	0 to -70 dBm
Log Linearity(1)	
@ 25°C	±1 dB Max.
Over Temperature	±1.5 dB Max.
Sensitivity (Slope)	
@ 25°C	25 mV/dB Nominal
Over Temperature	± 5%
Rise Time (10-90%)	50 ns Max.
Fall Time (90-10%)	400 ns Max.
Tangential Sensitivity	-75 dBm Max.
Voltage Output Range	0 to 2.0 V Nominal
VSWR	
Input	2.0:1 Max.
Output	2.5:1 Max.
Limited IF Output	-2 ± 2 dBm
RF Input Power	+10 dBm Max.
RF Impedance	50 Ohms Nominal
Video Load Impedance	93 Ohms Nominal
DC Power	+5 VDC @ 50 mA Max. -5 VDC @ 110 mA Max.
Operating Temperature	-54 to +85°C

(1) Best fit straight line at each frequency and temperature.

* Enhanced performance narrowband versions also available. Contact factory for details.



(Shown Actual Size)

Another Technological Breakthrough in Log Amplifiers.

RF Components' monolithic, ultraminiature, Log Amplifier offers unbeatable performance, at an unbeatable price.

$495.00

Quanity 1-24
Stock to 4 week delivery

RF COMPONENTS, INC.

a subsidiary of Signal Technology Corporation

28 Tozer Road, Beverly, MA 01915-5579
Tel: 508.922.0019 FAX: 508.927.9328

INFO/CARD 114

Please see us at RF Expo East, Booths #722, 724.

by the limiter and all-pass circuit. DTMF signals can be added to the audio (dialing, digital data communications, etc.). The processed voice signal is then ready for transmission.

At the receiving end, the voice signal is "deprocessed". Again, the received signal is screened by a bandpass filter to remove SAT (Supervisory Audio Tone) signals and noise before it goes through de-emphasis. De-emphasis unboosts the audio signal at higher frequencies, maintaining the same signal-to-noise ratio throughout the voice band and thereby avoiding the "colored noise" effects generated by FM demodulators in all FM receivers.

Finally, the audio signal is expanded back to its primary dynamic range, restoring the voice to its original state. The recovered audio then goes to on-chip power amplifiers which drive an earphone and an external speaker.

APROC Chipset Architecture

The APROC chipset divides audio processing functions between the two chips. Companding is handled in bipolar technology (on the Signetics NE5750), while filtering is carried out with switched capacitor techniques (on the NE5751) using CMOS. This architecture not only maximizes performance, it also allows either chip to be used in a system without the other. A typical configuration of the APROC is shown in Figure 2.

The NE5750's companding/amplifier features include a preamp with adjustable gain from 0 dB to 40 dB that allows the designer to boost low-level audio signals coming out of the microphone. The preamp output is sent to a noise canceler circuit, which minimizes background noise from transmission. This works in conjunction with a Voice Operated Transmitter (VOX) circuit to turn the preamp gain on and off. The VOX attack and release time must be carefully set to assure good audio quality.

The filter/control section of the NE5751 provides transmit bandpass, pre-emphasis and low-pass filters, as well as receive de-emphasis and bandpass filters. The device also features a programmable DTMF generator and attenuator. A final on-board circuit provides the interface for the I^2C serial control bus. This offers the designer a convenient means of controlling the configuration of both chips.

Noise Reduction Techniques with APROC

Noise can be introduced into the system in several ways: at the microphone (from background sounds), through a base station (as switching noise or cross talk) or in the RF channel (as cross-channel interference).

The APROC's noise canceler circuit is able to minimize background noise because it automatically provides a set gain of either 0 dB when no signal is present or 10 dB when there is a signal. This automatic gain setting can only be implemented when the noise canceler circuitry is used in conjunction with the chipset's VOX circuitry. With these noise canceler capabilities and the audio processing techniques discussed earlier, designers can be assured of controlling the signal-to-noise ratio throughout the system, from microphone to speaker.

Imagine A Single Source For Every Frequency Control Need...

Now Imagine What That Source Can Do For You.

With CTS, you can specify from one of the broadest lines of frequency control products available anywhere—crystals, clock oscillators, VCXO's, TCXO's and ovenized oscillators. If a standard product won't do, our engineers will design one that meets the requirements of your application. But there are more reasons for making CTS your single source for frequency control products.

Our cutting-edge technology assures you of the most advanced frequency control products. The in-house production of crystals, precision designs and strict quality control give you an added margin of reliability. Additionally, our technical support teams provide a problem solving capability that can be a real asset for your design and engineering teams.

Get the product your application requires, plus technical services and reliability proven in the most demanding military, instrumentation, telecommunication and data processing applications. All from a single source. Call now for the name of your CTS Sales Representative.

CTS
CORPORATION

Around The World,
Your Single Source For Excellence[SM]

CTS Frequency Control Division,
400 Reimann Ave., Sandwich, IL 60548, Tel: 815/786-8411, Fax: 815/786-9743

INFO/CARD 34
Please see us at RF Expo East, Booth #315.

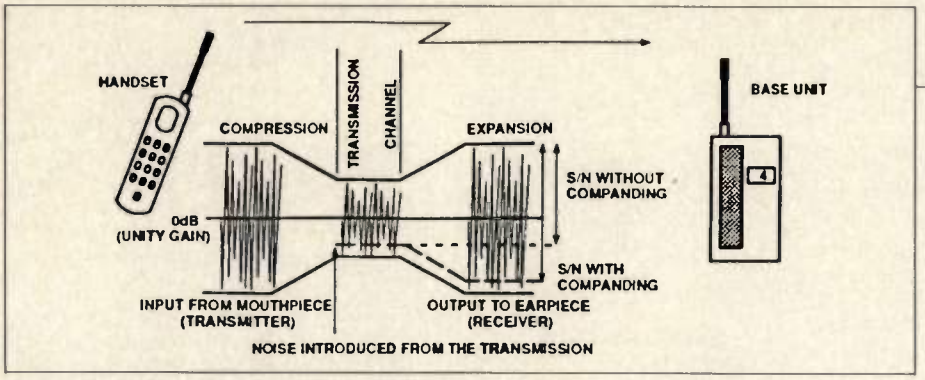


Figure 3. S/N ratio with companding vs. without companding.

As shown in Figure 3, companding substantially improves the S/N ratio for APROC. During compression, low-level signals are amplified to "jump" over the transmitter channel noise, while the high-level signals are compressed to prevent distortion. The S/N results, with and without companding, can be seen here for a cordless phone application.

Special APROC Features

The APROC chipset includes on-chip all of the functions necessary to implement applications such as cellular telephones. In fact, APROC meets all AMPS and TACS specifications while reducing the external chip count — an important consideration for portable devices.

The charts contained within Figure 4 reveal how the signal would appear on the bench with different input levels. Figures 4a, b and c all use the same audio input signal. The audio signal (0-6 kHz) varies from 20 dB to −30 dB in 10 dB steps.

Figure 4a represents the TX channel. Shown is the signal's increase in amplitude as the frequency is increased due to pre-emphasis. For large inputs, the slope of the signal decreases due to deviation limiting. The compressor function is readily shown, where a 5 dB change in the output level occurs for every 10 dB change in the input.

Shown in Figure 4b are the 2:1 expansion of audio (20 dB change in output for every 10 dB change in input), bandpass filtering and the de-emphasis filter response (300-3 kHz). The graph, which represents the RX channel, demonstrates the signal's decrease in amplitude as the frequency increases due to de-emphasis.

As seen in Figure 4c, a flat frequency response is achieved upon normal reception. Of note is the 20 dB gap, despite the fact that the input steps are for 10 dB. This is due to the noise canceler turning on. The decrease in amplitude for higher level, higher frequency tones is the result of the deviation limiter action.

The APROC chipset also features a power-down standby mode, available when the audio is not being used. The power-down mode provides the system just enough power to "stay alive" and is therefore not expected to be fully operational. The system is designed to return quickly to the power-up mode for full operation. This fast reaction time is the result of all capacitors maintaining their charges because the power was not completely cut off. The power-down function reduces overall current con-

MORE Building Blocks

RNet™ Telemetry Products from Motorola

RF Boards RF Modems Telemetry Radios

With more to come!

INTRODUCING

- RNet™ "SLM" Packaging
  Only 3.9" L X 2.5" W X 1" H
- RNet™ 9600 BPS Capable RF Modem in both Standard and "SLM" Packages

For years, design engineers seeking solutions have been turning to Motorola for product support. Now, as you envision new opportunities within the context of a wireless society, Motorola is there again with building block RF components that will enable you to move from design to production . . . the RNet™ Series of OEM RF boards, telemetry radios and RF modems.

It doesn't matter if you are dealing with remote control, RF Data Collection, alarm reporting, status monitoring, metering or SCADA applications, Motorola's heritage of quality engineering and world class products provides you with the "Building Blocks" to support your current and future requirements.

Envisioning . . . that's your job.
Enabling . . . that's ours.

For more information and detailed specifications on RNet™ RF modems, telemetry radios and OEM radio modules,

Call 1/800-624-8999 Ext. 105

RNet™ RF Modems

Frequency	403–430 MHz, 450–470 MHz
RF Output-TX	2 Watts or 4 Watts
Selectable Data Rate	1200/2400/4800/9600 BPS Asynchronous
Modulation	1200,2400-MSK; 4800,9600-DGMSK
Operation	Half-Duplex or Simplex
Protocol	Transparent to the User
Data Format	7 bits with even, odd, mark or space parity 8 bits with even, odd, mark, space parity or no parity
DTE Interface	RS-232 or TTL
Standby/RX Current Drain	32mA (RS-232) or 27mA (TTL)

MOTOROLA

1301 East Algonquin Road
Schaumburg, IL 60196

Ad#RT911

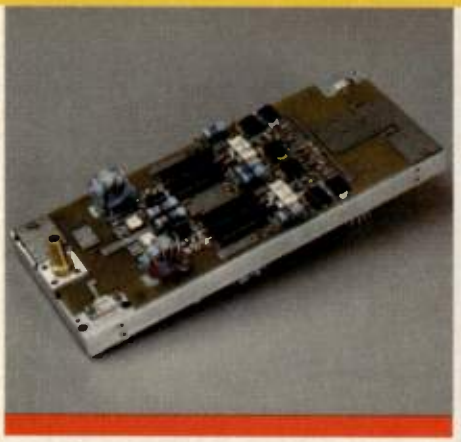
INFO/CARD 36

RF POWER FOR OEMS, Systems Integrators and End Users

For over 21 years ETO has supplied rugged, cost effective and technologically advanced RF power products for demanding industrial, scientific, medical, and communications applications. ETO alone serves all these markets with standard, semi-custom, and custom amplifiers and RF power supplies from LF to UHF, one watt to 20 kW.

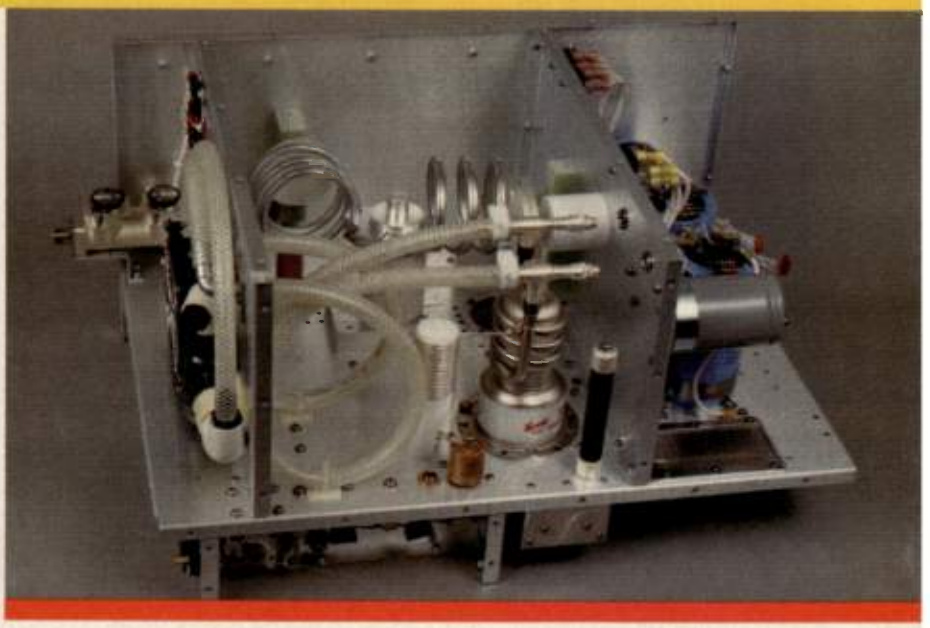
ETO's 15 and 20 kW, microprocessor-controlled linear amplifiers power more of the world's high-field MRI scanners than all competitors *combined!* And since 1970 we've delivered over 10,000 "standard" kilowatt-and-up RF power amplifiers and generators.

ETO understands the needs of OEMs, including responsive application engineering, fast prototyping, system integration assistance, and regulatory approvals. We combine rapid manufacturing ramp-up with strict quality standards, timely delivery, and international field service. We provide everything from small modules to complex systems with the "partnering" support OEMs require.



1 KW VHF POWER SUPPLY, ETO Model SGV-1D. *Water-cooled MOSFET design for plasma applications in the 50-150 MHz range. RF module only, or complete system including driver and power supply.*

HIGH PERFORMANCE



5 KW RF POWER GENERATOR, ETO Model PG-5DW *for plasma and general industrial applications. RF deck of water-cooled version shown; available for any frequency to 90 MHz as a complete system including power supply and controller.*

20 KW RF LINEAR POWER AMPLIFIER, ETO Model PL-20DP. *Being delivered now to OEM's of high-field MRI systems. Available promptly for any frequency to 90 MHz. Microprocessor-based control system with integral LCD display permits local or remote management of the amplifier and its integral diagnostics.*

1 KW HIGH EFFICIENCY MOSFET HF POWER SUPPLY, ETO Model SG-1D *for plasma and other industrial applications. Available for 13.56, 27.12, or 40.68 MHz, or any frequency 2-41 MHz. RF module shown.*

Contact Don Fowler or Alyssa Drew to learn how ETO can satisfy your RF power requirements.

INFO/CARD 37

ETO EHRHORN TECHNOLOGICAL OPERATIONS, INC.
RF Power for Communications, Industry, Science & Medicine

4975 North 30th Street, Colorado Springs, Colorado 80919 (719)260-1191 FAX (719)260-0395

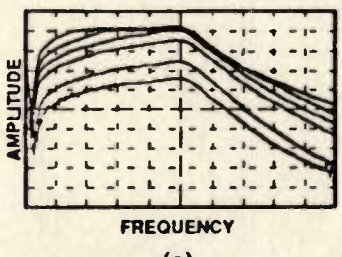
sumption by 74 percent when the system is not active and is especially helpful when the system is operating from a battery-powered source.

Development Aids

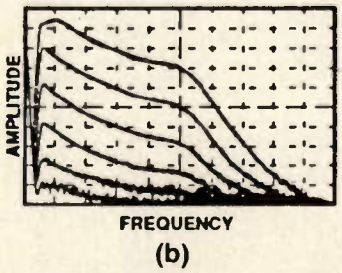
An APROC demonstration board is available to speed up the development process. It can be used in conjunction with an I²C Evaluation Program to determine if the chipset meets the designer's needs.

A separate board is used to interface the APROC demo board with the computer's parallel port. This converter uses the 74LS05 as a buffer scheme. Figure 5 shows how the interface board and the demo board are used in conjunction with a computer.

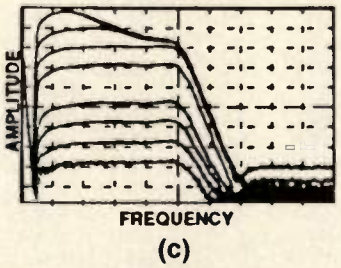
An I²C program for the APROC is provided, enabling designers to easily program and evaluate the chipset without writing an evaluation program. The



(a)



(b)



(c)

All Graphs:
10 dB/Div Center: 3000 Hz
SPAN: 6000 Hz

Figure 4. a) transmit channel (audio level decreasing), b) receive channel, c) loopback.

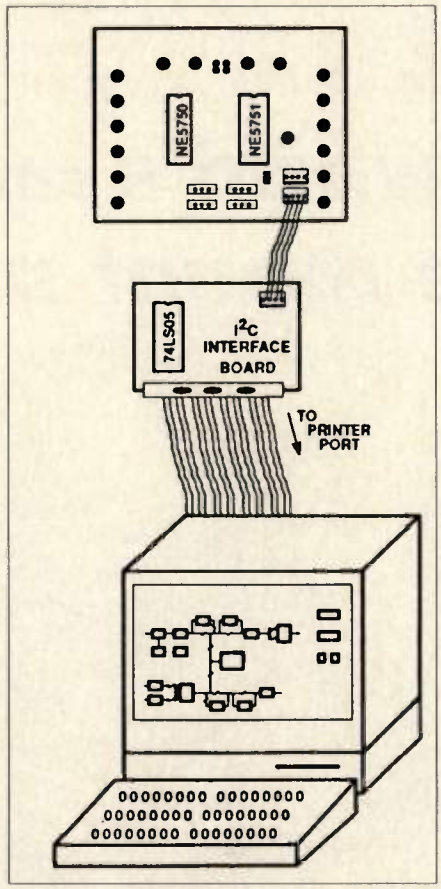


Figure 5. Interfacing the APROC demo-board with the I²C evaluation board.

APROC evaluation program features a graphic display capability that shows the transmit and receive path of the APROC. By selecting a function, a designer can toggle the space bar on the keyboard to turn on or off any key features. A designer can also type in the codes for any registers to control functions. The result is a demo system that allows designers to make any number of their own evaluations on the chipset without having to develop their own microcontroller hardware and software, which results in time savings and lower R&D costs. ***RF***

About the Author

Alvin Wong is a RF Application Engineer who has been with Signetics for 3 years. He holds a BSEE from San Jose State University. He may be reached at 811 E. Arques Avenue, PO Box 3409, Sunnyvale, CA 94088-3409. Tel: (408) 991-4544.

RF Prime...

The Other Source

for the *world's smallest* surface mount mixers.

RF Prime 5 Year WARRANTY MAXI-REL

Now Available in a Low Profile Package .125 max. height

At the highest frequency available–

up to ~~2500 MHz~~ 3GHZ; LO up to 17 dBm

from $5.25

RF Prime now offers a full line of "MAXI-REL" quality surface mount mixers with a 5-year warranty. These units are assembled utilizing RF Prime's all-welded construction. RF Prime, a leader in weld technology, is the first mixer manufacturer to use weld technology for its *entire* mixer line. These mixers are in a non-hermetic plastic/ceramic package .250 x .310 x .200. in. and are now available with an industry-first, low-profile height of only .125 in.

RF Prime has extended its wideband coverage to 2.5 GHz with the introduction of the RFMS-6, and now offers LO power up to 17 dBm on the RFMS-1A-17, RFMS-2-17, and the RFMS-5-17.

Now you don't have to settle for less. RF Prime is your source for superior quality, high technology, surface mount mixers. RF Prime, where quality is designed in — not just tested in.

Call today for information on our entire product line of RF/Microwave components: mixers, transformers, power splitters/combiners, and phase detectors.

Specifications, selected models

Model	Frequency, MHz		LO Level	Conv. Loss[1]	Price, $
	LO/RF	IF	(dBm)	(dB)	(1-9)
RFMS-1	0.5-500	DC-500	+7	8.0	5.25
RFMS-2	5-1000	DC-1000	+7	9.0	5.95
RFMS-2A	5-1000	10-1000	+7	8.0	5.95
RFMS-4	5-1500	DC-1000	+7	9.0	10.95
RFMS-5	10-2000	DC-1000	+7	9.5	15.95
RFMS-6	10-2500	DC-1000	+7	9.5	24.95
RFMS-1A-10	2-500	DC-500	+10	7.7	6.95
RFMS-2-10	5-1000	DC-1000	+10	9.0	7.95
RFMS-5-10	10-1500	DC-1000	+10	9.0	11.95
RFMS-1A-13	2-500	DC-500	+13	7.7	7.95
RFMS-2-13	5-1000	DC-1000	+13	9.0	8.95
RFMS-5-13	10-1500	DC-1000	+13	9.0	10.95
RFMS-1A-17	2-500	DC-500	+17	8.5	9.95
RFMS-2-17	5-1000	DC-1000	+17	9.0	10.95
RFMS-5-17	10-1500	DC-1000	+17	9.0	15.95

Note 1: Max. over total range.

So, it's about time.
Dial *800-878-4669*

RF Prime

RF Prime, Inc. • 11305 Sunrise Gold Circle • Rancho Cordova, CA 95742 • Ph: 916/852-8334 • Fax: 916/852-0689

INFO/CARD 39

Finding New Homes for RF Technology

By Gary Simonyan
NCI Systems
A Division of Noise Com, Inc.

Despite Desert Storm and the current fracturing of the Soviet Union, military spending is not soon likely to increase. Manufacturers of RF components, subsystems, and systems must now look for sources of revenue in the commercial sector. Fortunately there are many commercial telemetry and communications applications in which the radio waves provide a more desirable transmission path than cable. This article describes just a few.

There are many intriguing opportunities for RF systems in the commercial sector. They are found in applications as diverse as medicine, ocean surveying, networking, and remote monitoring, and they call upon the unique properties of RF to provide capabilities that would otherwise be provided at much greater cost by hard-wired alternatives.

Reaching Out

The greatest single driver of RF technology in the commercial sector is cellular telephone communications. The overwhelming support for the cellular concept in the top 30 markets has spread to the top 60 markets, and now into the top 120 markets. Each one represents a large sales opportunity for everything from the simplest RF component to systems integrating RF and digital components.

While the cellular market may be the largest and most visible commercial driver of RF technology, a large group of applications collectively called Supervisory Control and Data Acquisition (SCADA) use RF telemetry extensively. Communications without wires, the inherent advantage of RF technology, is their most enticing feature. When compared to the cost and restrictions imposed by leased telephone lines or fiber optic communications, RF telemetry systems often seem a bargain.

Surveillance is a good example of an application in which RF telemetry provides a cost-effective solution. An RF-based surveillance system, called a Remote Intrusion Monitoring System (RIMS), was constructed for the US Customs Service to detect the presence of activity at sensitive areas such as national borders.

Thousands of acoustic sensors, each one coupled to a tiny battery-operated wireless transmitter, are mounted in enclosures which are buried in the ground. When vibrations are detected, the sensor sends a signal to a central location. RIMS allows a surveillance system to be constructed and removed quickly, without reliance on hard-wired communications between the sensors and the central site. RIMS utilizes tiny custom-designed transmitters and a microprocessor-controlled receiver at the central site.

Going Underground

Every day, tens of thousands of people pass through the Holland and Lincoln tunnels spanning the Hudson River between New Jersey and New York. Some continue to listen to their favorite radio stations as they pass through, unaware that they have RF technology to thank for the convenience. The Port Authority of New York and New

The purpose of a radiating cable system is announced to motorists at the mouth of the Lincoln Tunnel.

Another use of RF: the portable noise jammer, which makes conference rooms safe for sensitive conversation.

Jersey rebroadcasts signals from some New York area radio stations on the tunnel's radiating cable transmission system. The system has been working faithfully since 1984.

The system consists of a broadcast band receiver, transmitter, linear amplifier, various passive components, a control system mounted in the control room, and enormous lengths of special coaxial cable that run the length of the tunnels. While simple in concept, the system requires considerable expertise to implement. For example, proximity of the radiating cable to other electronic systems operating in the tunnel has the potential to cause interference. In addition, the unusual propagation conditions in the tunnels make delivery of a good signal at all points a difficult task. Nevertheless, application of filters and a detailed analysis of signal propagation produced a system that delivers excellent results day after day. The system broadcasts traffic information as well as selected AM radio stations.

Energy management systems are also excellent applications for RF telemetry equipment. These systems monitor the performance of heating, cooling, and power equipment in a group of facilities and report the status to a central site. In more sophisticated two-way systems, the automated central controller has the ability to control the remote systems via the telemetry link. Such software-driven systems poll each remote site at specific intervals. In one-way systems, the remote points simply report information, which is dutifully sampled and recorded at the central site.

Dozens of facilities can be linked in this way, without reliance on leased lines. The RF portion of the central site system consists of a receiver, omnidirectional antenna, and some type of visual and audible indicator. The remote sites utilize electronic or electromechanical sensors that are connected to the source to be monitored (boiler, transformer, thermostat, etc.). They send signals to a transceiver, which in turn takes this input and sends it digitally via an RF modem and directional antenna to the central site.

More elaborate systems use the power of a computer to make decisions concerning conditions encountered at the remote sites. These decisions are transmitted to the remotes, which then send a signal to decrease or increase the controlled parameter or stop operation entirely.

RF is often the best solution in energy management systems because the cost of leasing telephone lines is sometimes an order of magnitude greater than the cost of installing and operating RF systems. The RF system is also a one-time purchase, and eliminates reliance on an outside source for the transmission path. Costs after the sale are for the minimal electricity required to operate the system, spares, and repair. Considering the mature state of RF technology, reliability is generally excellent.

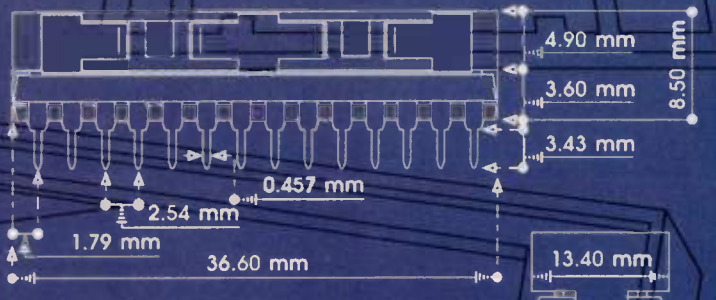
Making Waves in Medicine

Ask a technically knowledgeable person about the use of RF in medical applications and the discussion will most likely turn to Magnetic Resonance Imaging (MRI). This noninvasive tech-

EPSON PRESENTS ANOTHER LEADING TECHNOLOGY PRODUCT:

PC COMPATIBLE REAL TIME CLOCKS

- EISA BUS COMPATIBLE (µC and AT/XT compatible available soon)
- 4 KBYTES OF SRAM MEMORY
- CRYSTAL AND OSCILLATION CIRCUIT BUILT IN
- COMPARTMENT FOR 2 REPLACEABLE BATTERIES
- BASIC MOTOROLA RTC FUNCTION COMPATIBLE



A0	<	1	28	> A2
A1	<	2	27	> A3
TMODE	<	3	26	> V_{BB}
TCLOCK	<	4	25	> SQW
$\overline{STBY}$	<	5	24	> A4
D0	<	6	23	> A5
D1	<	7	22	> N/C
D2	<	8	21	> $\overline{IRQ}$
D3	<	9	20	> $\overline{RESET}$
D4	<	10	19	> $\overline{RD}$
D5	<	11	18	> N/C
D6	<	12	17	> $\overline{WR}$
D7	<	13	16	> $\overline{XRAM}$
V_{SS}	<	14	15	> $\overline{RTC}$

SPECIFICATIONS

RATING		VALUE	UNIT
OPER. VOLTAGE		5 ±0.5	V
OPER. TEMPERATURE		-10 TO 70	°C
CURRENT CONSUMPTION	OPER.	15 (MAX)	m A
	STAND-BY	2 (MAX)	µ A
	BACK-UP	0.5 (TYP)	µ A

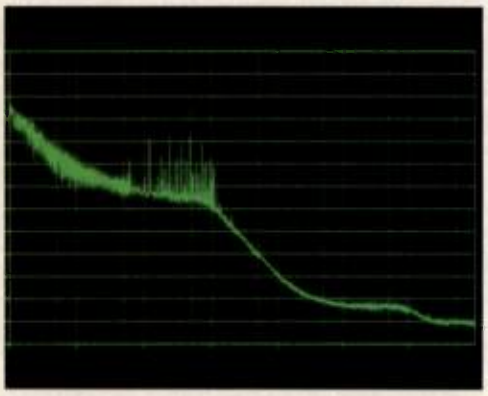
PRODUCED BY SEIKO EPSON CORP.

EPSON®

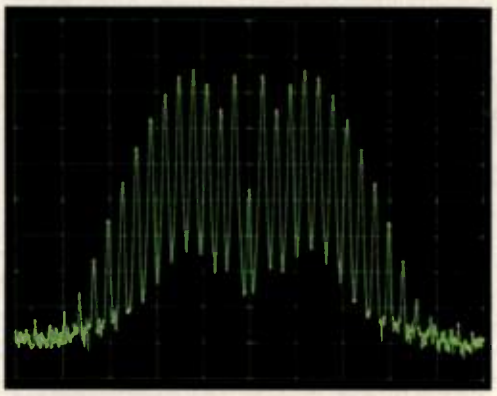
EPSON AMERICA, INC.
COMPONENT SALES DEPARTMENT
TEL: 213.787.6300
FAX: 213.782.5320

INFO/CARD 41

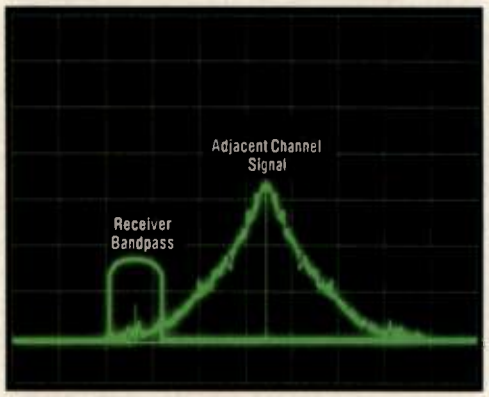
FLUKE®



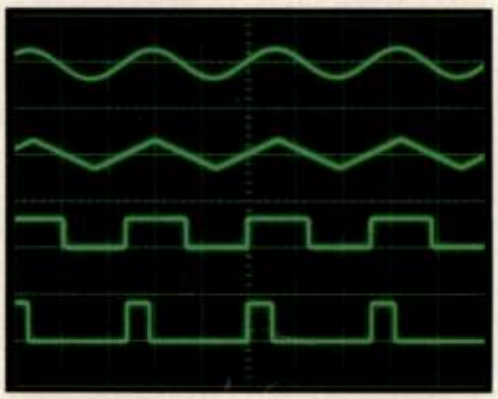
The 6080 Series is the best value today in high spectral purity RF signal generators. Phase noise at 1 GHz is -131 dBc/Hz at 20 kHz offset.



Wide FM deviation to 8 MHz for surveillance receiver testing or VCO simulation.



Low phase noise for receiver selectivity measurements and LO substitution is a definite plus.



Besides generating precise RF signals, the 6080 Series has a DDS modulation oscillator to generate multiple functions from 0.1 Hz to 200 kHz.

Catch the perfe

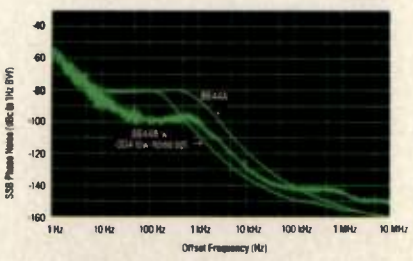
For spectral purity, versatility and value, Fluke 6080A and 6082A Signal Generators are totally awesome.

Short of a week off Australia's barrier reef or Oahu's North Shore, you'd be hard pressed to find more satisfying waveforms than those produced by Fluke 6080 Series 1 GHz — 2 GHz RF Signal Generators.

For the price, nothing comes close: Not Hawaii, not Australia. Not even HP.

Because with the Fluke 6080 Series you get all the performance you need for virtually all your critical receiver test, RF design, and ATE systems applications.

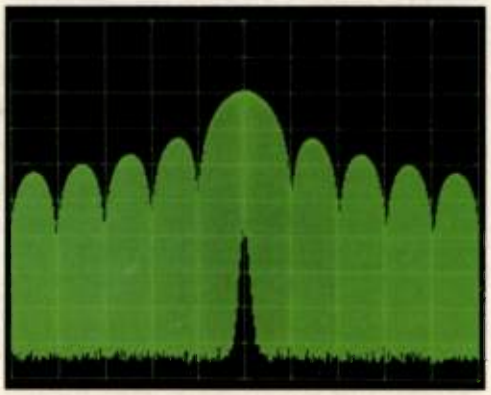
To begin with, the Fluke 6082A and its 1 GHz cousin, the 6080A, both offer nearly unheard of spectral purity in their price range. Phase noise at 1 GHz is -131 dBc/Hz at 20 kHz offset. Non-harmonic spurious is -100 dBc at 1 GHz. And residual FM is a low 1.5 Hz, perfect for high performance receiver testing and LO substitution.



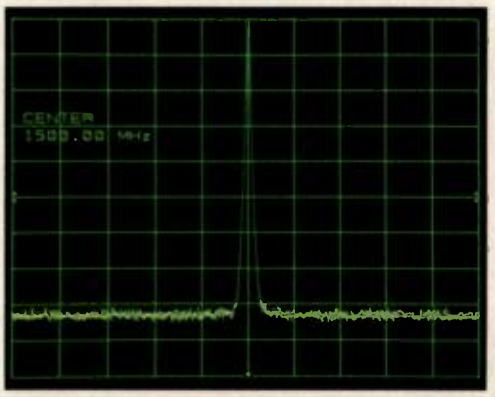
Compared to the HP® 8644A's SSB phase noise at 1000 MHz, the 6080A with high stability reference not only measures up, it outperforms.

Output level of +16 dBm provides the oomph you need for receiver overload test and driving high level mixers. Level accuracy is ±1 dB. A special user-defined level correction register allows you to

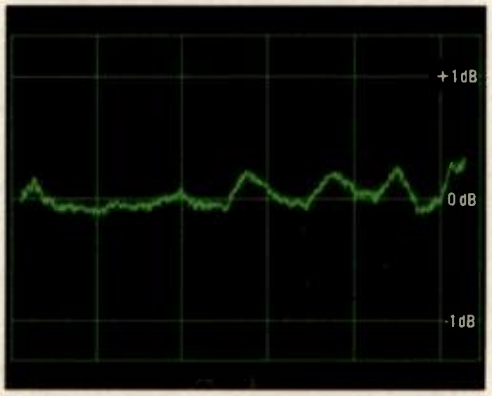
PHILIPS



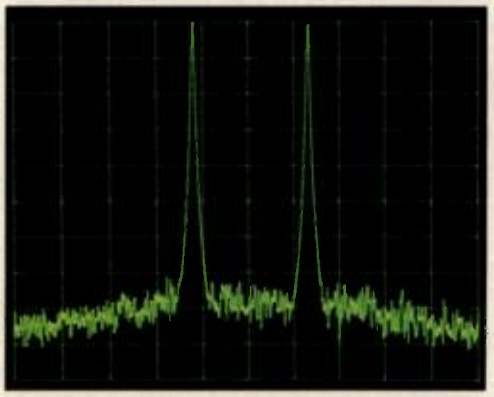
Fast pulse modulation: 15 ns edges, up to 80 dB on/off ratio. Perfect for radar component testing.



Both the 6080A and 6082A have the performance you need for even your toughest RF test applications.



Amplitude accuracy is spec'd to ±1 dB at -127 dBm over the entire frequency range, but typical performance is actually much better.



Low RF intermodulation distortion is ideal for receiver sensitivity testing in mobile, cellular, and military applications.

rt wave, dude.

compensate for external cable losses.

Flexibility is a major plus, too. Whether you're testing mobile, cellular, military communications, surveillance receivers, or doing RF design work, the Fluke 6082A is ready to go.

Modulation versatility is standard.

Fluke 6080 Series high performance signal generators. U.S. List Prices: 6080A $15,950; 6082A $21,950.

So is HP 8642A/B software and rack space compatibility. AM, FM, phase and pulse modulation are all included, and can be combined for complex signal simulation.

Pulse rise time is <15 ns (7.5 ns typical). And the 6082A's on/off ratio is 80 dB, ideal for radar applications.

Sound too good to be true? Take a peek at the Fluke 6082A and see for yourself what the new wave in high performance signal generators is all about.

Call **1-800-44-FLUKE** for the whole picture. And in the meantime, hang loose.

RF SIGNAL GENERATORS

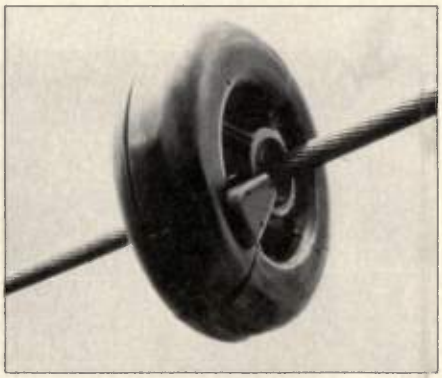
FLUKE®

INFO/CARD 42

Please see us at RF Expo East, Booths #404, 406.

nique is now in common use throughout the US, Europe, Japan, and Australia to diagnose a wide variety of afflictions. MRI equipment uses high-power (500 W to 2 kW) amplifiers extensively, as well as frequency synthesizers and passive transmission line components. It continues to provide a new source of revenue for RF equipment manufacturers.

However, MRI is not the only application for RF in medicine. Monitoring of cardiac and obstetrics patients allows them to move about relatively freely while a monitor attached to their bodies sends a signal to a small, battery-operated personal transmitter. The signal from the transmitter is captured by antennas mounted in the ceilings of the hospital ward and sent to a central receiver.



The Power-Donut System pioneered by Nitech allows comprehensive information about powerline conditions to be available at a central site.

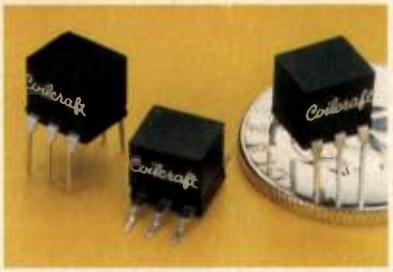
Changes in the patient or fetus are instantly available, even though the patient is moving from place to place. Before these systems were available, patients were required to be in bed so that heart or fetal monitors could transmit their signals to the central site. The patients were literally "hard-wired" to their beds. RF telemetry systems are also used in the field by paramedics to communicate vital signs via portable monitors.

Reporting on Power

Transmission of electric power by utilities has become an extremely complex task. With this increase in complexity has come a greater need to monitor the performance of these systems in many places over a wide geographic area. Advanced power monitoring systems are providing the means for this monitoring requirement.

RF telemetry systems are being used to transmit information collected by sensors mounted on high-voltage transmission lines to ground stations up to 5 miles away. Voltage, current and phase angle, conductor surface temperature, wind speed, humidity, and ambient air temperature are measured using solid-state sensors. These signals are digitized by A/D converters and transmitted to the ground in the 902 to 959 MHz band designated for utility use. The information is stored and later transmitted to the utility by telephone. This concept, now called the Power-Donut System, was pioneered by Nitech, Inc., (Fairfield, CT) and has gained wide acceptance in the power industry.

The tiny transmitters in toroidal-shaped enclosures mounted around the



Coilcraft offers low-cost wideband RF transformers

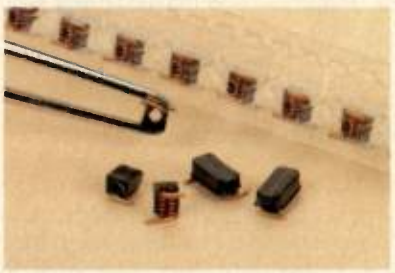
Coilcraft offers a family of low-cost wideband RF transformers that cover the frequency range from .005 to 600 MHz, with impedance ratios from 1:1 to 4:1.

The transformers are offered in tapped or untapped configurations and are packaged in a low-profile DIP-style plastic case. All parts are available in either a through- hole or surface mount version.

Applications include impedance matching, voltage or current transformation, DC isolation, balanced/unbalanced mixing, matching, power splitting, coupling, and signal inversion.

For more information, contact **Coilcraft**, 1102 Silver Lake Road, Cary IL 60013. 708/639-6400.

INFO/CARD 133



Surface mount "Springs" have tight tolerance, high Q

Coilcraft's SMD "Spring" inductors are ideal for high frequency RF applications, combining the low cost and high Q of air core designs with the convenience of surface mounting.

They cover the inductance range from 2.5 to 43 nH with minimum Q values of 100 to 145 at 150 MHz. Tolerance is ±5% and self resonance is typically greater than 3 GHz.

High temp jacketing assures mechanical stability and very close tolerance. It also forms a flat top, making the parts suitable for automatic placement and reflow soldering. They're available packaged in standard 12 mm EIA tape and reel.

For more information, contact **Coilcraft**, 1102 Silver Lake Road, Cary IL 60013. 708/639-6400.

INFO/CARD 134

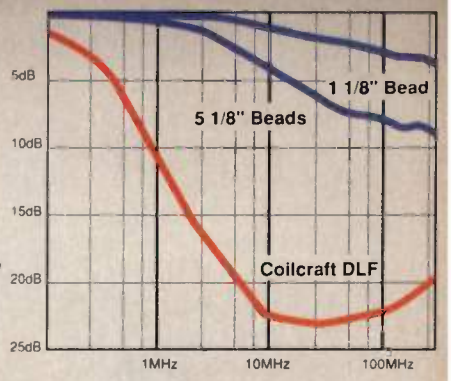
Higher performance EMI filtering for high speed data lines

All these ferrite beads can't equal the EMI suppression of a single Coilcraft Data Line Filter.

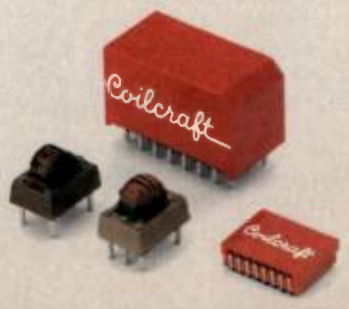
Our new DLFs are the most effective, low-cost way to eliminate common mode EMI from digital signals, logic level power lines, and inter-equipment cables.

Available in 8, 4, 3 and 2-line versions, Coilcraft DLFs provide >15 dB attenuation from 30 to 300 MHz. Up to 40 dB simply by adding capacitors!

Because they use a single magnetic structure to filter multiple lines, you get differential *and* common mode noise suppression, something other filters can't do.



Attenuation
(50 Ohm System)



Coilcraft Data Line Filters are easier to install and usually take less board space than beads or baluns. And they're far less expensive than filtered connectors–around 2¢ per dB per line.

For details on our complete line of Data Line Filters, circle the reader service number. Or call **800/322-2645** (in IL 708/639-6400).

Designer's Kit D101 contains 2,3,4 and 8-line filters. $65.

Coilcraft

1102 Silver Lake Road, Cary IL 60013

INFO/CARD 44

This radiosonde balloon uses a small, battery-powered telemetry transmitter to radio data to the ground station.

power line receive information as Manchester-encoded data from a logic card elsewhere in the enclosure. The transmitter delivers between 100 mW and 1 W, depending on the site requirements.

The ground station can transmit up to 160 parameters to a host computer via RS-232C serial communications or via an asynchronous modem on telephone lines. The Power-Donut System was originally developed for Niagara Mohawk Power Corp. The utility currently has more than 400 sensors in use throughout its system, some of which have been operating for 7 years.

Unlimited Possibilities

Any application that requires communication of data from one place to another is a potential home for RF telemetry equipment. The applications described in this article are only a few of the possibilities.

There is also ample evidence to show that the use of RF systems in commercial communications applications will grow faster in the future. For example, the wireless local area network, an experimental concept only a few years ago, is now being offered as a commercial product by nearly a dozen manufacturers. Each system utilizes transmitters, receivers, and RF modems for communications. Since each wireless LAN has the potential to serve dozens of nodes, and since each node has a LAN transceiver, the potential market is staggering.

In addition, the Data Personal Communications Services (Data-PCS) concept championed by Apple Computer may provide another market for RF products. This past January, Apple Computer petitioned the FCC to establish Data-PCS, which would be a new class of data communications that would operate within 40 MHz of the 1850 to 1990 MHz band. It was specifically designed in response to the growing market for laptop computers, which are inherently portable. Any wired system, or one designed to be usable with only one manufacturer's products, would be narrow in scope compared to Data-PCS.

Data-PCS would be a low-power network that would link computers within a 50-meter area, such as in a single floor of an office building. Manufacturers of Data-PCS compatible systems would have to meet a set of operating parameters and the services would be generic, so any manufacturer could build Data-PCS compatible products.

Data-PCS would accommodate data rates of up to 10 Mbits/sec., which Apple believes will adequately service personal computers for the foreseeable future. If the FCC authorizes Data-PCS, it would create an entirely new capability for computer systems, leading to a new subset of the computer industry. It would also move the personal computer away from the wall tether for good. And, it would provide a market of truly mammoth proportions for enterprising manufacturers of RF equipment.

Acknowledgment

The author wishes to thank Lee Masoian, Noise Com's director of telemetry product development; David Geller, staff services engineer at the Port Authority of New York and New Jersey; James Morrisey, of the Philips Air Force Laboratory at Hanscom Air Force Base; John Shew, president of J & K Communications; and Herb Schrayshuen, president of Nitech, Inc.; for their help in preparation of this article. ***RF***

About the Author

Gary Simonyan is president of Noise Com, Inc., a manufacturer of noise sources, frequency generation and control products, and RF-based telemetry systems. The telemetry products are manufactured by the company's NCI Systems Division. Many of these products are used in the commercial systems described in this article. Mr. Simonyan can be reached at Noise Com, Inc., East 49, Midland Avenue, Paramus, NJ 07652, telephone (201) 261-8797.

Our Standard Filter Family Keeps GROWING!

First came commercial 70 MHz . . .

3dB Bandwidth	Part Number
0.125	851539
0.25	851541
0.50	851542
0.75	851543
1.0	851544
1.5	851545
2.0	851546
2.5	851547
3.0	851548
3.5	851549
4.0	851550
4.5	851551
5.0	851552
5.5	851553
6.0	851554
6.5	851555
7.0	851556
7.5	851505
8.0	851557
8.5	851558
9.0	851559
9.5	851560
10.0	851475
11.0	851841
12.0	851842
13.0	851843
14.0	851844
15.0	851845
16.0	851846
18.0	851847
20.0	851848
22.0	851849
24.0	851850
26.0	851851
28.0	851852
30.0	851853
32.0	851854
34.0	851855
36.0	851856
38.0	851857
40.0	851858

Then commercial 140 MHz . . .

3dB Bandwidth	Part Number
0.25	851900
0.50	851901
0.75	851902
1.0	851903
1.5	851904
2.0	851905
2.5	851906
3.0	851907
4.0	851909
5.0	851911
6.0	851913
7.0	851915
8.0	851917
9.0	851919
10.0	851921
12.0	851923
14.0	851925
16.0	851927
18.0	851929
20.0	851931
24.0	851933
28.0	851935
32.0	851937
36.0	851939
40.0	851941
44.0	851943
48.0	851945
56.0	851947
64.0	851948
72.0	851949
80.0	854101

And *now* standard military 160 MHz SAW filters!

3dB Bandwidth	Part Number
0.25	851950
0.50	851951
0.75	851952
1.0	851953
1.5	851954
2.0	851955
2.5	851956
3.0	851957
4.0	851959
5.0	851961
6.0	851963
7.0	851965
8.0	851967
9.0	851969
10.0	851971
12.0	851973
14.0	851975
16.0	851977
18.0	851979
20.0	851981
24.0	851983
28.0	851985
30.0	851986
32.0	851987
36.0	851989
40.0	851991

▲ *Manufactured and inspected to military criteria*

▲ *Internally impedance matched to 50 ohms*

▲ *ESS screened using MIL-STD test methods*

▲ *Serialized with individual test data*

▲ *Next day delivery from Penstock!*

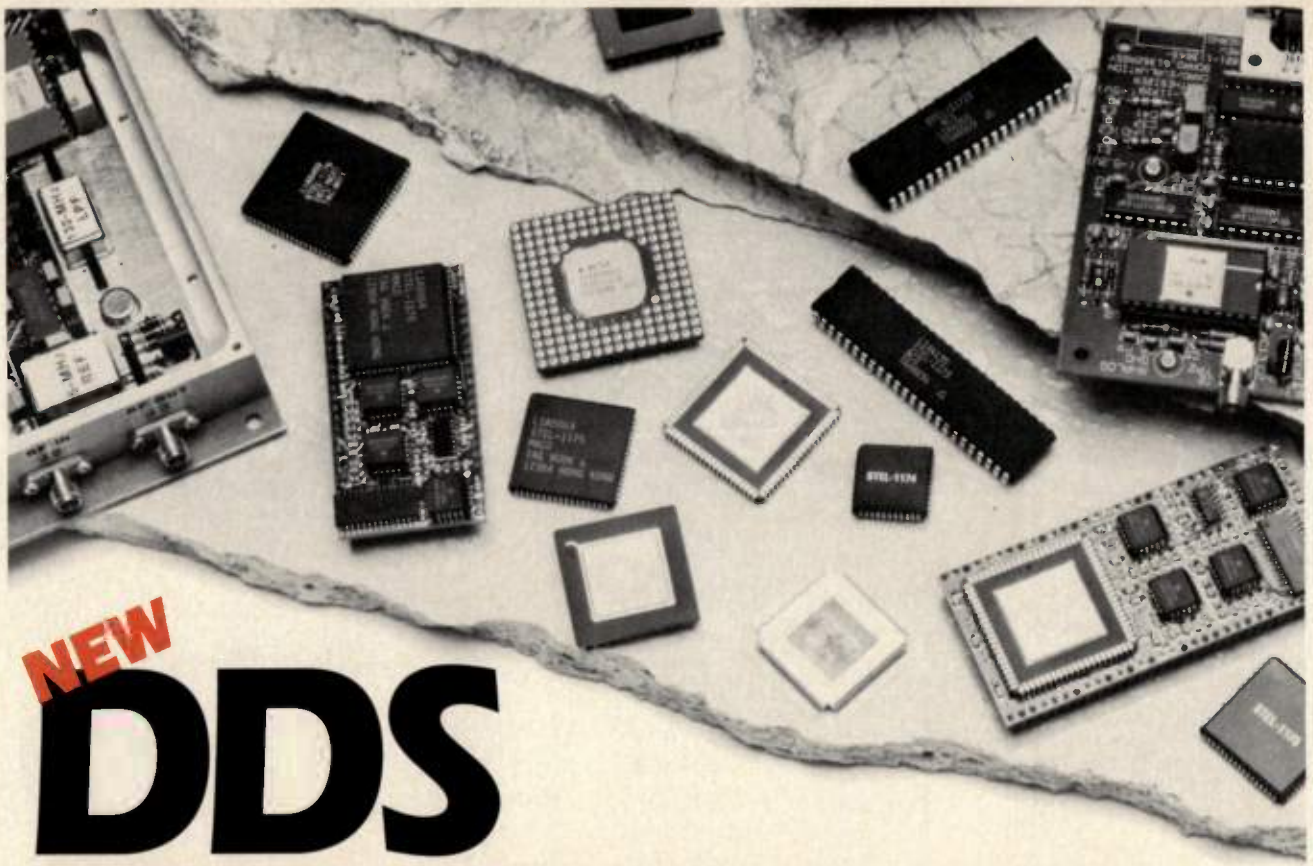
Get acquainted with the newest members of Sawtek's standard SAW filter family. Call Penstock now at ***1-800-PENSTOC*** and place your order. Every standard filter is available for immediate delivery. If, however, your application calls for a filter not listed above, please contact Sawtek at 407-886-8860 to discuss your requirement.

PENSTOCK™ INC
IF/RF/MICROWAVE DISTRIBUTION
Sunnyvale, California

SAWTEK INCORPORATED
Orlando, Florida

INFO/CARD 47

Please see us at RF Expo East, Booths #215, 217.



NEW DDS

PRODUCTS FOR DIRECT DIGITAL SYNTHESIS

Stanford Telecom . . .
continues to lead the way in providing the highest performance at the lowest cost.

These are but a few of the many outstanding products and prices available today and offered by Stanford Telecom for frequency synthesis and digital communications. For the highest performance and most cost effective solutions in integrated digital communications products, Stanford Telecom continues to stand out as the industry leader.

Call today to discuss how Stanford Telecom might become a member of your team.

STANFORD TELECOM®

ASIC Custom Products Group

2421 Mission College Boulevard
Santa Clara, California 95054-1298
Tel: (408) 980-5684 Fax: (408) 727-1482

MONOLITHIC NCOS

STEL-1172B	50 MHz, 32-bit, Quadrature
STEL-1173	50 MHz, 48-bit, High Resolution
STEL-1174	50 MHz, 16-bit, Low Cost
STEL-1175	60 MHz, 32-bit, Phase Modulated
STEL-1175/80	80 MHz, 32-bit, Phase Modulated NEW
STEL-1176	80 MHz, BCD/Decimal, High Speed CMOS
STEL-1177	60 MHz, 32-bit, full PM, FM, & Quadrature
STEL-1178	50 MHz, Dual NCO NEW
STEL-1179	25 MHz, Serial Input PM NCO, $5 in commercial quantities NEW
STEL-2172	300 MHz, ECL, 32-bit
STEL-2173	1 GHZ, GaAs, 32-bit, BPSK, QPSK

BOARD-LEVEL DDS

STEL-1272	based on 1172B, 0-20 MHz
STEL-1273	based on 1173, 0-20 MHz
STEL-1275	based on 1175, 0-25 MHz
STEL-1375A	miniature assembly based on 1175 MIL Spec version now available NEW
STEL-1376	miniature assembly based on 1176
STEL-1377	miniature assembly based on 1177 MIL Spec version now available NEW
STEL-1378	miniature assembly based on 1178 NEW
STEL-1277	based on 1177, 0-25 MHz
STEL-2272	based on 2172, 0-130 MHz
STEL-2273	based on 2173, 0-400 MHz
STEL-2373	based on 2173, 0-400 MHz - miniature hybrid NEW

CHASSIS-LEVEL DDS

STEL-9272	300 MHz Synthesizer based on 2172
STEL-9273	1 GHz Synthesizer based on 2173
STEL-9275	Synthesizer with 1 GHz internal clock NEW

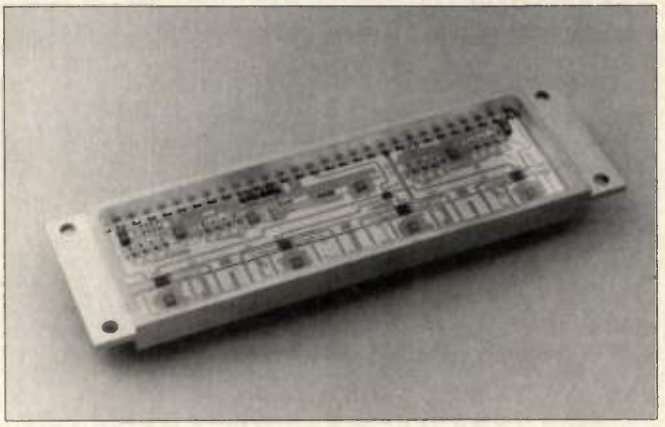
SP16T GaAs Switch Uses MMIC and Hybrid Technology

Daico Industries introduces the DS0918 SP16T broadband switch, using GaAs MMICs and hybrid thin-film technology to achieve high performance. Typical isolation and insertion loss is 54 dB and 3 dB, respectively, from DC to 1000 MHz; to 29 dB and 5.2 dB from 2000-4000 MHz. Switching speeds are typically 150 ns over the entire DC-4000 MHz range.

The unit requires +5 and −15 VDC supplies at 3 mA and 11 mA current, typical (10 mA and 25 mA maximum). Operating power level is +10 dBm, maximum, and the unit will survive +23 dBm without damage. Second and third order intercept points are +64 dBm and +33 dBm, respectively. Operating impedance is 50 ohms, with the maximum VSWR specified at 2:1.

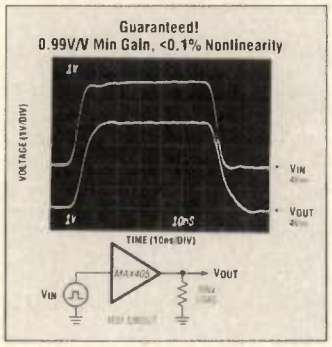
The DS0918 has an integrated TTL driver and terminations, and is packaged in a hermetic 58 pin DIP. Operating temperature is specified over the entire military range of −55 C to +125 C. Commercial screening or optional military screening is available.

Daico Industries, Inc.
INFO/CARD #250



180 MHz Precision Video Buffer

Maxim Integrated Products announces the MAX405, a 180 MHz video buffer amplifier offering accurate gain, differential phase



and gain, and 650 V/us slew rate with ±5 V supplies. For video systems, differential phase and gain are 0.01 degree and 0.03 percent, respectively. Unadjusted DC gain is better than 0.99 V/V over −40 to +85 C with loads as low as 50 ohms. Gain can be adjusted from 0.99 to 1.10 V/V. The MAX405 will drive a 50 ohm load to ±3 V, or as many as four 150 ohm loads to ±2.25 V. In addition to video applications, the device may be used as a coaxial line driver, A/D input buffer, or fast sample and hold buffer. Input impedance is 2.5 megohms and input capacitance is only 0.6 pF. In 1000 quantities, the commercial grade version is priced at $4.25.

Maxim Integrated Products
INFO/CARD #249

Medium Power 0.01-4.2 GHz Amplifiers

The VMA 10 M4 series amplifiers utilize MIC techniques to produce a high gain (up to 45 dB) unit with a low noise figure of 4.5 dB average across the 0.01 to 4.2 GHz band. Combined with high output power, up to +23 dBm, these features allow the amplifier to be used in applications requiring low harmonic levels. Maximum VSWR is 2:1. DC power requirement is +12 V, with the highest power versions also needing −12 V. Internal regulators with over and reverse-voltage protection are included. The largest models are provided in 0.22 × 1.0 × 1.5 inch packages. Pricing is $785 to $1350, depending on model.

Veritech Microwave, Inc.
INFO/CARD #248

Super Flexible Coaxial Assemblies

New flexible coaxial assemblies from Storm Product Co. can be wrapped around a 0.5 inch diameter object and maintain 1.25:1 VSWR through 18 GHz.

These assemblies are available in a variety of connector combinations.

Also announced are high performance RG style cables and assemblies which extend useful frequency range to 18 GHz. Versions of RG 316U and RG 142U have superior shielding for reduced crosstalk, low signal leakage and lower loss in high speed digital and GPS applications above 1 GHz. Quick delivery is available for Storm's cable products.

Storm Products Company
INFO/CARD #247

High Power Signal Generator

The Rohde & Schwarz model SMGL signal generator includes a broadband power amplifier to deliver precise power levels up to +30 dBm over 9 kHz to 1 GHz. Levels as low as −118 dBm are provided, as well. The combination of wide frequency range, high power and high speed or less than 15 ms settling time is ideal for EMC applications where a high power sweep can be used to advantage. Multi-source measurements such as intermodulation, crosstalk and crossmodulation often require combiners and splitters which can have substantial losses, which can be overcome by this generator. With high spectral purity as a primary feature, the SMGL can also be used to drive high level mixers. High power systems can be tested with one less amplifier stage than is typically required.

Rohde & Schwarz
INFO/CARD #246

RF products *continued*

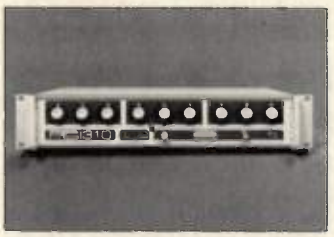
Digital Transmitter

Emhiser Research introduces the DC coupled digital transmitter, a 2.5 × 3.5 × 1.0 inch unit weighing less than 12 oz. The unit supports data rates up to 10 MBS. DC coupling allows the use of NRZ-L code, which has a DC component. Single frequency and channelized units are offered in 1, 2, 5 and 10 watts in the 1435-1540, 1710-1850 and 2200-2400 MHz bands.

Emhiser Research
INFO/CARD #245

Low-Noise, Fast Synthesizer

The PTS 310 offers fast switching and low noise over a range of 0.1 to 310 MHz. 1 Hz resolution



(0.1 Hz optional) is controlled by a parallel BCD or GPIB remote interface. Switching time is 3 us total for the 100 kHz to 1 Hz digits, 5 us for 1 MHz, and 20 us for the 100 and 10 MHz digits. Spurious suppression is 60 to 65 dB. The PTS 310 is priced under $6000.

Programmed Test Sources
INFO/CARD #244

MIL-STD Test Antennas

Two passive loop antennas designed specifically for MIL-STD 461/462 and MIL-STD 1541 testing are introduced by Antenna Research Associates. Both antennas operate from 20 Hz to 50 kHz. Model PLA-2050/A is used for magnetic field emission measurements with an electrostatically shielded 13.3 cm loop. The Model PLH-2050/A is a 12 cm diameter magnetic field generating coil used for susceptibility measurements.

Antenna Research Associates
INFO/CARD #243

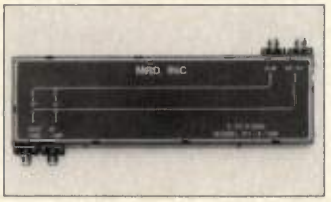
Failsafe Coax Switch

A new series of multiposition failsafe switches are available from K&L Microwave in 1P3T to 1P6T configurations. Packaged in the popular 2 inch diameter outline, the switches have SMA connectors in a 1.66 inch bolt circle. RF performance is from DC-18 GHz with 1.5:1 maximum VSWR. Insertion loss is 0.5 dB maximum, with minimum isolation of 60 dB.

K&L Microwave, Inc.
INFO/CARD #242

Broadband Coupler

Model H112-180 from MRD,



Inc. is a 180 degree coupler which operates from 1 to 12.4 GHz. Amplitude imbalance is ±0.4 dB and phase imbalance is 10 degrees, maximum. VSWR is rated at 1.6:1 for all ports. Isolation is 17 dB minimum and insertion loss is 2.0 dB.

Microwave Research and Development
INFO/CARD #241

SMT Inductor

Dale Electronics announces the IMC-1210 inductor, just 2.2 mm in height. The component meets EIA outline SOPM-3224. Inductance values are available from 0.01 to 100 uH, with low values having 20 percent tolerance and values over 1.0 uH at 10 percent. In 2000 quantity, 10 uH, 10 percent inductors are $0.35 each.

Dale Electronics, Inc.
INFO/CARD #240

1P8T Switch

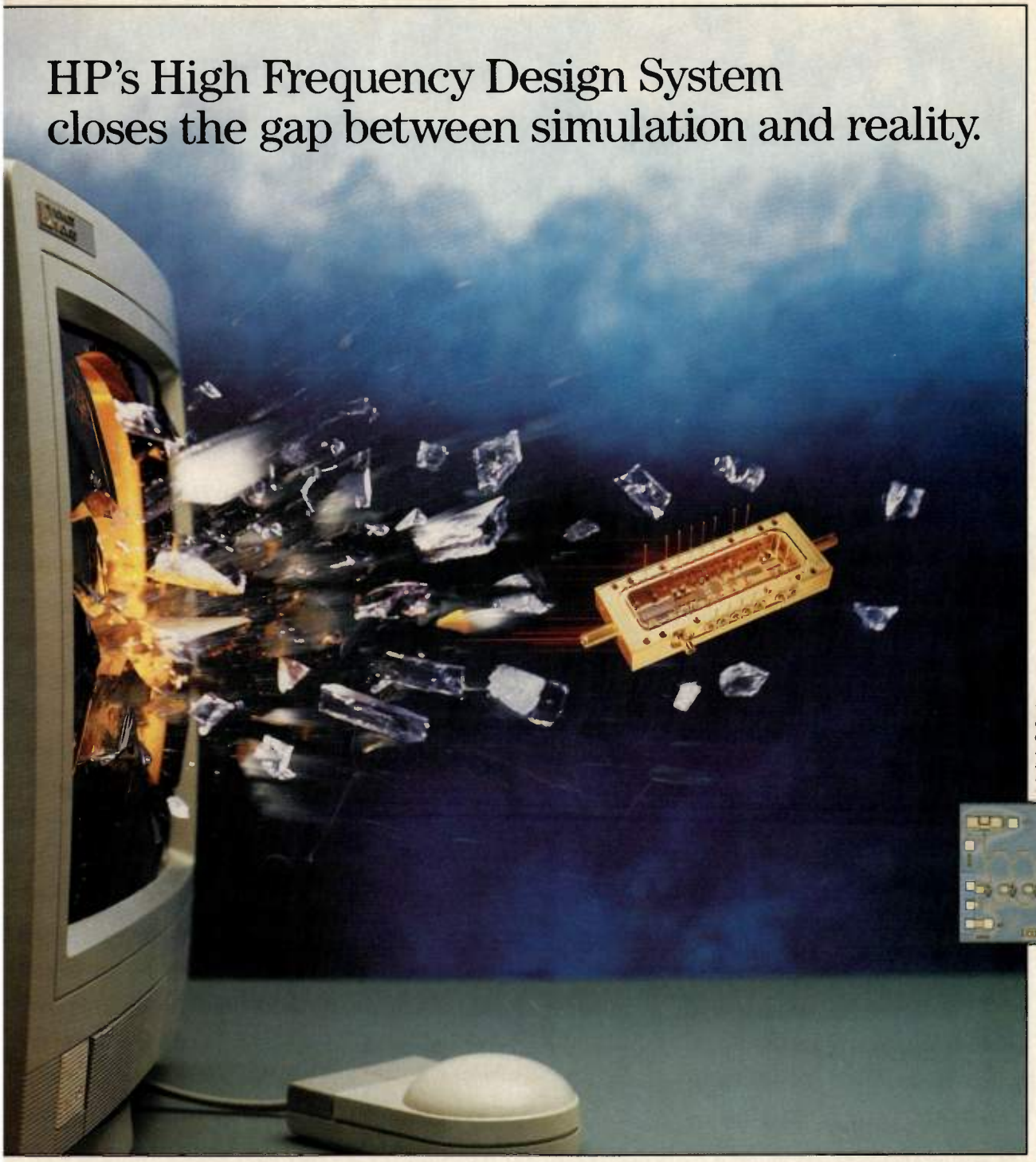
Robinson Laboratories' Model 3816-K12 operates over 0.5 to 18 GHz with 60 dB isolation and 1.8:1 maximum VSWR in all switching states. This high performance absorptive switch has less than 2 us switching speed, BCD TTL control, and will handle 0.5 watt average power. Pricing in unit quantity is $1900.

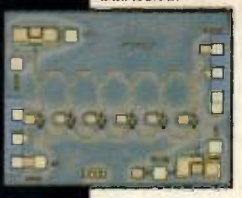
Robinson Laboratories, Inc.
INFO/CARD #239

7/16 DIN Connectors

New European type coaxial 7/16 connectors are made in the U.S.A. by Tru-Connector. A variety of plugs, receptacles, adapters and jacks are offered in 50 ohm designs with threaded cou-

HP's High Frequency Design System closes the gap between simulation and reality.





This 0.5-50 GHz amplifier design, created on the HFDS, met specifications the first time it was tested.

HP's High Frequency Design System (HFDS) brings single-pass design solutions closer to reality. It predicts the performance of your designs using a non-linear simulator that gives you accurate results, even under high levels of compression. So, you can take advantage of the most powerful and sophisticated models and libraries available. Models tested against field simulation tools and verified with actual measurements.

You can also generate your own proprietary libraries with parameters extracted using HP instrumentation links. Enter equations for active devices. Or use S-parameters calculated for 3-D structures with HP's High Frequency Structure Simulator. And since it runs on HP, Apollo, and Sun, the HFDS fits nicely into the computing environment you already work in.

Bring your high-frequency simulations closer to reality. For more information, call your local sales office or circle the reader service number.

There is a better way.

HEWLETT PACKARD

INFO/CARD 50

Please see us at RF Expo East, Booths #309, 311, 410, 412.

plings for cables from 3/8 to 7/8 inch diameter.
Tru-Connector Corp.
INFO/CARD #238

High Power Coupler

An 800 watt quadrature coupler is introduced by RF Power Components. The RFP-5213-90-800 covers 500-1000 MHz with ±0.5 dB maximum amplitude imbalance and 90 degree phase (±5 degrees maximum). the unit is provided in a flat package with solder tab mounting.
RF Power Components
INFO/CARD #237

70 dB Log Amp

A fully monolithic successive detection logarithmic amplifier (SDLA) with 70 dB dynamic range is now available from FEI Microwave. Using HBT GaAs technology from TRW, the AE-B101C covers 0.5 to 1.35 GHz with 18 ns and 22 ns rise and fall times. Linearity is ±1 dB and tangential sensitivity is 70 dB. Applications include EW channelized receivers and compressive receivers.
FEI Microwave
INFO/CARD #236

9600 BPS Radio Modem

Repco Inc. announces the SLR-96 radio modem for high speed

data transmission. Operating frequencies of 138 to 960 MHz can be provided, with 1 to 5 watts of RF power. A standard RS-232C interface is used, along with techniques to eliminate squelch noise.
Repco Incorporated
INFO/CARD #235

MIL-screened DDS

Qualcomm announces the Q2334M-20L, a 20 MHz dual DDS screened to MIL883 specifications. Applications include frequency hopping radios, sonar, radar, complex signal generation and other uses requiring the modulation and frequency control advantages of DDS.
Qualcomm
INFO/CARD #234

8-Way Power Dividers

New power dividers have been introduced by MCLI for coverage from 0.5 to 18 GHz. Features include maximum insertion loss of 6.5 dB, minimum isolation of 18 dB, and 0.7 dB maximum amplitude imbalance. Average power capability is one watt.
Microwave Communications Laboratories, Inc.
INFO/CARD #233

CW Signal Sources

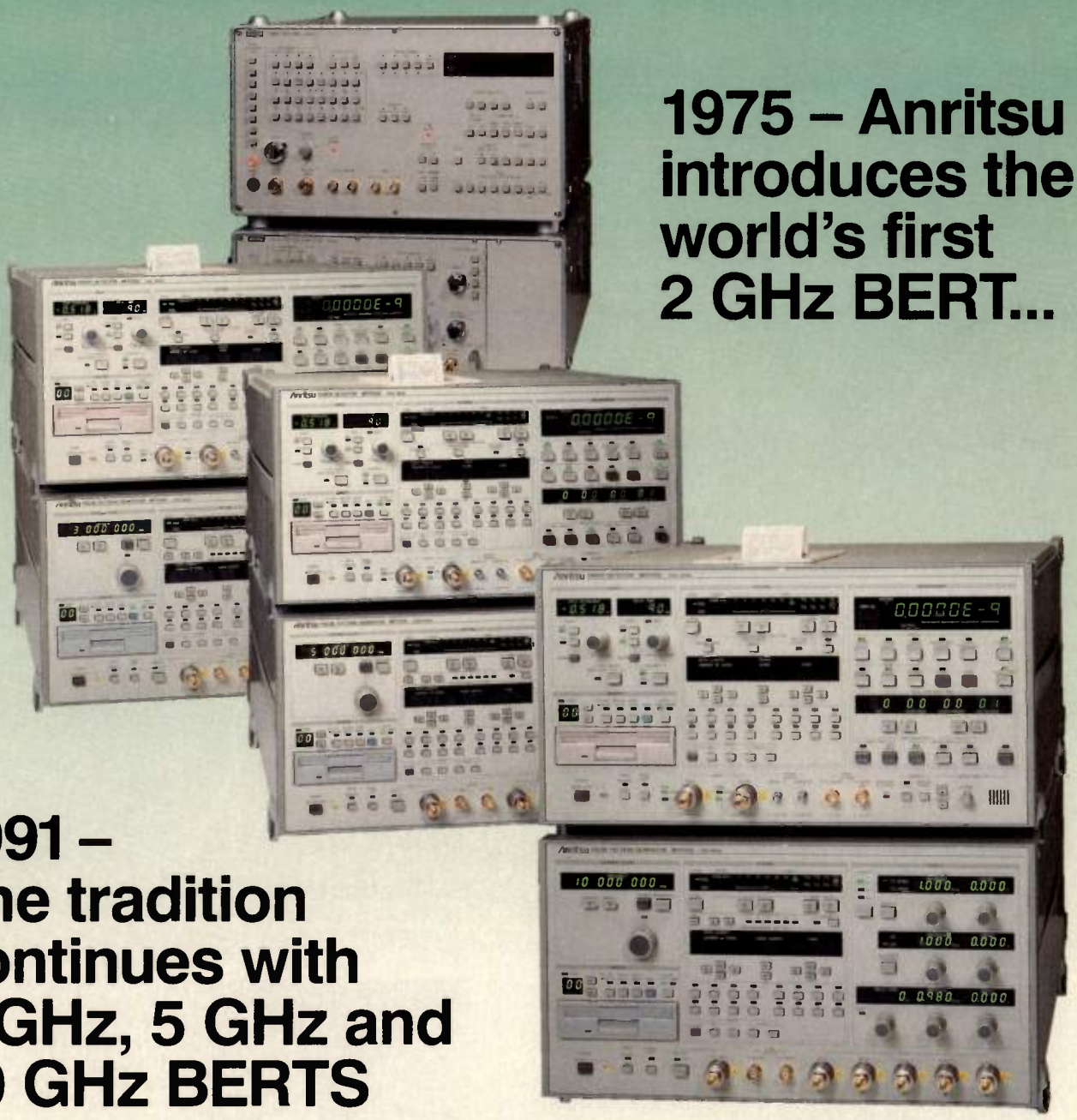
Models 4380 and 4381 from Lucas Weinschel are synthesized CW signal sources providing +10 dBm leveled output, IEEE-488 bus control, and 1 kHz or better resolution. The 4381 covers 2 to 10 GHz in 0.5 kHz steps and 10-20 GHz in 1 kHz steps. The 4380 adds a 0.01 to 2 GHz module for additional coverage.
Lucas Weinschel
INFO/CARD #232

GPS Receiver

Datum Inc announces its latest GPS Time and Frequency Receiver, the model 9390-5300 'CORE' series. The unit tracks GPS satellites to provide precise time transfer and geographical positioning data. A 1 pps output accurate to 100 ns or better is standard, and measurement of external sources of 1, 5 or 10 MHz can be made to better than 5×10^{-11}. Priced at less than $10,000, the system includes cable, preamplifier and antenna.
Datum Inc.
INFO/CARD #231

SOT-23 Mixer Diodes

Surface mount diodes for DBS and VSAT applications have been



1975 – Anritsu introduces the world's first 2 GHz BERT...

1991 – The tradition continues with 3 GHz, 5 GHz and 10 GHz BERTS

No one offers more experience, performance or selection in high speed BERTS!

Since 1975, Anritsu has been a leader in BERT technology. Over the years, companies around the world have turned to us for pattern generation and detection for system evaluation and analysis and we've delivered. Time after time.

Only Anritsu lets you choose from a full line of 3 GHz, 5 GHz and 10 GHz BERTS, to generate virtually any type of pattern including pseudorandom, variable mark ratios and programmable patterns up to 512 kbps...plus features like a low FM, FM/PM noise clock generator, memory mode for pattern frequency and output parameters, variable delay between Clock and DATA...plus more.

For detailed literature or a demonstration, contact Anritsu.

Anritsu

Anritsu America, Inc. 15 Thornton Road, Oakland, NJ 07436
Call 800-255-7234 • (in NJ) 201-337-1111 • FAX 201-337-1033

INFO/CARD 111

Please see us at RF Expo East, Booths #322, 324.

RF products *continued*

introduced by Hewlett-Packard. HSMS-8101 and HSMS-8202 Schottky diodes perform through Ku-band (14 GHz). Pricing in production quantities of 10,000 is $0.75 and $0.95 for the HSMS-8101 and 8202, respectively.
Hewlett-Packard Company
INFO/CARD #230

SMA Connectors

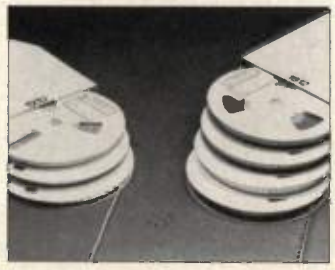
Hex crimp SMA connectors from AMP use industry standard crimp tooling for the center contact and outer ferrule. These connectors are designed for flexible cable, including RG types 58, 142, 188 and 316. pricing for straight plugs ranges from 1.50 to 2.00 each.
AMP Inc.
INFO/CARD #229

Antenna Test Services

A new antenna test range at Flann Microwave allows them to offer Radiocommunications Agency approved facilities in the MM bands above 21 GHz. The site is located at the firm's Bodmin, Cornwall (U.K.) facility, and uses a fixed test antenna and moveable sampling receive antenna.
Flann Microwave Inc.
INFO/CARD #228

SMT Inductors

99 values of SMT inductors are now available from J.W. Miller. PM20 '1210' series chip induc-



tors cover 0.01 through 220 uH, while PM40 '1812' devices cover 0.1 uH through 1000 uH. Prices in quantity start at 20 each, shipped in 500 or 2000-piece reels.
J.W. Miller Div., Bell Industries
INFO/CARD #227

Fiberoptic Interface Card

TriQuint has announced a high-speed fiberoptic interface card based on inexpensive CD-player 860 nanometer laser technology. The highest speed version, HRC-800FS, operates at 800 megabits/sec, the same rate as a 25 MHz 32-bit processor can send data to a system bus. Pricing ranges from $4962 for the 800 Mbps unit to $2999 for the HRC-250 250 Mbps board.
TriQuint Semiconductor Inc.
INFO/CARD #226

Rugged Attenuators

Mini-Circuits announces a one-piece attenuator design that can withstand high-impact shocks. 50 ohm attenuators are available in N-connector style, in values from 1-10 dB in 1 dB steps, plus 12, 15, 20, 30 and 40 dB. 75 ohms units include 3, 6, 10, 15 and 20 dB.
Mini-Circuits
INFO/CARD #225

SATCOM Antenna

A transportable crossed-yagi antenna for 240-318 MHz satellite

communications is announced by ADM. The ADM-C2 has right-hand circular polarization, with 10.25 to 14.4 dBic across the band. It will handle 200 watts, and includes a lightweight tripod for mounting.
Antenna Design & Manufacturing Corp.
INFO/CARD #224

Dual Coupler

Model RSU from Quartzlock Instruments is a dual directional coupler with 1 dB response over 800-1000 MHz and 3 dB response from 500 MHz to 1.3 GHz. Directivity is 30 dB and coupling is 40 dB, each ±0.5 dB. Signal integrity and high power handling are enhanced with a one-piece coupling line/connector center conductor.
Quartzlock Instruments
INFO/CARD #223

Programmable Attenuator

RLC Electronics introduces the PA-501-R, operating over DC-2

The 48 cent solution.

Wideband Amplifiers – From $.48 each

UPC1653 To 1300MHz 18dB G_p	**UPC1654** To 1100MHz 19dB G_p	**UPC1655** To 900MHz 18dB G_p	**UPC1656** To 850MHz 19dB G_p	**UPC1658** To 1100MHz 17dB G_p 2.0dB NF	
UPC1659 600MHz to 2300MHz 23dB G_p	**UPC1675** To 2100MHz 12dB G_p	**UPC1676** To 1300MHz 20dB G_p 4.0dB NF	**UPC1677** To 1700MHz 24dB G_p P_{out} = 19.5dBm	**UPC1678** Up to 1900MHz 23dB G_p P_{out} = 18dBm	**UPC1688** Up to 1000MHz 21dB G_p 4.0dB NF

Prescalers – From $2.20 each

UPB581 ÷ 2 500MHz to 2.8GHz	**UPB582** ÷4 500MHz to 2.8GHz	**UPB584** ÷2 500MHz to 2.5GHz	**UPB585** ÷ 4 500MHz to 2.5GHz	**UPB586** ÷ 512/256 500MHz to 2.5GHz	**UPB587** ÷ 2/4/8 50MHz to 1.0GHz V_{CC} 2.2 to 3.5V	**UPB588** ÷64/128 500MHz to 2.5GHz

Freq. Convertors – From $1.58 each

UPC1685 DC to 890MHz 14dB GAIN Double Balanced Mixer Applications	**UPC1686** DC to 890MHz 22dB GAIN	**UPC1687** DC to 890MHz 28dB GAIN I_{CC} of 38mA

IF Amplifiers – From $3.50 each

UPC1668 10 to 170MHz G_L=14.5dB 60dB Isolation	**UPC1669** 10 to 180MHz G_L=10.5dB 55dB Isolation	**UPC1670** 10 to 150MHz IM_3 of 56dBc 60dB Isolation

Transistor Arrays From $2.40 each

UPA101 F_T=9GHz Double Balanced Mixer Applications	**UPA102** F_T=9GHz Differental Amplifier
UPA103 F_T=9GHz Differental Amplifier	**UPA104** F_T=9GHz OR/NOR Functions

Special Function MMICs From $1.08 each

UPC1684 LED DRIVER 150mA Drive Current 300 Mbits NRZ	**UPC1663** VIDEO AMPLIFIER 170MHz @ A_{VOL}=100 1.6ns Propagation Delay

Note: MMIC prices based on 25K quantities

Want to make life simpler? Reduce the parts count in your design with silicon MMICs from NEC. They're the low cost, no-hassle way to achieve your design goals.

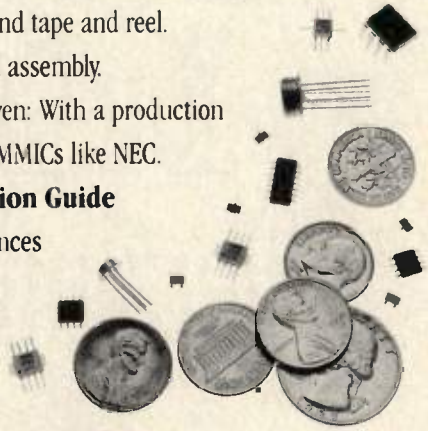
But be aware of the side effects!

Reducing your parts count can also make your QC easier. Your overall circuit more reliable. And your assembly, whether manual or automated, faster and more efficient.

NEC MMICs come in chips and a variety of packages, including hermetic, low cost plastic, surface mount and tape and reel. So they're ideal for high volume automated assembly.

And their quality and reliability is proven: With a production rate of *7 million a month,* no one knows MMICs like NEC.

Our **Silicon MMIC Product Selection Guide** lists specifications for dozens of parts. Chances are good it has just what you need. To get a copy, call your nearest CEL Sales Office or circle the number below.



NEC®

California Eastern Laboratories

CEL Headquarters, 4590 Patrick Henry Drive, Santa Clara, CA 95056-0964; (408) 988-3500 FAX (408) 988-0279 ☐ Santa Clara, CA (408) 988-7846 ☐ Los Angeles, CA (213) 645-0985 Bellevue, WA (206) 455-1101 ☐ Scottsdale, AZ (602) 945-1381 ☐ Richardson, TX (214) 437-5487 ☐ Shawnee, KS (913) 962-2161 ☐ Woodridge, IL (708) 241-3040 ☐ Cockeysville, MD (410) 667-1310 Peabody, MA (508) 535-2885 ☐ Hackensack, NJ (201) 487-1155 or 487-1160 ☐ Palm Bay, FL (407) 727-8065 ☐ Snellville, GA (404) 978-4143 ☐ Nepean, Ontario, Canada (613) 726-0626

INFO/CARD 56

Please see us at RF Expo East, Booth #416.

RF products *continued*

GHz. Binary attenuation values of 1, 2, 4, 8, 16, 32 and 64 dB provide 127 dB total attenuation in 1 dB steps. Operating voltage is 12 VDC with switching in 6 ms. The unit is specified for 10^7 operations. Price of the unit is $575 in quantities.
RLC Electronics
INFO/CARD #222

Logarithmic Amplifier

GEC Plessey Semiconductors extends its line of log amps with two new models. The SL3524 supports all frequencies from 1-200 MHz, and the SL2524 offers a limiting bandwidth of 600 MHz. Both supply IF and video ports for simultaneous phase, frequency and video (amplitude) information. In hundreds, prices are $579.28 for the '3524, and the '2524 is $359.79.
GEC Plessey Semiconductors
INFO/CARD #221

Phase Shifter

A DC-4 GHz in line phase shifter, the model 6707, is announced by Sage Laboratories. Insertion (and minimum) phase shift is 145 degrees per GHz, with 290 degrees per GHz at the maximum setting. Power handling is 150 watts average, 1 kW peak. Operation is mechanical, with various knob, dial, and shaft options.
Sage Laboratories, Inc.
INFO/CARD #220

Matched Switch Matrices

A 2 by 6 matrix features dual-mode, phase and amplitude

matched performance over a DC-20 GHz frequency range. Its compact size shortens signal paths and reduces insertion loss. Phase tracking is ±1 degree at 1 GHz, increasing to ±5 degrees at 20 GHz. Amplitude tracking is ±0.1 dB to ±0.3 dB over the same range. Minimum isolation in the 8-20 GHz range is 55 dB. The size of the unit is just 5.5 × 4.0 × 5.0 inches.
Teledyne Microwave
INFO/CARD #219

Portable Reflectometer

Millimeter Wave Technology announces a low cost hand-held reflectometer for measuring the reflectivity of surfaces. A hand-held RF measurement unit is attached by cable to the display unit, featuring microcomputer controlled electronics, keypad and LCD display. The RF unit operates at 10.25 GHz and measures surface reflectivity with 0.5 dB accuracy over a 20 dB dynamic range. At −30 dB, accuracy is 2 percent. Applications include measuring radar absorbing materials and EMI shielding materials.
Millimeter Wave Technology
INFO/CARD #218

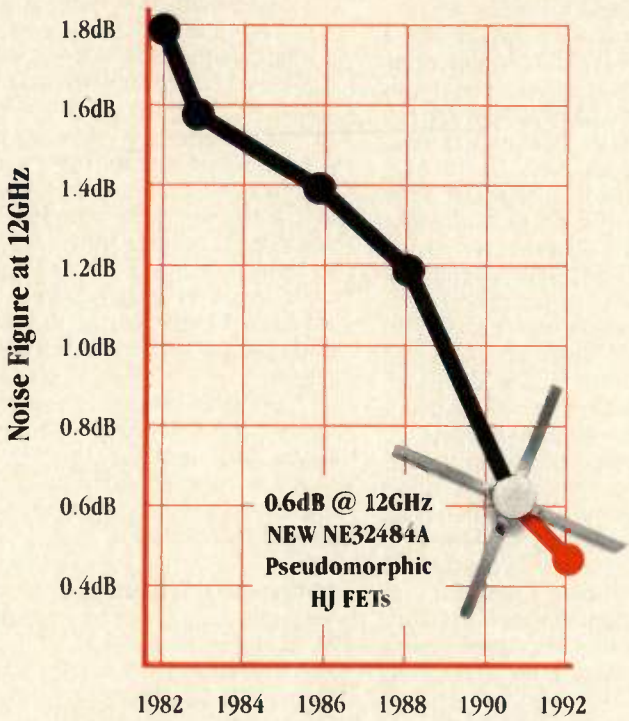
High Power Pulse Amplifier

Model BPHE58118-500/1280 is a solid state pulse amplifier operating in the 500-1100 MHz frequency range. Peak RF power output is 500 watts minimum, with 1 mW maximum input requirement. Operating in class AB mode, the amplifier is suited for use as a driver for high power radar transmitters. Pulse rise and fall times are less than 50 ns. The unit is housed in a 8 3/4 inch rack cabinet. Harmonic output is rated at −20 dBc, and spurious outputs are rates at −60 dBc.
Power Systems Technology, Inc.
INFO/CARD #217

Ovenized Oscillator

A low phase noise, low cost ovenized oscillator is announced by Reeves-Hoffman. The series 3188 features typical SSB phase noise at 10 MHz of −110 dBc/Hz at 10 Hz and −158 dBc/Hz at 10 kHz. Frequency stability is 1×10^{-8} over temperature, with an aging rate of 1×10^{9} per day. The units are available in frequencies from 8 to 14 MHz. Price ranges from $140 to $160 in quantity.
Reeves-Hoffman
INFO/CARD #216

Snow Removal Devices



The downward trend continues

Noise in a receiver means snow on the screen. With a noise figure of only *0.6dB* at 12GHz, our new NE32484A is helping keep viewers happy, even in peripheral transmission areas.

No matter what your application, our new family of Low Noise GaAs FETS can provide more margin in your LNA designs, potentially fewer gain stages, and overall lower costs.

Better yet, with a *family* of devices to work with, it's easy to match parts to your spec.

What are your requirements? Single or dual gate FETs? Chips? Plastic, low cost ceramic, or hermetic packages? Tape and Reel? Military or Space Qualified?

We have them all and can ship directly from onshore stock. And with device characterization done right here in our own engineering lab, we can shave weeks off your design cycle.

Part No.	Freq (GHz)	NF (dB)	Ga (dB)
NE32484A	12	0.6	11.0
NE42184A	12	0.9	10.5
NE76084	12	1.6	9.0
NE76038	4	0.8	13.0
NE76184A	4	0.8	12.0

For a copy of our **NEW** *Small Signal GaAs FET Selection Guide* and our latest data sheets, call your nearest CEL Sales Office or circle the number below.

NEC®

California Eastern Laboratories

CEL Headquarters, 4590 Patrick Henry Drive, Santa Clara, CA 95056-0964: (408) 988-3500 FAX (408) 988-0279 □ Santa Clara, CA (408) 988-7846 □ Los Angeles, CA (213) 645-0985 Bellevue, WA (206) 455-1101 □ Scottsdale, AZ (602) 945-1381 □ Richardson, TX (214) 437-5487 □ Shawnee, KS (913) 962-2161 □ Woodridge, IL (708) 241-3040 □ Cockeysville, MD (410) 667-1310 Peabody, MA (508) 535-2885 □ Hackensack, NJ (201) 487-1155 or 487-1160 □ Palm Bay, FL (407) 727-8045 □ Snellville, GA (404) 978-4443 □ Nepean, Ontario, Canada (613) 726-0626

INFO/CARD 59

Please see us at RF Expo East, Booth #416.

RF books

Phase-Locked Loop Circuit Design

By Dan H. Wolaver
Published by Prentice Hall, 1991,
262 pages.

This newly-released textbook provides engineers with a current reference on an essential RF topic. The author has developed a very readable book with many diagrams and plots to illustrate the principles discussed. After an introductory chapter that outlines major PLL applications, overall PLL basics and the components of a PLL (VCO, loop filter, phase detector) are covered. Next, performance aspects are introduced, including noise and locking mechanisms in both the acquisition and maintaining modes. Application areas conclude the book's coverage, with chapters on modulation and demodulation, clock recovery circuits, and frequency synthesizers.

The author's clear writing style and ample illustrations make this a good learning tool for engineers who are just beginning to develop expertise in PLL design. Basic PLL theory is presented, with block diagram type examples and the necessary mathematical relationships. Emphasis is on understanding PLL principles, rather than presenting circuits that can simply be copied, making this most useful as a tutorial text. For more information, circle **INFO/CARD #115.**

Analog Electronic Circuits

By Robert B. Northrop
Published by Addison-Wesley, 1990,
520 pages.

This is a college-level textbook on classical analog circuits. It is a comprehensive treatment of the design and analysis of active analog circuits using (primarily) transistors and operational amplifiers.

Although not RF-specific, the author achieves his goal of teaching basic analog circuits in a quality instructional textbook aimed at senior-level students. This should be a valuable reference for engineers involved in analog circuit design of all kinds. Circle **INFO/CARD #114.**

The ARRL Antenna Book (16th Edition)

Gerald Hall, Editor
Published by the American Radio Relay League (ARRL), 1991,
712 pages.

The latest edition of this practical amateur handbook follows the previous edition's major update and extensive expansion of antenna theory and practical construction. The few significant errors in the previous edition have been corrected, and the material presented has been updated and expanded.

Improvements in this edition include additional computer-modeled antenna patterns, using software that continues to be refined by several individual programmers and software companies. The proven accuracy of these models (as long as their limitations are observed), enhances the reader's ability to intuitively grasp the behavior of the various antenna types. Also new is a significant expansion of the chapter on antenna and transmission line measurements.

If the professional antenna engineer can accept that some of the material is technically simplistic, he or she will find that the book contains much excellent information. For more information, circle **INFO/CARD #113.**

Microwave Handbook — Volume 2, Construction and Testing

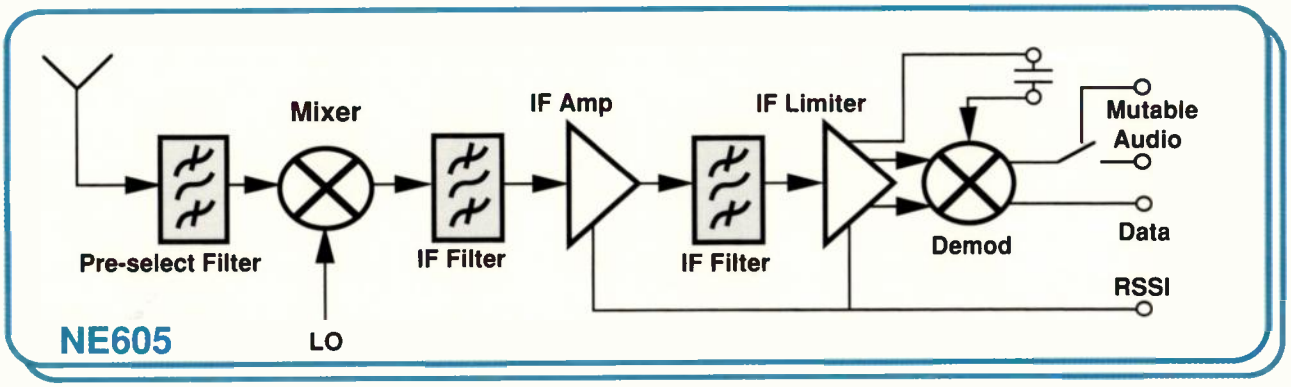
M.W. Dixon, Editor
Published by the Radio Society of Great Britain (RSGB), 1991,
244 pages.

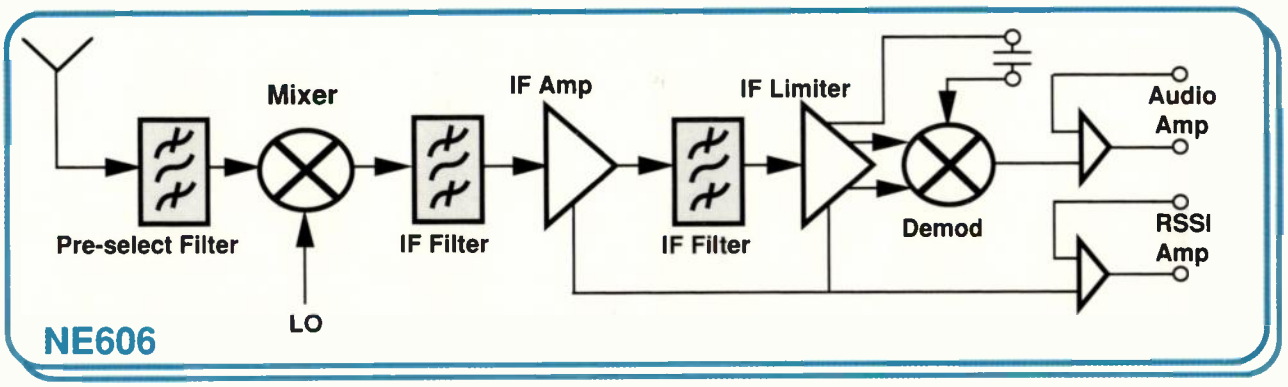
While this is another book directed to an amateur radio audience, it recognizes that most amateur microwave experimenters have a high level of technical understanding. In fact, many are professional microwave engineers.

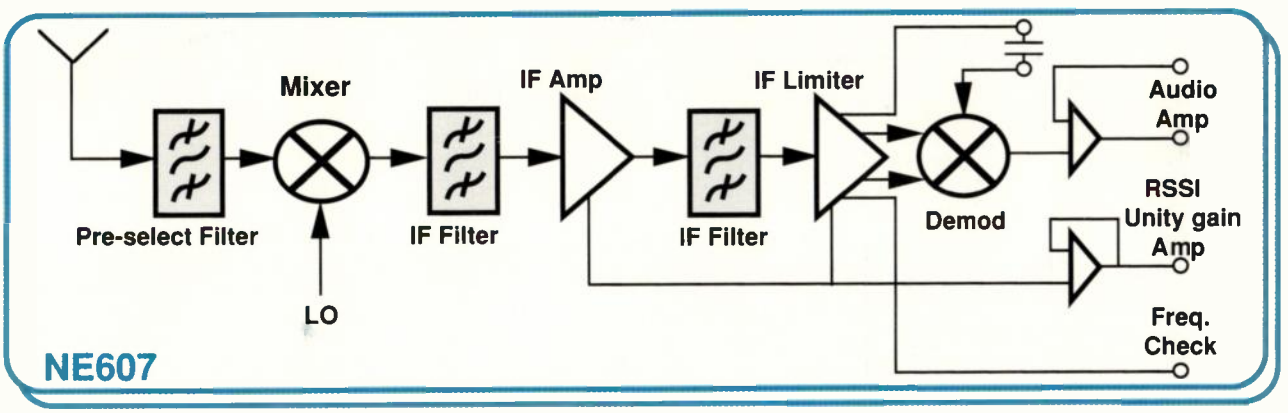
The most extensive sections are also of the most professional interest, covering test equipment, safety, and filters. The filter chapter is particularly comprehensive, presenting considerable theory and descriptions of the performance of various filter types used at UHF and microwave frequencies. The safety material is excellent background for any engineer working around microwave equipment, and concerns both hazardous radiation and hazards due to materials and chemicals. The test equipment chapter emphasizes inexpensive construction methods.

Beginning engineers will find this book (and its companion, Volume 1) to be an excellent addition to their college work, on-the-job training, and mentorship aspects of their 'apprenticeship.' Circle **INFO/CARD #112.**

Comparison of NE605, NE606 and NE607







NOTE:

- Function block internal to the device
- Function block external to the device
- Output/Input Pin

Signetics

For additional information call (800) 227-1817, ext. 739 AF.

Philips Semiconductors

PHILIPS

PHILIPS

Signetics' Family of FM IF Systems

	SIGNETICS NE604A	SIGNETICS NE614A	SIGNETICS NE605	SIGNETICS NE615	SIGNETICS NE606	SIGNETICS NE616	SIGNETICS NE607	SIGNETICS NE617
Vcc	4.5 - 8 V	4.5 - 8 V	4.5 - 8 V	4.5 - 8 V	2.7 - 7 V	2.7 - 7 V	2.7 - 7 V	2.7 - 7 V
Icc @ Vcc	3.3mA @ 6V	3.3mA @ 6V	5.7mA @ 6V	5.7mA @ 6V	3.5mA @ 3V	3.5mA @ 3V	3.5mA @ 3V	3.5mA @ 3V
Number of Pins	16	16	20	20	20	20	20	20
Package	Dip,SO	Dip,SO	Dip,SO,SSOP	Dip,SO,SSOP	Dip,SO,SSOP	Dip,SO,SSOP	Dip,SO,SSOP	Dip,SO,SSOP
Input Frequency (Max.)	Same as IF	Same as IF	500MHz	500MHz	150MHz	150MHz	150MHz	150MHz
Sensitivity Input Pin	0.22µV	0.22µV	0.22µV	0.22µV	0.31µV	0.31µV	0.31µV	0.31µV
Rin	1.6KΩ	1.6KΩ	4.7KΩ	4.7KΩ	8KΩ	8KΩ	8KΩ	8KΩ
Mixer Conversion Gain	N/A	N/A	13dB	13dB	17dB	17dB	17dB	17dB
Input 3rd Order Intercept*	N/A	N/A	+4dBm	+4dBm	-9dBm	-9dBm	-9dBm	-9dBm
Process ft	8GHz	8GHz	8GHz	8GHz	8GHz	8GHz	8GHz	8GHz
IF Frequency (Max.)	25MHz	25MHz	25MHz	25MHz	2MHz	2MHz	2MHz	2MHz
RSSI Range	90dB	80dB	90dB	80dB	90dB	80dB	90dB	80dB
RSSI Temp Comp	YES	YES	YES	YES	YES	YES	YES	YES
Conversion Stages	N/A	N/A	Single	Single	Single	Single	Single	Single
Features	- High Sensitivity - High IF Frequency	- High Sensitivity - High IF - Relaxed 604A	- High Sensitivity - High Input/IF Frequency - SSOP 20	- High Sensitivity - High Input/IF Frequency - SSOP 20 - Relaxed 605	- Low Power - Audio Op-Amp on Output - RSSI Op-Amp on Output - SSOP 20	- Low Power - Audio Op -Amp on Output - RSSI Op-Amp on Output - SSOP 20 - Relaxed 606	- Low Power - Audio Op-Amp on Output - Freq Check - Buffered RSSI - Differential Limiter Output - SSOP 20	- Low Power - Audio Op-Amp on Output - Freq Check - Buffered RSSI - Differential Limiter Output - SSOP 20 - Relaxed 607
Applications	- Can be combined with the NE602A to produce a single conversion receiver	- Can be combined with the NE612A to produce a single conversion receiver	- Cellular - High Performance Receivers - Industry Standard	- Cellular - Cordless Phones	- Portable Cellular - Portable Receivers - Cordless Phones	- Portable Cellular - Portable Receivers - Cordless Phones	- Portable Cellular • AMPS/TACS • NAMPS/NTACS - Portable Receivers - Cordless Phones	- Portable Cellular - Portable Receivers - Cordless Phones

*** Note- 50Ω Source**

98-2006-000

1206L/11FP/1091

A Guide to Coaxial Cable Shield Performance

By Robert D. Perelman and
Leonard J. Visser
Andrew Corporation

RF engineers have many factors to consider when selecting the right coaxial cable for an application. The element of a coaxial cable which is most critical to its performance, both electrical and mechanical, is its outer conductor, or shield. Unfortunately, the ideal coaxial cable outer conductor does not exist. The selection process requires weighing the performance advantages of the different types available and evaluating the tradeoffs based on the requirements of the applications.

This article provides a guide to the selection process by comparing the electrical and mechanical performance of the common types of coaxial cable outer conductors. Included are round braid, flat braid, smooth walled copper tube and corrugated copper tube. Similar sized cables with each of these outer conductors were selected for comparison. Table 1 lists the cable types that were used and gives their dimensions and construction materials.

The objective of a coaxial cable is to transmit a signal between two devices with minimal loss and minimal additional noise. Therefore, the contribution of the outer conductor to the electrical properties of the cable is the most important selection consideration. The different types of outer conductors are compared in terms of the normalized contribution to cable attenuation and shielding effectiveness in terms of transfer impedance.

Normalized Shield Attenuation

In order to compare the effects of different types of outer conductors on the attenuation of a cable, a comparison was made between the attenuation of the cable as measured (Figure 1) and the calculated attenuation that a cable of similar construction with a smooth copper outer conductor would have. The values obtained are shown in Table 2.

Smooth copper is the ideal surface for the inside of a coaxial cable outer conductor. Since the outer conductor of NA50325 3/8" semi-rigid cable is smooth copper, it has a normalized attenuation of 1.00. RG-213/U and RG-214/U have the highest ratio between actual and ideal attenuation because wire braid causes higher RF resistance than other shield types. The current in a braided outer conductor must flow at an angle to the cable axis, so it has a longer path to travel than in a cable with a solid shield. RG-214/U has a normalized attenuation value higher than RG-213/U because it has a larger braid angle resulting in an even longer current path.

SF-214 has a flat wire braid outer conductor, which results in attenuation 20 percent higher than for an ideal cable, but much lower than for the round wire braided cables. This is because the inside surface of the flat braid more closely approximates a smooth copper tube.

LDF2-50, with its shallow corrugated copper tube outer conductor has attenuation only 4 percent higher than would be realized with a smooth copper outer. FSJ4-50B has much deeper corrugations, resulting in a 20 percent increase over the ideal. The tradeoff is in mechanical characteristics, as will be shown later. The strong corrugated copper outer conductor allows the use of soft foam dielectric, resulting in lower cable attenuations as shown in Figure 1, while still maintaining good mechanical properties.

Shielding Effectiveness and Transfer Impedance

In most applications, it is very important that the signal in the cable not leak

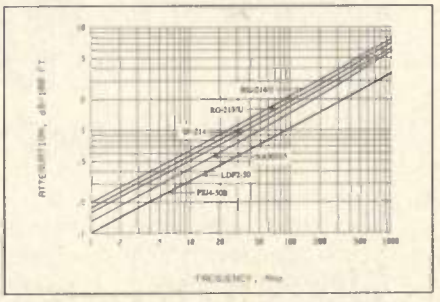


Figure 1. Attenuation versus frequency.

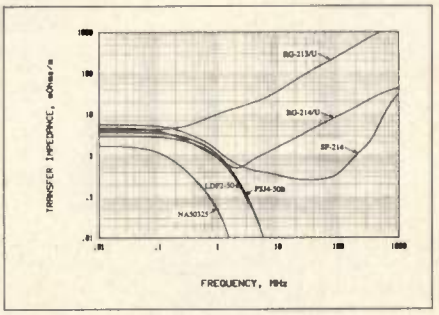


Figure 2. Transfer impedance versus frequency.

Cable Type	Inner Conductor	Diameter	Wt. lb/ft.	Dielectric	Shield Type
FSJ4-50B[1]	Cu-Clad Al	.520	.14	Foam PE	Corrugated Copper Tube
LDF2-50[1]	Cu-Clad Al	.440	.08	Foam PE	Corrugated Copper Tube
SF-214[2]	Stranded Cu	.426	.12	PE	Flat braid/ foil/braid
RG-213/U	Stranded Cu	.400	.11	PE	Braid
RG-214/U	Stranded Cu	.410	.12	PE	Double braid
NA50325[3]	Stranded Cu	.326	.15	PTFE	Copper tube

1 manufactured by Andrew Corporation
2 manufactured by Times Microwave
3 manufactured by Precision Tubes

Table 1. Cable types used for comparison.

Figure 3. RG-213/U cable.

Figure 4. RG-214/U cable.

Figure 5. SF-214 cable.

out and that unwanted signals from outside not leak into the cable. Signals getting into the cable can cause a degradation of system performance by adding noise, or in the case of electromagnetic pulse (EMP), damage to other components. Leakage out of the cable can result in noise in other parts of the system and can allow the signal being transmitted to be intercepted.

Transfer impedance, sometimes called surface transfer impedance, is the most consistent way of measuring and comparing the shielding effectiveness of cable shields. Transfer impedance is defined by the following equation:

$$Z_t = \left(\frac{1}{I}\right)\left(\frac{dV_t}{dz}\right)$$

Where Z_t is the surface transfer impedance; I is the interference current in the shield; and dV_t is the voltage generated by the current I on the dz length of the shield, and measured on the opposite side of the shield from the current I return path. It is desirable to have the lowest possible transfer impedance value so that shielding effectiveness will be maximized. Below 1 MHz, all the cables being compared have similar

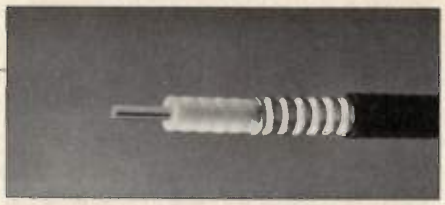


Figure 6. LDF2-50 cable.

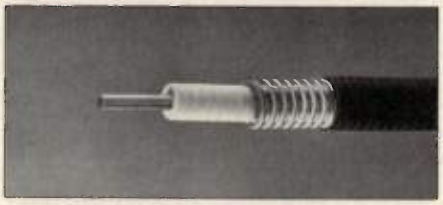


Figure 7. FSJ4-50B cable.

Figure 8. NA50325 cable.

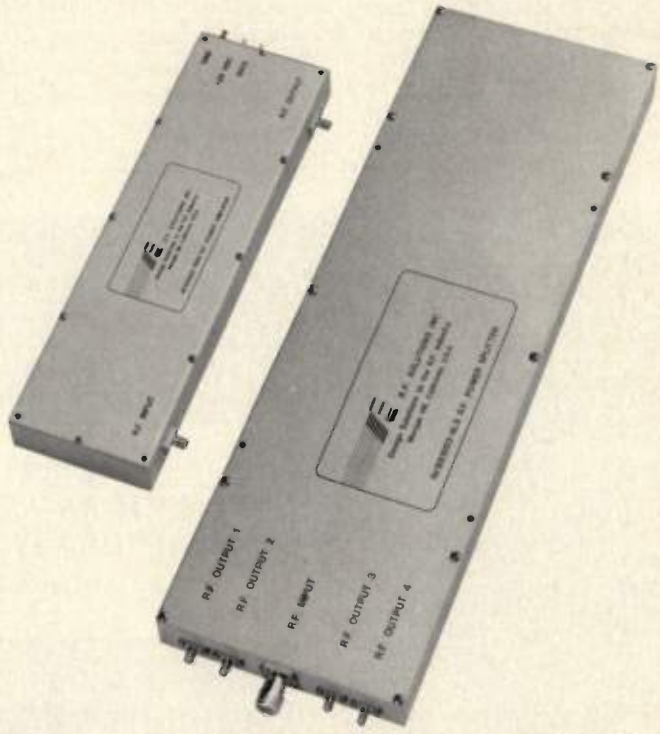
transfer impedance, as can be seen in Figure 2. NA50325 has the lowest transfer impedance because it has a thick, solid copper outer conductor re-

OFF THE SHELF

RF AMPLIFIERS

☐ **YES You Can Have EXPRESS DELIVERY**

MODEL NUMBER	POWER Watts	GAIN dB	SUPPLY Volts	PRICE
FREQUENCY RANGE 5 – 50 MHz				
RFP0550-100	100	44	50	$2,100.00
RFP0550-1000	1000	16	50	$5,040.00
FREQUENCY RANGE 50 – 100 MHz				
RFP0800-100P50	50	30	50	$1,485.00
RFP0800-100P100	100	30	50	$1,660.00
RFP0800-100P200	200	30	50	$2,200.00
RFP800-100	600	16	50	$2,424.00
FREQUENCY RANGE 1 – 100 MHz				
RFP01100-300	300	46	50	$3,150.00
FREQUENCY RANGE 76 – 108 MHz				
RFP0810-600	600	16	50	$1,780.00
FREQUENCY RANGE 75 – 150 MHz				
RFP0800-150P50	50	30	50	$1,485.00
RFP0800-150P100	100	30	50	$1,660.00
RFP0800-150P200	200	30	50	$2,200.00
RFP800-150	500	14	50	$2,424.00
FREQUENCY RANGE 100 – 200 MHz				
RFP0800-200P50	50	30	50	$1,660.00
RFP0800-200P100	100	30	50	$2,900.00
RFP800-200	400	13	50	$3,636.00
FREQUENCY RANGE 225 – 400 MHz				
RFP0204-4	4	20	28	$ 484.00
RFP0204-10	10	30	28	$ 685.00
RFP0204-25	25	30	28	$1,140.00
RFP0204-50	50	40	28	$1,695.00
RFP0204-100	100	40	28	$2,200.00
FREQUENCY RANGE 400 – 500 MHz				
RFP0405-4	4	20	28	$ 435.00
RFP0405-10	10	30	28	$ 616.00
RFP0405-25	25	30	28	$1,026.00
RFP0405-50	50	40	28	$1,525.50
RFP0405-100	100	40	28	$1,980.00
FREQUENCY RANGE 1 – 500 MHz				
RFP00105-4	4	20	28	$1,450.00
RFP00105-10	10	30	28	$2,300.00
RFP00105-25	25	30	28	$2,800.00
RFP00105-50	50	40	28	$3,752.00
RFP00105-100	100	40	28	$5,600.00
FREQUENCY RANGE 500 – 1000 MHz				
RFP0510-4	4	20	28	$2,610.00
RFP0510-10	10	30	40	$3,800.00
RFP0510-25	25	30	40	$4,900.00
RFP0510-50	50	40	40	$6,800.00
RFP0510-100	100	40	40	$9,800.00



OTHER PRODUCTS

- Power splitters and combiners
- Directional couplers
- Standard or custom microwave amplifiers
- Filters

R.F. SOLUTIONS INC.

16055 Caputo Drive, Morgan Hill, CA 95037, Phone (408) 778-9020, FAX (408) 779-4832

INFO/CARD 63

sulting in lower DC resistance.

Above one MHz, the transfer impedance of RG-213/U, RG-214/U, and SF-214 is much higher (indicating less shielding) than for the cables with solid outer conductors, because the signal can leak through the holes in the braids. The type of braid used results in the different performance levels. RG-213/U (Figure 3) has a single braid which provides less coverage than double braided RG-214/U (Figure 4). SF-214 (Figure 5) has a flat wire braided shield with smaller and fewer holes, plus a foil wrap and round wire braid over the flat braid resulting in substantially lower transfer impedance than the round braid cables up to 1 GHz.

Type	Normalized Attenuation
NA50325	1.00
LDF2-50	1.04
FSJ4-50B	1.20
SF-214	1.20
RG-213/U	1.34
RG-214/U	1.46

Table 2. Normalized attenuation.

Type	Reverse Bends
RG-214/U	500*
RG-213/U	500*
FSJ4-50B	400
SF-214	225
LDF2-50	38
NA50325	13

*Braided cables typically survive a greater number of bends.
Testing was stopped at 500 bends.

Table 3. Number of reverse bends on a mandrel ten times the shield diameter.

Type	Bending Moment, Ft./lb.
RG-214/U	0.17
RG-213/U	.21
FSJ4-50B	.62
SF-214	.67
LDF2-50	1.37
NA50325	6.54

Table 4. Bending moment on a mandrel ten times the shield diameter.

Cable Type	Min. Bend Radius, in.
NA50325	.75
FSJ4-50B	1.25
SF-214	1.25
LDF2-50	2.25
RG-213/U	2.50
RG-214/U	2.50

Table 5. Minimum bend radius based on 0.25 ohm impedance change.

Cable Type	Crush Strength, lb./in.
NA50325	336
FSJ4-50B	330
LDF2-50	122
SF-214	101
RG-214/U	88
RG-213/U	85

Table 6. Crush strength.

The performance of LDF2-50 (Figure 6) and FSJ4-50B (Figure 7) approaches the performance of the NA50325 (Figure 8). Because they use thinner shields than the semi-rigid cable, the DC resistance is greater and the transfer impedance is slightly higher. The shields are solid copper and have no holes to contribute to leakage at higher frequencies. Therefore, the transfer impedance of these cables is substantially lower than the braided cables above 2 MHz.

Mechanical Properties

A cable must have the mechanical properties that will allow it to survive in both installation and service. The outer conductor is key to achieving the re-

e Industry's Longest.
-YR. WARRANTY
on Antennas & Probes

The Art of EMI

This art is also functional. We begin with proven designs, use the highest quality materials and complete the picture with the latest manufacturing techniques. For 15 years this attention to detail has enabled industry and government to rely on A. H. Systems for the finest EMI test antennas and site hardware.

We offer a complete line of equipment to let you easily perform FCC/MIL-STD/VDE and TEMPEST testing. Our antennas and probes cover frequencies from 20Hz to 18GHz. Each comes with individual antenna factor and gain calibrations using ANSI, SAE, and NBS standard procedures performed on equipment traceable to the NBS.

See how precision equipment can brighten your testing picture.

Why pay more? Why wait 30–90 days when you want to test now? We can generally ship your order the day it is received.

A. H. Systems
9710 Cozycroft Ave., Chatsworth, CA 91311
Phone: (818) 998-0223 Fax: (818) 998-6892
Telex: 182640

A.H. SYSTEMS

INFO/CARD 65

quired flexibility and ruggedness.

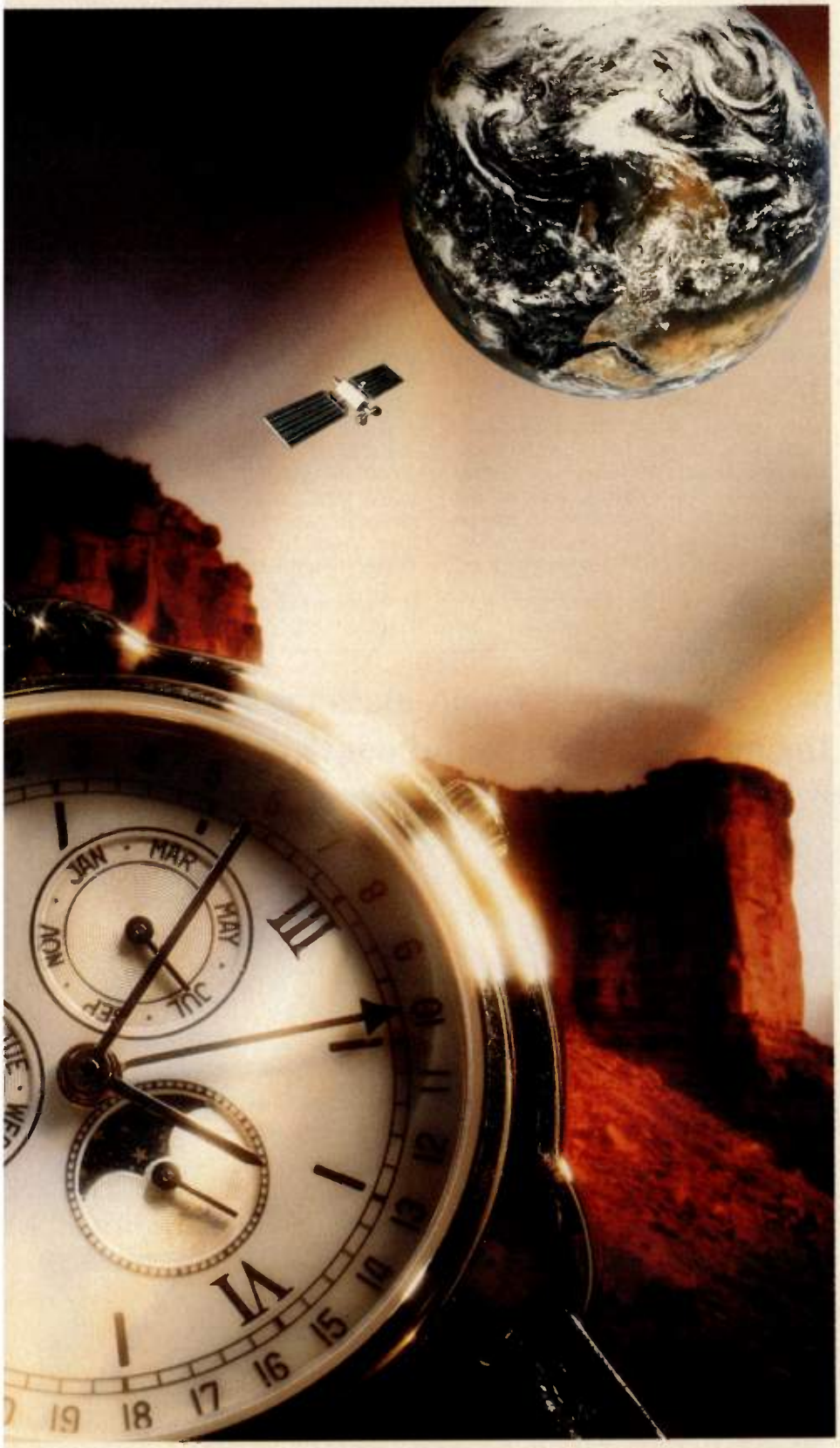
Flexibility — Flexibility is a particularly difficult characteristic to define and measure. Three measures of flexibility were used — reverse bends, bending moment and minimum bend radius.

Reverse Bends — The ability of the shield to withstand multiple bends in installation and service was measured by subjecting the cable to repeated multiple bends in installation and service was measured by subjecting the cable to repeated multiple bends on a mandrel with a radius of ten times the cable diameter. Failure was determined by examination of the outer conductor for cracks or broken wires.

As the Table 3 shows RG-213/U and RG-214/U are capable of withstanding more reverse bends than cables with solid copper outer conductors. Solid copper outer conductors eventually work harden and crack with repeated bending. The braid wires in RG-213/U and RG-214/U are thin and therefore experience less strain for a given bend radius. They can also move relative to one another allowing the braid to redistribute itself around the cable during bending.

FSJ4-50B has an outer conductor with deep corrugations which reduces the amount of strain during bending. The shallower corrugations of LDF2-50 result in more strain on the outer conductor and fewer reverse bends. NA50325 survives the smallest number

For those who dream of suspending time in the rush to the communications market.



HP helps speed up design cycles by verifying models with real-life signals.

In communication systems labs today, the focus is on improving time-to-market. Comdisco CAE software tools help by creating complex signals to verify models at the design simulation stage. Now, HP's 11755A takes verification a crucial step further, by linking CAE modeling with real-life test equipment to quickly and accurately test brassboards after simulation.

The HP 11755A RF simulator WorkSystem driver provides the link between Comdisco and the HP Vector Arbitrary Waveform Synthesizer. It lets you use real-world signals (10 to 3000 MHz with precision impairments) in the lab to test designs at the earliest possible stage. You get the test results you need to uncover deficiencies and modify designs fast. To speed up design iterations, just download your software signal formats and link testing with CAE software.

So, if you've ever wished you could suspend time in your communications systems design cycle, call **1-800-452-4844.** Ask for **Ext. 2410,** and we'll send you a brochure explaining how the HP 11755A can help make your dream come true.

There is a better way.

HEWLETT PACKARD

INFO/CARD 67

Please see us at RF Expo East, Booths #309, 311, 410, 412.

of reverse bends because its smooth, solid outer conductor experiences the most strain during bending.

For applications requiring repeated bending of the cable assembly in service, braided outer conductors are usually the best choice. As can be seen, the deeper corrugated copper shields also give long bend life, with the advantages of lower attenuation and better RF shielding.

Bending Moment — Another indicator of flexibility is bending moment or the force required to bend the cable. For purposes of comparison, the force required to bend each cable on a mandrel ten times the diameter of the outer conductor was determined. Values for the cables being compared are given in Table 4.

As would be expected, the braided cables have the lowest bending moments, with the corrugated copper outer cables coming next and the semi-rigid cable having a substantially higher value. This is important in applications where the cable needs to be repositioned in service and for ease of installation.

Minimum Bend Radius — The minimum bend radius of a cable is important to determine whether a cable will fit in a given mechanical configuration. To determine this, the smallest radius on which the cable could be bent with a maximum 0.25 ohm change in characteristic impedance was determined. The values shown in Table 5 differ in some cases from the manufacturers' specifications

NA50325 has the smallest minimum bend radius because of its solid dielectric and solid shield. Braided cables have larger minimum bend radii because the braided outer conductor buckles and pulls away from the core resulting in a change in impedance.

Corrugated copper tube outer conductor cables have small minimum bend radii, even though they use foam dielectrics, because the corrugations cause the tube to stay round during bending. FSJ4-50B has a smaller minimum bending radius than LDF2-50 because of its deeper corrugations and higher density dielectric.

Crush Strength — Crush strength is a good indicator of the ruggedness of a cable and its ability to withstand abuse during installation and service. Crush strength was determined by applying a compressive force to the cable using a flat plate and measuring the force required to cause a 5 percent reduction of the cable's diameter. The values obtained are shown in Table 6 and differ in some cases from the manufacturers' specifications.

NA50325 with its thick, solid outer conductor has the highest crush strength. Nearly the same crush strength is achieved by FSJ4-50B because of its corrugated copper outer conductor, even though it is much thinner copper and the cable uses a foam dielectric instead of the solid dielectric in NA50325. LDF2-50 with its shallower corrugations and lower density foam dielectric has much lower crush strength than these two, but still substantially higher than the braided outer conductor

cables which rely on their solid dielectrics for their crush strength.

Weight — In airborne and shipboard applications, cable weight is important. Table 1 includes a comparison of the weights of the cables. The single copper braid of RG-213/U has the lowest weight, but this is at the sacrifice of attenuation and shielding performance as we have seen.

The solid copper shield of LDF2-50 and composite shield used in SF-214 are about 50 percent heavier than the RG-213/U braid but offer substantially better attenuation and shielding performance. The double braid of RG-214/U is nearly twice the weight of the RG-213/U shield, but still does not provide as good attenuation or shielding performance as the solid copper shield of LDF2-50 or the composite shield of SF-214.

The very deep, closely space corrugations of FSJ4/50B outer conductor cause its weight to be more than twice that of RG-213/U, but they also result in an unmatched combination of flexibility, crush strength and excellent electrical characteristics. Semi-rigid NA50325 shield weighs slightly more than the shield of FSJ4-50B because it is thick walled copper. It also has excellent electrical characteristics, but lacks flexibility.

Conclusion

In this article we have shown a comparison between the main types of shields or outer conductors used on coaxial cables. The smooth wall copper outer conductor of semi-rigid cable provides ideal electrical performance, but the tradeoff is limited flexibility and high weight. Braided cables were shown to provide good flexibility, but low crush resistance, high attenuation and less effective shielding

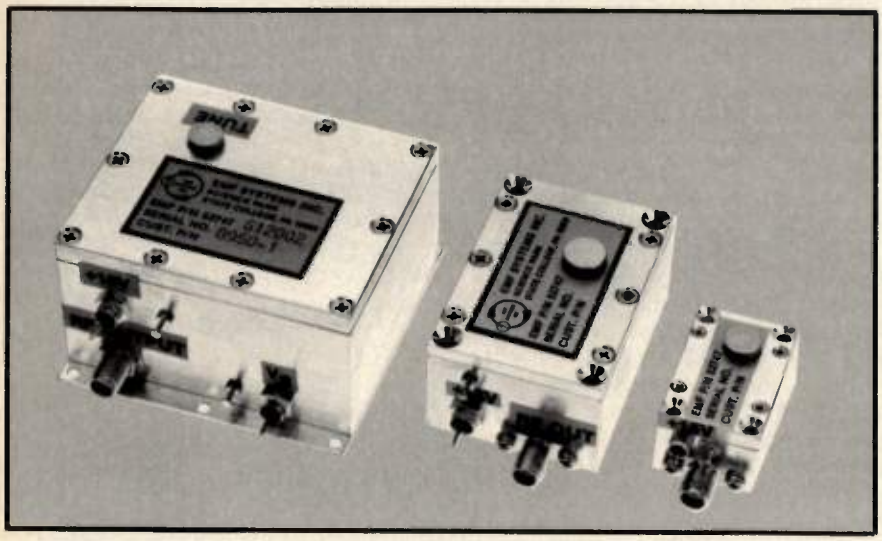
Semi-flexible cables with their corrugated copper outer conductors represent an excellent alternative. Their electrical characteristics approach those of a smooth walled copper tube, but with lighter weight and better flexibility. Their flexibility approaches that of a braided outer conductor cable, but with much higher crush strength, lower attenuation and more complete RF shielding.

All of the requirements of an application must be considered when selecting a coaxial cable. The information presented here is intended as a guide to help the RF design engineer in making the appropriate cable selection. The first step is to decide on the proper type of outer conductor. For both electrical and mechanical reasons corrugated copper is clearly a choice which offers many advantages. ***RF***

About the Authors

Robert Perelman is the Sales Manager for Government and Military Markets and Leonard Visser is the Senior Engineer, Transmission Lines, for Heliax® Products. They may be reached at 10500 West 153rd St., Orland Park, IL 60462. Tel: (708) 349-3300.

DIELECTRIC RESONATOR OSCILLATORS



SERIES 500
FREE RUNNING

SERIES 600
PHASE LOCKED

MILITARY • COMMERCIAL

EMF Systems Dielectric Resonator Oscillators feature low phase noise, rugged construction and the latest circuit techniques and components. Bipolar silicon transistors are used to approximately 10GHz and GaAs Fets above 10GHz.

Electronic and mechanical tuning are available as options on the 500 Series.

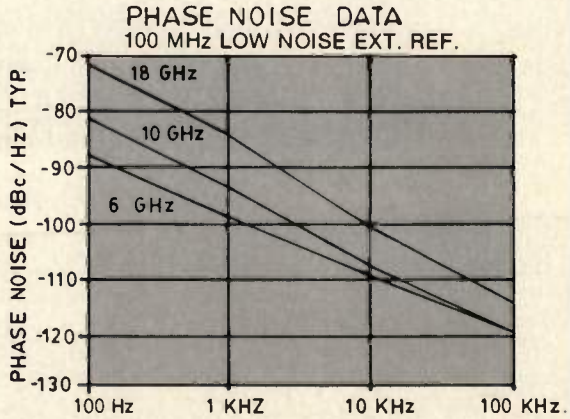
Series 600 are phase locked to internal or external references and are available with a lock alarm.

Options include regulators, isolators, buffer amplifiers, and temperature.

SPECIFICATIONS

	SERIES 500	SERIES 600
Frequency	< 4 > 18 GHz	< 4 > 18 GHz
Power Out	+ 10dbm (min.)	+ 10dbm (min.)
Harmonics	> 20dbc	> 20dbc
Spurious	> 70dbc	> 70dbc
Input Voltage	+ 15VDC	+ 15VDC
Temperature	– 20° to + 70°C	– 20° to + 70°C
Pushing	< .03%/Volt (max.)	
Pulling	< .03% 1.5:1 (max.)	
Stability	3-5 ppm/°c	Int. Ref. + 30 ppm Ext. Ref. Same as Ref.
Phase Noise 10GHz	100dbc @ 10KHz	See Curve
Input Current	40 ma Typ.	80ma Ext. Ref. 125ma Int. Ref.
Package Outline	See Figure 1,2,3	See Figure 4-7

For Frequencies Below 4 GHz, Call our Engineers for information on Series 400



EMF SYSTEMS **814-237-5738** **FAX 814-237-7876**

INFO/CARD 69

Ceramic Water-Cooled 20 kV Capacitor

Sprague-Goodman Electronics, Inc. has announced the addition of a new model, No. 40601, to the HWS Series of Radiocer™ power capacitors. These devices combine a 10,000 pF capacity and a 20 kV rating, and are designed for use in high frequency induction heating generators operating in the frequency range of 200 to 500 kHz. Other specifications include a nominal reactive power of 4000 kVAr, a nominal RMS current rating of 350 A, and an operating temperature range of 0 to 100 degrees C. The dimensions of the capacitor are 13.7 cm maximum diameter and 28.6 cm high. The tubular design offers the advantage of internal cooling. The HWS Series capacitors are coated with an elastomer for applications which may subject them to harsh environments. Prices start at under $1,600 (up to 4 pieces).

Sprague-Goodman Electronics, Inc.
INFO/CARD #199

Power JFET

A silicon power JFET series capable of providing 10 dB gain with power outputs from 15 to 120 Watts has been introduced by Microwave Technology. These new devices offer excellent linearity and efficiency for mobile communications base stations.

Microwave Technology
INFO/CARD #198

4.5 GHz Prescaler

Fluke will introduce a 4.5 GHz prescaler for the PM 6680 Timer/counter. With this option, the PM 6680 provides complete timer/counter functionality plus microwave counting. The PM 6680 has 19 measuring modes, 500 ps resolution, 2,000 readings per second, built-in math and statistics, and advanced arming capabilities. The unit is priced at $2,100.

John Fluke Mfg. Co., Inc.
INFO/CARD #197

CMOS Oscillator

The CXO-HG series of tri-state CMOS oscillators has been extended up to 70.0 MHz and offers CMOS or TTL output drive capability. The tri-state output is perfect for automated testing or frequency switching applications. Choose the CXO63HG for a 14 DIP package or the CXO23HG for a 8 pin DIP package. The CXO63GA Series is for frequencies above 70.0 MHz.

CTS Corp./Frequency Control Division
INFO/CARD #196

GaAs FET

New silicon bipolar and GaAs hetero junction FETs have been introduced by NEC. The NE46134 Si bipolar has a 1.5 dB noise figure, and 1/2 watt power output, while the NE32400 and NE24200 are GaAs FETs for C to Ka-band applications with 0.6 noise figure at 12 GHz.

California Eastern Laboratories
INFO/CARD #195

I and Q Modulator

Synergy Microwave Corporation has announced an off-the-shelf 34:1 bandwidth, I & Q modulator (SSB modulator), quad IF mixer and QPSK modulator. Typical conversion loss is 9 dB, amplitude balance is ±0.5 dB, phase balance is ±10 degrees and VSWR is 1.5:1. These devices are supplied in either plug-in or connectorized packages.

Synergy Microwave Corporation
INFO/CARD #194

Microwave Power Transistor

Motorola has introduced a high-gain, one watt microwave power transistor for use in large-signal output and driver amplifier stages operating in the frequency range of 1.0 to 4.0 GHz. The MRW 54602 power transistor is designed with all-gold metallization for improved reliability.

Motorola Inc./RF Products Division
INFO/CARD #193

Precision Trimmer Capacitors

Voltronics has produced a new line of sealed precision trimmer capacitors with Teflon replacing air as the dielectric. The voltage rating is 1,000 DC working volts and 2,000 DC withstanding volts. The capacitance range is 1 to 9 pF with a high Q.

Voltronics Corporation
INFO/CARD #192

Parallel Plate Capacitors

Compex parallel plate capacitors are designed with bare ceramic borders on the top side for use in applications where conductive epoxy shorting is a problem. They are also useful where image recognition equipment requires a distinction between the capacitor and any gold surface that it is mounted on.

Compex Corporation
INFO/CARD #191

FM IF System

Signetics has introduced the NE/SA 606/607 FM receiver devices designed to dramatically shrink the size and power consumption of portable communication systems such as cellular and cordless phones, wireless LAN's and other communication systems.

Signetics Company
INFO/CARD #190

Peak Power Meter

The Boonton 4400 peak power meter covers a frequency range of 30 MHz to 40 GHz and its dynamic range extends from −40 to +20 dBm. Measurements are made at a rate of 40 to 70 measurements per second, and waveforms are digitized at a 1 MHz rate. The Model 4400 is available in single-channel for $11,750 and two-channel $13,000.

Boonton Electronics Corporation
INFO/CARD #189

Substrate Test Fixture

Inter-Continental Microwave has introduced a universal substrate test fixture for testing hybrid substrates separately or on carriers, DC to 50 GHz. It features moveable RF launches and DC probes, and ground contact is always maintained under the launch.

Inter-Continental Microwave
INFO/CARD #188

Switching Matrices

A 19 inch rack mount IEEE-488 controllable RF switching matrices have been announced by Lorch Electronics. The units have up to 30 inputs by 30 outputs and an internal regulated power supply. Typical specifications are a 10 dB gain, 4 dB noise figure, 1.2:1 VSWR, and greater than 70 dB of isolation.

Lorch Electronics
INFO/CARD #187

RF expo products *continued*

Serenade PC and Microwave Harmonica PC

Compact Software, Inc. has introduced a new schematic editor for Super Compact, Microwave Harmonica and Success Simulators. Also shown is the new version of their linear/nonlinear simulator operating under DOS, Windows 3.0 or OS/2.
Compact Software, Inc.
INFO/CARD #186

Spectrum Analyzers

The MS2601B/K series of advanced spectrum analyzers has the following features: accurate measurement of frequencies and levels; high speed measurement using the zone marker and zone sweep; EMI measurement functions; new analysis display functions and PTA.
Anritsu America Inc.
INFO/CARD #185

New Products

Tele-Tech Corp. will be showing a host of new products including I-Q assemblies, frequency discriminators, power dividers and quadrature hybrids.
Tele-Tech Corp.
INFO/CARD #184

Phase Locked Oscillators

TML is offering phase locked oscillators from .4 GHz to 14 GHz utilizing surface mount construction techniques to reduce production costs. Proprietary sampling techniques offer wide temperature and frequency ranges.
Tampa Microwave Lab, Inc.
INFO/CARD #183

Power Amplifiers

Power Systems Technology, Inc. has announced the development of solid state high power amplifier model BHE4819-1000. The amplifier delivers 1000 watts CW output power in the frequency range of 400 to 1000 MHz, with an instantaneous bandwidth of 600 MHz. RF input is 1 mW for full output power.
Power Systems Technology, Inc.
INFO/CARD #182

Bonding PTFE Circuits to Heat Sinks

Poly Circuits has developed a new technology for bonding PTFE circuits to heat sinks and various ground planes called FLEX LINK™ using an elastic electrically conductive bonding adhesive. This patented process is considerably less costly and more reliable than prebonded or 'sweating' process.
Poly Circuits
INFO/CARD #181

Conduction Cooled Resistors

Florida RF Labs is offering a broad selection of high power conduction cooled resistors and terminations with power handling capabilities to 800 watts and a frequency range to 6.0 GHz.
Florida RF Labs, Inc.
INFO/CARD #180

Network Analyzers

The HP8751A vector network analyzer combines high speed and accuracy with advanced features to meet demanding requirements from 5 Hz to 500 MHz. The HP 8711A is fully integrated 300 kHz to 1300 MHz component test system. Key features include a fast, synthesized source with 50 ms sweeps and 1 Hz resolution, 90 dB dynamic range, built-in disk drive and instrument BASIC.
Hewlett-Packard Company
INFO/CARD #179

Multi-Pin Connector

A new Hermetic multi-pin connector that can be laser welded to any aluminum package/module has been announced by Balo Hermetics Company. The connector assembly features a flange that is weld compatible. It complies with MIL-C-83513 connector specifications and is available with 9, 15, 21 and 31 pins.
Balo Hermetics Company
INFO/CARD #178

RF Circuit Simulation

jOMEGA features a wide range of RF models for passive and active elements and includes a full set of microwave transmission line models. Other features include interactive tuning, and performance and yield optimization.
EEsof, Inc.
INFO/CARD #177

Inductors and Transformers

Vanguard Electronics is offering surface mount leadless power inductors and transformers to meet MIL-T-27/356 military speci-

fications. Features include a compact low profile, surface mountable package having tin plated phosphor bronze terminations, and a frequency range of 100 kHz to 300 MHz.
Vanguard Electronics Company, Inc.
INFO/CARD #176

Crystal Oscillator

The phase-locked crystal oscillator (PLXO) is a 16-pin, ceramic packaged device that provides frequency translation between telephone standard reference clocks associated with the DS-1, DS-1C, and CEPT-1 transmission rates. The internal phase locked loop provides two modes of operation.
AT&T Microelectronics
INFO/CARD #175

Amplifiers, Mixers Converters

Locus, Inc. will be showing many new products with an operating frequency of base band through 18 GHz. These products include image reject mixers, quadrature hybrids, low noise amplifiers, solid state power amplifiers and redundant amplifier systems.
Locus, Inc.
INFO/CARD #174

Cellular Direct I/Q Modulators

Anzac has announced the new EQKR8 Series I and Q modulators that offer direct modulation/demodulation at carrier frequencies of up to 1 GHz. These units, available in standard 8 pin relay headers, provide quadrature input and cover 25 MHz bandwidths.
M/A-COM, Inc.
INFO/CARD #173

Low Frequency Amplifier

ENI's Model 1140LA RF power amplifier produces up to 1100 watts of linear Class B output over the frequency range of 9 kHz to 250 kHz. Up to 1600 watts is available from 11 to 75 kHz; extended range performance is possible with somewhat reduced output power and linearity. Along with a gain of 55 dB, the 1140LA features advanced thermal and mismatch protection circuitry.
ENI
INFO/CARD #172

Four Channel Preselector Switch

Sierra Microwave Technology has introduced a four channel preselector capable of selecting lumped element filters with bandwidths from 10 percent to 100 percent in the 0.5 to 6 GHz frequency range. Passband insertion loss is typically less than 5 dB at a maximum VSWR of 1.5:1. Rejection is greater than 60 dB at all frequencies from DC to 12 GHz.
Sierra Microwave Technology
INFO/CARD #171

Spectrum Analyzer

The R3265 microwave spectrum analyzer covers the range 100 Hz to 8 GHz. It has user defined menus, 50 microsecond sweep, noise levels in high sensitivity mode as low as −140 dBm and a variety of user oriented features.
Advantest
INFO/CARD #170

Cable Bending Tool

Applied Specialties Inc. has introduced a new cable bending fixture for construction of semi-rigid coaxial assemblies.
Applied Specialties Inc.
INFO/CARD #169

Linear Amplifier

Part number PF880-39 is a 8 watt, Class A, linear amplifier covering the 869 to 896 MHz range. This amplifier features 40 dB of gain over 27 MHz of band width, power output at the 1 dB compression point is 39 dBm. Applications include cellular radio, PCN network and digital trunk base stations.
Trontech
INFO/CARD #168

Low Noise OXCOs

Series CO-724SI2 OCXO provides a low noise +7 dBm output at any frequency in the 25 through 140 MHz range in a 2 × 2 × 1 inch package. Temperature stability is $\pm 5 \times 10^{-9}$ over 0 C to +50 C and $\pm 5 \times 10^{-8}$ over −55 C to +85 C. Aging is 2×10^{-9} per day, 5×10^{-7} per year. Phase noise at 100 Hz is −130 dBc/Hz and at 50 kHz is −157 dBc/Hz.
Vectron Laboratories, Inc.
INFO/CARD #167

RF expo products *continued*

Oven Controlled Crystal Oscillator

Piezo Technology, Inc. has developed a new miniature oven controlled crystal oscillator. PTI Model XO5002C offers a standard ±.02 ppm stability over the temperature range of -30 to +70 C. The standard frequency is 10.0 MHz with optional frequencies available between 9.0 and 16.0 MHz.

Piezo Technology, Inc.
INFO/CARD #166

Integrated Switching Subassemblies

JFW Industries' current attention has been focused upon the design, development and manufacturing of integrated switching subassemblies. Each unit is available with operating software. P.C., RS-232 or IEEE-488 are control options, and DC or AC powered versions are available.

JFW Industries, Inc.
INFO/CARD #165

Surface Mount Mixer

EDSI/RF Prime has introduced a small 3 GHz surface mount mixer with a conversion loss of 9 dB at a low input of 7 dBm.

EDSI/RF Prime
INFO/CARD #164

RF Modem

RF Modem is a "plug-and-play" unit that provides wireless data communication between microprocessor-based devices. The RF Modem, which does not require any FCC site license, is fully compatible with most hardwire communication interfaces, providing high speed, multi-node, or point-to-point local network of distances up to 500 feet.

Proxim, Inc.
INFO/CARD #163

Tunable Bandpass Filter

Integrated Microwave Corporation has introduced a 5-Band, micrometer tunable bandpass filter. Features include a tuning range of ±8 percent, a 1.5 dB bandwidth of 8 MHz min., 20 dB bandwidth of 60 MHz max., 50 dB bandwidth of 200 MHz max., and VSWR of 1.5:1.

Integrated Microwave Corporation
INFO/CARD #162

Low Noise, Power Amplifiers

Amplidyne, Inc. has introduced cellular low noise and power amplifiers for radio links in the 1.7, 2.3 GHz frequency range. The solid state LNA's and power amplifiers are used for PCN and GSM applications.

Amplidyne, Inc.
INFO/CARD #161

Low Pass Filters

Sawtek has developed a series of low-loss filters for use in both cellular site and subscriber GSM/PCN applications. Features include small size, single level fabrication, quartz temperature stability, standard fixed value component matching and low cost. The center frequency can be placed anywhere from 20 MHz to 400 MHz with a 1 dB bandwidth that will accommodate the 200 kHz passband requirement typical of GSM/PCN applications.

Sawtek Incorporated
INFO/CARD #160

Motorola Products

Motorola has introduced four new products. The MC33110 is the latest audio processing device in Motorola's communications portfolio. The MC13135 is a second generation dual conversion receiver aimed at consumer and professional FM radio designs. The MC13175/13176 is the first monolithic crystal controlled UHF transmitter subsystem. The MC33218 is a third generation hands free speaker phone IC.

Motorola Inc.
INFO/CARD #159

Standard Waveguide Horns

A complete range of standard waveguide horns, double ridge multioctave band horns and dual polarized horns has been announced by Antenna Research Associates, Inc.

Antenna Research Associates, Inc.
INFO/CARD #158

High Power Low Pass Filters

TTE has introduced miniature 9 pole Chebyshev low pass filters covering the range of 250 kHz to 100 MHz. Features include power levels up to 250 watts CW and a

small size of 2×4×.25 inches high.
TTE, Incorporated
INFO/CARD #157

Synthesized Pulse/ Function Generator

Wavetek has announced a new 20 MHz synthesized pulse/function generator. Its pulse capability generates pulses to 50 MHz and square waves to 100 MHz. The Model 91 provides a source of sine, triangle and square waveforms with 15 volts peak-to-peak output into 50 ohms.
Wavetek San Diego, Inc.
INFO/CARD #156

Ultra Low Noise Transistors

The ATF-35 family of ultra-low-noise GaAs pseudomorphic high-electron-mobility transistors offer noise figures as low as 0.75 dB at 12 GHz with 11 dB associated gain. These transistors are provided in a new commercial-grade 0.070 inch metal/ceramic micros-trip surface-mount package.
Avantek
INFO/CARD #155

Solid State Amplifier

The new Model 300A100 all solid state broadband amplifier delivers 300 watts minimum linear (less than 1 dB compression) over its 10 kHz to 100 MHz bandwidth. Typical applications are RF susceptibility testing, antenna and component testing, and wattmeter calibration.
Amplifier Research
INFO/CARD #154

Test Cable Assemblies

Rugged, multi-use, phase stable cable assemblies offered by Applied Engineering Products are manufactured in standard three foot lengths. AEP cable assemblies utilize high quality, heavy duty low loss cable and are fabricated with captive contact, passivated SMA plugs per MIL-C-39012. Assemblies are also available with precision type N-plugs, SMA jacks or any combination of connectors.
Applied Engineering Products
INFO/CARD #153

Instrument Test Cable

This instrument test cable is designed for the phase, amplitude, and VSWR stability requirements of the HP 8510 or Wiltron 360 Vector Automatic Network Analyzers operating to 40 GHz. The Model 2030-0024-8785 provides stability under normal flexing and stressing of the laboratory environment.
M/A-COM Adams-Russell
INFO/CARD #152

High Bandwidth CATV Modules

New CATV modules from Philips Semiconductors have sufficient bandwidth to carry 110 TV channels. BGY600 series amplifier modules and BGD600 series power doubler modules have a bandwidth of 40 to 600 MHz, while BGY700 and BGD700 series devices offer bandwidth extension to 750 MHz.
Philips Semiconductors
INFO/CARD #151

Simulation and Analysis Software

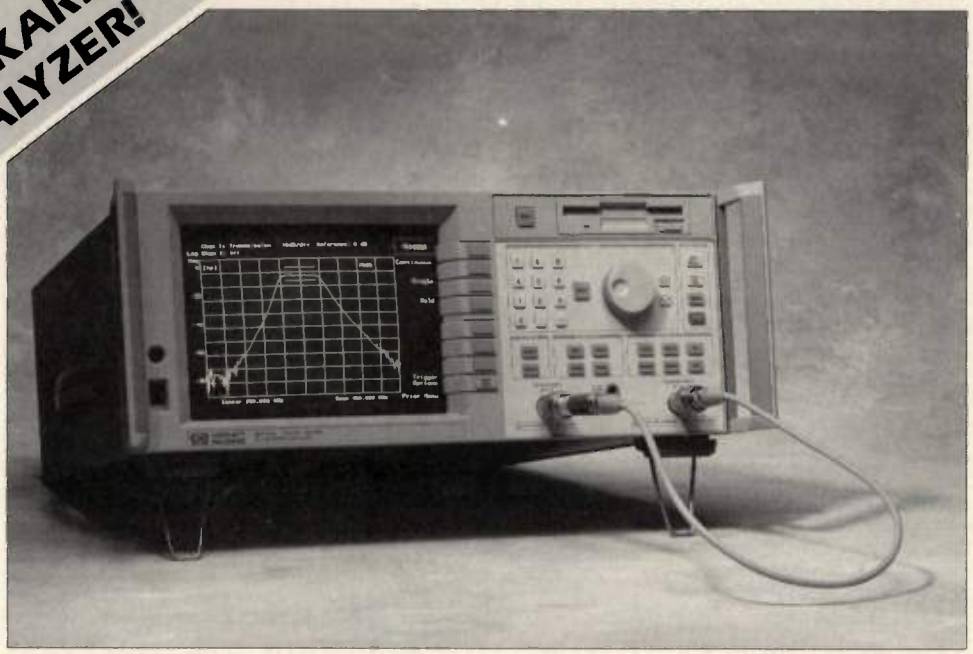
LINMIC+ is a suite of modules integrating simulation, optimization, global noise analysis, parameter extraction and layout generation. Developed by Jansen Microwave and distributed and supported by Eagleware.
Eagleware
INFO/CARD #150

Interference Tracker

The PLI-150 is an instrument designed to find AC power distribution sources of radiated RF interference. The system includes a hand-held receiver, antennas, mounts, and carrying case.
Trilithic, Inc.
INFO/CARD #149

The Circuit Design Contest Grand Prize:

A HEWLETT-PACKARD NETWORK ANALYZER!



Watch for even more great prizes!

The Circuit Design Contest Grand Prize is a HP 8711A Vector Network Analyzer from Hewlett-Packard! This analyzer provides insertion loss, gain, power return loss and SWR measurements from 300 kHz to 1300 MHz with 1 Hz resolution and 90 dB narrowband dynamic range, 66 dB broadband. A 50 ms full band sweep means fast measurements, and the built-in reflection test set has 40 dB directivity and 20 dB port match. Internal computing power offers complete marker options (eight of them), direct printer and plotter control, and stored measurement routines. Provided by Hewlett-Packard, Network Measurements Division.

1992 RF Design Awards Contest Official Rules

The 1992 RF Design Awards Contest provides recognition for innovation and engineering excellence among RF designers. Prizes are donated by companies which recognize the importance of creative engineering ideas.

Again this year, there are two separate entry categories, and two sets of prizes. Please note that the rules may not be the same as previous years' contests.

I. The DESIGN Contest

RULES

1) Entries shall be circuits with an RF function, operating in the below-3 GHz frequency range.

2) Circuits entered shall have a complexity equivalent to that of a circuit using 8-10 discrete active devices, or 6-8 integrated circuits. The entry can be a portion of a larger system. This rule is intended to make judging equitable by maintaining a degree of similarity among entries.

3) Entries which emphasize design methods should include an example circuit. Entries demonstrating a test method should include a description of the device or system under test.

4) The entries shall be the original work of the entrant, not previously published. If developed as part of the entrant's employment, entries must have the employer's approval for submission.

5) A maximum of two entries per person is permitted. An entry may have two or more co-authors.

6) Submission of an entry implies permission for publication by RF Design. All prize-winning entries will be published, plus additional entries of merit.

7) Winners are responsible for any taxes, duties, or other assessments which result from the receipt of their prizes.

8) Entries must be postmarked by March 20, 1992 and received no later than March 27, 1992.

(9 All entries will remain confidential until the publication of the July 1992 issue of *RF Design*.

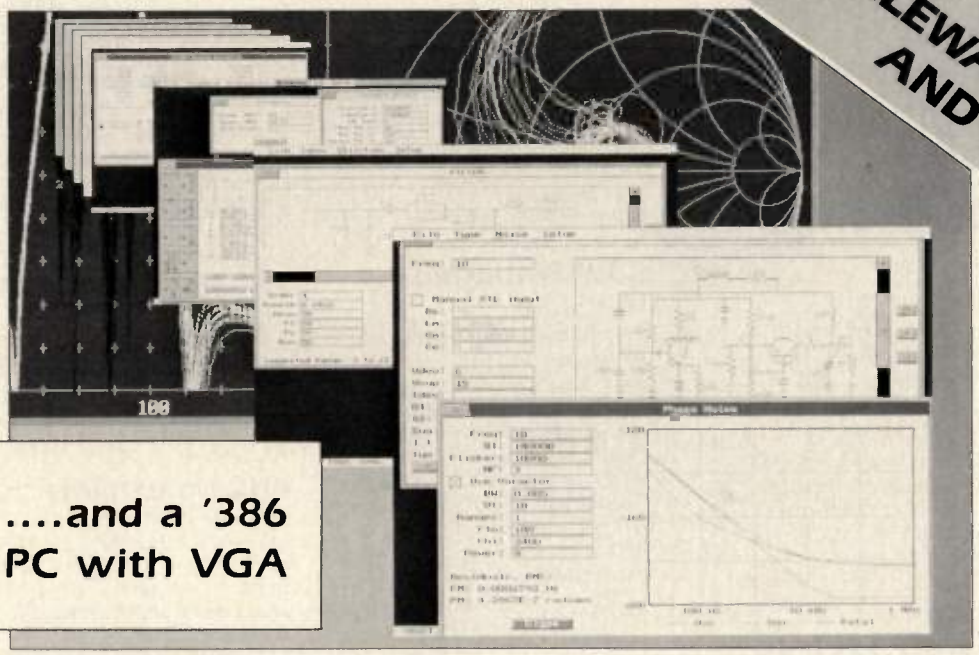
JUDGING CRITERIA

Originality — Each design will be evaluated for similarity to work by others, unusual application of a device or technique, and other factors which represent unique contributions.

Engineering — Since engineering is a problem-solving profession, entries should clearly identify the purpose of the entry, and how it was created in response to a need.

Documentation — A complete description of the circuit or technique is required, including sufficient theoretical background, explanation of circuit operation, and performance data.

The PC Software Contest Grand Prize:
EAGLEWARE RF SOFTWARE AND A '386 PC!



....and a '386 PC with VGA

Start working on your entry today!

The PC Software Contest Grand Prize begins with a complete set of RF design software from Eagleware, including: =SuperStar= circuit simulator with optimization; the new =MATCH= active or passive matching program; =FILTER= synthesis package for filters and equalizers; =OSCILLATOR= for synthesis of L-C, SAW, crystal and T-line oscillators; and the =TLINE = physical and electrical parameter calculation program.

PLUS — A complete '386 computer system, with math coprocessor, 80 Mbyte hard drive, VGA graphics card, VGA monitor and mouse. System set-up and software installation is included. All this provided by Eagleware.

II. The PC SOFTWARE Contest

RULES

1) Each entry shall be a computer program which assists in the design, test, or contol of RF circuits.

2) Programs must operate on computers compatible with MS-DOS/PC-DOS or Apple Macintosh operating systems. Any special hardware requirements should be noted (i.e., memory, graphics).

3) Programs should be provided in a form that can be run without special support software. For example, programs written in languages other than GWBASIC/BASICA should be provided in compiled, directly executable form. Programs operating within spreadsheets or mathematics packages cannot be accepted unless they are capable of operating stand-alone.

4) Entries must be submitted on disk, along with supporting documentation on theory of operation, references, operating instructions, and source code. Supporting material must be supplied in printed form.

5) The entries shall be the original work of the entrant, not previously published or distributed (including public access BBS or shareware). If developed as part of the entrant's employment, entries must have the employer's approval for submission.

6) A maximum of two entries per person is permitted. An entry may have two or more co-authors.

7) Submission of an entry implies permission for publication by *RF Design* and distribution by the RF Design Software Service. All prize-winning entries will be published, plus additional entries of merit. Some restrictions on publication and distribution of source code may be acceptable.

8) Winners are responsible for any taxes, duties, or other assessments which result from the receipt of their prizes.

9) Entries must be postmarked by March 20, 1992 and received no later than March 27, 1992.

10) All entries will remain confidential until the publication of the July 1992 issue of *RF Design*.

JUDGING CRITERIA

Technical Merit — Computer programs will be compared to accepted standards for accuracy. They will also be judged for achievement in translating RF theory into software tools.

Usefulness — The value of the software to the RF engineering community will be evaluated. Both the merit of the subject matter and the operation of the program will be considered.

DEADLINE FOR ENTRIES:
POSTMARKED BY MARCH 20, 1992 —
RECEIVED BY MARCH 27, 1991

Send entries to: **RF Design Awards Contest**
***RF Design* magazine 6300 S. Syracuse Way, Suite 650**
Englewood, CO 80111

RF expo products *continued*

PC-Mount Attenuator

Alan Industries' 50CAL( ) PCB is a continuously variable attenuator available in 10, 15 and 25 dB ranges for operation up to 400 MHz. Average power handling is 0.5 watt.

Alan Industries, Inc.
INFO/CARD #148

SAW-Stabilized Receiver

RF Monolithics will demonstrate an advanced version of their SAW-stabilized superregenerative receiver, the RB1018. This 418 MHz receiver features -105 dBm sensitivity, 500 kHz bandwidth, and low reradiation to allow certification to FCC, DOT and DTI requirements.

RF Monolithics
INFO/CARD #147

1-Watt Amplifier

A high-gain, medium power amplifier with greater than 1 watt output over 100-400 MHz with 32 dB gain is introduced. Packaged in 1.0×2.0×0.75 inch case, the unit draws less than 0.5 amp from a 12 VDC supply.

LCF Enterprises
INFO/CARD #146

15 kW MRI Amplifier

NMR-4, a 15 kW solid-state RF amplifier for NMR and MRI is announced by Erbtec Engineering. Self-protection circuitry is included to monitor operation. Current models cover 40-80 MHz and 155-180 MHz.

Erbtec Engineering
INFO/CARD #145

BNC Connectors

Amphenol introduces a new right angle bulkhead BNC receptacle isolated from ground. This model is designed for printed circuit board applications.

Amphenol Corporation
INFO/CARD #144

Analysis of Phase Noise in Oscillators

By Jonathon Y.C. Cheah
Hughes Network Systems

Designing a PLL for communications equipment often requires the design engineer to optimize its phase noise variance to meet a specific system requirement, such as the Bit Error Rate (BER). Although theoretical analyses can estimate the phase noise contents a priori, *on-the-bench effort is inevitably needed. The debugging process is greatly expedited if one can determine the areas where the unwanted energy can be minimized.*

This program provides a means for analyzing the output of phase noise measurements during debugging. It allows the designer to have a clear picture of the problem areas and keeps track of the BER performance degradation contributions from the PLL. In some cases, the use of this analysis can quickly pin-point the problems with a faulty design if the predicted noise variance profile differs significantly from the measured. For instance, common problems such as a bad loop filter or an out-of-specification VCO are discernable from the plots generated.

Theory

Following Rohde's (1) analysis on the power law model for phase noise spectral density,

$$S(f) = Kf^x \tag{1}$$

Equation 1 can be reorganized as a straight line equation by taking the logarithmic values on both sides of the equation,

$$\log S = x\log f + \log K \tag{2}$$

The gradient x and K, the anti-log of the intercept point, can easily be found by knowing 2 consecutive points ($dBc_1 f_1$) and ($dBc_2 f_2$) of the phase noise spectral density profile.

$$x = \frac{dBc_2 - dBc_1}{10(\log f_2 - \log f_1)} \tag{3}$$

$$K = 10^{\left(\frac{dBc_1}{10} - x\log f_1\right)} = \frac{10^{\frac{dBc_1}{10}}}{f_1^x} \tag{4}$$

Then, the phase noise variance can be conveniently expressed as σ^2,

$$\sigma^2 = \int_{f_1}^{f_2} S(f)df = \int_{f_1}^{f_2} Kf^x df \tag{5}$$

$$= \frac{K}{x+1}\left(f_2^{x+1} - f_1^{x+1}\right) \quad \text{for } x \neq -1$$

$$= K(\log f_2 - \log f_1) \quad \text{for } x = -1$$

It can be seen that the results are rather complicated expressions of x and K. A simple logarithmic manipulation and substituting $x = -1$ allows the following expressions to be derived,

For $x = -1$

$$\sigma^2 = 10^{\frac{dBc_1}{10}} f_1 \log \frac{f_2}{f_1} \tag{6}$$

For $x \neq -1$

$$\sigma^2 = \frac{f_1}{x+1}\left(\left[\frac{f_2}{f_1}\right]^{x+1} - 1\right)10^{\frac{dBc_1}{10}} \tag{7}$$

With the knowledge of the noise variance, it is important to know how much of this noise energy a particular communication system can tolerate within its link performance limitations in terms of signal to noise ratio losses. It is often not prudent to demand the best possible phase noise specifications. For an optimum commercial product design, cost is the primary design driver. It is still not uncommon to find excessively good phase noise specifications with respect to link budget performance in commercial products, especially in satellite ground equipment.

The effect of phase noise has different degrees of impact on the system's performance dependent on the modulation type. It is appropriate, however, to consider the spectrum efficient modulations such as PSK.

The performance degradation of phase noise effect on digital communications can be characterized by the increase in the energy per bit to noise ratio, E_b/N_o, necessary to achieve the same bit error rate. The additional signal energy needed to overcome the degradation is accounted for in the system's implementation loss margin in a link budget.

From the above analysis, the value $\sigma 2$ represents an RMS SSB phase noise variance. Therefore, the noise contribution for both side bands can be expressed as

$$\varrho = \sqrt{2}\sigma \tag{8}$$

In Reference 1, a 3 dB addition to spectral density is recomended to convert the SSB phase noise variance into a DSB one. For clarity, the factor 2 is explicitly expressed in ϱ.

To obtain the BER degradation expression, it is necessary to select a suitable model for the probability density function of the loop phase error ϕ. For a first order PLL with zero detuning, i.e. without loop stress, the Tikhonov density function is typically used (2). However, without the assumption of any loop elements, a Gaussian density function is more suitable here. From Reference 3, the conditional probability of error averaged over ϕ is,

$$P_e = \frac{1}{\sqrt{2\pi}\varrho}\int_{-\infty}^{\infty} \exp\left(-\frac{\phi^2}{2\varrho^2}\right) \text{erfc} \quad (9)$$

$$\left(\sqrt{\frac{2E_{bi}}{N_o}}\cos\phi\right)d\phi$$

Where erfc(x) is the complementary error function. E_{bi}/N_o is the ratio of energy per bit over noise. Bit energy is used here rather than symbol energy because the basic Pe curve will be universally true irrespective of the M'ary nature of the modulation of interest.

For $\varrho = 0$ or a small ϱ, which is the region of interest, the computation is very difficult using this direct form. To overcome this problem, a simple parametric substitution is made:

let $\phi = \varrho\phi$, then the probability function can be written as:

$$P_e = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} \exp\left(-\frac{\theta^2}{2}\right) \text{erfc} \quad (10)$$

$$\left(\sqrt{\frac{2E_{bi}}{N_o}}\cos\theta\varrho\right)d\theta$$

In this way, the singularity in the region of interest is removed. The equivalent QPSK probability of error can be derived in a similar manner,

$$P_e = \frac{1}{2\sqrt{2\pi}}\int_{-\infty}^{\infty} \exp\left(-\frac{\theta^2}{2}\right)\Big[\text{erfc} \quad (11)$$

$$\left(\sqrt{\frac{2E_{bi}}{N_o}}(\cos\varrho\theta + \sin\varrho\theta)\right)$$

$$+ \text{erfc}\left(\sqrt{\frac{2E_{bi}}{N_o}}(\cos\varrho\theta - \sin\varrho\theta)\right)\Big]\, d\theta$$

Program Description

More than 50 percent of the length of this program is taken up by the plotting routines. This is a necessary evil for the program to be useful. This program was written in a manner so that only modest computing resources are needed. The plotting routine library used was IPC-MF-006 from Quinn-Curtis, and if recompilation of this program is desired, the

```
200.00, -60.038
400.00, -65.371
600.00, -63.705
800.00, -58.538
1000.00, -61.871
1200.00, -63.538
1400.00, -59.705
1600.00, -55.371
1800.00, -58.038
2000.00, -57.438
4000.00, -63.271
5000.00, -62.167
6000.00, -64.938
8000.00, -64.271
10000.00, -63.302
12000.00, -64.271
14000.00, -64.271
15000.00, -59.500
16000.00, -62.271
18000.00, -65.105
20000.00, -64.292
25000.00, -66.833
30000.00, -73.333
35000.00, -72.833
40000.00, -76.386
45000.00, -77.167
50000.00, -78.000
60000.00, -84.271
80000.00, -86.605
100000.00, -93.271
120000.00, -95.938
140000.00, -96.771
160000.00, -96.605
180000.00, -101.271
200000.00, -99.205
400000.00, -105.471
600000.00, -108.638
800000.00, -108.471
1000000.00, -109.638
1200000.00, -112.971
1400000.00, -113.305
1600000.00, -111.471
1800000.00, -111.805
2000000.00, -110.971
0.0
```

Figure 1. The structure of the "PH-NOISE.TXT" file. The first column contains the values of the frequency offsets from the carrier in Hz, and the second, the measured phase noise spectral density in dBc/Hz. The file should be terminated with 0.0 frequency. This set of measurement data belongs to a carrier of a VSAT transmitter at 14.25 GHz.

Software Eagleware

Fast and interactive high-frequency design synthesis and simulation software for personal computers and workstations

New! =MATCH=

Several matching techniques in one package:

- Narrow or broadband with complex source & load
- Single or multistage, active & passive networks
- Choose simple or high-order solution for each network
- Best solutions available, or your money back!
- $895. Only $595 with =SuperStar=

=OSCILLATOR=

A unified design process for oscillators:

- L-C, distributed, SAW, and crystal oscillators
- Estimates SSB and residual FM & PM noise
- Process addresses tuning, pulling, starting, output level and harmonics
- $795. Only $495 with =SuperStar=

=FILTER=

A complete L-C filter synthesis package:

- Conventional plus narrowband, flat-delay, symmetric & zig-zag topologies
- Complete set of all-pole and elliptic transfer functions
- Includes =EQUALIZE= for group-delay equalizers
- $795. Only $495 with =SuperStar=

=TLINE=

Relate line physical & electrical parameters:

- Microstrip, coupled microstrip, stripline, coupled stripline, coplanar and coaxial geometries
- Accurate & fast algorithms with references
- Extensive set of output data
- Synthesis and analysis
- $595. Only $395 with =SuperStar=

New GUI!

These programs have a new Graphic User Interface with mouse support, easy data entry, and schematic display

The above programs automatically write circuit files for the Eagleware simulators =SuperStar= ($695) and =SuperStar= Professional ($995). The simulator, with real-time tuning and optimization, is used to finalize the design.

All programs run on standard IBM and compatible personal computers, include a 30 day money-back guarantee, free support and no annual maintenance fees. Immediate shipment arranged with PO, COD, VISA or MasterCard.

For info or to order, call (404) 939-0156

VISA MasterCard

Eagleware Corporation, 1750 Mountain Glen, Stone Mountain, GA 30087, USA, FAX (404) 939-0157

INFO/CARD 81

Please see us at RF Expo East, Booth #209.

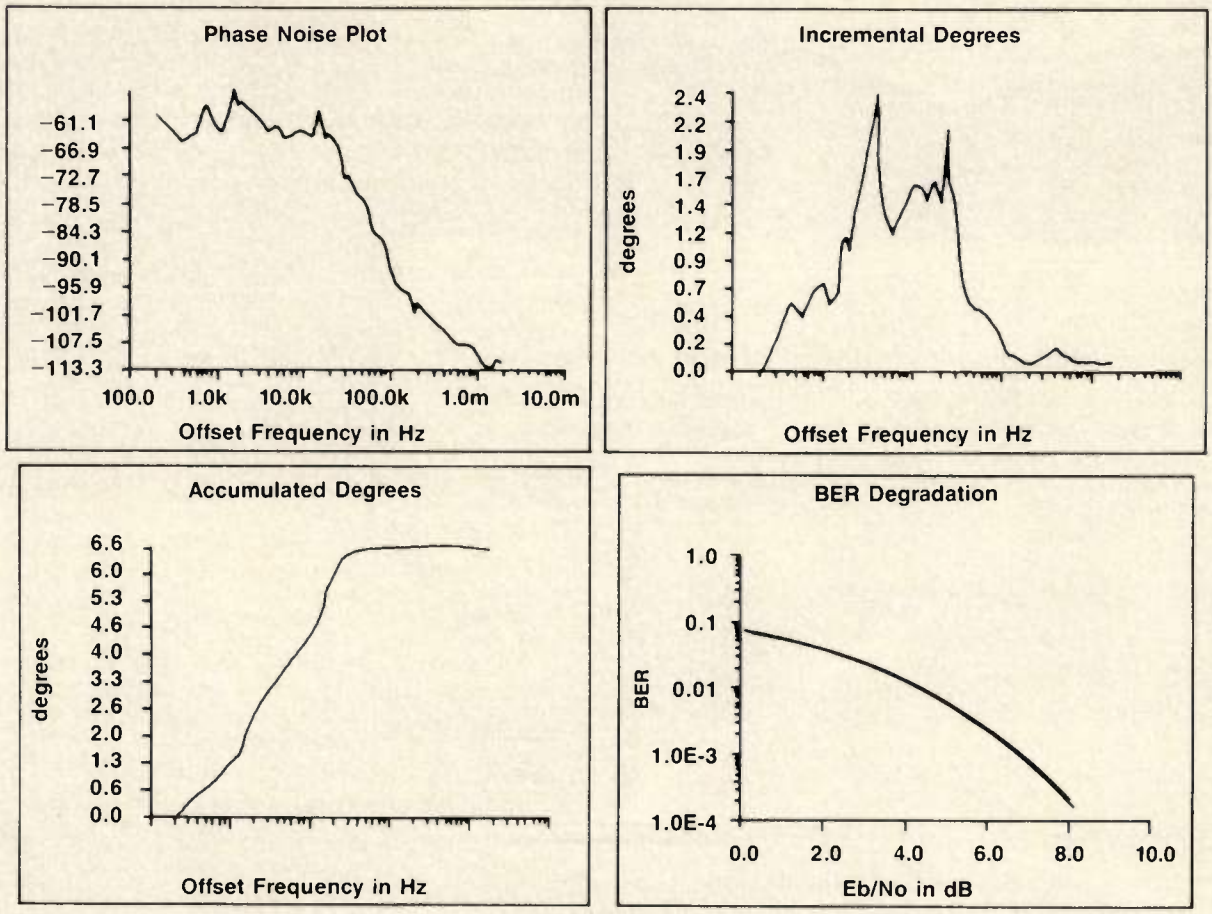


Figure 2. This figure is produced by "PH-NOISE.PS". This is what the VGA screen shows when running "PH-NOISE.EXE". In the VGA screen, all the active data plots are shown in red.

library can be obtained at a reasonable cost. The compiler used was Microsoft Fortran Compiler 5.0. Simple routines for erfc and integration functions are included to avoid the need for more professional libraries such as IMSL.

The erfc function routine is adapted from Reference 4 and more efficient integral routines than the one used in this program can also be found in there.

The flow of the program follows the equations derived above directly and it should be self explanatory. The ease of modifying this program to enhance or extract any part of this analysis is carefully maintained. One can perhaps get a high resolution plot of the BER curves with the change of only a few parameters.

The program begins by looking for a file called "PH-NOISE.TXT" which contains the spectral density measurement data. From this file, this program produces 3 files. "PH-NOISE.DAT" gives all the intermediate values of the noise variance calculation in units of degrees RMS. "BER.DAT" gives the theoretical BER versus E_{bi}/N_o data and the phase noise degraded data. "PH-NOISE.PS" is a post-script file which allows the plots shown on a VGA screen to be plotted on a laser printer.

Instructions

This program runs on an IBM AT 286/386 with a VGA monitor. As the program requires rather lengthy processor time, it is recommended that these faster machines be used. The run-time on a typical 12.5 MHz IBM AT 286 clone with a 287 co-processor is about 3 minutes. A 25 MHz 386 without a co-processor takes about 11 minutes, and it takes 45 seconds if a 387 co-processor is used. The program will need a Microsoft Fortran Compiler 5.0 *.FON library at "C:\FOR" directory. This directory pathname can be changed by changing the "INITSEGRAPHICS" call in the "PH-NOISE.FOR" file.

The compiled program can be made portable and be independent of the Microsoft Fortran Compiler library by copying "COURB.FON" from the library into the same directory as "PH-NOISE.EXE" or into "C:\FOR".

An ASCII file "PH-NOISE.TXT" containing the spectral density of the oscillator under test has to be present in the same directory as the program. The construction of the file is shown in Figure 1. The offset frequency step in Hz need not be uniform and can be of any step size to suit the convenience of

the measurement. The unit of the spectral density is dBc/Hz, thus if the spectral density measurement is done by a spectrum analyzer, then it is necessary to normalize the raw measurement data by the analyzer's resolution bandwidth. For example, if the resolution bandwidth used is 1 kHz, and the raw spectral level is measured as −30 dBc, then the spectral density in this case is −60 dBc/Hz. For a more accurate measurement, it is also necessary to use smaller frequency spans to measure the side band levels in contiguous segments. A detailed description of the measurement technique can be found in Reference 5.

The selection of the noise bandwidth of interest is dependent on the system's requirements. For example, in a typical PSK demodulator with matched filters, one need not be too concerned with noise energy within the receiver AFC loop bandwidth ω_{afc} offset from the oscillator frequency. Also the noise energy that is higher in frequency than the signal bandwidth ω_{sig} offset from the carrier will be rejected. Thus, the phase noise measurement of interest can be confined to frequency offsets of 1.67 π ω_{afc} to 2.4 $\pi\omega_{sig}$ approximately.

In this program, only BPSK modulation is assumed. QPSK modulation also can be implemented very easily by using the expression derived above. Figure 2 shows the output of the post-script laser printer which is also the VGA screen output.

This program is available from the RF Design Software Service. See ad on this page for ordering information. ***RF***

References

1. U.L. Rohde, *Digital PLL Frequency Synthesizers*, NJ, Prentice-Hall, 1983.
2. J.K. Holmes, *Coherent Spread Spectrum Systems*, NY, John Wiley and Sons, 1982.
3. J.J. Stiffler, *Theory of Synchronous Communications*, NJ, Prentice-Hall, 1971.
4. W.H. Press, et al, *Numerical Recipes*, NY, Cambridge University Press, 1989.
5. K. Feher, *Telecommunications Measurements, Analysis, and Instrumentation*, NJ, Prentice-Hall, 1987.

About the Author

Dr. Jonathon Cheah is a Senior Principal Engineer at Hughes Network Systems. He may be reached at 10790 Roselle St., San Diego, CA 92121. Tel: (619) 546-1953.

Simple SMT Bridge Circuit Mimics Ultra-Broadband Coupler

By Joel Dunsmore
Hewlett-Packard

Directional couplers are often used in microwave systems to sample or combine signals, and an RF version can be quite useful. Traditional microwave couplers are only a few octaves wide, and are unsuitable for the many decades of frequency range used in the RF world. RF transformers are generally not useful up to the GHz frequency range. The design presented here is a unique implementation of a resistive (Wheatstone type) bridge, with loss, coupling and directivity closely matching coupler characteristics over a frequency range of kilohertz to gigahertz. This circuit was entered in the 1991 RF Design Awards Contest.

Directional couplers have the characteristics of low loss in the through path, flat frequency response in the coupled path, and high isolation in the reverse coupling path (directivity), Figure 1. Ideal couplers are lossless, that is, no energy is absorbed in the coupler. An ideal, lossless coupler with 16 dB coupling factor would have only 0.11 dB of loss. In practice, all couplers have through arm loss. For applications other than high power, this loss, often about 1 dB, is acceptable. These applications include power leveling, and signal sampling for phase- and frequency-locked loops.

The Resistive Bridge

The two key characteristics of directional couplers, as the name implies, are the ability to sample (or couple) signal flow, and to do so in only one direction. A resistive bridge, if driven in the proper way, also has this directional property. Figure 2 shows a bridge structure. A sample of the drive voltage is present across each resistor. If the bridge is balanced, $R_1 \times R_3 = R_4 \times R_5$, then no voltage appears across R_2. For balance, a bridge often has all the resistors the same value, say 50 ohms, but balance only requires that the ratios of each string be equal ($R_1/R_5 = R_4/R_3$).

Figure 3a shows a bridge with nonsymmetric resistors, driven in the forward signal flow direction. In this case the voltages across certain nodes have been labeled consistent with the coupler in Figure 1. For the resistors chosen, V_{coup} is 16 dB down from V_{p1} (16 dB coupling), and V_{p2} is 1.5 dB down from

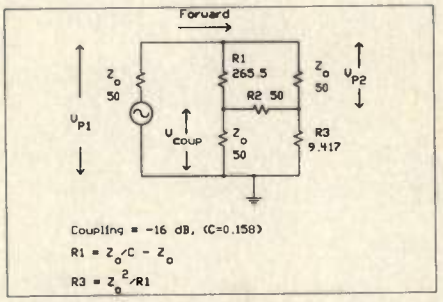


Figure 3a. Bridge/coupler driven in the forward direction.

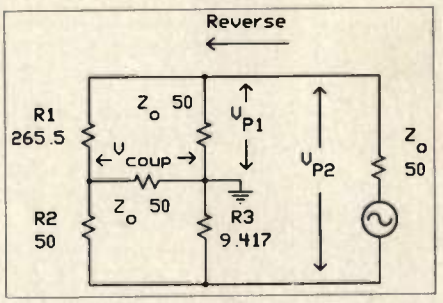


Figure 3b. Bridge/coupler driven in the reverse direction. Note that V_{coup} is across the balanced node.

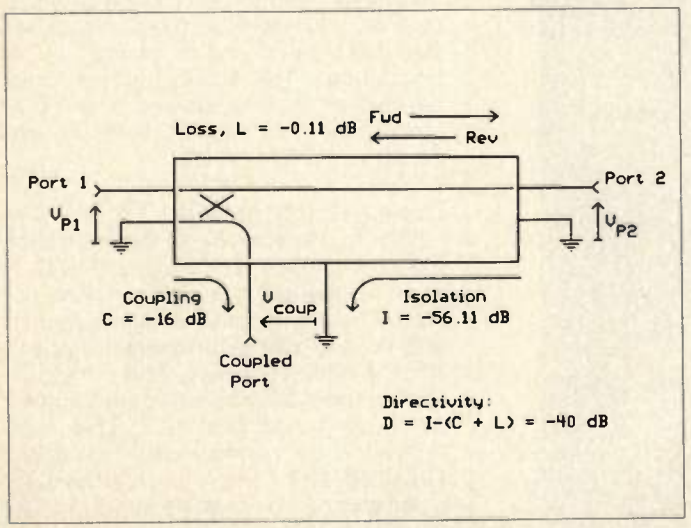


Figure 1. Definition of terms for a directional coupler.

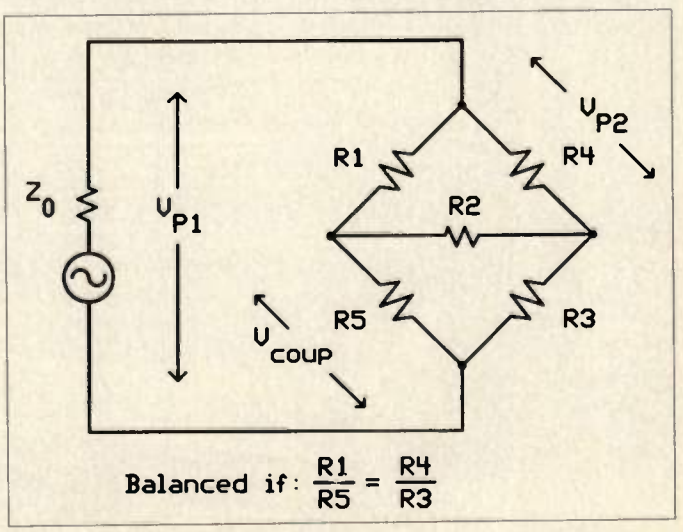


Figure 2. Basic bridge structure.

V_{p1} (1.5 dB loss). The equations shown in Figure 3a demonstrate how to calculate resistance values for any coupling factor. The directional nature of the bridge is demonstrated by redrawing the figure to put a voltage source in series with the V_{p2} resistor, and "stretching" the remaining elements about to achieve Figure 3b. Note that none of the connections have been changed, except moving the drive voltage from port 1 (V_{p1} resistor) to port 2 (V_{p2} resistor). Drawn this way, it is easy to see that no voltage appears across the coupler port (V_{coup} = 0), as the bridge is balanced when driven in this fashion.

In the RF implementation of this bridge, the V_{p1} resistor represents the port 1 impedance (50 ohms in this case), the V_{coup} resistor represents the coupled port impedance, and V_{p2} resistor represents the port 2 impedance. The difficulty with this structure is that port 2 must be isolated from ground; this may be accomplished with a transformer of some sort. Figure 4 shows a diagram of the bridge, with the port 1 and coupled port represented by coaxial transmission lines, and port 2 isolated by a transformer. The 1:1 transformer may be realized in a clever way by using a ferrite loaded coaxial transmission line balun.

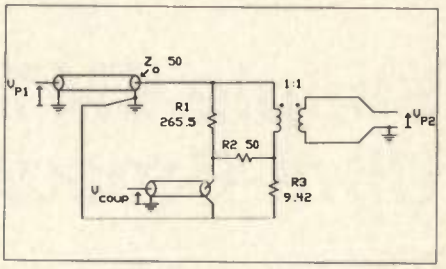


Figure 4. Bridge/coupler realization with coax ports on port 1 and coupled port and transformer on port 2.

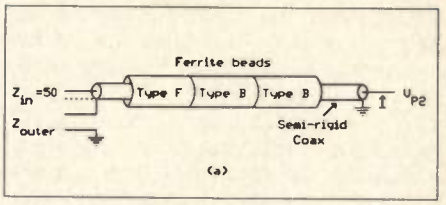


Figure 5a. Coax balun.

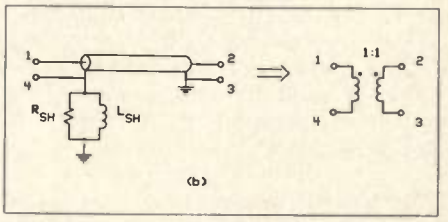


Figure 5b. Coax balun implementation of a 1:1 transformer showing parasitic shunt impedance.

Coax Balun Structure

The implementation of the 1:1 transformer might use a simple wire-wound core, but the low frequency response is limited by the mutual inductance, and it is difficult to maintain a constant impedance at high frequency. The 1:1 transformer function can be approximated by using a length of coaxial cable, with a ferrite bead on the outer conductor, Figure 5a. This forms a balun, which has a constant 50 ohms impedance from the inner to outer conductor. One or more

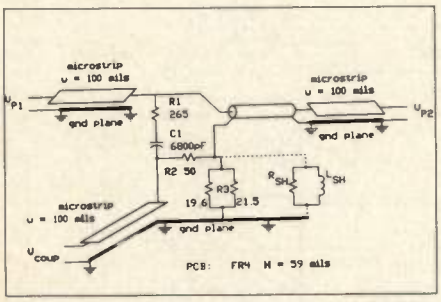


Figure 6. Final microstrip implementation of the bridge coupler.

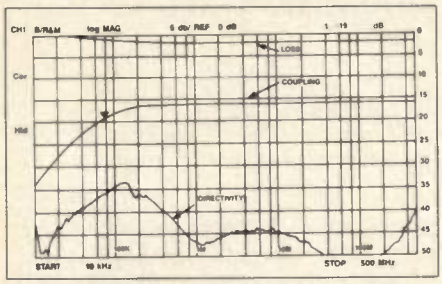


Figure 7. Low frequency response of the bridge/coupler.

ferrite beads raises the impedance of the outer conductor to ground by the impedance of the bead. In the bridge structure, this is a parasitic impedance which may be modeled as a resistor in parallel with an inductor, from the outer conductor to ground, Figure 5b. In the implementation used, the beads were of varying inductive index, with one Ferronics type F bead (#21-083-F), and three type B beads (2 of 21-129-B, and 1 of 21-083-B). These beads were chosen because they fit on standard 0.086 semi-rigid coax. Varying the inductive index allows using a high frequency, low permeability (μ) bead (type F) near the bridge structure, with a low frequency, high μ bead following to raise the low frequency inductance.

The final implementation of the circuit is shown in Figure 6. Here, micro-strip transmission lines are used for port 1 and the coupled port. The coax balun described above is used as the 1:1 transformer to port 2. Surface mount resistors are used for the resistive elements. Note here that the 9.4 ohm resistor (R3) is replaced with two resistors in parallel, with values of 19.6 and 21.5 ohms. The parasitic effect of the ferrite beads on the outer conductor is shown connected across R_3 by dotted lines.

Another addition to the final implementation is a capacitor, C_1, in series with R_1. It will block DC from the main arm path, such that no current will flow in the resistors of the bridge. This is important as some situations may have DC bias at the center conductor of the main arm, such as at the output of an amplifier. In the actual implementation, C_1 was chosen to be the standard value of 6800 pF.

Figure 7 shows the low frequency performance of the bridge/coupler on a log frequency scale. It is remarkable that the directivity remains better than 30 dB down to 100 kHz. The "bump" in the low end directivity is due to changes in inductance of the ferrite beads. It may be reduced by selecting a better value for C_1. Above 300 kHz, the directivity is better than 40 dB to 500 MHz.

The loss and coupling are also shown,

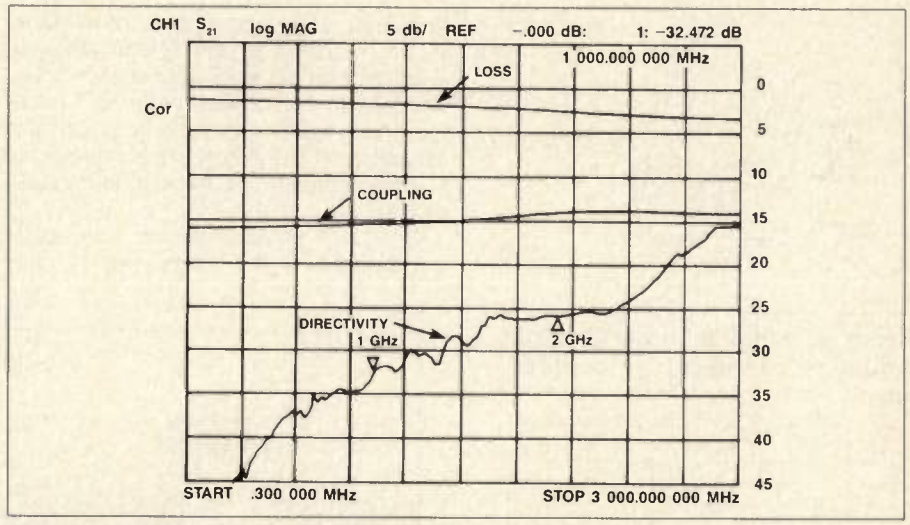


Figure 8. High frequency response of the bridge/coupler.

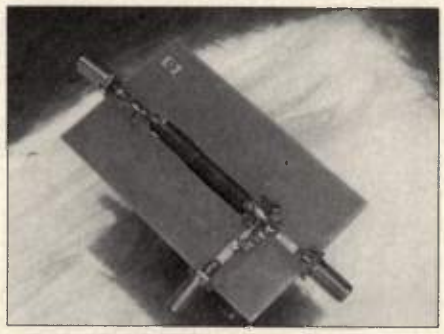


Figure 9. Photo of completed SMT bridge circuit.

in the range of 300 kHz to 500 MHz, there is less than 0.25 dB of rolloff in the through path, and less than 0.5 dB of rolloff in the coupled path. The -3 dB rolloff in the coupled path is below 80 kHz.

Figure 8 shows the high frequency performance of the bridge/coupler on a linear frequency scale. The coupling rolls up by about 1 dB above 1 GHz, and 2 dB above 2 GHz. The through loss increases by about .5 dB/GHz. The directivity remains quite good, even at high frequencies, with 32 dB directivity at 1 GHz, and 26 dB directivity at 2 GHz. I must admit, though, that a small piece of copper tape was used to tune out discontinuities of the input connector to improve the match. A measurement of the source match of the bridge/coupler revealed better than 30 dB match to 1 GHz, and better than 21 dB match to 2 GHz.

The power handling capability is determined by the maximum power dissipated in the SMT resistors. In this case, R_1 has the highest dissipation. For R_1 rated at 0.125 watts, the drive power may be 0.937 watts, or 29.7 dBm. Of course, larger or multiple resistors would increase the power handling capability.

The bridge/coupler built with SMT parts, and using the standard available ferrites and coax line, can be built for less than $5.00, not including the connectors. Because it is built in PC board material, it can be integrated in an RF PC board for very low cost, while providing very nice performance.

The low frequency measurements were made on an HP 8751 Network Analyzer, and the high frequency measurements were made on an HP 8753C Network Analyzers.

Acknowledgements

I would like to thank Wayne Frederick for contributions to the thin film bridge detector which was the seed for a family of resistive bridge couplers. The ferrite beads were from Ferronics Inc. *RF*

About the Author

Joel Dunsmore is an R&D engineer at Hewlett-Packard's Network Measurement Division. He received his BSEE and MSEE from Oregon State University. His work includes several papers on RF measuring techniques and lightwave measurements with network analyzers. He may be reached at 1400 Fountain Grove Pkwy., Santa Rosa, CA 95403. Tel: (707) 577-4042.

A Vertical Mounting Construction Technique for RF Power Modules

By Fulvio Perri
Itelco, S.p.A.

The new generation of solid-state transmitters operating up to UHF involves the design of amplifier modules which handle high power levels over a wide range of frequencies. Generally specifications for these "building blocks" are very strict in regards to maximum power, efficiency, reliability, ruggedness, electrical performance, cooling, easy maintenance, and cost. This article will emphasize the electrical design and construction of a broadband amplifier module for FM broadcast (87.5 - 108 MHz). This design was entered in the 1991 RF Design Awards Contest.

To minimize the number of modules and the size of the equipment, each building block must be capable of supplying maximum output power (1). For this reason, a push-pull configuration has been chosen. Power combiners using baluns make integrated transformers easy to construct. These intrinsically wide-band components supply two signals phase-shifted by 180 degrees and bring the line impedance (50 ohms) significantly closer to that of the devices (2, 3, 4). Other design considerations, in regard to transistors, shall be reliability and component efficiency. Nowadays, these requirements make active components in the BJT family the choice instead of MOSFETs. In fact, in current technology, field-effect devices are more vulnerable than bipolars in regards to high return loss values (5, 6).

Selection of the Active Device

Transistor manufacturers offer models with up to 300 W output power. The few models available in this range have an input impedance at the limit of practical use, the result of paralleling of several devices. A careful look at the market shows that for models around 150 W, established technology, wide choice, good reliability, and affordable prices are available. Transistor gain depends on the technology and geometry of the single chip.

The families available represent a few basic topologies, which differ in the number of transistors making up the die, the value of the emitter resistors, the quality and type of passivation, the length of the wire bonding, the thickness of the beryllium (BeO) ceramic, the type of case, and therefore the heat dissipation capability. The choice of the device falls on transistors with larger chips, which, although their gain is lower, are more reliable and have better collector efficiency.

The choice of the device voltages must also be carefully considered. A 28 V working voltage is a good compromise between reliability, gain, and price but the V_{ce0} must be at least 60 V and I_{cmax} must be greater than 15 A.

It is preferable to use unmatched devices which benefit from safer building technology even though their Z_{in} is very low. In fact, the doubling of the number of wire bondings to insert the matching components reduces the reliability, occupies active space, increases the risks from overdriving, forces the use of more expensive cases and worsens the in-phase repeatability, thus offering users only a narrow selection of devices. Thus, prematched transistors cost more, are produced with greater difficulty, and behave strangely outside the matching area.

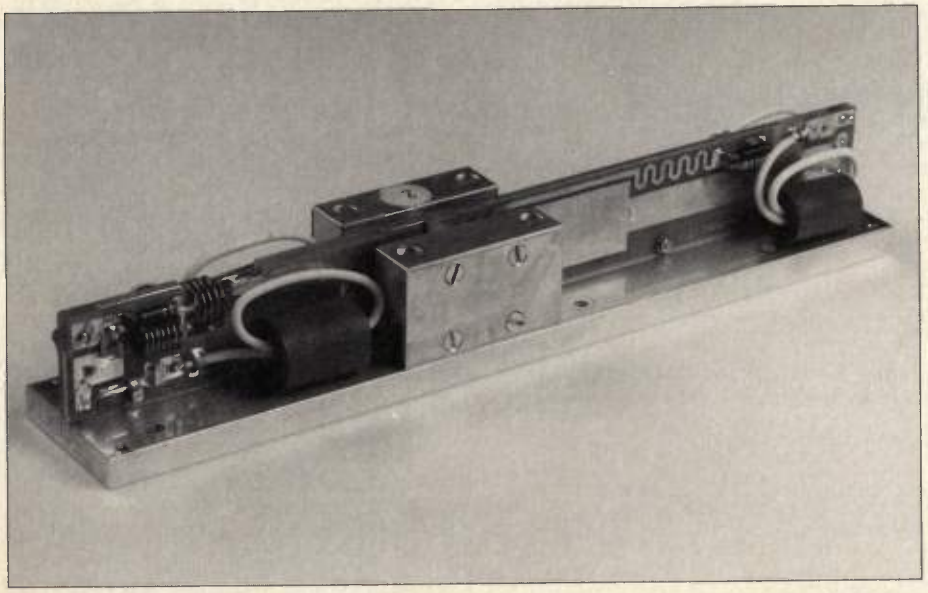


Figure 1. Photograph of the amplifier module using the vertical mounting technique.

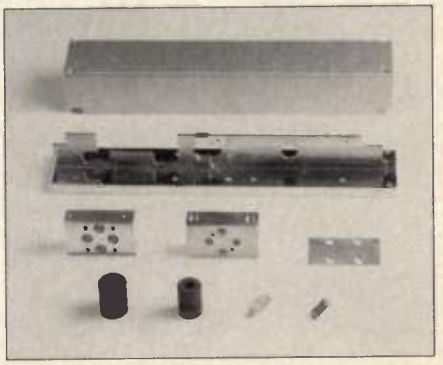


Figure 2. The mechanical components of the vertical mounting assembly.

Design Concepts

Based on the previous considerations, the SGS-Thompson SD1460 transistor has been chosen as the primary source and the Motorola TP9383 as the secondary source. In general, these transistors belong to a family that has an inductive base behavior at 100 MHz. To compensate for this characteristic, a high value capacitor is required between the base and the emitter. In the push-pull configuration, the capacitor must be placed between the two bases and therefore, the capacitive value is halved with easier matching as a consequence.

A major problem is the physical arrangement of the capacitor. Given the extremely low values of the R and L input components of the transistor, the capacitor must be mounted as close as possible to the two cases so that the mounting parasitics are minimum in respect to the intrinsic reactive values of the active device. In traditional planar mounting the most elegant solution is the old RCA proposal which suggests rotating the cases by 45 degrees so that the bases are brought as close together as possible.

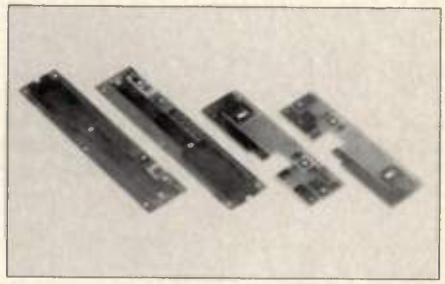


Figure 3. The circuit boards used in the amplifier, including microstrip transformer sections.

In order to solve this problem another way, a new mounting idea was devised (Figures 1 and 2). In reality, it consists of mounting the two transistors front to front in a vertical mounting system. In this arrangement the base of the two transistors is naturally at a physical distance comparable to the size of one ATC capacitor case B. Therefore, the only parasitics involved are those intrinsic to the capacitor itself.

The vertical mounting technique not only solves the base-to-base capacitor problem, it also has a series of advantages in respect to planar mounting.

In fact, the microstrips from the matching circuit (Figure 3) operating at wide-band have very low characteristic impedances, especially in the first low-Z transformers. With this mounting technique the physical limits for the widths of these strips are essentially dictated by the higher order spurious modes. Moreover, the sandwich arrangement of the ground planes prevents possible coupling between the two parallel lines.

A careful choice of the substrate thickness (e.g., 1/32 inch fiberglass with $\varepsilon_r = 4.7$) allows the capacitors to be set in the strips. The sum of the substrate thicknesses plus the vertical carrier thickness can in fact be equal to the chip capacitor thickness with the complete advantage of mounting repeatability during manufacturing. In contrast to planar mounting, the capacitors are located at the center of the transmission lines. The input is inductive whereas the output of the active device is capacitive.

A method for compensating this be-

havior is to place an inductor between the two collectors, composed of a U-shaped strap soldered directly to the terminals. In the vertical mounting configuration, the compensating line is located in the upper end of the circuit board and is easily trimmed. Also, the power supply can be connected to the center of the line itself.

An unexpected advantage is that balun mounting is suitable in the vertical topology since the two sections are back to back. Another result is easy mounting of the transistors and therefore quick replacement of components during factory testing or service.

Basically, the module devised in this way takes up volume instead of area (planar mounting) which allows several modules to be assembled in a more compact and functional arrangement. The only price to pay for all these advantages is the increased thermal resistance. Therefore, the shape and size of the vertical blocks which support the transistors must be carefully calculated.

Input and Output Matching Networks

The device selected is the SD1460. The measured values of the input and output impedances are the following at 97.75 MHz and 150 W output power:

$Z_{in}(s) = 0.715 + j0.8$ ohms
$Z_{out} = 3.65 - j3$ ohms

The limit band frequencies are:

$F_L = 87.5$ MHz, and $F_H = 108$ MHz
$F_0 = (F_L + F_H)/2 = 97.75$ MHz

Since the band at −3 dB is in relation to the band at −0.5 dB with a factor of 3, the following is obtained:

Q_{max} (0.5 dB) = 1.59

To determine the in and out Qs of the device:

$Q_{in} = X_s(in)/R_s(in) = 1.11$
$Q_{out} = X_s(out)/R_s(out) = 0.82$

From the observation of the Qs it appears that the device can be employed in the desired wide-band range since:

$Q_{max} > Q_{in} > Q_{out}$

For compensation of the inductive part, transform the base impedance from serial to parallel:

$R_p = R_s[1 + (X_s/R_s)^2] = 1.6$ ohms
$X_p = (R_s R_p)/X_s = 1.45$ ohms

Therefore, an in-parallel capacitance is needed to compensate the base inductance. The type ATC case B capacitor that will be employed has a series inductance of 0.5 nH for the values needed. X_L for this value is 0.31 ohms at 97.75 MHz.

It is also estimated that the minimum value of X_L that cannot be eliminated is 0.7 Ohms. This corresponds to the distributed inductance of the RF mounting and the mechanical layout. The total inductance to be compensated shall

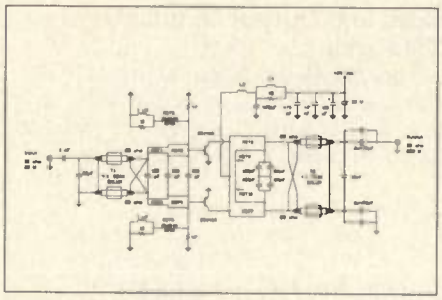


Figure 4. Circuit diagram of the amplifier module.

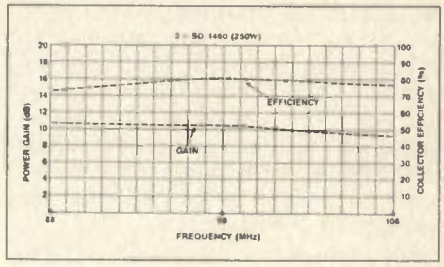


Figure 5. Gain and efficiency performance over the FM broadcast band.

therefore be the sum of the transistor input, layout, and capacitor inductances, or 2.46 ohms.

X_c should be the same magnitude, which corresponds to 662 pF. This is halved for the push-pull configuration, very close to the standard value 330 pF. At this point we have a purely resistive value equal to 1.6 ohms.

This value must be transformed to 6.25 ohms, which is the Z characteristic towards the ground of each branch of the 4:1 balun transformer from the low Z side. Choose the value of 2.5 Ohms as an intermediate impedance for a good compromise of Q between the initial and final value (1.6 → 2.5 → 6.25). For reasons based on the physical dimensions, two microstrip lines with 5 and 10 ohm impedance respectively have been chosen for the two transformers.

Using the same procedure with just one microstrip transformation of the 3.65 ohm collector impedance before the balun, the output network can be determined. The final schematic (with slight variations due to optimization) is shown in Figure 4. The module's gain and efficiency are plotted in Figure 5.

For mounting, the transistor terminals are pressed by four teflon pressure pads and by four sturdy springs located inside the support blocks of the transistors. To avoid abruptly bending the terminals, during the mounting and dismounting phases, the pressure pads must be released by unscrewing the outer cover of each block. Only after this step can the two screws fastening the block to the horizontal carrier be unscrewed. If the sequence of operations is known, it is very easy to replace the transistors.

Conclusions

This article presents a vertical mounting technique for devices in an RF power module. This new approach, in respect to traditional planar mounting, can provide larger bandwidth, greater repeatability, easier modeling of the circuits, ruggedness, reliability, and reduced parasitic effects. It also takes up space in three dimensions instead of two. ***RF***

Acknowledgement

The author wishes to thank Dr. V. Alleva for his support in this endeavor, for discussion and helpful suggestions.

References

1. Lee B. Max, "FM Broadcast 88 to 108 MHz 4,000 W Amplifier Subsystem," *RF Design*, February 1986.
2. H.O. Granberg, "Broadband Transformers and Power Combining Techniques for RF," Application Note AN-749, Motorola Semiconductor, Inc., AZ, 1975.
3. C.L. Ruthroff, "Some Broadband Transformers," *IRE Proceedings*, Vol. 47, August 1959, pp. 1337-42.
4. D. Myer, "Equal-Delay Networks Match Impedances Over Wide Bandwidths," *Microwaves & RF*, April 1990.
5. S. McIntyre, "Demystifying New Generation Silicon High Power FETs," *Microwave Journal*, April 1984.
6. H.O. Granberg, "Power MOSFETs Versus Bipolar Transistors," *RF Design*, November/December 1981.

About the Author

Fulvio Perri is the Research and Development Manager for Itelco S.p.A., an Italian broadcasting equipment manufacturer. He has been involved in the development of solid state FM and TV components since 1973. He may be reached at Piazza Febei, 3, PO Box 114, I-05018 Orvieto, Italy. Tel: 39 763-40131.

Automated Noise Measurements Eliminate Drudgery

By Robert N. Cash
John Fluke Mfg. Co., Inc.

No one likes to measure phase noise. The measurements are tedious and error prone. But many RF applications require establishing the noise contribution of each source in the system. Automating these measurements is the best answer. Noise measurements are still no picnic, but the software takes out the drudgery and gives more consistent results than manual methods.

As an example, one signal generator application that requires attention to phase noise performance is radio receiver adjacent channel testing. The receiver's filter response is not perfect so there is a potential for signals in an adjacent channel to interfere with the desired signal. To determine how well the receiver rejects those unwanted signals, apply a high level signal at the adjacent channel frequency and measure the receiver output. This measurement depends on the purity of the applied signal. Phase noise and spurious signals from the generator will fall in the receiver's selected channel, causing errors.

Phase noise is defined as the single-sided, phase modulated noise power in a one Hertz bandwidth at some frequency offset from the carrier frequency. It is expressed in dBc per root Hertz. Two other measures of noise performance of signal sources are residual FM and residual PM. Residuals are specified as the RMS noise power within a particular band of frequencies offset from the carrier. FM residual is often specified in two bandwidths: 300 Hz to 3 kHz, and 50 Hz to 15 kHz and is expressed in Hz. Residual PM is usually specified in a 10 Hz to 15 kHz bandwidth and is expressed in dBc.

Frequency and phase modulation are related in the low deviation case by the formula:

$$pm = fm / mf \qquad (1)$$

where pm is phase deviation in radians, fm is frequency deviation in kHz, and mf is the modulation frequency in kHz. Since noise is definitely in the low deviation case, FM noise can be derived from phase noise where the offset frequency corresponds to the modulation frequency.

Getting to First Base

Depending on the RF and offset frequencies, phase noise specifications on high performance generators may range from −60 dBc per root Hz to lower than −150 dBc per root Hz. Direct measurements using a spectrum analyzer are not possible because the noise floor of the analyzer is too high. How then can we measure phase noise accurately?

One method uses a carrier nulling or down conversion technique with low frequency spectral analysis. A mixer is used as a phase detector to translate the carrier to DC and get a high degree of carrier suppression. Amplifying the IF output of the mixer puts the phase detected noise signals within the amplitude range of an analyzer. Fast Fourier Transform (FFT) analyzers are ideal for this purpose, allowing very low frequency measurements with short measurement times (Refer to Figure 1).

A phase noise measurement can be made by putting the analyzer marker at the offset frequency, taking the reading, and applying corrections. You must avoid spurs when placing the marker. Residuals are another matter because they must be summed over a band. But why not simply use a modulation meter to measure residuals? The residuals of high performance sources are so low that the residual noise of the modulation meter dominates the reading. About the only reliable way to measure residuals in this case is to sum the noise and spurs as measured by an FFT analyzer over the required band. And the only way to do that is with the test software.

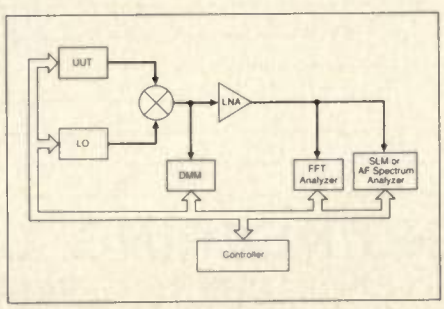


Figure 1. Phase noise test system.

Hardware Requirements

When the LO and RF input signals to a mixer are 90 degrees apart in phase, the mixer functions as a sensitive phase detector. The IF output is the noise and other phase related modulation signals such as spurs. The response of the mixer is quite linear about zero in the small signal case. Zero volts DC at the mixer IF output indicates that the two signals are 90 degrees apart. Some method of controlling the phase of the two input signals is necessary.

Synthesized signal sources are phase locked together by using a common reference. There are two easy ways to adjust the phase difference between two synthesized signals. One is to use the DC output from the mixer to frequency modulate one of the sources. This DC FM approach has the disadvantage of potentially introducing spurious signals into the modulation port and does not truly represent the CW case. Also, the loop bandwidth of the system changes the frequency response at the output of the mixer and must be measured to correct the results. The other method is to change the frequency of one of the units by one Hertz or a fraction of a Hertz

Noise floor in dB below measured noise	error in dB
0	3.00
−5	1.19
−10	.41
−15	.14
−20	.04

Figure 2. Measured phase noise.

until the phase relationship is 90 degrees apart. It is called twitching a digit. Some signal generators provide a means of incrementally shifting the phase of the output signal which makes the job much easier. Both of these methods work well over a broad range of RF frequencies. For fixed frequency signal sources, use an electrical delay element such as an adjustable air line.

Choosing System Components

Noise combines in RMS (root mean square) fashion, so system noise contributions will combine with the noise to be measured and will cause errors if the noise signal is not high enough above the system noise floor (Refer to Figure 2). Ideally, the noise of the system at a particular offset frequency is at least 15 dB lower than the noise to be measured.

Phase Noise Test Set — Since spectrum analyzers alone have too high a noise floor, an amplifier is required. It should have perfectly flat frequency response from DC to 10 MHz, a gain of 60 dB, and no noise. For the system used at John Fluke in testing the 6080A and 6082A, we settled for one specially designed for the application which has flatness of ±0.2 dB from less than 1 Hz to 5 MHz and 50 dB of gain. A method will be shown later to evaluate the noise of the system. The amplifier, mixer, and power supply were combined with some RF switching and an AM detector into one package, a phase noise test set. The RF switching and AM detector enable the system to measure AM noise also.

One of the most difficult aspects of building the phase noise test set was achieving optimum spurious signal performance. A multitude of spurs come from the digital controller and printer. Some instrumentation is not particularly designed for use in this type of system, most notably the DVM, which is used to measure the mixer IF DC voltage when adjusting the phase between the test unit and the LO. It has low level digital signal spurs coming out of its input which is connected to the most sensitive point in the system. The DVM spurs were resolved using simple RC filtering, both inside the test set and at the input to the DVM. Controller and printer spurs were reduced by placing them at some distance from the other equipment and using separate line outlet. RF coaxial lines wrapped on large toroid cores helped reduce ground loop problems.

Spectrum Analyzers — Spectrum analyzers give the most complete information about the offset frequency spectrum. An FFT analyzer is ideal for most of the measurements. Typically, specified response extends from below 1 Hz to 25 or 100 kHz. This frequency range covers all of the residual measurement bands described above and most of the phase noise offset frequencies of interest. Also, FFT analyzers offer wide dynamic range and very good sensitivity. The offset frequency range can be extended using a high performance HF spectrum analyzer.

Selective Level Meter — Phase noise can also be measured using a level detector with a pass band filter provided that the filter skirt response can be estimated for bandwidth correction. Selective level meters (SLM) perform well for these measurements. A measurement of the total power in a bandwidth,

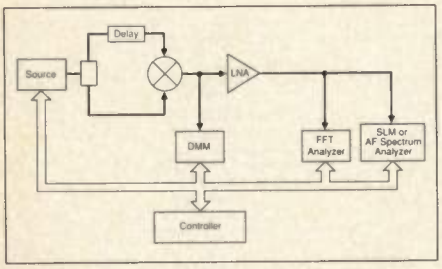


Figure 3. Determining system noise.

after correction for skirt response, can be converted to a 1 Hz bandwidth by subtracting 10log(BW in Hz). A simple way to determine a filter skirt correction is to first calibrate the SLM against the FFT using a high level signal. Then compare noise readings, correct both for bandwidth.

SLMs are limited in how close to the carrier they can measure and in the inclusion of spurious signals in the phase noise measurement. It is not possible to extract any other data from the measurement than the total power measured, so this measurement does not permit curve plotting. However, the selective level meter is a good choice to extend the frequency range for production test because it is lower in cost than a high performance HF spectrum analyzer, and the measurements are much faster. A wide bandwidth, practical at high offset frequencies, reduces the error from spurs because the signal power of a spur is much less than the total noise power in a wide band. For example, a spur 20 dB above the noise included in a 3 kHz bandwidth measurement would cause an error of 0.14 dB.

System Calibration

Since the carrier is suppressed and the degree of suppression is unknown and is not directly measurable, the obvious reference for a dBc measurement is unavailable. Though it is possible to characterize the system by precisely measuring generator drive levels and system gains and losses, these characteristics vary with RF frequency. A far simpler method is to use signal injection. The simplest technique when test unit or LO characteristics permit is to use modulation. A low level of modulation applied to either the test unit or the LO can be set to give a sideband of known frequency and amplitude relative to the carrier and is well suited for automated testing.

Phase modulation injection for calibration requires a very low deviation signal. In the Fluke 6080A, the low deviation FM is more accurate than low deviation PM and is the better choice. Since the calibration signal is a low deviation case, the formula given above relating FM to PM applies. The modulation signal should be set accurately in advance using a modulation meter of a HF spectrum analyzer at the RF frequency. Typically the setting used with this system is 125 Hz deviation at a 20 kHz modulation rate, which results in a −50 dBc sideband at 20 kHz offset. Note that the phase detector yields two sided detection but we are calibrating for single sided noise, hence the factor of two in the equation.

Cal signal in dBc = 20 log (fm/(2 mf)) (2)

In some test systems it isn't possible to modulate either the test unit or the LO. In this case, signal injection may be performed by using a power divider as a combiner to sum a signal from a third source with the test unit. The third source amplitude is set to the calibration signal level, say 50 dB below the test unit level. The frequency is set to the test unit frequency plus a convenient offset, say 20 kHz. The calibration will be valid as long as the two arms of the divider are equal, which can be verified by reversing them. The calibration signal level as measured in the system is used to correct subsequent measurements for system gains and losses.

$$\text{correction} = \text{cal signal level} - \text{measured signal level} \quad (3)$$

The correction is added to the measurements. For example, a −50 dBc cal signal might measure −8.8 dBv on the FFT. The correction is −41.2 dB. The negative of the correction is the total system gain.

Figure 3 illustrates how a single source is used to measure the noise performance of the system. Use a power splitter to drive both mixer ports from the same source. The delay element is a 4 to 6 foot length of coaxial cable. Adjust the source amplitude for correct LO drive level and the attenuator for correct RF input level. If the same drive levels are used as were used for the system calibration above, that same calibration factor can be used to correct the readings. Adjust the source frequency to zero the DC voltage from the mixer.

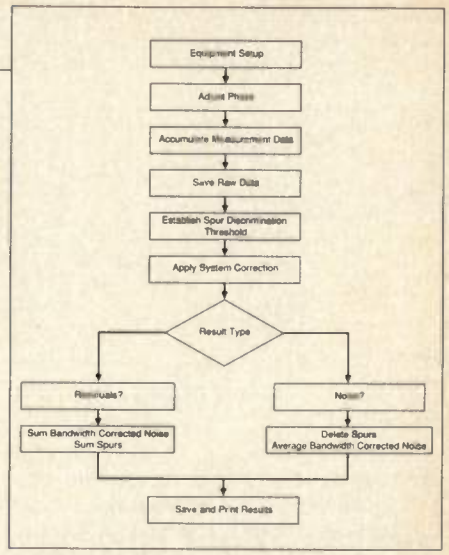


Figure 4. Software flow chart.

```
0  test type, phase noise or am noise
1  thru 10 - rf frequency list
11 thru 19 - level list
20 - lo level
21 thru 60 - phase noise offsets and limits
61 thru 70 - residual am or fm bands, 3 allowed
             defined by start, stop, and limit
71 thru 80 - residual pm bands, 3 allowed
             defined by start, stop, and limit
81 thru 90 - spur search bands, 3 allowed
             defined by start, stop and limit
91 thru 100 - special functions and mod settings
   91 thru 93 - uut special functions
   94 thru 96 - test special functions, bit enclosed
   97 - modulation type
   98 - fm/pm deviation
   99 - am depth
   100 - modulation rate
101 thru 104 - factors governing system calibration
   101 - cal modulation rate
   102 - cal depth or deviation
   103 - nominal cal signal level
   104 - 0 = use uut, 1 = use LO as modulated generator
   105 - noise subtraction control
   106 - plot and measurement starting offset
   107 - plot and measurement stop offset
108, 109, 110 - phase locking parameters
   108 - capture range for initial lock
   109 - drift range, allowable phase drift during test
   110 - averages to use in reading dvm
```

Figure 5. Control data elements for one test setup.

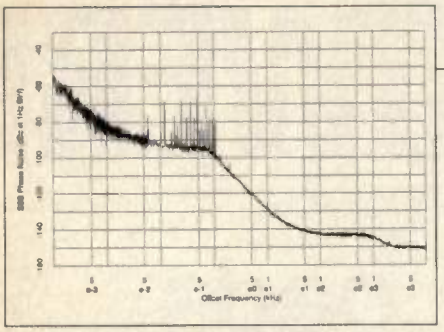


Figure 6. Phase noise plot.

Since the delay is very short, the noise of the source cancels and what's left is the residual noise of the system, including the mixer.

Finally, There's the Software

When designing system software it is wise to define the data and control flow requirements first (Figures 4 and 5). In this system we must consider control, measurement, correction, and results data. Control data defines how to make the measurements, measurement data is information from the measuring devices, correction data defines conversions, and results data are what get finally presented.

Control Data — Both engineering evaluation and production testing require the ability to define different RF frequencies, offset frequencies, types of corrections to apply, test limits, etc. The test control definitions must also be easy to change. Since offset frequencies and limits change with RF frequency, a measurement step is defined as all measurements made at one RF frequency. The control data fits well into a two dimensional array where one dimension is test steps and the other defines control values. A simple editor program facilitates defining and maintaining the test control data.

Measurement Data, Who Needs It? — Phase noise results are best presented in graphical form yet more precise reporting of results at particular offset frequencies is also required. There must be provision for plotting or printing results after a series of measurement steps are complete. Since all the data is needed for a plot, which may extend from 1 Hz to 10 MHz, as shown in Figure 6, careful attention must be paid to the data storage problem.

Fortunately, phase noise plots are presented on a log frequency scale so the offset frequency resolution need not be constant. Low offsets require high resolution and narrow analyzer spans which come with a severe time penalty. As the offset frequency increases, the analyzer span can be increased. Different analyzers may not offer the same start frequency and span combinations, so another control data structure is needed to define what the start frequencies and spans are.

The two analyzers used in this system are the HP3561A FFT analyzer and the HP8568 HF analyzer, which have 400 and 2002 data points per span, respectively. Also it was desired to support the HP3582A, an older FFT analyzer already owned by production, which has 255 data points per span.

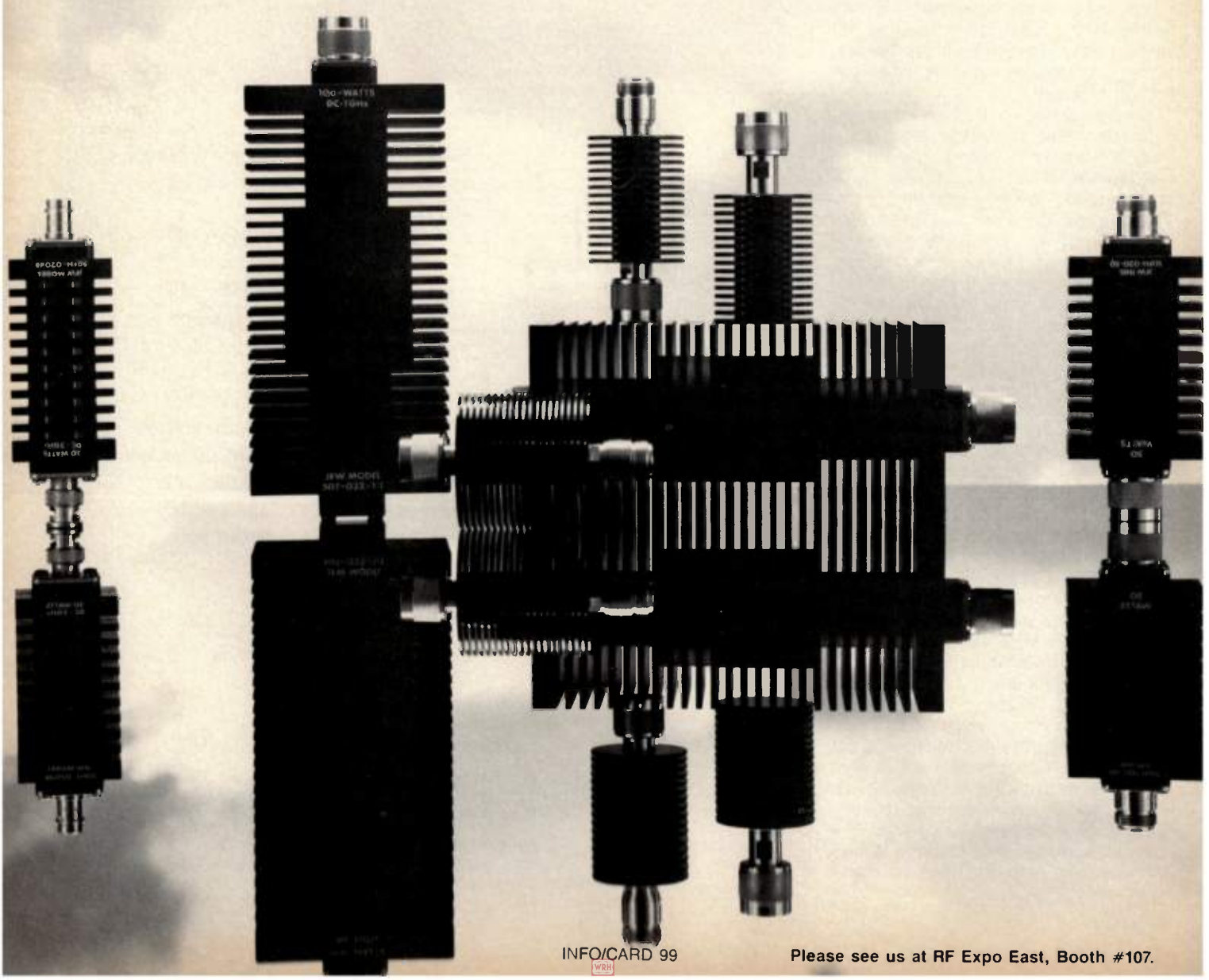
In the data downloaded from an analyzer, one point represents a graphically displayed point on the analyzer trace. The offset frequency of the point is determined by the start and stop frequencies and the number of points per span. The value of a trace data point is the amplitude of the trace at that point.

INVINCIBLE POWER!

Attenuators and Loads

Power Range From 1 To 300 Watts

JFW Industries, Inc.
5134 Commerce Square Drive, Indianapolis, Indiana 46237
(317) 887-1340 Fax: (317) 881-6790



INFO/CARD 99

Please see us at RF Expo East, Booth #107.

The HP8568 and HP3582A amplitude data is an integer corresponding to vertical screen position. To convert the integer to dB requires the full scale screen value, the dB per division scale, and the integer full scale value. The HP3561A uses an amplitude encoding scheme of dividing the amplitude dB value by .005 to convert the value to an integer with no noticeable loss in amplitude resolution.

In order to simplify the data structures, the data from the other analyzers is translated to the same format as the 3561A, which offers a good compromise between graphical resolution and the quantity of data that must get stored. A complete measurement trace consists of a series of contiguous spans, each span having 400 data points regardless of analyzer type. Typically, eight HP3561A spans are used for one complete trace. For engineering evaluation, four more HP8568 spans extended the trace to 10 MHz. Because of its different span and start frequency scheme, the HP3582A requires 12 spans to provide coverage to only 25 kHz.

One complete trace requires storage allocation for at least 6400 integers. To avoid tight linkage between the test control data, the analyzer control data, and the measurement data, additional storage allocation is needed for system correction, analyzer frequency span definitions, plotting parameters and other data such as serial numbers, dates, etc.

Have Data, Will Crunch — With each new analyzer span, the bandwidth represented by a single point changes. For example, in a span of 10 Hz to 15 Hz, each point represents 5/400 Hz or 0.0125 Hz. For a span of 1 kHz to 5 kHz, each point represents 4000/400 Hz or 10 Hz. Phase noise results are always normalized to a 1 Hz bandwidth. However, spurs don't get normalized. Spurs are single frequency points even though represented in the analyzer data by more than one point. One of the first jobs for the software is to discriminate data points that represent spurs.

For offsets far from the carrier, large spans are used and averaging is fast so

many averages may be used to get a fairly smooth noise curve at small cost in measurement time. The smoother the noise curve, the easier it is to discriminate spurs, and those that are difficult to discriminate are so low that they don't contribute to error. However, at low offset spans, averaging time is much longer so fewer are used, consequently the noise has many peaks. Further complicating the problem are the many harmonics of the line frequency which are relatively close together, especially at the higher harmonics.

Some statistics can resolve the problem. To avoid slope problems yet still have a statistically significant number, groups of 50 points work well. They also fit evenly into each 400 point span. No nasty leftover points within a span. And most importantly there are no level changes due to changing bandwidths within a group of points. Large spurs may take several points to define in the trace, but spurs would have to be truly massive to cause large error in the statistics for a group. If the spurs are that bad, noise isn't your problem.

For each group of 50 points, calculate the mean and standard deviation. Any point higher than the mean plus three times the standard deviation can be considered a spur. There are two problems with this simple approach. The first is in low offset frequency areas where noise has many peaks due to low averaging. The second is in any area where spurs are numerous and, though perhaps low in amplitude, close enough together to give errors in the mean. By using a two pass approach, both problems are reduced considerably.

A first pass determines an initial mean and standard deviation. Then the initial mean and deviation are used in a second pass to eliminate most spurs from the second mean and standard deviation. This second mean and standard deviation are used as the final test for whether a data point constitutes part of a spur.

The Home Stretch — First trace data points are converted from integer values to dB and the system calibration correction applied. Then the statistical process described above is applied to groups of points to establish a limit above which a data point is considered to be part of a spur.

For phase noise results, the noise data must be normalized to a 1 Hz bandwidth. 10log(1/BW) yields a bandwidth correction in dB where BW is the bandwidth represented by any one point. In the example used above, points in a span of 10 to 15 Hz have a BW of 0.0126 Hz and a correction of 19 dB. Points in a span of 1 to 5 kHz have a BW of 10 Hz and a correction of −10 dB.

Even with a lot of averaging, the noise curve is bumpy. Rather than trying to pick a single point to best represent the phase noise at an offset, a group of points equally distributed about the offset frequency are averaged. Equal distribution about the offset frequency removes error due to slope, since the width of the group is small. The group mean is substituted for spur data points, all points are bandwidth corrected, converted to power, averaged in power, then converted to the final result in dBc.

Residuals are defined as the RMS of noise plus spurs in a given band. Spurs

must be summed into the result but must not be bandwidth corrected, so spur detection is essential for correct results. Spur power exists in only a single point, but in the analyzer trace, several points may be included in defining a spur, reflecting detection bandwidth. All points considered part of a spur have the bandwidth corrected mean summed along with the spur peak amplitude, since noise exists at all points whether a spur is there or not. The offset frequency must be factored in as a conversion when summing for residual FM. The summing is done as RMS, the square root of the sum of the squares.

Noise Subtraction

The noise values determined so far include the noise of both the test unit and the local oscillator. To obtain the true noise of the test unit, a local oscillator could be used which has sufficiently lower noise than the test unit. This requires a noise differential of at least 15 dB though, to minimize errors and is not practical for a high performance source.

If the local oscillator is assumed to be the same as the test unit, then 3 dB could be subtracted from the results to give the test unit noise. This does not give the most accurate results. A better method is to characterize the noise of the local oscillator so that it can be subtracted from subsequent measurements to obtain the test unit's true noise. But how can the noise of the local oscillator be determined starting with uncharacterized units?

By measuring three units, each in combination with the others in what is often referred to as a round robin, the noise of each can be calculated. Noise sums in RMS fashion, so if n1 is the noise of measurement one and so on.

$$n1 = \mathrm{sqr}((\text{noise of unit 1})^2 + (\text{noise of unit 2})^2) \quad (4)$$

$$n2 = \mathrm{sqr}((\text{noise of unit 1})^2 + (\text{noise of unit 3})^2) \quad (5)$$

TFL HAS YOUR OSCILLATORS

MOXO

Miniature Oven Controlled Crystal Oscillator

Frequency Range:
8 – 20 MHz
Frequency Stability:
$\pm 1 \times 10^{-7}$ in temp range
Operating Temp. Range:
0° to +50°C
(optional −20°C to +70°C)
Aging Short Term Stability:
8×10^{-10} at 1 Sec
Long Term Stability:
$< 1 \times 10^{-6}$/year
Warm Up:
< 20 seconds to $\pm 1 \times 10^{-7}$
Input Voltage: 15 V ±5%
5 V (TTL)
Input Power:
< 0.5 W During Warm-up
0.38 W Stabilized at Room-Temp.
Size: 1.26″ × 1.26″ × 0.7″
Output Waveform:
TTL (optionally Sine)

OCXO

Oven Controlled Crystal Oscillator

Frequency Range:
to 50 MHz
Short Term Stabilities:
up to 5×10^{-12} (1 sec)
Warm-Up Time:
As low as 1 min
Temperature Stability:
$\pm 5 \times 10^{-10}$
(0° to +50°C)
Low Aging Rate:
$< 5 \times 10^{-11}$/Day
Low Noise:
< −157 dBc@
10 kHz Offset
Low Vibration Sensitivity:
3×10^{-10}/g
Temperature Range:
−55° to +120°C

TCXO

Temperature Controlled Crystal Oscillator

Frequency Range:
0.02 Hz to 20 MHz
Frequency Stability:
±0.8 PPM
(−40° to +85°C)
Aging: ±1.0 PPM/yr typ.
Supply Voltage:
2 to 15 Vdc
Supply Current:
As low as 1.0 mA
Size:
Standard:
1.5″ × 1.5″ × 0.5″
As small as:
0.960″ × 0.5″ × 0.2″

CXO

Crystal Clock Oscillator

Frequency Range:
TTL: 10 Hz to 100 MHz
C-MOS: 1 Hz to 5 MHz
ECL: 5 MHz to 500 MHz
Sinewave: 1 Hz-1 GHz
Frequency Stability:
Typ. ±50 PPM (−20° to +70°C, Industrial)
Typ. ±50 PPM (−55° to +125°C, Military)
Up to ±10 PPM available (−20° to +70°C)
Aging:
±10 PPM/yr (Industrial)
±5 PPM/yr (Military)
Outputs: TTL, C-MOS, ECL, Sinewave
Packages: TO-5, TO-8, DIP, Hermetically Sealed Metal Case

TFL

At TFL The Quality Is Crystal Clear.

Time & Frequency Ltd.

Only RALTRON has it all.

RALTRON

RALTRON ELECTRONICS CORP.
2315 NW 107th Avenue, Miami, Florida 33172
(305) 593-6033 Fax (305) 594-3973 Telex 441588 RALSENUI

INFO/CARD 105

$n3 = sqr((noise\ of\ unit\ 3)^2 + (noise\ of\ unit\ 2)^2)$ (6)

and equations can be expressed which yield the actual noise of each unit.

$unit1 = sqr((n1^2 + n2^2 - n3^2) / 2)$ (7)

$unit2 = sqr((n1^2 + n3^2 - n2^2) / 2)$ (8)

$unit3 = sqr((n3^2 + n2^2 - n1^2) / 2)$ (9)

This is no problem when dealing with single offset frequency points. Noise subtraction must be made practical at any point of the trace because noise should be subtracted before summing for residuals since the noise curves of the test unit may not be the same as the local oscillator. The measurement uncertainty at any individual point is small for a particular measurement but can result in significant errors in the characterized noise. Calculations to derive characterized noise over three complete traces take a long time and so should preferably be performed once.

All these problems are resolved with minimal error by characterizing the local oscillators at the middle of each 50 point group. These values are stored for each local oscillator and are used as required by interpolating between them for subtraction values. For best results, the units to be characterized and used as local oscillators must be carefully selected, not so much for low noise but for equal noise because the effect of measurement error increases rapidly with the noise difference between the units. ***RF***

About the Author

Robert N. Cash joined John Fluke Mfg. Co., Inc. in 1976 as a technical writer with a background in calibration and communications equipment. Software has been the primary focus for the past ten years, both in production test and test data analysis. He can be reached at PO Box 9090, Everett, Washington 98206-9090. Tel: (206) 356-5993.

Spectrum Analyzers Have Cautious Customers

By Liane G. Pomfret
Associate Editor

Today's market for spectrum analyzers is consumer driven. Talking and responding to the customer has become even more important in this highly competitive field. As a result, new features, pricing, and applications clearly reflect the actual marketplace.

In the spectrum analyzer marketplace, responding to market demands is foremost on manufacturer's minds. They've learned that the customer has a great deal of insight with regard to new features. Dave Kruse, sales and marketing engineer at Stanford Research Systems comments that "people are looking for full functionality in an instrument." For example, FFT analysis and time domain measurement features have been improved or developed in response to customer requests. Because of the explosion in communications equipment, time gating, or time domain measurements have also become extremely important. Customers need to be able to measure a signal over time. Other new features include new frequency breakpoints because much of the new communications equipment falls on or near current spectrum analyzer breakpoints. Companies are also adding higher microwave frequencies, phase noise measurement capability, demodulation capability and more dedicated personalities for specific applications.

The majority of these changes have come about as a result of a change in the market focus. It is no surprise that digital communications is one of the biggest markets for spectrum analyzers. David Ringoen, a product line manager for low frequency analyzers at Hewlett Packard agrees, "Digital radios are big business, and their modulation schemes demand advanced capabilities in spectrum analayzers." There are always the more traditional military/aerospace markets which have remained stable, but now manufacturers are looking to other markets. The EMI/EMC market has grown lately as has communications systems and education. Communications equipment, whether it be digital, analog or a combination continue to account for the largest share of the market.

Perhaps the most interesting part of the spectrum analyzer market is the customer. A tough economy has guaranteed that manufacturers have to work harder to sell their product and today the customers want more bang for the buck. "In general, customers are expecting more and expecting to pay the same or less," says Jim Leonardis, a marketing product manager at Hewlett-Packard. They don't mind paying the same price but the instrument must offer more features or better performance for the same price. "Customer demand is toward higher coaxial input capability, e.g. 40 GHz," says Len Garrett, product marketing manager at Tektronix. "High performance synthesized local oscillators place increasing demands on spectrum analyzers with very good close-in phase noise at higher microwave frequencies." Customers are looking at other alternatives to buying such as leasing, renting or used equipment. Tom Dideum, marketing manager for IFR Systems notes, "They're still buying, but they're buying differently. People are renting or buying used." These are logical alternatives to buying new equipment that would be considered a capital expenditure.

While today's customer is well aware of economic conditions that are affecting their buying power, many manufacturers feel the customer still has a lot to learn when it comes to actually buying a spectrum analyzer. Very often companies see bids for a piece of equipment that are so tightly written, that only one analyzer by one manufacturer fits the bill. If the customer has done his research and really knows what he wants, then this works fine. But in today's world of two engineers doing the job of ten, they often don't have the time to sit down and do the necessary research. This type of buying or specifying more often causes problems because the customer ends up with an analyzer that isn't quite what they wanted. It's also discouraging for the manufacturers as well. Any manufacturer will tell you that they would rather have a well informed, educated buyer, even if it means educating them themselves. This is Avcom's approach, "The people that use our analyzers, are often first time users. We educate our customers," says sales and marketing manager Charlie Odom.

The market itself has polarized into a high end or low end market. There is always a market for high end R&D instruments and "Once a customer has decided he needs a high accuracy and high resolution spectrum analyzer, price is not a problem," says Steve Gledhill, sales and marketing manager for microwave products at Marconi. But with increased competition there is now a growing market for lower cost, field or production oriented instruments. While these analyzers are lower cost, in some cases, certain performance characteristics are just as good as the more expensive analyzers. With the technology getting better on a daily basis, customers are finding that they don't have to sacrifice performance for price. In the last year alone, several large companies and even some of the smaller ones, have introduced spectrum analyzers at lower cost with excellent performance characteristics.

Spectrum analyzer manufacturers are staying quiet about their product and about the market. Competition is fierce and customers can get exactly what they want if they are willing to spend the time and do their homework. ***RF***

RF software

Active Filter Design Programs

Burr-Brown announces three active filter programs. Sallen-Key low-pass filters are covered in Application Bulletin AB-017B, covering Bessel, Butterworth and Chebyshev designs. Exact resistor values or the closest 1 percent standard values may be selected. AB-034 includes a program for multiple-feedback (MFB) filter topologies, including the Sallen-Key configuration as a subset. The program allows examination of the circuit for component and Q sensitivity. Bulletin AB-035 has a program for the UAF42 Universal Active Filter, allowing design and implementation of all kinds of filters using its state-variable configuration with an uncommitted op amp.
Burr-Brown Corp.
INFO/CARD #140

Wideband Power Amplifier Design

uW-PADS from Focus Microwaves is a network analysis program for the design and optimization of wideband power amplifiers. The program uses ISO contour data generated by the Contour Controlled Microwave Tuner (CCMT), which includes output power, gain, power added efficiency and intercept. The company can provide this device data for users who do not have a CCMT system. Manual tuning is available to examine network elements and verify their sensitivity. Three optimization methods are also provided. The price is $14,500.
Focus Microwaves Inc.
INFO/CARD #139

Semiconductor Cross-Reference Disk

Richardson Electronics announces an enhanced version of its extensive semiconductor cross-reference disk, following suggestions of many users. The disk allows the user to view prices and selection of equivalent products from E.F. Johnson, GE, Motorola, Regency/Wilson and other major radio manufacturers. Also included are 2SC numbers and Japanese-type hybrid modules. New features include quotation requests on a printer and copy the program to hard disk.
Richardson Electronics, Ltd.
INFO/CARD #138

BASIC Newsletter

A newsletter for users of HP BASIC has been introduced by Hewlett-Packard's Measurement Systems Operation (MSO). Letters, applications, and notes from users of HP BASIC will be included in future issues, along with announcements of product introductions and upgrades. Products covered include all BASIC versions, including the /UX and /WS versions for UNIX and Workstations.
Hewlett-Packard Co.
INFO/CARD #137

FO Spice Models

Non-linear Spice models for fiber optic systems are now available from Analog and RF Models, including laser diodes with and without internal PIN monitor diodes, PIN receiver diodes, and cable runs. Diode models include proper temperature compensation and capacitance characteristics, and cable models have loss and time delay, with optional dispersion.
Analog and RF Models
INFO/CARD #136

Radio System Design

JMA Applied Spectrum Research announces the newest release in their Radio System Design Software (RADS) for PCs. New features include SMR signal planning capability . This option supports FCC methods in Docket 90-34 for calculating signal level and interference ranges for existing and proposed sites. RSDS allows for both single and multi-site design, frequency re-use planning, propagation studies using digitized terrain data, FCC broadcast, and Carey contours. Existing bands as well as newly proposed bands are included, such as 1800-2000 MHz. Output is plotted exactly on any map or map overlay.
JMA Applied Spectrum Research
INFO/CARD #135

RF literature

Klystron Amplifier Brochure

Series 10000 klystron amplifiers are described in this brochure from MCL/Inc. Models cover 1.5 to 20 GHz with power levels up to 40 kW continuous, 350 kW peak. Proven reliability and a two-year warranty are features of this series. Applications include communications, military systems, space systems and broadcasting.
MCL/Inc.
INFO/CARD #130

Coil EMI Gasketing

Bal Seal's catalog 3.2 describes canted coil springs for electrical shielding and grounding applications. These EMI/RFI gasketing products can be supplied in heights between 0.015 and 0.450 inch, in continuous lengths beyond 1000 feet. The catalog includes dimensions, loading information and shielding effectiveness data for the various models.
Bal Seal Engineering Company
INFO/CARD #129

Anritsu Company Information

A corporate newsletter published eight times a year is available from Anritsu. Management, market and technical topics are covered in each issue.
Anritsu America, Inc.
INFO/CARD #120

EMI Shielding Products

A short-form catalog from Electro-Kinetic Systems describes their line of electromagnetic interference shielding products and services. Windows, door gaskets, adhesives and air filters are among the products covered.
Electro-Kinetic Systems, Inc.
INFO/CARD #124

Miniature OCXOs

A one-page data sheet and short form catalog contains specifications and mechanical data on low noise miniature ovenized oscillators. Specifications include frequency, phase noise, thermal stability, aging and tuning ranges.
QK Genwave Corp.
INFO/CARD #123

Components Catalog

Teledyne Components new catalog includes data on their analog, power, sensor, digital and discrete products. Among the products listed are op amps, analog switches, video drivers, multiplexers, V-F and F-V converters, battery charger controls, bipolar and JFET transistors, plus DMOS devices formerly made by Topaz.
Teledyne Components
INFO/CARD #127

RFdesign MARKETPLACE

WHEN YOU ARE READY TO BUY-SELL-TRADE CALL *RF DESIGN* MARKETPLACE
Increase your REVENUES with *RF Design Marketplace* advertising! Over 40,000 prospects read and buy from this section each month. To reach this sophisticated, targeted market call today (303) 220-0600.

RFdesign MARKETPLACE

RF SYNTHESIS SOFTWARE

Smithsoft Plus by Somersoft

PC Software for Every RF Engineer

INTERACTIVE SMITH CHART

Data are entered directly onto the chart by using the mouse, keyboard, or by loading a disk file. Component arcs, including parasitic effects, are drawn on the chart by making component selections from the top menu bar. A schematic is automatically generated and displayed as components are selected. Once a circuit is entered, the circuit editor allows you to randomly tune, cut, copy or paste any component. This makes it very easy to experiment with many different kinds of circuit topologies in order to achieve the best design. This also makes the software very educational for those who are just learning the Smith chart.

... PARTIAL LIST OF FEATURES ...

Network Analyzer Z-Theta Chart
H, S, Y, Z, ABCD Conversions
Common B ~ Common E ~ Common C
Simultaneous Multiple File Analysis
Operating and Available Power Gain Circles
Unilateral Power Gain Circles
Noise Circles Stability Circles
S-Parameter Stack for Recursive Operations
Data Tables on Screen or Dump to Printer
Internal Graphic Screen Dump

$259.00, Somersoft, (707)829-0164

INFO/CARD 120

ANALOG & RF MODELS — RF SPICE MODELS

- BIPOLAR, FET DIODE
- NON-LINEAR MODELS
- ACCURATE TO >5GHz
- OPTO LOGIC OPAMPS

6987 N. Oracle Rd., Tucson, AZ 85704
PHONE (602) 575-5323 FAX (602) 297-5160

INFO/CARD 121

BUY-SELL-TRADE FOR ONLY $175/MO.

UPGRADE TO CATEGORY A

- **Meets FCC Part 74**
- **8 Foot Truncated Antenna**
- **Windload No Greater Than A 6 Foot Solid**
- **Available In 2,7 and 13 GHz**
- **Dual Frequency Model 7 and 13 GHz Also Available**

Radiation Systems, Inc.
Mark Antennas Division
P.O. Box 1548 / Des Plaines, IL 60017
Tel 708-298-9420 / Fax 708-635-7946

INFO/CARD 122

RF Power

Now Available From Stock

New from RF Products Inc. and available exclusively from Richardson

Acrian Replacement Devices
- Selected "drop-in" replacement devices using the original Acrian die and packages.

STARs
Stripline Terminations Attenuators and Resistors. Drop-in replacements for the Acrian "RATs" and other lines of passive components.

Bias Devices (FYI-10)
- Temperature-compensating devices for high power silicon FETs.

Unit Amplifiers
- Broadband 50 ohm class "A" unit amplifiers.

Also new from Richardson:

Test Fixtures - For High Power RF Transistors
- RF test stands
- Compression heads
- DC test fixture

Transclamps
- Hold-down assemblies for Gemini packages, such as the MRF141G, SD1920-2, UF28150J and BLF278.

Richardson is a franchised specialty distributor for Motorola, SGS-Thomson, Philips and M/A-COM PHI. If you need quality RF products from any of these manufacturers, we can ship your requirements the same day you call.

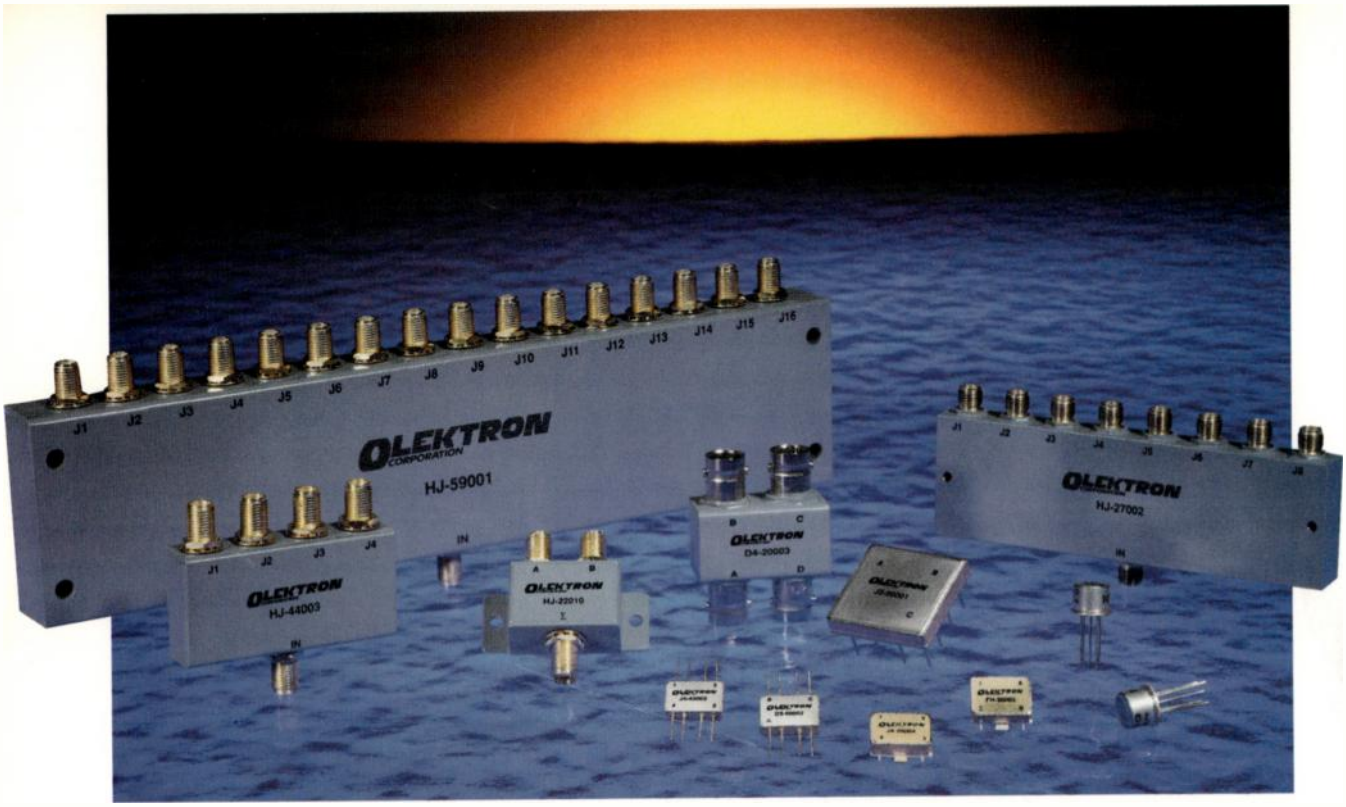
Richardson Electronics, Ltd

Toll free in the U.S. and Canada
800-348-5580 ■ 708-208-2200

INFO/CARD 110

RF engineering opportunities

Advertising Index



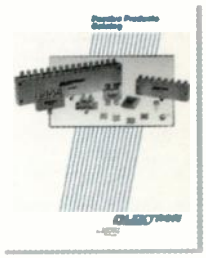
Your source for PASSIVE PRODUCTS in the 90's

With over 24 years experience designing and building state-of-the-art standard and custom passive products, Olektron is pleased to offer over 170 different power dividers, couplers and hybrids **AVAILABLE FROM STOCK.** These devices are competively priced and are built to the highest quality standards.

At Olektron, we appreciate the systems and equipment designer's form, fit, and function requirements. We are always ready to make changes in package configuration or modify circuits for optimum performance in a particular frequency range.

Providing the performance, price, and delivery requirements you need to compete TODAY and TOMORROW. Olektron is **Your source for Passive Products in the 90's.**

Get your Passive Product Catalog today by circling the Reader's Service Number shown below or by calling 1-508-943-7440, ext. 350
(or fax your request to us at 1-508-949-1804)

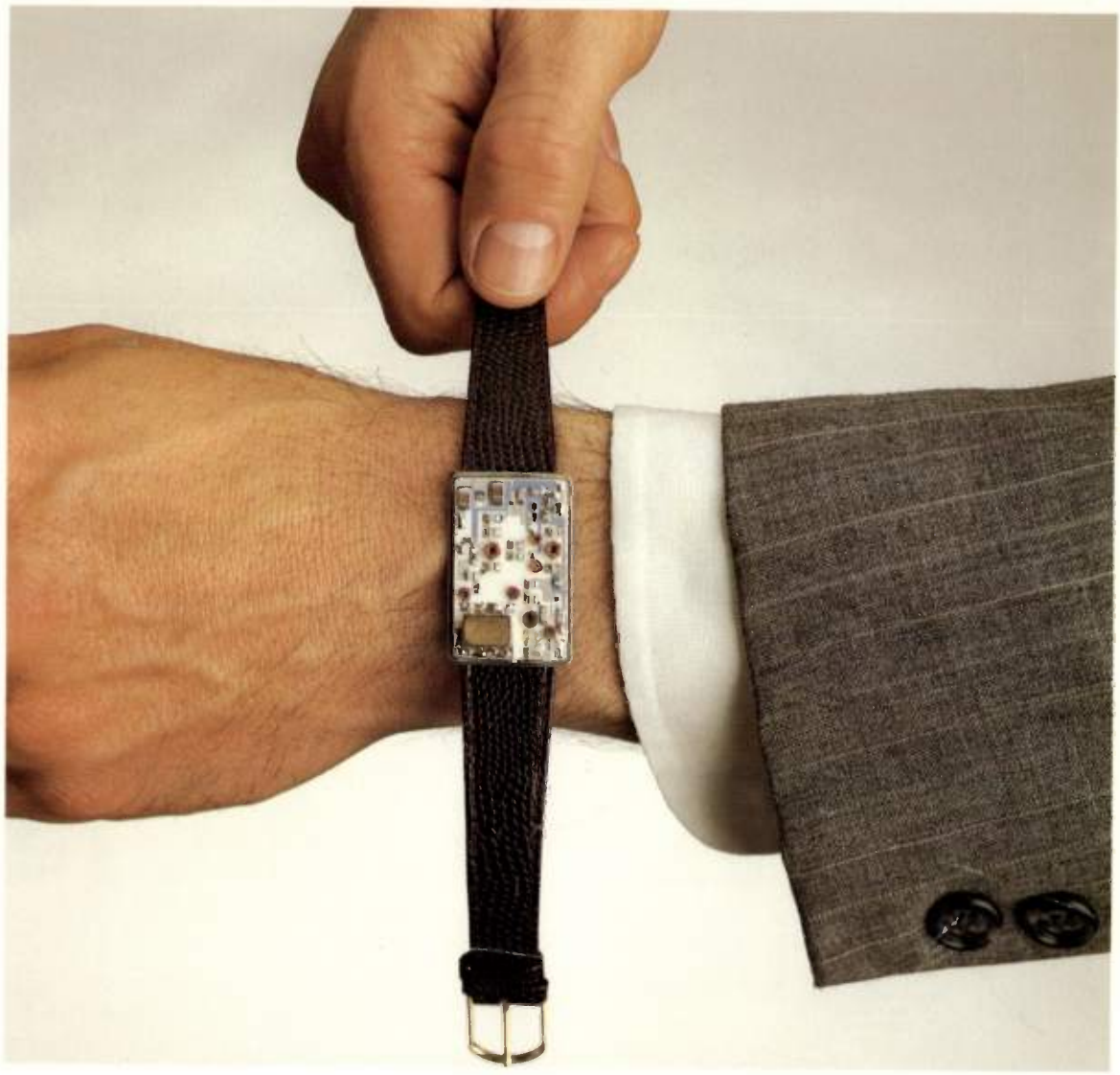


OLEKTRON CORPORATION

61 Sutton Road
Webster, MA
01570

a subsidiary of Signal Technology Corporation

INFO/CARD 115
Please see us at RF Expo East, Booths 722, 724.



You can't buy a better precision timepiece for under 2.4 GHz.

If you're operating in a frequency range from 100 MHz to 2.4 GHz, you can't buy a better oscillator than an Andersen VCO. It gives you the highest spectral purity with the lowest spurious (> -60dB). And typical single sideband phase noise of > -119dBC @1 KHz offset.

It's compact. It's rugged. It operates in temperatures up to 100°C. It can be tuned up to 1.5 MHz or phase-locked to a reference. Plus, its low mass and low profile make it ideal for surface-mount technology, DILS or flatpaks.

Isn't it about time you discovered the precision, the versatility and simplicity of designing with Andersen oscillators? Contact Andersen Laboratories, 45 Old Iron Ore Road, Bloomfield, CT 06002. Telephone (203) 286-9090/FAX 203-242-4472.

ANDERSEN LABORATORIES

INFO/CARD 112