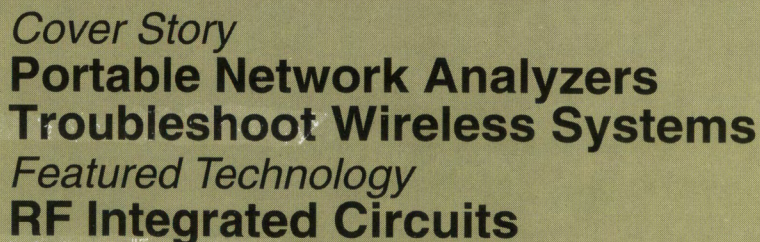
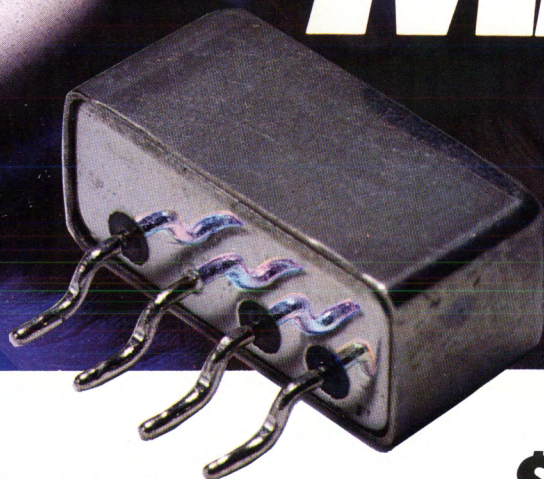


April 1994



TOUGH ALL-WELDED MIXERS



SURFACE-MOUNT or PLUG-IN FROM **\$395** (10 qty)

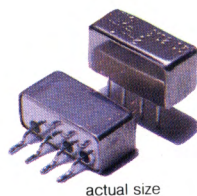
Expose Mini-Circuits' TUF-mixers to 250°C for five minutes, or to the extreme shock and vibration stresses of MIL-M-28837, or to 200 cycles of thermal shock from -55° to +100°C... they'll survive without any change in specs. They are mighty tough mixers!

Available with LO drive levels from +7 to +17dBm, performance features include very low conversion loss flat over the entire band, high isolation (L-R, L-L), and well-matched VSWR at all ports.

All-welded internal and external construction is used to assemble and package the TUF-unit in its tiny 0.5 by 0.2 by 0.25 in. metal case, for plug-in or surface-mount* assembly.

TUF-Ultra-Rel™ mixers are guaranteed for five years and boast unprecedented "skinny" sigma (δ) unit-to-unit repeatability as shown in the Table.

Tough, tiny, and with tight repeatability... Mini-Circuits' Ultra-Rel™ TUF-mixers with a five-year guarantee, priced from \$3.95... available only from Mini-Circuits.



actual size

ULTRA-REL™ MIXERS

5-YR. GUARANTEE

with extra long life due to unique HP monolithic diode construction, 300°C high temp. storage, 1000 cycles thermal shock, vibration, acceleration, and mechanical shock exceeding MIL requirements.

finding new ways...
setting higher standards

Mini-Circuits

WE ACCEPT AMERICAN EXPRESS AND VISA

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Distribution Centers/NORTH AMERICA 800-654-7949 • 417-335-5935 Fax 417-335-5945 EUROPE 44-252-835094 Fax 44-252-837010

For detailed specs on all Mini-Circuits products refer to • THOMAS REGISTER Vol. 23 • MICROWAVES PRODUCT DIRECTORY • EEM • MINI-CIRCUITS' 740-pg HANDBOOK.

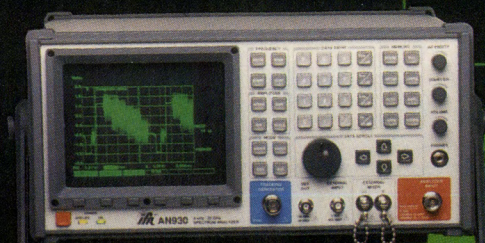
SPECIFICATIONS

Model	LO Power (dBm)	Freq. LO/RF (MHz)	Conv. Loss (dB)		Isol. L-R (dB)	Price, \$ Ea.
			\bar{X}	δ		
TUF-3	7	0.15-400	4.98	0.34	46	5.95
TUF-3LH	10		4.8	0.37	51	7.95
TUF-3MH	13		5.0	0.33	46	8.95
TUF-3H	17		5.0	0.33	50	10.95
TUF-1	7	2-600	5.82	0.19	42	3.95
TUF-1LH	10		6.0	0.17	50	5.95
TUF-1MH	13		6.3	0.12	50	6.95
TUF-1H	17		5.9	0.18	50	8.95
TUF-2	7	50-1000	5.73	0.30	47	4.95
TUF-2LH	10		5.2	0.3	44	6.95
TUF-2MH	13		6.0	0.25	47	7.95
TUF-2H	17		6.2	0.22	47	9.95
TUF-5	7	20-1500	6.58	0.40	42	8.95
TUF-5LH	10		6.9	0.27	42	10.95
TUF-5MH	13		7.0	0.25	41	11.95
TUF-5H	17		7.5	0.17	50	13.95
TUF-860	7	860-1050	6.2	0.37	35	8.95
TUF-860LH	10		6.3	0.27	35	10.95
TUF-860MH	13		6.8	0.32	35	11.95
TUF-860H	17		6.8	0.31	38	13.95
TUF-11A	7	1400-1900	6.83	0.30	33	14.95
TUF-11ALH	10		7.0	0.20	36	16.95
TUF-11AMH	13		7.4	0.20	33	17.95
TUF-11AH	17		7.3	0.28	35	19.95

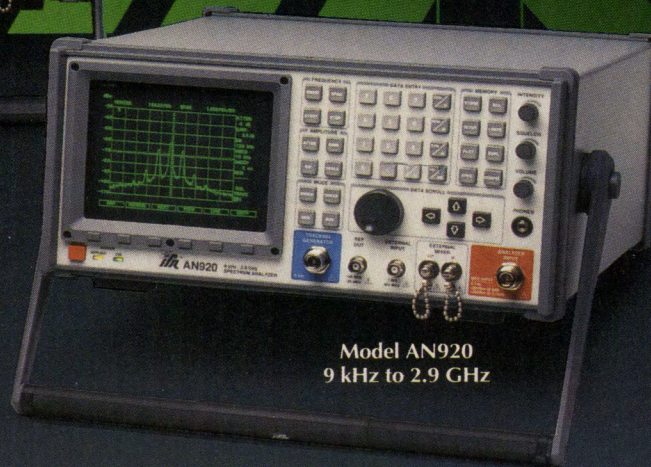
*To specify surface-mount models, add SM after P/N shown.

■ \bar{X} = Average conversion loss at upper end of midband ($f_u/2$)
 δ = Sigma or standard deviation

Model AN930
9 kHz to 22 GHz



Model AN940
9 kHz to 26.5 GHz



Model AN920
9 kHz to 2.9 GHz

AN900 S E R I E S

REDEFINING PERFORMANCE & VALUE

THE AN900 SERIES PORTABLE SPECTRUM ANALYZERS

With frequency coverage of 9 kHz to 2.9 GHz for the AN920, 9 kHz to 22 GHz for the AN930, and 9 kHz to 26.5 GHz for the AN940, the AN900 series of spectrum analyzers can match your RF and microwave testing requirements.

In addition to being full-featured, portable spectrum analyzers, each AN900 series model provides unique measurement features never before available on any spectrum analyzer.

A wide 30 MHz resolution bandwidth filter provides unequalled measurement capability on wideband or spread spectrum signals. When used in combination with the built-in FM/AM receiver and modulation measurement scales, direct measurement of wideband signal modulation components, including frequency agile signals, is possible.

A 25 MHz digitizing rate enables zero span measurements on pulsed RF and digital signals at sweep rates as fast as 200 ns/div. Pretrigger and posttrigger delay allow precise time interval or gated measurements.

An automatic trace limits test function performs unattended monitoring and detection of erroneous signal conditions. Captured signals can be automatically stored in memory with time and date stamp for later recall and analysis or sent directly to a plotter via the standard RS-232 or IEEE-488 interfaces.

A logical front panel control layout that avoids the use of menus or shift keys simplifies operation and enhances user productivity. For field use, a rugged portable design is complemented by the ability to operate from DC power sources or from an optional rechargeable battery pack.

Other optional built-in features, including a 2.9 GHz tracking generator, quasi-peak detector, and 0.02 ppm time base, expand each model's possible uses.

Contact IFR for more information or to arrange for a demonstration of the AN920, AN930 or AN940.



IFR SYSTEMS, INC.

10200 West York Street / Wichita, Kansas 67215-8935 U.S.A.
Phone 316/522-4981 / 1-800-835-2352 / FAX 316/522-1360

RENT DIRECTLY FROM IFR
Call 1-800-835-2352, Ext. 207 for details



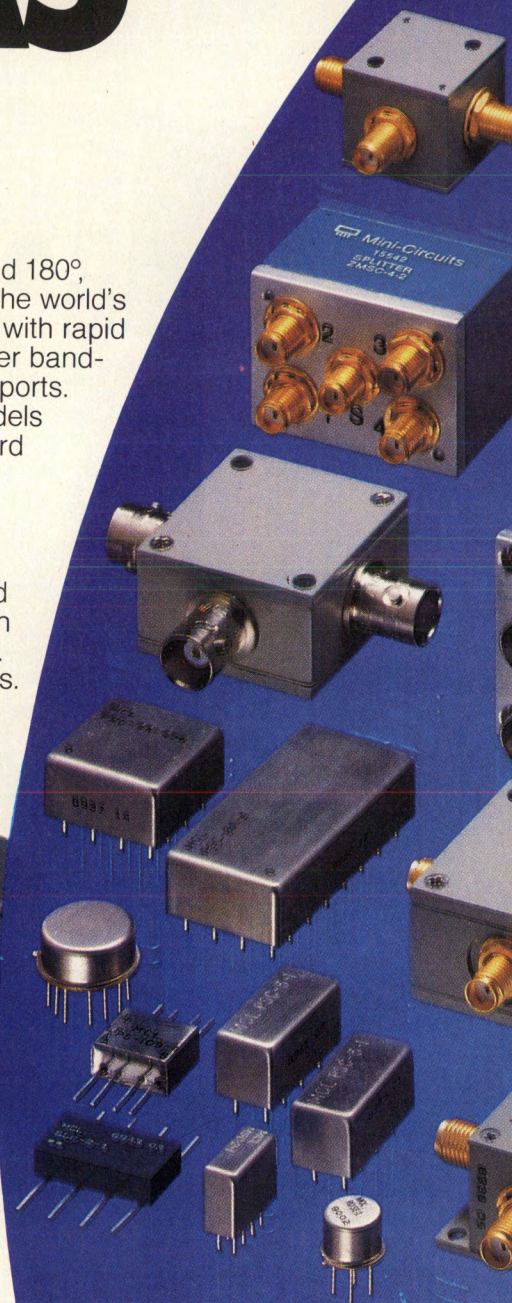
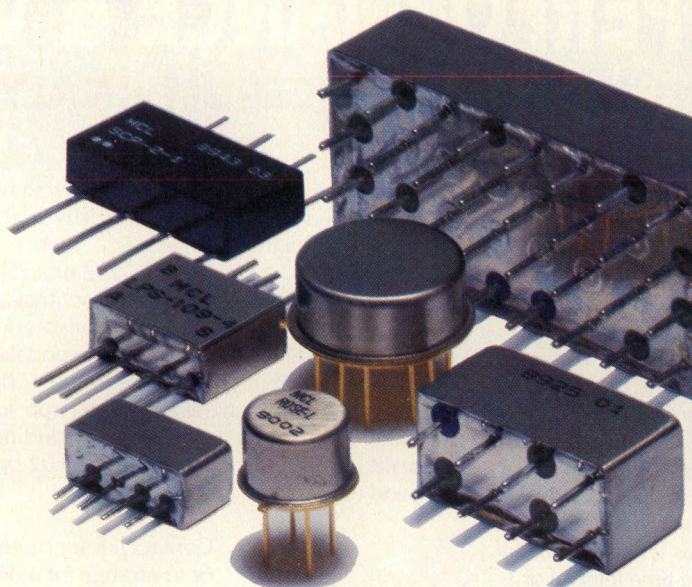
POWER SPLITTERS/ COMBINERS

the world's largest selection
2KHz to 10GHz from \$2⁹⁵

With over 300 standard models, from 2-way to 48-way, 0°, 90° and 180°, 50- and 75-ohms, covering 2KHz to 10GHz, Mini-Circuits offers the world's largest selection of off-the-shelf power splitter/combiners. And, with rapid turnaround time, we'll also supply "special" needs, such as wider bandwidth, higher isolation, lower insertion loss and phase matched ports.

Available for use in military and commercial requirements, models include plug-in, flat-pack, surface-mount, connectorized standard and custom designs. New ultra-miniature surface mount units provide excellent solutions in cellular communications, GPS receivers, Satcom receivers, wireless communications, and cable systems.

All units come with a one-year guarantee and unprecedented "skinny" sigma unit-to-unit and production run-to-production run repeatability. All catalog models guaranteed to ship in one week. Mini-Circuits...dedicated to exceed our customers' expectations.



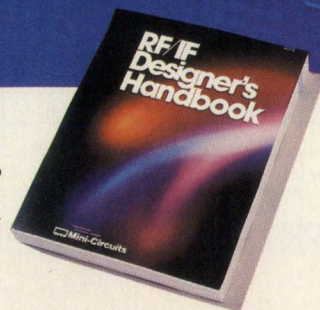
finding new ways ...
setting higher standards



Mini-Circuits™

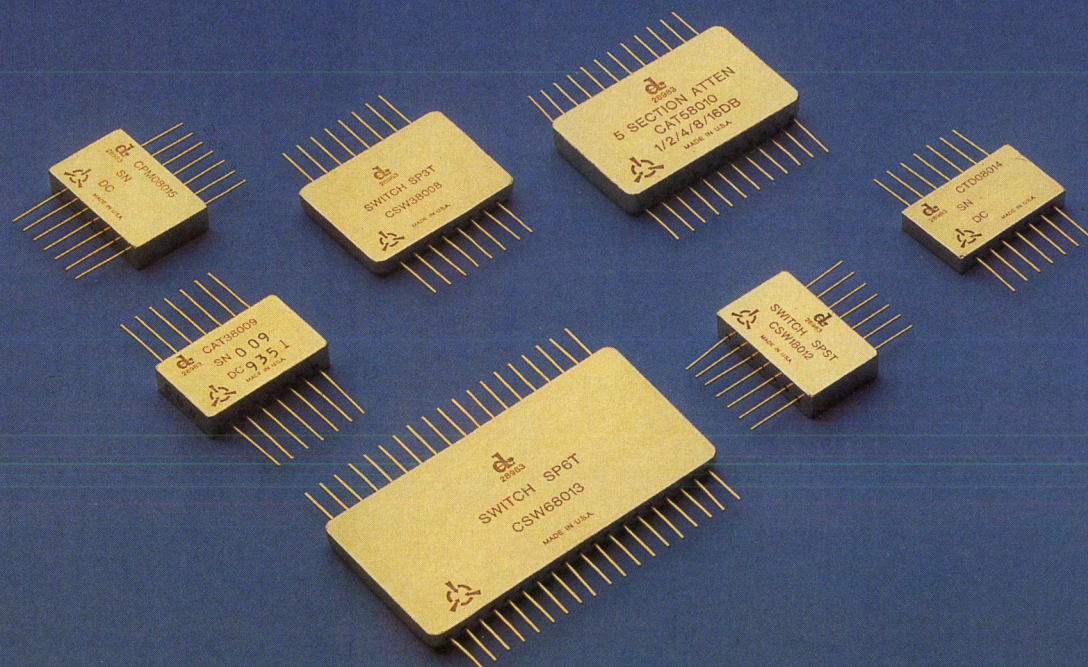
WE ACCEPT AMERICAN EXPRESS AND VISA

Distribution Centers / NORTH AMERICA 800-654-7949 • 417-335-5935 Fax 417-335-5945 EUROPE 44-252-835094 Fax 44-252-837010



F134 Rev D

Leader of the FLATPACK



Flatpacks

Con-fig	Freq MHz	IL dB	Iso dB	Switch Speed n SEC	Part No.
SPST	10-1000	1.25	70	35	8012
SPST	400-2000	0.9	67	185	DS0551
SP2T	10-1000	0.7	55	40	DS0860
SP2T	5-2000	1.0	57	24	DS02800
SP2T	5-1000	0.5	70	72	DS0962
SP3T	10-1000	1.2	40	100	8008
SP4T	DC-2000	1.5	50	30	CS048024
SP6T	10-1000	0.75	50	1000	8013
1 Sect Atten	5-1000	0.9	10	30	DA0944-10
1 Sect Atten	800-1200	0.9	50	80	DA0879
3 Sect Atten	30-300	1.0	.25, .5, 1.0	200	8009
5 Sect Atten	10-400	1.7	1, 2, 4, 8, 16	100	8010
Pulse Modulator	10-1000	2	80	300	8015
Threshold Det	10-3000	Detects -25 to -10 dBm	—	—	8014

Daico broadens it's product line with a proven series of Flatpacks and almost every part in our catalog can be manufactured in one of these packages! Please call us...we have creative ways to meet all of your price, quality and performance requirements.

Daico...always in control.



DAICO INDUSTRIES, INC.

2453 E. Del Amo Blvd., Rancho Dominguez, CA 90220
Telephone 310/631-1143 • FAX 310/631-8078

INFO/CARD 4

WE ACCEPT VISA AND MASTERCARD

SWITCHES

ATTENUATORS

PHASE SHIFTERS

MMICS

BIT DETECTORS

COUPLERS

MODULATORS

AMPLIFIERS

featured technology

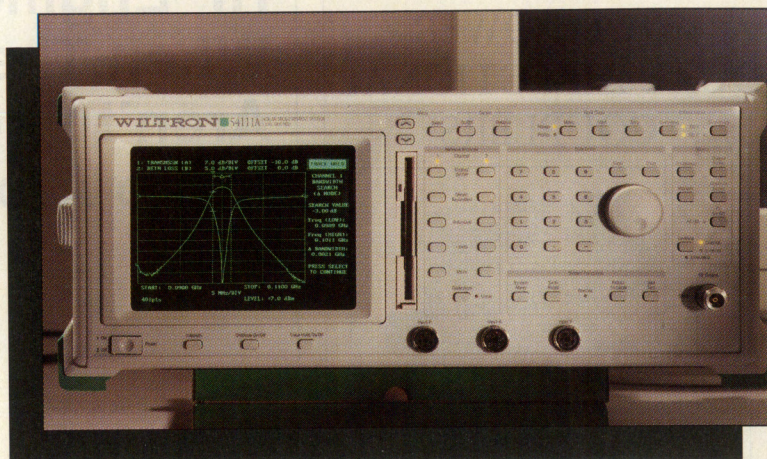
26 Use Emitter Coupled Logic in Your RF Applications

ECL is the fastest available logic family, operating at frequencies well into the RF range. Its non-saturated operating mode and high speed make ECL a candidate for both analog and high-speed digital RF circuits.

— R.N. Mutagi

34 New RF ICs and Modules Boost Market Development

New RF IC and module products are appearing at a rapid pace. Here are some of the most recently announced products from eight companies.



cover story

38 Portable Network Analyzers Troubleshoot Wireless Systems

A new scalar network analyzer series is designed for accurate and flexible field installation and service support. Measuring transmission loss, return loss and SWR establish system performance, while distance-to-fault capabilities allow precise identification of problem components.

— Ken Harvey

tutorial

48 A First Introduction to Direct Sequence Spread Spectrum

New wireless applications use this technology to provide resistance to interference and allow re-use of the spectrum. This article is an entry-level introduction to the characteristics of direct sequence spread spectrum, and methods used for its implementation

— Gary A. Breed

design awards

52 NPOLE Helps Design Phase-Shift Networks

This article describes a method, and accompanying computer program, for the design of allpass networks that are used to form constant phase difference networks.

— R. Dehoney

departments

- 8 Editorial
- 14 Calendar
- 16 Courses
- 18 News
- 22 Industry Insight
- 42 New Products
- 58 Product Report
- 60 Marketplace
- 63 New Software
- 63 Advertiser Index
- 64 New Literature
- 65 Company Index
- 68 Info/Card

RF DESIGN (ISSN:0163-321X USPS: 453-490) is published monthly and semi-monthly in August. April 1994. Vol.17, No. 4. *RF Design* is a registered trademark of Argus Inc. Copyright 1994 by Argus Business, a division of Argus Inc., 6151 Powers Ferry Road, NW, Atlanta, GA 30339, (404) 955-2500. Editorial and advertising offices at 6300 S. Syracuse Way, Suite 650, Englewood, CO 80111, (303) 220-0600. Printed in USA. Second-Class Postage paid at Englewood, CO and at additional mailing offices. Subscription office: *RF Design*, P.O. Box 1077, Skokie, IL 60076. Subscriptions are: \$39 per year in the United States; \$49 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 (313) 761-4700. Authorization to photocopy items for personal use is granted by *RF Design*, provided the base fee of \$3 is paid directly to Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923 and provided the number of copies is fewer than 100. For authorization, contact the Copyright Clearance Center at (508) 750-8400. The Transactional Reporting Service fee code is: 0163-321X/94/\$3.00. For those seeking 100 or more more copies, please contact the magazine directly at (303) 220-0600.

SUBSCRIPTION INQUIRIES: (708) 647-0756.

WERLATONE

DECADES AHEAD

HIGH POWER DUAL DIRECTIONAL COUPLERS



MULTI-OCTAVE BANDWIDTH TYPICAL SPECIFICATIONS

FREQ. RANGE 80-1000 MHz
INS. LOSS 0.1 db
FLATNESS +/-0.5db
DIRECTIVITY 20 db min.
VSWR ML 1.2:1max.

MODEL C3240

COUPLING 40db nom.
POWER CW 200 watts

MODEL C3271

COUPLING 50 db nom.
POWER CW 1500 watts

BROADBAND HIGH POWER

- DIRECTIONAL COUPLERS
- POWER COMBINERS
- HYBRID JUNCTIONS

P.O. BOX 47 • ROUTE 22 • BREWSTER, N.Y. 10509
914-279-6187 • FAX 914-279-7404

RF editorial

How to Find RF Engineers When There Aren't Enough to Go Around



By Gary A. Breed
Editor

There is a puzzling contradiction in the engineering community — there are too many unemployed engineers, but industry believes there is a shortage of engineers! This is a subject I've noted before, but it needs to be brought up again.

First, without question, a lot of engineers are out of work or working at non-engineering jobs. Places like Los Angeles, Boston and Long Island have relied on military contractors for much of their engineering employment, and now many good engineers are on the unemployment roles.

It is also without question that companies looking for engineers are not finding what they want. The skills that are needed today (fast development, low cost design, design-for-manufacturing, integrated digital/RF systems) are relatively new, and there is only a small pool of existing talent to draw from.

Compounding the problem, because these demands are new, only a few engineering schools have professors with the experience to teach these subjects well. And because these skills represent a specialty, they are addressed in graduate programs, adding at least another year to the pipeline that supplies new engineers.

So, what can industry do to get the engineers it wants, without having to wait for the development of the skills that it demands? The answer is simple in concept, but difficult to accomplish — find those engineers within the existing ranks of the profession who have the potential to learn these skills quickly.

As I see it, this is the only choice that

a growing communications industry can make if it wants to accomplish the ambitious goals that have been touted with such public hoopla — from the business section of your local newspaper to TV ads during the Super Bowl.

The difficulty lies in identifying raw talent in an engineer with lots of experience in specific areas. The most obvious way to begin is to see if his or her employment history has variety. Then, was that engineer successful in each of those varied responsibilities?

A set of screening questions can help, designed to identify the engineer's grasp of important concepts like modulation and occupied bandwidth, manufacturing tolerances and yield, or just familiarity with commodity-type RF components (not just high performance stuff).

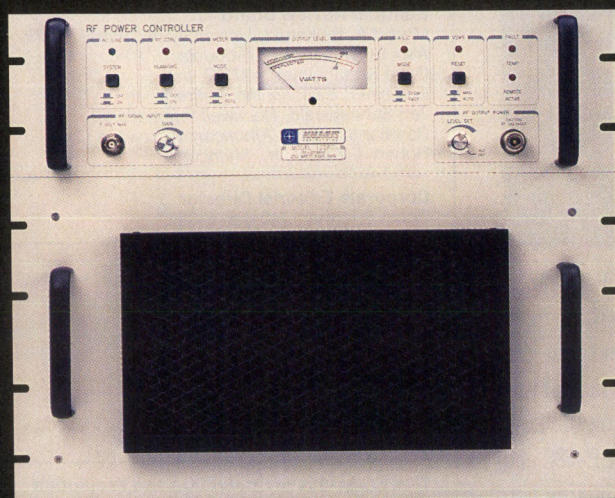
This kind of analysis takes time, and it takes an engineer to do it. Personnel staff can only do the most fundamental screening; it will take an engineering manager to dig far enough into a prospective employee's experience to find latent talent. That is an expensive proposition in terms of man hours, but it may be necessary.

We inside the industry know that good RF engineers don't grow on trees! With new applications growing fast, the branches are pretty bare. I wouldn't want to be an engineering manager looking for RF engineers right now — it's guaranteed to cause headaches.

But if the need is great enough, some extra effort may help you spot an engineer who doesn't have the right experience, but learns fast and knows how to successfully complete projects.

WHAT YOU'VE BEEN WAITING FOR!

**Technology of the Future
Available Today**



***250 Watts CW
.01 - 220 MHz***

WORLD'S FIRST

***14 Octave 250W
SOLID-STATE RF Amplifier***

MODEL 122FC

- Instantaneous bandwidth, no warm-up
- Fully protected
- No VSWR shutdown, drives mismatched loads
- ALC gain leveling & power limit set
- All front panel controls available via remote connector
- IEEE488 / RS232 interface capability
- 19" rack mountable, weight 50 kg
- US \$19,950.00

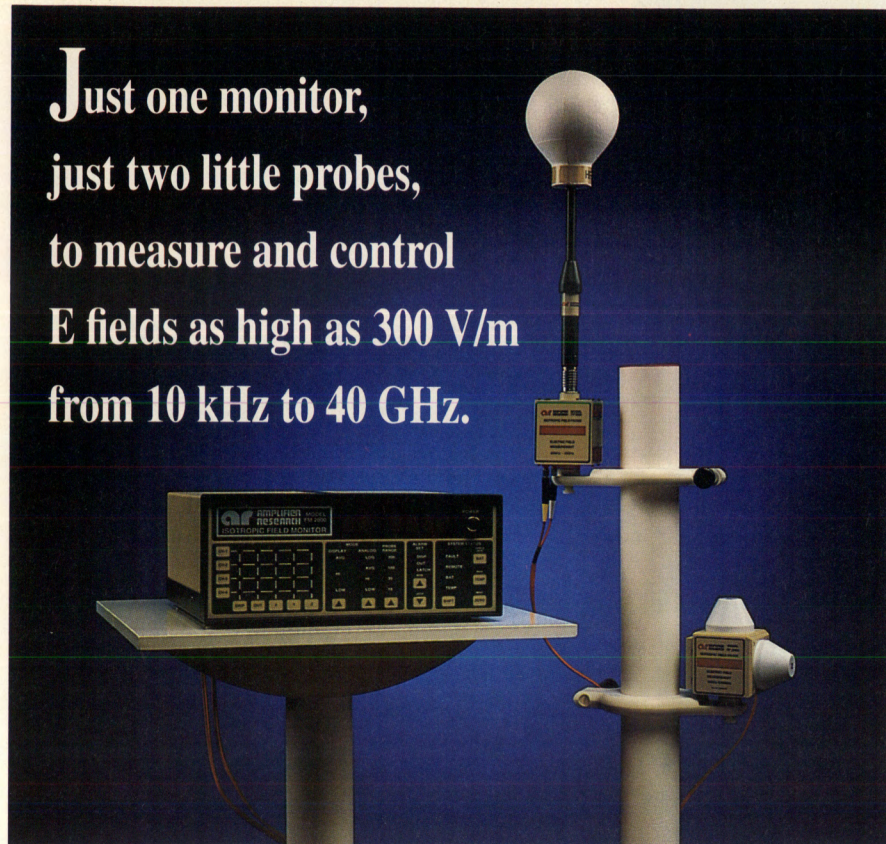
***The World's Most Complete
Line of RF Power Amplifiers***

***More Than 200 Standard Models
to Choose From***



1-800-344-3341
(206) 485-9000 **fax (206) 486-9657**
21820-87th S.E. • Woodinville, WA 98072 • USA
Paris, France
phone 1-4645-0945 **INFO/CARD 6** **fax 1-4645-2403**

**Just one monitor,
just two little probes,
to measure and control
E fields as high as 300 V/m
from 10 kHz to 40 GHz.**



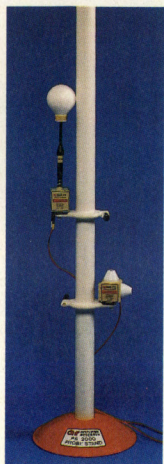
Such simplicity and breadth!

With this one compact system, you enjoy complete E-field monitoring capability up to 40 GHz, for fields from one to 300 volts per meter.

Inside your shielded room: A probe with frequency response from 10 kHz to 1 GHz (enough bandwidth for 82% of susceptibility-test applications); and another probe with a range from 80 MHz to 40 GHz. Both probes have rechargeable batteries for operation up to 40 hours.

Outside the shielded room, connected through glass fiberoptic cables that can carry signals as far as 1,000 meters, is the remarkable new FM2000 monitor — offering you total flexibility for measuring and leveling fields around the EUT.

The FM2000 accommodates up to four probes of either or both frequency ranges, for placement at various



84-inch probe stand (easily cut to lower height) lets you position probes where you want them. One screw clamp included with each stand, additional clamps available.

locations in the shielded room. Each probe delivers its own signals through an input card to the control console, and you can select HI/LO/AVG readings from multiple probes at the touch of a finger on the keypad. Outputs are provided to IEEE-488 and RS-232 interfaces and 0-4 Vdc, giving you the widest choice for automatic field control — plus audible signal and SPDT contact closure for excessive-field-level or low-battery alarm.

With European and American immunity requirements increasing daily, you need a reliable ultra-broadband field-monitoring system, available from stock now, for your susceptibility testing. Get all the technical data you need on the FM2000 system. One of our applications engineers will pick up the phone himself when you call, toll-free, **1-800-933-8181**.



160 School House Road
Souderton, PA 18964-9990 USA
Phone 215-723-8181. Fax 215-723-5688

For engineering assistance, sales, and service throughout Europe, call EMV: Munich, 089-612-8054; London, 0908-566556; Paris, 1-64-61-63-29

RFdesign

Established 1978

President — Argus Business
Jerrold France

Editorial and Advertising Offices
6300 S. Syracuse Way, Suite 650
Englewood, CO 80111
(303) 220-0600 Fax: (303) 773-9716

Vice President and Group Publisher
David Premo (303) 220-0600

Editor
Gary A. Breed (303) 220-0600

Technical Editor
Andrew M. Kellett (303) 220-0600

Assistant Editor
Ann M. Trudeau (303) 220-0600

Consulting Editor
Andy Przedpelski, *The Shedd Group*

Editorial Review Board
Madjid A. Belkridj, *University of Central Florida*
Alex Burwasser, *RF Products*
Dave Krautheimer, *MITEQ, Inc.*
Ed Oxner, *Siliconix Inc. (retired)*
Jeff Schoenwald, *Rockwell International*
Raymond Sicotte, *American Microwave Corp.*
Robert J. Zavrel, Jr., *Metricom*

Corporate Editorial Director
Robin Sherman (404) 618-0267

Account Executives
Jessica Caid (303) 220-0600
Mike Henry (703) 257-1202
Tisha Hill (303) 220-0600
Brian Noto (303) 220-0600
Jeff Peck (303) 220-0600
Cindy Solomonson (303) 220-0600

Classified Advertising Manager
Michael Applegate (404) 618-0217

Vice President — Production and Promotion
Cheryl Greenman (404) 618-0302

Production Manager
Jenny Tague (404) 618-0401

Reprints Manager
Vivian Peterson (303) 220-0600

Creative Director
Brian Buxton (404) 618-0108

Art Director
David Alden (404) 618-0188

Circulation Manager
Shawn DeMario (404) 618-0259

List Rental Manager
Etta Davis (404) 618-0266

Argus Business Corporate Offices
6151 Powers Ferry Rd., N.W.
Atlanta, GA 30339-2941
Tel: (404) 955-2500



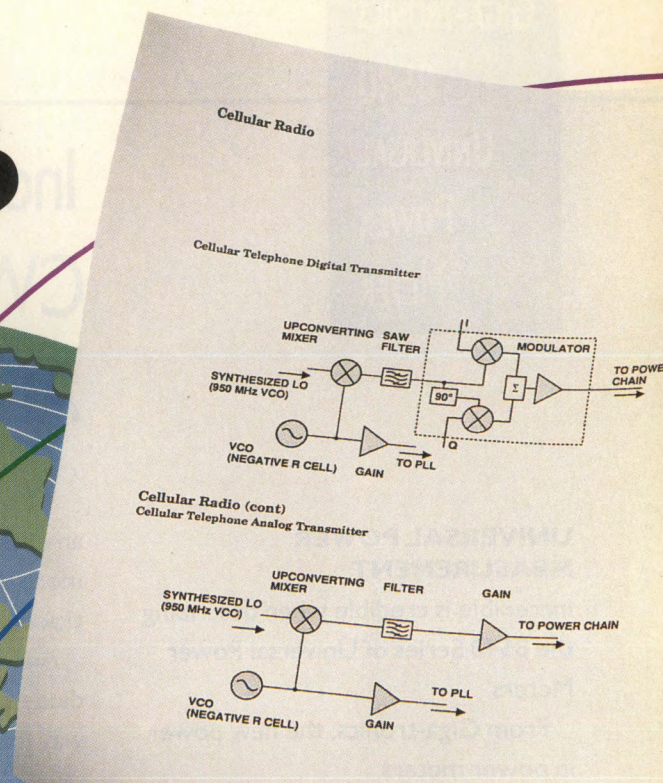
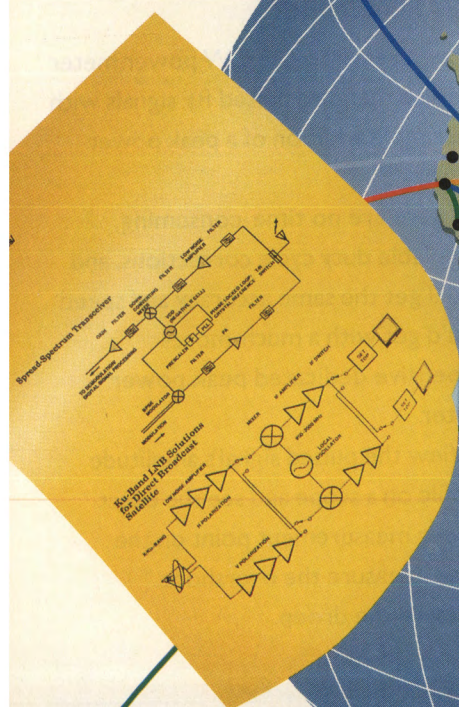
President — Argus Inc.
Scott Smith (404) 618-0286

Vice President, Finance — Argus Inc.
Wayne Otterbourg, C.P.A. (404) 618-0153

Senior Vice President — Argus Inc.
Arthur E. Sweum (404) 618-0109

President — Argus Trade Shows
Dennis Corcoran (404) 618-0485

FREE BLOCK DIAGRAMS



RF SOLUTIONS FOR...

- Cellular Radio
- Personal Communications Systems
- Cordless Telephones
- Commercial Wireless/Spread-Spectrum Transceivers
- Ku-Band LNB Direct Broadcast Satellite
- C-Band LNB Television Receive Only
- CATV Distribution & Set Tops
- Global Positioning Systems
- Millimeter Wave & Collision Avoidance Radar

Find out how to receive the new HP communications catalog with Block Diagrams. Over 900 pages of GaAs and silicon products.

In today's highly competitive environment you need all the design tools to win. HP provides the solution. Penstock provides the products with overnight delivery.

Call 1-800-PENSTOCK

(408-730-0300)

Canada: 613-592-6088



**HEWLETT
PACKARD**

PENSTOCK
WORLD'S LARGEST RF/MICROWAVE DISTRIBUTOR

Penstock has 17 offices nationwide with staffed engineers to answer your questions.

INFO/CARD 8

GIGA-TRONICS
8540
UNIVERSAL
POWER
METER

Incredibly Fast and Accurate CW and Peak Power Measurements At A Truly Incredible Price.

UNIVERSAL POWER MEASUREMENT

Incredible is credible when describing the 8540 Series of Universal Power Meters.

From Giga-tronics, the new power in power meters.

For the very first time, you can make CW and peak power

an exclusive Burst Mode capturing more than 2,000 readings in the same tick of a clock.

And because the 8540 Series uses diode sensors, you can measure all the way from -70 to $+20$ dBm with the same sensor, and without range changing delays.

If you're worried about having to write new code for your computer controlled testing, don't be: The 8540 Series uses the same GPIB command set as HP's 436A, 437B and 438A.

Think about what all this will do for your ATE productivity as well as for your company's bottom line.

FAST, EASY PEAK POWER MEASUREMENT

Now, an easy-to-use CW power meter can also measure pulsed RF signals with the simple addition of a peak power sensor.

There are no time-consuming, unreliable duty cycle corrections, and you'll get the same accuracy and speed you'd get with a much-more-expensive dedicated peak power meter.

View the pulsed signal's amplitude profile on a scope and see the exact power measurement point on the pulse. Measure the overshoot. Measure the droop.



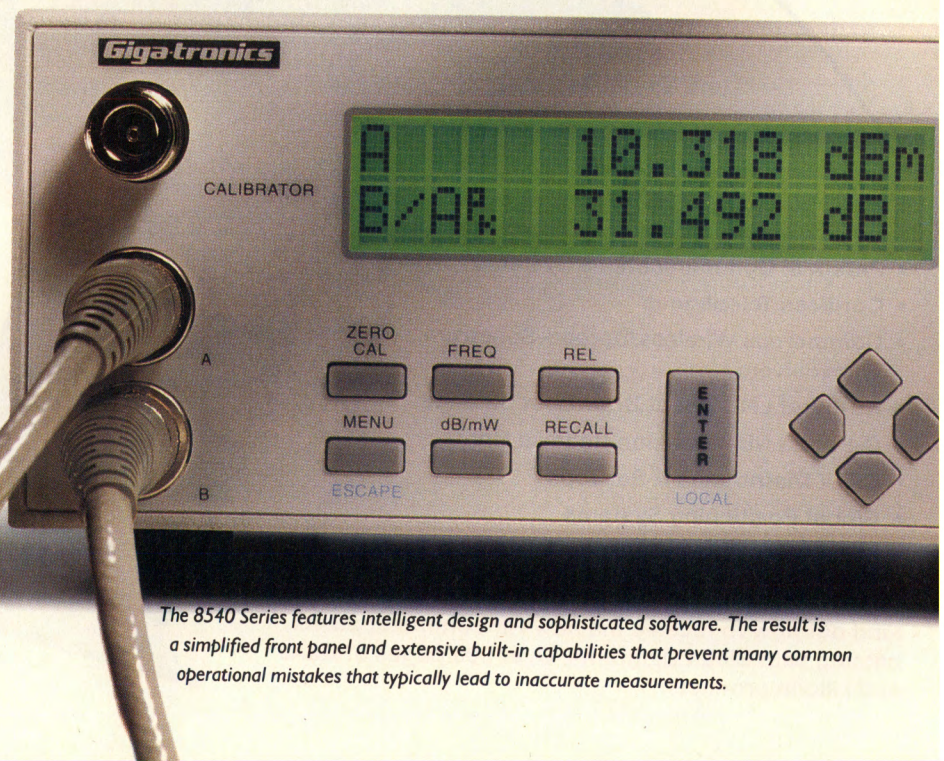
The two-line display also lets you set the desired resolution and select either Lin or Log readout for each line.

measurements quickly and accurately with a single meter—a Universal Power Meter.

And all for about the same price you'd pay for the competitor's CW only power meter.

POWER MEASUREMENTS INSTANTLY

Imagine seeing display updates instantly: measurement speeds over the GPIB exceeding 200 readings per second and



The 8540 Series features intelligent design and sophisticated software. The result is a simplified front panel and extensive built-in capabilities that prevent many common operational mistakes that typically lead to inaccurate measurements.

The Secret Is The Sensors.

Surface Mount technology
assures greater sensor
accuracy and reliability.

Just look
at the incred-
ible improvement
in speed you'll get with
Giga-tronics' diode sensors.

You'll be confident of your peak
power readings, and still have all the
benefits of an incredibly fast CW
power meter.

ONE OR TRUE TWO CHANNEL OPERATION

If a single-channel meter is what you
need, the Model 8541 is the meter for
you. But if you need two-channel capa-
bility, the Model 8542 lets you see read-
ings from both channels *simultaneously*.

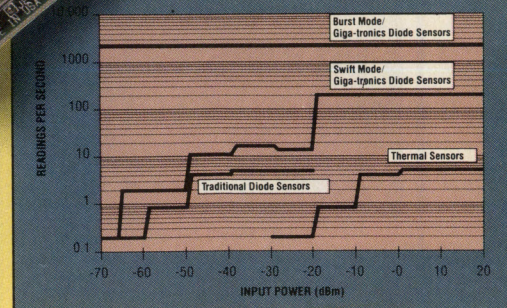
SIMPLE, INTELLIGENT OPERATION

The 8540 Series has only half as
many controls as other power meters,
but don't let that fool you. Intelligent design
and sophisticated software give you easy

access to extensive built-in capabilities.

For example, you use the same key
to zero and calibrate the power
sensors. The meter automatically
determines the function you want by
detecting whether a sensor is
connected to the calibrator.

Imagine all this power and perfor-
mance. But why just imagine? Get the
truly incredible Giga-tronics 8540 Series
Universal Power Meter, and start
measuring CW and peak
power in a fraction
of the time.



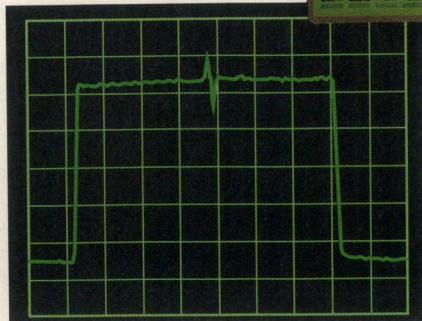
The Giga-tronics 8540 Series delivers
incredible performance by taking full
advantage of the speed and dynamic
range of diode sensors.

What's more, Giga-tronics has solved
the challenge that previously limited
diode sensors to the "square law"
region—below -20 dBm—by utilizing
a built-in power sweep calibration
system. So you get speed and a
full 90 dB dynamic range

without sacrificing
accuracy.

A two-line back lit LCD display
provides you more data in less time.

A R -14.375 dBm
DLVA 122.010 US



The peak sensor adds a
marker on a monitor output
for setting an exact measure-
ment point on pulsed signals.

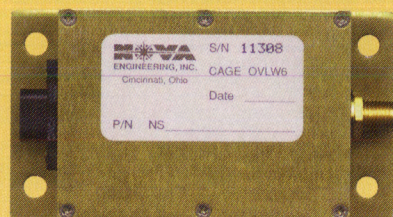
call 001 408 734 5780. We'll send you
more information or arrange for an
incredible hands-on demonstration.

Call us toll-free at
1 800 726 GIGA.
Outside the U.S.
call your local
Giga-tronics
representative, or

Giga-tronics

Giga-tronics Incorporated
488 Tasman Drive
Sunnyvale, California 94089
Telefax: 408 747 1265

NS-SERIES MINIATURE LOW-POWER SYNTHESIZERS



Size shown 2/3 actual

A Complete Low Cost Frequency Generation Solution

- 50-1200 MHz Coverage In Bands
- Compact EMI Sealed Package
1.5" x 2.0" x 0.625" Enclosure
- Low Power Consumption
<100 mW Most Models
- Internal TCXO:
2 PPM 10 MHz Standard
Other Stabilities Available
- Wide Frequency Tuning Range
Up to 2:1
- Simple Three-Line Control
PC Driver Software and
Application Notes Supplied
- Low Phase Noise
<-115 dBc/Hz @ 100 kHz
- High Level Buffered Output
+5 dBm \pm 2 dB
- Frequency Steps Available:
5 kHz to 100 kHz
- Evaluation Units
Start at \$470.00
Production Prices
Less Than \$100.00

Custom Designs Available



ENGINEERING, INC.

4747 Devitt Drive • Cincinnati, OH 45246

Call Toll Free 1-800-341-NOVA

In Ohio (513) 860-3456

Fax (513) 860-3535

INTERNET: sales @ novaengr.com

RF calendar

April

- 12-15** EMC/ESD International
Anaheim, CA
Information: EMC/ESD International, Registration
Coordinator, 6151 Powers Ferry Rd. NW, Atlanta, GA
30339. Tel: (800) 828-0420. Fax: (404) 618-0441.
- 20-27** International Workshop on Computer-Aided Modeling
Analysis and Design of Communication Links and
Networks
Princeton, NJ
Information: Benjamin Melamed, NEC USA Inc., 4 Independence
Way, Princeton, NJ 08540. Tel: (609) 951-2450.

May

- 10-12** IEEE Instrumentation & Measurement Technology
Conference
Hamamatsu, Japan
Information: Electronic Industries Association, EIA Components
Group, 2001 Pennsylvania Ave. N.W., Washington, DC
20006-1813. Tel: (202) 457-4930.
- 23-24** Microwave and Millimeter-Wave Monolithic Circuits
Symposium
San Diego, CA
Information: Richard B. Gold, Pacific Monolithics, 245 Santa
Ana Court, Sunnyvale, CA 94086-4512. Tel: (408)
732-8000. Fax: (408) 732-3413.
- 23-26** IEEE/MTT-S International Microwave Symposium
San Diego, CA
Information: MTT-S Symposium 1994, c/o LRW Associates,
1218 Balfour Drive, Arnold, MD 21012.
- 27** Automatic RF Techniques Testing 43rd Conference
San Diego, CA
Information: Bill Pastori, Maury Microwave Corp. Tel: (909)
987-4715. Fax: (909) 987-1112.

June

- 1-3** 1994 IEEE Frequency Control Symposium
Boston, MA
Information: Michael Mirarchi or Barbara McGivney, Synergistic
Management, Inc., 3100 Route 138, Wall Township, NJ
07719. Tel: (908) 280-2024.
- 1-3** Virginia Tech Symposium on Wireless Personal
Communications
Blacksburg, VA
Information: Conference Registrar, Donaldson Brown Hotel
and Conference Center, Virginia Tech, Blacksburg, VA
24061-0104. Tel: (703) 231-5182. Fax: (703) 231-3746.
- 19-24** 1994 IEEE AP-S International Symposium and URSI
Radio Science Meeting
Seattle, WA
Information: Jan Kvamme, Conference Manager, UW Engi-
neering Professional Programs, 3201 Fremont Avenue North,
Seattle, WA 98103. Tel: (206) 543-5539. Fax: (206) 543-
2352.

GORE-SHIELD™ form-in-place gaskets allow quick and inexpensive EMI/RFI seal

Ideal for prototype and field repairs



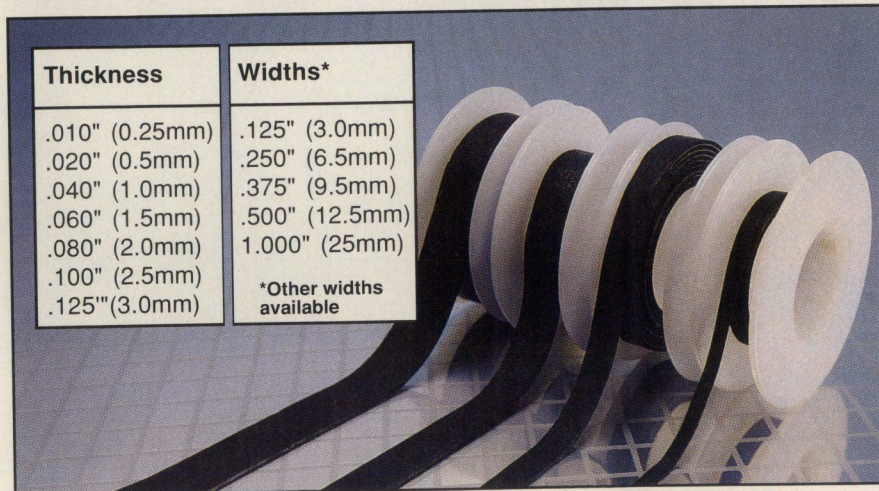
GORE-SHIELD strip gaskets provide an effective solution to quick, on-the-spot requirements for low cost EMI/RFI shielding. They are excellent for retrofits, prototypes, high volume production, and even field repair of damaged gaskets.

GORE-SHIELD strip gaskets offer proven EMI performance plus environmental sealing in a single, user friendly package. The EMI strip gasket is easily formed in place which allows maximum design flexibility. This greatly simplifies flange designs by eliminating the requirement for grooves. They are available in a variety of widths and thicknesses, with or without conductive pressure sensitive adhesive, and are conveniently packaged on easy-to-use dispenser rolls. GORE-SHIELD strip material is made of chemically inert, expanded PTFE so it is soft and conformable. This conformability and exceptional inertness also provides a strong environmental seal to combat corrosion, and other chemical attack. Best of all, GORE-SHIELD strip gaskets are available for same day shipment. Call Richardson Electronics, Ltd., the country's leading RF and microwave specialty distributor. Take advantage of Richardson's extensive inventory of GORE-SHIELD strip gaskets and other RF and microwave components. To order from any of Richardson's 16 North American sales locations, call:

1-800-RF POWER

(1-800-737-6937)

Canada 1-800-348-5580



Thickness	Widths*
.010" (0.25mm)	.125" (3.0mm)
.020" (0.5mm)	.250" (6.5mm)
.040" (1.0mm)	.375" (9.5mm)
.060" (1.5mm)	.500" (12.5mm)
.080" (2.0mm)	1.000" (25mm)
.100" (2.5mm)	
.125" (3.0mm)	
	*Other widths available

1994 Richardson Electronics, Ltd.
40W267 Keslinger Road, LaFox, IL 60147 USA
Tel: (708)208-2200, Fax: (708) 208-2553
GORE-SHIELD is a trademark of W. L. Gore & Associates, Inc.

Richardson Electronics, Ltd.



RF courses

Mobile Communication Engineering

May 4-6, 1994, San Diego, CA

Digital Transmission Systems

May 9-12, 1994, Washington, DC

Low Earth Orbit Satellite Systems (LEO's)

May 16-18, 1994, Washington, DC

Simulation of Communication Networks

May 23-26, 1994, Washington, DC

Radio Frequency Spectrum Management

June 6-10, 1994, Washington, DC

Global Positioning System: Principles and Practice

June 7-10, 1994, Orlando, FL

Digital Transmission for the Cellular Telephone Systems

June 20-22, 1994, Washington, DC

Information: The George Washington University, Continuing Engineering Education, Academic Center, Room T-308, 801 22nd Street, N.W., Washington, DC 20052. Tel: (202) 994-6106 or (800) 424-9773. Fax: (202) 872-0645.

Circuit Board Level Microwaves: Issues and Solutions

May 23-24, 1994, San Diego, CA

Information: Tom Laverghetta, TPL Associates, Inc., 516 E. First St., Auburn, IN 46706. Tel: (219) 925-1819.

Phased-Array Radar System Design

April 19-22, 1994, Atlanta, GA

Information: Georgia Institute of Technology, Continuing Education. Tel: (404) 894-2547.

Microwave/Millimeter-Wave Monolithic Integrated Circuits

May 17-20, 1994, Los Angeles, CA

Information: UCLA Extension, Engineering Short Courses, 10995 LeConte Ave., Ste. 542, Los Angeles, CA 90024. Tel: (310) 825-1047. Fax: (310) 206-2815.

VSAT Networks

April 20-21, 1994, Cambridge, UK

Satellite Communication Systems

April 18-22, 1994, Cambridge, UK

Mobile Cellular and Microcellular Telecommunications

April 20-22, 1994, Cambridge, UK

Information: CEI-Europe/Elsevier, Mrs. Tina Persson. Tel: (46) 122-175-70. Fax: (46) 122-143-47.

Spread-Spectrum Communication Systems & Applications

May 4-6, 1994, Ann Arbor, MI

Information: Engineering Conferences, 400 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109-2092. Tel: (313) 764-8490.

EW Receivers

May 3-5, 1994, Washington, DC

Introduction to Radar Systems and Signal Processing

May 17-19, 1994, Washington, DC

Information: Research Associates of Syracuse, Incorporated, Hancock Army Complex, 510 Stewart Drive, N. Syracuse, NY 13212. Tel: (315) 455-7157.

FRONT END FILTERS
CRYSTAL FILTERS
CRYSTALS
LC FILTERS
DISCRIMINATORS

TEMEX
ELECTRONICS, INC.
3030 W. Deer Valley Rd.
PHOENIX, AZ 85027
(602) 780-1995 FAX (602) 780-2431

Richardson Electronics is Your Global Partner in RF Technology

Offering solutions to customer problems for more than 40 years, Richardson Electronics, Ltd. has grown into one of the world's premier suppliers of RF devices.

THE NEXT GENERATION

This Month's Feature . . .

RF Gain, Ltd.

RF Gain, Ltd. presents MMIC Evaluation Kits for the ever-growing wireless markets

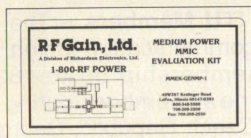
These kits contain the hottest MMIC devices for all markets & applications including low-noise amplifiers, general medium power applications, upconverter/downconverter and antenna switching for cellular, PCN, and other applications.

With the market demanding the reduction in "cycle time to market"- the evaluation kit gives you the edge you need against the growing competition.

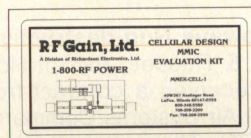
The RF Gain, Ltd. MMIC Designer Kit makes the evaluation of MMIC devices on the market-fast and accurate.

COMING SOON...

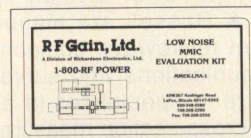
PCN Design MMIC Evaluation Kit
MMEK-PCN-1
and more kits to come!



Medium Power MMIC Evaluation Kit
MMEK-GENMP-1



Cellular Design MMIC Evaluation Kit
MMEK-CELL-1



Low Noise MMIC Evaluation Kit
MMEK-LNA-1

Richardson Electronics, Ltd. has been offering solutions to customer problems for more than 40 years. The MMIC Evaluation Kits are exactly what design engineers have been asking for. Call 1-800-RF POWER for all your RF & Microwave needs.

Our industry-leading RF suppliers . . .



MOTOROLA



SGS-THOMSON

Amphenol®



EF JOHNSON



PHILIPS



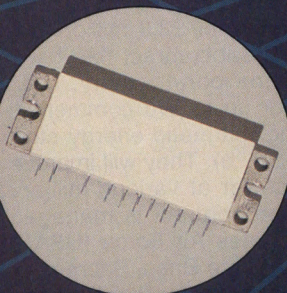
RF PRODUCTS



PINEAPPLE TECHNOLOGY



- Technical Expertise
- Experience
- Inventory
- Market Knowledge
- Supplier Literature



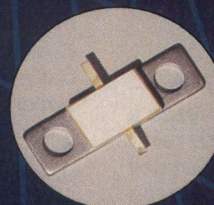
U.S. (800) RF POWER
CANADA (800) 348-5580
U.K. (0522) 542631
FRANCE (1) 34-26-4000
ITALY (055) 420-10-30
SPAIN (1) 528-37-00
GERMANY (089) 80-02-13-1
JAPAN (3) 3874-9933
SINGAPORE (65) 298-4974



Committed to the RF Market—

Richardson Electronics, Ltd.

40W267 Keslinger Road
LaFox, Illinois 60147
(708) 208-2200



Latin America and other international inquiries, contact Corporate Headquarters at (708) 208-2200

Reports Predicts \$10 Billion Phone, Pager Sales by 1999

Frost & Sullivan, a subsidiary of Market Intelligence, is an international high-technology research firm that released a study in January 1994 forecasting a 21 percent compounded annual rate increase in sales for the wireless communications industry. The report, U.S. Cellular and PCS Telephone, Pager and Accessory Markets: Time to focus on Applications, states that sales are expected to increase from \$2.5 billion in 1992 to \$9.5 billion in 1999. The subsidiary of Market Intelligence said the increase in demand will be coming from healthcare, security and blue-collar businesses, and retail consumers. Though primarily used in business, sales, and service industries up to this point the market is expected to expand in response to declining prices and the motivation for safety and convenience. This will enable families access to the services. Pagers are the biggest growth from the family standpoint. Numeric pagers will keep pace while tone-only pagers will become obsolete. Handheld phones that can be taken out of cars will show the fastest growth. New handsets will offer dispatch and two-way calling capabilities, providing increasingly integrated communications and eliminating the need to subscribe to multiple services. The report said that as individual consumers enter the market retail sales will rise from 22 percent of the total sales in 1992 to 34 percent of the total by 1999.

Raytheon Developing Zenith Chip – Raytheon Semiconductor is designing the circuitry for the digital cable transmission system developed by Zenith Electronics Corporation. Raytheon will provide the IF amplifier/demodulation integrated circuit (IC) for digital set-top decoders based on Zenith's 16-level vestigial sideband (16-VSB) transmission system. The system increases the data that can be transmitted on a single cable channel without additional video compression—expanding the expected 500 channels to 1,000.

U.S., Canada Renew Accreditation – The U.S. Department of Commerce's National Institute of Standards and Technology and the Standards Council of Canada renewed an agreement on

Feb. 22, 1994, that facilitates trade between the world's two largest trading partners. The agreement provides mutual recognition of testing laboratories. For the U.S. that means accreditation by the NIST National Voluntary Laboratory Accreditation Program and for Canada approval by SCC's Program for Accreditation of Laboratories. NIST and SCC base decisions to accredit testing laboratories on similar but not always identical criteria. Both programs meet the requirements of international standards for accrediting laboratories under ISO/IEC Guide 25: 1990—General Requirements for the Competence of Calibration and Testing Laboratories. The operation of accrediting programs under ISP/IEC Guide 58: 1993—Calibration and Testing Laboratory Accreditation Systems-General Requirements for Operation and Recognition, also meets these requirements.

New ITU Members – The International Telecommunication Union has brought its membership up to 182 by adding nine new members during 1993. They are: Czech Republic, Georgia, Slovakia, Kazakhstan, Micronesia, The Former Yugoslav Republic of Macedonia, Turkmenistan, Eritrea, and Andorra.

Microwave Non-destructive Testing – Flam & Russell, Inc. of Horsham, PA, has received a contract from the U.S. Naval Air Systems Command, Washington, DC. This will allow the transfer of high-resolution microwave imaging technology developed for military use to be investigated for civilian applications. Flam & Russell are manufacturers of custom microwave components, radar, communications and surveillance systems, and specializes in antenna and radar cross-section measurements.

Middle East GSM Contract – Motorola's International Cellular Infrastructure Division has signed a \$32 million contract with Kuwait's Mobile Telephone Systems (MTSC). The nationwide Global System for Mobile Communications (GSM) system was designed as an open architecture system. This enables network operators to combine equipment from a variety of suppliers. The Kuwait system will consist of Motorola base stations and Siemens EWSD® switches.

Acquisition of Canadian Company – Polyflon Company, New Rochelle, NY, acquired Shawinigan Research & Tech-

nology Ltd., Nepean, Ontario, Canada lines of Polyguide low-loss clad laminates and SRT bonding film. This gives Polyflon, a manufacturer/processor of components and materials for microwave and RF applications, an ideal material for the commercial antenna market.

Commercial GPS Sold – Leica, Inc., Buffalo, NY, has purchased the commercial GPS positioning and navigation systems from Magnavox Electronic Systems Company. According to the Leica Geodesy Business Unit in Switzerland, 40 Magnavox employees will become Leica employees and will work in a newly established facility in Torrance, California. This transaction includes Magnavox's marine and land-based GPS products as well as the company's high-accuracy differential GPS systems, including the ACC-Q-POINT FM-broadcast DGPS network. The sale will not affect the commercial satellite communications business group and in fact will allow Magnavox to focus on its traditional Inmarsat market.

Tektronix Has Canadian Agreement – Tektronix Inc. has broadened the alliance, with Rohde & Schwarz GmbH & Co. KG., Munich, Germany, that was announced August, 1993. Tektronix Canada Inc. will assume exclusive marketing, distribution and support responsibility for Rohde & Schwarz' test and measurement, and RF/microwave communications products.

Superconducting Energy Storage Device – A three-year \$8.6 million federal government subcontract has been signed with Superconductivity, Inc., Madison, WI, for up to five commercial superconducting magnetic energy storage devices (SSD®s). They will improve the quality of power at various military installations. The contract is managed by the United States Air Force (USAF) at McClellan Air Force Base, Sacramento, CA, and is funded by the Defense Nuclear Agency. The SSD® protects sensitive electronic equipment from power disruptions by using a patented superconducting coil that can store electricity without resistance or voltage loss, and can quickly discharge and recharge.

New Office and a Correction – Johnstech International moved at the end of 1993 into a new facility but unfortunately they were given the wrong street address which, in turn, was passed on

Richardson Covers the Spectrum of M/A-COM Products

Availability

From the new M/A-COM MED line of MMICs, mixers, hybrids and passive components to microwave and RF transistors and semiconductors, you'll find the M/A-COM products you need in stock at Richardson Electronics. Call 1-800-348-5580 to reach any of our 16 North American sales locations for same-day shipment of M/A-COM products from our \$1 million inventory.

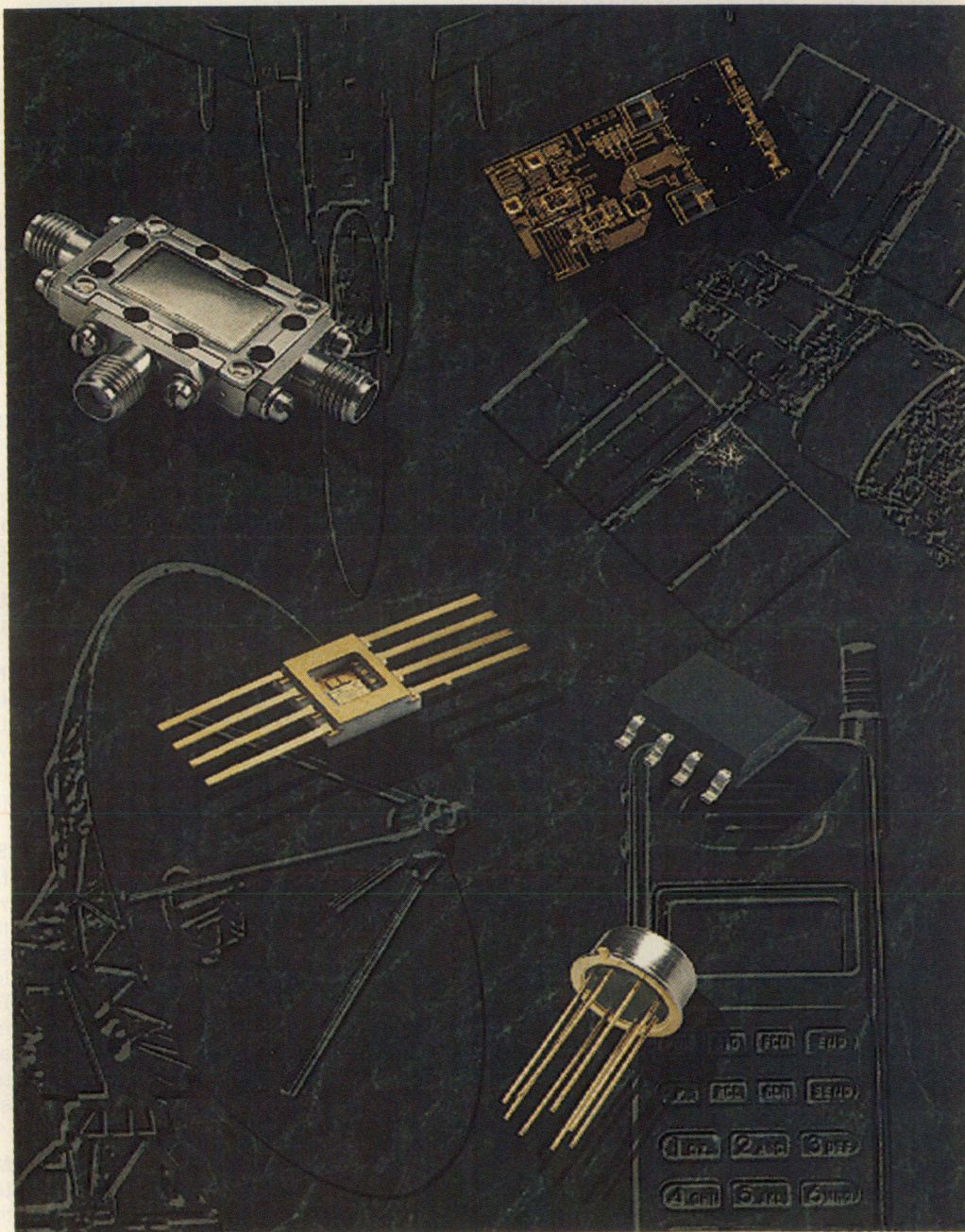
Product Knowledge

For technical support on current designs or future applications for M/A-COM components, call 1-800-RF POWER to reach our team of engineers. WE SPEAK RF so your specific requirements are not lost in the translation.

Value-Added Support

We offer custom stocking programs, JIT and EDI capabilities in addition to special component testing and packaging. Call 1-800-RF Power and let our design staff assist with all your questions.

If your requirements enter the spectrum for M/A-COM products, you'll find Richardson Electronics operating at the frequency capable of meeting all your demands.



Richardson Electronics, Ltd.

Corporate Headquarters
40W267 Keslinger Road,
LaFox, IL 60147 USA
Fax (708) 208-2553

WE SPEAK RF!
1-800-RF POWER

(1-800-737-6937) in Canada 1-800-348-5580

to the reader. The correct information is: 1210 New Brighton Blvd., Minneapolis, MN 55413-1641. Tel: (612) 338-2020. Fax: (612) 338-2030. Johnstech, a manufacturer of test sockets, also has opened a West Coast office. That address is: 19925 Stevens Creek Blvd., Cupertino, CA 95014. Tel: (408) 973-7215. Fax: (408) 725-8885.

Location Change for Monsanto – The

new address for the Metalized Materials of Monsanto's Chemical Group that manufactures shielding products is: 3481 Rider Trail South, St. Louis, MO 63045. Tel: (800) 843-4556. Fax: (203) 854-6034.

Exclusive Representation for Capacitors – North American Capacitor Company (NACC) is the sole distributor of

Israel's Microelectronics Ltd. capacitors which, effective immediately, will be sold as Mallory/Microelectronics. They sell precision high-powered, high-quality multilayer ceramic capacitors, porcelain chip and leaded capacitors, and variable capacitors. Sample kits are stocked.

Fil-Mag Acquired – Technitrol, Inc. (AMEX-TNL) of Philadelphia, PA has purchased Fil-Mag and it will operate it as Fil-Mag, Inc., a Technitrol Company. Fil-Mag designs and Manufactures magnetic components for data and telecommunications networks such as Token Ring and Ethernet. Technitrol is a manufacturer of electronic components.

RF Suppression Products – Oxley Development Co. Ltd. will open by late spring of 1994 an 11,000 square foot facility that will be dedicated to producing Planar Capacitor Arrays and other dielectric products. The site will be in Ulverston, Cumbria, English Lake District, U.K. An associate company, Oxley Inc., has offices in Branford, CT.

New Location – LKPF CAD/CAM Systems is moving to a new location effective March 1, 1994. The new address will be 6840 SW Canyon Drive, Portland, OR 97225. Tel: (800) 345-5753, (503) 297-2720. Fax: (503) 297-2820.

Sonnet Resumes Marketing of Electromagnetic Software – Sonnet Software, Inc., of Liverpool, NY, said that the year and a half long marketing and sales relationship with EEsos has been terminated because in September 1993 EEsos was sold to HP. Sonnet, producing electromagnetic software for the analysis of 3-D microwave circuits, will assume all responsibility for marketing, sales, and support of their products.

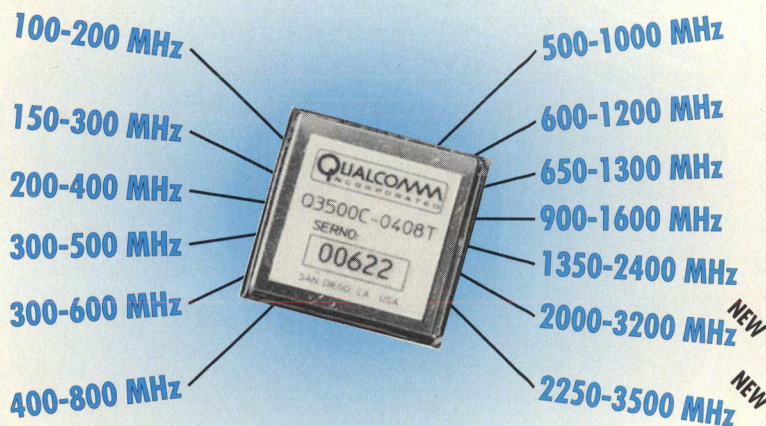
Military Contract to Cubic Corporation – The Electronic Systems Center of the U.S. Air Force awarded a two-year contract worth \$12.5 million for eight additional ground data terminals for the Joint Surveillance Target Attack Radar System (Joint STARS). The A.F. exercised the first option of the September 1993 contract and if the second options is exercised the contract would result in the purchase of 27 ground terminals and raise the contract value to \$41 million. Cubic Defense Systems developed the jam-resistant Surveillance and Control Data Link (SCDL), which transmits data in real time from aircraft to ground stations.

WIDEBAND VCOs*

Designed for professional applications where reliable performance and dollar value are equally important:

- VSATs
- SATCOM Systems
- Test Equipment
- Synthesizers

Available in These Ranges:



***Designed to Meet Your Needs:**

- Consistent performance - 100% Factory Tested
- Robust operation without Moding, Dropout or Subharmonic Pumping over full temperature range
- K_v optimized for PLL gain normalization
- Available NOW!

**Ask About Our Synergistic Line of
DDSs, DACs, and Wideband PLLs.**

QUALCOMM
VLSI Products

10555 Sorrento Valley Road
San Diego, CA 92121 USA
TEL: 619-597-5005
FAX: 619-452-9096

No One Stocks More

RF & Microwave Transistors, Semiconductors and Modules



**Richardson
Electronics, Ltd.**

1-800-RF POWER (U.S.A.)

**40W267 Keslinger Road
LaFox, Illinois 60147
(708) 208-2200**

INFO/CARD 16

CANADA	(800) 348-5580
U.K.	(0522) 542631
FRANCE	(1) 34.26.4000
ITALY	(055) 420.10.30
SPAIN	(1) 528 37 00
GERMANY	(089) 80 02 13 1
JAPAN	(3) 3874-9933
SINGAPORE	(65) 298-4974

Dealing with Signal Degradation

By Andy Kellett
Technical Editor

A perfect signal launched into the proverbial "channel" of information theory is always less than perfect when it emerges from the other end. Often the degradation, and its cure, are apparent. Other times, more experimentation is required to find the cause. For example, given a good receiver and a good transmitter, what could be causing third-order audio distortion in an FM broadcast? (The answer to this real-life problem can be found at the end of this report.) This report looks at some of the phenomena that affect particular systems, the tools that allow designers to predict or track down signal degradation problems, and what can be done to directly combat these problems.

The phenomena that affect RF transmissions are as varied as the transmissions themselves.

"Literally thousands of factories in the U.S. are using wireless data communications," says Dr. Theodore Rappaport, Associate Professor and Director of the Mobile and Portable Radio Research group at Virginia Polytechnic Institute and State University (Virginia Tech). RF data communications in factories and offices are most prone to impulsive noise and large dynamic fluctuations in signal strength caused by objects moving in and out of the propagation path, says Rappaport. Fan-blade-modulation and reflection-induced polarization changes are also problems in factory and office RF communication systems says Eric Creviston, a product manager at Teledyne Electronic Technologies.

The phenomena that affect cellular radio transmissions depend on the environment says Scott Kushino, an RF Design Engineer at Cellular One in Denver. "Your concerns in an urban environment tend to be completely different than those in a rural environment, which are different than those in a mountainous environment," says Kushino, "Co-channel and adjacent channel interference are uppermost in our minds when looking at coverage and frequency planning in city areas."

Cable television has its own set of signal degradation phenomena which it must deal with. Micro-reflections originate at every discontinuity in a cable system, and signal leaking into a cable,

(called ingress), is also something to be dealt with.

Modeling and Simulation

Software which simulates RF systems and their transmission paths at various levels is available. Propagation analysis software, like the Terrain Analysis Package (TAP) from SoftWright, integrates geographical information with propagation calculations. Topography information with resolutions as great as 30 meters are available with TAP and it can be used in calculations ranging from line-of-sight calculations to signal strength calculations.

RF systems and their sensitivity to signal degradation can be modeled at the link-budget level with programs such as MIL 3's OPNET Modeler /Radio™. In this program, models of antenna gain, propagation effects, background and interference noise, and transmitter/receiver characteristics can be used to simulate their impact on systems and network performance.

Tesoft's block diagram simulation program, Tesla, simulates circuits in the time domain at the level of filters, VCOs, splitters, etc. Individual blocks can be assembled to form PLLs, modems and complete receivers. "System level design can be quite useful at the debug stage of design because often a difficult problem will have many different potential causes," says Steve Lafferty, president of Tesoft, Inc.

Hardware which helps simulate signal degradation is also available. Arbitrary waveform generators such as Wavetek's Model 395 can simulate baseband or first IF signals undergoing almost any process. "I think the RF market's application for the 395 will be its noise capability. It produces exact, repeatable Gaussian white noise," says Bob Ottinger, Design Engineer at Wavetek. Noise-Com's UFX-BER for bit error rate applications is another instrument which capitalizes on Gaussian white noise production capability. By adding white noise to an ordinarily low-noise transmission channel, the UFX-BER allows engineers to measure statistically significant numbers of errors in a short time. The BER calculated at the higher noise level can then be extrapo-

lated to the noise level at which the system normally operates.

Another phenomena which afflicts RF transmission is multipath, and here too, equipment is available which can simulate this effect on the benchtop. Noise-Com's MP2400 can split an actual transmitter signal into 12 independently delayed and attenuated signals, which are then recombined at an output port. The amounts of the delays and attenuations can be directly specified, or automatically specified by dynamic simulation of a vehicle's path among a set of reflectors.

Directly Combatting Degradation

Finally, once the degradation has been identified and quantified, what can be done?

Some techniques attack the source of degradation itself – downtilting cellular base station antennas to avoid transmitting into adjacent cells, for example. Other techniques accept the degradation and work to minimize its effects. There are many different ways of doing adaptive equalization to compensate for micro-reflections, says Doug Greene, Senior Satellite Video Engineer at Jones Intercable. "The equalization we use depends on the modulation we use," says Greene, "This is all cutting edge and we're trying to find out what works best in our environment."

Signal degradation effects every RF transmission system built, but it effects each system in its own specific way. Engineers have tools with which to attack even the most unique problems.

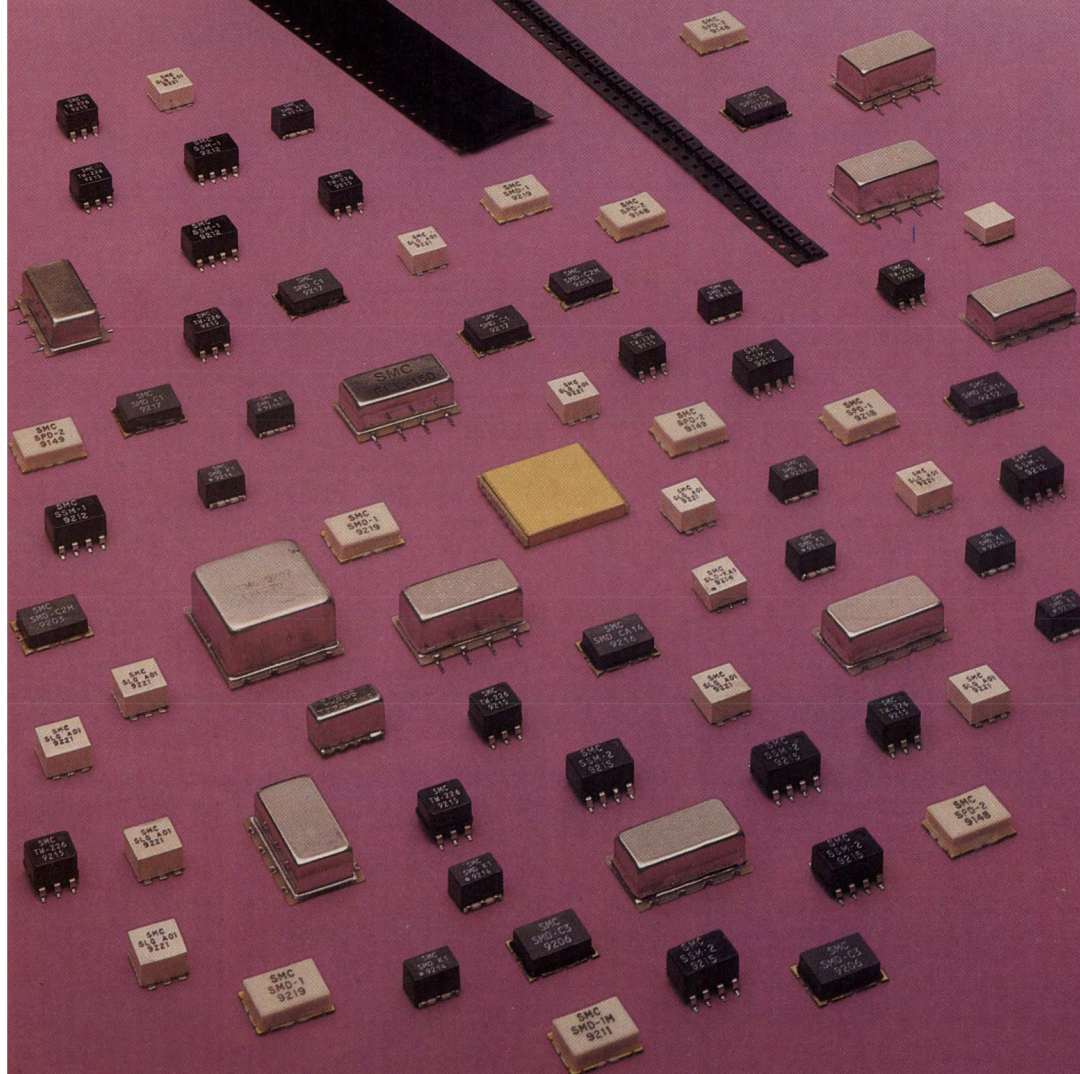
How was the third order audio distortion problem dealt with? Tesoft's Lafferty reports that Bob Plonka of Harris Broadcast suspected standing waves on the transmitting antenna system. A TESLA simulation showed that direct and delayed signals transmitted by different parts of the antenna system caused a phase shift which varied sharply with carrier frequency. As the audio modulated the broadcast signal, the resulting phase shifts were also broadcast. At the receiver the phase shifts were demodulated as FM distortion. The solution was to improve the SWR on the transmission line leading to the antenna.

RF

■ LARGEST SELECTION

■ INDUSTRY PIONEER

SURFACE MOUNT



MIXERS • POWER DIVIDERS • COUPLERS • FILTERS
I/Q MOD. & DEMOD. • PHASE DETECTORS • PHASE SHIFTERS
ATTENUATORS • VECTOR MODULATORS and more...



483 McLean Boulevard • Paterson, New Jersey 07504 • (201) 881-8800 • Fax: (201) 881-8361

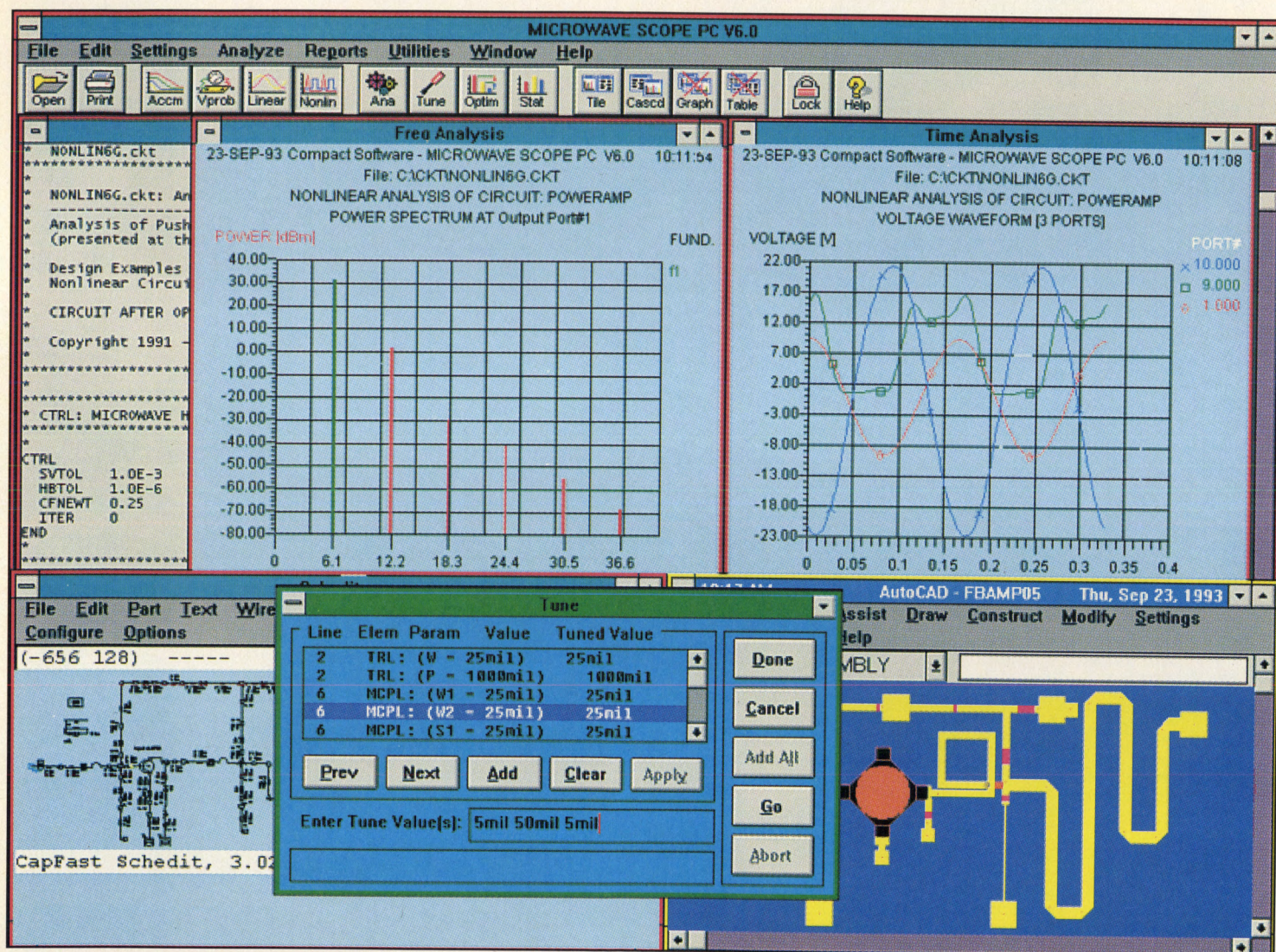
INFO/CARD 17

ENHANCED
TUNE MODE

VERSION 6.0

Serenade® PC for Windows™

Super-Compact®, Microwave Harmonica®, and Microwave Scope®
RF, Microwave, and Lightwave Circuit Simulators
Integrated with Schematic and Layout Editors



Compact Software®

201 McLean Boulevard
Paterson, NJ 07504
Tel: (201) 881-1200
FAX: (201) 881-8361

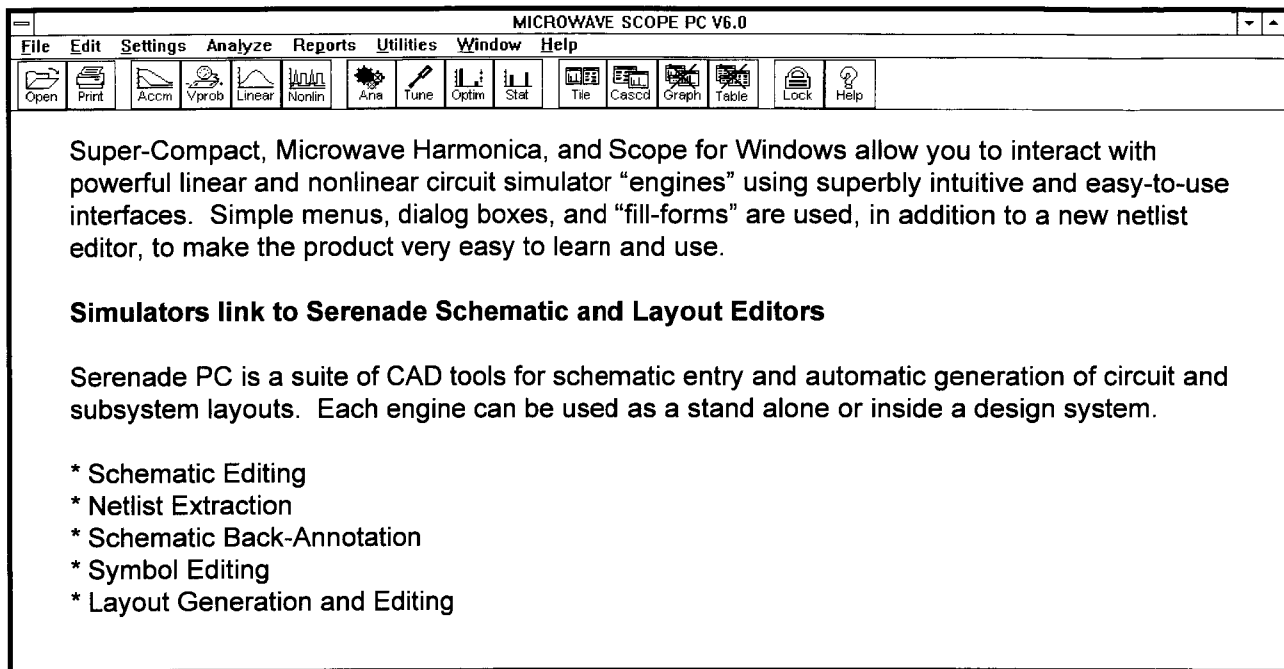
INFO/CARD 18

Super-Compact®
Linear Circuit Simulator

Microwave Harmonica®
Nonlinear Circuit Simulator

Microwave Scope®
Lightwave Circuit Simulator

Serenade® PC for Windows™



*In order to receive complete literature and a **free demo software kit**, please fax or send this page to Compact Software, or to the representative in your country.*

European Support Center
Austria, Denmark, Finland, France, Germany, Italy, Luxembourg,
Norway, Portugal, Spain, Sweden, Switzerland
Technical Software Service (Germany)
FAX: 49-7309-3275 - PHONE: 49-7309-5075

Belgium – See The Netherlands

Ireland – See United Kingdom

Israel
J.S.I.E. Ltd.
FAX: 972-3-93-02558 - PHONE: 972-3-93-45979

Japan
Seki Technotron Corp.
FAX: 81-3-3820-1433 - PHONE: 81-3-3820-1714

The Netherlands
3FI Ibexsa Electronics, S.A.
FAX: 31-20-65-31-353 – PHONE: 31-20-65-350

South Africa
Microwave & Electronic Technology
FAX: 27-12-663-2978 - PHONE: 27-12-663-2975

Taiwan
Evergo Corporation
FAX: 886-2-712-2466 - PHONE: 886-2-715-0283

Turkey
Momentum Projects & Consulting
FAX: 90-1-257-7663 - PHONE: 90-1-257-7170

United Kingdom
3FI Ibexsa Electronics, S.A.
FAX: 44-622-882469 - PHONE: 44-622-882467

Name: _____

Title: _____

Company: _____

Address: _____

Fax #: _____

Phone #: _____

Interested in:

- ☐ Super-Compact
☐ Microwave Harmonica
☐ Microwave Scope
☐ Serenade Schematic Editor
☐ Serenade Layout Editor

Platform: ☐ Workstation ☐ PC

CSBQ001F

Compact Software®
201 McLean Boulevard • Paterson, NJ 07504
Tel: (201) 881-1200 • FAX: (201) 881-8361

Use Emitter Coupled Logic in Your RF Applications

By R.N. Mutagi
Space Applications Centre

Emitter Coupled Logic (ECL) is the fastest logic device family currently available. It is used in high speed digital logic circuits employed in computers, test instruments and high speed digital communication systems. High speed is achieved in ECL by its non-saturated mode of operation and the low RC time constants maintained in the circuit by the use of smaller resistor values. Due to this, the ECL devices draw high, but constant, currents, eliminating the switching spikes characteristic of TTL. This reduces the system noise. Typical delay for a 10,000 series ECL gate is 2 nanoseconds and the toggle rate for a flip-flop is more than 125 MHz. Because of its non-saturated operation, the ECL can also be used in linear applications. This article shows how a number of communications circuits, which are conventionally built with discrete devices and analog integrated circuits, can be implemented with the ECL devices.

Communications systems are using more and more digital techniques and technology. These systems invariably employ ECL devices in their implementation. Naturally, if the RF circuits used the same devices as the digital circuits, the system would have many advantages. The number of power supply voltages required is reduced because the linear devices which need a variety of voltages are replaced by ECL devices to achieve the the same functions. The multiple gates within a chip minimize the

circuit size and cost. Finally, the circuits built with ECL devices are easily repeatable, are more stable, and can interface with the baseband circuits directly.

Major building blocks of a typical communication system that can be realized with ECL devices are: oscillators, amplifiers, limiters, different types of modulators and demodulators, phase detectors, and frequency multipliers and dividers.

Gates Work as Amplifiers

ECL OR/NOR gates' switching transfer characteristics have a small input voltage range V during which the output varies linearly. The upper end of this range for which the output just starts limiting its amplitude is about 370 mV. Of this range, about 300 mV is quite linear and has a slope that provides a voltage gain of approximately 3.6. This gain remains constant over a wide range of temperature, (-30°C to 85°C), but the threshold value varies by as much as 50 mV. By biasing the input to the threshold value and applying the signal at this point an amplified signal is obtained at the output.

To obtain a stable bias the threshold voltage can be derived from a gate with complementary outputs [see Biasing ECL for Linear Operation]. In the case of line receivers, where both the differential inputs are biased from a single reference source, the temperature variation does not affect the operation.

Figure 1 shows an amplifier built with quad OR gates (MC10103) for wideband operation at 70 MHz. Three gates are

used as amplifier stages and the OR/NOR gate is used to bias them. This circuit provides a minimum gain of 20 dB and a maximum undistorted output (with no current limiting) of about 0 dBm across a load impedance of 50 ohms. A four stage amplifier, shown in Figure 2, is built with the line receivers MC10115 and provides a gain of 30 dB with 0 dBm output across 50 ohms load impedance.

Amplitude Limiters

Since emitter coupled logic gates operate in a current-limited mode they can be employed in demodulators, such as FM, PM, FSK and PSK, that require constant carrier amplitude. From a single ECL gate, a current-limited output is obtained with a minimum input voltage swing of 350 mV. When the available input voltage level is low, a number of gates can be cascaded to obtain additional gain.

The output voltage swing is limited to the ECL values of -0.9 V and -1.75 V which corresponds to about 0.8 dBm across 75 ohms and 2.6 dBm across 50 ohms. Since each gate has a gain of about 7 dB, addition of each gate in cascade improves the dynamic range of the limiter by 7 dB on the lower end. A three stage limiter starts limiting the signal at -20 dBm . On the upper side, the input can go up to 0.8 dBm, limited only by the device ratings. Thus, a large dynamic range of nearly 21 dB is obtained with a single chip limiter employing three gates.

The transfer characteristics for NOR output shows a droop for increasing

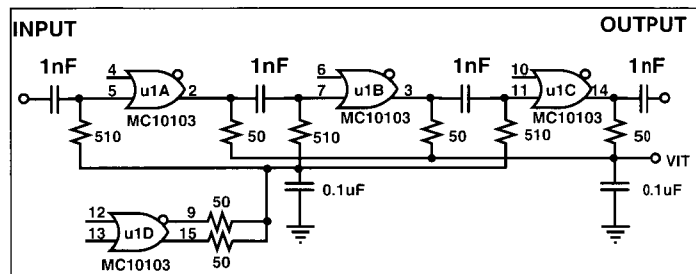


Figure 1. A 20 dB amplifier implemented with four OR gates. Three provide gain, one is used to bias the other three.

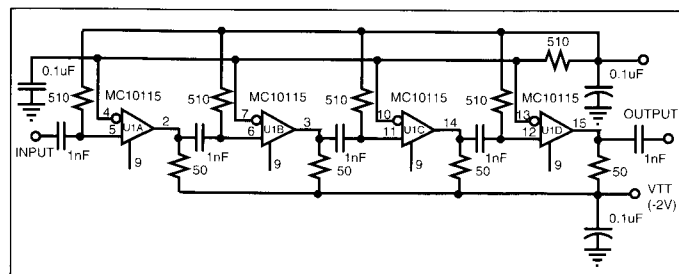


Figure 2. A limiter built with four line receivers with differential outputs provides about 28 dB gain as an amplifier and has 30 dB dynamic range as a limiter.

You don't always get what you pay for.



With PTS synthesizers, you get more.

Because we're synthesizer specialists, we give you *more for your money* in more ways than one.

From our economy PTS x10, to our space-saving PTS 310, to our top-of-the-line PTS 1000, we have *more models* to cover your source needs from 100 KHz to 1 GHz.

And more options, including:

- OCXO, TCXO or external standard,
- choice of resolution from 100 KHz to 0.1 Hz,
- DDS with phase-continuous switching,
- digital phase rotation,
- BCD or GPIB remote control,

and almost a hundred others to let you specify a synthesizer so well-tailored to your requirements that it's like having one custom made for you.

Our priority in design and manufacturing is to make our synthesizers *more reliable*, and this has led to a demonstrated MTBF of 25,000 hours. That's why we can back them with our all-inclusive 2-year warranty, along with a flat-rate service charge for eight years following the warranty period.

But wait, there's less!

All of our synthesizers feature *low power* consumption, *low spurious output* (as low as -75 dBc), *low phase noise*, and fast frequency switching (as fast as 1 μ second).

And all of our models are available, at a lower price, in a remote-only OEM configuration for easy integration into your OEM system.

Our full catalog has all the information you need to specify the most synthesizer for your money.

Call or FAX us for your copy, or for immediate engineering assistance.



PTS

PROGRAMMED TEST SOURCES

P.O. Box 517 Littleton, MA 01460
508/486-3008 FAX 508/486-4495

INFO/CARD 19

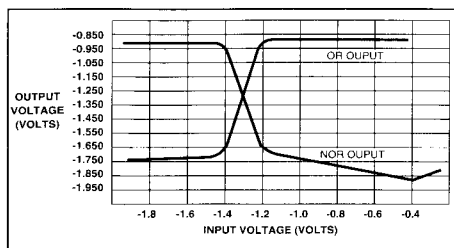


Figure 3. Transfer characteristic of a typical OR/NOR gate.

amplitude beyond the linear range (Figure 3). In the limiter applications where the gates are over-driven the input exceeds the linear range and the negative amplitude keeps increasing with increasing input. The transfer characteristics for the OR gate, on the other hand, shows a good limiting characteristics and, hence, is preferred to a NOR gate in limiter applications. The amplifier circuit shown in Figure 2 provides limiting to the signals whose power level exceeds -28 dBm.

Oscillators

Oscillators are widely used in communication systems for generating the carrier and clock signals, both at the transmitter and the receiver. Crystal oscillators are used for better frequency stability. Voltage controlled oscillators are used in phase locked loops, AFC applications and frequency modulators. In all these applications the ECL 10,000 series gates can be employed for generating frequencies well above 100 MHz. For still higher frequencies the ECL 1600 series or ECL 100,000 series gates can be used. Figure 4 shows a crystal oscillator built with a single OR/NOR gate. The crystal is connected in the feedback path between the NOR output to input which is biased for threshold voltage. The input tank circuit is tuned to the crystal frequency. A second gate is used as a buffer.

Digital and Analog Modulators

Three types of modulators are used with digital signals: amplitude shift keying (ASK), frequency shift keying (FSK) and

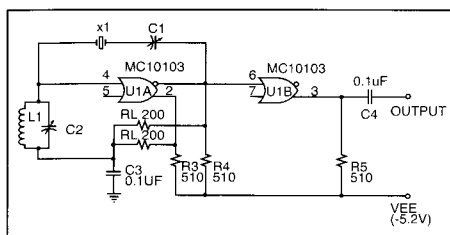


Figure 4. An OR/NOR gate used as an oscillator. The second gate acts as a buffer.

phase shift keying (PSK). These are easily implemented with ECL devices. Figure 5 shows an ASK modulator (also known as on-off keyed or OOK modulation). Basically it is an RF switch operated with data. The carrier is switched on and off with the data. Although a single gate could do this switching job, additional gates U1B and U1C are used to eliminate the DC bias in the output waveform (waveforms in Figure 5). The gates U1A and U1B are switching the same carrier, but the output of U1B is wire ORed with the complementary data and hence the outputs at A and B have complementary DC levels on which the carrier burst is superimposed. When these signals are combined at C a DC level equal to the ECL threshold voltage is obtained over which the carrier bursts are superimposed. The output blocking capacitor eliminates the DC and provides a pulsed RF carrier. A single chip OOK modulator provides carrier isolation in excess of 30 dB in the off state.

An FSK modulator shown in Figure 6 employs two oscillators built with NOR gates U1A and U1C. The NOR gates U1B and U1D, with wire ORed outputs, function as a multiplexer, selecting one of the frequencies. The OR/NOR gate (U2A) acts as a buffer to the data and provides complementary outputs which are used as select inputs to the multiplexer.

A biphas shift keying (BPSK) modulator is implemented with a single XOR/NOR gate (MC10107) with one input biased at threshold voltage and the

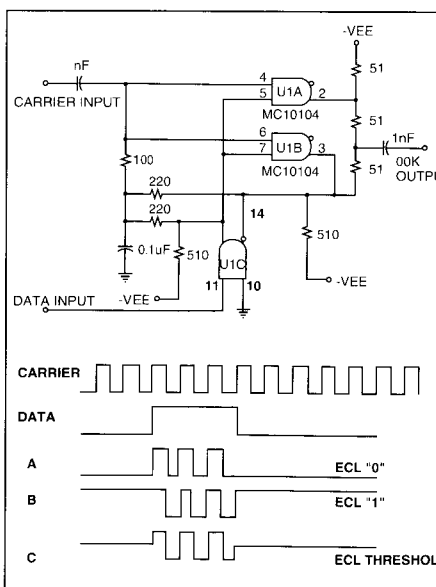


Figure 5. An AND gate used to provide on-off keying, along with input and output signals.

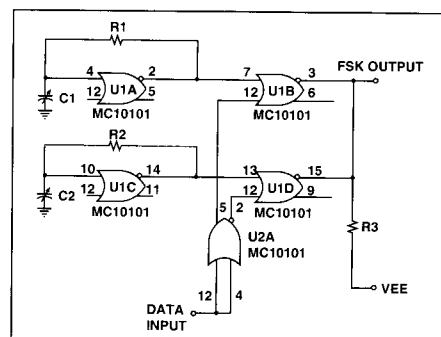


Figure 6. An FSK modulator implemented with two NOR gate oscillators and a NOR gate 2:1 multiplexer.

carrier capacitively coupled to it. The data is applied to the other input as shown in Figure 7. A QPSK modulator for 70 MHz operation for TDMA application, implemented with a phase shifter, two D flip-flops and a 4:1 data multiplexer, is described in Reference 2. An extension of this technique is used in the 8-PSK modulator shown in Figure 8.

The advantage of this circuit over the conventional circuit employing balanced modulators, drivers and adders etc. is quite obvious. This modulator employs only three phase shifters and three ECL ICs to get 8PSK modulation.

The basic oscillator at $2f_0$, where f_0 is the carrier frequency, is also built with an ECL gate as explained earlier. The first phase shifter provides two quadrature outputs which are separately divided by two, with two D flip-flops FF-1 and FF-2. The outputs of the flip-flops are at carrier frequency f_0 . The first flip-flop is connected in toggle mode with its Q output fed back to the D1 input. The second D flip-flop has its D2 input obtained from the Q1 output of the first flip-flop. This connection ensures that Q2 always lags behind Q1 with phase of 45° .

The Q1 and Q2 outputs are applied to two quadrature phase shifters to obtain 0° , 90° , 45° and 135° . Each of these signals are applied to OR/NOR gates to get 180° phase shift for each input. Thus, eight phases of the carrier at 45° separation are available from the gates which are applied to a 8:1 multiplexer. The output is a carrier with its phase chosen according to the data bits applied to the multiplexer. This circuit can operate at 70 MHz, a widely used IF frequency, and accept the data at rates in the ECL range.

Besides digital, the ECL devices can be used in analog modulators too. For example, the ECL voltage controlled oscillator, MC1648, can be used for FM



Increasing
your production
line efficiency
requires your
technicians
to learn one
important
skill.

The HP 8647A Signal Generator: a new level of productivity at the touch of a button.

Lowering manufacturing costs couldn't be simpler.

Start with one of the lowest priced (under \$5,000) and most reliable synthesized signal generators in its class. Then put it at your technician's fingertips with a remote interface that makes testing as easy as pushing a button.

A button that sets up and runs measurement sequences with a single push. Using a simple user interface that lets you get employees up and testing with a minimum of training.

Yet the HP 8647A brings more performance to the production line. The 250 kHz-1 GHz range and clean +10 dBm output lets you tackle more applications. Separate manual frequency and amplitude control knobs make dialing in signals as easy as tuning a car radio. And the reliability of an

electronic attenuator virtually eliminates the most common cause of failures.

Call HP DIRECT at **1-800-452-4844, Ext. 8030*** today for a FREE data sheet and brochure on the HP 8647A Signal Generator.

You'll find there's not a lot to learn.

*In Canada call 1-800-387-3867, Dept. 485.

There is a better way.



©1994 Hewlett-Packard Co. J7MMID370/RFD



FREQUENCY PRODUCTS

ELECTRO DYNAMICS CRYSTAL CORP.

Crystals

- Microprocessor
- Military Spec/QPL
- Communication
- Custom Crystals

Oscillators

- Hybrid Clock
- TCXO
- VCXO
- Custom Oscillators

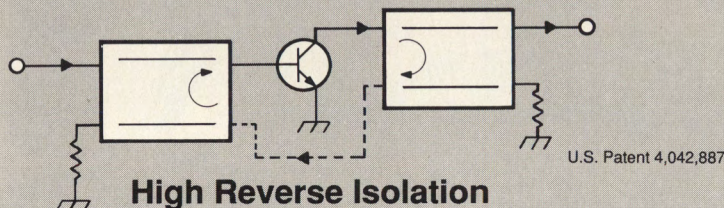
9075 Cody Overland Park KS 66214

Phone (800) EDC-XTAL Fax (913) 888-1260

INFO/CARD 21

Power Feedback™

Technology in a Hybrid Amplifier for



High Reverse Isolation

Since 1974, Q-bit has been the industry leader in high reverse isolation RF amplifiers.

High reverse isolation provides improved repeatability and better VSWR when systems include poorly-behaved sources and loads. Using Q-bit's **Power Feedback** amplifiers allows designers to achieve near-ideal system performance, regardless of variations in device impedance, by helping to avoid VSWR build-up when cascading devices.

All of these amplifiers utilize patented power feedback technology. Specify them in your next design.

Guaranteed Specifications

Model Number	Frequency Range (MHz)	Gain (dB)	Gain Flatness (dB p-p)		1dB Compression (dBm)		Noise Figure (dB)		Reverse Isolation (dB)		Output Intercept 3rd/2nd (dBm)		Power (V/mA)		Price For Quantity 1-9
			Rm	Temp	Rm	Temp	Rm	Temp	Rm	Temp	Rm	Temp	Rm	Temp	
QBH-103	5-300	11.3	0.4	0.6	22.0	21.0	6.8	7.5	26	26	37/51	36/49	15/91	95	\$75
QBH-105	5-300	12.2	0.4	0.7	8.0	7.0	3.7	4.0	30	30	22/33	21/30	15/18	19	\$65
QBH-110	5-500	15.0	0.6	1.0	9.0	9.0	3.0	3.5	25	25	23/33	22/32	15/29	31	\$90
QBH-126	5-500	15.0	0.6	1.2	16.0	15.0	3.8	4.2	25	24	30/38	28/38	15/50	54	\$95
QBH-133	10-500	10.3	0.6	1.0	16.0	14.5	4.5	4.9	25	24	29/45	28/44	15/57	60	\$90
QBH-135	3-350	14.3	0.6	1.0	1.0	1.0	2.1	2.4	30	30	14/18	13/17	15/11	11	\$65
QBH-146	20-1100	13.0	0.8	1.4	6.0	5.0	2.9	3.1	22	22	19/27	18/24	15/17	18	\$90
QB-258	10-250	47.0	1.0		15.0		2.4		65		30/40		15/70		\$324
QB-442	10-400	41.5	1.0		32.0		3.5		75		40/50		24/550		\$665
QB-744	2-200	24.0	1.0		30.0		7.0		48		46/60		20/440		\$330
QB-815	10-1000	34.0	1.0		14.0		3.5		60		25/35		15/70		\$425

NOTES: 1) Package: QBH-XXX => Hybrid (TO-8 Package) QB-XXX => Modular Units with Connectors
2) Temperature Range: QBH-XXX => -55°C to +85°C QB-XXX => 25°C (See Data Sheet for Temp. Specs.)

Q-bit standard product TO-8 designs, like the amplifiers above, are also available in a flatpack with leads formed for surface-mounting as an option.

Call us for a catalog available on a PC compatible data disk.



Q-bit Corporation

TELEPHONE (407) 727-1838

2575 PACIFIC AVENUE NE, PALM BAY, FL 32905
TWX (510) 959-6257 • FAX (407) 727-3729

INFO/CARD 22

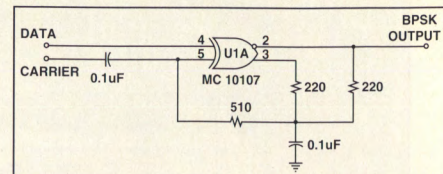


Figure 7. An XOR gate used as a phase inverter.

generation at carrier frequencies in excess of 100 MHz. A large frequency deviation with good linearity can be achieved. For example, a peak deviation of ± 20 MHz is easily obtained at 70 MHz.

XOR Gates Double the Frequency

A frequency doubler can be implemented with an ECL XOR gate (MC10107) as shown in Figure 9. The gates G1 and G2 are fed with input signal of frequency f through a coupling capacitor C1 and the inputs are biased to the threshold voltage. The gates G2, G3 and the capacitor C2 provide a delay to the input which is then applied to the second input of gate G1. At the output of G1 pulses at each zero crossing of the input appear. The width of these pulses is equal to the delay provided by the gates G2, G3 and capacitor C2. These pulses have a frequency of $2f$. The fundamental frequency is then selected by the notch filter formed by L1 and C3. For input frequencies exceeding 150 MHz MC1672 XOR gate can be used for G1 and single gate can replace G2 and G3.

Mixers and Dividers with Flip-Flops and Counters

ECL counters provide frequency division by any value. When the division factor is an even number it can be implemented in two stages. For example, when frequency division by 14 is required, a counter can be used to obtain the division by 7 and then a flip-flop connected in a toggle mode can provide further division by a factor of two. This ensures a square wave output which can be easily filtered to get a sine wave. ECL dividers form the backbone of high frequency synthesizers.

Besides these, there are other functions that can be implemented with high speed ECL devices. An MC12000 D flip-flop can act as a harmonic mixer, and the MC12040 works as a phase detector. These devices find extensive applications in the high speed phase locked loops.

An Example of ECL Application

A simplified block schematic of a typical QPSK demodulator is shown in Figure 10. This comprises clock, carrier and data recovery branches. A heavy outline marks the blocks that can be implemented with ECL devices, and the suggested

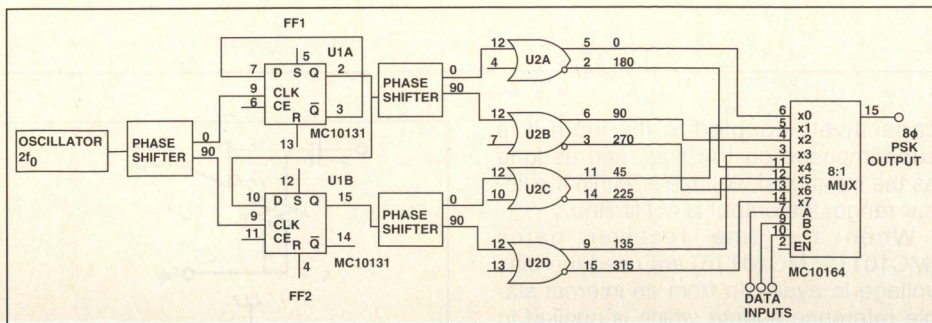


Figure 8. An 8-PSK modulator built with a succession of phase shifters and a multiplexer.

devices are given inside.

For clock recovery, the input signal and its one-bit-delayed version are multiplied in a phase detector (MC12040). The output is filtered and shaped in a limiter formed with ECL gates (MC10101). This clock is used for retiming the demodulated data using the D flip-flop (MC10131). For carrier recovery the input signal is multiplied by four, using a set of XOR gates (MC10107) and tuned circuits. The resulting 280 MHz signal is devoid of any modulation. When this signal is divided by four, using two D flip-flops a 70 MHz carrier signal is obtained. Two carriers in quadrature are obtained from the divider itself. These signals provide the demodulated data when exclusive ORed with the input data in the two branches. This data is then low pass filtered, amplified with gates (MC10115), and quantized with threshold comparators (MC1650). The output of the comparators are re-timed as mentioned above to get the I and Q channel demodulated data.

Basics of Emitter Coupled Logic

The basic emitter coupled logic (ECL) device is a two input OR/NOR gate. This gate's circuit is shown in Figure 11. It comprises two transistors Q1 and Q2 connected in parallel and forming a differential pair with a third transistor Q3.

All the emitters are tied together and connected to the supply voltage V_{EE} through a resistor R5 which acts as a constant current source. The base of the transistor Q3 is held at a temperature compensated, stable reference voltage V_{BB} . The bases of Q1 and Q2 are used as inputs and the collector outputs are

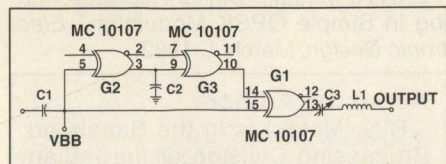


Figure 9. Two XOR gates and a capacitor provide the delay needed for a third XOR gate to detect data edges.

buffered through emitter follower transistors Q4 and Q5 to provide low impedance outputs. An emitter pull-down resistor R6 is connected from the output to V_{EE} . Normally, the V_{EE} terminal is kept at -5.2 V and the V_{CC} terminal is grounded. The corresponding V_{BB} is -1.29 V.

When the potential at the inputs A or B (base of Q1 or Q2) increases above V_{BB} , Q1 (or Q2) starts drawing more current from the constant current source. Current through Q3 starts reducing and finally it stops conducting. This change in the collector current flowing through resistors R3 and R4 produces a voltage swing between -0.05 V and 0.98 V. These voltage levels are shifted by the emitter followers to the logic levels of -0.8 V and -1.75 V. These are the typical voltage levels for logic 1 and 0 conditions.

As seen from the transfer characteristics of a typical 10,000 series ECL OR/NOR gate there is a transition range during which the output varies linearly with the input. Although this is a small

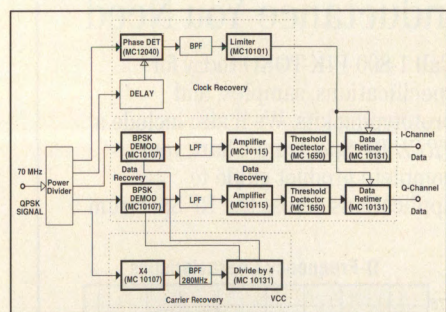


Figure 10. Block diagram of a QPSK demodulator. Heavier boxes are implemented with ECL gates.

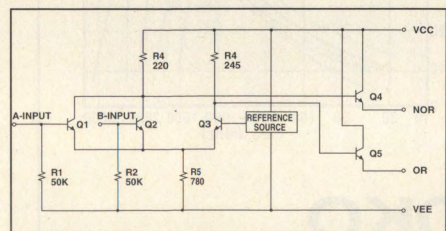


Figure 11. Schematic of a basic ECL OR/NOR gate.

FREQ OUT!

CESIUM ACCURACY — AT 1/10 THE PRICE!

Introducing **GPStat™**, the first low-cost GPS referenced frequency error measurement system. GPStat uses the Global Positioning System Satellites to report frequency error in your clock or oscillator system.

Key features include: measures any frequency from 50KHz to 11MHz, automatic determination of popular frequencies, user selectable input frequency, 1PPS output, optional Windows™ software.

GPStat applications include: telecommunications, metrology calibration, oscillator LORAN C frequency monitor replacement.



GPStat™

Odetics

PRECISION TIME DIVISION

1515 South Manchester Avenue
Anaheim, California 92802-2907

(714) 758-0400

Fax (714) 758-8463

INFO/CARD 23

range, of about 360 mV, it is good enough for small signal applications.

Biasing the ECL

The key point in the linear operation of ECL devices is to bias the input to a threshold voltage of -1.29 V. Since this linear range is small, this potential should be held stable as any deviation in this reduces the usable linear range. When a signal of small amplitude is

capacitively coupled to the input it is superimposed on the bias, and as long as the input peak voltage is within the linear range, the output is not limited.

When the line receiver gates (MC10115, MC10116) are used the bias voltage is available from an internal stable reference source which is applied to both the inputs of the gate used through equal resistors and the signal is fed to one input through a capacitor (Figure

Two of the World's Smallest Footprints



The TOKO LL1608 Chip Inductor

Actual Size

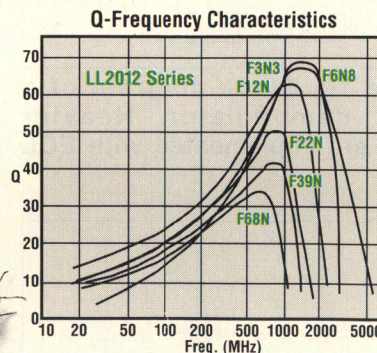
The North American Ant

But Only Toko Has the Inductance You Need

Pack more components into smaller designs with the world's smallest chip inductors. Available in a wide range of inductances, these low profile devices give your design important advantages.

- 0603 package for smallest size and 0805 package for higher Qs
- E-12 Series pitch from 1.5 to 82nH
- Ideal for high frequency designs up to 3GHz eliminates coupling between parts, delivering the highest possible SRF. Inherently more reliable and consistent versus wire wound types
- Tape and reel packaging for high volume, low cost automated manufacturing
- 5% tolerance available

Call 1-800-PIK-TOKO today for specifications, samples, and prototyping kits. We'll also include a *FREE* RF Spectrum Chart, your complete product guide to applications across the RF Spectrum.



TOKO

Toko America, Inc. 1250 Feehanville Drive Mt. Prospect, IL 60056

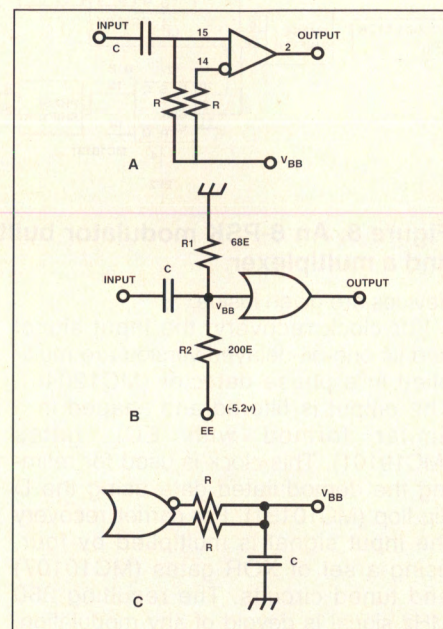


Figure 12. Three ways of obtaining an ECL threshold bias voltage using ECL gates.

12a). For other gates, a resistor divider between ground and V_{EE} can provide a threshold voltage. The value of the resistors shown in Figure 12b also provides an input impedance of 50 ohms.

Alternatively, if complementary outputs are available from a gate (an OR/NOR gate for example), the outputs are summed through equal resistors to get the threshold voltage (Figure 12c). This technique provides a stable threshold voltage because the two complementary outputs move symmetrically about their mean, which is the desired bias point.

It is apparent that, except the filters, a large majority of the RF circuits can be implemented with ECL devices. The advantages are in the low cost, small size and lower complexity of the resulting system. A possible disadvantage is the increase in the power dissipation. **RF**

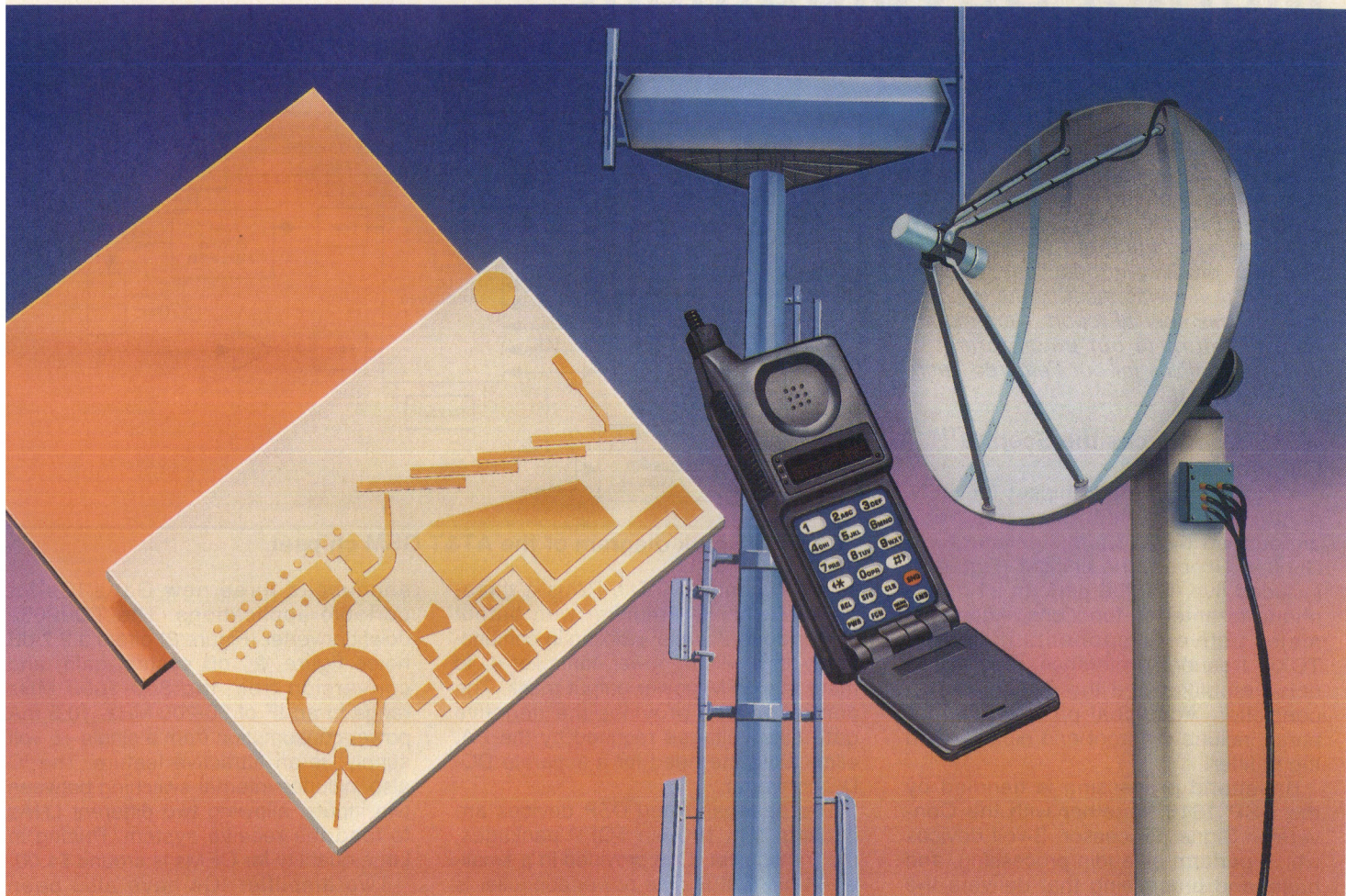
References

1. *MECL System Design Handbook*, Motorola Inc., 1971.
2. R.N. Mutagi, "Digital Replaces Analog in Simple QPSK Modulator," *Electronic Design*, March 4, 1982.

About the Author

R.N. Mutagi is in the Baseband Processing Division of the Indian Space Research Organisation's Space Applications Centre. He can be reached at SAC P.O., Ahmedabad-380 053, India.

RO3003™ circuit board material puts the le\$\$ back in wireless.



Introducing RO3003 from Rogers. High performance, low price.

Reducing material cost
in wireless applications used to
mean sacrificing performance.
Until now!

RO3003 high frequency
circuit material provides a
temperature stable dielectric
constant of 3.0, typical dissipa-
tion factor of 0.0013 and a CTE
that is matched to copper for
excellent dimensional stability.

And, RO3003 is priced
competitively with the least

expensive high frequency
wireless materials. Rogers
quality and price are tough
to beat.

Call or write for more
RO3003 product data, samples
or to speak with an Application
Engineer concerning your
next project.

ROGERS

Rogers Corporation • Microwave & Circuit Materials Division • 100 S. Roosevelt Avenue, Chandler, AZ 85226 • Tel: 602-961-1382 • Fax: 602-961-4533

Rogers Japan Inc., Tokyo: Tel: 033-807-6430 • Rogers-Mektron, N.V., Gent, Belgium: Tel: 32 (9) 235 36 11

RO3003 is a trademark of Rogers Corporation.

New RF ICs and Modules Boost Market Development

This month's Featured Technology highlights RF ICs and modules. Normally, we include two or three technical articles on our featured topic, such as the preceding article on ECL applications. But this month there are several important new product introductions, and we decided that it was most useful to cover them in this special report. Next month, we will return to our usual format of technical articles for our Featured Technology subject.

AT&T Announces the Sceptre™ Chipset for GSM

A highly integrated chipset for GSM digital cellular telephones has been announced by AT&T Microelectronics. Dubbed Sceptre, the chipset (Figure 1) includes five ICs that perform all microphone-to-antenna functions. Additional major active components include a TCXO frequency reference, receive low noise amplifier and the system microcontroller. Additional passive components include the front end duplexer and the IF filter.

Baseband processing is handled by the DSP 1618, together with the Conversion Signal Processor, 3-volt devices which perform all audio processing, and baseband processing that delivers the proper GSM-compatible modulated I and Q signals to the modulator, and accepting similar I and Q signals from the demodulator.

The most highly integrated RF device in the chipset is the W2020 Transceiver, which also operates from a 3-volt supply. This IC includes a frequency-agile UHF synthesizer as the main frequency control element, plus two fixed-frequency synthesizers that generate up- and down-conversion local oscillator signals. The receive path includes an RF mixer, digital gain-controlled IF amplifier, and quadrature demodulator. The transmit path includes an offset oscillator, mixer and quadrature modulator with an accurate 90 degree phase splitter. Only one IF filter is required for both the transmit and receive paths.

A two-chip power amplifier section was used to take advantage of the performance of GaAs and the economy of

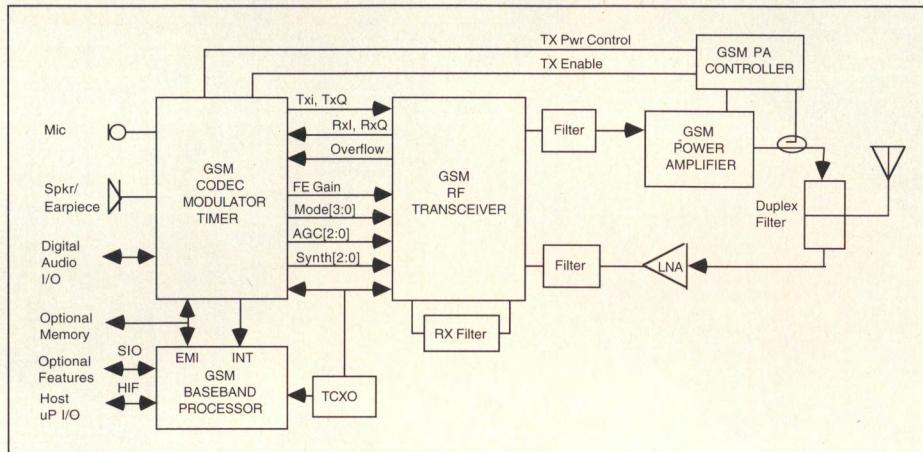


Figure 1. Block diagram of the AT&T GSM chipset.

silicon technology. The PA is a three-stage GaAs IC amplifier with output power up to 2 watts, working in conjunction with a silicon power controller IC to meet the GSM power output mask. The controller also provides the negative gate bias voltages required by the PA, eliminating the need for a separate DC-DC converter.

The baseband and DSP devices are packaged in 100-pin TQFP packages, the transceiver IC is provided in a smaller 64-pin TQFP. The power controller is in a 20-pin SSOP, and the PA uses a 20-pin PSOP (power small outline package) that includes a metal bar on the underside of the package for improved heat dissipation.

New Driver, Downconverter and LNA from TriQuint

TriQuint Semiconductor recently

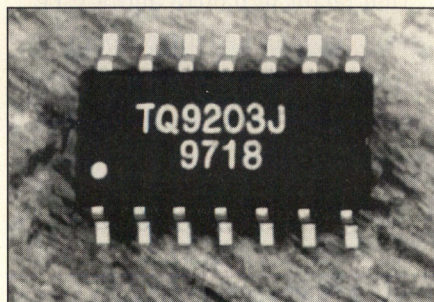


Figure 2. The TQ9203J downconverter in a SO-14 package.

announced three new GaAs ICs for portable applications. The TQ9203J downconverter (Figure 2) offers a 2.7 dB noise figure, 20 dB system gain, and conversion from the 800-1000 MHz range to an IF of 30-200 MHz. 10.5 mA power consumption from a single +5 volt supply is an attractive feature. The IC also includes internal switching between two inputs, allowing two different LNAs to feed the receive system. Pricing in large quantity for OEMs is around \$4.00.

Two amplifier ICs have also been introduced. The TQ9122N is a low noise amplifier for 500-2500 MHz, provided in a SO-8 package. Specifications include 25 dB gain at 1575 MHz, under 1.5 dB typical noise figure, output matched to 50 ohms, and 18 mA supply current from a +5 volt supply.

A driver amplifier covering 800-2500 MHz provides 50 mW power. The TQ9132N has 17 dB gain at 2000 MHz, input and output matching to 50 ohms, and operation from 3 to 5 volts with 90 mA current drain. Both amplifiers are about \$3.00 in OEM quantities.

ITT Debuts GaAs Power Amplifier for Single 3.3 Volt Supply

The ITT Gallium Arsenide Technology Center (ITT GTC) has developed a series of power amplifiers for DECT, PCS and AMPS applications. The ITT332201BD delivers 500 mW in the 1880-1930 MHz band, with 24 dB mini-

VISIT US AT
THE MTT-S SHOW
BOOTH 714

FINALLY! 3 VOLT RF ICs FOR HANDHELD WIRELESS PRODUCTS

New 3 Volt NEC Silicon ICs

UPC2745 Ultra Broad Band Amplifier

DC to 2.7 GHz
12 dB Gain
-1 dBm PSAT
7.5 mA Icc

UPC2747 Broad Band Low Noise Amplifier

100 MHz to 1800 MHz
12 dB Gain
3.3 dB NF, 5 mA Icc

UPC2746 High Gain Amplifier

DC to 1500 MHz
19 dB Gain
0 dBm PSAT
7.5 mA Icc

UPC2748 High Gain Low Noise Amplifier

200 MHz to 1500 MHz
19 dB Gain
2.8 dB NF
6 mA Icc

UPB1502 Frequency Divider

0.5 to 2.2 GHz
Divide by 64/65, 128/129
6 mA Icc

UPB587 Frequency Divider

50 to 1000 MHz
Divide by 2/4/8
5.5 mA Icc

*...plus dozens of Bipolar Transistors
characterized at 2.5 Volts, including:*

$f = 1500 \text{ MHz}$
NE68519
1.3 dB NF
10.0 dB GA
@ only 3 mA Icc

$f = 2.5 \text{ GHz}$
NE68030
1.90 dB NF
7.2 dB GA
@ only 3 mA Icc

$f = 1000 \text{ MHz}$
NE68039
1.0 dB NF
11.6 dB GA
@ only 1 mA Icc

Surface Mount packages shown actual size

...and a wide variety of 5 Volt RF ICs including:

UPC2708 Wide Band Amplifier

DC to 2.9 GHz
15 dB Gain
10 dBm PSAT

UPC2710 Wide Band Amplifier

DC to 1000 MHz
33 dB Gain
3.5 dB NF

UPC2713 Wide Band Amplifier

DC to 1200 MHz
29 dB Gain
3.2 dB NF

**UPC2723
AGC Amplifier**
100 MHz to 1100 MHz
38 dB AGC
13 dB Gain

**UPC2721
Down Converter**
RF=0.4 to 3.0 GHz
IF=50 - 600 MHz
Conversion Gain=15 dB

**UPC2726
Differential
Amplifier**
400 MHz to 1400 MHz
15 dB Gain

NEC

Typical Performance at 25°C, Frequency Range is 3 dB Bandwidth

NEC's NEW LOW CURRENT SILICON ICs not only reduce power consumption in your 3 Volt designs, they reduce the parts count, improve the reliability, and simplify the assembly.

NEC is committed to 3 Volt Silicon technology; these parts are just an introduction.

There are more on the way. Soon.

If 5 Volt ICs are the solution, NEC has a wide selection of them as well, all available right now.

And don't forget NEC's huge family of discrete devices. Many are characterized at 2.5 Volts and they're available in a variety of packages, including a new ultra-small SMD that's a third the size of a SOT 23!

For a **FREE Product Selection Guide**, call your nearest CEL Sales Office. Or circle the number below.

California Eastern Laboratories

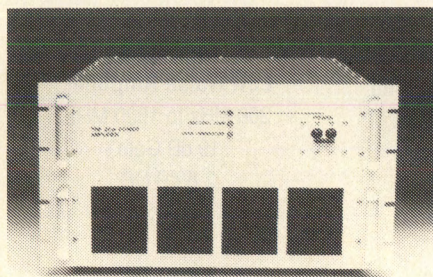
CEL Headquarters, 4590 Patrick Henry Drive, Santa Clara, CA 95056-0964; (408) 988-3500 FAX (408) 988-0279 □ Santa Clara, (408) 988-7846 □ Los Angeles, CA (310) 645-0985
San Diego, CA (619) 467-6727 □ Bellevue, WA (206) 455-1101 □ Richardson, TX (214) 437-5487 □ Olathe, KS (913) 780-1380 □ Woodridge, 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

© 1993 California Eastern Laboratories

INFO/CARD 26

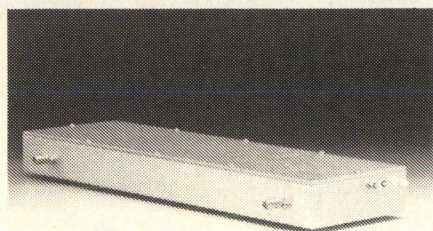
DESIGN SOLUTIONS FOR THE RF INDUSTRY

The best of RF technology, quality, and design comes from Silicon Valley Power Amplifiers, a leading manufacturer of high-performance amplifiers and components.



AMPLIFIERS

Part Number	Power Output Watts	Gain dB	Frequency Range MHz
V-1000	1000	60	100-200
U-1000	1000	60	225-450
C-500	500	60	100-500



MODULES

Part Number	Power Output Watts	Gain dB	Frequency Range MHz
10-150-4	4	36	10-150
10-100-25	25	40	10-100
10-100-100	100	40	10-100
80-220-300A	300	60	80-220
220-500-300A	300	60	220-550
100-500-25	25	30	100-500
100-500-100	100	40	100-500
100-500-150	150	10	100-500

This high-quality hardware is backed by:

- Excellent service
- Customized design
- Fast response
- Expert technical support
- In-stock delivery
- Standard/special parts

For a free catalogue describing our complete range of power amplifiers and modules, call 408.986.9700 today!



1530 O'Brien Drive Δ Menlo Park, CA 94025
408 . 986 . 9700 Δ Fax 408 . 986 . 1438

INFO/CARD 27

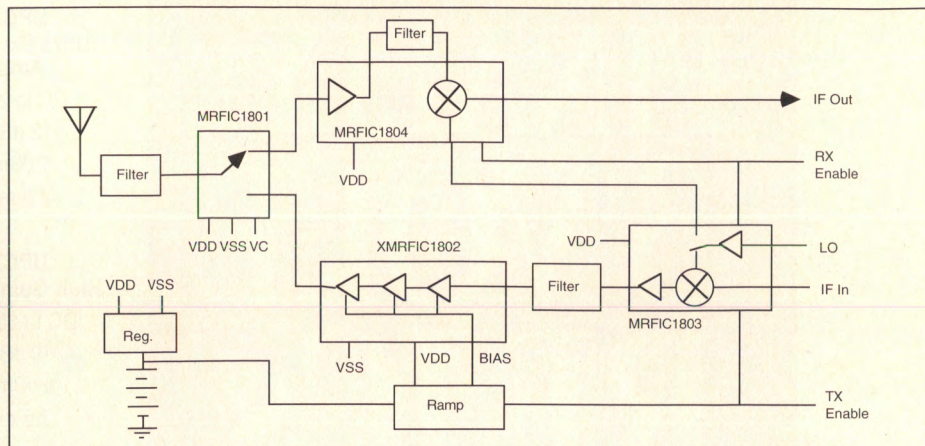


Figure 3. Block diagram of the Motorola PCS/PHP RFIC1800-series.

imum power gain. The ITT332202 covers 1700-1900 MHz with similar specifications. For AMPs cellular, the ITT332101 provides 1 watt output over 824-849 MHz with 30 dB minimum gain.

3.3 volt single-supply operation is the primary feature that ITT is promoting, and these specifications are all referenced to operation at that voltage.

All these GaAs power RFICs are matched to 50 ohms input and output, with very minor compensation necessary to obtain optimum performance. The devices are packaged in a power 16-pin SOIC which dissipates heat via the lead frame and wide ground pins.

Motorola Targets PCS and PHP With New GaAs RFICs

Three new RFICs are available, and another is in final development for the RF functions in the 1.8-2.5 GHz bands. The MRFIC1801 antenna switch will handle 2 watts in the 1.5-2.5 GHz range, the XRMRIC1802 developmental power amplifier produces 500 mW in the 1.8-1.95 GHz range, the MRFIC1803 upconverter brings the IF up to an operating frequency of 1.7-2.5 GHz, and the

MRFIC1804 LNA/downmixer offers 2.3 dB noise figure and 18.5 dB conversion gain for translation of 1.8-1.925 GHz signals to an IF of 70-325 MHz.

The devices are all designed for 2.7 to 3.3 volt operation, although the power amplifier and antenna switch ICs require a negative bias supply. All are provided in SOIC packages for economical high-volume manufacturing. The chip set includes all signal path functions between the IF and the antenna. Figure 3 is block diagram of the family.

RFICs from Temic Designed for UHF Data Transmission

A family of low-power UHF receiver ICs from Temic Telefunken Microelectronics initially addresses automotive security systems, wireless LANs and household appliance controls. Typically operating at 433 MHz, the U 431X B family features 1 mA standby current for power savings in battery-powered systems. The receiver IC family is suitable for either AM or FM data transmission, using an integrated log amplifier for AM demodulation and a quadrature detector for FM. Data recovery is accomplished

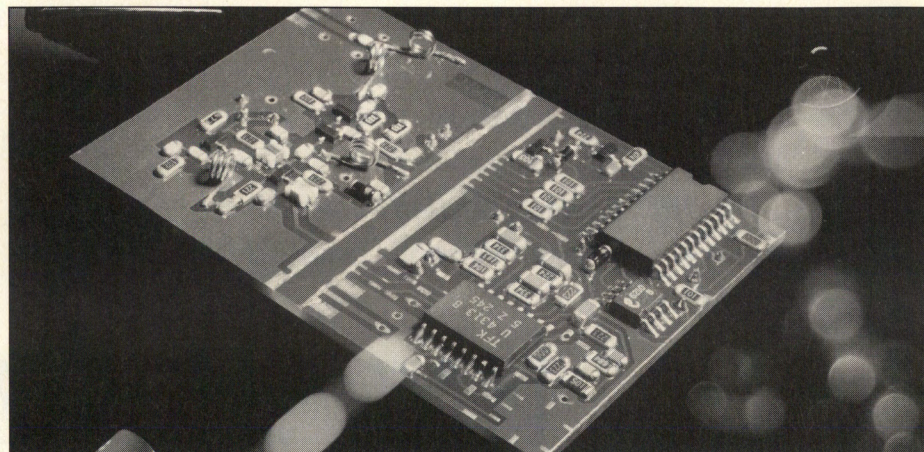


Figure 4. Data transmission for UHF remote control systems are the applications targeted by TEMIC's low power receiver ICs.

with a clamping comparator and operational amplifier. In 1000s, the U 431X B is priced at \$2.72. Figure 4 is a photo of a receiver board using the device.

MOSFET RF Power Modules from Hitachi Aim for Cellular Phones

Hitachi America offers four new MOSFET-based RF power modules for analog (AMPS) and dual-mode (AMPS + IS.54 and AMPS + IS.95) cellular phones. The use of MOSFETs offers high efficiencies and linearity, and single-voltage power supply operation. Gate bias characteristics of MOSFETs permit simplified power control, with no separate path for shutdown.

The PF0045 covers AMPS analog cellular with 1.2 watts output and 6 volt supply requirements. The PF0045A is a 4.8 volt version. For digital cellular, the PF0210 provide 6.0 watts from a 12 volt supply, and the PF0231 delivers 0.6 watts with a 6 volt supply requirement.

Analog Devices Shows First Product from RF Group

The recently-formed RF group at Ana-

log Devices has introduced the AD831 500 MHz mixer. Readers interested in this device should see our New Products section on page 42.

Hewlett-Packard Promotes High Integration Capability

The Components Group of Hewlett-Packard has announced a developmental RFIC featuring a high level of integration. The RFIC is a modulator/transmitter chip with on-chip frequency synthesis functions, quadrature modulator and image-reject upconversion. **RF**

For More Information

Readers can obtain product data by circling these Info/Card numbers:

AT&T Microelectronics	243
TriQuint Semiconductor	244
ITT GTC	245
Motorola Semiconductor	246
Temco Telefunken	247
Hitachi America	248
Analog Devices	249
Hewlett-Packard Components	250

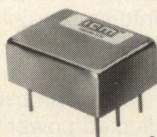


948 Years Experience!

When reliability and accuracy count, call us. 948 years of combined employee crystal experience and 43 years of service to businesses like yours translates into our dedication to the quality products and customer satisfaction that you deserve.

- ENGINEERING AND DESIGN SUPPORT
- EXPERIENCED SALES STAFF

- CRYSTAL ANALYSIS
- EXPEDITE SERVICE
- CUSTOM CRYSTALS TO YOUR SPECS
- MICRO-BALANCED/LAB CRYSTALS
- SOON TO BE ISO 9001 CERTIFIED
- LIFETIME CRYSTAL GUARANTEE



Call or FAX for more information about Crystals, Elements, Oscillators and Accessories.

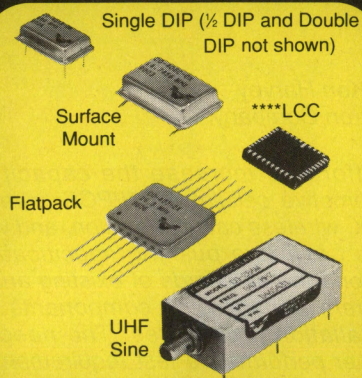
WHEN QUALITY COUNTS...

INTERNATIONAL CRYSTAL MANUFACTURING CO., INC.

PHONE 24-HOUR FAX
1-800-725-1426 • 1-800-322-9426
 P.O. BOX 26330 • OKLAHOMA CITY, OK 73126

Clock and Sinewave Crystal Oscillators (1 Hz thru 2600 MHz)

**SPECS
UPDATED!
NEW!**



	TTL	CMOS	*HCMOS	**ECL	SINE
Frequency	16KHz-100MHz	1 Hz-15 MHz	1 Hz-175 MHz	***5-700 MHz	***50 Hz-2.6 GHz
Input:	5V	5V or 8-15V	5V	-5.2V or -4.5V	12-24V
Accuracy: (25°C):	Five options: ± 50 ppm, ± 25 ppm, ± 15 ppm, ± 10 ppm and in some models externally selectable to ± 1 ppm				
Stability:	Standard: ± 25 ppm over 0°C to + 70°C Option: ± 50 ppm over -55°C to + 125°C Option: ± 5 ppm over 0°C to + 50°C				

Improved accuracy/stability available on some models

Logic Oscillators available QPL (TTL: M55310/16; CMOS: M55310/18; HCMOS: M55310/26; ECL: M55310/25)

Tri-state available 4 MHz to 175 MHz

** 10K, 10KH, MECLII, 100K, or ECLiPs

*** ECL > 825 MHz and sine > 500 MHz are non-hybrid designs

**** LCC limited to TTL (1-60 MHz) and HCMOS (12.5-50 MHz)

To order a Free catalog, or for engineering assistance, call:

(203) 853-4433

Fax: **(203) 849-1423**

VECTRON

The Crystal Oscillator Company

VECTRON LABORATORIES, INC.

166 Glover Ave., P.O. Box 5160, Norwalk, CT 06856-5160

A **DOVER** TECHNOLOGIES COMPANY

Portable Network Analyzers Troubleshoot Wireless Systems

By Ken Harvey
Wiltron Company

Efforts to increase the capacity of automotive cellular, PCN/PCS, wireless PBX, wireless cable television, and wireless LANs are pushing specifications beyond the standards of existing analog system transmission components and installation procedures. The need for higher performance test requirements is answered by classical trouble shooting techniques supporting microwave cabling tests in US military avionics test systems. This article introduces the 54111A Scalar Measurement System, which can easily identify, isolate, and document SWR performance from 0.001 to 3.0 GHz using a low -60dBc harmonic signal source, high 40 dB directivity SWR Autotesters, FFT based distance-to-fault software with resolution to better than 0.1%, and an integrated 1.44 Mb DOS disk drive.

New wireless digital communication systems are being designed for optimum system capacity. As new digital speech compression codes and bandwidth efficient modulation techniques have evolved, the high frequency performance limitations of cables, connectors, antennas, and installation procedures used in existing analog systems becomes an increasingly important factor in maintaining adequate transmission quality.

Competition, aggressive component suppliers, restricted capital budgets, and simple bargain hunting can often leave RF engineers and telecom purchasing departments in a dilemma — purchase marginal products at a bargain price or pay the premium for top quality components. Combined with tight schedules and modestly trained third party installers, system engineering teams responsible for proper system coverage are rightly concerned.

Furthermore, as operating frequencies increase, component specifications are increasingly difficult — and more expensive — to achieve. Will the base station

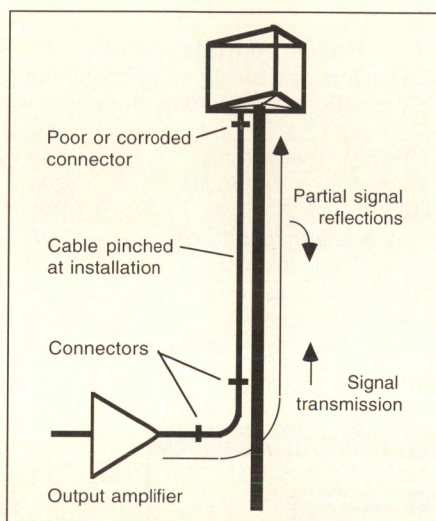


Figure 1. Transmission line faults and almost all antennas reflect some transmitter energy back toward the source.

system pass installation tests and continue to fulfill regulatory requirements? Will the cell site's coverage areas contract and expand intermittently as poor cable connections are rattled by storm winds?

Identifying SWR Problems

Most RF components have one critical specification in common — input SWR (often specified as return loss). Since every component in a transmission system will reflect some of the transmitter's signal energy, RF system engineers must specify each component's contribution to the transmission system's overall SWR specification.

One obvious drawback of excessive reflected power is reduced output power and coverage area. Usually the output power reduction is less than 1.0 dB and is therefore inconsequential: the system will still operate without noticeable degradation. However, some surprisingly common, and difficult to diagnose,

Cable Problems

- Cable Discontinuities
- Braid Wire Ground Shield Fault (Appears As A Notch Filter)
- Damaged/Cut Ground Shields
- Dielectric Fault or Narrowed Dielectric Diameter
- Fasteners Pinch Cables
- Connector Problems
- Low Quality Connectors
- Connector Pin Offset (Poor Mating Contact)

Antenna Problems

- Antenna Out Of Specification
- Antenna Storm/Shipping Damage

Table 1. Common cable and antenna faults that can cause excessive transmitter power reflection.

problems can cause excessive out of channel emissions. If left uncorrected, some transmission line installation problems will eventually degenerate into intermittent or complete failure.

Excessive reflected power will load an unisolated transmitter amplifier. The initial symptoms appear as a slight adjacent channel interference problem or a third order intercept problem that is particularly difficult to bring into tolerance, even when the transmitter is replaced.

If the transmitter amplifier has output isolation, reflected power from transmission line connector faults will be reflected again by the isolator causing a delayed interference signal which has effects similar to multipath fading. Depending on the level of the reflections, this can produce excessive random phase distortion as the vector phase of the various reflections combine with the desired output signal constructively or destructively as a function of instantaneous phase.

Failure Causes

Improperly installed connectors are difficult to identify because they may be marginally acceptable at the time of installation, but degrade over time. The performance deficiencies of poorly tightened connectors, incorrect connector pin offsets, and poor environmental seals of shields are exacerbated by acid rain and normal metallic corrosion. Eventually, these problems cause intermittent outage and failures at exactly the times they are least welcome — during thunderstorms or during periods of extreme cold. These are some of the reasons high quality digital systems such as GSM and DSC 1800 have strict requirements on connector types, pin depth tolerances, torque loading, and installed system return loss.

These problems are apparent only during the installation stage rather than on the engineering bench or during normal incoming inspection tests. Fortunately, however, the most common of these failure conditions (See Table 1) are easy to fix, if the problem is diagnosed and isolated by the test system.

Adapting Military Techniques

Some characteristics of test equipment developed for US military usage such as high cost, large mass, and 40 GHz frequency range are undesirable in RF applications. However, other attributes such as high accuracy, rugged construction, fast setup, and single button operation are a good fit for field testing wireless RF systems.

Microwave manufacturers and military organizations utilize scalar network analysis systems on the bench top and in the field for several reasons. First, since scalar measurement systems are designed specifically for measuring return loss and transmission loss of components, they are easy to use, accurate, and require a minimum of setup time.

Second, they're about half the price of, and considerably more rugged than, vector network analyzers. Thus, scalar systems are used for both depot component tests, and flight line tests that quickly determine the return loss performance of on-board aircraft cables and waveguides. Measured data is then com-

pared to previous data to identify any changes, that is, changes indicating loosened connectors or other damage.

Saving Time

Finding loosened connectors (quite common in EW and radar equipment) and other transmission line problems saves time for two reasons. First, the high resolution allows technicians to easily identify which side of a bulkhead should be opened to gain access to the loose or corroded connector. Second, automated test systems would fail due to the transmission line problem. Test procedures would then prescribe removal and replacement of an entire module — which, of course, would later prove to be operating properly. Worse yet, modern logistics support systems frequently send the supposedly defective modules back to commercial repair centers, causing an unnecessary repair bill. How many times have you seen "No Problem Found" on a repair report? Finding the problem in a cable or connector prior to module removal avoids this unnecessary effort and expense.

WBE

Circle Info/Card #125 for Catalog and Price List

For faster service fax ad and address information to 602-254-1570

MINIATURE RF AMPLIFIERS

Series A82 satisfies applications that require the following specifications in a rugged miniature package. Series A82 is ideal for direct antenna mounting. Applications include airborne equipment, test instrumentation, sweep equipment, spectrum analysers, frequency counters, telemetry, radio astronomy, wide band communications, or a convenient all around test bench amplifier.

Each stage is transformer coupled for highest power output with minimum distortion. Selective feedback is used to maintain flatness and impedance match over the entire bandwidth.

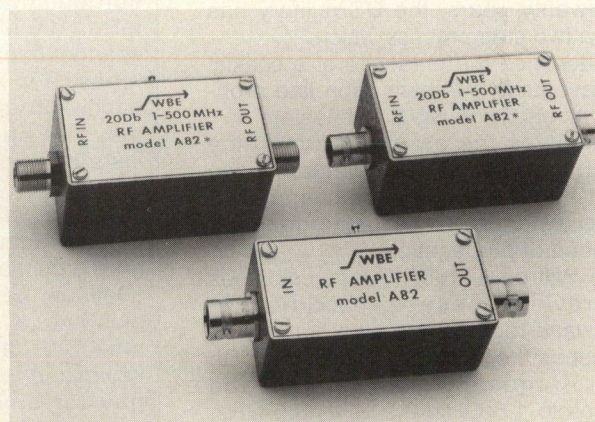
MODELS AVAILABLE

Models A82 and A82A are amplifiers of ultra wide bandwidth, extreme flatness, and excellent impedance match.

Models A82L and A82LA offer a more limited or specific bandpass with less stringent flatness specifications.

Models A82/RP, A82A/RP, A82L/RP, and A82LA/RP are remote power option amplifiers which may be remotely powered through the output connector.

O.E.M. and quantity pricing available. Consult factory with specifications.



Model	Freq. Range (Full Spec.)	Approximate 3 dB points MHz	Gain	Gain Flatness	Output Capability in V output for 1 dB Compression	Power Requirements ±12 VDC @ _____ mA	VSWR	Noise Figure	Reverse Attenuation	Weight oz.
A82	1-500	.3-650	20 dB Stable ±5 dB -40 - 170 °F	±.15	.7	28	1.5:1 max	7 dB max	-30 dB typical	2 1/2
A82A	1-500	.3-650		±.15	.7	28				1.1:1 typical
A82L	.1-50	.050-150		±.5	1.0	50	3			
A82LA	.4-30	.3-100		±.5	1.0	50				

WIDE BAND ENGINEERING COMPANY, INC.

P. O. Box 21652, Phoenix, AZ 85036

Phone: (602) 254-1570

Fax: (602) 254-1570

INFO/CARD 30



Figure 2: This swept frequency plot of a transmission line cable and antenna marginally meets the -15 dB return loss specification.

Finding Faults

The same basic measurement principles which were used for measuring microwave waveguide and coaxial transmission systems are now being applied at 0.001 to 3.0 GHz. Today, these transmission line test systems are lighter, self contained, easier to operate, and sell for about one third the cost of even the least expensive microwave test systems.

The Wiltron 54100A Scalar Measurement Systems provide a simple means of verifying the transmission line and antenna system performance during installation and at regular maintenance intervals (Figures 2 and 3). Over the past twenty years, the US military has used a two step process which:

- 1) Identifies the presence of a coaxial (or waveguide) transmission line problem with precision SWR Autotesters
- 2) Isolates the exact position of the fault using an FFT translation of the swept frequency reflection characteristics to distance (time domain factored for speed of propagation).

The Wiltron 54100A Series continues to provide these capabilities in microwave regions and also dramatically reduces the cost for RF systems with lower frequency components and sources to 1.5 GHz, 2.2 GHz, 3.0 GHz, and 8.6 GHz.

Distance-To-Fault Test Operation

First, a low harmonic source with better than -40dBc harmonic levels and a precision SWR autotester (35 to 40 dB directivity) are used to accurately measure the return loss of the microwave cables (see Figures 4 and 5).

If the SWR is out of specification, the problematic connector, cable, or antenna is quickly isolated with an automated FFT based distance-to-fault location technique. The principal is similar to airline techniques which are used to extend the directivity of standard SWR

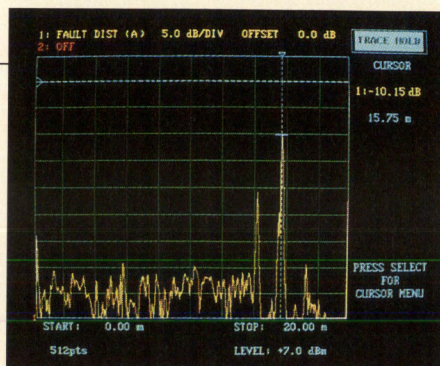


Figure 3: A distance to fault measurement reveals that the second connector is the source of excessive reflection.

bridges. Reflected signals combine with the fundamental to create a ripple pattern. Distant transmission line faults create more ripples in a given frequency sweep than faults closer to the transmission line input. Even at the medium resolution setting, faults can be isolated to 3 millimeters or 0.25% of total distance.

In wireless transmission systems, connector problems are often hard to identify



Figure 4: The actual return loss of this low pass filter is grossly distorted by a source's excessive second and third harmonics.

fy (partial pin-to-pin contact) and the connections are usually located up a tower. When testing tower mounted equipment, it makes a lot of sense to be able to isolate a problem from the transmission line input at ground level.

Total Quality Management

TQM processes rely on the use of properly operating components prior to

High Speed Digital LANs

High speed digital LANs and cable television systems have the same problems as wireless systems. The burgeoning demand for faster data rates (100 Mbs, 145 Mbs) and added channel capacity (to 1GHz today and higher for HDTV) has pushed the bandwidth requirements to levels that may not be supported by existing, installed coax cabling.

However, that doesn't mean that existing cables can't support the required bandwidth. In many cases a simple connector change will boost the available bandwidth of the transmission line. If cables can be proven to meet SWR and loss specifications, the savings in installation costs will easily pay for any necessary connector replacements. Determining the quality of the existing installed cables requires only two critical tests, transmission loss and SWR (return loss).

Sweep coaxial LAN cables for transmission loss and SWR through at least 3 times the digital data rate. This would be 300 MHz for a 100 Mbs system or 435 MHz for a 145 Mbs ATM transmission line. As a minimum, energy through the square wave's third harmonic must be transmitted to achieve a reliable connection. If the SWR increases rapidly at these higher frequencies, the distance-to-fault software will quickly isolate problem components.



A technician uses the distance-to-fault mode to isolate the location of a poor (high SWR) connection in a high speed LAN.

When testing for SWR or return loss on LAN or CATV cables, be sure to use a swept source with very low harmonics. Source harmonics will distort the passband characteristics of any low pass or band pass filter. Most LAN connectors will behave like lowpass filters and reflect the harmonic — causing an erroneously high SWR display. Thus, a source with poor harmonics can display a failure condition when none actually exists. Similarly, test signal separation devices with poor directivity will mask the true performance of the cables. Test component errors can be minimized using a high directivity SWR autotester.

assembly. Since only one set of cables and antennas are usually shipped to a new site, defective antennas or coaxial cables can cause delays which easily exceed the cost of the components themselves.

Scalar measurement systems are used to verify RF components at incoming inspection and after installation. Technicians perform a simple return loss test and document conformance to specification on a DOS disk which is later downloaded into the company database. Afterward, during the site's maintenance phase, the stored data records are available for comparison to the installation team's initial tests.

The 486 microprocessor in the 54100A Series Scalar Measurement Systems easily stores system setups and previous measurement data on a DOS compatible floppy disk. The data is stored and recalled from disk in a standardized ASCII format which is easily transferred to DOS and Windows computer software spread sheets and databases. Most common spread sheet programs are easily configured to automati-

cally produce graphical reports of historical performance or other statistics such as mean and standard deviation (see Figure 6).

Fast access to data in the PC environment is provided by the standardized ASCII format which allows easy integration of statistical process controls for both high throughput component manufacturing processes and remote field service applications. Data acquisition and encapsulation into PC data files is aided using an automated file naming system that will automatically increment the DOS filename by one character every time new data is saved. Thus, data acquisition, presentation, and statistical performance are implemented in a simple, streamlined process.

The 54100A Series Scalar Measurement Systems includes models with frequency ranges to 1.5 GHz, 2.2 GHz, 3.0 GHz, 8.6 GHz, 20 GHz, 32 GHz, and 40 GHz.

For more information, contact Wiltron Company, 490 Jarvis Dr., Morgan Hill, CA 95037; tel: 408-778-2000 or circle Info/Card #242.

RF

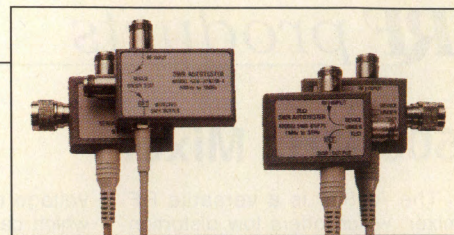


Figure 5. Precision SWR measurements require high directivity SWR Autotesters and low source harmonics.

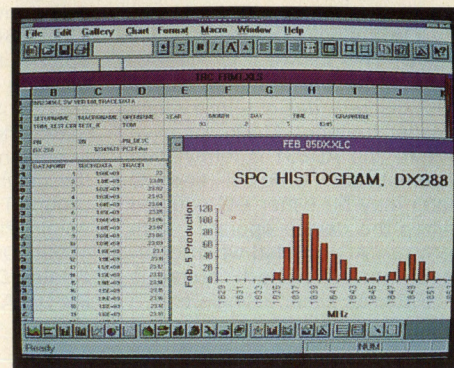
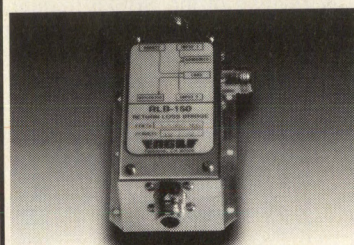


Figure 6. Test data integrates easily into common spread sheet data bases.



Return Loss Bridges

Return Loss Bridges are a low cost solution for swept SWR measurements. These bridges can be used with a spectrum analyzer/tracking generator or service monitor. Being a self contained unit, no external attenuators, amplifiers, comparators or detectors required. Five watt power rating, unmatched in the industry, protects YOUR bridge from power coming down the feedline during antenna measurements at crowded sites. Rugged nickel plated brass enclosures assure excellent durability and shielding.

FREE application note, "High Performance VSWR Measurements", call and ask for it!

Application note covers the uses of return loss bridges such as: tuning antennas, receivers, cavities, duplexers, isolators, and pre-amps. The relationship of VSWR, return loss and reflection coefficient is also discussed.

Features

- Directivity: >50 dB typical
- Internal reference
- RF reflected port
- High power rating: 5 watts
- Swept measurements
- Rugged construction
- .04 Mhz to 3.0 GHz

Model	Freq Range MHz	Directivity	Price
RLB150B1	.040 to 150	45 dB	\$259.00
RLB150N3A	5 to 1000	35 dB	\$329.00
RLB150N3B	5 to 1000	45 dB	\$389.00
RLB150N3C	5 to 1300	45 dB	\$425.00
RLB150N5A	5 to 3000	40 dB	\$579.00
RFT050NM2	DC-3000 reference load	40 dB	\$125.00
CCS050-NN5	Coaxial cable set 3 ft	NA	\$31.00

EAGLE

Phone: Voice: (316) 265-2050
FAX: (316) 265-2255
P.O. Box 9446 Wichita, KS 67277

INFO/CARD 31

Leave nothing to chance.

For quick response to your special needs...

PRECISION CRYSTAL PRODUCTION • PROTOTYPING
TECHNICAL ASSISTANCE AND ENGINEERING
IN-HOUSE MANUFACTURING AND TESTING

JAN Crystals

1-800-JAN-XTAL
P.O. BOX 60017 • FORT MYERS, FLORIDA 33906

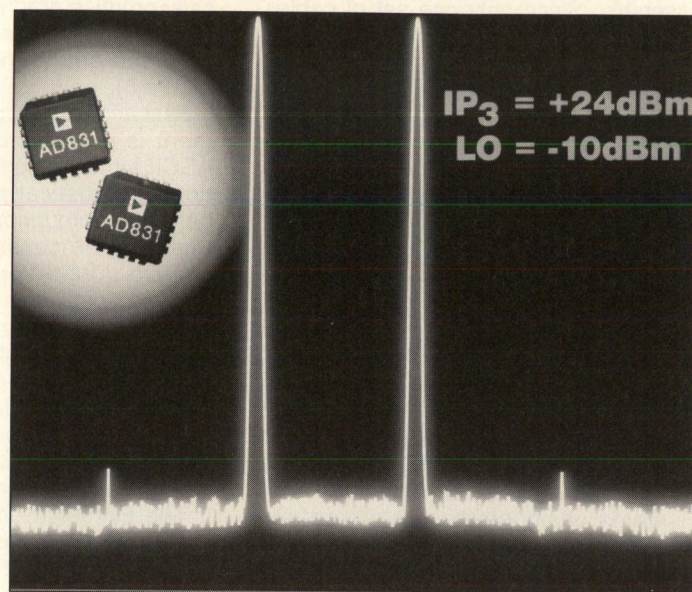
INFO/CARD 32

500 MHz Mixer

The AD831 is a versatile RF mixer, which offers low distortion (+24 dBm IP₃) for low LO power (-10 dBm) over a 500 MHz bandwidth. The mixer also features better than 70 dB LO-RF at 100 MHz. The AD831 integrates the LO driver and low noise output amplifier together with the mixer core in a single, compact 20-pin PLCC. This allows it to meet or exceed the performance of the best discrete designs in a much smaller footprint. Unlike passive mixers, the AD831 is termination insensitive. The RF, IF and LO ports may be either DC coupled (when the device operates from ± 5 V) or AC coupled when operated from +9V. The IF output is available as either a single-ended

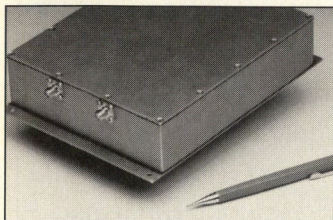
voltage or a differential current, which can be taken directly from the mixer cell, allowing users to provide their own amplifiers. For voltage output, the AD831 includes a dedicated low-noise amplifier, which can be used to drive filters, 50 ohm loads, and A/D converters, and provides a +10 dBm 1-dB compression point. Although Analog Devices' products have long been used in RF applications, the AD831 marks the first product specifically designed for this market from the newly formed dedicated RF group. The AD831, available in 20-pin PLCC, is priced at \$12 in 1000s. Delivery is from stock.

Analog Devices, Inc.
INFO/CARD #240



Digitally Tuned Preselector

A digitally tuned broad spectrum RF preselector from Pole/Zero can cover any four bands within 1.5 MHz to 1000 MHz in one small package measuring $6 \times 5 \times 1.5$ inches. The RF preselector may be tuned to 1000 center frequencies within 10 to 200 us across the band and provides 0.5% tuning accuracy from -40 to +85 C. The preselectors have a wide dynamic range and low intermodulation with third order intercept point of +40 dBm. Power handling capability is 1 W inband and 5 W in the stopband. Selectivity is excellent with a 3 dB bandwidth as low as 2% and a 30 dB bandwidth of 18%. Any four MINI-POLE™ and/or MAXI-

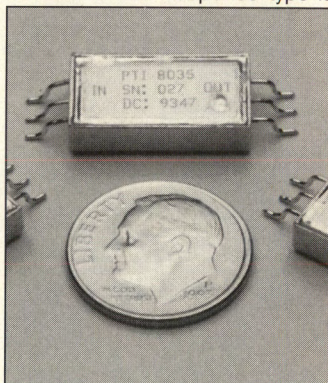


POLE™ filters in different bands can be selected to cover the appropriate frequencies. The bands available are 1.5-4, 4-10, 10-30, 30-90, 90-200, 200-400, 400-700 and 700-1000 MHz. Prices for standard broad spectrum RF preselectors start at \$3280 for small quantities.

Pole Zero Corp.
INFO/CARD #239

GPS Filter

Piezo Technology, Inc. (PTI) has introduced an LC filter specifically for the GPS receiver market. Model 8035C is available at 173.9 MHz with a 3 dB bandwidth of 20.5 MHz ± 1 MHz, a 40 dB bandwidth of ± 60 MHz, and a 50 dB bandwidth of ± 90 MHz to 375 MHz. The filter response type is

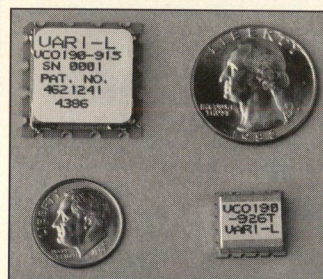


Chebyshev. Other features include a 1.5:1 VSWR, 10 ns maximum differential group delay, 32 ± 2 ns absolute delay at f_0 , and 3.0 dB maximum insertion loss. Source and load impedance are 50 ohms. The unit operates over the temperature range of -55° to 110° C. The model 8035C is housed in a hermetically sealed, $0.70 \times 0.40 \times 0.17$ inch (L x W x H) surface mount package. Pricing is less than \$175 in small quantities, and less than \$100 for quantities greater than 100.

Piezo Technology, Inc.
INFO/CARD #238

VCOs for Wireless Designs

The VCO 190 series of low cost VCOs produce 0 dBm output power over the wireless communications bands from 45 to 3000 MHz. All models are application specific designed for exceptionally low phase noise (-118 dBc/Hz at 10 kHz offset at 490 MHz) with tuning bands from 3% to 30% of center frequency. The miniature surface mount unit operate from 5 VDC with usage down to 3 V allowed from -35° to +85° C. A unique patented circuit is used to

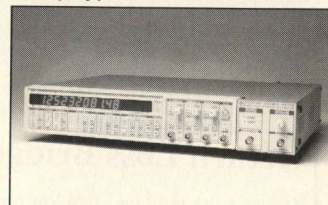


achieve full specified performance into 4:1 VSWR loads with less than 10 mA of typical current gain. Models with separate low modulation sensitivity ports are also offered for direct FM transmitter or high speed dual loop applications. These devices are robotically assembled in an ISO 9000 approved facility, and automatically tested to produce uniformity consistent with volume production applications.

Vari-L Company, Inc.
INFO/CARD #237

Rb Timebase Counter

Stanford Research Systems announces the commercial release of the SR625 frequency counter, designed for making traceable frequency calibrations of base stations, transmitters and many types of communication



systems. The SR625 combines the high resolution of the SR620 counter with the atomic accuracy of a rubidium timebase to measure frequency drift and stability with extremely high accuracy. The counter directly measures signals up to 2.2 GHz with twelve digits of resolution in a one second measurement interval. The Rb timebase has an accuracy of 5×10^{-11} and a monthly drift of 5×10^{-11} to ensure accurate and traceable measurements over time. The SR625 has a ten minute warmup time, is compact, and also has a 10 MHz Rb output to drive other test equipment such as spectrum analyzers or synthesizers. The unit measures $14 \times 17 \times 3.5$ inches and weighs 16 pounds. U.S. list price is \$14,850 with delivery four weeks ARO.

Stanford Research Systems
INFO/CARD #236

CABLES & CONNECTORS

Mini-UHF to SMA Adapter

The RFU-642 between-series connector adapts a mini-UHF female and a (Motorola) SMA style female connector. The connector body is produced entirely of nickel-plated machined brass with machined teflon dielectric and gold plated female contacts.

RF Industries, Ltd.
INFO/CARD #235

Jumper Cables

VALUFLEX™ cable assemblies are manufactured using genuine HELIAX® coaxial cable and are designed for indoor use up to 3 GHz. The jumper cable assemblies are available in 1/4 inch FSJ1-50A HELIAX for general connectivity, 3/8 inch FSJ2-50A for more demanding applications, and 1/4 inch ETS1-50T for high power and plenum applications. The cables are stocked in the most popular sizes and with N, UHF, and BNC connectors.

Andrew Corp.
INFO/CARD #234

Flexible Jumpers

The jumper cable developed by the coaxial cable department of Huber+Suhner AG can undergo 15,000 bending cycles with a radius of 110 mm and an angle of ± 90 degrees without affecting transmission characteristics. Connectors have been specially designed to accompany these cables and are available in the most widely used styles.

Huber+Suhner AG
INFO/CARD #233

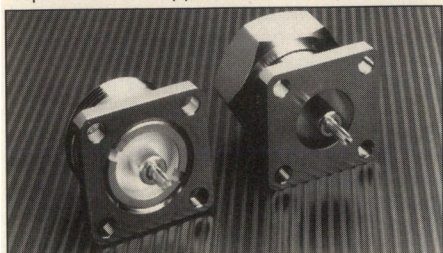
Flexible, 100% Shielded Cables

Re-Flex™ cables from Insulated wire utilize a unique alloy laminate underneath a copper braid, offering the shielding equivalent while remaining easily formable by hand. These cables are reformable with no electrical or mechanical degradation.

Insulated Wire, Inc.
INFO/CARD #232

7/16 Connectors

A line of quick-change RF 7/16 DIN connectors designed to fit all popular models of multilevel; wattmeters from Tru-Connector meet DIN 47223 and IEC 169.4 interface requirements. Supplied individually, the con-



nectors provide 50 ohm impedance, low VSWR up to 7.0 GHz, and have a voltage rating of 2700 Vrms. Cable assemblies can also be provided.

Tru-Connector Corp.
INFO/CARD #231

SIGNAL SOURCES

TCXOs for GPS

Tele Quarz offers low phase noise TCXOs at standard frequencies of 32 MHz and 8 MHz for use in GPS receivers. The oscillators feature a 20 x 20 mm enclosure, an internal temperature sensor, and analog and two cophasal outputs. The units are vibration insensitive. Other frequencies are available.

Tele Quarz GmbH
INFO/CARD #230

OCXO

The 252-1130 ovenized crystal oscillator (OCXO) by MTI offers 5 MHz output with thermal stability of 1×10^{-9} ($\pm 5 \times 10^{-10}$) over a temperature range of -30 to $+70^\circ\text{C}$. Aging is better than $5 \times 10^{-11}/\text{day}$ and $1 \times 10^{-8}/\text{year}$. Phase noise is specified at -110 dBc/Hz at 1 Hz offset, -145 dBc/Hz at 100 Hz, and -160 dBc/Hz at 10 kHz. HCMOS or $+7$ dBm sinewave output is available. Dimensions are 60 x 67 x 27 mm. Other industry-standard packages are available. Prices for the 252-1130 start at \$640.

Milliren Technologies, Inc.
INFO/CARD #229

TEST EQUIPMENT

Quartz Frequency Standard

Starting at \$995, the model 2950A quartz frequency standard has simultaneous sinewave outputs of 5 MHz, 1 MHz and 100 kHz. The 2950A-01 has less than 1×10^{-9} daily aging and costs \$995; the 2950A-02 has $< 1 \times 10^{-10}$ daily aging and costs \$1395; the 2950A-03 has $< 5 \times 10^{-11}$ daily aging and costs \$1995. Harmonic outputs are down < -40 dBc, phase noise is -152 dBc/Hz at 100 Hz offset for the 2950A-03, and a voltage-controlled fine frequency adjustment allows locking to a primary standard.

Novatech Instruments, Inc.
INFO/CARD #228

RF Emulator

The TAS 4500 can be configured to emulate two independent RF channels, each with three paths. Delay, path loss, Rayleigh fading, Rician fading, and log-normal fading characteristics can be programmed for each path. The two channels can be combined to form a single six-path channel. The unit has a built-in frequency synthesizer, and is GPIB and RS-232 controllable.

Telecom Analysis Systems, Inc.
INFO/CARD #227

Sprague-Goodman



Surftrim® Surface Mount Trimmer Capacitors

- 2 sizes:
3.2 x 4.5 x 1.6 mm
4.0 x 4.5 x 2.7 mm (sealed)
- 4 mounting configurations
- Carrier and reel, or bulk pack
- 1.7 to 50 pF in 7 cap ranges
- Operates to 85°C

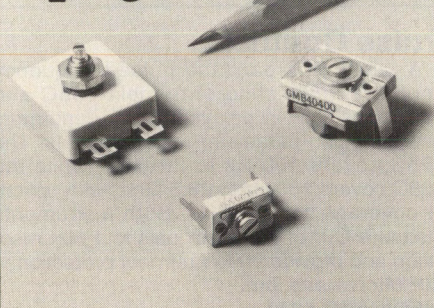
Phone, fax or write today for
Engineering Bulletin SG-305B.



134 Fulton Ave., Garden City Park, NY 11040
Phone: 516-746-1385 • Fax: 516-746-1396

INFO/CARD 33

Sprague-Goodman



Mica Compression Trimmer Capacitors

- Cap ranges: 2.5-7.0 pF to 1400-3055 pF
- Q to 600 at 1 MHz
- Rated working voltage to 500 V
- Can handle higher RF currents
- Operating temp: -35° to $+85^\circ\text{C}$
- 8 mounting styles for PC, panel, and bracket mounting

Phone, fax or write today for
Engineering Bulletin SG-500B.



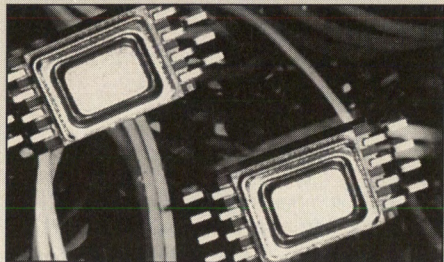
134 Fulton Ave., Garden City Park, NY 11040
Phone: 516-746-1385 • Fax: 516-746-1396

INFO/CARD 52

Product Spotlight: Amplifiers

Low Voltage MMIC Amps

Low voltage power amplifiers have been added to Mitsubishi's line of ultra-small GaAs MMICs for PCN applications. The



devices operate in the 1.89 to 1.95 GHz band. The MMICs measure $8.4 \times 12.2 \times 1.7$ mm and feature minimum power output of 26 dBm. The MGF7132 operates on a 4.7 V supply, and the MGF7133 operates on 3.3 V. Unit price for both is \$45.00 in quantities of 25.

Mitsubishi Electronics America, Inc.
INFO/CARD #226

Low Noise Amplifier

The VMA0518D-120 ultra-low-noise

amplifier instantaneously spans 0.5 to 18 GHz, featuring 2.8 dB maximum noise figure and 20 dB gain coupled with ± 0.8 dB ripple and ± 10 dBm output power. Housed in a $1.0 \times 1.0 \times 0.22$ inch package with removable SMA-F connectors, the unit operates from +15 VDC at 140 mA. Other amplifiers in this family are available with gains to 46 dB and output powers to +19 dBm.

Veritech Microwave, Inc.
INFO/CARD #225

CATV Amplifiers

Three new devices extend Motorola's portfolio of trunk and line extender amplifiers to 1 GHz. The MHW7182 covers 40 to 750 MHz with 110 channels, 18.8 dB gain and 5.5 dB typical noise figure. The MHW8182 covers 40 to 860 MHz with 128 channels, 19.0 dB gain and 6.0 dB typical noise figure. The MHW9182 covers 40 to 1000 MHz with 152 channels, 19.2 dB gain and 6.5 dB typical noise figure. The MHW7182, MHW8182 and MHW9182 cost \$47.19, \$54.54 and \$65.84, respectively.

Motorola Semiconductor
INFO/CARD #224

High-Mu Power Triode

The Svetlana 3CX3000A7 is a high performance ceramic/ metal power triode designed for use in zero-bias, class AB, or class B RF or audio amplifiers. A modern mesh filament is used, replacing the old-fashioned hairpin

construction. The low-inductance, mesh-filament basket also forms a natural extension of the cylindrical stem geometry into the active area, giving superior VHF performance.

Svetlana Electron Devices
INFO/CARD #223

50 W, UHF Amplifier

ENI's model 550L power amplifier produces 50 W of class A output power over a 1.5 to 400 MHz frequency range. With a gain of 50 dB, the 550L features low harmonic and intermodulation distortion; all harmonics are more than 23 dB below the main signal at full power. The amplifier is unconditionally stable, has +13 dBm overdrive protection, and infinite maximum load VSWR. The 550L is available for 30-day delivery at a cost of \$7965.

ENI
INFO/CARD #222

Cellular Hybrid Amp

Model PA1032 from Phoenix Microwave offers ultra linear output power of +27 dBm, over the 800 to 900 MHz range with a typical third order intercept of 44 dB. Using proprietary design techniques, this amplifier has 1 dB maximum noise figure across the entire operating frequency. The unit is offered in 24-pin DIP and surface mount packages.

Phoenix Microwave Corp.
INFO/CARD #221

Pulse Counters

A family of broadband pulsed frequency counters, consisting of models 585C and 588C, has built-in delaying pulse generators and full pulse parameter measurements. The 585C covers 100 Hz to 20 GHz, while the 588C covers 100 Hz to 26.5 GHz, with optional coverage to 170 GHz. Both instruments measure CW or pulsed signals to 1 Hz resolution and provide 200 W burnout protection.

EIP Microwave, Inc.
INFO/CARD #220

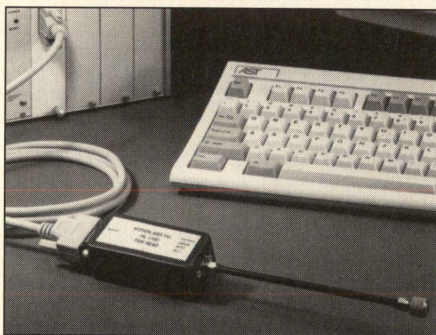
Arbitrary Waveform Generator

Model 2650 is a 50 MS/s programmable arbitrary waveform generator. The unit provides 12-bit vertical resolution and 64k points per channel, with an expansion option to 256k. The 2650 is fully supported by National Instruments' LabWindows® and RapidSystems' R4 drivers. The model 2650 is priced at \$3995 as a single channel generator, \$5990 for dual channels. Additional memory is \$495 per channel.

Analogic Corp.
INFO/CARD #219

PC-Based TDR

The time domain reflectometer (TDR) head from Hyperlabs has 35 ps risetime capability. The HL-1100 remotely connects to a National



Instruments SCXI mainframe, isolating the TDR circuitry from the noise generated by the PC, and allowing connection to inconveniently located test connectors. The HL-1100 TDR head is priced at \$4995.

Hyperlabs, Inc.
INFO/CARD #218

SIGNAL PROCESSING COMPONENTS

High Power Splitter

A high power, two-port splitter/combiner pair for the 88 to 108 FM broadcast band uses Wilkinson principle. Microstrip design

makes these units compact, and a caseless design makes them inexpensive. Standoffs for mounting are standard, as are BNC connectors. The power handling capability is 600 + W. Price is \$74.99 per pair in quantities of 1 to 9 units.

RF Power Systems
INFO/CARD #217

Miniature Mixers

The RMS-11X mixer is a surface mounted, all-ceramic package measuring only $0.25 \times 0.31 \times 0.2$ inches and costing \$3.95 each in quantities between 10 and 49. This mixer operates in the 5 to 1900 MHz range and has 1 dB compression at 1 dBm RF input. Conversion loss is 6 dB. All specs are statistically controlled to within 4.5σ from the mean.

Mini-Circuits
INFO/CARD #216

Low-Loss Mixer

Merrimac's DMG-2D series of mixers is designed for wideband applications from 2.5 to 6.5 GHz, or narrower bands within that range requiring more exacting specifications. The IF frequency range extends from DC to 2000 MHz, with a typical midband SSB conversion loss of 4.5 dB. The surface mount package measures 0.45 inches square and nominally weighs 0.1 oz.

Merrimac Industries, Inc.
INFO/CARD #215

ZRON

2-8GHz AMPLIFIERS



Up to 100mW, 20dB Gain, 2-8GHz,

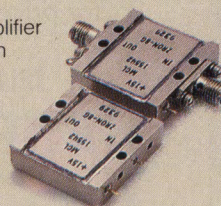
only \$495⁰⁰

Mini-Circuits fused the science of economy and technology together to create the very broad band, 2 - 8GHz ZRON-8G amplifier. Each SMA connector on this amplifier can be easily removed for quick conversion to drop-in assembly capabilities...and with a price tag of just \$495, the ZRON-8G will fit as well into your budget as it will your project. But, don't let the small price fool you. Each hermetically sealed unit is built extremely tough. Even if the power supply voltage is shorted under full RF power, the ZRON-8G amplifier will survive without damage.

Suitable for both lab and systems applications, this multi-functional GaAs amplifier delivers 20dBm minimum power output at 1dB compression and has a linear gain of at least 20dB over the full frequency range. To that, add a VSWR of 2.0:1 maximum over the whole band and you have a unit that's unconditionally stable for all load and source impedance magnitude and phase.

So, call your Mini-Circuits distribution center for guaranteed one week shipment and seize the competitive power packed in the new ZRON-8G amplifier!

Available with or without heat sink



SPECIFICATIONS Model: ZRON-8G

Freq. Range GHz	2-8
Gain (dB) Min.	20
Power (dBm)	
Min. Output (at 1dB Comp.)	+20
Dynamic Range	
NF(dB) Typ.	6
Intercept Point (dBm) 3rd Order Typ.	30
VSWR In/Out	2.0:1
DC Power	
Voltage	+15
Current mA Max.	310

INFO/CARD 34

Mini-Circuits®

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

For detailed specs on all Mini-Circuits products refer to • THOMAS REGISTER Vol. 23 • MICROWAVES PRODUCT DIRECTORY • EEM • MINI-CIRCUITS' 740-pg HANDBOOK.

CUSTOM PRODUCT NEEDS... **Let Our Experience Work For You.**

F-170 Rev. Orig.

High Power RF

Amplifiers and Power Generators

Our specialty is producing quality high power RF amplifiers, power generators and transmitters in the frequency range of 1 MHz to 250 MHz and at power levels up to 5000 watts.

We can deliver amplifiers from stock, custom build your design or design a product to your specifications.

We manufacture from start to finish using modern CAD tools and

CNC machinery.

Whether you need one or OEM quantities, you'll get the lowest prices and the fastest delivery in the industry.

For more information, call toll-free 800-647-1801 and ask for Steven Pan.

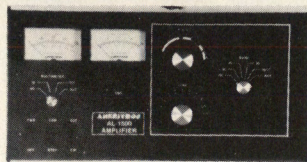
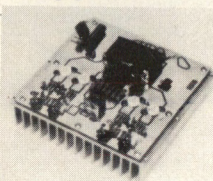
Free Information

Write or call Steven Pan ... 800-647-1801



This FET linear amplifier covers VLF to VHF with 200 watts continuous power output or 1500 watts output in pulse applications.

200 Watt FET Linear Amplifier Module is ready-to-use. Can be combined to produce several kilowatts. Modules available for 2-30 MHz; 30-120 MHz; 120-250 MHz. Evaluate one today!



The rugged Eimac® 3CX1500A7 tube in this HF amplifier delivers over 750 watts of continuous power or up to 4 KW of pulsed output power.

We sell Eimac® tubes
Call toll-free 800-647-1801

AMERITRON®

... the high power RF specialists

921 Louisville Road • Starkville, MS 39759

(601) 323-8211 • FAX: (601) 323-6551

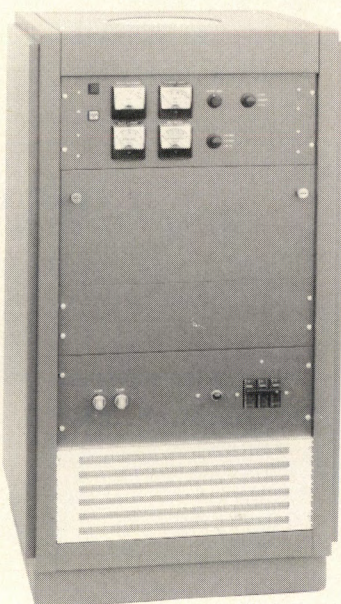
8 a.m. - 4:30 p.m. CST, Monday-Friday

Prices and Specifications subject to change © 1994 Ameritron, Inc.

INFO/CARD 35

HF POWER AMPLIFIERS

High Reliability, Commercial Quality



- ◆ 1.8 to 30 MHz
- ◆ 1500 to 10,000 Watts

HENRY HF Power Amplifiers have been the reliability standard for 30 years. Thousands are in use at commercial, government, and military installations around the world.

If you require trouble-free, 24-hour-per-day, year-round operation, call or write today for prices and specifications.

TOLL-FREE (800) 877-7979

HENRY RADIO



2050 South Bundy Drive
Los Angeles, CA 90025

Phone (310) 820-1234
FAX 310-826-7790

INFO/CARD 36

RF products

Reed Relays

Kilovac's "S" series of high power reed relays are PC board mountable. DC performance ratings range from 300 V, 2 amp relays to 10,000 V, 5 amp relays. The series can handle RF power handling duties. Prices start as low as \$20.50 each for 1 to 9 pieces.

Kilovac Corp.

INFO/CARD #214

Isolators/Circulators

KW Microwave has introduced a line of commercial isolators/circulators to its line of ferrite products. An example is the cellular band, 890 to 935 MHz isolator with detector. The unit has 0.3 dB typical insertion loss, 23 dB isolation minimum, and VSWR of 1.15:1 maximum.

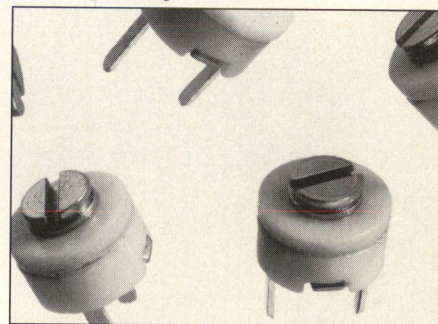
KW Microwave Corp.

INFO/CARD #213

DISCRETE COMPONENTS

Trim Caps

The RS series of ceramic trimmer capacitors from Voltronics is 0.2 inches in diameter, with two axial leads on 0.15 inch centers. Three capacitance ranges are available: 0.6 to 3.0 pF, 1.0 to 5 pF, and 2 to 10 pF. The series' working voltage is 50 V, with withstanding voltage of 100 VDC. TC is -500



±1000 ppm/°C. Q is over 250 at 1 MHz. Prices are \$0.46 each in 10,000 piece quantities. Delivery is from stock for orders up to 5000.

Voltronics International Corp.

INFO/CARD #212

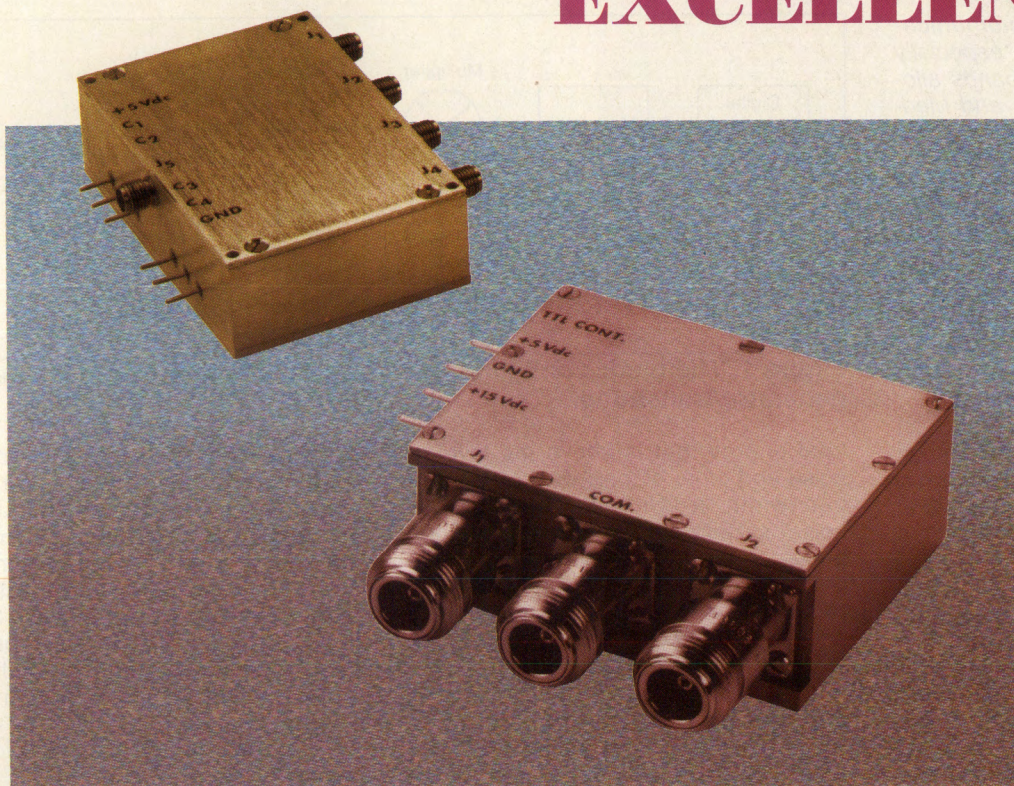
SMT Crystals

The H-180 series quartz crystals are only 1.8 mm high and are packaged in resin-sealed ceramic packages. The crystals are available in four accuracies: ±10, ±30, ±50, ±100 ppm at 25° C, and in four temperature sensitivities: ±10, ±30, ±50, ±100 ppm over -10 to +60° C. Fundamental frequencies are available from 10 to 40 MHz; 3rd overtones to 90 MHz. In 10,000 unit quantities, the H-180 series crystals are priced from \$0.90 to \$3.00 each, depending on performance.

Raltron Electronics Corp.

INFO/CARD #211

QUALITY
Innovation
PERFORMANCE
Reliability
EXCELLENCE



50S-092 SMA • 1P4T • Solid State Switch
500-1000 MHz

50S-788 N • 1P2T • Solid State Switch
20 Watts Average Power • 500-1000 MHz

- Many standard models
- 50 and 75 Ohm
- Matrix switches
- Many configurations

*We Are The
Last Word In
Switches.*



JFW Industries, Inc.

5134 Commerce Square Drive
Indianapolis, Indiana 46237
Tel. 317-887-1340
Fax 317-881-6790

INFO/CARD 37

A First Introduction to Direct Sequence Spread-Spectrum

By Gary A. Breed
Editor

Spread Spectrum (SS) communications is growing in popularity, especially in the unlicensed frequency bands allocated for Industrial, Scientific and Medical (ISM) applications. With its roots in military secure and anti-jamming transmission techniques, SS has been thoroughly analyzed and developed, and much of the reference material is based on such high-performance applications. This tutorial reviews the basic concepts of one type of SS, direct sequence.

Direct sequence spread spectrum can be characterized as a single carrier, with modulation applied that creates an RF signal with a bandwidth that is much wider than the bandwidth of the information it is carrying. This characteristic is what gives SS its name — the signal is spread across a part of the spectrum.

The modulation applied is designed to create an RF signal with properties much like random noise. The resulting signal looks like noise, yet it is deterministic since the modulation is mathematically generated using a pseudo-noise (PN) code.

The noise-like properties make the signal difficult to detect and demodulate, yet its deterministic nature makes it possible for a receiver to “unspread” the signal using the same PN code.

The above combination of properties demonstrate the attractiveness of direct sequence SS:

- It is difficult to demodulate without knowing the PN code.
- Multiple channels with different PN codes can occupy the same band.
- It causes low interference, since the energy is spread over a wide bandwidth.
- It has low susceptibility to interference because modulation and demodulation are synchronous, not responding to other signals.

The most significant disadvantage to direct sequence SS is that it requires a

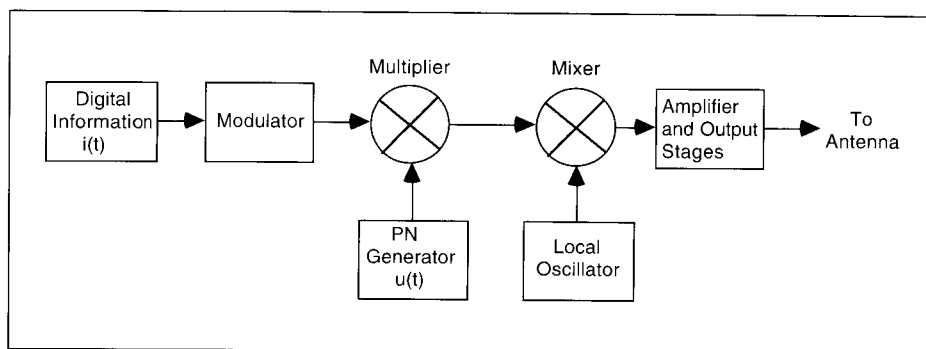


Figure 1. The basic configuration of a direct sequence spread spectrum generator/transmitter.

total energy that is above the level of noise and other signals within the same bandwidth. It is neither a “below the noise” system, nor is it as robust in the presence of interference as some people believe [1]. However, it offers high-reliability transmission with relatively small signal-to-noise ratios, a big advantage over narrowband modulation.

Generating Direct Sequence SS

There are four contributors to the final SS signal, as shown in Figure 1 — the digital data stream being transmitted, $i(t)$; the PN code in the form of “chips,” $u(t)$, with a phase that varies rapidly compared to the data rate; the modulation type, which may be any type of phase modulation, but is typically QPSK; and the operating frequency, usually involving one or more upconversion stages.

The high rate of phase change created by the chipping sequence results in a very wide bandwidth. The signal contains several chips per bit of data, which a correlated receiver will see as redundant information, but which an uncorrelated receiver will see as a rapid series of bits that approximate noise. The number of chips per bit of input data typically is in the range of hundreds to a few thousand.

The PN code may also be applied directly to the digital data stream, rather

than multiplying the modulated baseband signal. In this case, the PN sequence is considered to be a voltage waveform which multiplies the data stream by either +1 or -1. If the data stream is considered to be return-to-zero (the digital states are 1 and 0), then the resulting encoded waveform has three-states, -1, 0, and +1. If the data stream is considered to be non-return-to-zero (the digital states are +1 and -1), the resulting encoded waveform will have two states, +1 and -1.

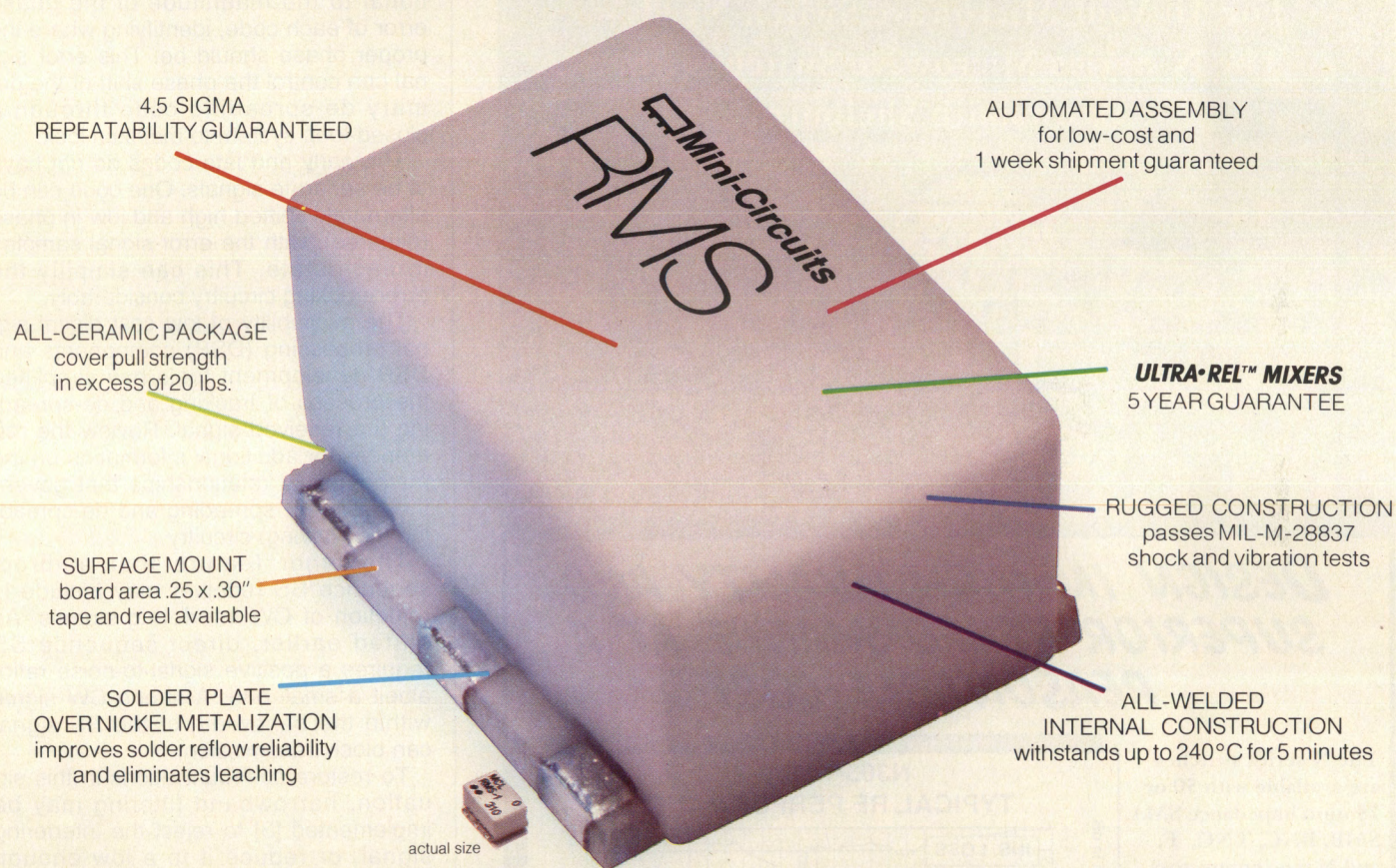
A more complex method generating a direct sequence SS signal takes advantage of the quadrature signals necessary for QPSK. In this method (Figure 2), the in-phase (I) and quadrature (Q) paths are each phase modulated with different chipping sequences, $u_1(t)$ and $u_2(t)$. The resulting complex, wideband signal is more difficult to intercept, since it requires two PN codes.

There is not sufficient opportunity to analyze these methods in detail in this short tutorial. They are presented to make the reader aware of the configurations he or she may find when pursuing further research on this subject.

Receiving Direct Sequence SS

A spread spectrum receiver is essentially the reverse of the generator/transmitter. However, a few additional circuit elements are often added to compen-

MIXERS UNPRECEDENTED IN VALUE.



ALL-CERAMIC 5 to 3000MHz **\$395**
from (10-49 qty)

Now you can buy very low-cost, high-performance commercial mixers with the ruggedness and reliability required for military applications. That's value! ... Only from Mini-Circuits.

Model	LO (dBm)	Freq. (MHz)		Midband, dB			\$ ea. (10-49)
		LO, RF	IF	Conv. Loss	Isol L-R	L-I	
RMS-11X	+7	5-1900	5-1000	7.1	29	31	3.95
RMS-11F	+7	350-2000	DC-400	5.5	31	30	4.95
RMS-30	+7	200-3000	DC-1000	6.5	26	22	6.95
RMS-25MH	+13	5-2500	5-1500	7.5	32	32	7.95

finding new ways ...
setting higher standards



Mini-Circuits®

WE ACCEPT AMERICAN EXPRESS AND VISA

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

Distribution Centers / NORTH AMERICA 800-654-7949 • 417-335-5935 Fax 417-335-5945 EUROPE 44-252-835094 Fax 44-252-837010

For detailed specs on all Mini-Circuits products refer to • THOMAS REGISTER Vol. 23 • MICROWAVES PRODUCT DIRECTORY • EEM • MINI-CIRCUITS' 740-pg HANDBOOK.

CUSTOM PRODUCT NEEDS... **Let Our Experience Work For You.**

F166 REV. ORIG.

INFO/CARD 38

sate for the "real world" that accompanies the signal in its transmission path.

For example, the usual bandpass filter will be needed to eliminate signals outside the desired frequency range. Automatic gain control (AGC) and frequency synthesis are other typical receiver functions that apply to all receivers, including those intended for SS.

A specific problem for SS is that the

receiver will not be automatically synchronized with the transmitted signal. Even if both are phase-locked to a single stable reference, such as WWVB or the Global Positioning System (GPS), propagation will introduce both long- and short-term delays which appear as phase shifts.

Receiver tracking of the spreading PN code can be done in two ways. The first

is a simple search mode, where the receiver phase is shifted until the system is synchronized with the incoming signal. This trial-and-error approach is not the most reliable way to achieve synchronization unless the signal path is such that it introduces a minimum of error. For short-range systems, it may be appropriate.

The other major way to maintain synchronization is the use of "early" and "late" codes, de-spreading PN codes that are phase shifted to lead and lag the signal to be received [2]. An error signal can be generated that is proportional to the magnitude of the phase error of each code, identifying where the proper phase should be. This error signal can control the phase shift of the primary de-spreading code through a closed-loop system to maintain lock.

The early and late codes do not have to be separate signals. One code can be alternately shifted high and low in phase (dithered), with the error signal sampled in each state. This can simplify the error-tracking circuitry considerably.

The availability of low cost digital signal processing (DSP) components and DSP development tools has simplified the process of tracking and de-spreading the received signal. Review the references for additional information on the mathematical relationships that govern the design of spreading and de-spreading (convolving) circuitry.

The other feature that a direct sequence SS receiver may include is rejection of CW interfering signals. As stated earlier, direct sequence SS requires a positive signal-to-noise ratio, albeit a small one. A strong CW signal within the bandwidth of the SS signal can block transmission.

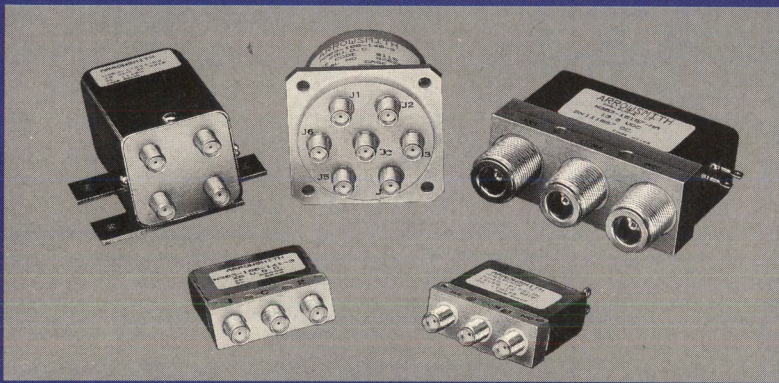
To restore communications in this situation, narrowband filtering may be implemented [3] to reject the interfering signal, or reduce it to a low enough amplitude that the SS system is again functional. Technology is readily available for tunable IF notch filters using crystals at IFs typically below 70 MHz, or SAW filters above 45 MHz. In the event of a failure, the receiver can either detect the interfering signal, or simply sweep the passband with the notch to see if the SS signal can be restored.

General Considerations

Data rates in the several megabits per second range can be supported in a direct sequence SS system. Combined with the inherent security of PN codes (along with other encryption tech-

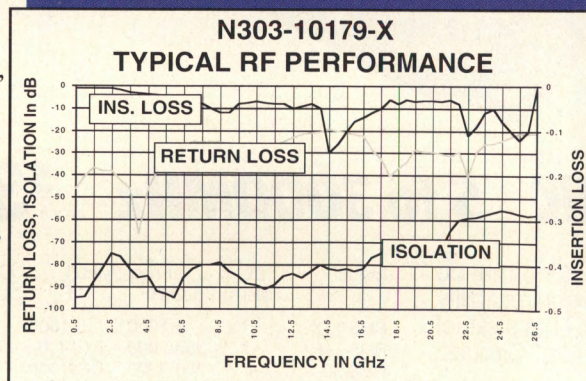
SWITCH TO ARROWSMITH!

For All Your Microwave Switch Needs -
The N-Series Microwave Switches from
Arrowsmith Shelburne



DESIGN IN HIGH QUALITY AND SUPERIOR PERFORMANCE AT A REASONABLE COST

The N series switches are available with 50 or 75 ohm impedance SMA, SMB, BNC, TNC, F, and N type connectors. Custom voltages are available. Other options include TTL compatibility, self de-energizing, indicator circuitry and suppression diodes. Please contact a sales representative for price and availability today.



ARROWSMITH
Shelburne, Inc.

2085 Shelburne Road • Shelburne, Vermont 05482
802-985-8621 • FAX: 802-985-1042

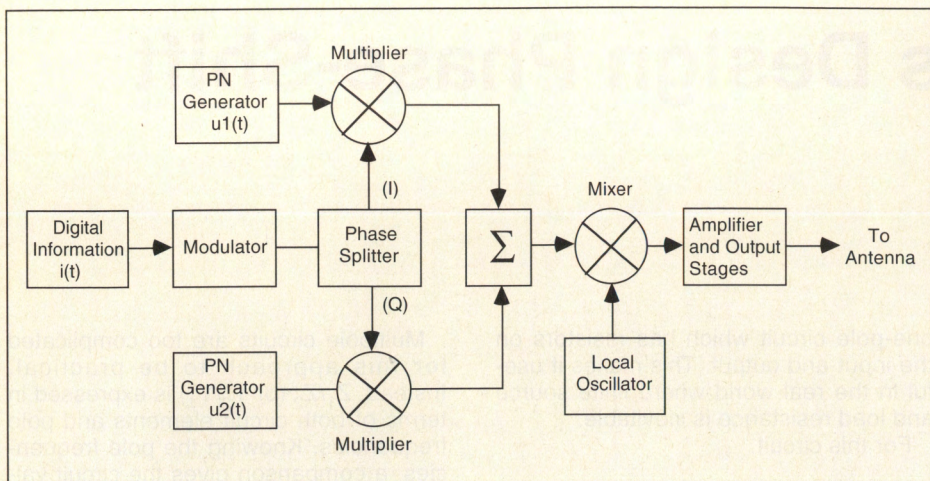


Figure 2. QPSK direct sequence SS generation using separate PN codes in the I and Q paths.

niques), this makes direct sequence SS an attractive choice for wireless local area networks in critical applications such as banking.

The ability to use well-established QPSK modulation methods and highly-integrated DSP devices combine to

make equipment design relatively straightforward and inexpensive.

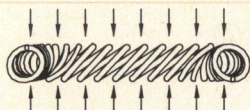
Finally, the simple fact that SS is a reliable means of radio transmission explains its popularity among designers of new wireless data communications equipment. *RF*

References

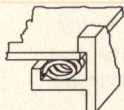
1. R. Zavrel, "An ISM Band Design for WLAN and PCS," *Conference Proceedings*, RF Expo West 1993.
2. H. Brown, "An Improved Tau-Dither Technique for Spread Spectrum Code Tracking," *RF Design*, December 1991.
3. S. Eo, C. Ma, I. Jang, "Designing a Direct Sequence Spread Spectrum Secure Communication System," *RF Design*, April 1991.
4. D. Nicholson, *Spread Spectrum Signal Design*, Computer Science Press, 1988.
5. R. Dixon, *Spread Spectrum Systems*, John Wiley & Sons, 1984.
6. K. Feher, *Digital Communications*, Prentice-Hall, 1983.
7. J. Proakis, *Digital Communications*, McGraw-Hill, 1983.
8. R. Ziemer, R. Peterson, *Digital Communications and Spread Spectrum Systems*, Macmillan Publishing Co., 1985.
9. M. Simon, et. al., *Spread Spectrum Communications*, 3-volumes, Computer Science Press, 1985.
10. G. Myers, "Performance of Envelope Detectors in Direct Sequence Spread Spectrum Systems," *RF Design*, March 1990.

EMI Spring Gaskets

For Demanding EMI-RFI Applications



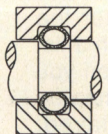
Axial



For EMI Gasketing



Radial



For Grounding Shafts

Patented Canted-Coil Spring Design

- Excellent conductivity across metal interfaces
- Unique electrical & mechanical properties
- Ideal shielding effectiveness in low and high frequency service
- Available in beryllium-copper alloys and stainless steels
- Coil heights as small as .015" allows packaging in tight spaces
- Available in continuous lengths or welded to almost any diameter

For free literature or design assistance call

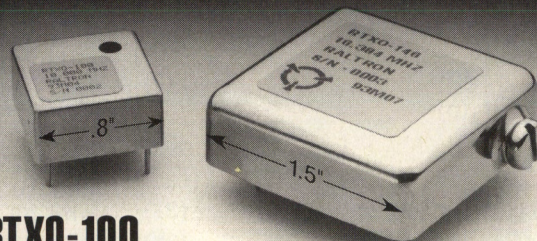
Tel: 800-366-1006 • 714-557-5192 or FAX: 714-241-0185



**BAL SEAL
ENGINEERING COMPANY, INC.**

620 WEST WARNER AVENUE • SANTA ANA, CALIFORNIA 92707-3398

THE NEW TCXO SOLUTIONS FROM RALTRON.



RTXO-100 RTXO-146

- Small size
- Wide temperature range
- +5 VDC, +12 VDC
- Wide frequency range
- Voltage control option
- Custom options
- Lower cost

FREQUENCY STABILITY:

100: -30° C to +70° C: ±1ppm

146: -40° C to +85° C: ±1ppm

DIMENSIONS:

	100	146
Length	.8"	1.5"
Width	.8"	1.5"
Height	.4"	.5"

Call or fax your specs to Sandy Cohen.

RALTRON
ELECTRONICS CORP.

2315 NW 107 AVENUE
MIAMI, FLORIDA 33172 U.S.A.
FAX (305) 594-3973
TELEX 441588 RALSEN
(305) 593-6033

ONLY RALTRON HAS IT ALL

Crystals / Crystal Oscillators
Crystal Filters / Ceramic Resonators

NPOLE Helps Design Phase-Shift Networks

By R. Dehoney
Consultant

This article gives the theory for the design of one, two, three and four pole RC active and passive allpass networks. With suitable choice of pole frequencies, these networks can be used to form wideband constant phase difference circuits. The programs discussed in this article continue the work started in reference 1. They calculate the element values for some active and passive RC one-, two-, three-, and four-pole allpass networks, given pole frequencies, which may be calculated using the program described in [1] or some other program. The work is based on the work of Albersheim and Shirley [2] and Toffer [3].

The passive and active versions of the circuit are shown in Figures 1 and 2. For either circuit,

$$\frac{V_o}{V_i} = \frac{(Z_2 - Z_1)}{(Z_2 + Z_1)} \quad (1)$$

For the circuit to be allpass, $|V_o/V_i|$ must be constant, therefore,

$$\frac{V_o}{V_i} = G \frac{f_1(p)}{f_2(p)} \quad (2)$$

where

$$f_1(p) = (p_1 - p)(p_2 - p)(p_3 - p) \dots \quad (3a)$$

$$f_2(p) = (p_1 + p)(p_2 + p)(p_3 + p) \dots \quad (3b)$$

$$p = j2\pi f \quad (3c)$$

and the constant output is $|V_o| = G \cdot V_i$.

Single pole circuits are simple enough to analyze directly. Figure 3 shows a

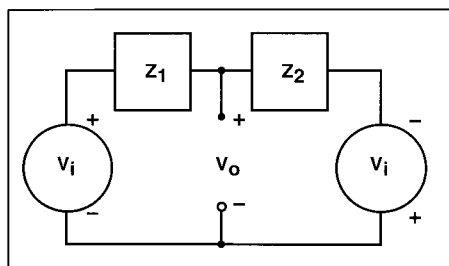


Figure 1. Passive allpass network.

one-pole circuit which has resistors on the input and output. This makes it useful in the real world where finite source and load resistance is inevitable.

For this circuit,

$$\frac{V_o}{V_i} = A \frac{(p - \omega_1)}{(p + \omega_2)} \quad (4)$$

where:

$$A = \frac{(R_2 - R_1)}{\left(R_1 \left(1 + \frac{R_2}{R_L}\right) + R_2\right)} \quad (5a)$$

$$\omega_1 = ((R_2 - R_1)C_1)^{-1} \quad (5b)$$

$$\omega_2 = \frac{\left(1 + \frac{R_2}{R_L}\right)}{C_1 \left(R_1 \left(1 + \frac{R_2}{R_L}\right) + R_2\right)} \quad (5c)$$

To be allpass, $\omega_1 = \omega_2 = p_1$, the pole frequency. Given p_1 and choosing the values of C_1 and R_L , the equations can be solved.

The first of the programs to be described here, 1POLE, does the drudgery. You are asked to enter the pole frequency and C_1 after which a list of gain vs. R_L is printed out. When you choose R_L , R_1 and R_2 are calculated and all of the values are displayed, along with V_{out}/V_{in} . You then have the option of choosing new values or a new pole frequency.

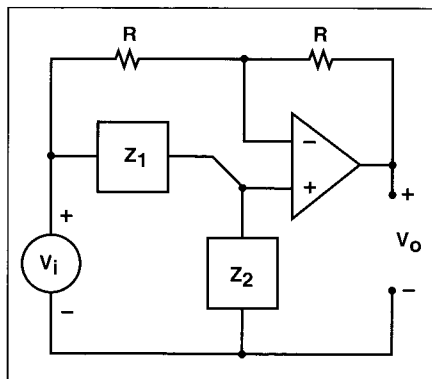


Figure 2. Active allpass network.

Multipole circuits are too complicated for this approach to be practical. Instead, Z_1/Z_2 (or Y_2/Y_1) is expressed in terms of both circuit elements and pole frequencies. Knowing the pole frequencies, a comparison gives the circuit values.

Two-Pole Circuits

Program operation can best be understood by considering the two-pole circuit. For this circuit to be allpass,

$$f_1(p) = (p_1 - p) \cdot (p_2 - p) \quad (6a)$$

$$f_2(p) = (p_1 + p) \cdot (p_2 + p) \quad (6b)$$

From (1),

$$\begin{aligned} \frac{Z_1}{Z_2} &= \frac{1 - \frac{V_o}{V_i}}{1 + \frac{V_o}{V_i}} \\ &= k \frac{g_1(p)}{g_2(p)} \end{aligned} \quad (7)$$

where

$$g_1(p) = p^2 + b_1 \frac{p}{k} + b_0 \quad (8a)$$

$$g_2(p) = p^2 + b_1 \cdot p \cdot k + b_0 \quad (8b)$$

$$k = \frac{(1 + G)}{(1 - G)} \quad (8c)$$

$$b_1 = p_1 + p_2 \quad (8d)$$

$$b_0 = p_1 \cdot p_2 \quad (8e)$$

For Z_1 and Z_2 to have realizable values, $g_1(p)$ and $g_2(p)$ must have real roots. If we choose k to make the two of roots of $g_1(p)$ merge, then the roots will be real and the circuit will have the least

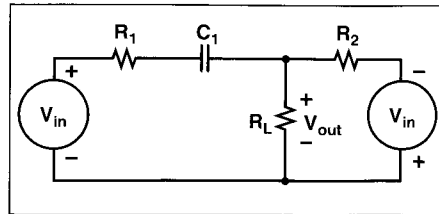
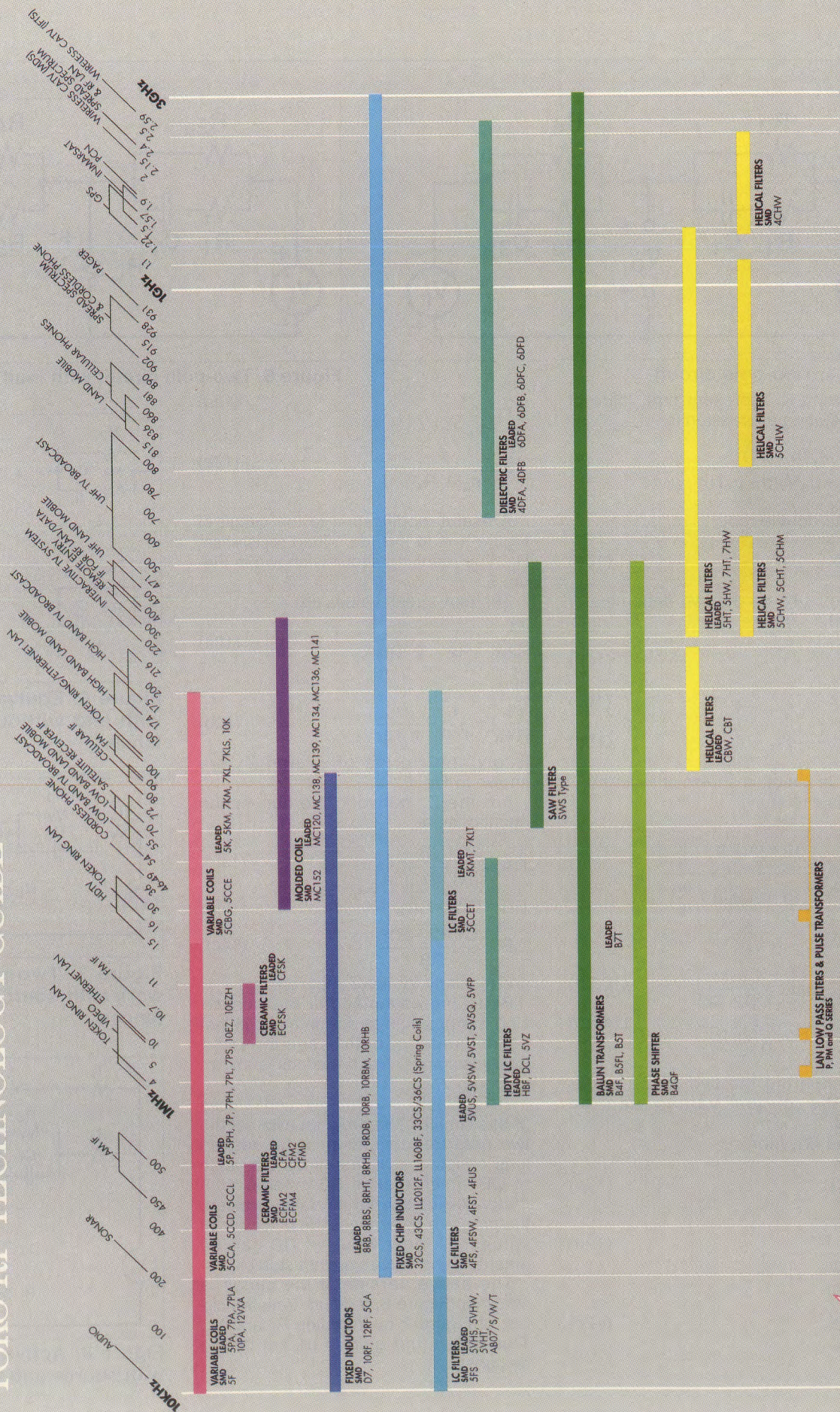


Figure 3. Single pole circuit.

**For a FREE 10" x 15" reproduction,
call 1-800-PENSTOCK (408-730-0300)**

From TOKO & PENSTOCK

CUT HERE AND DISPLAY



A Product for Every Application
Penstock is ready for your order with over 2,500,000 TOKO parts in inventory. Call **1-800-PENSTOCK** (800-736-7862) 408-730-0300 CANADA 613-592-6088

PENSTOCK TM ^{INC}
Offices Nationwide

Call for Complete Specifications:
1-800-PIK-TOKO
1-800-745-8656

InfoTOKO
INFO/CARD 42

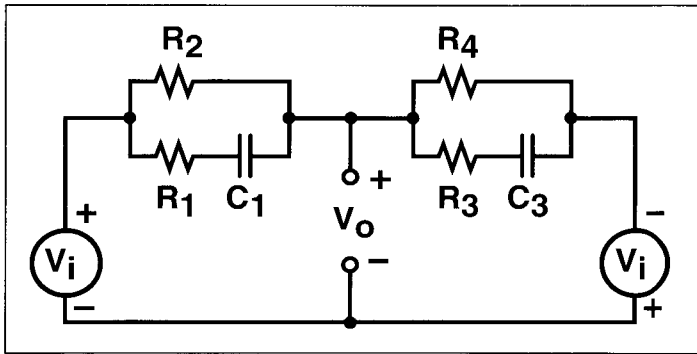


Figure 4. Two-pole circuit.

loss. Letting k_c represent that value of k , the resulting expression is:

$$\frac{Z_1}{Z_2} = \frac{k_c (p + p_a)^2}{(p + p_a M)(p + p_a N)} \quad (9)$$

where the double root,

$$p_a = \sqrt{b_0} \quad (10a)$$

$p_a \cdot M$ and $p_a \cdot N$ are the two denominator roots and,

$$k_c = \frac{b_1}{2p_a} \quad (10b)$$

$$M = 2k_c^2 + \sqrt{4k_c - 4} \quad (10c)$$

$$N = 2k_c^2 - \sqrt{4k_c - 4} \quad (10d)$$

A two-pole circuit is shown in Figure 4.

For this circuit:

$$\frac{Z_1}{Z_2} = \frac{R_2}{R_4} \cdot \frac{a}{b} \frac{(p + \omega_1) \left(p + \frac{\omega_2}{a} \right)}{(p + \omega_2) \left(p + \frac{\omega_1}{b} \right)} \quad (11)$$

where

$$\omega_1 = \frac{1}{R_1 C_1}, \quad \omega_2 = \frac{1}{R_2 \cdot C_2} \quad (10a,b)$$

$$a = \frac{R_4}{R_2} + 1, \quad b = \frac{R_3}{R_1} + 1 \quad (11a,b)$$

By comparing the two Z_1/Z_2 equations, the circuit values can be obtained.

Choose R_1 , then

$$R_3 = \frac{R_1}{k_c} \quad (12a)$$

$$R_2 = \frac{R_1}{\left(\frac{2}{N} - 1 \right)} \quad (12b)$$

$$R_4 = \frac{R_2}{k_c} \quad (12c)$$

$$C_1 = \frac{1}{p_a R_1}$$

$$C_3 = \frac{1}{p_a M \cdot R_3} \quad (12e)$$

A useful modification to the circuit of Figure 4 is to include a load resistance, R_L . The resulting circuit is shown in Figure 5.

The new circuit values are:

$$\frac{1}{R_{2a}} = \frac{1}{R_2} - \frac{1}{2 \cdot R_L} \quad (13a)$$

and

$$\frac{1}{R_{4a}} = \frac{1}{R_4} - \frac{1}{2 \cdot R_L} \quad (13b)$$

Equivalent forms of Z_1 and Z_2 are shown in Fig. 6.

For the Z_1 network, the conversion equations are:

$$R_A = \frac{R_1 \cdot R_2}{(R_1 + R_2)} \quad (14a)$$

$$R_B = (R_2 - R_A) \quad (14b)$$

$$C_B = \frac{C_1(R_2 + R_1)}{R_B} \quad (14c)$$

and similarly for the Z_2 network.

By taking advantage of this conversion it is possible to design a circuit that accommodates both a source and a load resistance. Such a circuit is shown in Figure 7.

2POLE solves for the element values of this circuit. The program asks for the two pole frequencies and the desired load resistance. It then finds the value of C_B which makes R_B infinite. With that value or any larger value entered, the program determines the other circuit values. A new value of C_B can be entered if the values are not suitable.

The active version of the circuit is shown in Figure 8. It differs from the circuit of Figure 2 by including R_x and R_y . This allows the gain to be set by the designer.

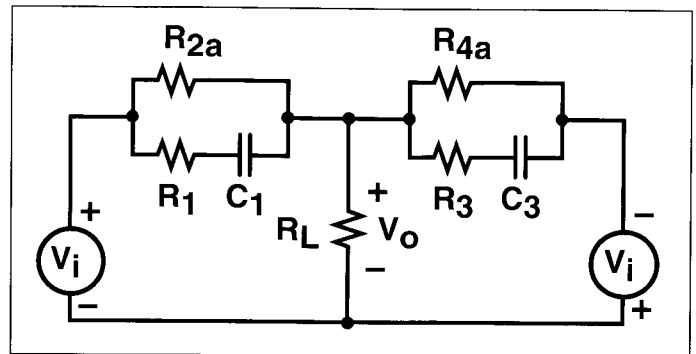


Figure 5. Two-pole circuit with load resistor.

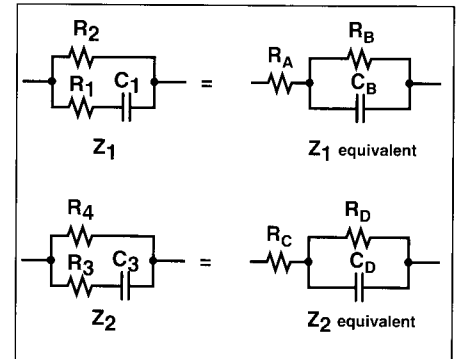


Figure 6. Equivalent impedances with and without a series resistance.

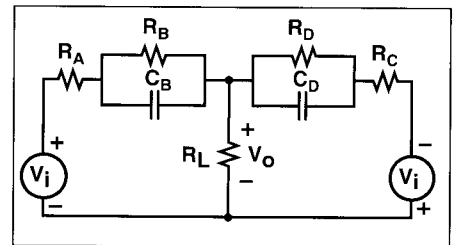


Figure 7. Two-pole allpass network with source and load resistances.

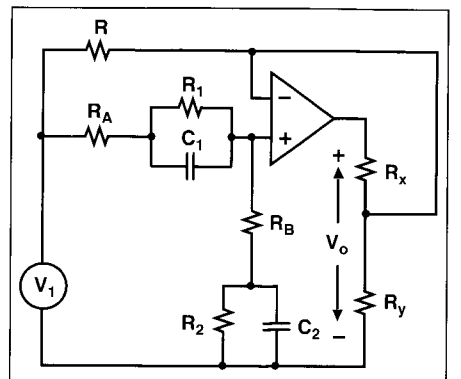


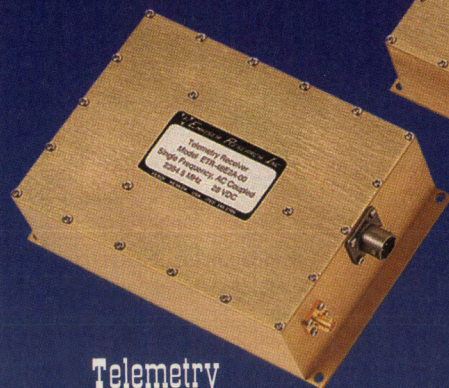
Figure 8. Active allpass network with source and load resistances.

RECEIVERS

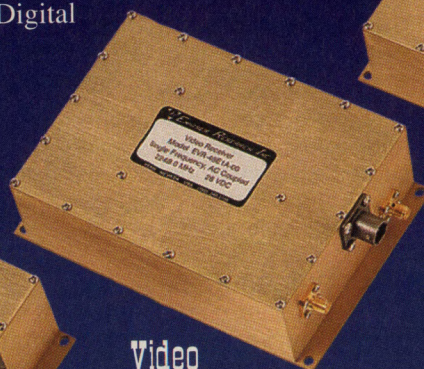
\$ 4,538.00 each

45-Day Delivery for the First Unit of our Standard Single Frequency, AC Coupled Receiver in any of the following configurations:

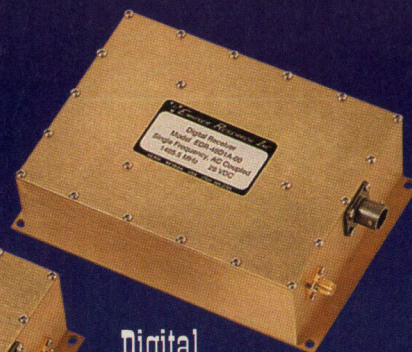
Telemetry, Video, or Digital
L, L/S, or S Band
SMA, N, or TNC
RF Connector



Telemetry



Video



Digital

OTHER PRODUCTS:

Beacon Transmitters • Amplifiers
Command Encoders & Decoders
Transmitters • VCOs
(Rack Mount Available)

OTHER RECEIVERS AVAILABLE IN ANY COMBINATION OF THE FOLLOWING FEATURES:

- Telemetry, Video, or Digital
- Single Frequency or Channelized
- Frequency Bands:
 - D1 = 1435 to 1540 MHz (L Band)
 - D2 = 1710 to 1850 MHz (L/S Band)
 - E1 = 2200 to 2299 MHz (Lower S Band)
 - E2 = 2300 to 2400 MHz (Upper S Band)
- SMA, N, or TNC RF Connector
- 48 Cubic Inch (4.0" x 6.0" x 2.0")

Call for Price and Delivery
Starting from Single Piece Price of
\$ 5,288.00 each

*Call our engineers with your
specific requirements*

- **Options:** De-Emphasis, Subcarrier Discriminator(s), RF Signal Strength, Extended Temperature, Other Special Requirements



EMHISER RESEARCH, INC.

2705 Old Highway 40 West
P.O. Box 189
Verdi, Nevada 89439-0189 USA

TEL: (702) 345-2705
FAX: (702) 345-2484

Since 1978

INFO/CARD 43



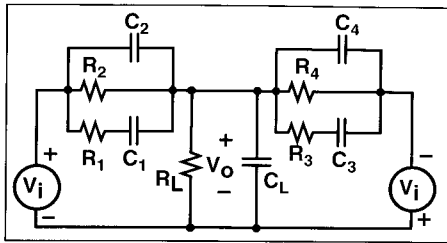


Figure 9. Three-pole network.

3- and 4-Pole Circuits

The design of three- and four-pole circuits follows the same steps as outlined above: The equations for Z_1/Z_2 are developed from V_o/V_i . The value of k giving confluent roots is found and the equations expressed in terms of those roots. The equation for Z_1/Z_2 is found in terms of circuit elements, and the two equations are compared to obtain the element relations.

3POLE and 4POLE automate this procedure. Given the pole frequencies and an element value, the programs calculate and display the other element values. If the values are not suitable, new values can be obtained. Active and passive three- and four-pole circuits can be chosen.

Figure 9 shows the passive circuit used in 3POLE.

The RC load is optional. If it is included, the element values are changed as follows:

$$\frac{1}{R_{2a}} = \frac{1}{R_2} - \frac{1}{2 \cdot R_L} \quad (15a)$$

$$\frac{1}{R_{4a}} = \frac{1}{R_4} - \frac{1}{2 \cdot R_L} \quad (15b)$$

$$C_{2a} = C_2 - \frac{C_L}{2} \quad (15c)$$

$$C_{4a} = C_4 - \frac{C_L}{2} \quad (15d)$$

An alternate three-pole network is included in 3POLE. This network includes resistors on input and output. The circuit is shown in Figure 10.

4POLE analyzes one active and two passive circuits. The basic four-pole circuit is shown in Figure 11.

It can be modified to include a resistive load by changing values as shown below:

$$\frac{1}{R_{3a}} = \frac{1}{R_3} - \frac{1}{2 \cdot R_L} \quad (16a)$$

$$\frac{1}{R_{6a}} = \frac{1}{R_4} - \frac{1}{2 \cdot R_L} \quad (16b)$$

A version with input and output resistors is included in the program. The circuit is shown in Figure 12.

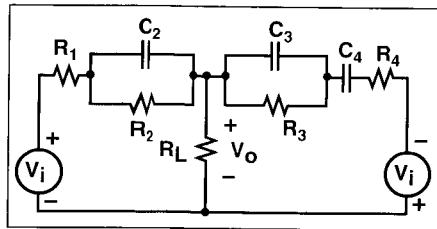


Figure 10. Three-pole network using resistors on the input and output.

The circuit is shown in Figure 12.

The program asks for the four-pole frequencies and a value for R_S . It then calculates a minimum R_L and asks for an R_L input. It then calculates and displays all element values.

Push-Pull Sources

The passive circuits can be implemented in various ways. All that is required is a push-pull source. Figure 13 shows one convenient way using the so-called long-tailed pair.

Choose a network having source resistors and modify the calculated values to account for the resistance looking back into the FET circuit.

Other techniques include the use of a 180 degree hybrid, unity gain inverter, or one of the new transconductance amplifiers with differential output such as the Maxim MAX435.

Conclusion

It is my hope that these circuits will usefully augment the circuits presented in Reference 1, (which presented the constant phase difference network design program PHASEDIF), and that this work will encourage others to analyze and describe other allpass circuits.

The programs are all unsophisticated BASIC programs and should run on any PC. Please call or write me if you come across errors or if you have questions.

The program, NPOLE, is available through the RF Design Software Service. For ordering information, see page 64. **RF**

References

1. R.J. Dehoney "Constant Phase Difference Networks", *RF Design*, January 1993, pp 65-67
2. W.J. Albersheim and F.S. Shirley, "Computation Methods for Broad-Band 90 Degree Phase-Difference Networks", *IRE Transactions on Circuit Theory*, May 1969, pp. 189-196
3. R. Toffer, "Delay Equalizer", Fairchild Application Bulletin, May 1965.

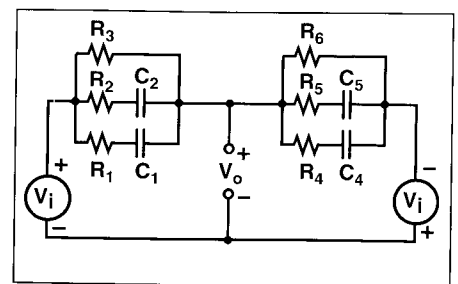


Figure 11. Four-pole network.

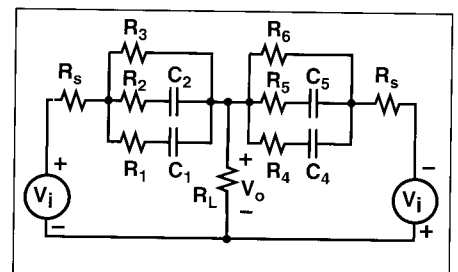


Figure 12. Four-pole network with input and output resistors.

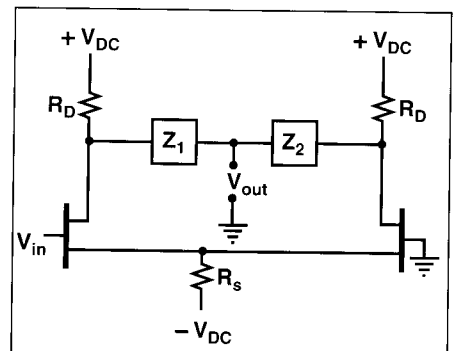


Figure 13. Push-pull source using a long-tail pair

About the Author

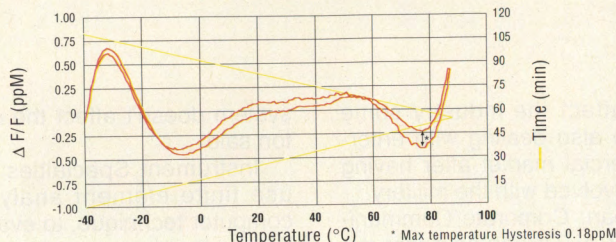


Robert Dehoney received his BSEE from MIT in 1950. After graduation, he worked for the Allen B DuMont Labs designing RF equipment for UHF TV. He retired from Fairchild Weston in 1987 as a Technical Director in ECM. He is now a private consultant. He can be reached at 4602 Palm Blvd., Isle of Palms, SC 29451, or by phone at (803)-886-5785.

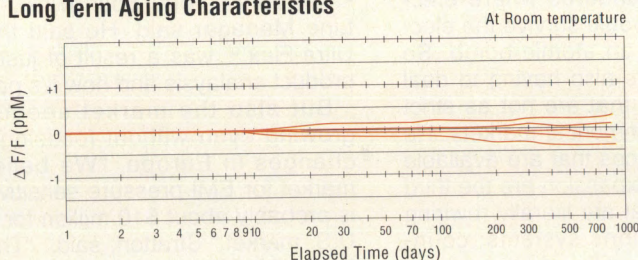
RAKON TCXO's

OUTSTANDING QUALITY & PERFORMANCE

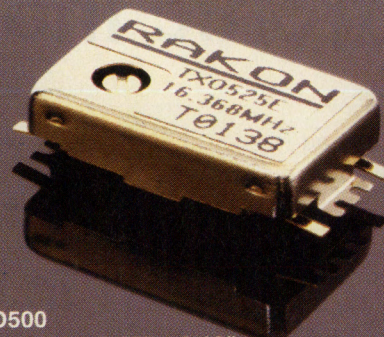
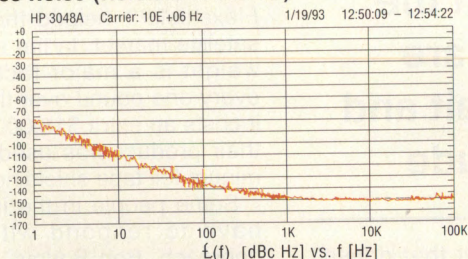
Frequency Stability vs Reciprocal Temperature Ramp @ 2°C/min



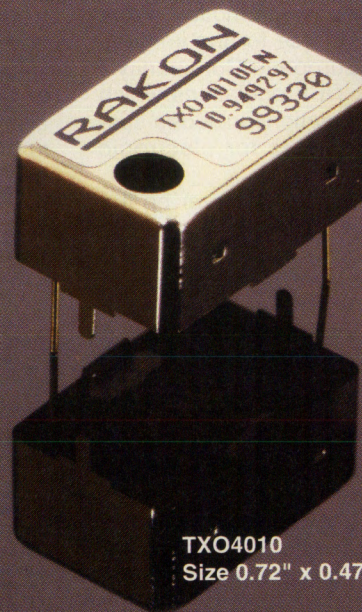
Long Term Aging Characteristics



SSB Phase Noise (Relative to carrier)



TXO500
Size 0.72" x 0.47" x 0.18"



TXO4010
Size 0.72" x 0.47" x 0.35"

- Miniature size
- SMD Low profile package available
- Excellent temperature stability performance
±1 to 2.5 ppm from -40 to 85°C
- No frequency perturbations
- Low power consumption of only 1.5mA

- Very low Hysteresis
- Low parts in 10⁻¹⁰ Allan Variance
- G sensitivity of 2x10⁻¹⁰ typical
- Excellent vibration performance
- Clipped sinewave output
- Frequency range of 9.6 to 20 Mhz

RAKON

RAKON LIMITED

Private Bag 99943, New Market,
One Pacific Rise, Mt. Wellington, Auckland, New Zealand.

Fax: 64-9-573-5559, Phone: 64-9-573 5554.

FAX YOUR ENQUIRY NOW. 64 IS THE COUNTRY CODE, 9 IS THE AREA CODE.

INFO/CARD 48

Shielding Products Makers Wait for Electronic Industry to Focus

By Ann Marie Trudeau
Assistant Editor

Shielding products, the items that are needed if engineers can't design out radio frequency interference (RFI), are in a market that seems to be unfocused for the future. The market itself is growing for a number of reasons but what is unstable is the wait to see how U.S. electronic manufacturers are going to respond to the various market choices and forces that are now in motion. What may be the largest force for the immediate future is the European Community's tightening of their RFI regulations which unlike the U.S. regulations includes susceptibility requirements for electronic equipment.

As the only American observer on the European EMC Information Technology committee (EMCIT) for the last four years Gary Fenical has developed strong opinions. Fenical is Manager of EMC at Instruments Specialties Co., Inc. and is the informal liaison between the committee and the registered test labs in the United States.

Fenical pointed out that some in the industry are taking a wait and see attitude while others are acting as if the Europeans are not going to actually implement stronger requirements. "Well, it's too late already," Fenical said, "because at the first of January 1996 all electronic or electrical equipment must comply, no ifs, ands or buts; no grandfathering. The ones that have not done anything or are just starting are in trouble." He also pointed out that if you sell new piece of equipment in Europe and there Europe has a requirement change the manufacturer will be given time to comply. You don't have to retrofit but there's no grandfathering now or in the future. That isn't how it happens in the U.S. But, however the industry responds the FCC has responded to the European rules. Fenical said that it's now official that any equipment compliant with the European rules and regulations will be honored here in the U.S. But, he also observed that the reverse wasn't true.

In addition to concerns about how

Europe may affect the industry some companies are also dealing with entering the commercial market after having been heavily involved with the military.

James L. Pean, Corporate Communication Manager of Technit said that the military followed TEMPEST regulations. These are the standards where electronic equipment would survive the electronic pulse from an atomic bomb. So now the industry is also having to deal with requirements that are not as strict to get into the commercial markets. He also sees the choices that are available to the market for expansion are the third world countries that are literally rewiring their communications systems; countries like Vietnam and Russia.

...some in the industry are taking a wait and see attitude

The part of the market that doesn't seem to be worried about the time frame to meet changing regulations is the injection molding part of the shielding industry. Ralph Starkey, Sales Manager of Windsor Plastics, said that they could respond in about six to nine months to stricter regulations. He also sees that even though engineers eventually design out the need for shielding the increase in clock speeds are ahead of those efforts so shielding needs will be driven by the delayed response of designers to the market demand. Bill Stratton, Marketing Manager for Electronics for Adhesives Research, said that design problems do show up because of customer expectations. The person in an airplane who is using a notebook computer and a cellular phone at the same time has the computer wiped out. "You have to make sure one

system doesn't affect the others," Stratton said.

Instrument Specialties is gearing to use finite element analysis (FEA), a computer technique, to evaluate designs before building a prototype. "You can test drive it without taking it out of the showroom," Tony Sosnowski, Product Line Manager said. He said that their Ultra-Flex™ was a result of just such a product analysis and now it's patented.

But also the market seems to be growing even without focusing on the changes in Europe. "We believe the market for EMI pressure sensitive tapes is probably about \$10 million for just the U.S. market," Stratton, said. "That's not for the future, that's now."

He said that the ability of Adhesives Research to come up with their Flexshield™ helped them in the space satellite market. In the satellite business weight is a major factor because for every one pound over the design weight it costs an extra \$18,000 and that is why their product was used to replace aluminum foil tape shielding.

Some people in the industry may not have to respond with an either/or approach. Bob Barlow, Business Director for the Metalized Materials Business of Monsanto Chemicals, said that the European changes may give Europe a marketing advantage, but that there may be enough differences between the markets in other areas that would make it feasible for a U.S. company to make a separate product for each market.

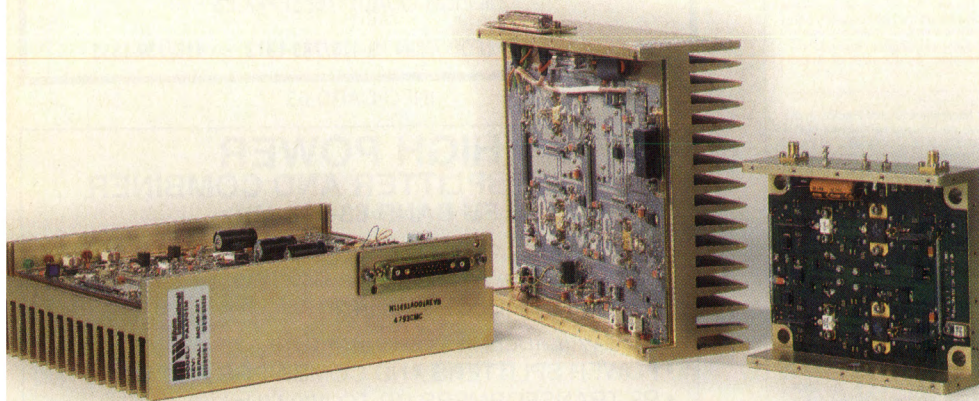
Summary

The shielding products manufacturers are in a good place. The drive for faster clock speeds to meet demands and the inability of engineers to keep up with designing out all RFI before the products hit the market, the growing third world markets, and traditional markets keep them in business. The big guessing game is how the electronic industry is going to respond the European changes.

RF

WE'VE RAISED AMPLIFIER STANDARDS IN COUNTLESS UNHEARD WAYS

Milcom International is a world leader in designing and manufacturing high quality amplifiers for a diverse array of precision applications, including military and wireless communications, and introducing our new line of **DIGITAL CELLULAR** (TDMA, CDMA) products. High volume production and custom design encompass a spectrum of frequency and power requirements, from 1 MHz to 4 GHz, 1-2000 watts, in a wide range of products. Utilizing such innovative features as surface mount technology, Milcom combines sophisticated field-tested features with proven quality, reliability, and an unprecedented technical support program.

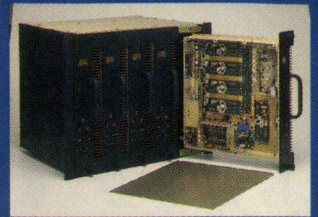


Linear amplifier for cellular base station 800-960 MHz, 250 Watts P.E.P., -30DBC IMD

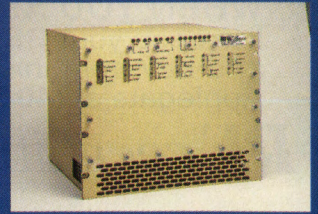
For world class quality, look to a world class company. Put our experience to work for you. Call Milcom International today.



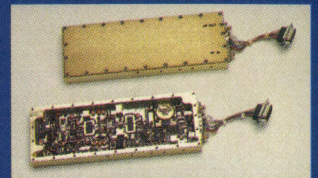
Plug in type for easier maintenance, 30-960MHz, up to 350 Watts per channel



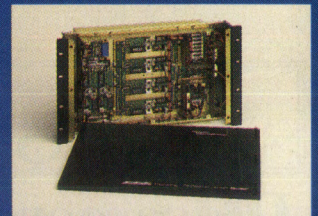
Feed forward amplifier for multichannel use, 800-960 MHz, up to 1000 Watts peak power



Linear amplifier module for cellular, 800-960 MHz, 25 Watts P.E.P.



High power RF amplifiers for paging and SMR 30-960 MHz, up to 500 Watts



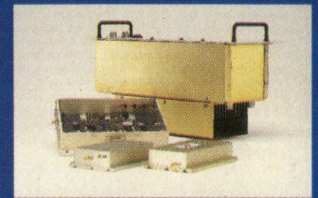
Plug in amplifier for analog cellular 869-894 MHz, 45 Watts



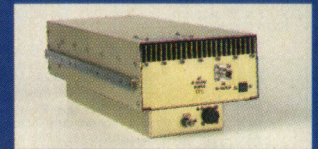
Broad band amplifier for lab and EMI/RFI testing, 1-512 MHz, 50 Watts class A



Wide Band linear amplifier modules for multiband transceivers, EMI/RFI test, medical and cellular repeaters. 20-550 MHz, 150W; 500-1000 MHz, 120W; 800-960 MHz, 300W



Electronic counter measure test set for U.S. Navy UHF, 150 Watts, 2.9-3.5 GHz, 40 Watts



UHF high power amplifier for SATCOM and LOS 225-400 MHz, 250 Watts FM, 100 Watts AM



RF design 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 Michael Applegate at (404) 618-0217 today.

RF recruitment

IOWA MIDWEST
RF/MICROWAVE WIRELESS
WORK WITH AN RF ENGINEER IN YOUR MOVE TO THE MIDWEST!

My clients need top-notch RF Design Engineers and Managers, 3 to 10+ years experience, HF to 3.0 GHz, Receivers, Transmitters, Power Amplifiers, Synthesizers, Spread Spectrum, ASIC/MMIC Design, Modems, Communications DSP.

DON GALLAGHER MSEE

Phone: 319-895-8042 Fax: 319-895-6455
1145 LINN RIDGE RD. MT. VERNON, IA 52314
40 YEARS OF RF ENGINEERING, MANAGEMENT, AND PLACEMENT OF ENGINEERS

INFO/CARD 60

MARKETPLACE
404•618•0217

RF career opportunities

...YOUR CAREER

Cellular Engineers: Design/develop RF and analog circuits for high capacity cellular systems. Requires minimum of 2 years experience in any of the following: DSP, ASIC Design, Cae Development, Digital Modulation, Digital Mobile Communications, Channel Equalizers, Transmitter-Receiver Synthesizer or Audio Design, Digital Signal Processing.

Director R&D: One of the three largest suppliers of Microwave Digital Radios in the US. Common Carrier and Cellular markets is seeking an RF and Microwave circuit design engineer with the following minimum qualifications: MSEE or BSEE, 10 years experience in Microwave circuit design such as microstrip circuits, low noise amplifiers, power amplifiers, mixers, oscillators and RF circuits. Commercial experience in cost effective design and knowledge of digital communication theory is desirable.

Product Marketing Manager: Our client, a well known microwave firm, seeks an experienced professional to perform classical marketing functions for a product line: i.e., develop short and long term business plan, determine marketplace, etc. Excellent compensation package along with executive benefits.

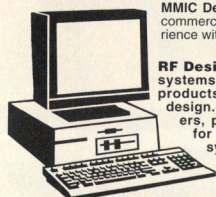
Design and Sr. Design Engineers: Design and develop advanced microwave subsystems and components for applications in communications; perform subsystem level design/analysis, design of up/down converters, and/or synthesized source design; MIC component design of amplifiers, filters, switches, limiters, mixers and oscillators, as required to support subsystem activities. Experience with customers, project engineering, and supervision desirable. Positions require a BSEE or equivalent, and min. 2 yrs. experience in microwave or RF design.

Filter Design Engineer: B.S. (prefer M.S. or Ph.D.). Minimum 3 years experience in the filter design and development of Broad Band, comb-line, strip line, interdigital, low pass and high pass filters, multiplexers, diode switches, (phase shifters), attenuators and microwave sub-systems desirable.

RFIC Design: MS or PhD in Electrical Engineering with minimum 5 years related experience preferred. The candidate should have a good knowledge and experience in Linear Bipolar High Frequency IC design and measurement techniques in design IC's like Amplifiers, Mixers, Oscillators, VCO's, Prescalers, Synthesizers, Limiting Amplifiers, etc. operating up to 2 GHz in Bipolar or BiCMOS technologies.

MMIC Design Engineer: Develop L/S band GaAs MMIC power amplifiers for commercial wireless communications. Requires: M.S. or BSEE, +2 years experience with GaAs MMIC design, simulation, packaging and test.

RF Design Engineer: Responsible for the design of analog and RF systems and circuits for consumer and commercial digital wireless products. Five to ten years experience in RF systems analysis and design. Experience with low-cost techniques for frequency synthesizers, power amplifiers, up/down converters and baseband circuits for digital communications systems. Must be able to derive RF systems and module requirements to meet overall performance and cost goals. Familiarity with time division duplex or CDMA a plus.



MICRO COMMUNICATIONS EXECUTIVE SEARCH

800 Turnpike St. • North Andover, MA 08145
We specialize in the placement of communications both nationally and internationally.
FOR THESE AND OTHER OPENINGS
CALL COLLECT: TEL: 508-685-2272 FAX : 508-794-5627

INFO/CARD 61

RF products & services

ANALOG & RF MODELS

SPIICE models from DC to 10 GHz
Full non-linear models including:
RF pin diodes, class C, opto, & logic.
We also do measurements and consulting.
Give us a call at (602) 575-5323

INFO/CARD 62

COMTRONIX SYSTEMS, INC.

CUSTOMIZED

SOLID STATE • HIGH POWERED • VHF/UHF

AMPLIFIERS

DESIGNED AND BUILT TO YOUR SPECIFICATIONS

UP TO 200 WATTS
HIGHEST QUALITY/BEST PRICES

CALL OR SEND FOR INFORMATION TEL 413/785-1313 FAX 413/739-1352

INFO/CARD 63

HIGH POWER 2 PORT SPLITTER AND COMBINER FM BAND 88-108 MHz

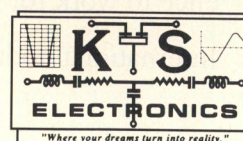
- 50 Ohm interface in all ports
- 600 watt power handling capability
- VSWR guaranteed less than 2:1

ALSO AVAILABLE:

- POWER SPLITTERS AND COMBINERS 2-30 MHz
- RF TRANSFORMERS UP TO 300 MHz

FOR MORE INFORMATION CONTACT RF POWER SYSTEMS
17827 N. 26th STREET PHOENIX, AZ 85032
PHONE 602 867-0389 FAX 602 971-9295

INFO/CARD 64



- STD. 5 AND 10 MHZ OCXO
- TCXO • VCXO • TC-VCXO
- VCO's • CLOCK OSCILLATORS
- CUSTOMIZED CRYSTAL FILTERS
- STD. 10.7 MHZ, 21.4 MHZ and 45 MHZ
- L/C FILTERS

Call or Fax requirements.

16406 N. Cave Creek Rd. #5
Phoenix, AZ 85032-2919
Phone & Fax (602) 971-3301

INFO/CARD 65

NOVA RF Systems, Inc. The Complete RF/Microwave Solution



- RF/Microwave Systems
- Custom Design/Consulting
- Simulation Software
- Synthesizers (PLL/DDS)
- Complete Lab/Machine Shop
- TDMA/CDMA/Spread Spectrum

International Inquiries Welcome

1740 Pine Valley Dr. Vienna, VA 22182
(703) 255-2352

INFO/CARD 66

O.E.M. Electronic Products

- Computerized • RF Systems
- Spread Spectrum Communications
- Custom, RF/Digital ASICs • 14 Year History
- Harris and Hitachi Authorized Design Center
- Complete, Fulltime Professional Staff

by: LOCUS, Inc

1842 Hoffman St., Madison, WI 53704
TEL 608/244-0500 FAX 608/244-0528

INFO/CARD 67

CAL CRYSTAL LAB., INC. • COMCLOCK, INC.

Need Clock Oscillators or Crystals? Call 1-800-333-9825 • 714-991-1580
Quartz Crystals 50Khz to 200Mhz

TTL Clock Oscillators 250Khz to 70Mhz

HCMOS Clock Oscillators 3.5Mhz to 50Mhz

Tri-State, Half Size and Surface Mount also available on request

Fast Service • 3 weeks or less
Special frequencies our specialty

1142 N. Gilbert, Anaheim, CA 92801 • FAX 714-491-9825

INFO/CARD 68

RSG-10 SIGNAL GENERATOR

The \$2495 profit generator
Quality crafted in the USA

Finally, a synthesized signal generator that's designed to help you generate more than just signals. The Ramsey RSG-10, is the signal generator you can afford, the signal generator that's designed to do what a signal generator is meant to do—provide a very stable, accurate, easy to control signal from 100 KHz to 1.0 GHz.

For the price, you wouldn't expect any more. But, there is more to the RSG-10. An intelligent microprocessor controlled/programmable memory, for example, can store up to 20 of your most commonly used test set-ups. And unlike other units, just one touch of the memory exchange button is all it takes to quickly shift from one test set-up to another. You get more work done, easier and faster.

At \$2495, the Ramsey RSG-10 is your profit generator.



RAMSEY ELECTRONICS

793 CANNING PARKWAY, VICTOR, NY 14584
Fax: (716) 924-4555
TELEX: 466735 RAMSEY CI

ORDER DIRECT—CALL 1-800-446-2295



INFO/CARD 69

RF help wanted

We're right on course

Technically-driven engineers don't just stay on course at Pacific Communication Sciences, Inc. (PCSI)... they define it. We are a San Diego-based leader in wireless communications and internetworking products. We seek individuals whose exceptional talent and ability will help us define the course of things to come.

Senior RF Systems Engineer/ Manager

Key technical leader of highly integrated radios for digital cellular and cordless applications. We are seeking an individual with a proven track record in developing small, low cost radios for consumer applications. The successful candidate will lead a highly talented team of engineers developing new architectures and approaches for future PCS and CDPD applications. Extensive experience with systems definition, analysis, and implementation of low cost miniaturized consumer RF products required. Must be able to derive RF systems and module requirements to meet overall performance and cost goals. Must have a thorough understanding of analog/RF

ASIC technology, modem signal processing, RF systems analysis and design. BSEE required; PhD preferred. Dept. RFS/JD.

RF/Analog IC Design Engineer

Will be responsible for designing Wireless Digital Cellular Mixed Mode ASIC's. Minimum of 4 years Bipolar/CMOS/BiCMOS experience in the complete ASIC design process. Experience in the development of Synthesizers, Mixers, A/D's, D/A's, S/H's, and Amplifiers. Knowledge of circuit design techniques in the frequency range from DC to 3 GHz, and top down design methodology using the latest in CAD tools. Experience designing for low power and low voltage highly desired, plus a record of successful design accomplishments. BSEE required; MSEE preferred. Dept. AIC/JD.

PCSI enjoys a vigorous intellectual environment marked by collaboration, freedom and urgency. Please respond using the appropriate dept. for the position you wish to be considered for and



send resume to: PCSI, Attn: Professional Staffing, 10075 Barnes Canyon Road, San Diego, CA 92121. Fax: 619/535-9235. Internet mailbox: careers@pcsi.com Equal Opportunity Employer/Smoke-Free Environment.

PCSI®
A Cirrus Logic Company

Telepoint Systems Division

RF ELECTRICAL ENGINEERING OPPORTUNITIES

Motorola's Telepoint Systems Division is the world leader in the development and manufacture of next generation cordless telephony products and personal communications systems. To support our continuing efforts to enhance our product portfolio, and expand upon our technological leadership, we are seeking qualified RF Electrical Engineers for the following opportunities at our **Fort Worth, Texas and Plantation, Florida** facilities:

Fort Worth, Texas

Responsibilities include the design and implementation of RF systems for FDMA and TDMA systems. Job duties will include direct implementation of RF modules from specifications, maximizing product reuse and taking the design from concepts through production. Qualified candidates will possess a B.S. degree in Electrical Engineering (or equivalent) and a minimum of 3 years RF design experience. Knowledge of Digital modulation techniques, RF design and test methods from 900 MHz to 2GHz is required. Experience with Mentor's Schematic entry and simulation tools is desired.

Plantation, Florida

Responsibilities include the design and implementation of a transceiver system for next generation, full duplex TDMA cordless telephony products and systems. Job duties include direct implementation of RF/IC designs from concept through production. Qualified candidates will possess a B.S. degree in Electrical Engineering (or equivalent) and a minimum of 3 years RF design experience. A working knowledge of digitized voice (PCM or ADMCP) implementation, digital modulation schemes and RF design experience at 2GHz is preferred.

Motorola rewards talent and dedication with excellent salaries, comprehensive benefits and outstanding growth opportunities.

To find out more about joining the team that's making it happen in the communications industry, please send resume with salary expectations to:

B.J. Simo, Motorola Telepoint Systems Division, 8000 West Sunrise Blvd., Room 1304, Plantation, FL 33322.

An equal opportunity/affirmative action employer. We encourage minority, female and disabled candidates to apply.



MOTOROLA
Advanced Electronics for
A More Productive World.


INFO/CARD 71

Reprints: Available and Invaluable

You can order reprints of any article that appears in any of RF DESIGN's regular issues. Reprints make effective sales tools, develop strong direct mail campaigns and can educate your sales force. Reprints are also great for distributing at trade shows and conferences to generate interest from your target audience with informative and attention-getting copy. Reprints are available in standard or customized formats.

Minimum order: 100

For more information and orders, phone Ed LaBorwit, Reprint Sales Manager, at (404) 618-0481.



*Branch into direct marketing
to promote your product or services.
Rent the circulation file of this publication
to reach responsive decision makers.*

A
ARGUS

Call Renae Sutherland (404) 618-0154
Diane Johnson (404) 618-0391

6151 Powers Ferry Road • Atlanta, GA 30339
Fax (404) 618-0347

RF software

Digital Modulation Simulation

Tektronix has released the latest version of IQSIM, an MS-DOS software package developed by Rhode & Schwarz that simulates digital modulation standards such as GSM, DECT, CT-2, PHP and PCS. IQSIM also allows the generation of digital signals with custom combinations of coding, filtering and modulation. The software can be used with the Rhode & Schwarz ADS arbitrary waveform generator and SMHU.58 signal generator. IQSIM comes standard with the ADS waveform generator, which is priced at \$14,210.

Tektronix
INFO/CARD #199

Inductance, Resistance and Current Solver

A new multi-plane inductance, resistance and current solver from the CAE Division of Contec Microelectronics allows designers to solve planar structures with greater accuracy and speed than alternative solutions. The geometries to be studied by ContecPLANE can be entered textually or can be imported from AutoCAD™ DXF files. ContecPLANE outputs current distribution plots and reduced n-port SPICE sub-circuit models. The pro-

gram is available now in versions for the Sun SPARCstations and HP9000 Series 700 workstations. Licenses for the stand-alone version of ContecPLANE start at \$15,000.

Contec Microelectronics U.S.A.
INFO/CARD #198

Coverage Prediction

EDX Engineering has released version 1.2 of MCS™. This IBM-PC compatible program predicts multipath degradation of digital broadcast signals. It can explicitly take into account reflections from buildings and other surfaces to model the amount of digital pulse distortion or "spread" which directly lead to bit errors in the digital signal.

EDX Engineering, Inc.
INFO/CARD #197

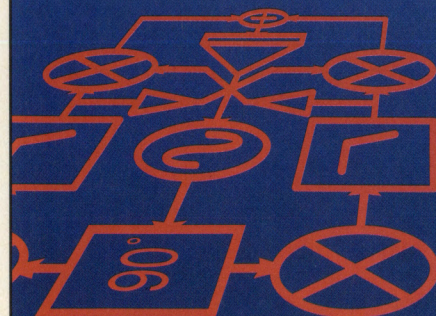
Schematic Capture/Copper Pour for AutoCAD

CAD Design Services is an authorized third party developer of software for AutoCAD. Their schematic capture software generates parts lists and net lists in varied formats. Gerb2CAD brings any Gerber file into AutoCAD, and the user can pour copper or produce Gerber output with GerbArt.

CAD Design Services, Inc.
INFO/CARD #196

TESLA

Award Winning Communications Simulation



"You have no idea how much effort this package has saved me." — A.C. Brookfield, CT



Microwaves & RF and Spread Spectrum Scene have each awarded TESLA top honors for its contributions to RF engineering. What makes TESLA so special? It's simple and easy to use, yet it has the power you need. Does full nonlinear, mixed analog & digital simulation. Built-in spectrum analysis shows you the results. You get the best tech support in the business and a 30-day trial. At \$695 it's a steal! Ask about TESLA's powerful options. **Why not see for yourself? Call:**

800-631-1113
U.S. and Canada

Intl: 404-751-9785 Fax 404-664-5817
TESOFT Inc. PO Box 305, Roswell GA 30077

RF advertising index

ADVERTISER.....PAGE #	ADVERTISER.....PAGE #
Ameritron.....46	Micro Communications.....60
Amplifier Research.....10	Executive Search.....59
Analog and RF Models.....60	Milcom.....59
Arrowsmith Shelburne.....50	Mini Circuits.....2, 4-5, 45, 49
Bal Seal Engineering.....51	Motorola.....62
Cad Design Services.....65	Nova Engineering, Inc.....14
Cal Crystal Lab., Inc.....61	Nova RF Systems, Inc.....61
California Eastern Labs.....35	Odetics.....31
Compact Software.....24-25	Pacific Communication Sciences Inc.....61
Comtronix.....60	Penstock, Inc.....11, 53
Daico Industries.....6	Power Systems Technology.....69
Eagle.....41	Programmed Test Sources.....27
Eagleware.....65	Q-Bit Corp.....30
Electro Dynamic Crystal.....30	Qualcomm.....20
Emhiser Research.....55	Rakon.....57
Equipto Electronics Corp.....67	Raltron Electronics Corp.....51
Gallagher & Associates.....60	Ramsey.....61
Giga-tronics Inc.....12-13	RF Power Systems.....60
Henry Radio.....46	Richardson Electronics.....15, 17, 19, 21
Hewlett Packard MCG Marcom.....29	Rogers Corporation.....33
IEEE - EMC.....66	Silicon Valley Power Amps.....36
IFR Systems Inc.....3	Sprague Goodman Electronics.....43
Int'l Crystal Mfg.....37, 65	Synergy Microwave.....23
Jan Crystals.....41	Temex Electronics.....16
JFW Industries.....47	Tesoft, Inc.....63
Kalmus Engineering.....9	Toko America, Inc.....32
KS Electronics.....60	Vectron Labs, Inc.....37
Locus, Inc.....61	Werlatone, Inc.....8
M/A Com (3 Divisions).....70	Wide Band Engineering Co., Inc.....39

RF Design Software

Programs from *RF Design* provided on disk for your convenience

April Program — RFD-0494

"NPOLE Helps Design Phase-Shift Networks" by R. Dehoney. Program aids in design of single- and multi-pole allpass networks that make up constant phase difference networks. (Programs are in BASIC, should run on any MS-DOS PC)

March Program — RFD-0394

"Program Uses Two-Port Models for Design of Small-Signal Amplifiers" by Christopher Buckingham. Program is a Spice accessory, to assist in the study and design of small-signal amplifiers prior to a full analysis in Berkeley Spice. (Requires VGA, will run on 80286/386/486 class MS-DOS PCs)

NOTE! New Pricing (as of March 1):

Monthly program disks:

\$25.00 (US/Canada)
\$30.00 (foreign)

Yearly disk sets, available for 1989 through 1993: Order #RFD-(year)-SET

\$120.00 (US/Canada)
\$135.00 (foreign)

Special!

All five years' sets (1989-1993) at a package price:
\$500.00 (US/Canada)
\$575.00 (foreign)

Annual Subscriptions are offered — get every program for a year:

\$170.00 (US/Canada)
\$220.00 (foreign)

All prices include shipping

All orders must be pre-paid by check, money order, or major charge card. All checks must be in US dollars and payable to a bank located in the U.S.

**RF Design Software
Argus Direct Marketing Dept.
6151 Powers Ferry Rd., NW
Atlanta, GA 30339-2941**

**Tel: (404) 618-0219
Fax: (404) 618-0347**

RF literature

Test, Measurement Catalog

Tektronix's 1994 catalog provides comprehensive test and measurement product specification information for electronic users in digital design, general purpose, telecommunications, television, industrial, and semiconductor markets. Also listed are Advantest RF microwave and telecommunications products and Rohde & Schwarz test and measurement instruments as Tektronix is their sole distributor in North America.

**Tektronix
INFO/CARD #200**

Capabilities Brochure

This brochure features Taconic Plastics, Ltd. copper clad, PTFE woven glass substrates. They also offer TLY, TLT, TLX, TLC, and TLE laminated lines. Their products are used by various commercial and military microwave systems including phased array antennas, mobile communication, radar systems, microwave test equipment and transmission devices and RF components.

**Taconic Plastics, Ltd.
INFO/CARD #201**

SPICE Newsletter

Intusoft's free February newsletter covers SPICE circuit simulation programs that model photodiodes and vacuum tubes. The tubes' subcircuits include vacuum triode and pentode models and provides models for the 12AU7A and EL9000. Two models of photodiodes are presented; one for a specific part (Siemens BPW34).

**Intusoft
INFO/CARD #202**

Cellular Filter Data Sheet

K & L Microwave Incorporated offers a two page data sheet featuring specifications, plots and mechanical drawings for the K & L model #9FVSP-836.5/25 cellular bandpass filter.

**K & L Incorporated
INFO/CARD #203**

Low Noise Oscillators

A six page brochure gives detailed specifications on Vari-L Company, Inc.'s new VCO-190 series of 5 volt 10 mA surface mount low noise voltage controlled oscillators. Noise, power and modulation sensitivity plots are provided as well as detailed package and installation information. Thirty-five robotically assembled models are described for wireless designs spanning 45 to 3000 MHz. Devices with separate modulation ports are also described.

**Vari-L Company
INFO/CARD #204**

RF Product Catalog

Microelectronics's free 78-page catalog lists all their RF and Microwave capacitors.

**Microelectronics Ltd.
INFO/CARD #205**

Passive Components Catalog

Trilithic's new 93 page 1994 catalog details specifications and outline drawings on a variety of passive components in the frequency range of DC to 18 GHz. Components included are fixed and tunable filters; fixed, high-power, programmable, and variable attenuators; high-power loads; SPDT, SP4T, and SP8T programmable switches; and built-to order switching and control rack-mountable subsystems.

**Trilithic
INFO/CARD #206**

Filter Application Note

Webb Laboratories' four page application note demonstrates advanced capabilities of the AFDPLUS active filter design software. A Multi-octave 90 degree phase splitting network is designed and analyzed taking advantage of the user-defined pole/zero location files, transfer function math, macro and graphics capabilities incorporated with the AFDPLUS environment.

**Webb Laboratories
INFO/CARD #207**

EMC Accessories Catalog

A new 24-page free catalog from Hewlett-Packard describes transducers, antennas, preamplifiers and other electromagnetic compatibility (EMC) accessories that design engineers and test technicians need to evaluate their product design, or to equip a lab for conducted and radiated emissions compliance testing. It also includes an application guide for commercial and military measurements.

**Hewlett-Packard Company
INFO/CARD #208**

HP Microwave Test Catalog

An updated version of Hewlett-Packard's Microwave Test Accessories Catalog includes 1000 products for testing and characterizing components. The 88-page catalog is free

**Hewlett-Packard Company
INFO/CARD #209**

Pulse Generator Catalog

Avtech Electrosystems has introduced a new 16-page Update Catalog No. 8S2 which describes recently introduced high-speed pulse generators and laser diode drivers. Attention is given to DC to 10 MHz laser diode drivers, 10 MHz to 1.5 GHz laser diode bias tee modulation heads, 100 volt, 1MHz lab pulse generators.

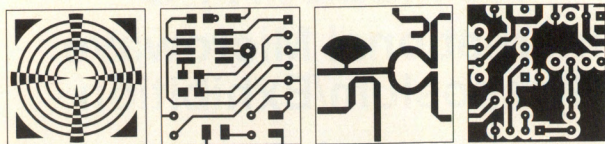
**Avtech Electrosystems Ltd.
INFO/CARD #210**

Electronic Control Brochure

Eaton Corporation highlights is offering a capabilities brochure which includes products for space vehicles, weapon systems, communications, and computer equipment.

**Eaton Corporation
INFO/CARD #195**

See Us at Booth 841: RF Expo West
PCB Design within AutoCAD



RF - Microwave - Analog - Flex

EPD - AutoSchem - Hybrid - GerbArt - Gerb2CAD - Pour

EPD - Electronics Packaging Designer: Adds an intelligent PCB layout tool to AutoCAD

- Pour complex ground planes (Pos or Neg)
- Automatic Parts, FAB, Rats, Netcheck, DRCs, etc.
- Advanced Edge Vector programs

AutoSchem - Finally! One that really works in AutoCAD

- Works inside EPD/PCB drawing for Auto-Annotation.
- Flexible format part list which updates schematic.

Hybrid Designer - MultiChip Module • Thick Film

- Automatic die, bond wire and bond patterns
- Works with EPD and AutoSchem

GerbArt Deluxe - AutoCAD ↔ Gerber Translator
Recommended by Gerber Systems

- Converts all AutoCAD variations
- Fast, Powerful and Automatic

Free shareware/demo disks!

phone: 408-462-6494

fax: 408-475-0738



CAD Design Services, Inc.

2806-C Soquel Ave., Santa Cruz, CA 95062

AUTOCAD IS A REGISTERED TRADEMARK OF AUTODESK, INC.

INFO/CARD 45

RF company index

A list of companies and institutions mentioned in this issue's editorial pages

Analog Devices	37, 42	Motorola Cellular	18
Analogic Corp.	44	Motorola Semiconductor	36, 44
Andrew Corp.	43	NIST	18
AT&T	22, 34	Noise Com	22
Avtech Electrosystems	64	North American Capacitor Company	20
CAD Design Services	63	Novatech instruments	43
Cellular One	22	Oxley Development Co.	20
Contec Microelectronics	63	Phoenix Microwave Corp.	44
Cubic Corporation	20	Piezo Technology Inc.	42
Eaton Corporation	64	Pole Zero Corp.	42
EDX Engineering, Inc.	63	Polyflon Company	18
EIP Microwave	44	Raltron Electronics Corp.	46
ENI	44	Raytheon Semiconductor	18
Fil-Mag, Inc.	20	Rohde & Schwarz	18
Flam & Russell	18	RF Industries Ltd.	43
Frost & Sullivan	18	RF Power Systems	44
Harris Broadcast	22	Shawinigan Research & Technology	18
Hewlett-Packard Co.	37, 64	Softwright, LLC	22
Hitachi	36	Sonnet Software	20
Huber+Suhner AG	43	Stanford Research Systems	42
Hyperlabs, Inc.	44	Superconductivity, inc.	18
Insulated Wire, Inc.	43	Svetlana Electron Devices	44
International Telecommunications Union	18	Taconic Plastics	64
Intusoft	64	Technitrol, Inc.	20
ISRO Space Applications Centre	63	Tektronix	18, 63, 64
ITT GTC	34	Telecom Analysis Systems	43
Johnstech International	18	Teledyne Electronic Technologies	22
Jones Interchange	22	Tele-Quartz GmbH	43
K&L Inc.	64	Temic Telefunken Microelectronics	36
Kilovac Corp.	46	Tesoft	22
KW Microwave	46	Trilithic	64
Leica Inc.	18	Tru-Connector Corp.	43
LPKF CAD/CAM Systems	20	TriQuint Semiconductor	34
Magnavox Electronic Systems	18	Wavetek	22
Merrimac Industries	44	Vari-L	42, 64
Microelectronics Ltd.	64	Veritech Microwave, Inc.	44
MIL-3, Inc.	22	Virginia Polytechnic Institute & State Univ.	22
Milliren Technologies	43	Voltronics International	46
Mini-Circuits	44	Webb Laboratories	64
Mitsubishi Electronics America, Inc.	44	Wilton Company	38
Monsanto Metalized Materials	20	Zenith Electronics	18



RELIABILITY & ACCURACY.

Precision Quartz CRYSTALS

70 KHz to 200MHz.

ICM is a major supplier to the commercial, communications, industrial, and O.E.M. crystal markets.



INTERNATIONAL CRYSTAL MFG. CO., INC.

10 N. Lee • P. O. Box 26330

Oklahoma City, OK 73126-0330

Phone (405) 236-3741 • FAX (405) 235-1904

Toll Free Phone 1-800 725-1426

24 Hour Toll Free FAX 1-800 322-9426

INFO/CARD 46

NEW BOOK HF FILTER DESIGN & COMPUTER SIMULATION

by Randall W. Rhea

is a complete design guide for L-C, machined and printed filters for RF and microwave applications. Going beyond theory, it takes design from concept through fabricated units with photos and measured results. It's a must for filter designers!

TRANSFORMS

HP/BP/Bandstop
Conventional plus
narrow, Blinchikoff,
tubular, symmetric
zig-zag, Richard's,
Norton's, Kuroda's,
general k & Q

PRACTICAL ISSUES

Unloaded Q
Discontinuities
Radiation
Tolerances
Rapid prototypes
Manufacturing
Tuning techniques

MODELS

Caps & Inductors
T-lines
Resonators
Substrates

CAE TECHNIQUES

Synthesis
Simulation
Optimization
Statistical

DISTRIBUTED

End, edge,
hairpin, combline,
interdigital, stub,
elliptic, step-Z,
evanescent

448 pages, 180 illustrations, 61 tables, 301 equations

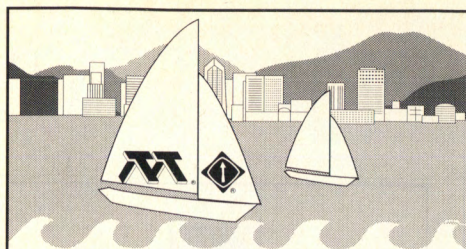
NOBLE PUBLISHING

TEL (404) 908-2320
FAX (404) 939-0157

\$59

CALL OR FAX
FOR ORDER FORM

INFO/CARD 47



Waves and Microwaves

Register Early!

1994 IEEE MTT-S International Microwave Symposium/Exhibition

May 24-26, 1994 San Diego, CA

■ An Outstanding Technical Program of Full Length, Short Papers and an Open Forum

Featuring Sessions on:

Biological Effects and Medical Applications • Passive Components • Filters and Multiplexers • Ferrite Components • Acoustic and Surface Wave Components • Sources and Control Components • Non-Linear Modeling and Analysis • Transistor Power Amplification • High Power Sources and Control Components • Low Noise Detectors and Receiver Technology • Microwave Integrated Circuits • Monolithic Circuits and Modules • Millimeter Wave Technology; Submillimeter Wave Techniques and Devices • Field Theory • EM Analytical and Numerical Techniques • CAD Procedures, Techniques, and Modeling • Guided Waves and Propagation Characteristics • Measurement Theory and Techniques • Microwave and Communication Systems • Phased Arrays • Lightwave Technology and Techniques • Superconductivity Technology • Manufacturing Methods, Production Techniques and Packaging • Active and Quasi-Optic Antennas; Digital Signal Processing

■ The World's Largest Microwave Exhibition

Visit the displays of more than 300 microwave component, device, instrumentation, material, and sub-system suppliers.

■ Full Social Program

Spouses' tours, an exhibitor reception and the MTT-S Awards Banquet provide a memorable complement to the industry's premier event.

■ Special Workshops and Panel Sessions

Accuracy in Materials • CAD Engineering Applications of Electromagnetic Field Solvers • Ultra Low Noise in Amplifiers — Part II • Measurement of Noise in Amplifiers • High Power Microwave Processing of Design of Superconducting Microwave Components • On-Wafer Measurements • Lightsats: Microwave Technology Requirements and Opportunities • High Power Superconducting Microwave Technology • CAD of Microwave Systems • Circuit Level Design and Modeling of Quasioptical Circuits and Systems • Millimeter-Wave Technology Applications in Automobiles • Emerging Millimeter-Wave Technologies • Interconnect and Packaging Technologies and Issues • Designing Signal Processing MMIC's for Commercial • Communications Systems • Wireless Communications I — Circuits and Components • Filters for Mobile Communications Network • Wireless Communications II — Systems and Applications • Power MMICs for Commercial Applications: Real Products for a Change • Design and Producibility of Ferrite Components • Microwave & Millimeter Wave IC Interconnect Technology • Circuit Design With Direct Optimization-Drive Electromagnetic Simulators • Low Noise Amplifier Linearity • Software Law From an Engineers Perspective

■ Register Now

Send now for the program, advance registration and hotel reservation forms. Complete the coupon below and return it to the *Microwave Journal*®
685 Canton St.
Norwood, MA 02062

Symposium Program on Electronic Bulletin Board

The full 1994 MTT-S Symposium Program will be available from a computer bulletin board at the Horizon House Publications office after February 15, 1994. Access and downloading is available to personal computers

with communications packages and modems. The file is in a self-extracting compressed format. It should be copied to a hard drive and will self-extract when run.

Phone No.: (617) 769-9901
Rate: 2400 baud

Stop bits: 1
File name: MTTs94.EXE

Data bits: 8
Parity: none

National Telesystems Conference

(held concurrently with the 1994 MTT-S International Microwave Symposium and Exhibition)

Sessions Include:

Dual-Use Technology Applications
Advanced Technology for Telesystems
Aircraft Navigation/Landing Systems
Communications Systems & Networks
Infrared Imaging Systems

Transportation Systems
Active Array Radar Systems
Acoustic Array Systems
Satellite Communications Systems
Space Navigation Systems

Environmental Sensing Systems
Telerobotics/Unmanned Vehicles
Tethered Systems & RPV's
Simulation & Systems Modeling

Contact: National Telesystems Conference General Chairman, John B. Horton
TRW, One Space Park, M/S R5/1070, Redondo Beach, CA 90278, Fax: (310) 812-7111

☐ Yes, I would like additional information on attending MTT-S '94. Please send it to:

Name _____ Title _____

Organization _____

Address _____

City _____ State _____ Zip _____

Country _____ Telephone _____

Are you an MTT-S member? Yes ☐ No ☐

Have you ever attended MTT-S before? Yes ☐ No ☐ How many times? _____

Microwave Journal® 685 Canton Street, Norwood, Massachusetts 02062

RFD

SERIES BHE/BHC...
SOLID STATE AIR-COOLED AMPLIFIERS...

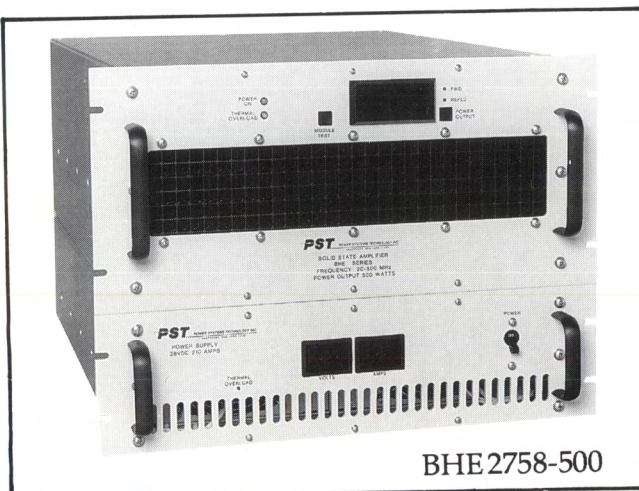
CLASS AB LINEAR OPERATION...
HIGH RELIABILITY, LOW MTTR...

**FEATURING OUR ULTRA-BROAD
BANDWIDTH MODEL BHE 2758-500:
20-500MHz, 500 WATTS...**

State-Of-The-Art **PST**
Solid State Power From

Series BHE/BHC amplifiers are available in a full selection of frequency ranges from 1.5-30 MHz to 1400-1800 MHz, with output powers from 100 to 1000 watts. The ultra-broad bandwidth Model BHE 2758-500 is particularly noteworthy for its instantaneous frequency coverage from 20 to 500 MHz and its high power boost

capability: from 1 milliwatt to 500 watts - making it especially suitable for many applications such as EMI/RFI susceptibility tests, VHF and UHF communication, EW and ECM jamming, radar pattern testing, and laboratory calibration testing.



All Series BHE/BHC models include important state-of-the-art design and high performance features such as: connectorized, modular circuit elements that are pre-aligned and field replaceable; integral protection against thermal overload, input/output overdrive and load VSWR; graceful degradation; built-in

test diagnostics. Their wide bandwidths make them ideal for use in multi-octave, frequency-agile systems, totally unattended or remotely computer controlled. Optional IEEE bus interface for remote operation is available.

*Write or call for complete BHE/BHC information - ask for
Product Data 2010 - or to inquire about our many other
standard and custom amplifier designs: Class A, C, narrow band
and pulsed; power outputs up to 10KW; frequencies up to 8.4GHz.*

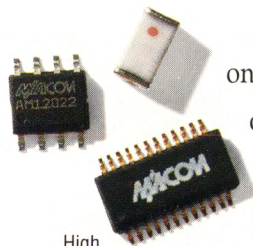
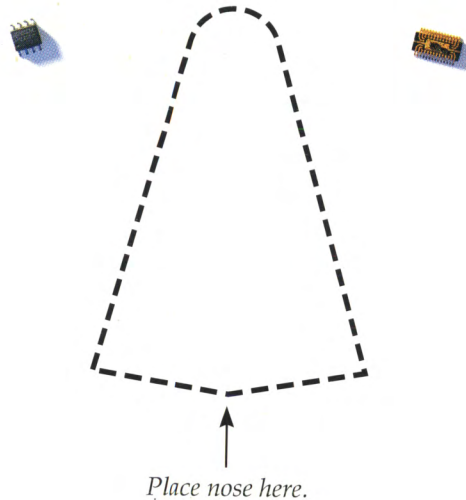
PST

A SUBSIDIARY OF COMTECH
TELECOMMUNICATIONS CORP.

POWER SYSTEMS TECHNOLOGY INC.

105 BAYLIS ROAD, MELVILLE, NY 11747
TEL. 516-777-8900 • FAX 516-777-8877

Now, To See All The Advanced Features Of Our Wireless Components, You'll Have To Take A Closer Look.

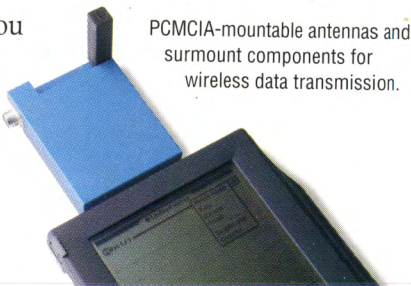


High performance, low-cost MMICs and RF chip sets.

It's easy to see why M/A-COM is one of the world's leading manufacturers of wireless components.

Of course, we're experts at making ever smaller, lighter components that consume less power. But that's just one of the reasons you should be working with us.

Take our wide range of component solutions. Everything from GaAs and silicon MMICs to transceiver chip sets. Which means that no matter what type of wireless portable product you are producing—handsets, PDAs, computers, bar code scanners, whatever—chances are, we've got the components that can help you get to your market faster.



PCMCIA-mountable antennas and surmount components for wireless data transmission.

Another advantage to doing business with M/A-COM is our experience with both analog and digital technology.

What's more, our in-depth knowledge of RF and microwave technologies is vital to helping our customers get products right the first time. And you'll be pleased to find that M/A-COM components are always priced very competitively.

To see how our tiny components could make a big contribution to your success, call M/A-COM today at 1-800-366-2266, or the distributor nearest you. In Europe, +44 (0344) 869 595. In Asia, +81 (03) 3226-1671.



Components for cellular handsets, PCN and private radio networks.



INFO/CARD 50