rf design

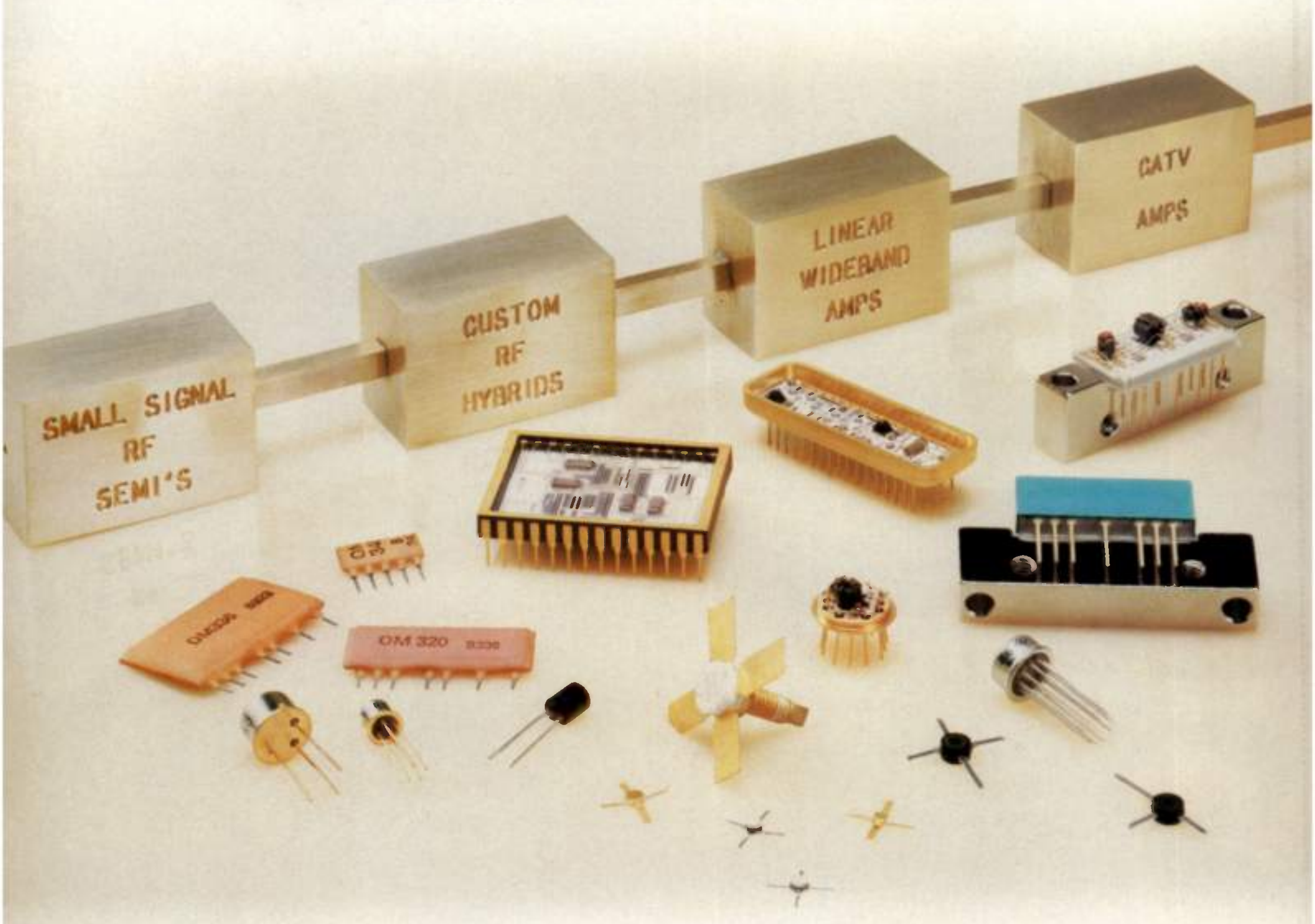
ideas for engineers

September 1985

Special Report:

The New Look in RF Circuits — Packaging

In advanced RF products, one name stands out.



Amperex produces RF small signal transistors, standard linear wideband amplifiers, and custom RF hybrids for communications, instrumentation, and military applications.

For over two decades, we have been a leader in the advancement of low noise semiconductor technology utilizing ion implantation, silicon nitride passivation, and titanium-platinum-gold metallization.

Amperex RF small signal transistors are available in metal cans, stud packages, ceramic X-paks, plastic X-paks, plastic T-paks and ceramic LID's.

Our linear wideband amplifiers and RF hybrids are designed for optimum high frequency performance. Backed by 15 years of thin film hybrid experience, our RF circuits are designed and manufactured to meet the requirements of all types of high reliability applications.

When your communications, instrumentation and military applications require RF products, look to Amperex, a name that stands out. Amperex Electronic Corporation, Slatersville Division, a North American Philips Company, Slatersville, RI 02876. Phone (401) 762-9000. TWX: 710-382-6332.

Amperex®

Modulation measurement reaches new peaks in performance

For sheer performance there is nothing to compare with the new Marconi 2 GHz Modulation Meter.

- Outstanding accuracy of ±0.5% on FM and ±1.0% on AM.
- Direct tuning to a known input signal, or set to automatic to locate any signal in a fast 500ms.
- A total measurement package that includes AM, FM, and phase modulation, frequency, noise, r. f. power, frequency response and signal to noise ratio. Options provide distortion and weighted noise measurements.
- A non-volatile memory, built-in auto-calibration, extensive self-diagnostic facilities, and optional GPIB interface . . . all further reduce test time and cost of ownership.

A MODULATION METER THAT'S A COUNTER, R.F. POWER METER AND AUDIO ANALYZER

This latest modulation meter from Marconi reaches new peaks in performance, and sets new standards in value-for money. Call Marconi to evaluate how cost-effective the new Marconi 2305 will be for you.

ANOTHER GIANT!
Price Now.... $6,500
Delivery Stock

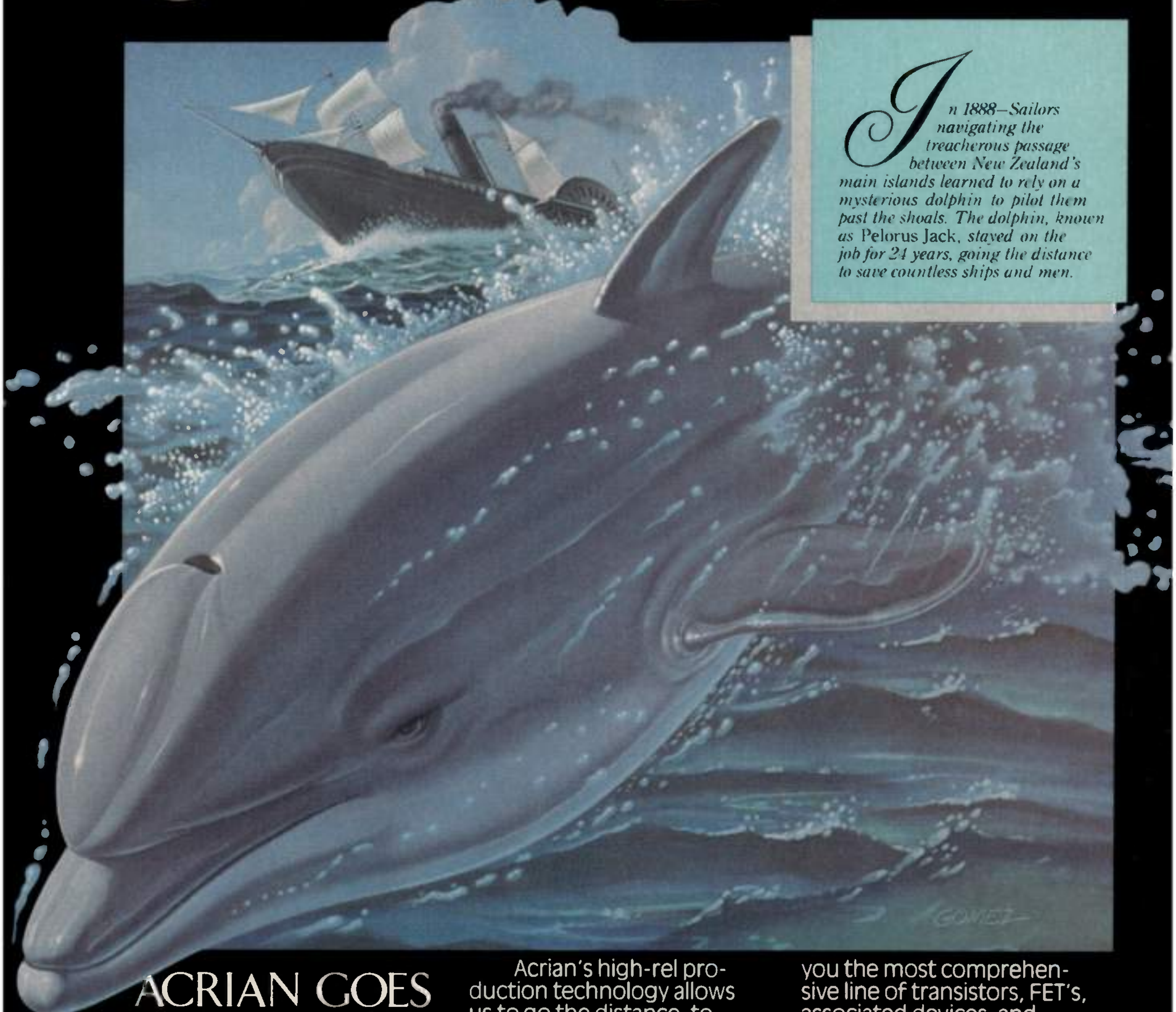
marconi instruments

U.S.: 3 Pearl Court, Allendale, NJ 07401
(201) 934-9050 (East) (714) 895-7182 (West)
U.K.: Longacres, St. Albans, Herts AL4 0JN
Country Code 44 (0727) 59292. TELEX 23350
FRANCE: (1) 687-36-25 GERMANY (089) 845085

N2305A -1

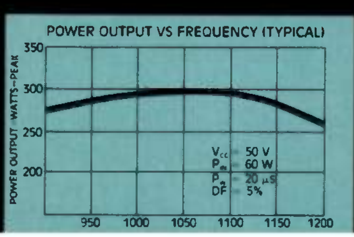
INFO/CARD 2

GOING THE DISTANCE



In 1888—Sailors navigating the treacherous passage between New Zealand's main islands learned to rely on a mysterious dolphin to pilot them past the shoals. The dolphin, known as Pelorus Jack, *stayed on the job for 24 years, going the distance to save countless ships and men.*

ACRIAN GOES THE DISTANCE IN HIGH-REL PRODUCTION CAPABILITY



Acrian's high-rel production technology allows us to go the distance, to meet the toughest military requirements with consistently high repeatability.

Here's a good example—the TAN250A, delivering 250 watts of pulsed power across the entire 960–1215 MHz TACAN band. With features like gold metalization, gold controlled-loop wire bonding (256 bond wires), low thermal resistance, and a hermetically sealed package. To date, we've delivered more than 75,000 worldwide.

Thanks to our production technology, we offer you the most comprehensive line of transistors, FET's, associated devices, and higher-level assemblies from 2MHz to 4.5 GHz—and beyond.

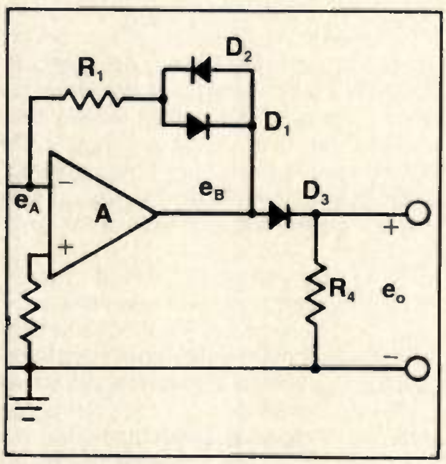
To get complete information on the TAN250A or any of more than 500 Acrian products for communications, radar, and avionics, call (408) 294-4200 or TWX (910) 338-2172.

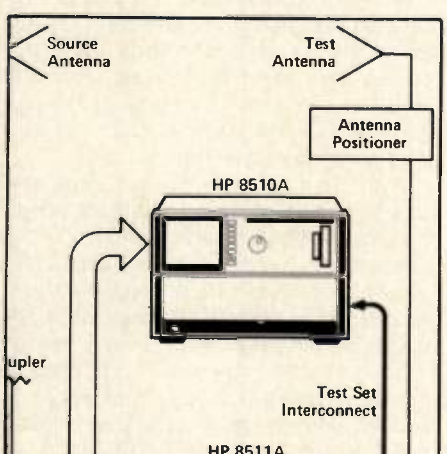
Acrian Inc. 490 Race Street
San Jose, California 95126

ACRIAN

rf design

September 1985





Cover

This month's cover features a representative sampling of Metaramics/W.R. Grace Co.'s line of advanced ceramic-metal packaging assemblies, including standard high power RF and microwave designs and custom designs for Gallium Arsenide, Indium Phosphide and specialized integrated circuit packaging.

Features

Departments

R.F. DESIGN (ISSN: 0163-321X USPS: 453-490) is published monthly plus one extra Issue in August. September 1985, Volume 8, No. 9. Copyright 1985 by Cardiff Publishing Company, a subsidiary of Argus Press Holdings, Inc., 6530 S. Yosemite Street, Englewood, CO 80111 (303) 694-1522. Contents may not be reproduced in any form without written permission. Second-Class Postage paid at Englewood, CO and at additional mailing offices. Subscription office: 1 East First Street, Duluth, MN 55802, (1-800-346-0085). Domestic subscriptions are sent free to qualified individuals responsible for the design and development of communications equipment. Other subscriptions are: $22 per year in the United States; $29 per year in Canada and Mexico; $33 (surface mail) per year for foreign countries. Additional cost for first class mailing. Payment must be made in U.S. funds and accompany request. If available, single copies and back issues are $5.50 each (in the U.S.). This publication is available on microfilm/fiche from University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106 USA (313) 761-4700.
POSTMASTER & SUBSCRIBERS: Please send address changes to: R.F. Design, P.O. Box 6317, Duluth, MN 55806.

rf editorial

Growing With The Industry We Serve

James N. MacDonald
Editor

Gary Breed joins our staff this month as Technical Editor. He has been Chief Engineer at four radio and/or television stations during the past 10 years, and we look forward to the viewpoint he will bring to the magazine as a result of this experience. He also has published 13 articles in Broadcast Engineering, from which he has gained an understanding of the requirements of magazine writing. He will assist with staff written articles and will work with authors to prepare their manuscripts for publication.

The addition of a technical editor is part of a substantial increase in Cardiff Publishing Company's commitment to *RF Design* over the past year. First, the magazine went from bimonthly to monthly publication; now we have, in fact, doubled the editorial staff. The latter action is, of course, largely a consequence of the earlier decision. It is also a testimony to the correctness of that decision. There is far too much knowledge being generated in this field to be adequately exchanged every two months.

A business can grow for two reasons — in anticipation of a larger market or as a result of it. Usually both reasons are influential in the decision to expand, and this has been the case with *RF Design* magazine. Publisher Keith Aldrich's faith and understanding of the industry provided the impetus to double the publication frequency. The encouraging response of readers and advertisers has convinced us that the growth has just begun.

The growth of the magazine is not just due to the appropriateness of its content for our readers, although we take a great deal of pride in that content and know from reader comments that it is appropriate. We are part of the growth of the RF electronics industry, in general. We talk about this growth often, because there is much gloom in some parts of the general electronics industry. We want our readers to know that the slump is not industry-wide. Typical of the kind of news that crosses this desk almost every day is the following paragraph from a news release announcing that Raytheon Company's second quarter earnings were up 10.7 percent over a year ago.

"The company's improved performance for the quarter was generated principally by Electronics, Raytheon's largest business segment, which continued to be paced by defense electronics systems."

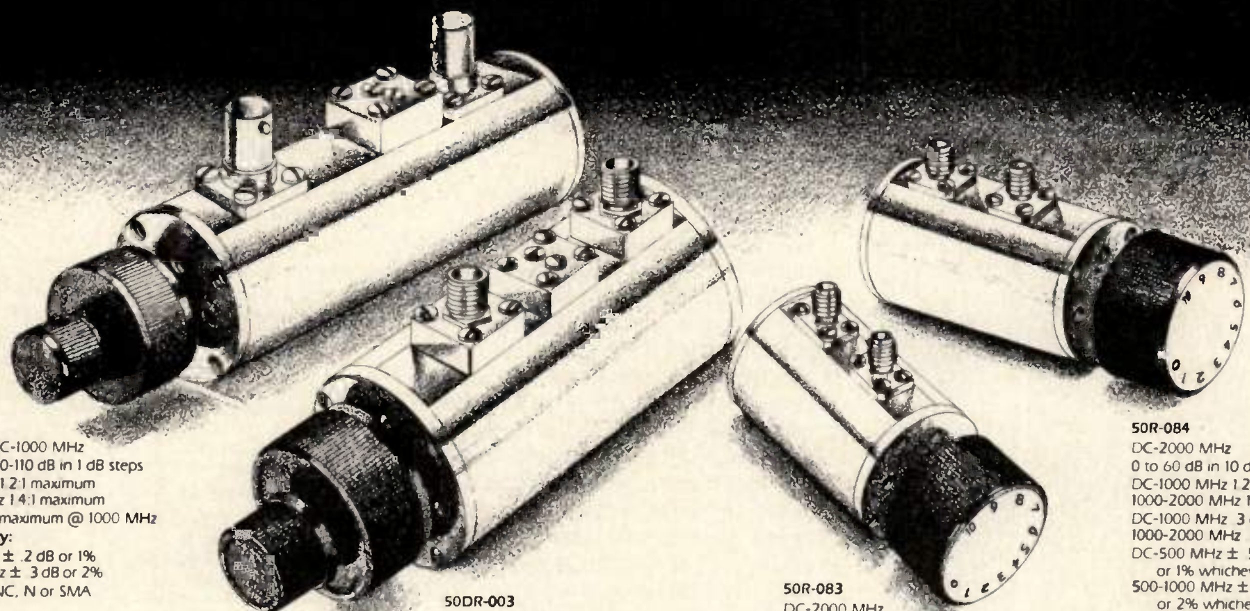
Most defense electronics systems operate in microwave frequencies, but we have mentioned before the increasing interest of the military in the lower frequencies. Other news releases tell similar success stories about commercial RF products. It is our observation that most companies are doing quite well, although some segments of their operation may be curtailed because the particular industry they serve is in a slump.

With this addition to the staff, *RF Design* will be able to expand the scope of its coverage of the electronics industry, and one expansion will be into economic news. In the near future you will see reports on economic activity in the RF sector, helping you keep up with trends.

Many of you will be receiving telephone calls and visits from Gary about technical matters. For you hams, Gary's call is K9AY. Mine, by the way, is NØFXB.

James N. MacDonald

ROTARY ATTENUATORS



lel: 50DR-001
juency Range: DC-1000 MHz
nuation Range: 0-110 dB in 1 dB steps
/R: DC-500 MHz 1.2:1 maximum
500-1000 MHz 1.4:1 maximum
rtion Loss: 5 dB maximum @ 1000 MHz
nuation Accuracy:
DC-500 MHz ± .2 dB or 1%
500-1000 MHz ± .3 dB or 2%
nectors: BNC, TNC, N or SMA

50DR-003
DC-1000 MHz
0-50 dB in 1 dB steps
DC-250 MHz 1.1:1 maximum
250-500 MHz 1.2:1 maximum
500-1000 MHz 1.4:1 maximum
.5 dB maximum
DC-250 MHz ± .2 dB
250-500 MHz ± .5 dB
500-1000 MHz ± 1.0 dB
BNC, TNC, N or SMA

50R-083
DC-2000 MHz
0-10 dB in 1 dB steps
DC-1000 MHz 1.2:1 maximum
1000-2000 MHz 1.4:1 maximum
DC-1000 MHz .2 dB maximum
1000-2000 MHz .4 dB maximum
DC-1000 MHz ± .2 dB maximum
1000-2000 MHz ± .4 dB maximum
SMA female

50R-084
DC-2000 MHz
0 to 60 dB in 10 dB steps
DC-1000 MHz 1.2:1 maximum
1000-2000 MHz 1.4:1 maximum
DC-1000 MHz .3 dB maximum
1000-2000 MHz .5 dB maximum
DC-500 MHz ± .5 dB
or 1% whichever is greater
500-1000 MHz ± .5 dB
or 2% whichever is greater
1000-2000 MHz ± .5 dB
or 3% whichever is greater
SMA female

'W Industries, Inc.
4 Commerce Square Dr.
ianapolis, Indiana 46237
7) 887-1340

INFO/CARD 5

HIGH POWERED!

Low Cost
Fast Delivery

JFW Industries, Inc.
5134 Commerce Square Dr.
Indianapolis, Indiana 46237
(317) 887-1340

Fixed Attenuators 1-5-10-30-50-100 watt
50F-xxx-N 1 watt DC-2GHz
50FH-xxx-5-N 5 watt DC-2GHz
50FH-xxx-10-N 10 watt DC-2GHz
50FH-xxx-30-N 30 watt DC-2GHz
50FH-xxx-50-N 50 watt DC-2GHz
50FH-xxx-100-N 100 watt DC-1GHz
xxx-insert attenuation value 1-30dB

INFO/CARD 5

rf publisher's note

Getting Ready For Tomorrow

By Gary Breed
Technical Editor

Publisher Keith Aldrich has given his space this month to RF Design Technical Editor Gary Breed for an introductory column.

In a lifetime, each of us may get only one or two opportunities to make a major impact in our chosen field, taking part in a major discovery or an important achievement. For many RF design engineers, such an opportunity will present itself in the next few years. Technological knowledge is still growing at an exponential rate, markets for RF-related products continue to expand, and the integration of RF functions into the design of traditionally non-RF equipment continues at a rapid pace. We need to be ready to meet the challenges which are coming our way, to be ready for the rare opportunity to make our mark.

To be able to make such a personal impact on the world of RF, the engineers and managers who are responsible for "getting the work done" need every available tool at their disposal. We all know that engineers need the support of current-generation test equipment, computers and software. We know that ongoing education in the field of RF is necessary. We know that advanced components are becoming available almost daily. But sometimes we forget that the human mind is still the most important tool in the creative design process, and the most important role of the human mind is *COMMUNICATION* with others.

This is where I have seen my own opportunity to make an impact in my chosen field. As Technical Editor, my primary duty will be to see that communication between engineers takes place. *RF Design* is an important participant in the exchange of ideas among the most capable minds in the field of RF: Your minds!

RF Design will be expanding its role in the coming months, with your help. I want to hear from you about your work, and the unique problems you have had to solve in achieving a successful design. In turn, I'll try to find out everything I can about the industry that might affect your work, and see that it is reported to you.

Just as there are no limits to the imagination of mankind, there are no limits on the applications of RF. The boundaries between analog and digital realms become blurred at high frequencies, as is demonstrated by GHz-speed logic devices which have 50-ohm input/output impedances. The combination of optical, digital, video, and RF functions in a single system has taken place in Local Area Networks and common-carrier telecommunications. Automotive electronics, test equipment, consumer electronics, as well as communications equipment will all have combinations of technologies in the future, and RF is the common denominator. We will be exploring in depth these areas of interface between RF and other technologies as our growth allows us to add to our present coverage of RF topics.

Start your own process of communications by sharing your ideas with us. Somebody has the need for your insight, and you can take advantage of the ideas of other engineers. Let's keep the lines open.

Gary Breed

Publisher
Keith Aldrich
Editor
James N. MacDonald
Technical Editor
Gary Breed

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

Sales Supervisor
Kathryn L. Walsh
Account Executive
Eric Nieman
Eastern Sales Manager
Douglas Markhouse
Advertising Services
Elizabeth Van Brocklin

Circulation Director
Pam Greenberg
Circulation Manager
Trish Shapiro
Circulation Assistant
Michelle Schwinghammer

Production Manager
Madeline Price
Assistant Production Manager
Mary Barr Felker

Artists
Carol Bates
David Hauschild
Maurice Lydick
Matt Park
Bill Schmitt

Composition
Jay Jarrett
Ellen Wilson

President
Robert A. Searle
Vice President
Judy L. Rudrud
Controller
Mike Drake
Operations Manager
Cherryl Greenman

Published by

CARDIFF
PUBLISHING COMPANY, INC.

6530 S. Yosemite St.
Englewood, CO 80111
(303) 694-1522

BPA

R.F. Design
Eastern Sales Office
167 South Broadway
Hastings on the Hudson, NY 10706
914-478-0909
914-478-4349

Member of Business Publications Audit of Circulations, Inc

Please address subscription inquiries to:
RF Design, Cardiff Publishing Company,
P.O. Box 6317, Duluth, MN 55806
Postmaster: send form 3579 to the above address.

50% smaller than you'd expect ...available now!

CTS Hybrid VCXO

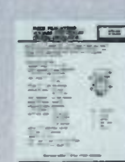
Actual size:
.860" x .830" x .350"

End the trouble of designing your oscillator— now you can specify this highly reliable CTS component!

Solve your space limitations and put an end to specifying a crystal and designing your own oscillator. This CTS hybrid VCXO comes in a package that is 50% smaller than usual—and you can simply specify and order the oscillator as you do any other component. Because CTS Knights Division *specializes* in precision crystal products, we have the largest staff of engineers in the industry. We even make our own crystals to assure precise uniformity.

This subminiature JKVXO-100 voltage controlled crystal oscillator is available today, with the specs listed here. Or, if you have a special application, we will customize a design to meet your requirements. Either way, you'll get traditional CTS reliability at very competitive prices.

WRITE TODAY for full specifications on this CTS subminiature crystal oscillator. Contact: CTS Corporation, Knights Division, 400 Reimann Ave., Sandwich, IL 60548. Phone: (815) 786-8411.



INFO/CARD 6

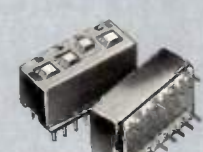
Specifications
JKVXO-100, Crystal Oscillator

Small Size	.860" x .830" x .350"
Wide Pullability	± 200 PPM minimum
Temperature Stability	0°C to +60°C ± 40 PPM
Center Frequency @ Room Temperature	± 10 PPM when shipped

CTS® MEANS RELIABILITY

CTS CORPORATION • ELKHART, INDIANA

Series CCXO-140 Leadless Chip Carrier Crystal Oscillator for surface mounting.
Phone: (815) 786-8411
INFO/CARD 61



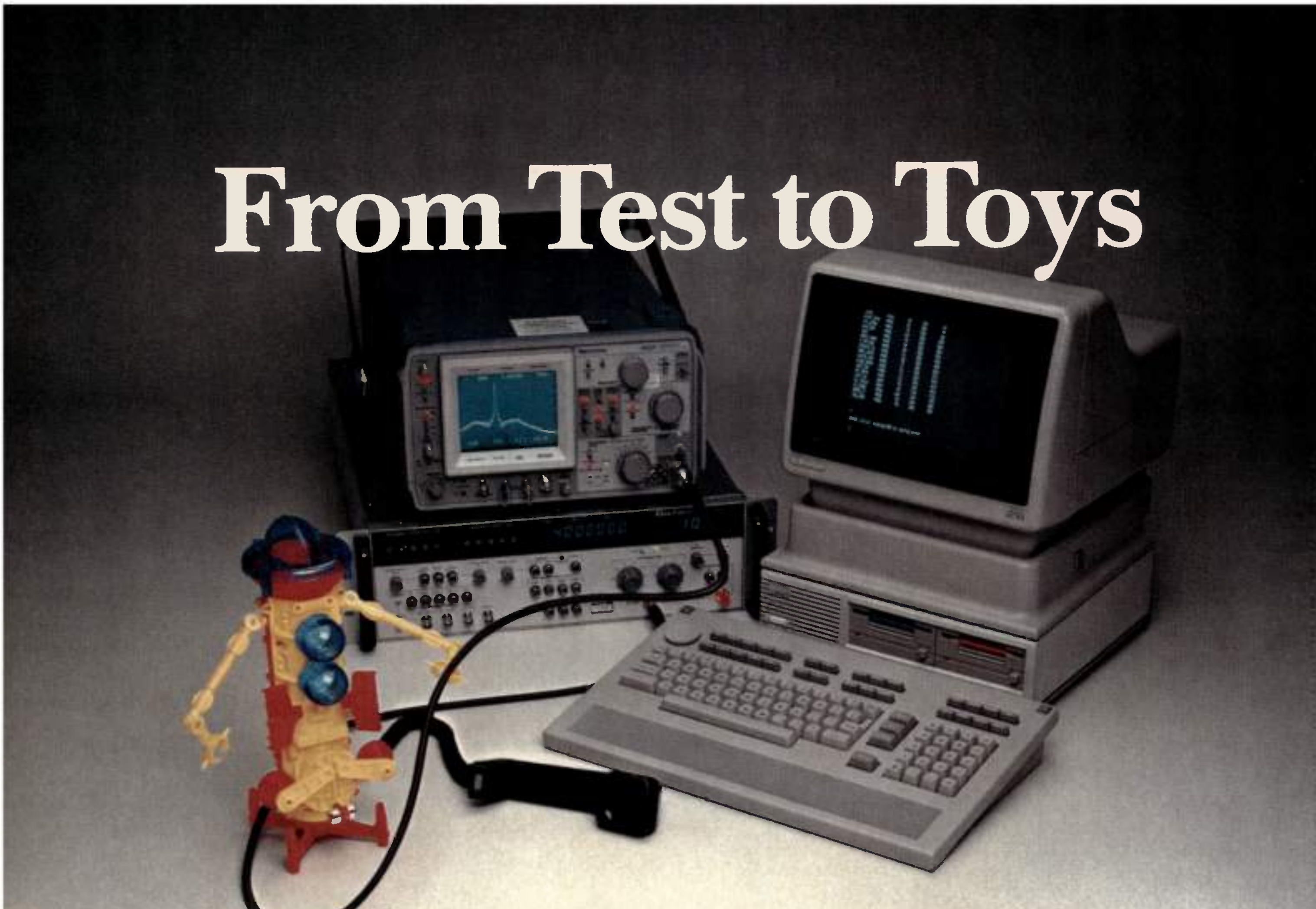
DIP Attenuator Switchable attenuator in standard DIP package.
Phone: (317) 463-2565
INFO/CARD 62

Printed Circuit Boards Complex double-sided and multilayer styles.
Phone: (415) 964-5000
INFO/CARD 63

Custom Crystal Oscillator with multiple integrated functions.
Phone: (815) 786-8411
INFO/CARD 64


One more reason
to buy Anzac!
ACKERLEY
ANZAC has just added
A.I. Grayzel
Unconditionally Stable
• Phase-Locked Sources
• Frequency Synthesizers
• Multipliers
to its own fine family of precision
components. Send for new data.
AMPLIFIERS • MIXERS • HYBRIDS • PASSIVES • CONTROL DEVICES • SUBSYSTEMS
Adams Russell
ANZAC DIVISION
80 Cambridge Street, Burlington, MA 01803 (617) 273-3333 TWX 710-332-0258
INFO/CARD 7

From Test to Toys



Plastic MMIC gain blocks. Avantek 4-Pac amplifiers. $1.80 each*.

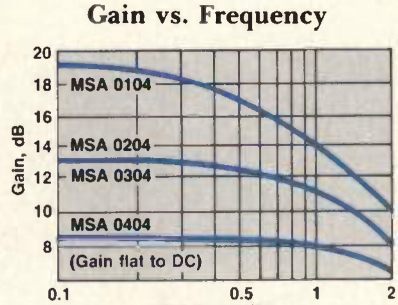
Avantek's series of MODAMP™ silicon monolithic microwave integrated circuit amplifiers are ready to drop into your 50-ohm circuit, with no design problems — virtually no concern for what comes before or after. These MMICs are unconditionally stable and provide cascadable gain blocks at any frequency up to 2 GHz.

4-Pacs are small (140 mil) plastic packages suitable for PC board or stripline applications in products ranging from instrumentation to toys, from fiber optic systems to mobile communications. They're simple to use and readily available.

Available in volume.

Avantek 4-Pac MODAMP MMICs are available today from your nearest distributor. Prices start at $2.75 and go to $1.80 in 10,000 piece quantities. Don't forget — because of their very wide operating range, the same amplifier can work from DC through video all the way up to 2 GHz. And you can stack them like building blocks to add whatever gain you need. Avantek innovation — designed to make your design job easier.

Gain vs. Frequency



*price in 10,000 piece quantities.

Avantek MODAMP MMICs are the most universal low-cost RF amplifiers available. Try some today. Contact your nearest Avantek distributor or call us for complete details.

Avantek Distributors

EAST
Applied Specialties
Beltsville, MD
(301) 595-5393

Sickles Dist. Sales
Lexington, MA
(617) 862-5100

Technical Marketing Asso.
Hackensack, NJ
(201) 342-4008

CENTRAL
Component Dist.
Ft. Lauderdale, FL
(305) 971-4950

Peak Distributors
Arlington Heights, IL
(312) 255-0707

Thorson Dist.
Dallas, TX
(214) 233-5744

WEST
Pen Stock, Inc.
Los Altos, CA
(415) 948-6552

Sertek, Inc.
Los Angeles, CA
(213) 477-9051

Spirit Electronics
Scottsdale, AZ
(602) 998-1533

AVANTEK

3175 Bowers Avenue
Santa Clara, California 95051
Sales: (408) 496-6710

INFO/CARD 9

rf letters

Editor:

I look forward each month to receiving your magazine, *RF Design*. You have been publishing some excellent articles which I find useful in my work.

In order to better utilize the information in some of your articles I clip and save many of them. One obstacle occasionally arises. Two articles which are of interest to me may be located consecutively in your magazine. The last page of the first article is printed on the flipside of the first page of the next article. Would it be feasible to organize your advertisements in such a way as to separate design oriented articles. I do appreciate your keeping individual articles together instead of scattering them out as "continued on pp." throughout your mag. Thanks for the great mag which fills a need.

By the way, have you or are you going to collect the papers presented at the L.A. show and publish them under one cover? It would certainly help us unfortunate souls who did not have the opportunity to attend. Thank you.

E.E. Truckenmiller
Applied Automation, Inc.

The Proceedings of Expo 85 are available for sale. You probably already noticed the ad in last month's issue. — editor

Editor:

In the July 1985 issue, in the article on materials, I take exception to the statement, "Anyway, below 200 MHz GaAs noise increases." There are many amateur radio operators that use high frequency GaAs devices that have low noise figures at, say, 1 GHz, and use them at 144 MHz and get less noise figure.

Most certainly there is a knee in the curve somewhere. I would like to see a more definitive report on this subject.

Lawrence Joy
Magnavox

Photo Credit

We have been informed by the photographer that two of the photographs used on the cover of the July issue are copyrighted. They were not so identified when we received them. It is always our practice to print appropriate credits when we know material is copyrighted. The photographs of the filter and the engineer looking through the microscope were taken by Ken Thompson, 200 E. 95th St., New York, NY 10028. — Editor.

rf news

RF Technology Expo 86 Exhibit Space Sells Out Early

Every exhibit booth for the RF Technology Expo 86 was taken as of August 1. Although the number of booths was doubled from the January 1985 show, they were claimed quickly after promotion began for the 1986 show.

"I've never seen it happen before," said Kathy Kriner, Convention Manager for Cardiff Publishing Company. "Six months before the show and we're sold out."

Nearly half the 150 booths were reserved at the end of the 1985 show by exhibitors there. Exhibitors at the show were pleased with the RF focus of the program and the fact that nearly all attendees were RF design engineers.

The Cardiff Convention Management staff have started a waiting list for booths that may become available. Kriner said a letter would be sent to those who have not returned signed contracts with a deadline for doing so. This amounts to about 30 exhibitors, she said.

RF Design publisher Keith Aldrich said the response shows how difficult it is to judge the demand for this type of show.

"We doubled the exhibit space for this second show and sold it almost immediately. Who knows how many booths we could have filled?"

Aldrich, the show's organizer, will be studying the demand for Expo 86 to try to judge the size of future shows. "We might have to move to a wing of the Anaheim Convention Center in 1987," he said.

OK Industries Forms 'Electronics Division'

OK Industries Inc. has formed the OK Electronics Division to develop and market the company's new family of electronic bench test instruments. To date, the line includes function, sweep and pulse generators, frequency counters, DMMs, digital thermometers and accessories. The division is located at the company's New York headquarters.

Commented David Weltman, OK president: "This division represents a major commitment by OK Industries to the customers and distributors of our new family of test instruments. Rather than being absorbed within our existing production equipment lines, the test instrument program will be separately staffed, marketed and financed to ensure the highest possible levels of product quality as well as customer service and support."

Many of the instruments include capabilities which are not available on other equipment in the same price class. Most of the instruments are list priced at under $500, and even the more sophisticated generators are under $1,000.

"Our objective is to put test instruments within reach for the thousands of lab technicians and design engineers at smaller to mid-size firms who have had to make do with less — or worse, simply do without," Weltman said.

The new family of products will be featured at Wescon '85, November 19-22, in San Francisco.

RFD, Inc. Receives Contract for AWACS Radar Transmitters

RFD, Inc., Tampa, Fla., announces receipt of $3.7 million in new contracts including $1.8 million from Eaton Corp./AIL Division in Deer Park, N.Y., for production of AWACS radar transmitters and for design and production of dielectric resonator oscillators for the B-1B aircraft. RFD, Inc. also received contracts totaling $1.2 million from SATT Communications AB, Stockholm, Sweden, for design and production of airborne radar transmitter systems.

RFD, Inc. is a Tampa-based designer and manufacturer of microwave transmitters, receivers, oscillators and amplifiers for radar and communications systems. RFD, Inc. also manufactures microwave transmitting and receiving components for satellite terminals and telecommunications systems.

Rental Car Cellular Phones

Bell Atlantic Mobile Systems and Budget Rent-A-Car of Pittsburgh have established a new marketing partnership to put cellular mobile telephones in 300 Pittsburgh Budget rental cars by the end of 1985.

The new marketing plan is designed to promote the use of rental cars and cellular mobile telephone service. One hundred rental cars equipped with Alex(SM) cellular telephones are available at six Budget locations. There is no premium fee for renting the phone-equipped cars and customers pay only for their calls, billed at 95 cents per minute.

"Cellular telephones and rental cars are a natural match, since both serve customers who are on the move," said Richard J. Lyons, Bell Atlantic Mobile Systems vice president — marketing and sales. "Until today there has not been a successful plan to serve this market. This program will help make rental-car telephones commonplace, instead of a rarity."

Although cellular phone-equipped rental cars have appeared in various cities since cellular mobile telephone service first became available in the fall of 1983, the Alex/Budget rental car plan is the first to offer customers a cellular phone without a premium charge in the basic rental price of the car. In the past, customers were not encouraged to use the phones because they were generally available only in luxury class models. The phone-equipped cars in the Pittsburgh Budget fleet are available in intermediate, full-size and luxury models, making the phones more accessible.

"Besides providing rental car customers with the convenience of cellular communications while they are on the road in the Pittsburgh area," said Lyons, "this marketing program also allows customers to get some experience using cellular phones before they make a decision to buy or rent one for their own car."

"There is an Alex in your Budget" is the theme of the joint marketing program. Alex is the trade name of Bell Atlantic Mobile Systems' cellular telephone service. Both companies will promote the phones in a variety of ways. Customers boarding the Budget shuttle buses at Pittsburgh airport will hear messages about the cellular phones over the bus audio systems.

Budget cars equipped with cellular phones come with a special sun visor display that tells customers how to use the phone, depicts the geographic coverage of the cellular system and lists important local numbers to call, such as airlines, hotels and information services.

New HF Frequency Hopping Radio

An HF, frequency-hopping radio system, designed for maximum security and capable of evading jammed channels, has been introduced by Reunert Technology Systems (Reutech). Called the Lancer, it forms part of a radio family that has been used in active combat for over a decade.

A building block approach has been followed in the design of the Lancer system. The basic driver unit can be configured into a portable manpack, as well as 20W and 100W vehicle units with low and high power options. The range offers reliable communications across the complete HF band from 2 to 30 MHz.

The highly sophisticated frequency-hopping facility of the Lancer employs some 200 diffferent code sequences on any one of the 28,000 available center frequencies and between frequency channel steps. The bandwidth employed by the radio while engaged in frequency hopping tracks the bandwidth of the Antenna Tuning Unit. It provides at all times the largest possible number of channels to be included in the hopping coverage.

Together with the long-period non-linear pseudo-random sequences, the hopping facility of the Lancer offers a high measure of security while evading disturbed or jammed channels. The Lancer also has a late entry facility for other stations wishing to join the hopping net.

The Lancer operates in upper side band or lower side band and a CW mode with tone injection. Speech processing provides an increased average speech power at power outputs selectable as 6 or 20 watts (PEP) in the lower power configuration and 20 or 100 watts (PEP) in the high power configuration.

Compact Software Curtails Operations

In a move company officials say is not caused by financial difficulties, Compact Software closed its Palo Alto offices Aug. 8. The company is owned by Comsat Technology Products, a half-billion dollar diversified corporation. Jeffrey L. Rubin, vice president and general manager for Compact Software, said the closure reflected a decision made some time ago by Comsat that the software company did not fit their long-range goals.

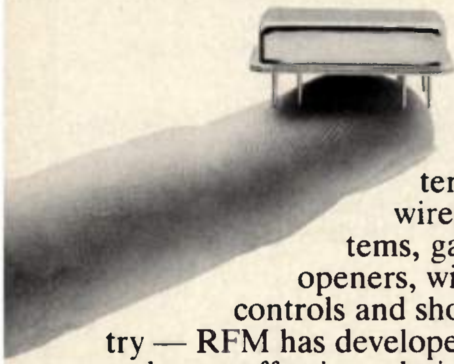
In a prepared statement, Compact Software pledged to honor all existing maintenance contracts and any other contractual obligations. "Money is set aside for honoring maintenance contracts," a Compact Software spokesman said. The company will complete its latest version of the PC program, version 3.0, and updates will be sent to qualified customers, the spokesman said.

A spokesman for Comsat verified that the company was seeking to divest itself of operations that did not fit into its corporate plan. Compact Software is one of several companies considered too small by Comsat.

Comsat issued the following statement: "We are still assessing precisely what we are going to do about Compact Software. Earlier this year, we announced that Compact Software was being integrated into a new business, Comsat Technical Services. As this integration takes place we are seeking to strengthen Compact's capabilities and offerings. The business is definitely for sale; we have not reached a conclusion beyond this."

The solution to FCC Part 15 is right at your fingertips.

Introducing the easiest solution to FCC Part 15 UHF transmitter requirements.



For the many applications that use low-power UHF transmitters under Part 15 — wireless security systems, garage door openers, wireless remote controls and short-range telemetry — RFM has developed an easy, rugged, cost-effective solution to transmitter design.

With our SAW resonator stabilized hybrid transmitters, you just add a simple antenna, 9V battery and digital input. Our hybrids do the rest. No need for a protracted rf design effort on your part.

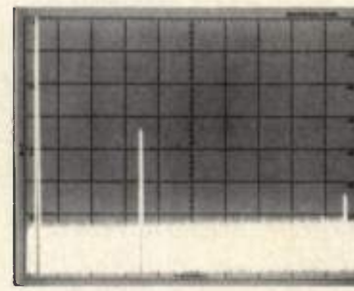
Hybrid oscillators are designed for wireless security products and other remote control devices.

Full operating range.

RFM's hybrid transmitters can be easily adjusted to achieve full legal radiated power (operating range) with a variety of simple wound-coil or print-loop antennas.

Excellent stability and signal purity.

Quartz SAW resonator frequency control assures that our transmitters won't drift out of your receiver's bandpass — or into a military "forbidden band" — despite temperature or battery voltage changes, component aging or body capacitance effects.



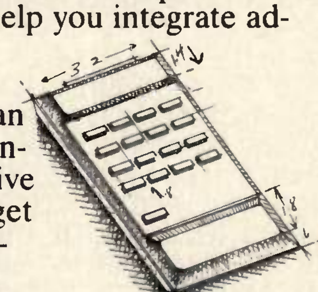
Typical harmonic spectrum of hybrid transmitter.

Also, our transmitters feature low harmonic output and tight modulation bandwidth control. Harmonic radiation above 1000 MHz is well under 125 uV/m @ 3 meters when used with recommended antennas.

The right options. The right support.

Both pulse and FSK modulation options are available to match either superregenerative AM or superheterodyne FM receivers. Matching hybrids are also available for receiver local oscillators (10.7 MHz i-f). Plus, we offer two transmitter output power ranges — for FCC Part 15 Subpart D or Subpart E. All RFM transmitters are fully compatible with CMOS encoder chip drive levels.

At RFM we have a staff of expert rf engineers ready to help you integrate advanced SAW technology into your product. And you can always count on an innovative, cost-effective solution. We didn't get to be the world's volume leader in UHF SAW resonators and hybrids by following the competition.



Hybrid oscillators make low-cost AM/FM UHF-based remote control systems possible.

RFM

THE NEW WAVE IN RF

RF Monolithics, Inc. • 4441 Sigma Rd. • Dallas, Texas • 75244 U.S.A.
Phone: (214) 233-2903 • Telex: 795022 • FAX: (214) 387-8148 • TWX: 910-860-5474

INFO/CARD 11

rf calendar

September 9-12, 1985
Fifteenth European Microwave Conference
Paris
Information: M.Y. Bernard, c/o GIEL, 11 Rue Harmelin, F-75783, Paris, Cedex 16, France.

September 10-12, 1985
Midcon/85 High Technology Electronics Exhibition and Convention
O'Hare Exhibition Center
Rosemont, Illinois
Information: Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (213) 772-2965.

September 11-12, 1985
Mid-Atlantic Electronics Design & Production Exhibition
Valley Forge Convention Center
King of Prussia, Pennsylvania
Information: International Mktg. Services Ltd., 1719 S. Clinton St., Chicago, IL; Tel: (312) 421-7000.

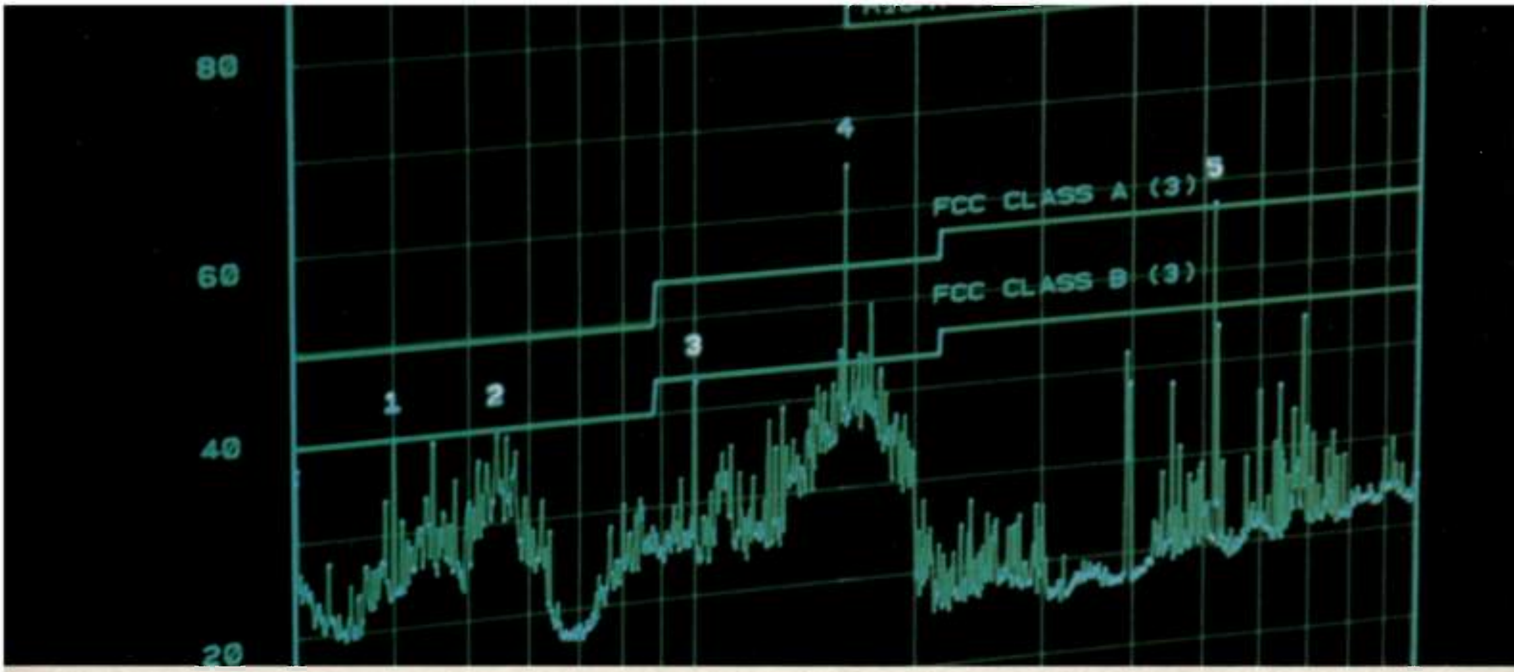
October 8-10, 1985
Electronic Imaging Expo
Sheraton Boston
Boston, Massachusetts
Information: Kathie Hallberg, IGC, 375 Commonwealth Ave., Boston, MA; Tel: (617) 267-9425.

October 21-23, 1985
Fifth International Electronics Packaging Conference
Mariott Hotel
Orlando, Florida
Information: Evelyn Ashman, International Electronics Packaging Society, P.O. Box 333, Glen Ellyn, IL 60137; Tel: (312) 260-1044.

October 22-24, 1985
Northcon/85 High Technology Electronics Exhibition and Convention
Portland Memorial Coliseum
Portland, Oregon
Information: Electronics Convention Management (see Midcon/85).

November 19-22, 1985
Wescon/85 High Technology Electronics Exhibition and Convention
Moscone Center, Brooks Hall/Civic Auditorium
San Francisco, California
Information: Electronics Convention Management (see Midcon/85).

January 30-February 1, 1986
RF Technology Expo 86
Anaheim Hilton and Towers
Anaheim, California
Information: Kathy Kriner, Cardiff Publishing Co., 6530 S. Yosemite St., Englewood, CO 80111; Tel: (303) 694-1522.



CONFIDENCE

From design through compliance testing, HP's Spectrum Analyzer/EMI Receiver delivers unprecedented versatility and CISPR receiver accuracy.

Your complete EMI measurement solution.

HP's new Spectrum Analyzer/EMI Receiver delivers fast, accurate EMI compliance measurements *and* complete EMI diagnostic capabilities—all for the price of an EMI receiver alone.

Featuring the new HP 85685A RF Preselector—with improved sensitivity and overload protection—this versatile spectrum analyzer-based EMI receiver is designed to CISPR* Publication 16 recommendations and meets the measurement requirements for military and commercial standards, including FCC and VDE. Which makes it the ideal instrument to conduct your final open-site EMI compliance tests with complete confidence.

And unlike EMI receivers that are dedicated solely to compliance testing, the HP Spectrum Analyzer/EMI Receiver is also an indispensible EMI diagnostic aid throughout your product's design and evaluation stages.

The ideal EMI diagnostic tool.

Using the HP8566B or 8568B Spectrum Analyzer and simple probes, you can quickly locate problem emissions and evaluate potential solutions. These powerful analyzers sweep quickly over a broad 100Hz to 1.5 GHz or 22 GHz frequency range, instantly displaying measurement results on the easy-to-read CRT, or as hard copy plots. Built-in capabilities include: multiple-trace digital storage for instant A vs. B comparison, frequency and amplitude markers, maximum hold for capturing elusive intermittents, and direct plotter control—to name just a few.

Perform open-site tests with confidence.

When it's time for final compliance testing, the same HP spectrum analyzer used during the design and evaluation stages can be combined with

the HP85685A RF Preselector and the HP85650A Quasi-Peak Adapter. The result is an EMI receiver system with the sensitivity, overload protection and ±2 dB amplitude accuracy you'll need for both indoor and outdoor compliance testing.

System features include multiple detection modes with peak detection for the fastest possible measurement time, quasi-peak detection for compliance with CISPR Publication 16 recommendations, and average detection for discrimination between narrowband and broadband signals.

Automate your EMI measurements for increased productivity.

With the HP85864B EMI Measurement Software, featuring an easily understood menu structure, you'll be able to quickly automate your commercial and military emission measurements. Choose from a library of FCC, VDE and MIL-STD emission tests, or design your own. Test results can be annotated and notes generated as part of the test documentation.

Consider the HP advantage.

Now is the time to discover the distinct advantages of HP's Spectrum Analyzer/EMI Receiver, a total solution for EMI measurements. After all, why invest in both an EMI receiver for compliance testing *and* an additional spectrum analyzer for design/evaluation, when you can accomplish both tasks confidently with a single, versatile system that costs far less?

For more information, call the Instrument department of your local HP sales office listed in the White Pages. Or write Hewlett-Packard, 1820 Embarcadero Road, Palo Alto, CA 94303.

*CISPR (Comite International Special Des Perturbations Radioelectriques) Publication 16 is the "CISPR specification for radio interference measuring apparatus and measurement methods."

HEWLETT PACKARD

INFO/CARD 13

A New Dimension in Portable, Digital Spectrum Analyzers!

The A-7550 Spectrum Analyzer

The A-7550 Spectrum Analyzer by IFR is the most advanced, low cost, portable spectrum analyzer on the market today.

Two powerful microprocessors, menu driven display modes and single function keyboard entry aid the user in the operation of all analyzer functions.

To further enhance the operational simplicity of the A-7550, the microprocessor system automatically selects and optimizes the analyzers bandwidth, sweep rate, center frequency display resolution and the rate of the frequency slewing keys. An operator override is also provided when non-standard settings are required.

Features...Performance...Dependability... The A-7550 portable Spectrum Analyzer by IFR—innovative accomplishments in design.

A Subsidiary of Regency ELECTRONICS INC

Impressive Standard Features Include:

▪ 100 kHz to 1 GHz frequency coverage ▪ VRS™ (Vertical Raster Scan) CRT display ▪ Single function keyboard entry ▪ Menu driven display modes ▪ Automatic amplitude calibration ▪ Selectable linear/log display modes ▪ Digital storage of all displayed parameters ▪ 70 dB dynamic range ▪ 300 Hz resolution bandwidth ▪ 16 selectable scan widths ▪ Accurate center frequency readout ▪ Direct center frequency entry ▪ Automatically scaled electronic graticule ▪ Variable top scale reference (+30 to −95 in 1 dB steps) ▪ IF gain in 1 dB steps ▪ Line, bar, average and compare display modes ▪ 300 Hz and 30 kHz video filters

Optional Features Include:

▪ Internal rechargeable 5 APH battery for portable operation ▪ Tracking generator with 10 dB step attenuator ▪ Tracking generator with 1 dB step attenuator ▪ FM/AM/SSB receiver ▪ IEEE-488 interface bus ▪ RS-232 interface bus ▪ 75Ω adaptor ▪ Quasi-peak detector

Contact your local IFR authorized distributor for a demonstration.

ifr INC

10200 West York Street / Wichita, Kansas 67215 U.S.A.
316 / 522-4981 / TWX 910-741-6952
INFO/CARD 14

rf special report

The New Look in RF Circuits — Packaging

By James N. MacDonald

In this final part of our series on advancements in RF circuit design we take a close look at two companies specializing in miniature circuits. We interviewed sales and engineering executives at Metaramics and Avantek, two Silicon Valley firms, to learn the directions their companies were taking. We believe what we learned applies to other design houses as well and shows one direction of development in RF circuits.

Metaramics is in Sunnyvale, Calif. We spoke there with sales manager B.J. McDaniel about the company's orientation in the industry.

"We are in our sixth year now, a spinoff from an RF transistor manufacturer," B.J. told us. "Our business started with the standard packages and then we expanded into special packages — hermetic packages with multilayer construction, window frames, alconite flanges for larger packages, good thermal dissipation, no cracking of the BeO — the next step of sophistication.

"Next we got into metallization and brazing of high reliability assemblies. We might metallize alumina, fire it, nickel-plate it and braze it into various housings for extremely high reliability connectors. They might be used in medical applications, ordinance, space or even well drilling.

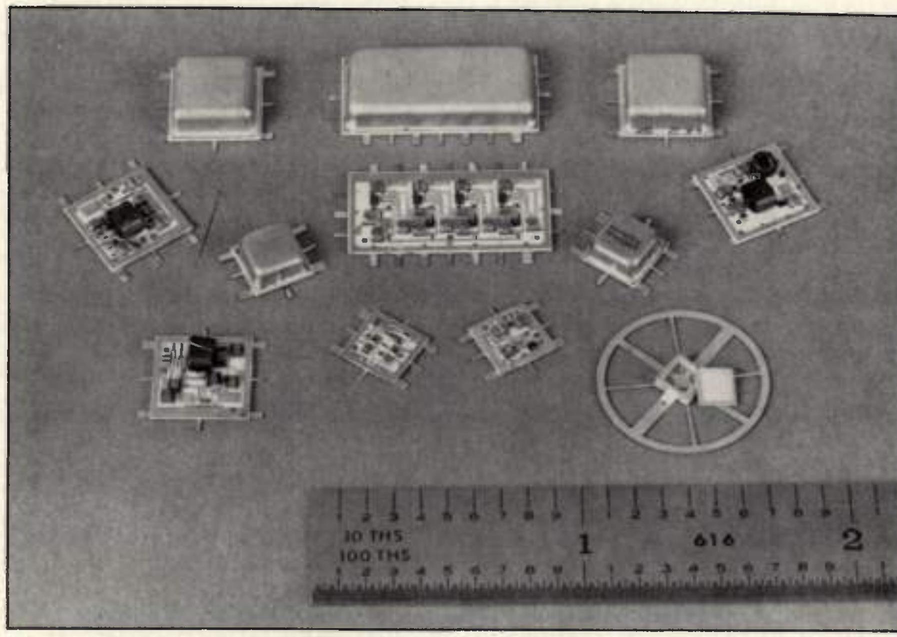
"A fourth area that we are just becoming interested in is integrated circuit packaging. We are specifically looking for applications that require the use of beryllium oxide, rather than alumina. We're looking for thermal situations, where the chip is getting so large that the customer has to find some way of getting the heat out of the package that cannot be solved with conventional methods in alumina packages. Such a part might have a beryllium oxide base and some cofired layers on the top to form the area where the interconnects are.

B.J. explained the process of bonding metal to ceramic.

"In brazing two dissimilar pieces of metal together, a ceramic piece and a metal piece, care has to be taken because the ceramic is very rigid and metals seem to have more expansion capability at temperature. So, when we are building these packages we have to take extreme care that they are matched up in terms of temperature, otherwise as they are starting to cool down the metal may cool faster and crack the ceramic. Both ceramics, alumina and BeO, are susceptible to that problem. They are equal in terms of their modular elasticity.

"We use tungsten and moly-manganese metallization for refractory metal. This is to form an adhesion layer between the surface of the ceramic and the next step, which would be the brazed material. So, we put down the refractory metal, it forms a glassy face with the surface of the beryllium oxide, then we nickel plate that refractory metal, then we're able to braze the ceramic in a housing or lead frame onto the package using either silver or cusil.

"We are a thick film technology house and we have some limits in how close we can make the lines. In terms of 'let's take a standard operation and make it as small as possible' we're not leading the market in that area. But when you are trying to make smaller RF power modules using chip carriers, we're in that field."



A few of the PlanarPak devices produced by Avantek, Santa Clara, Calif. For additional information circle INFO/CARD #110.

In Santa Clara we visited Avantek and spoke with David Herron, advertising manager for the MIC/Semiconductor Division, Northe Osbrink, publications editing manager and Bill Koehn, marketing manager for modular components.

The founders of Avantek started the company in 1965 to serve the market for solid state amplifiers. The technology existed to produce a transistor to operate at 1 GHz, although most higher frequency amplifiers at the time were tube type. They developed their own transistor facility and eventually began doing their own thin film hybrid construction. The company maintains this concept of vertical integration.

Osbrink told us, "We now offer at very economical pricing essentially a complete amplifier in a transistor package. What could be more miniaturized than that? Instead of having to take a transistor and incorporate components around it to turn it into a circuit, you now have something that only needs an input and output voltage to operate as a complete amplifier."

Herron said the Semiconductor Division is taking the functions of these amplifiers and putting them on a single chip. It is the company's vertical integration that allows them to incorporate these building blocks into various sizes of devices for various functions, he said.

"We're making microwave technology for the RF price. We're taking that expensive sub-micron, semiconductor geometry and selling it to the RF world for the RF price. To do that we have to come up with more functions per block. There are many marketplaces opening up that require the 1 to 2 GHz or 3 to 4 GHz frequency range — TVRO, GPS. Those types of programs perform a lot better if they have the microwave technology. That is why we're moving that way. That is why the whole industry seems to be moving that way."

One of the company's most recent developments is the PlanarPak. This design does not put the substrate in the package, the substrate becomes the package.

Koehn told us, "We're not starting out with a header and putting a substrate on it, we're adding the surface mount leadframe to the ceramic substrate itself.

"It is indeed a surface mounting package up to a certain frequency range, so you don't have to go through other things on your PC board. It lends itself to automated insertion, and the package itself lends itself to automated assembly."

Built around a ceramic substrate, the PlanarPak is compatible with larger substrates of MICs. Designers can add these ready-to-operate amplifiers directly to a circuit. In addition to the hybrid amplifiers already available, Avantek hopes to have switches, detectors, mixers and limiters ready for distribution about the time this issue is published.

Avantek is one of the modern electronics companies moving as fast as possible to meet the future. Company literature says, "Future integrated assembly products will include both microwave and digital processing functions. With this integration, requiring ultrahigh speed digital integrated circuits to support these products, Avantek began expansion of its existing GaAs technology into digital integrated circuits in 1984."

Osbrink summed it up, "The long-term future is absolutely incredible in terms of size and packaging."

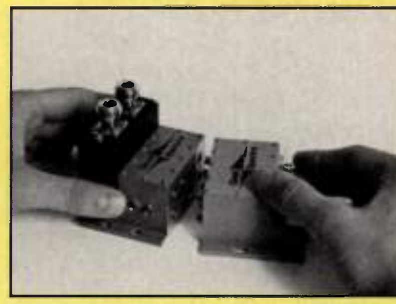
Putting it Together

Throughout this series we have described miniature components and the designs developed to mount and connect them on boards and substrates. There comes a time, however, when these devices must be connected to other devices. The advantage gained by miniaturization may then be lost by the space occupied by connectors and cables.

Connector companies are well aware of the need to reduce the size of their products. In this part of the Special Report we look at a new design by a connector manufacturer to allow multiple interconnections in a minimum space. This, too, is part of the new look in RF circuits.

M/A-Com, Omni-Spectra, has developed a modular plug-in connector that allows the system designer to make a variety of connections to a printed circuit board. The OSP module uses low profile, blind mating, plug-in connectors in modules that can be combined as the designer wishes. The connection system can be redesigned easily by rearranging the modules. Omni-Spectra says the modular plug-in concept allows flexibility in packaging design and access for repair without sacrifice in electrical performance or mechanical reliability.

The OSP modular blind mating design is being tested and studied by the Defense Electronics Supply Center as a possible new military standard. For additional information circle INFO/CARD #109.



M/A-Com Omni Spectra's family of OSP™ blind mating connectors offer a space saving alternative for the packaging designer. OSP™ connectors are designed for blind mating of modules and components, eliminating cables and threaded RF coaxial connectors. A unique contacting mechanism permits both axial and radial misalignment and low mating forces.

Package Types

From the east coast, Howard Levine, vice-president for marketing for Synergy Microwave, Paterson, New Jersey, provided us with a description of traditional package styles and some of their advantages and disadvantages. He concluded with a description of the company's surface mounted package for double-balanced mixers.

In the world of "lumped-element" double-balanced mixers (DC-3.5 GHz), Levine told us, many different package styles are available. To a great extent, the industry has standardized around seven different PC mountable configurations. Examining manufacturers' specifications on the same basic device offered in several packages, one often sees no perceptible difference. However, these performance specifications do not address such issues as ease of mounting, ease of achieving a good "ground" when used in a production environment and quality assurance concerns that may come into play in production.

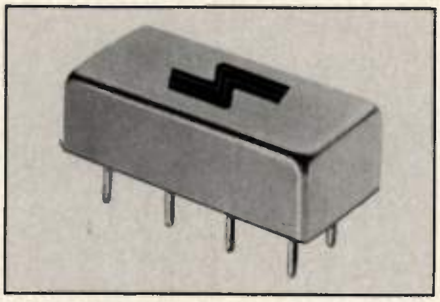
Mix these details with pricing and space considerations and the user is faced with a maze of choices. When realizing that the packaging represents anywhere from 10% to 85% of the materials cost in a mixer, the decision-making process becomes critical. The selling price of the "same" device in different PC board packages can vary 200%! The following explanation attempts to unravel this situation.

Eight-Pin Relay Header (Full Sized)

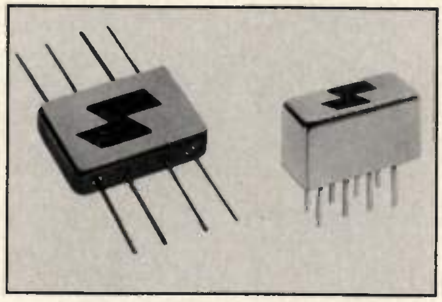
Without a doubt, the lowest cost packaging is the 8-pin Relay Header. This traditional package is rectangular, .4" x .8" and varies in available heights. The most typical (and lowest cost) are those of approximately .4" in height.

The Relay Header offers the additional advantage of having the widest diameter (.030") pins. This rigid pin pattern makes production insertion an easy matter. These pins do not bend easily, and the possibility of a bent pin causing a defect in its surrounding glass-to-metal seal is reduced.

From an electrical performance point of view, the relay header offers (typically) four ground pins spread out around the package, allowing good, consistent grounding. The package's large size does cause some excess wiring length internally, causing 0.5-1.0 dB more conversion loss at the high band edge of devices



The 8-pin Relay Header is the lowest cost standard package. The rigid pin design (.030" dia.) makes production insertion easy. Pins do not bend easily, minimizing risk of damage to the glass-metal seal around them.



The 8-pin miniature package (right) is the smallest user of PC board space. It is available in 4-pin or 8-pin configurations. The flatpack (left) offers the advantage of horizontal leads but is the most expensive package.

operating at frequencies above 1 GHz compared to the same circuit in a smaller package. However, the exceedingly low cost allows one to "trade-up" to a more broadband or higher frequency device at a still attractive cost.

What is the drawback? The Relay Header requires two to three times more PC board surface area than any other PC board package. Its "cubic" volume is two to five times that of any other package. However, if the space causes no grief, *this* is the package to use.

Miniature Relay Headers

These devices are .230" x .500", with typical heights from .25" to .4". Devices are available covering most frequency ranges in the .25" height package. Traditionally available in both 4-pin and 8-pin configurations, the 4-pin unit has become much more popular. This package has the unique position of being (along with the TO-5) the smallest user of PC board space, yet it is only second in cost, behind the full-sized Relay Header. This is due primarily to its rectangular configuration, allowing simple and rapid internal construction.

Many users are concerned about the grounding of a 4-pin package. This is a valid concern. However, the 4-pin header traditionally uses ground studs placed at approximate locations (internally only) to keep ground leads short. These pins (again due to rectangular construction) do not really limit useable internal space and, therefore, do not affect cost. The fact is that there *are* only four pins coming out, but circuit grounds are established at several points internally (due to the ground studs), yielding *good* ground performance (unlike other 4-pin packages such as TO-8/TO-5s).

Lastly, the package uses sturdy .020 pins which, though not as "stiff" as the .030 pins of the full-sized relay header, are very good mechanically.

The trade-offs here are cost. The 4-pin miniature costs 30-90% more than the Relay Header. However, this is *still* lower than all other packages. If one can accommodate the .25" height and "plug-in" format and needs small board area and volume utilization, this is the package.

TO-8

TO-8 packages are an old carry-over from the "discrete" transistor packaging of earlier years. They are the next price bracket up from the miniature headers and use typically twice the volume and 70-150% more surface area. The 4-pin TO-8 (.5" diameter) costs more because of the smaller internal space (round shape vs. rectangular), making assembly costs higher.

The presence of only one ground pin often necessitates internal grounds being soldered right onto the header surface. This meets all military requirements, if done properly. However, the susceptibility to damage due to poorly controlled user production process control (reflow overheating in hand soldering operations) is obvious.

The typical .25"-.30" height offers no special advantage compared to lower cost devices, and the configuration requires resistance or laser welding to seal the cover. The hermeticity yield of these processes is not nearly as high as the solder seal of the various relay headers.

The 12-pin version of the TO-8 (.6" diam.) still has the overall volume and surface area detriments of the 4-pin package. However, its larger diameter (.6" vs. .5") allows the typical height to be reduced to .2", shorter than the relay headers or 4-pin TO-8's.

The 4-pin TO-8 offers no real user advantages. Its thinner (.018" diam.) pins are another drawback. The 12-pin does offer a height advantage and is useful where a round package fits the board space better. However, getting proper alignment on twelve .018" pins can sometimes be quite a trick.

TO-5

The 4-pin TO-5 uses roughly the same area and volume as the 4-pin miniature header. The round configuration (as opposed to rectangular) reduces internal usable space by 50% compared to the miniature relay header, driving up the cost. Along with its thinner pins (.018" vs. .020") and Q.A. considerations, this creates a particularly undesirable option.

Flatpacks

Historically, flatpacks are the highest cost of the PC mounted devices. However, they offer many useful features. A .150" height (allowing closely spaced PC cards) and "radial" leads instead of perpendicular "down-pins" allows the part to be assembled by accessing only one side of the board. Flatpacks offer unique performance advantages that justify the high cost (twice the price of the Relay Header).

SMD (Surface Mounted Device)

In June, 1985, Synergy Microwave introduced the first true surface mounted package for double-balanced mixers. The package is approximately the same size as a traditional flatpack, but *without leads.* The mounting surface of the device is an alumina substrate with "wraparound" (top, side, bottom) contacts for RF, IF, LO and GROUND. The device mets all MIL-STD requirements and has several critical advantages:

1) No pins to use up space. Flatpack pins mounted on the surface can take up a space as large as the device itself.

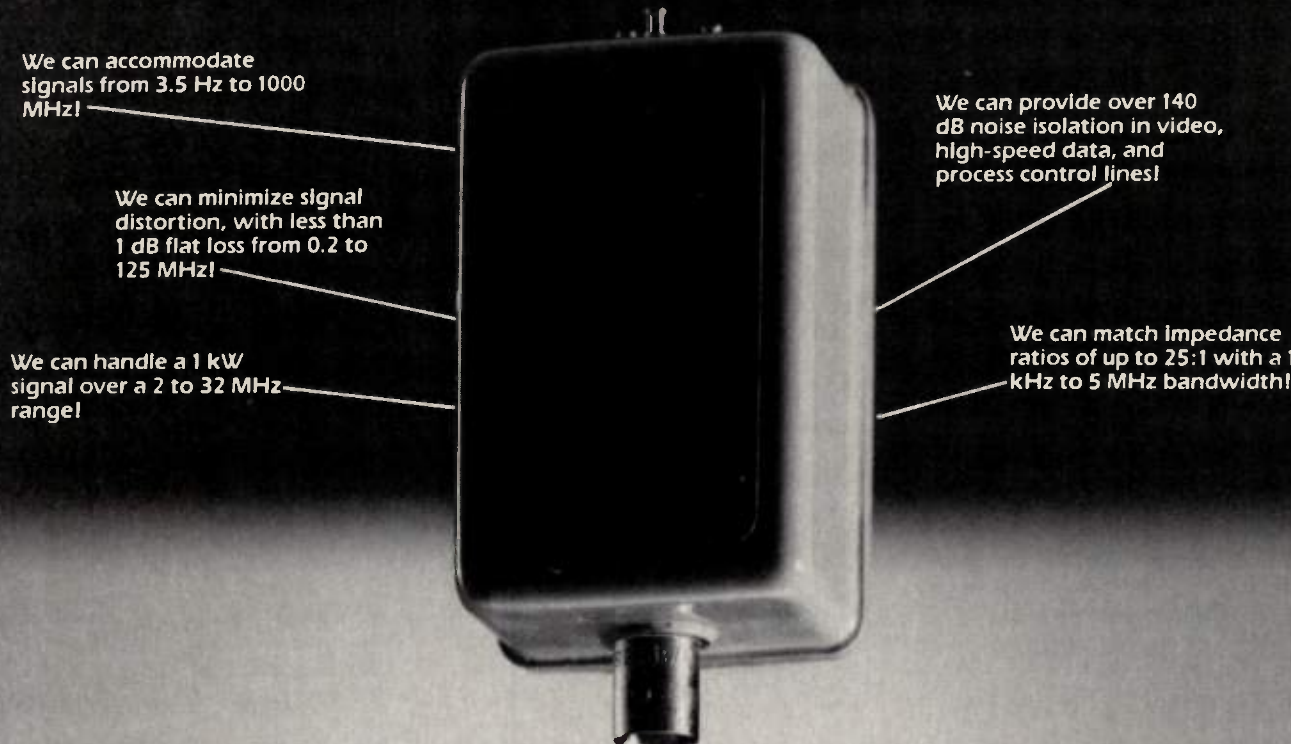
2) No glass-to-metal seals. The traditional stress points for hermeticity and mechanical integrity are the glass-to-metal seals in a flatpack.

3) No need to drill holes or cut notches to achieve true flush surface mounting.

4) Simple production handling — "pick and place," then reflow.

The SMD package is equal or lower in cost than the traditional flatpack. The only tradeoff is slightly higher loss at the high frequency band edge due to the non-metallic package forming an "incomplete" ground-plane. For additional information about these surface mounted mixers and other Synergy Microwave products, circle INFO/CARD #108.

WE CAN DO THINGS WITH A SIGNAL TRANSFORMER YOU NEVER DREAMED POSSIBLE!



Let's face it. Even in a digital world, many of your design problems are still analog. Like the need to match transmission lines of different characteristic impedances. Or to eliminate ground-loop currents in video lines. Or to filter out common-mode noise in data lines. Applications like these call for specialized signal transformers.

That's where we come in. Wideband transformers are our business. We offer over 400 models. All available from stock. All 100% tested to insure specified performance for any of the following applications:

Impedance Matching—Balun and unb/unb designs for maximum signal strength and minimum distortion when connecting circuits of different impedances.

Isolation—To eliminate transmission problems due to differences in ground potential or induced common-mode noise.

Power Combining/ Dividing—For low-loss distribution of signals to or from multiple isolated ports.

Data Bus Coupling—To protect data networks or signal busses from shorts and spikes at each port per MIL-STD-1553 or IEEE 802.5 LANs.

Pulse Transmission—To insure clean, high-speed data.

Nobody offers a wider choice of off-the-shelf wideband transformers. Nobody! And, if necessary, we'll custom design to meet your specific needs.

Just call Sales Engineering: 516-671-5700. Or write for our free catalog.

North Hills Electronics, Inc.

1 Alexander Place, Glen Cove, NY 11542-3796 (516) 671-5700 Telex: 46-6886 INFO/CARD 15

SUPER
Delivery & Service
2 Weeks
SUPER Market in NOISE

NOISE/COM

The next generation in Noise Technology is here!!

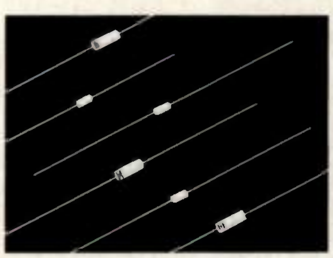
NOISE COM, INC.
111 Moore St., Hackensack, N.J. 07601
(201) 488-4144 TWX 910-380-8198
For "SUPER SERVICE" ask for Gary Simonyan

BROAD BAND NOISE INSTRUMENTS
10 Hz to 2 GHz / (+ 13 dBm and + 30 dBm OUTPUT)

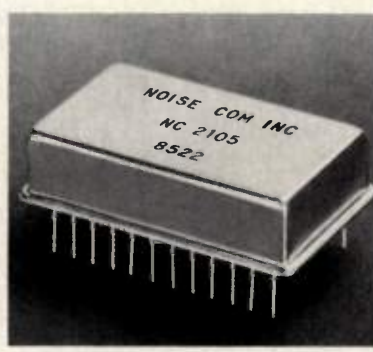
AMPLIFIED NOISE MODULES
10 Hz to 1500 MHz (+ 13 dBm OUTPUT)

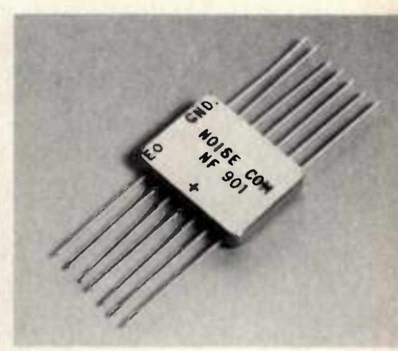
STANDARD OFF-SHELF CATALOG NOISE SOURCES

For other higher outputs & frequencies consult factory.

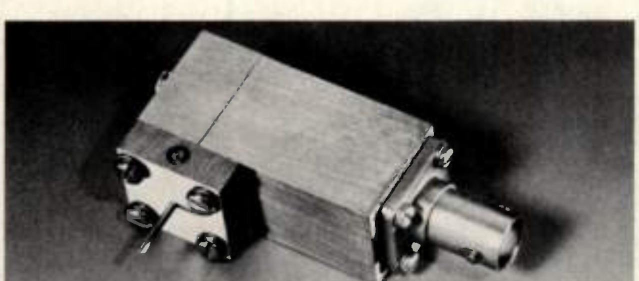


CHIPS and DIODES
10 Hz to 50 GHz

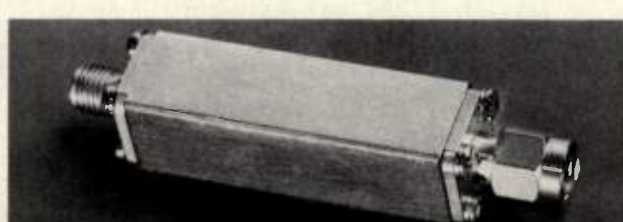




MINIATURE AMPLIFIED NOISE MODULES
Dual-In-Line and Flat Pack
100 Hz to 20 MHz (150 mv OUTPUT)



PRECISION WAVEGUIDE NOISE SOURCES
18 GHz to 50 GHz / 15.5 dB ENR and 23 dB ENR



PRECISION COAXIAL NOISE SOURCES
10 KHz to 18 GHz / 15.5 dB ENR and 30 dB ENR

INFO/CARD 16

EIMAC cavities cover 54 to 970 MHz at power levels to 30 kW —our design or yours

Varian EIMAC has complete cavity design and production capability. We make sure that tube and cavity are compatible. If it isn't an off-the-shelf-item, we have the designers and engineers for any specific job.

EIMAC has expertise in all disciplines including pulse, CW, FM, and TV. We match tube, power, bandwidth and operating mode to achieve optimum performance.

More information on EIMAC cavities and tubes is available in our Cavity Capability brochure from Varian EIMAC. Or for prompt consideration of your special design requirements, contact Product Manager, Varian EIMAC, or the nearest Varian Electron Device Group sales office. Call or write today.

EIMAC Cavity	Matching EIMAC Tube	Tuning Range (MHz)	Power Output
CV-2200	4CX20,000A	86–108	30 kW
CV-2220	3CX1500A7	86–108	1.5 kW
CV-2225	4CX3500A	86–108	5 kW
CV-2240	3CX10,000U7	54–88	10 kW†
CV-2250	3CX10,000U7	170–227	10 kW†
CV-2400	8874	420–450	300/1250 W*
CV-2800	3CX400U7	850–970	225 W
CV-2810	3CX400U7	910–970	190 W

*pulsed power
†peak sync, or 2.5 kW combined in translator service

Electron Device Group
Varian EIMAC
301 Industrial Way
San Carlos, California 94070
415-592-1221

Varian A.G.
Steinhauserstrasse
CH-6300 Zug, Switzerland
Tel: (042) 23 25 75
Telex: 868-841

varian

INFO/CARD 19

Wide Dynamic Range Linear Detection

By William C. DeAgro,
Hazeltine Corporation

In many signal processing applications, it is desired to extract the AM of a signal accurately over a wide dynamic range. Such applications may include high fidelity audio and video systems, high accuracy direction finding systems or any signal processing application where signal amplitude is important. Ordinary series diode-resistor detectors are not very linear and can only achieve roughly a 20 dB dynamic range in the linear region; an active detector, however, using nonlinear feedback can yield linear detections exceeding 60 dB dynamic range. The following is a brief discussion and some results of a scheme using an op-amp with nonlinear feedback to achieve a linear detection exceeding 60 dB of dynamic range.

The basic AM linear detector is composed of two parts: a linear half or full wave rectifier and a low pass filter, in succession. In order to achieve wide dynamic range linear detection it is necessary for the rectification portion of the circuit to have an output directly proportional to the input signal level over a wide dynamic range. Therefore, most of this discussion will concern the rectification portion of the circuit.

The schematic in Figure 1 shows the structure of a wide dynamic range linear half wave rectifier. Its function is to produce an output (e_o) that is a linear function of the input (e_i) when the input is negative and no output when the input is positive. The ideal transfer characteristic, e_o vs. e_i, is shown in Figure 2.

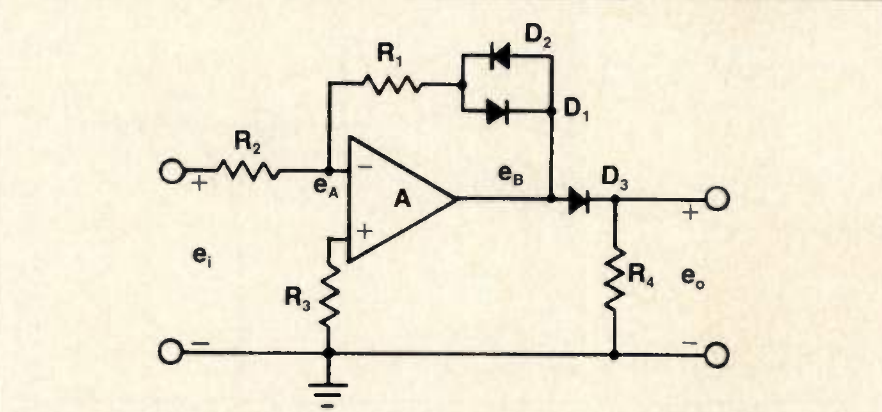


Figure 1. Schematic diagram of wide dynamic range linear detector (without filtering)

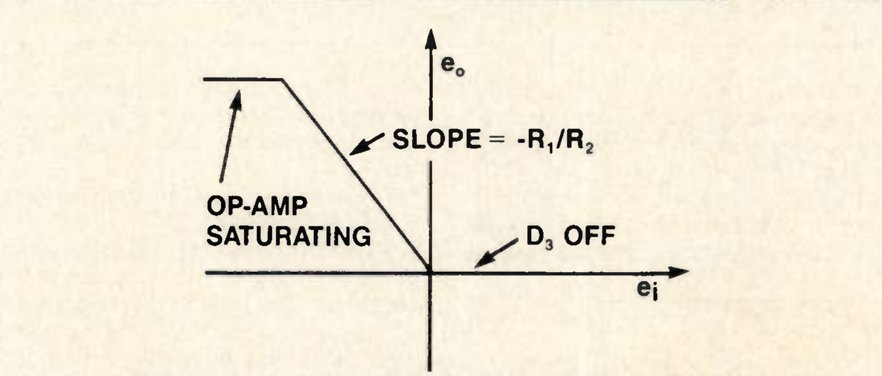


Figure 2. Ideal transfer characteristic of Figure 1

The reason this circuit behaves this way is because when e_i is negative, e_B becomes positive, which places D_2 and D_3 in the forward bias region. The gain (e_B/e_i) is given by:

$$\frac{e_B}{e_i} = -\frac{R_1 + r_{D2}}{R_2}\,;\ A \rightarrow \text{LARGE} + e_i < \phi \qquad (1)$$

and the gain function (e_o/e_B) is clearly given by:

$$\frac{e_o}{e_B} = \frac{R_4}{R_4 + r_{D3}} \qquad (2)$$

Knowing (from feedback theory) that e_A is at virtual ground and setting $R_4 = R_1$ and matching D_2 and D_3 leads to $i_{D_2} = i_{D_3}$ and $r_{D_2} = r_{D_3}$, the overall gain (e_o/e_i) when $e_i < \phi$ is given by:

$$\frac{e_o}{e_i} = \left(\frac{e_B}{e_i}\right)\left(\frac{e_o}{e_B}\right) = \left(\frac{-R_1 + r_{D_2}}{R_2}\right)\left(\frac{R_4}{R_4 + r_{D_3}}\right)$$

$$= \frac{-R_1}{R_2}\,;\ e_i < \phi \qquad (3)$$

Clearly when $e_i > \phi$, e_B is less than 0, D_3 is reverse biased and the overall gain is given by:

$$\frac{e_o}{e_i} = \phi\,;\ e_i > \phi \qquad (4)$$

For large fractional bandwidth type signals sometimes it is desired to use linear full wave rectification to eliminate spectral overlap (with nonbaseband compon-

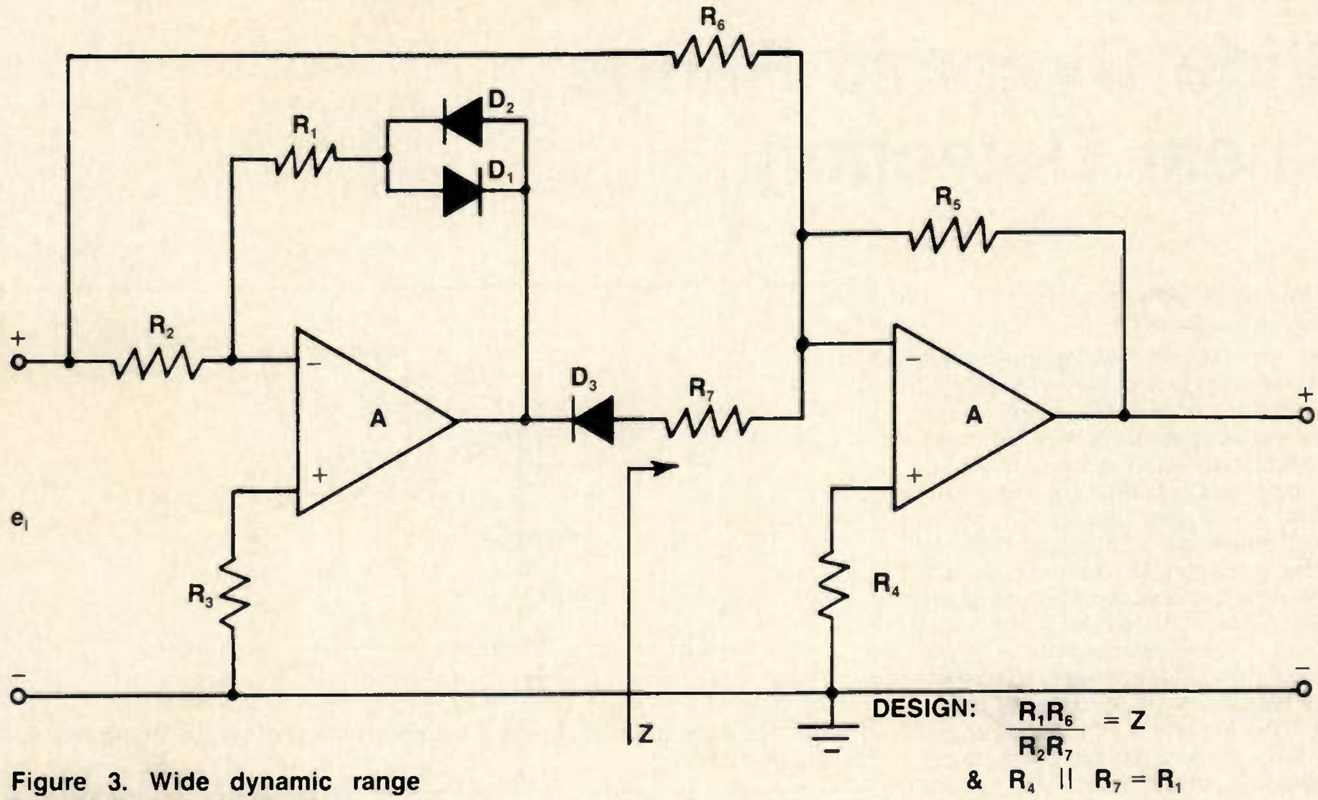


Figure 3. Wide dynamic range linear full wave rectification

ents) without reconverting to a higher center frequency prior to detection, or to reduce the rolloff constraints of the succession filter, as would be required in the half wave rectification type detector. In order to obtain a wide dynamic-range linear full-wave rectifier circuit, an extension of Figure 1 (with D_3 reversed) may be employed as shown in Figure 3. Note that the impedance Z looking into R_7 is roughly R_7.

Therefore, the parallel combination at R_4 and R_7 should equal R_1.

In order to perform the complete detection, filtering of either e_o or e_o is necessary. This can be done by placing a capacitor across R_4 for the half wave rectification type or placing a capacitor across R_5 for the full wave rectification type. The 3 dB radian bandwidth of the filter is the reciprocal of the RC product. If it is necessary to use a sharper rolloff filter (for the larger fractional bandwidth type signals), R_4 may be replaced by an n-pole filter with a passband impedance equal to that of R_1 or an n-pole filter may be placed at the output e_o. Note that the ideal filter would be flat in the passband, have a linear phase characteristic and have a rolloff sharp enough to degrade nonbaseband components to a specified level. Implementation of these higher order filters will not be addressed here.

The circuit of Figure 1 was designed using an NE5538 op-amp made by Signetics. The values for R_1, R_2 and R_4 were 1.1 kΩ and the value for R_3 was 750 Ω. The diodes were all IN5712 Schottky barrier, which have a low turn-on voltage of 0.34V. The filtering was performed by placing a capacitor of 0.01 μF in parallel with R_4 to give roughly a 15 kHz audio bandwidth. A schematic diagram of the practical circuit is shown in Figure 9. Prior to placing the filtering capacitor on the output, the transfer characteristics were plotted on an oscilloscope in X-Y mode and are shown in the oscillograms of Figures 5, 6 and 7. From these figures, it is clear that the rectifier circuit is linear over a dynamic range greater than 60 dB.

To show the performance of the complete detector circuit, a 3 MHz carrier frequency was used with a 10 kHz AM signal with modulation index greater than 1. The input waveform along with the detected waveform is shown in Figure 8.

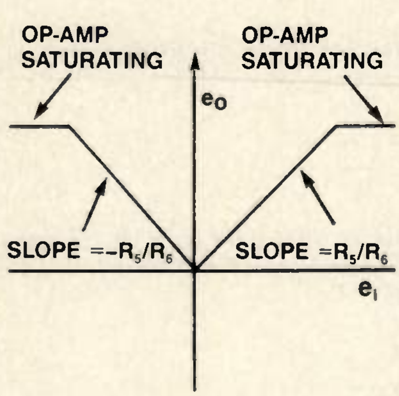


Figure 4. Ideal transfer characteristic of Figure 3.

Conclusions

It was found that the detector circuit built could detect signals in a linear region over a 60 dB dynamic range for roughly 11 kHz bandwidth signals of carrier frequencies ranging from 1 MHz to 4 MHz when using a simple RC succession filter. It is believed that much larger fractional bandwidth signals (e.g. 1/2) could be

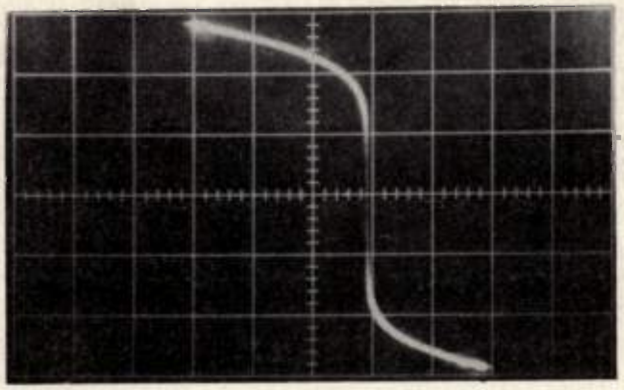


Figure 5. Non-linear characteristic
e_B vs e_i
Y: 5 mV/div
X: 100 mV/div

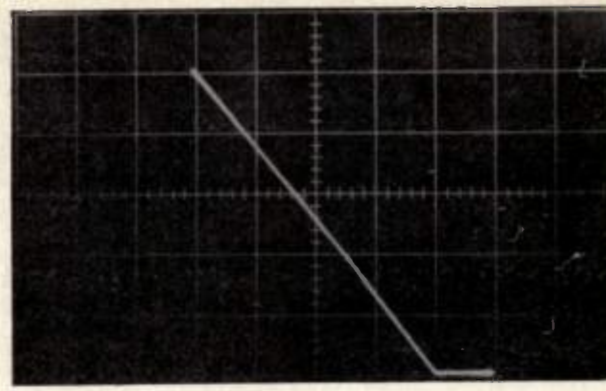


Figure 7. Linear characteristic
e_o vs e_i
Y: 2.5 mV/div
X: 2.5 mV/div

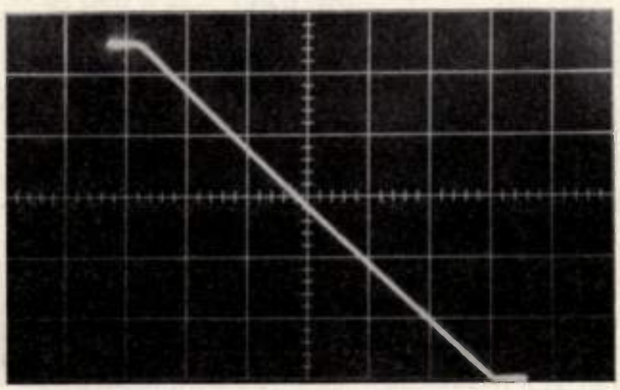


Figure 6. Linear characteristic
e_o vs e_i
Y: 5 V/div
X: 6.3 V/div

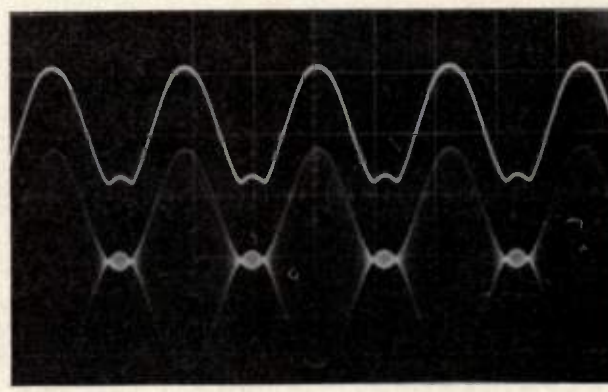


Figure 8.
Upper Trace: Detected output
Lower Trace: Input waveform (3 MHz Carrier, 10 kHz modulation, modulation index > 1)

detected with this circuit if more exotic filtering were employed. In addition, it is believed that much higher carrier frequencies (up to 200 MHz) could be achieved when using state of the art type op-amps. Some of these op-amps may include the Comlinear CLC220AI, the OEI9914A and the Plessey SL541B.

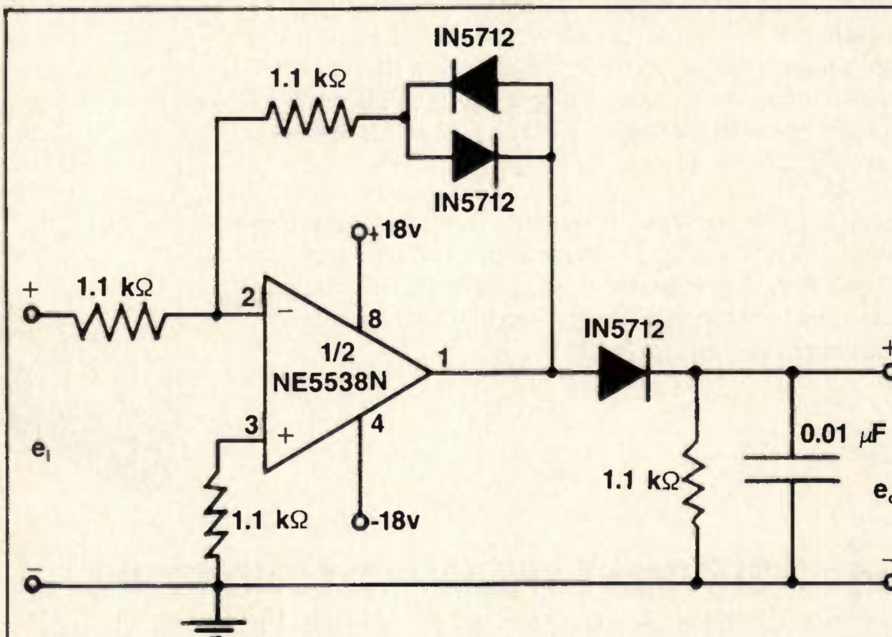
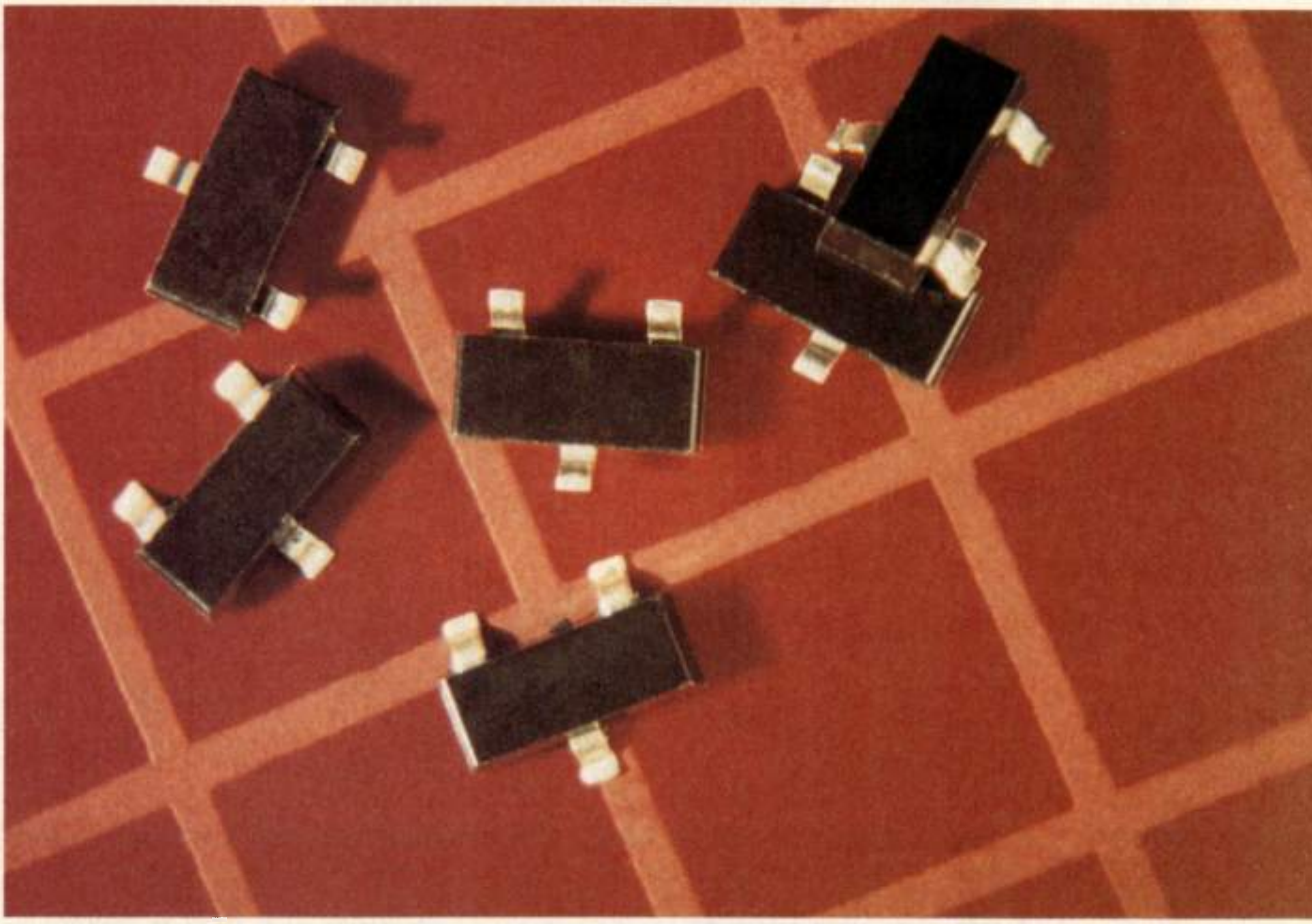


Figure 9. Practical circuit of wide dynamic range linear detector

About the Author

William DeAgro is a senior engineer in Research Labs at the Hazeltine Corporation, a defense contractor. Bill has a BSEE and a MSEE from the Polytechnic Institute of New York where he was a Cum Laude graduate and was elected Who's Who Among Students in American Universities and Colleges. Bill is a member of the Association of Old Crows, the International Society of Hybrid Microelectronics, Eta Kappa Nu Association and the Tau Beta Pi Association. Address correspondence to him at Hazeltine Corporation, Cuba Hill Road, Greenlawn, N.Y. 11740.

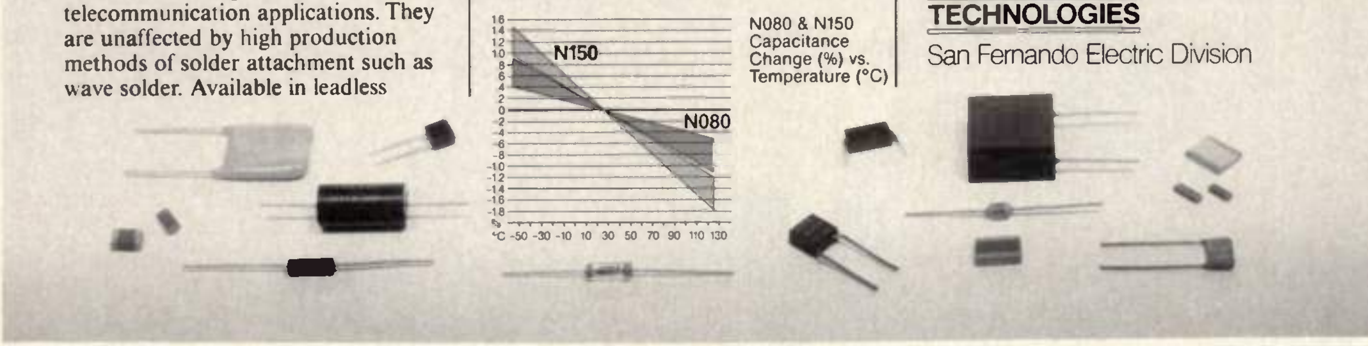


New MLCs with negative TC available from SFE Technologies combine excellent stability and tight tolerances with a wide choice of packaging.

With a temperature coefficient of –80 ppm/°C and –150 ppm/°C, our negative TL MLCs span a capacitance range of 1 pF to .056 uF with tolerances to 1%, working voltages from 25 to 500 VDC, and have all other characteristics of standard NPO series ceramics. Their stable performance compared to plastic film capacitors makes them ideal replacements for polystyrene, polypropylene and polycarbonate components, in filters for modems, cable TV, RF amplifiers and other telecommunication applications. They are unaffected by high production methods of solder attachment such as wave solder. Available in leadless chips, 2-pin DIPs, molded axials and radials, glass encased axials and conformal-coated radials. In all standard packaging methods including bulk, tape-and-reel for pick-and-place and automatic insertion.

Check these additional advantages:

- Cost effective — eliminates multiple capacitor trimming.
- Compensates for positive TC of inductive components, giving superior filter performance over temperature changes.
- Capable of high-density packaging in thick-film hybrid or printed circuits.



For more information, call Steve Klein at (818) 365-9411. Or write to SFE Technologies, San Fernando Electric Division, 1501 First Street, San Fernando, CA 91340-2793.

SFE TECHNOLOGIES
San Fernando Electric Division

INFO/CARD 22

PIEZO's Mini Wonder.

Superb performance in 3 cubic inches with an aging rate of 5×10^{-10}/day.

- ☐ Stress compensated (SC) cut crystal
- ☐ Single supply voltage
- ☐ Low power consumption
- ☐ High short-term stability
- ☐ Low phase noise
- ☐ Fast warm up

1.98" × 1.59" × .96" (LWH)

PIEZO's new Model Number 2850038 Series oscillators are designed for equipment requiring a miniature, rugged, precision frequency standard. The stress compensated (SC cut) crystal offers the advantages of a longer life and low vibrational sensitivity. This makes the 2850038 an ideal, cost effective oscillator for precision time keeping, instruments, communication and navigation equipment.

The PIEZO standard of quality guarantees you this kind of performance:

- Aging rates: < 5 parts in 10^{10}/day
- Phase noise: Better than -153 dBc/Hz at 10 kHz offset
- Warm up: Within 1 part of 10^7 of final frequency in 2½ minutes at +25°C; within 5 minutes at -40°C
- Time domain stability: Better than 5 parts in 10^{12} for a 1 second averaging time
- Power consumption: Approximately 1.5 watts after warm up at +25°C
- Output frequency: 10 MHz or 10.23 MHz standard, custom frequencies available.

PIEZO Systems is an affiliate of PIEZO Crystal Company, a leader in the production of piezo-electric crystals since 1936. For more information call your nearby PIEZO representative, or write to PIEZO SYSTEMS, P.O. Box 619, Carlisle, PA 17013. Telephone (717) 249-2151.

PIEZO SYSTEMS

INFO/CARD 23

One Antenna Kit with everything, to go please.

A complete line of kits with upper limits to 18GHz that satisfy FCC, VDE, and MIL-STD 461 specifications, and more.

Available now from your source for the finest EMI test equipment and accessories.

Antenna kits that meet your specifications of high quality and frequency response, and that are also responsive to your demands of portability and easy use. A.H. Systems offers nine different kits that fill the bill. Each comes in a single, lightweight case. Just one kit can contain all the antennas, probes and cables to perform E-Field 1KHz-18GHz, H-Field 20Hz-50KHz and conducted 20Hz-100MHz testing. Antenna factor calibrations are provided with each antenna.

So order one to go, with everything, or one of our other tantalizing specials.

MODEL #	FREQ. RESP.	DESCRIPTION
SAS-200/510	300 - 1800 MHz	Log Periodic
SAS-200/511	1000 - 12000 MHz	Log Periodic
SAS-200/512	200 - 1800 MHz	Log Periodic
SAS-200/518	1000 - 18000 MHz	Log Periodic
SAS-200/530	150 - 550 MHz	Broadband Dipole
SAS-200/540	20 - 300 MHz	Biconical
SAS-200/541	20 - 300 MHz	Bicon'l Collapsible

MODEL #	FREQ. RESP.	DESCRIPTION
SAS-200/542	20 - 300 MHz	Biconical, Folding
SAS-200/550	001 - 60 MHz	Active Monopole
SAS-200/560	per MIL-STD-461	Loop - Emission
SAS-200/561	per MIL-STD-461	Loop - Radiating
BCP-200/510	20 Hz - 1 MHz	LF Current Probe
BCP-200/511	100 KHz-100 MHz	HF VHF Crnt. Probe

AH Systems
9710 Cozycroft Ave
Chatsworth, CA 91311
Tel: 818 998-0223
Telex: 182 640 WKVG

A.H. SYSTEMS

INFO/CARD 26

"Outdoor" Emissions Testing Moves Indoors

Submitted by Keene Ray-Proof

For years, electronic companies have tested their new devices for RF emissions outdoors, and FCC regulations supported that approach. But today, more and more companies are taking their "open field" testing indoors, saving money and actually getting better results. And the FCC is going along, tacitly.

"Ironically, it's electronically 'cleaner' in today's electronic testing chambers than in the great outdoors," says the test engineer of a Colorado telecommunication company. "In fact, with all the satellites and aircraft navigation systems operating out there, and all the microwave telecommunication, the 'pure desert' air suffers from electronic clutter."

The testing is being done in RF anechoic test chambers. "Basically, that means unwanted radio waves can't get in or out; and further, those waves needed to run the test inside them don't echo off any of the walls," explains Keene Ray-Proof's Brian Lawrence.

"We still do the final FCC compliance tests in open space as prescribed by the FCC," says a spokesman for the telecommunications manufacturer. "But the preliminary testing, really the majority of the testing from an operational standpoint, is done in the RF anechoic chamber.

"Compared with driving out to the desert with two truckloads of gear, setting up and knocking down, indoor testing is certainly much more efficient. It's easier to schedule, far more secure and actually 'cleaner' electronically. There's a different ambient level almost every time we go outside, and that takes a lot of time to calibrate for."

The Keene Ray-Proof indoor testing chamber may not appear imposing, but electronically it does the job. It's been in virtually continuous use, sometimes around the clock, for both preliminary FCC qualification testing and product development.

The chamber itself is essentially square with a high ceiling. A computer floor with built-in emissions absorber lets all wiring run underfloor without interfering with test readings. Two manual doors are for personnel entry and moving equipment in and out. The control room is adjacent and attached, but isolated electronically from the test area.

A Non-Reflective Environment

To keep the test space electronically clean and free of RF reflections from the device under test or any instrumentation, the entire exterior of the chamber has a continuous metal skin hidden within it. Even electrical service and telephone lines, doors, ventilation ducts and other penetrations are designed to block passage of unwanted electronic signals.

Availability of such test chambers as pre-engineered modules is a recent development, according to Bob Barbour of Ray-Proof.

"We've built custom RF-shielded chambers for espionage-proof government and defense applications for decades," he said. "It's been a matter of distilling all we've learned into a more or less standard product for commercial application."

Compared with custom RF-anechoic chambers of comparable size and features, the modular test chamber costs 25 to 40% less, and is in place and running in about half the time of a custom facility, he said.

"Considering that every electronic device from Donkey Kong to a space shuttle computer must pass FCC-type 15 testing, the modular RF shielded anechoic chamber should catch on quickly."

The manufacturer's indoor testing methodology is virtually identical to open space testing. The device to be tested is installed on a rotating platform, connected and brought up to operating condition. At the other end of the room, three meters away per FCC test procedures, is a sensing antenna. During the test, the device under test is operated as it rotates through a full 360 degrees. The antenna picks up any emissions and feeds it to analyzers in the control room.

Anechoic materials on the walls and ceiling of the chamber assure that the antenna receives only direct signals from the device under test. No mixture of direct and reflected signals, or any electronic "clutter" from the atmosphere, can affect the testing operation. So far, there has been excellent correlation between in-chamber tests and open space tests.

Whenever the chamber is not in use, calibrations tests are run to determine baseline levels of EM radiation and reflections. But there's not much time for calibration. Sometimes it runs around the clock, something obviously not possible out in the back country.

Although final FCC testing is still done in open space, Keene Ray-Proof expects that to change shortly. The question of in-chamber testing as an acceptable substitute for open space emission testing is now before the FCC.

"Based on our experience so far, there's every reason to allow in-chamber testing as an alternative," the spokesman said. "The correlations between our indoor and open space tests are exceptional."

MICROWAVE CAD. INACCURATE SOFTWARE IS DIFFICULT TO DISGUISE.

SUPER-COMPACT PC

With competition growing in the technical software industry, you're bound to see more than a few promises.

You'll see promises of future developments, soon-to-be-here products and right-around-the-corner results. Initially, it may all look pretty exciting.

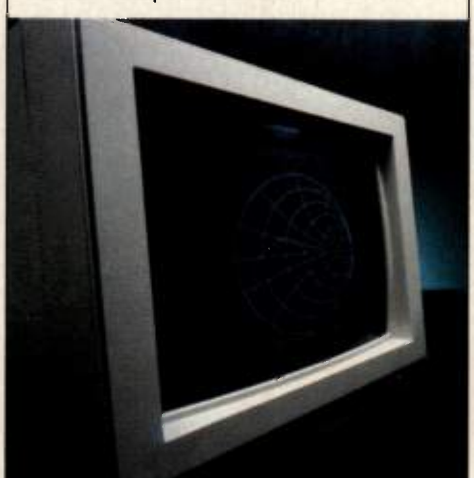
At COMPACT SOFTWARE we know you as an engineer are looking for something a little more exciting than promises.

You're looking for accurate and proven performance.

And proven performance is exactly what has made SUPER-COMPACT® the industry standard for computer-aided design tools in the development of high-frequency and microwave circuits.

SUPER-COMPACT can now run on your IBM® PC XT, AT, COMPAQ™ and other IBM compatible computers. It offers the same design and full modeling capabilities as our mainframe versions.

- Analysis of the simplest to the most complex circuits



- Two different optimizers, Random and Gradient, to help you achieve the best design. (You'll want to use the Gradient optimizer when optimizing for global optimum results in High-Q circuits.)
- Transmission Line Synthesis and Analysis (TRL)
- Statistical Analysis with Monte Carlo Simulation, yield prediction, histogram plotting and stability circles
- Synthesis for lumped and distributed networks

SUPER-COMPACT is unique in that it allows you to use formulas to define parameters in circuit design. And SUPER-COMPACT PC and the mainframe version offer the most extensive element model library available.

In addition to these standard features, our IEEE-488 Interface allows users to download measured S-parameters from the HP8510 Network Analyzer via the HP200 series computer to the IBM PC XT and compatibles.

You'll also be able to set up private data banks for S-parameters. The data bank information is stored on floppy disks and is part of the SUPER-COMPACT PC software distribution package.

A TRADITION OF ACCURACY

As an engineer, competition demands that you keep up with the pace of technology. Your products must be brought to the market not only faster, but without costly remanufacturing time.

When you combine our AUTOART™ PC software, an interactive two-dimensional drafting program for microwave circuits, with SUPER-COMPACT PC, you have a fully complemented microwave design workstation.

SUPER-COMPACT and AUTOART give you the competitive edge you need by giving you the potential to significantly reduce your product design cycle.

Whether running SUPER-COMPACT on a mainframe or a PC, the proven accuracy, power and speed are there to save your company manpower, money and to deliver your product to the market before your competition.

SUPER-COMPACT COMPATIBILITY

SUPER-COMPACT PC's compatibility with our mainframe versions means you save money by not having to invest in additional costly equipment such as photoplotters, printers, and terminals.

If you have large circuits to optimize, use SUPER-COMPACT PC for your circuit preparation and data graphics output, while using MAINFRAME SUPER-COMPACT for your analysis and optimization.

You can include input files as part of standardized reports and can transfer designs to other design groups for further value-added customization.

COMSAT LABS

SUPER-COMPACT, as well as our other software products, are designed and developed in a joint effort between our own and Comsat Labs' engineers.

It's an ongoing team effort that guarantees a long term commitment to service, support and innovation.

SUPER-COMPACT offers you a solution that saves time and money while providing you with the most accurate, powerful and reliable software available.

Call us today for detailed information about the new SUPER-COMPACT PC and AUTOART PC. And while you're at it, look around for our competition.

They're amazingly easy to recognize.

Compact Software

1131 San Antonio Road,
Palo Alto, CA 94303
(415) 966-8440

A COMSAT COMPANY

INFO/CARD 28

Measuring a Dipole Antenna Radiation Pattern Using Time Domain and Gating

HP 8510 Network Analyzer Can Remove Ground Clutter Effects

By John W. Boyles
Hewlett-Packard Company
Santa Rosa, CA

A classical problem encountered when measuring the far-field radiation pattern of an antenna in a medium-distance range is the degradation that occurs when undesirable reflections (from the ground or nearby objects) are present. To reduce this problem, the source and test antennas are often installed on towers to remove them from reflective objects, RF absorptive materials are used to reduce the amplitude of the reflected signals and diffraction fences are installed in the range in order to null out the reflections and "clean up" the range. These solutions are often limited in their effectiveness and can be prohibitively expensive to implement.

The HP 8510 network analyzer can be used to reduce the effects of reflected signal paths in an antenna measurement and determine the response of the antenna to the main path signal only, without costly range modifications. This is done by using the HP 8510 to measure the swept frequency response of the antenna and compute the Inverse Fourier Transform to give the time domain impulse response. The time domain response allows the user to identify the reflected signal path reponses in time and then remove them with the gating feature. In converting back to the frequency domain, the effects of the responses outside the gate are removed. This article summarizes the results of using this technique to measure the radiation pattern of a standard gain dipole antenna at RF frequencies on a medium-distance antenna range.

The HP 8510 is a microwave network analyzer designed to make S-parameter measurements in the frequency domain. It also has the optional capability to compute the Inverse Fourier Transform of the measured data to give the time domain response. When used with the HP 8511A frequency converter, the HP 8510A can be configured as a general purpose four-channel phase-locked receiver, and it can simultaneously display in real time the frequency and time domain responses of any channel or the ratio of any two channels. One channel of the HP 8511A frequency converter must be used as a reference to achieve phase lock and therefore must have an input signal level between −10 and −50 dBm. The other three channels can be used to measure signals at the reference frequency with a dynamic range of close to 100 dB (−10 dBm max input).

A general block diagram for making antenna pattern measurements with the HP 8510 is shown in Figure 1. The required test equipment includes the HP

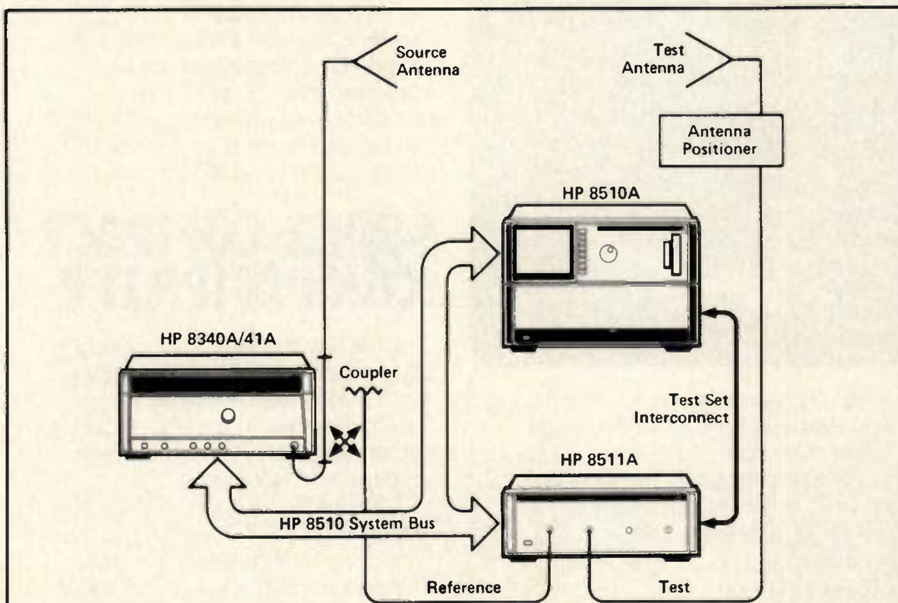


Figure 1. General Antenna Measurement Configuration Using the HP 8510 Network Analyzer.

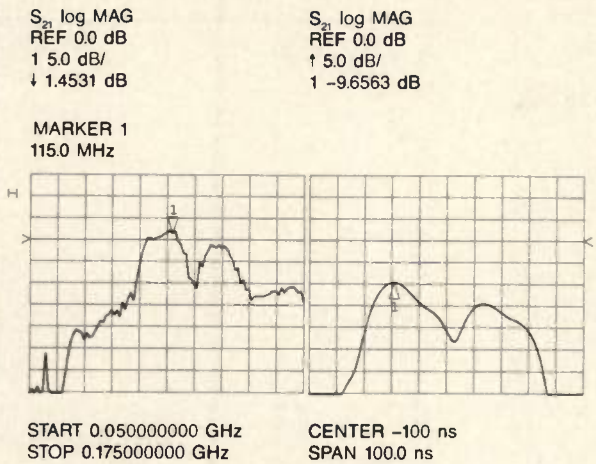


Figure 2. Frequency and Time Domain Responses of Dipole Antenna at Boresight, Measured from 50 to 175 MHz at 101 Points.

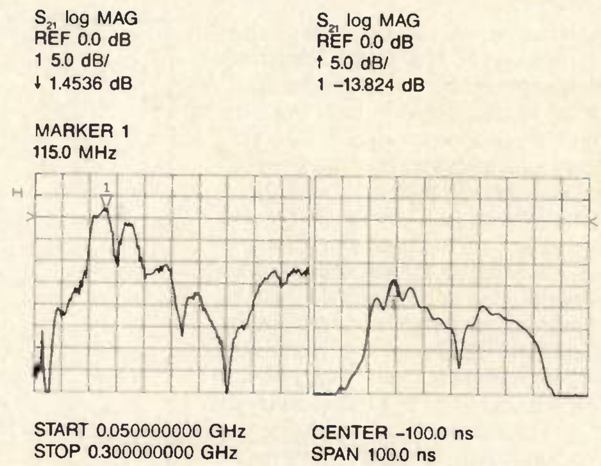


Figure 3. Frequency and Time Domain Responses of Dipole Antenna at Boresight, Measured from 50 to 300 MHz at 201 Points.

8510A network analyzer, a synthesized source (HP 8340A or 8341A) and the HP 8511A frequency converter (test set). The source and test set are controlled by the network analyzer via the HP 8510 system bus. The output of the source is sent through a coupler to the source antenna. The secondary output of the coupler is used to provide the reference signal which is sent back via low loss cable to the HP 8511A. The signal received by the antenna under test is also input to the HP 8511A, and the HP 8510 is set up to display the ratio of the test and reference signals.

To illustrate the gating measurement technique with the HP 8510, consider measuring a dipole antenna (Scientific Atlanta model 15-115). The dipole antenna is particularly difficult to measure because its radiation pattern is only slightly directional in azimuth (with a figure-eight shape) and omnidirectional in elevation. Therefore, the dipole picks up reflections from almost every direction and is particularly sensitive to reflections from the ground. Because of its sensitivity to ground reflections and because it has a calculable (1) radiation pattern with which to compare measured results, the dipole antenna is a good device to test out the new measurement procedure.

The standard way to characterize the far-field radiation pattern of an antenna is to make the measurement at a single (CW) frequency as the positioner is rotated. However, in order to generate a time domain response, the measured data must be taken over a span of frequencies. The time domain representation of a CW signal is, by definition, a sine wave. In order to generate an impulse response, the measurement frequency span must be inversely proportional to the desired time domain impulse width.

The frequency domain response of the dipole from 50 to 175 MHz and the corresponding time domain impulse response (Band Pass mode) are shown in Figure 2. The antenna was tuned to 115 MHz. The large amount of ripple in the frequency domain response is caused by interference due to reflections from the ground and other reflective objects within the antenna range.

The time domain display shows the measured transmission response of the antenna as a function of time. Because no calibration was used in this measurement to balance out the phase difference between the test and reference signal paths, the absolute location of the time domain response is somewhat arbitrary. Because the reference signal is routed through cable and the test signal travels a shorter distance through air, the difference in electrical length causes the time domain response to arrive in negative time. However, it is the relative path difference between the time domain responses that is most useful.

Identifying the Time Domain Responses

The plot in Figure 2 shows two major time domain responses that are separated in time by 33 ns, which corresponds to a physical separation of 9.89 m. The first time response is that of the main path signal, and the second response is that of the signal reflected from the ground plane which, because it travels a longer distance, is lower in amplitude and arrives later in time. The 6 dB difference in amplitude between the two responses represents the additional path loss of the reflected signal and also accounts for the large amount of ripple in the frequency domain response.

The required measurement bandwidth and separation between the two responses are determined by the characteristics of the antenna under test. The 50 percent (-6 dB) impulse width of the time domain stimulus is inversely proportional to the frequency span, and for a span of 125 MHz it is calculated (2) to be 9.6 ns. This represents, in the best case, the absolute minimum separation in time that the two responses can have and still be distinguished from one another. However, to use the gating feature effectively to remove the second response, the actual separation should be several times this minimum value to prevent overlapping of the responses.

A second factor to consider, which affects the required separation of the responses, is the bandwidth of the antenna under test. The dipole is a narrow band antenna that has a dispersive phase characteristic which causes its time domain impulse response to be smeared out in time. The result, observable in the time domain responses of Figure 2, is that the actual measured impulse width is more than twice the calculated width.

Figure 3 shows the response of the

same antenna measured over a frequency range of 50 to 300 MHz. Because the measurement bandwidth is doubled, the width of the time domain impulse stimulus is reduced by one half, which results in an improvement in the time domain response resolution. Notice, however, that the overall shape of the two responses is unchanged and that the amount of overlap of the responses is also unchanged. This is because the distributed shape of the response is caused by the dispersive nature of the dipole antenna. This indicates that the only way to decrease the amount of overlap between the two responses is to increase the relative travel time between them by increasing the height of the antenna under test above ground. In this example, there exists some overlap between the two responses, however (as will be demonstrated) they are adequately separated to use the gating feature to remove most of the effects of the second response.

This also indicates that the gating operation can be used to remove only the effects of reflections that are far enough out in time to be beyond the distributed main path response of the antenna. In this measurement, the effect of any signals that are picked up from reflections from the antenna positioner or other close in reflective objects will not be removed. However, the major error is due to the reflection from the ground plane, which is far enough away from the main path response to be removed using gating.

The gating feature of the HP 8510 provides a way to remove the effects of unwanted time domain responses and view in the frequency domain the effects of only those responses that are inside the gate. A gate is a time filter. In Figure 4, the center of the gate is set to the peak of the first time domain response, and the gate span is increased to include all of the first distributed time domain response. With the gate turned on, the second time domain response is removed, and the resulting frequency domain response is that of only the main path signal. As expected, the gated frequency response very closely resembles the ungated response except that the ripple caused by the reflection from the ground plane has been removed.

The two major sources of error in this measurement are the tracking error between the test and reference signal paths and the interference error caused by the signal reflected from the ground. A simple model depicting these measurement errors is shown in Figure 5.

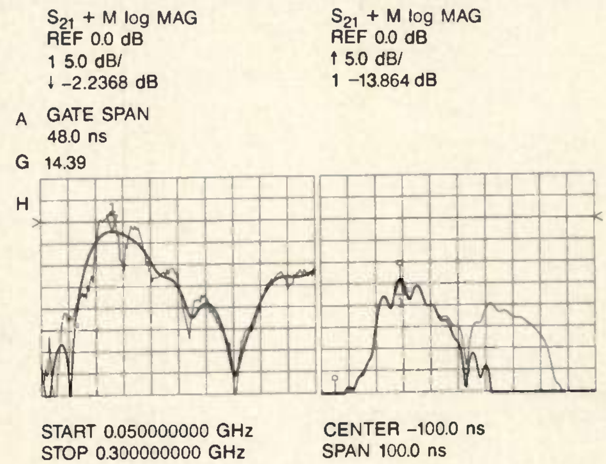


Figure 4. Gated Frequency and Time Domain Responses of Antenna Showing the Removal of the Ground Path Reflection.

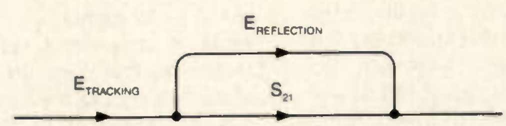


Figure 5. Antenna Measurement Error Model.

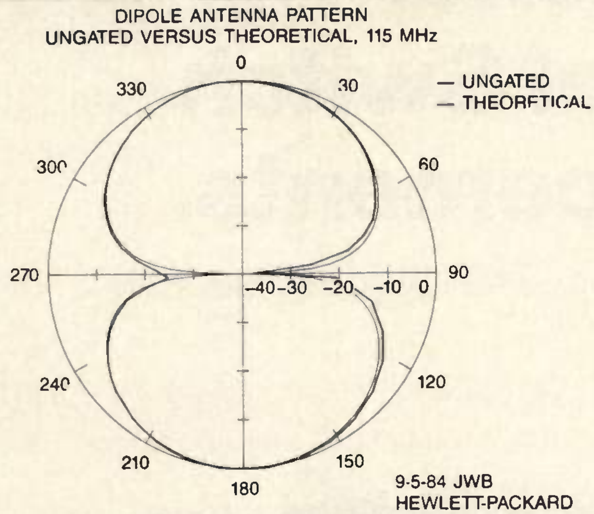
The correction for these two errors is accomplished in two steps. The first step is to remove the interference signal (E_{refl}) using gating. Then, assuming that the tracking error (E_{tr}) does not change as the antenna is rotated, it is removed using normalization. The procedure for doing this is as follows:

First, the gated response of the antenna at boresight (main beam) is saved into a memory register of the HP 8510A. Then, as the antenna is rotated, the gated response of the antenna at each angle is normalized to the boresight trace (using the data-divided-by-memory feature of the HP 8510). This gives the response of the antenna relative to the boresight response. Because the tracking error is common to both the measured and stored responses, it is normalized out in the ratio.

To take advantage of the time domain capability of the HP 8510 the measured data must be taken over a sweep of frequencies at each angle of rotation. Therefore, the time to make a pattern measurement is greater with this technique than for a comparable CW measurement. Because of the difference in test and reference path lengths involved the frequency accuracy is critical, and therefore the source (HP 8340A or 8341A) should be operated in the stepped (synthesized) sweep mode. The sweep time for this mode is 50 ms per point, so for a 201 point measurement each sweep will take approximately 10 seconds. However, in addition to the frequency stability of a synthesizer, the stepped sweep mode has the benefit of allowing up to 128 averages without significantly changing the sweep time, which greatly reduces the effects of measurement noise.

Allowing 10 seconds per sweep, 5 seconds to increment the antenna positioner and 1 second to perform the gating operation and record the data, the measurement time is approximately 16 seconds per positioner setting. For a full 360 degree rotation at 5 degree increments, the total measurement time is approximately 19 minutes. If the frequency data is taken at 101 points (5 second sweep time), the total measurement time reduces to 13 minutes. (If the test and reference channel paths are balanced, it may be possible to use the ramp sweep mode, which would reduce the measurement time to approximately 7 seconds per positioner setting (8 minutes total).)

This longer measurement time is a



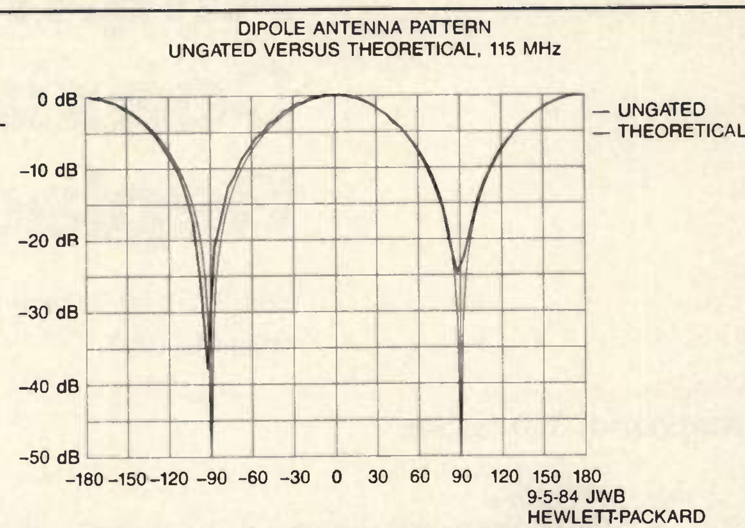


Figure 6a. Ungated Antenna Pattern versus Theoretical at 115 MHz: Plotted in a Polar Format.
Figure 6b. Ungated Antenna Pattern versus Theoretical at 115 MHz: Plotted in a Rectangular Format.

tradeoff for being able to use time domain and gating. If CW frequency testing is desired, the HP 8510 can be used as a CW receiver. However, although the swept frequency measurement technique requires additional time, the radiation pattern of the antenna at 201 frequencies of interest from 50 to 300 MHz can be plotted after only one rotation of the antenna positioner, and the improvements derived from gating more than offset the additional test time.

Measurement Results

The dipole was measured with 201 points from 50 to 300 MHz at each 5 degree increment of azimuth rotation (72 sets of 201 point data). The radiation pattern of the dipole was measured at several frequencies, and both the gated and ungated responses were compared with the theoretical response. (Because the antenna was boresighted visually, the measured antenna patterns were plotted with a small offset angle to correct for the resulting misalignment.)

Fig. 6 shows the measured radiation pattern of the dipole at 115 MHz with no gating, plotted in a log scale with the theoretical pattern. This is the CW measurement. The difference between the theoretical and the ungated pattern is due primarily to the reflected signal from the ground that causes the uneven sidelobes and offset nulls.

Fig. 7 shows the same measured pattern using gating to remove the effects of the ground plane reflection, plotted together with the theoretical response in a log scale. The gated response is virtually identical to the theoretical response with an average disagreement of only 0.18 dB. This improvement in antenna pattern measurement accuracy is due only to gating. (The measured antenna pattern is plotted point to point at 5 degree increments, and because of the offset in alignment the actual nulls at 90 and 270 degrees were not measured.)

A more dramatic improvement in the antenna pattern occurred at 125 MHz. At this frequency, the effect of the ground path interference was more severe. Fig. 8 shows the ungated response. In this conventional CW plot, there is very little resemblance between the measured pattern and the theoretical pattern. Fig. 9 shows the measured antenna pattern obtained using gating. In this case, the gating technique has improved the measurement of the nulls by better than 25 dB.

Fig. 10 shows the antenna pattern measured at 100 MHz without using gating, and Fig. 11 shows the pattern obtained using the gating technique. The improvement with gating is again very dramatic, however at this frequency there is also larger disagreement between the gated and theoretical responses. The gated pattern has a symmetrical shape that is very close to that of the theoretical pattern, however, it also has a rotational offset. The cause of this offset is unknown. Because of the nearly perfect results that were obtained at the resonant frequency (115 MHz), it is assumed that the offset is the result of an imbalance in the antenna at 100 MHz. This would also account for the lack of symmetry in the original ungated (CW) pattern.

In all, the radiation pattern of the antenna at 201 frequencies can be plotted from the data taken from one rotation of the antenna positioner.

Reduced Bandwidth Antenna Pattern

The actual measurement was made with 201 points from 50 to 300 MHz. The first 101 data points (from 50 to 175 MHz) were taken and used to re-compute the antenna pattern of the dipole at 115 MHz using gating. The resulting frequency and time domain responses at boresight are those previously shown in Figure 2. As mentioned, this bandwidth reduction doubles the time domain impulse width which reduces the response resolution, but it also reduces the measurement time. Fig. 12 shows the resultant gated pattern of the antenna at 115 MHz obtained with the reduced bandwidth data. This pattern is virtually identical to the one generated with the wider bandwidth information.

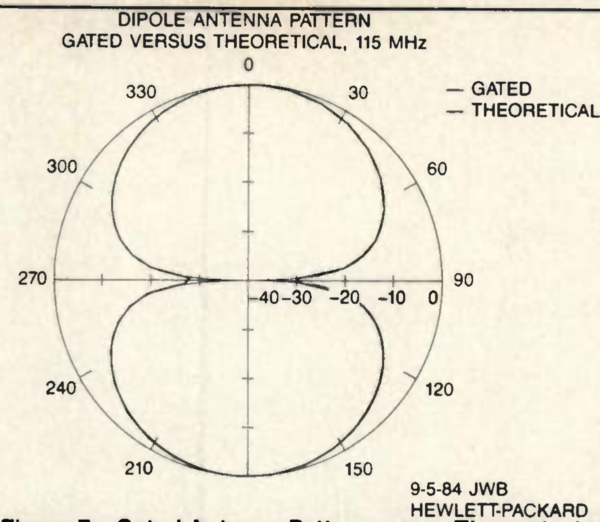
About the Author

John Boyles is an applications engineer for microwave vector network analyzers, Hewlett Packard Network Measurements Division, Santa Rosa, CA 95401. He has a BSEE from North Carolina State University and an MSEE from Georgia Institute of Technology.

References

1. Jordan, E.C. and K.G. Balmain, *Electromagnetic Waves and Radiating Systems,* Prentice-Hall, Inc., Englewood Cliffs, N.J., 1968.

2. *HP 8510 Network Analyzer Operating and Service Manual,* Hewlett-Packard Company, Santa Rosa, CA, 1984, pp.127-149.



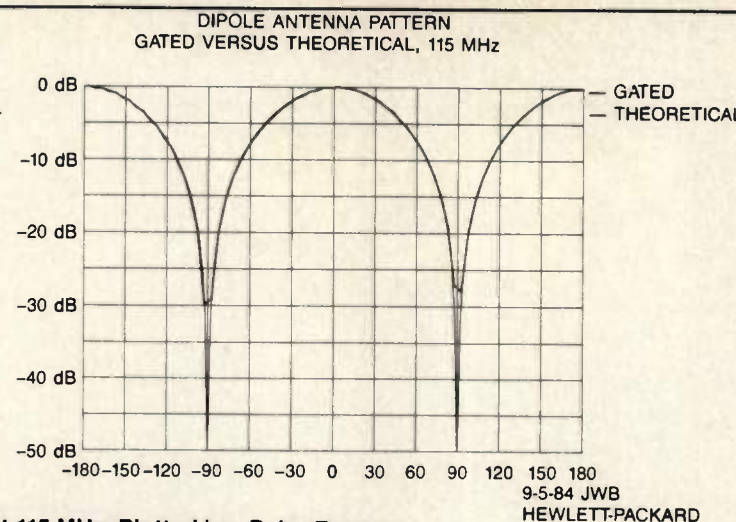
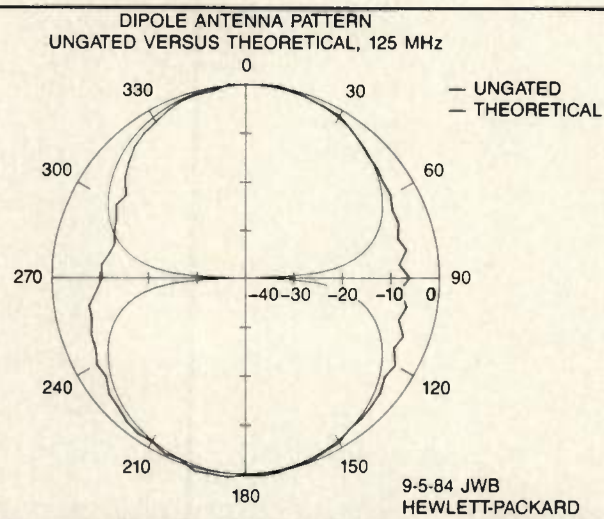


Figure 7a. Gated Antenna Pattern versus Theoretical at 115 MHz: Plotted in a Polar Format.
Figure 7b. Gated Antenna Pattern versus Theoretical at 115 MHz: Plotted in a Rectangular Format.



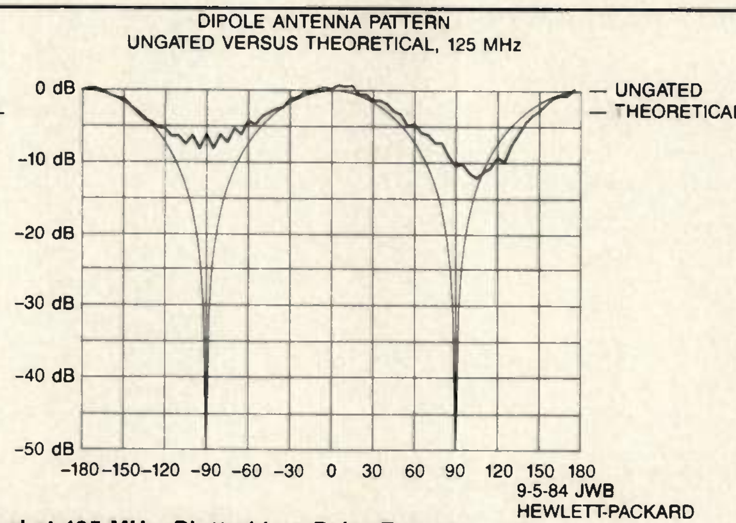
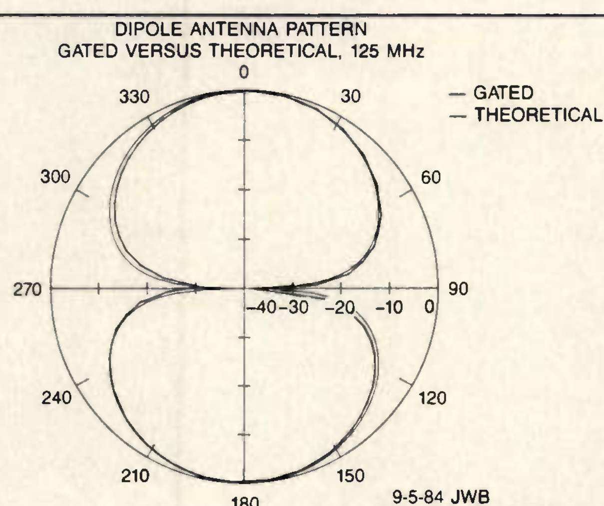


Figure 8a. Ungated Antenna Pattern versus Theoretical at 125 MHz: Plotted in a Polar Format.
Figure 8b. Ungated Antenna Pattern versus Theoretical at 125 MHz: Plotted in a Rectangular Format.



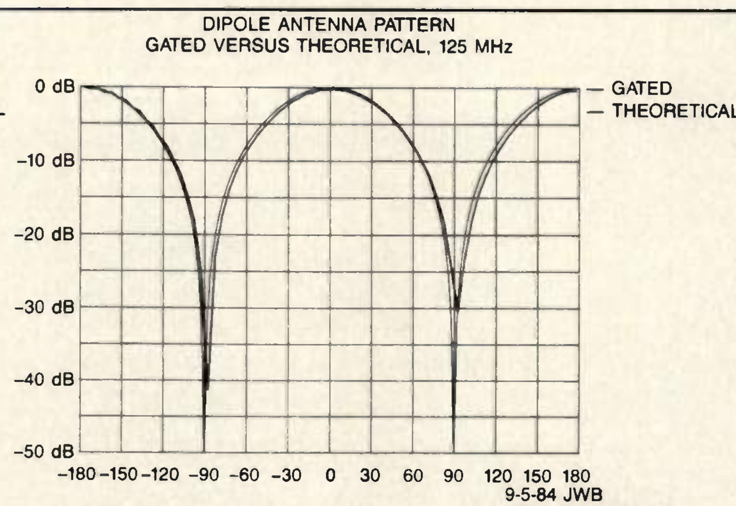
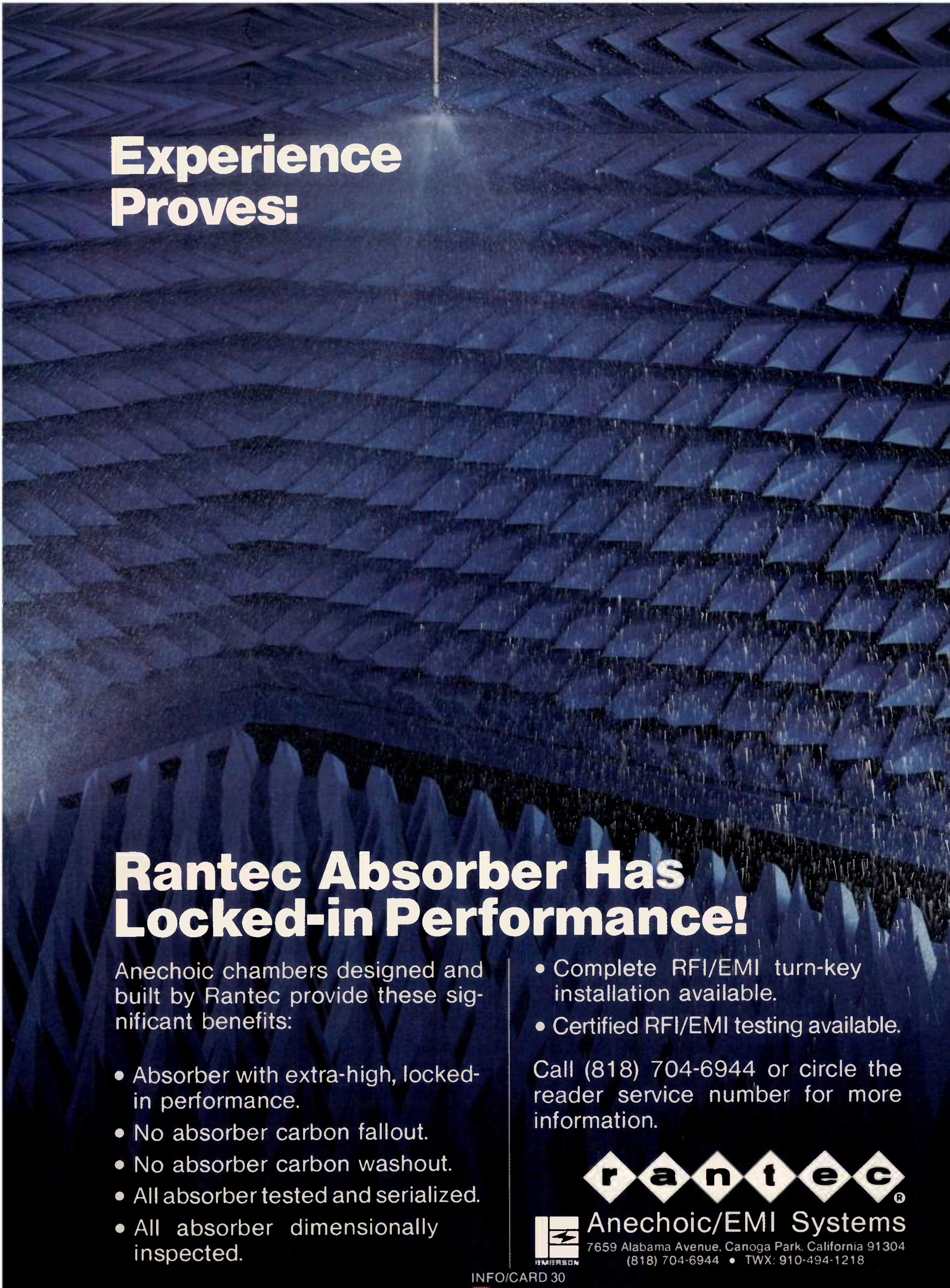
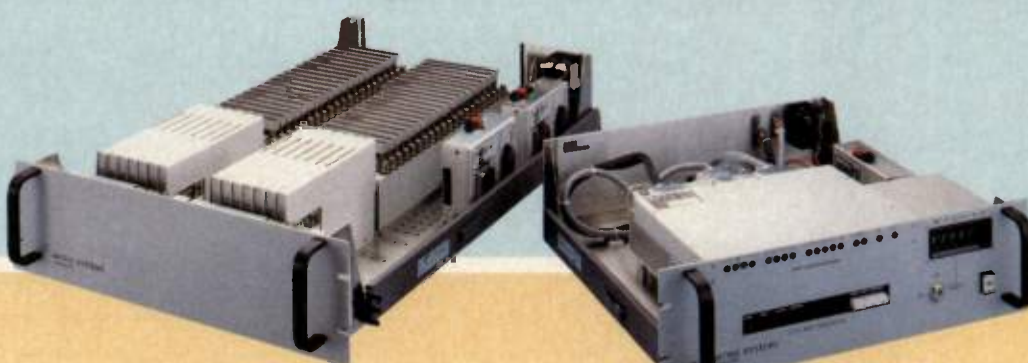
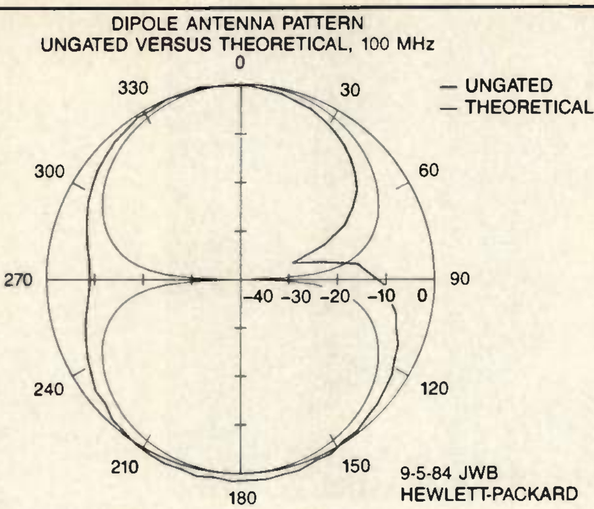


Figure 9a. Gated Antenna Pattern versus Theoretical at 125 MHz: Plotted in a Polar Format.
Figure 9b. Gated Antenna Pattern versus Theoretical at 100 MHz: Plotted in a Rectangular Format.



Experience Proves:
Rantec Absorber Has Locked-in Performance!
Anechoic chambers designed and built by Rantec provide these significant benefits:
• Absorber with extra-high, locked-in performance.
• No absorber carbon fallout.
• No absorber carbon washout.
• All absorber tested and serialized.
• All absorber dimensionally inspected.
• Complete RFI/EMI turn-key installation available.
• Certified RFI/EMI testing available.
Call (818) 704-6944 or circle the reader service number for more information.
rantec®
EMERSON
Anechoic/EMI Systems
7659 Alabama Avenue, Canoga Park, California 91304
(818) 704-6944 • TWX: 910-494-1218
INFO/CARD 30





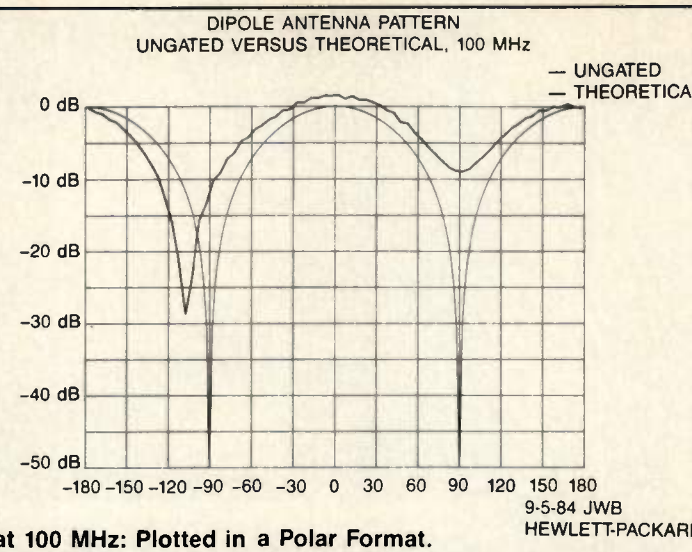
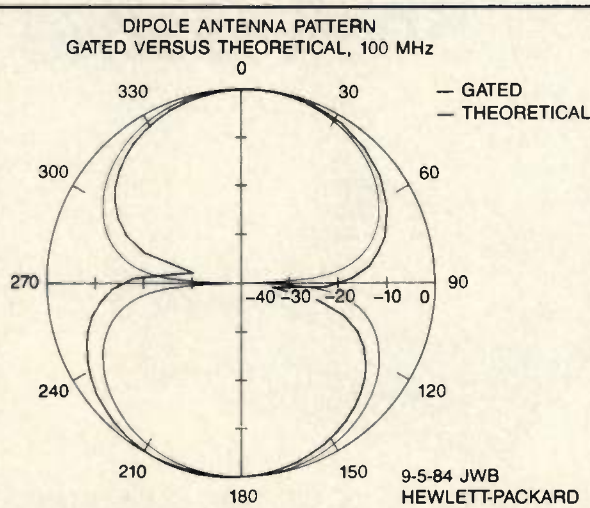


Figure 10a. Ungated Antenna Pattern versus Theoretical at 100 MHz: Plotted in a Polar Format.
Figure 10b. Ungated Antenna Pattern versus Theoretical at 100 MHz: Plotted in a Rectangular Format.



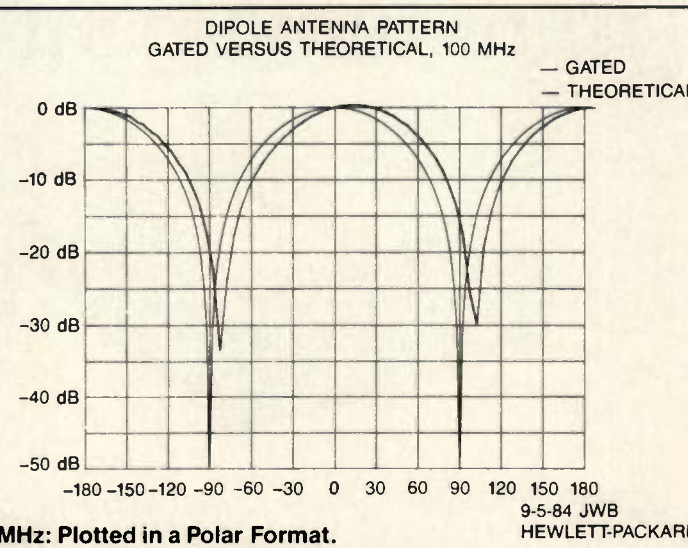
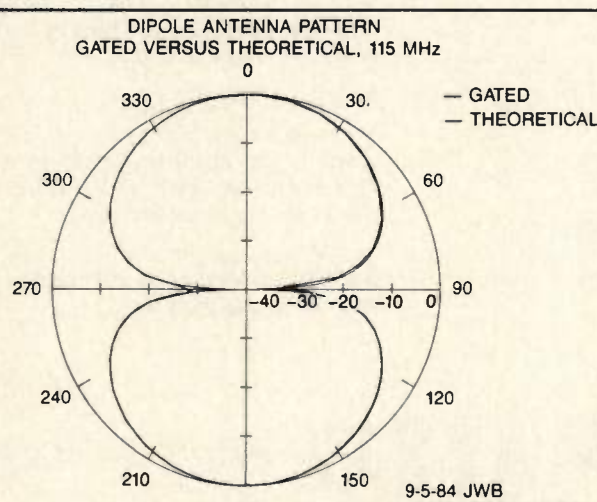


Figure 11a. Gated Antenna Pattern versus Theoretical at 100 MHz: Plotted in a Polar Format.
Figure 11b. Gated Antenna Pattern versus Theoretical at 100 MHz: Plotted in a Rectangular Format.



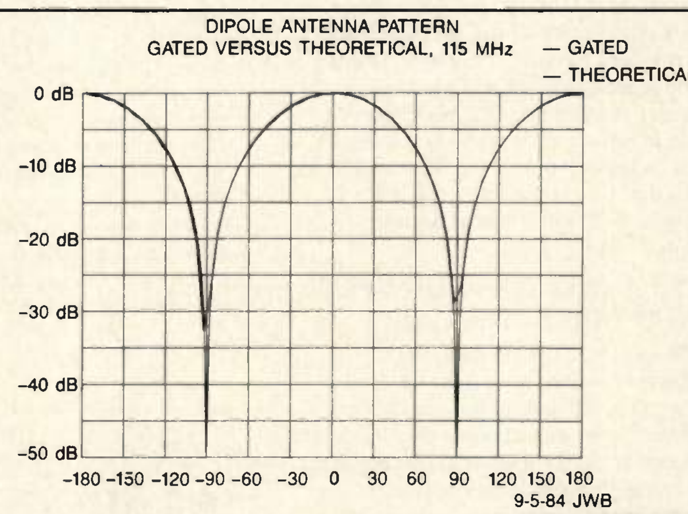


Fig. 12a. Gated Antenna Pattern vs. Theoretical at 115 MHz: From Reduced Bandwidth Data (50 to 175 MHz, 101 Points).
Fig. 12b. Gated Antenna Pattern vs. Theoretical at 115 MHz: From Reduced Bandwidth Data (50 to 175 MHz, 101 Points).

The

Wideband

IFI's M5500 Combines A .01 MHz — 1000 MHz Frequency Range With Near Limitless Applications.

The Model M5500 is the latest in a distinguished line of wideband power amplifiers from IFI. Rugged, compact and economical, this superior unit is forgiving of load mismatches and generous in application.

So when your R&D Department or laboratory needs to boost 1 mw signals up to 10 watts of clean power over the 10 KHz to 1000 MHz range, then count on the IFI Model M5500. From advanced medical research to susceptibility testing, this linear amplifier is the unit that delivers.

Specifications

Amplifier Type
Class A Linear All Solid State

Frequency Range
10 KHz — 1000 MHz in two bands

Band 1: 10 KHz — 500 MHz
Band 2: 500 MHz — 1000 MHz

Min. Power Output
10 Watts (40 db (min.) gain)

Harmonic Distortion (Worst Case)
-24 dbc

Input and Output Impedance
50 Ohms (Nominal)

Unconditionally Stable

Size
5''H x 20''D x 19''W
(12.7 cm. x 50.8 cm x 48.0 cm.)

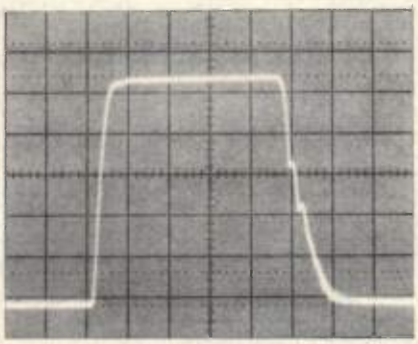
Weight
Approx. 50 lbs.

Instruments For Industry
151 Toledo Street
Farmingdale, N.Y. 11735
(516) 694-1414 TWX 510-222-0876

The M5500: Another One of 'The Dependables' From IFI

INFO/CARD 25

NEED FAST LOG RESPONSE?



LOG TECH HAS THE SOLUTION

DO YOU NEED HIGH FIDELITY LOGGED RF OR IF RESPONSE? THEN STUDY THIS ACTUAL PHOTOGRAPH SHOWING THE LOGGED RESPONSE OF A ONE MICROSECOND PULSE USING THE CLA SERIES OF LOG AMPLIFIERS.

THE CLA SERIES OFFERS STATE OF THE ART RISE AND FALL TIMES TO PROVIDE A "HIGH FIDELITY" LOG RESPONSE.

SPECIFICATIONS:

Frequency Range
30MHZ—1.2GHZ

Input Dynamic Range
30 to 80 db (Selectable)

Meets Environmental Requirements of MIL-E-5400

WE INVITE INQUIRIES CONCERNING YOUR SPECIAL REQUIREMENTS.

LOG TECH, INC.
3529 Old Conejo Rd.
Suite 123
Newbury Park, Ca. 91320
(805) 499-6462

INFO/CARD 32

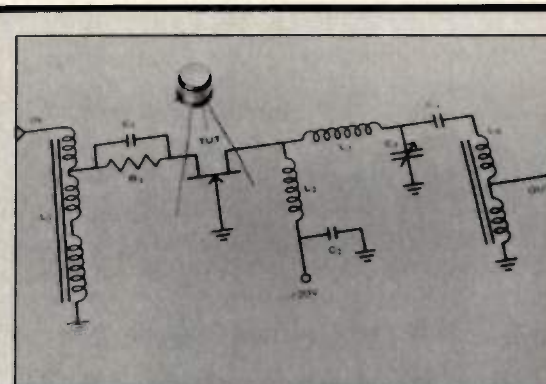
A52U UHF RF SWEEP AMPLIFIER

Similar in appearance to the A62 RF Sweep Amplifier pictured, the A52U RF Sweep Amplifier has a frequency range of 1-900 MHz. Flatness is ±.5 dB. Gain is 30 dB nominal. Input VSWR is 1.5:1 max with typical VSWR of 1.2:1. Available in 50 or 75 ohm impedance, the unit is an excellent general purpose lab amplifier amplifying signals for receivers, frequency counters, spectrum analyzers, oscilloscopes, markers and detectors. It is rugged enough for mobile applications. Line filtering and double shielding prevent ambient and power line interference.

Wide Band Engineering Co., Inc.

P.O. Box 21652 1838 East University Dr. Phoenix, AZ 85036 Ph. (602) 254-1570

INFO/CARD 33



HIGH VOLTAGE BROADBAND RF FET

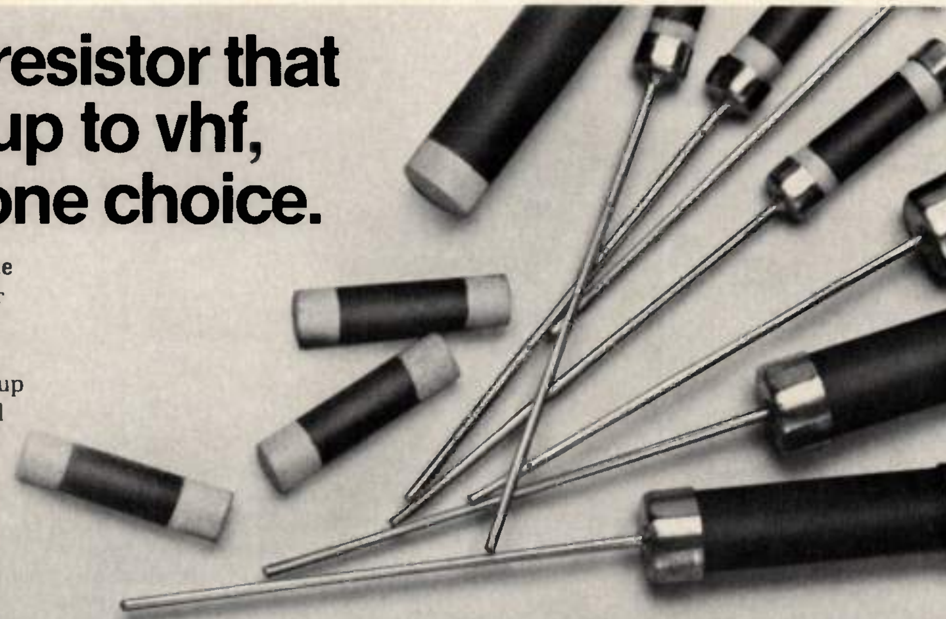
High dynamic range RF FET now available up to 50V BVDGO, for use with 24 & 32V supplies, and where higher drain voltage improves dynamic range. The CP664 (30V), CP665 (40V), and CP666 (50V) have third order intermodulation intercept >+40 dBM, and 50 Ohm VSWR <1.5 to 1 over 0.5 to 50 MHz range.

HIGH VOLTAGE RF FET

TELEDYNE CRYSTALONICS
147 Sherman Street, Cambridge, MA 02140
Tel: (617) 491-1670 • TWX 710-320-1196

INFO/CARD 46

For a power resistor that stays non-X up to vhf, there's only one choice.



The Carborundum® Type SP. Only the Carborundum ceramic power resistor behaves like a pure resistance rather than an inductor and/or capacitor. It operates from low audio frequencies up into the vhf range. Each unit is a solid body of resistive material. No windings, no film. Ideal for frequency-sensitive rf applications like feedback loops.

And it gives you extremely high power density, with great surge-handling capability because it's solid.

Our Type 234SP, for example, is about the size of a 2-watt carbon comp, but dissipates a full 10 watts in 40°C ambient air. Moreover, it can consistently absorb surges of over 10X rated power for several seconds and come back for more with very little Δ R. Forced-air-cooled, water-cooled or immersed in oil, it will handle even greater power overloads.

Other Carborundum Type SP resistors—including high-power, water-cooled configurations—are rated from 2.5 to 1000 watts. For further details, call or write us today.

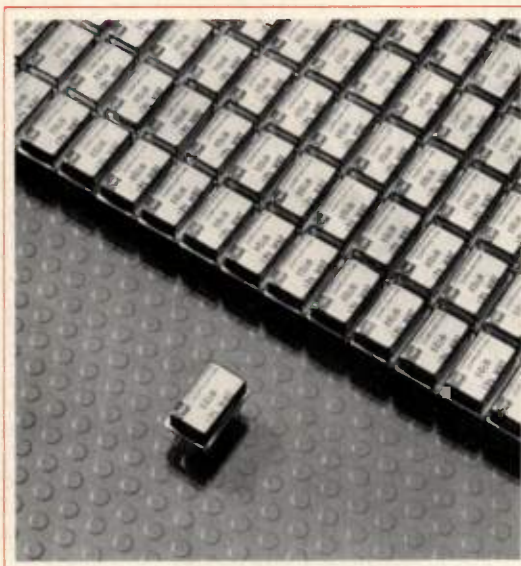
Sohio Engineered Materials Company
Refractories Division
Electric Products Plant, P.O. Box 339
Niagara Falls, New York 14302
716/278-2553

SOHIO CARBORUNDUM

INFO/CARD 35

CONNOR-WINFIELD OSCILLATORS

SHORT-ORDER SPECIALISTS



But we can cook up a big batch, too!

Connor-Winfield is ready to serve. Whether the oscillators you need are in stock or custom designed or whether you need 1 or 10,000, our special of the day—everyday—is meeting your needs with the right combination of quality and low cost. Are you ready to order? Call or write us today for more information.

ECL DIP High Frequency	Models:	ECLA, ECLB		
	Frequency:	8MHz—200MHz, ±.01%		
	Supply:	−5.2Vdc ±5% or −4.5Vdc ±5%		
	Output:	10K ECL or 100K ECL		
	Package:	All metal, hermetically sealed		
DIP SINEWAVE Low Freqency	Models:	DPS1	DPS2	
	Frequency:	1KHz—75KHz	100Hz—100KHz	
	Tolerance:	±.01%, THD ≤5%	±.01%, THD ≤5%	
	Supply:	5Vdc ±10%	8Vdc—15Vdc	
	Package:	All metal, hermetically sealed		
TTL CLOCKS Tight Tolerance	Models:	S10C	S10D	S10E
	Frequency:		31KHz—25MHz	
	Tolerance:	±.001%	±.0025%	±.005%
	Temp. Range:	0°—50°C	0°—70°C	−25°—75°C
	Package:	All metal, hermetically sealed 14 pin DIP		
TTL CLOCKS Stock Frequencies/ Low Cost	Models:	S14R8	S15R8	
	Tolerance:	±.005%	±.01%	
	Supply:	+5Vdc ±10%, 60mA max		
	Frequencies:	1,2,4,5,6,8,10,12,16,20,24,40,70MHz		
	Package:	All metal, hermetically sealed 14 pin DIP		

CONNOR-WINFIELD CORPORATION
West Chicago, IL 60185 USA
Phone: 1-312-231-5270
TWX No. 910-230-3231
Cable: CONWINWCGO

INFO/CARD 36

A New Approach to Op Amp Design

By Scott Evans
Comlinear Corporation

This article describes a high speed op amp topology that offers high frequency performance an order of magnitude faster than conventional op amp designs. One of the results of this design is the elimination of the gain-bandwidth product. Bandwidth remains virtually constant as the gain is changed; as a result, ease of use and predictability of performance have been greatly improved.

Conventional op amps have a differential, high input impedance stage that feeds several subsequent gain stages. The open loop output of the amplifier is $V_o = A(s)\,[V_1 - V_2]$. (See Figure 1.)

With the feedback connection made, feedback in the form of a voltage is applied to the inverting input. The closed loop gain becomes:

$$\frac{V_o}{V_1} = \frac{\dfrac{R_1+R_2}{R_1}}{1+\dfrac{\dfrac{R_1+R_2}{R_1}}{A(s)}}$$

By letting $(R_1 + R_2)/R_1 = G$:

$$\frac{V_o}{V_1} = \frac{G}{1+\dfrac{G}{A(s)}}$$

To see the effect that gain setting, G, has on the frequency response it is instructive to break the open loop gain, A(s), into a ratio of a numerator, N(s), and a denominator, D(s). N(s) contains the zeros of the response and D(s) contains the poles of the response.

$$A(s) = \frac{KN(s)}{D(s)}$$

where K is the DC value of the open loop gain.

Substituting this ratio into the closed loop gain and rearranging:

$$\frac{V_o}{V_1} = G\,\frac{KN(s)}{KN(s)+(G)D(s)}$$

G not only scales the magnitude of the gain (as desired) but also multiplies the effect of D(s) on the closed loop response. The locations of the closed loop poles are now a function of G; thus, if an application requires a large G, the poles will be at a lower frequency than for a low value of G. This is the chief failure of conventional high speed op amp designs. This is a major cause of instability problems in conventional op amps, correcting the problem leads to performance far inferior to data sheet specifications.

Figure 2 shows the closed loop frequency response of a conventional single-pole op amp for various gains. Notice that increasing the gain decreases the bandwidth.

In addition to poor high frequency performance, there are several other severe problems with conventional op amp design.

Compensation — Conventional high speed op amps are instable at most gain settings so compensation must be used. Compensation creates a very low frequency pole that limits bandwidth so severely that the problematic high frequency poles are no longer dominant. Unfortunately, compensation does not allow complete control of the pole and zero locations, so simultaneously optimizing bandwidth, gain flatness and settling time is difficult if not impossible.

External Compensation — Compensation is usually connected external to the amplifier so the designer can tailor the response to the application. Unfortunately, conventional op amps are very sensitive to stray reactance in the PC board layout, temperature, loading and variations in the transistors of the op amp itself that make reliable compensation difficult. In addition, production can become expensive since each op amp compensation network must be individually "tweaked" to the desired response or the op amps must be individually tested and selected.

AC Feedforward — In order to achieve faster rise times and wider bandwidths, conventional op amps often use a technique called AC feedforward. This techni-

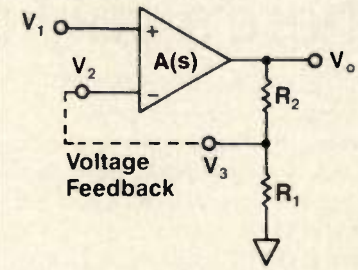


Figure 1. Open loop output

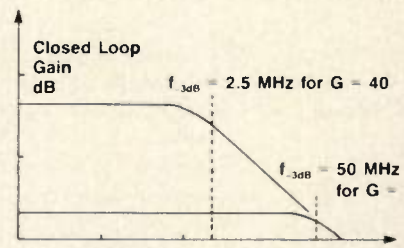


Figure 2. Closed loop frequency response of a conventional single-pole op amp.

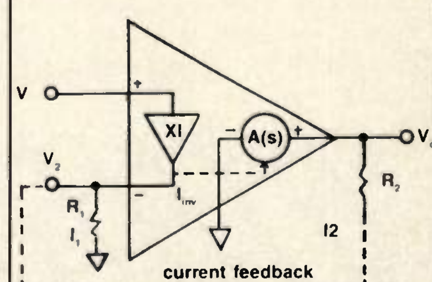


Figure 3. The Comlinear op amp

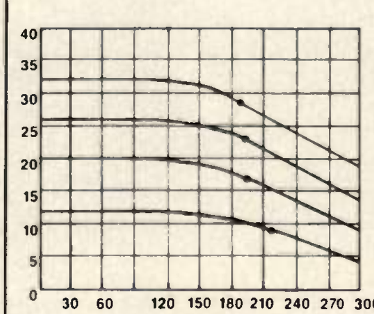


Figure 4. Gain vs. frequency response of the Comlinear op amp.

que cancels a low frequency pole by introducing a zero at the same frequency. Unfortunately, temperature, aging, loading and supply voltages affect pole locations. Pole locations also change with gain setting so the degree of cancellation depends on gain. This is part of the reason why conventional op amp performance is usually specified at a gain of –1. At this gain, the performance is optimal, but it deteriorates rapidly at other settings.

Slew Rate Limiting — In order to obtain high open loop gain, several internal gain stages must be used. As a result, transmit times through the amplifier are large. In addition to reducing the phase margin this also leads to problems when large or fast rise time signals are present at the input. These large or very fast signals can cause an internal gain stage to saturate or be cut off before feedback can propagate back to the input to reduce the error signal. To prevent this behavior the slew rates of the internal stages are simply limited so nonlinear behavior cannot occur before the signal propagates through the amplifier. Consequently, the slew rate and large signal bandwidth of the op amps are reduced severely.

The Fallacy of the Gain-Bandwidth Product

The gain-bandwidth product has for years been a key specification for op amps; in fact, the concept of the gain-bandwidth product is a major topic of op amp tutorials. Unfortunately, this often touted specification means little to the engineer who must work with very high speed op amps. For most high speed op amps the gain-bandwidth product is actually very misleading.

The basis for the gain-bandwidth product is the assumption that the open loop gain rolls off due to a single pole. When the assumption is valid, as is the case with some low frequency op amps, the gain-bandwidth product concept is also valid. Having frequency performance depend on gain is troublesome, but at least with a single pole rolloff the bandwidth is easily determined and stability is assured. High speed op amps, however, have several poles before unity gain crossover is reached.

Clearly, a conventional op amp with a gain-bandwidth product of 1 GHz will not yield a bandwidth of 500 MHz at a gain of 2. This is why most manufactures specify their gain-bandwidth products at very high gains, typically 1000.

A much more useful (and accurate) way to show frequency performances is to actually show the performance for various gains. This allows the engineer to fully characterize the amplifier without having to actually test the device. Although the performance of Comlinear amplifiers varies little with changes in gain, Comlinear provides complete specifications for at least three representative gain settings.

$$I_{inv} = I_2 - I_1$$

$$I_{inv} = \frac{V_2}{R_1} - \frac{V_o - V_2}{R_2}$$

Then, since $V_o = I_{inv} \cdot A(s)$ and $V_2 = V_1$ (because of the buffer)

$$\frac{V_o}{A(s)} = V_1\left(\frac{1}{R_1}+\frac{1}{R_2}\right) - \frac{V_o}{R_2}$$

Then, rearranging

$$\frac{V_o}{V_1} = \frac{\dfrac{R_1+R_2}{R_1 \cdot R_2}}{\dfrac{1}{R_2}+\dfrac{1}{A(s)}} = \frac{1+\dfrac{R_2}{R_1}}{1+\dfrac{R_2}{A(s)}}$$

Again, letting $1+\frac{R_2}{R_1}=G$

$$\frac{V_o}{V_1} = \frac{G}{1+\dfrac{R_2}{A(s)}}$$

Letting $A(s) = \frac{KN(s)}{D(s)}$

$$\frac{V_o}{V_1} = G\frac{KN(s)}{KN(s)+R_2D(s)}$$

Table 1. Mathematical justification of the Comlinear op amp design.

The Comlinear Innovation

Most of the problems with conventional op amps shown are either directly or indirectly caused by the limitation of having G, the gain setting, affect the frequency response. If G could be removed from the denominator of the expression, performance and ease of use could be extended dramatically. This is exactly what Comlinear designers have done. The drawing of the Comlinear op amp (Fig. 3) shows an unusual (and patented) circuit configuration.

The input buffer is a unity gain voltage amplifier that is connected across the inputs of the op amp. In operation, the buffer forces V_2 to equal V_1 *independent of any external feedback through R_2*. This causes the inverting input to have a very low input impedance. When feedback around the loop is applied, the impedance of this node is reduced further and V_2 becomes a "virtual ground" with respect to V_1. This low impedance allows current to flow easily into or out of the inverting input.

The transimpedance amplifier is the gain block inside Comlinear op amps. In operation, the transimpedance amplifier senses the inverting input current (literally the current flowing into or out of the inverting input) and transforms this current into the output voltage. The transfer function of this transimpedance amplifier is A(s); the units are in ohms.

Feedback in the form of a current is applied through R_2 to the inverting input.

A Comparison: Conventional vs. Comlinear

Table 1 shows the mathematical justification of the Comlinear op amp design. As a result of these mathematical operations the closed loop gain equations are in the same form and can be compared directly.

For the conventional op amp:

$$\frac{V_o}{V_1} = G\frac{KN(s)}{KN(s)+(G)D(s)}$$

For the Comlinear op amp:

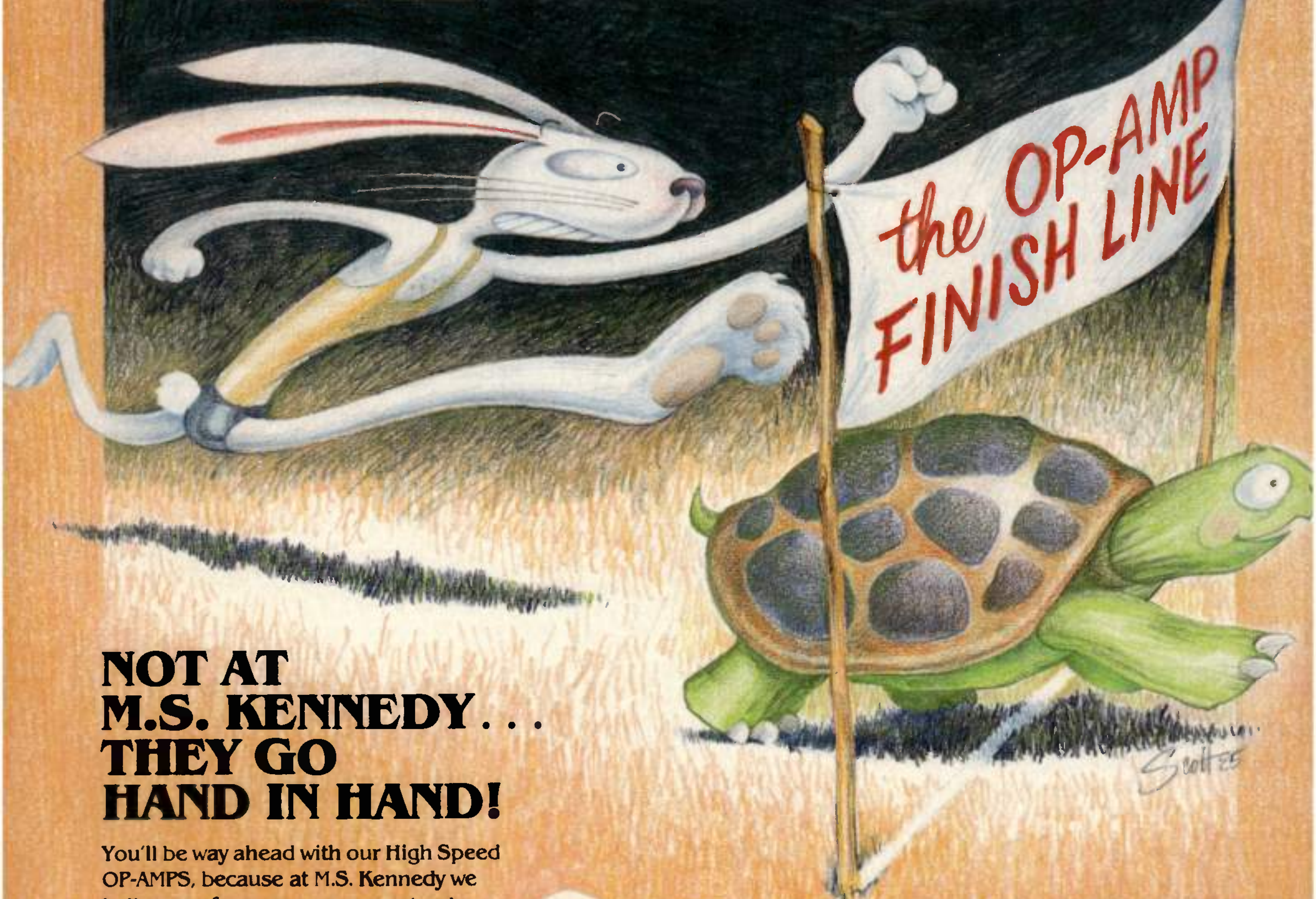
$$\frac{V_o}{V_1} = G\frac{KN(s)}{KN(s)+(R_2)D(s)}$$

R_2 has replaced G in the frequency-dependent portion of the transfer function. Since R_2 can be held constant, whereas G cannot, the pole locations and hence the performance can be held constant. ($G=1+R_2/R_1$, so the gain setting can be varied by changing R_1).

The results of this new approach to op amp design are dramatic:

Elimination of the Gain-Bandwidth Product — The frequency response of the Comlinear op amp changes very little when the gain is increased by a factor of 10, from a gain of 4 to a gain of 40. Other specifications are similarly unaf-

SPEED vs PERFORMANCE SAME OLD STORY?



NOT AT M.S. KENNEDY . . . THEY GO HAND IN HAND!

You'll be way ahead with our High Speed OP-AMPS, because at M.S. Kennedy we believe performance means not only speed, but D.C. Accuracy and long term reliability. We don't sacrifice one for the other.

The M.S. Kennedy Corp. has been producing high speed operational amplifiers for military and high reliability industrial applications for over 10 years. Our quality and performance have led to the design-in of MSK products on nearly every airborne application in the U.S.A.

Full Screening to MIL-Std. 883C

You can rely on our products to finish the job they're designed for, time after time. The proof is in the performance of our units designed into these programs: F-14, F-15, F-16, F-18, F-20, F-111, EA-6B, B-1B, LAMPS, AH-64 APACHE, MAVERICK and AEGIS.

Winning Specs

- Up to DC to 400 MHz Small Signal Band Width
- Up to 4000 V/μs Slew Rates
- Up to 140V Output Swings
- $< 10\mu$V/°C Offset Drift Available.

MSK

M.S. KENNEDY CORPORATION
8170 Thompson Road, Clay, New York 13041
Tel. (315) 699-9201 TWX 710-541-0465

INFO/CARD 37

fected by gain changes. A similar change in gain with a conventional op amp could reduce the bandwidth by a factor of 10, even under ideal single pole conditions. As shown in Figure 4, the –3dB bandwidth remains constant over a wide range of gains. Small second order effects explain the slight deviation in performance from that predicted by the equations.

Excellent Performance — The high speed performance of Comlinear op amps is dramatically better, usually by an order of magnitude, then conventional op amps. A typical rise time for a 5V output step can be as low as 1.6 ns, for example. With a conventional op amp rise times of 30 to more than 100 ns are common. Other outstanding specifications include settling times which can be as low as 10 ns for a 0.2 percent tolerance and slew rates that range from 3000 V/μs to over 7000 V/μs, depending on which model is chosen. (The slew rate was intentionally kept very fast so it would not limit the response of the amplifiers under large signal conditions. Bandwidth, not slew rate, controls amplifier response and keeps it linear.)

Linear Phase — Although phase linearity is a rarely mentioned specification, it is very important for signal fidelity. Comlinear op amps have excellent phase linearity, usually the deviation from linear phase is less than two degrees from DC to over 50 percent of the bandwidth. Conventional op amps, however, must use techniques like AC feedforward which increase bandwidth but degrade phase linearity; thus, signal fidelity is sacrificed.

Predictable Performances — Since most of the specifications are virtually independent of gain setting, the performance of Comlinear op amps remains consistent even with varying circuit configurations. As design requirements change, adjustments in gain usually can be achieved by a change in one resistor; with a conventional op amp a change in gain could require a redesign of the entire circuit.

Internal Compensation — With R_2 fixed and the poles of the frequency response consequently fixed, internal compensation is provided to simultaneously optimize bandwidth, settling time, linearity and distortion. Since the compensation is internal, Comlinear op amps can save time and money in production with no compensation networks to "tweak." Although Comlinear uses an internal high precision resistor for R_2, on many models an external resistor of another value can be used. Since this would change the pole locations, the internal compensation is made accessible to the user through one package pin. One external capacitor is then used to re-optimize the performance.

Standard Usage — Determining the gain for Comlinear op amps is the same as that for conventional op amps, where $G=1+R_2/R_1$. The same ease of use applies equally well to both inverting and differential configurations.

About the Author

Scott Evans is a product marketing engineer for Comlinear Corp., P.O. Box 20600, 4800 Wheaton Drive, Fort Collins, CO 80522. His telephone number is (303) 226-0500.

Take the guess out of rfi testing.

You've decided not to take chances with rfi susceptibility. Then why mix and match the tools you'll use to test for it?

Instead, you can equip your entire test loop with instruments from Amplifier Research that have been thoroughly tested and work well with our high-performance broadband rf amplifiers.

From 1W to 10kW, 10 kHz to 1,000 MHz, in 32 standard models, AR amplifiers give you optimum power, bandwidth, and versatility for your cw, sweep, and pulse requirements. Each model provides instantly available bandwidth without bandswitching or tuning, is completely immune to load mismatch, and won't shut itself down when you may need it most.

But a high-quality test presumes high-quality test equipment throughout. So we also supply specialized antennas, leveling preamplifiers, field sensor systems, fiber-optic telemetry links, TEM cells, matching transformers, and directional couplers.

With this full-system approach, equipment variables are less likely to show up in your test results. It'll pay you to talk with us about *all* your rfi test requirements.

ar AMPLIFIER RESEARCH

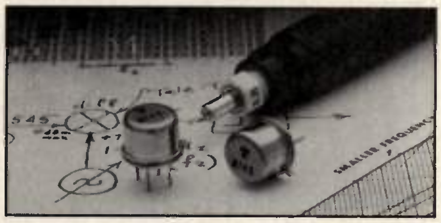
160 School House Road, Souderton, PA 18964-9990 USA
Phone 215-723-8181 • TWX 510-661-6094

7977

INFO/CARD 39

TO-5 Mixer

Model MT45 is a double balanced mixer operating in the frequency range 2-1000 MHz for applications in cellular radio, mobile VHF and UHF communications and cable television equipment. The high performance includes 7.5 dB max-



imum conversion loss at 250 MHz with LO-RF, and LO-RF isolation of 25 dB minimum at 500 MHz. **March Microwave Ltd., Braintree, Essex, UK, please circle INFO/CARD #139.**

10 kW Power Tetrode

A compact power tetrode tailored to operate at 10 kW in FM and VHF TV broadcast service has been developed by Varian EIMAC. The EIMAC 4CX7500A, a ceramic-to-metal tetrode represents another advance in the development of increasingly efficient power tubes for broadcasters who are seeking ways to cut power and equipment costs, and improve operating efficiency. Broadcast system designers will find that the compact, forced-air cooled tube features an advanced anode cooler design. The unique mechanical structure of the tetrode keeps RF losses low, permitting high efficiency operation at full ratings to 220 MHz. For FM broadcast service (86-108 MHz), a matching amplifier cavity, the EIMAC CV-2228 is available. It has a stage gain of up to 20 dB, and an overall efficiency of approximately 79 percent. **Varian EIMAC, San Carlos, Calif., please circle INFO/CARD #158.**

FET RF Power Source

A new FET RF power source for plasma use occupies less than one-half the space and power of competitive units. The AMT Model 1010 boosts over 600 W of CW output power from 100 kHz to 400 kHz, and is capable of remote or local operation. The Model 1010 has a bidirectional digital power meter to monitor load and reflected power and an active power protection

INFO/CARD 40

INFO/CARD 41

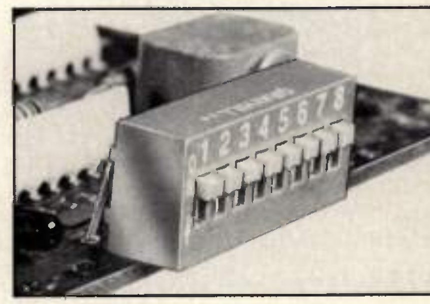
system to allow maximum power to be delivered into any load VSWR. System status and control lines can be accessed via rear panel connection. **American Microwave Technology, Inc., Fullerton, Calif., INFO/CARD #157.**

Precision Laboratory Attenuator

Alan Industries, Inc., now offers a low cost precision laboratory attenuator for measuring receiver sensitivity, signal noise ratio and cross modulation. The first model, the 50BLA20, has a frequency range of DC-300 MHz, VSWR is 1:20 max, and accuracy is ±0.2 dB or 2 percent indicated measurement. Other specifications include impedance, 50 ohm nominal; insertion loss, .6 dB max.; power average, 1 watt; available connector BNC, TNC and SMA and an attenuation range of 0-20 dB in 1 dB steps. Other attenuation ranges of 30, 40, 50 and 60 dB are available. **Alan Industries, Inc., Columbus, Ind., INFO/CARD #159.**

Front Panel Access Dip Switch

Grayhill, Inc., has developed a unique terminal frame allowing front panel access for standard DIP switches normally back panel mounted. When edge mounted on a PC board that is perpendicular to the panel, Grayhill right angle



DIP switches can be operated through a panel cutout. The right angle DIP switch has grown in popularity due to an increasing variety of equipment functions that must be checked before actual operation. **Grayhill, Inc., La Grange, Ill., please circle INFO/CARD #143.**

Microminiature D Series Connector

With contact spacing of 0.050" the Series 50 Micro D Family of connectors from AMP Incorporated is a scaled-down version of the self-polarizing subminiature D connectors. Designed to meet the requirements of MIL-C-83513, the connector is available in eight shell sizes, ranging from 9 through 100 contact positions. All contacts are fully potted and connector assemblies are supplied with flying leads or solid solder posts in either metal shell or all-plastic housings. **AMP Incorporated, Harrisburg, Penn., please circle INFO/CARD #162.**

Hybrid DIP VCXO

The CO-400V Series Hybrid VCXOs are designed specifically for phase locking applications. They provide TTL output at any specified center frequency from 32 kHz through 24 MHz. Deviation over 0 to +5V control voltage ranges from ±30 ppm to ±100 ppm; this deviation is adequate to permit locking onto the specified center frequency over the operating environment (0/50°C to −55/+85°C) for 10-20 years without adjustment. These 0.2" (5.1 mm) high DIP packaged oscillators are available in both 4-pin (Model CO-401V) and 14-pin (Model CO-402V) configurations. They conform to MIL-O-55310 and are available level B screened. The resistance welded case meets 10-8 atm/cc fine leak testing per MIL-STD-883, while the rugged 3-point mount crystal results in sine and random vibration levels exceeding 20g to 2 kHz. **Vectron Laboratories, Inc., Norwalk, Conn., please circle INFO/CARD #147.**

Precision Test Connectors and Adapters

Gilbert Engineering's GPC-7 (an improved 7mm connector) is a new contact design precisely manufactured and tested to maintain contact forces which assure repeatability during precise calibrated measurements. The contact can be easily removed, cleaned and replaced without damage. A replacement contact is also available. VSWR is 1.003 + .002 (F) GHz per IEEE 287 specification. **Gilbert Engineering, Phoenix, Ariz., please circle INFO/CARD #146.**

Semi-Adjacent Bandpass Filter for the Hyperband

The 4930 (channel) is available for any hyperband channel AA-YY (300-450 MHz). It passes the specified channel

INFO/CARD 44

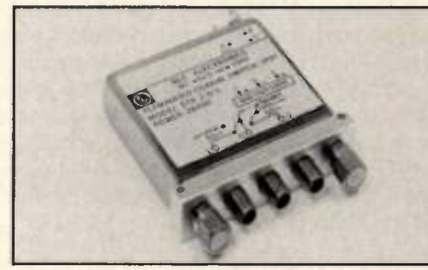
with a 2.0 dB maximum loss and rejects the semi-adjacent channels (2nd channel down and up) a minimum of 25 dB. This bandpass filter can be used to clean up the desired channel at the input of the processor or at the output before combining. Impedance is 75 ohms and the 4930 comes with F connectors. **Microwave Filter Company, Inc., East Syracuse, N.Y., INFO/CARD #145.**

Microwave Synthesis and Analysis Software

EEsof, Inc. announces the release of Linecalc™, the newest product in their expanding line of integrated engineering software. Linecalc is an analysis and synthesis program which provides microwave circuit designers with new ways to explore and adjust values of transmission line parameters. It works like a spreadsheet and provides highly reliable analysis and synthesis of transmission lines. The program uses the same transmission line models as Touchstone™, EEsof's computer-aided analysis and optimization program, to ensure consistent performance. Linecalc analyzes physical parameters and displays the corresponding electrical parameters. The program also synthesizes physical parameters after the engineer specifies the desired electrical parameters. **EEsof, Westlake Village, Calif., INFO/CARD #143.**

Coaxial Switches

RLC Electronics has introduced a line of terminated single-pole, double-throw coaxial switches for termination of the unused switch port. Electrical characteristics feature low insertion loss and .3 dB max., VSWR of 1.3 max. and isolation of 60 dB min. over the entire frequency range of DC-18 GHz. **RLC Electronics, Inc., Mt. Kisco, N.Y., INFO/CARD #146.**



INFO/CARD 34

Line Impedance Stabilization Networks

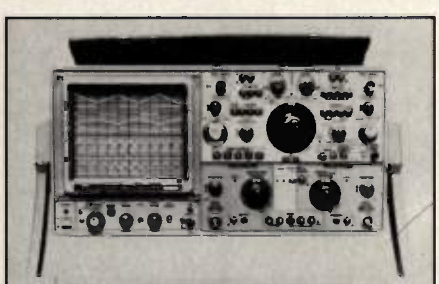
Fischer Custom Communications, Inc. announces a new Line Impedance Stabilization Network developed for conducting EMI measurements in accord with FCC and CISPR standards. This new LISN is available in currents of 25, 50 and 100 amperes, and can be used for long periods of time without excessive heat generation. The shielded unit contains two LISN networks, providing the user with the capability of measuring a phase and neutral or two phases of a powerline. **Fischer Custom Communications, Inc. Inglewood, Calif., INFO/CARD #144.**

MDS/ITFS Video/Aural Combiner

Series 4869 diplexers combine separate video and aural transmitters to a common antenna output. The design technique used results in high isolation and low insertion loss. Insertion loss for video and aural is .25 dB (max.) and 1.5 dB (max.) respectively. Video/aural isolation is 30 dB (min.). Power relay is 100 W minimum. Input and output connectors are 50 ohm, type N, female. The 4869 is available for any MDS channel (2150 to 2162 MHz) or ITFS channel group A through H (2500 to 2686 MHz). **Microwave Filter Company, Inc., East Syracuse, N.Y., INFO/CARD #141.**

4-Input, 8-Trace, 200 MHz Oscilloscope

Iwatsu Instruments has added a new high quality 4-input, 8-trace DC to 200 MHz oscilloscope to its SS-5700 Series. This dual trace unit, Model SS-5712 is designed to handle fast digital signals, stresing the basic characteristics of wider than specified frequency response, highly



accurate deflection factor and sweep rate, plus excellent linearity. For digital diagnostics, the SS-5712 offers an optional 4-bit combination trigger probe, which can specify 16 trigger conditions and extract the required sequence from a digital circuit when testing the right conditions of a microprocessor. **Iwatsu, Carlstadt, N.J., INFO/CARD #151.**

Four-Section MIC Step Attenuator

A new Four-Section MIC step attenuator with 1, 2, 4 and 8dB bits is available from Daico Industries, Inc. Frequency range of 300-1300MHz is covered with typical switching speed of 300 nanoseconds. This device has an internal TTL driver and operates on +5 V at 40mA maximum DC supply. Other key parameters include insertion loss 2dB typical, VSWR 1.2/1 typical, 50 ohm impedance and +10dBm RF power handling. Operating temperature is −55 to +125°C. **Daico Industries, Inc. Compton, Calif., INFO/CARD #133.**

Microstrip Circuit Design Software

MICRO is an engineering program written for the microstrip designer. MICRO provides the microstrip designer with the ability to analyze and design microstrip circuits. With MICRO you can design lowpass or bandpass filters, stepped impedance transformers and hybrid rings. MICRO will also analyze or synthesize single or coupled strips and at extreme S/H or W/H will perform a Bryant and Weiss analysis using a dielectric Green's function for better than 1% accuracy. All the synthesis programs in MICRO contain correction factors for fringing field errors and bandwidth shrinkage to provide you with a "real world" design the first time. **THS Engineering, Escondido, Calif., INFO/CARD #100.**

Coaxial Crystal Detectors

The new Micronetics coaxial crystal detectors cover a frequency range of 0.01 to 12.4 GHz and a frequency response within ±0.5 dB absolute. Relative matching excluding bias sensitivity, is within ±0.2 dB. Other specifications include; output impedance, 15 ohms shunted by 10 pF; output polarity, negative (positive optional); connectors, RF input, type N, male; VSWR, values to 12.4 GHz maximum, maximum power, 100 mW peak or coverage. **Micronetics, Inc., Norwood, N.J., INFO/CARD #101.**

Precision Analog Array Family

Solitron Devices, Inc. has announced the development of the first precision analog array family in the industry. Identified as the HTL Series, the devices offer a variety of components including precision thin-film laser trimmed resistors. The typical degree of precision is ±0.005% with a temperature coefficient of 35 PPM/°C. Certain arrays in the family offer a selection of high current components ranging from 0.5A to 5A. The HTL Series is designed for use in military, aerospace, telecommunication, medical and precision industrial applications such as precision op amps, precision references, analog/digital circuits and high current drivers. **Solitron Devices, Riviera Beach, Fla., INFO/CARD #102.**

Ultra Broadband Noise Generating Instrument

Noise Com's Model NC6111 Noise Generating Instrument has 24 octave wide, +10 dBm of Gaussian-white noise within -2.5 dB flatness. It operates from 115 V line voltage at temperature range -10°C to +60°C. It has an output impedance of 50 ohms and the standard unit comes with 10 dB in 1 dB step attenuator. Options are; other attenuator values, 230 V, 50 Hz power-in, resistive power combiner, marker input and higher output levels. **Noise Com Inc., Hackensack, N.J., INFO/CARD #154.**

Voltage Controlled Fundamental Oscillators

The new VCO-100 series of varactor tuned oscillators offer full octave tuning ranges from 25 MHz to 2 GHz in compact TO-8 packages. Model VCO-105 covers 200-400 MHz with a tuning input of 1 to 20 VDC. Power output is +13 dBm into 50 ohms flat to within ±1 dB while power dissipation is less than 180 mW from -55 to +100°C. All units are encapsulated and welded closed for very low microphonic performance in severe military or commercial environments. **Vari-L Company, Inc., Denver, Colo., INFO/CARD #145.**

Microwave Counter makes Automated Measurements Up to 40 GHz

New GaAs technology, combined with the latest concepts in microwave-instrument design, have resulted in a 10 Hz to 40 GHz microwave frequency counter. The HP 5352A offers the same feature set as the HP 5350A (10 Hz-18 GHz) and HP 5351A (10 Hz-26.5 GHz) counters introduced in January. This family of instruments which share the same

rf products Continued

package dimensions, also provides high-speed data transfer, optional low-aging-rate oscillators and a single-input connector for frequency measurements from 500 MHz to the upper limit of each counter. The HP 5352A derives its high-frequency performance from the GaAs sampler first used in the HP 5350A/5351A. The choice of GaAs over silicon (previously used in microwave-frequency designs) was made in anticipation of adapting the design to higher-frequency applications. A GaAs sampler down-converter allows greater control of circuit response. This results in dependable high-frequency characteristics, and, therefore, predictable and repeatable performance at millimeter frequencies. **Hewlett-Packard Company, Palo Alto, Calif., INFO/CARD #156.**

Automatic Test Program Generator

AMS-Advanced MicroSolutions has introduced an Automatic Test Program (ATP) generator designed to automate the process of developing test programs and documentation. With the ATP generator, a test programmer familiar with BASIC language can generate simple ATPs in just a few hours and modify an ATP in minutes. The Generator and ATPs are available for use with the HP 9000 Series 200 Technical Computers and GP-IB (IEEE-488) controllable instrumentation. **AMS-Advanced MicroSolutions, Menlo Park, Calif., INFO/CARD #150.**

High-Speed Silicon-Gate DMOS Analog Switch in Surface-Mount SO-14 Package

The SD5400 family of DMOS analog switches with 1 ns switching time is now available from Siliconix in the surface-mount small-outline SO-14 package. This miniature 14-lead plastic DIP is ideal for hybrid design; it is one-third the size of the standard 14-lead DIP and has been pretested. The SD5400 quad switch array is built on the Siliconix-developed oxide-isolated, silicon-gate DMOS process, which provides greater device stability and reproducibility over metal-gate designs. Available in three grades — SD5400CY, SD5401CY, and SD5402CY — the device is specified for analog signals up to ±10 V, ±5 V, and ±7.5 V, respectively. Drain-to-source leakage current is only 10 nA (maximum), while gate-leakage current is 1 μA (maximum) for all three variations. Typical drain-to-source on-resistance is only 50 ohms at a gate voltage of 5 V. The operating temperature range is 0°C to 70°C, and maximum breakdown voltage at 25°C ambient temperature is rated at 20 V for the SD5400CY, 10 V for the SD5401CY, and 15 V for the SD5402CY. **Siliconix, Inc., Santa Clara, Calif., INFO/CARD #155.**

Monte Carlo Analysis Program Offered with Touchstone

Monte Carlo analysis and yield prediction with the capability to vary substrate and measured S-parameters is now available to RF/microwave circuit designers using Touchstone, a computer-aided engineering program from EEsof, Inc. for the IBM PC/XT/AT and HP 200 computers. Manufacturing yield of RF/microwave circuits is projected by selecting certain circuit parameters for random variation. Any parameter that can be optimized can also be used as a toleranced value. For example, tolerances may be assigned to 1- and 2-port S-parameters and 2-port noise parameters to analyze how a random variation in transistor performance affects overall circuit performance. One- and two-port data may be specified as s-, y-, z-, g- or h-parameter data in various formats. EEsof customers who have purchased Touchstone before July 1, 1985 will be sent the Monte Carlo program as part of their software support service. After July 1, Touchstone-MC will be available as an added-cost option to Touchstone. **EEsof, Inc., Westlake Village, Calif., please circle INFO/CARD #154.**

Programmable Attenuator

Specs for Model 50P-076 of JFW Industries are: DC-1000 MHz; 0-127 dB in 1 dB steps; switching speed: 6

milliseconds; connectors; BNC, TNC, N or SMA. **JFW Industries, Inc., Indianapolis, Ind., INFO/CARD #148.**

Main Frame Scope Accepts up to 3 Plug-In Units

Iwatsu Instruments has announced a new, plug-in type general-purpose oscilloscope which allows total flexibility in selecting or changing functions. The SS-8120 accepts up to three plug-in units that provide either a 4-channel 100-MHz oscilloscope, a 4-channel 1-GHz sampling oscilloscope, a 2-channel digital measuring oscilloscope or a 2-channel ultra-high-deflection oscilloscope. The mainframe features a 7 inch dome-mesh CRT and incorporates a character generator so data from the plug-in units can be displayed on the CRT in easy to read values. In addition, the versatility of the SS-8120 is enhanced with signal output terminals provided for the output of vertical signals, timebase signals, gate signals and calibration voltages. **Iwatsu Instruments, Carlstadt, N.J., INFO/CARD #153.**

Bipolar Power RF Transistor

A new high power, class "AB" bipolar RF transistor for military communications and ECM applications is now available from the RF Devices Division of TRW Electronic Components Group. The MRA0204-60 device provides 60 W of CW linear power in broadband applications. Gain is 9.5 dB minimum at 400 MHz and 28 V. The device is usable over a 225 to 400 MHz frequency range. The MRA0204-60 can withstand a 5:1 VSWR load pull at 400 MHz with a power output of 60W. **TRW Electronics Components Group, Lawndale, Calif., INFO/CARD #152.**

Intelligent Impedance and Gain-Phase Analyzer

A new impedance and gain-phase analyzer from Hewlett-Packard Company, the HP 4194A, is an intelligent instrument that makes both impedance and transmission measurements. Frequency coverage is 100 Hz to 40 MHz for impedance measurements and 10 Hz to 100 MHz for gain-phase measurements. The HP 4194A has a 7.5-inch (19 cm) color display for presenting measurement data, making it the first HP instrument with a color CRT. Designed for lab and quality-assurance applications of component manufacturers, and communications and consumer equipment manufacturers, the HP 4194A can be used to evaluate materials, discrete components, ICs and circuits. The analyzer's Auto-Sequence-Program (ASP) function easily can automate the measurement and analysis functions without using a separate computer. **Hewlett-Packard Company, Palo Alto, Calif., INFO/CARD #150.**

Short Form Catalog

A new short form catalog from Ballantine Laboratories, Inc., describes key specifications and features for its broad line of precision electronic test and measuring instruments. Covered are oscilloscopes, both for portable general purpose use and laboratory units; scope calibrators; voltmeters and special purpose instruments; multimeters; counters and counter-timers; and AC calibration standards. Also included are the company's programmable instruments and automated computer-based systems for calibrating oscilloscopes and meters. **Ballantine Laboratories, Inc., Boonton, N.J. INFO/CARD #123.**

Electronics Catalog

The 176-page 1985 edition of the Mouser Electronics Catalog offers over 17,000 items stocked in depth. It serves as an excellent guide for engineers, purchasing agents, or anyone needing quick access to up-to-date product data and pricing of standard stocked industrial electronic components. It includes potentiometers, capacitors, resistors, transformers, lamps, switches, battery holders, jacks, plugs, speakers, knobs, fuses, semiconductors, hardware, tools, test equipment, relays, cabinets, meters and more. **Mouser Electronics, Santee, Calif. INFO/CARD #122.**

Low Pass EMI Filter Catalog

A new 36-page low pass EMI filter catalog is now available from Murata Erie North America, Inc. This new catalog contains complete technical information on the company's high quality EMI filters and filtering systems for MIL spec and other applications. Details on mechanical configurations, electrical specifications and environmental performance are thoroughly discussed. In addition, cross references for Military Part Numbers MIL-C-39014/16, MIL-C-39014/17, MIL-C-39014/18 and MIL-C-39014/19 with Murata Erie part numbers are given. **Murata Erie North America, Inc., Marietta, Ga. INFO/CARD #121.**

Surge and ESD Handbooks

Two handbooks have been announced by KeyTek Instrument Corp., to help modern electronic equipment survive powerline and dataline surges as well as ESD (electrostatic discharge). The Surge Protection Test handbook describes surges conducted via signal lines and the AC power line. The Electrostatic Discharge (ESD) Protection Test Handbook describes ESD itself, prevention techniques and a guide for diagnostic ESD testing. Written in clear basic terms, these handbooks will be helpful to both the experienced engineer and the newcomer to environmental testing. All the necessary information is included to assist a user in hardening his equipment, from the design stage through final acceptance testing. **KeyTek Instrument Corp., Burlington, Mass., INFO/CARD #120.**

Conformal and Molded Axial Leaded Capacitors

AVX Corporation has published a new catalog on conformally coated and molded axial-lead multilayer ceramic (MLC) capacitors. The 20-page publication gives complete specifications for NPO, X7R, and Z5U dielectrics used in conformally coated (SpinGuard™) and molded axial-lead MLC capacitors. Although these MLC capacitors are ideal for low-cost, high-volume applications, redundant testing of capacitance and dissipation factors (D.F.) ensures parametric accuracy of these components. General specifications for each dielectric cover capacitance range and tolerances, operating temperature range and characteristic, and voltage ratings. D.F., insulation resistance, dielectric strength, life test, moisture resistance, thermal shock, and immersion cycling information are also shown for both SpinGuard and molded axial-lead capacitors to help design engineers specify the best capacitor for the application. **AVX Corp., Myrtle Beach, S.C. INFO/CARD #117.**

Beam-Lead and Chip MIS Capacitors Brochure

Alpha Industries, Inc. has released a new 20-page brochure describing their beam-lead and chip MIS capacitors. The brochure includes technical information and data sheets on Alpha's complete capacitor product line, including MIS chip, binary trimming, FET chip mounting, beam-lead, and millimeter-wave beam-lead capacitors. An application note that covers bonding methods and packaging is also included. **Alpha Industries, Inc. Woburn, Mass. INFO/CARD #115.**

rf courses

FCC Requirements and Test Methods
October 9-10, 1985, Philadelphia
October 30-31, 1985, Boston
Information: Greg Gore, R&B Enterprises, 20 Clipper Road, West Conshohocken, PA 19428; Tel: (215) 825-1965

Selecting Materials and Systems for EMI Shielding
September 26-27, 1985, Columbus, Ohio
Information: Katrinna Fischer, Battelle's Columbus Laboratories, 505 King Ave., Columbus, OH 43201-2693; Tel: (614) 424-5724

Interference Control Technologies

Grounding and Shielding
September 24-27, 1985, Las Vegas
October 15-18, 1985, Philadelphia
November 12-15, 1985, San Diego
November 19-22, 1985, Bermuda
December 3-6, 1985, New Orleans

EMC Design and Measurement
November 11-15, 1985, Orlando

TEMPEST — Design Control — Testing
October 7-11, 1985, Washington, DC
December 2-6, 1985, Sunnyvale

Introduction to EMI/RFI/EMC
December 3-5, 1985, Los Angeles

MIL-STD 461/462 and System Level Testing and Procedures
September 24-27, 1985, San Diego

EMC for Packaging Engineers
October 8-9, 1985, Philadelphia

Fundamentals of EMI/EMC
September 10-11, 1985, Boston
December 10-11, 1985, Houston

Grounds and Shields in Instrument Design
October 1-2, 1985, San Diego
Information: Penny Caran, Interference Control Technologies, State Route 625, P.O. Box D, Gainesville, VA 22065; Tel: (703) 347-0030

Continuing Education Institute

Microwave Circuit Design: Linear Circuits
October 7-11, 1985, Cambridge, Massachusetts
October 14-18, 1985, Zurich, Switzerland
November 4-8, 1985, Palo Alto, California

Microwave Circuit Design: Non-Linear Circuits
December 2-6, 1985, Palo Alto
Information: Helen Hegnsdal, Continuing Education Institute, 10889 Wilshire Blvd., Los Angeles, CA 90024; Tel: (213) 824-9545

Kathi Walsh
Classified Advertising Manager

rf design

A Cardiff Publication

**6530 South Yosemite Street
Englewood, Colorado 80111
(303) 694-1522**

Advertiser Index

Yes. Silicon Frequency-Linear Tuning Varactors.

Eliminate costly linearizer circuits with FSI field proven Frequency Linear Tuning Varactors. The GC-15000 series FLTVAR is produced by state-of-the-art computer controlled epitaxial technology, which provides the resistivity gradient and resulting CV curve necessary for linear tuning.

The FLTVAR is well suited for use in bipolar and FET VCO's, Gunn VCO's and tunable filters for wideband tuning through KU band.

Engineering services are available to provide assistance in the event our standard catalog types do not meet your requirements.

and GaAs Varactors too.

Where ultra high Q is desired, these GC-51000 series abrupt junction GaAs Tuning Varactors are available. These devices are ideal for tunable VCO's, frequency synthesizers, voltage tunable filters, phase shifters, as well as linear frequency and phase modulators for communications equipment.

Quality workmanship and reliability of FSI's GaAs Tuning Varactors are assured by our strict process control standards.

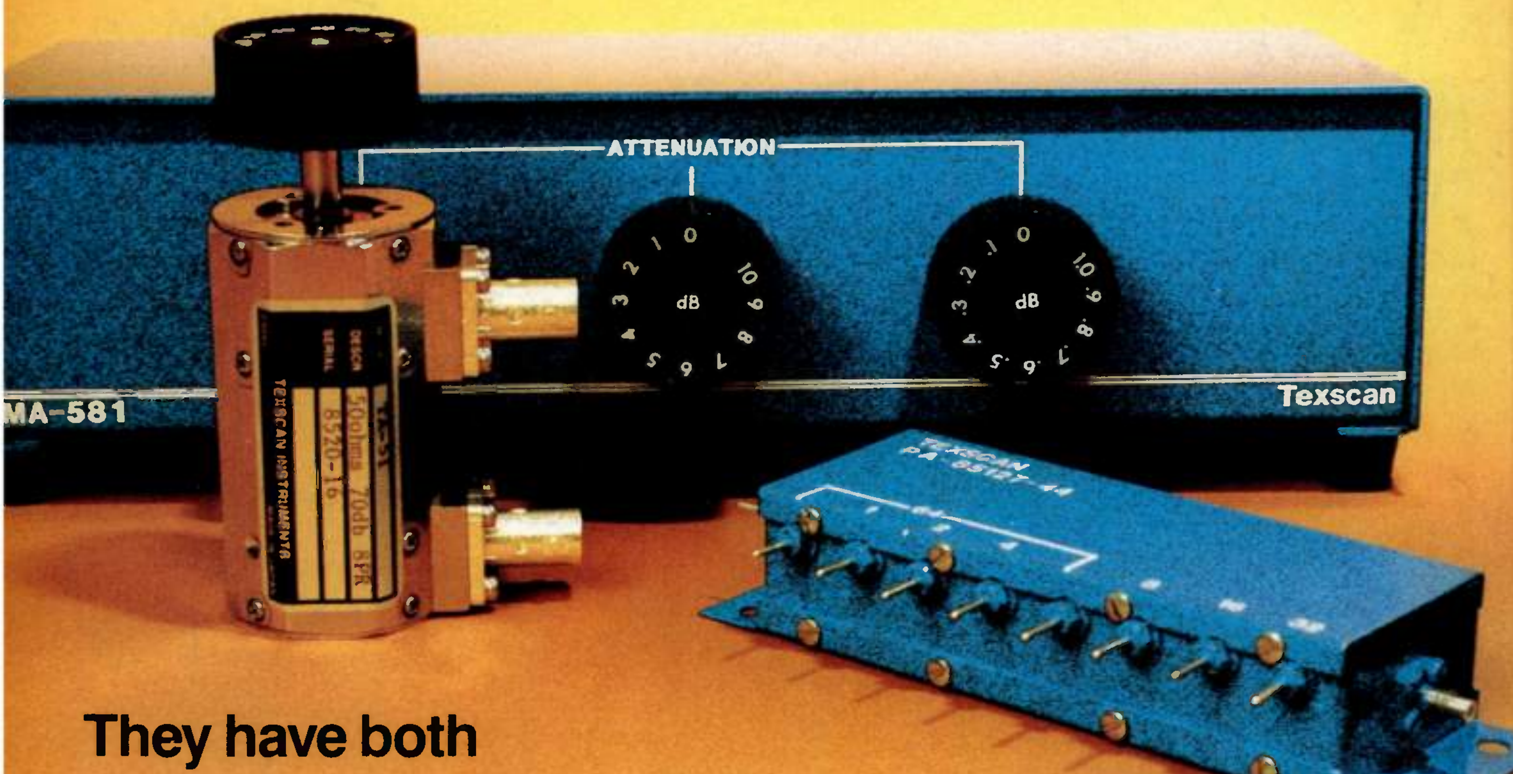
Write for complete details.

FREQUENCY SOURCES
SEMICONDUCTOR DIVISION
A SUBSIDIARY OF **LORAL** *CORPORATION*

16 Maple Road
Chelmsford, MA 01824
(617) 256-8101
TWX (710) 343-0404

Specifications vs. Price

Texscan's new attenuators eliminate the choice between good specifications and a good price



They have both

	BENCH MOUNT		PROGRAMMABLE		ROTARY		
	BMA 580/780	BMA 581/781	PA 85127	PA 6563	TA 50/70	TA 51/71	TA 53/73
IMPEDANCE	50/75 ohm	50/75 ohm	50 ohm	50 ohm	50/75 ohm	50/75 ohm	50/75 ohm
STEP	1 dB	0.1 dB	1 dB	1 dB	1 dB	10 dB	0.1 dB
ATTENUATION	80 dB	81 dB	127 dB	63 dB	10 dB	70 dB	1.0 dB
FREQUENCY	DC-2.1GHz	DC-1 GHz	DC-1 GHz	DC-1 GHz	DC-2.1GHz	DC-2.1Ghz	DC-1 GHz
CONNECTORS	BNC, SMA or N		BNC, SMA or SMB		BNC or SMA		
PRICE (U.S. DOMESTIC)	$290	$450	$360	$260	$79 BNC $89 SMA	$79 BNC $89 SMA	$79 BNC $89 SMA

OTHER STEP AND ATTENUATION VALUES AVAILABLE TO SPECIAL ORDER

CALL OR WRITE US TODAY:

3169 North Shadeland Ave • Indianapolis, Indiana 46226 • (317) 545-4196

Texscan CORPORATION

INFO/CARD 59