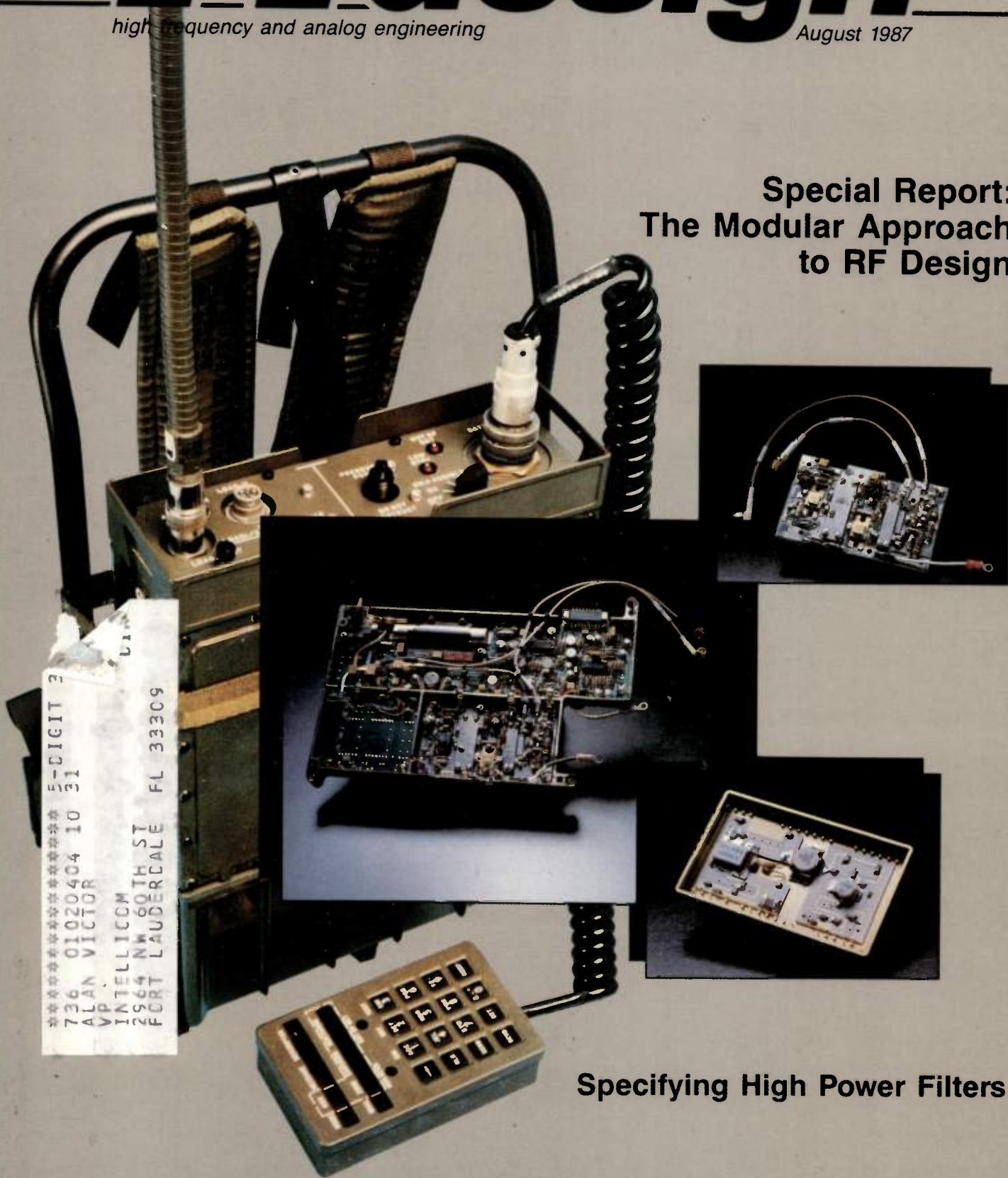


rfdesign

high frequency and analog engineering

August 1987

Special Report: The Modular Approach to RF Design



***** 5-DIGIT 3
736 01020404 10 31
ALAN VICTOR
VP
INTELLICOM
2864 NW 60TH ST
FORT LAUDERDALE FL 33309

Specifying High Power Filters

What RLC's Coaxial Filters Can Do For You... PERFORM!

From DC to 40 GHz
with low insertion loss,
high rejection and
low VSWR.

RLC's complete line of filters have the high quality and superior performance you need. Select a standard filter from our catalog or have us build a custom one to your exact specifications. Prototype delivery takes less than four weeks, standard delivery from stock.

Types:	Band pass, Low pass, High pass
Configurations:	TO-5, TO-8, Tubular, Cavity, Comb Line, Interdigital, Micro Miniature
Frequency:	DC to 40 GHz
3dB Bandwidths:	0.1 to 100%
Sections:	2 to 20
Rejection:	Spurious Free to 40 GHz
Power:	milliwatts to kilowatts
Environmental Conditions:	MIL-F-18327, MIL-E-5400
Connectors:	SMA, N, BNC, TNC, SC, HN, Tabs, Pins

**Call or write today for complete
specifications.**

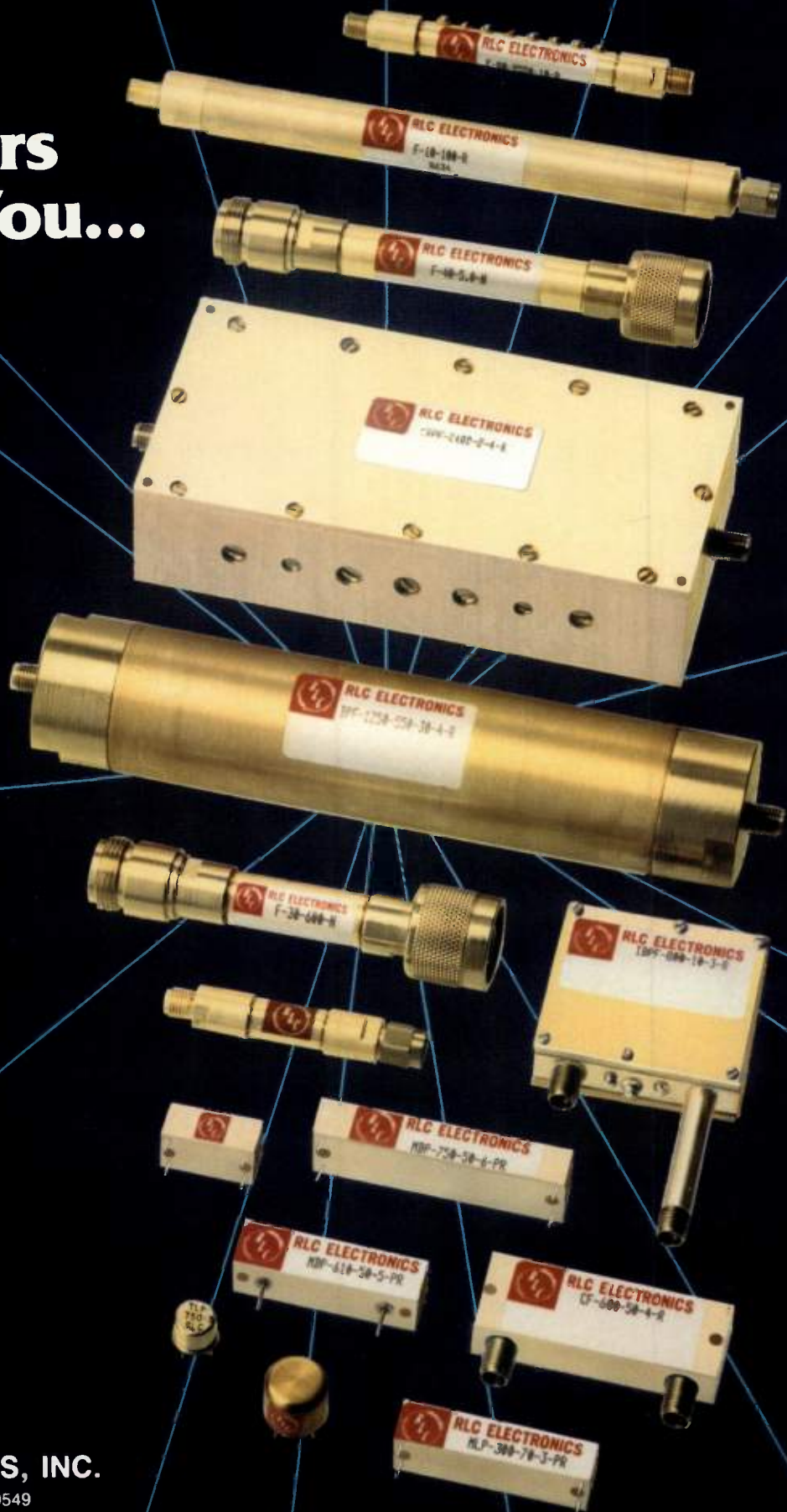


RLC ELECTRONICS, INC.

83 Radio Circle, Mt. Kisco, NY 10549
(914) 241-1334 • TWX: 710-571-2103

Belgium: 011 (32) 02-511-22-77 • France: 011 (33) 1-534-75-35 • Germany: 011 (49) 906-4091 • India Bangalore: 011 (91) 602120 • Italy: 011 (39) 2-7380641/2 • Israel: 011 (97) 23 259598 • Japan: 011 (81) 270-5921 • Taiwan: 011 (02) 751-3733/44 • United Kingdom: 011 (44) 1-979-0123

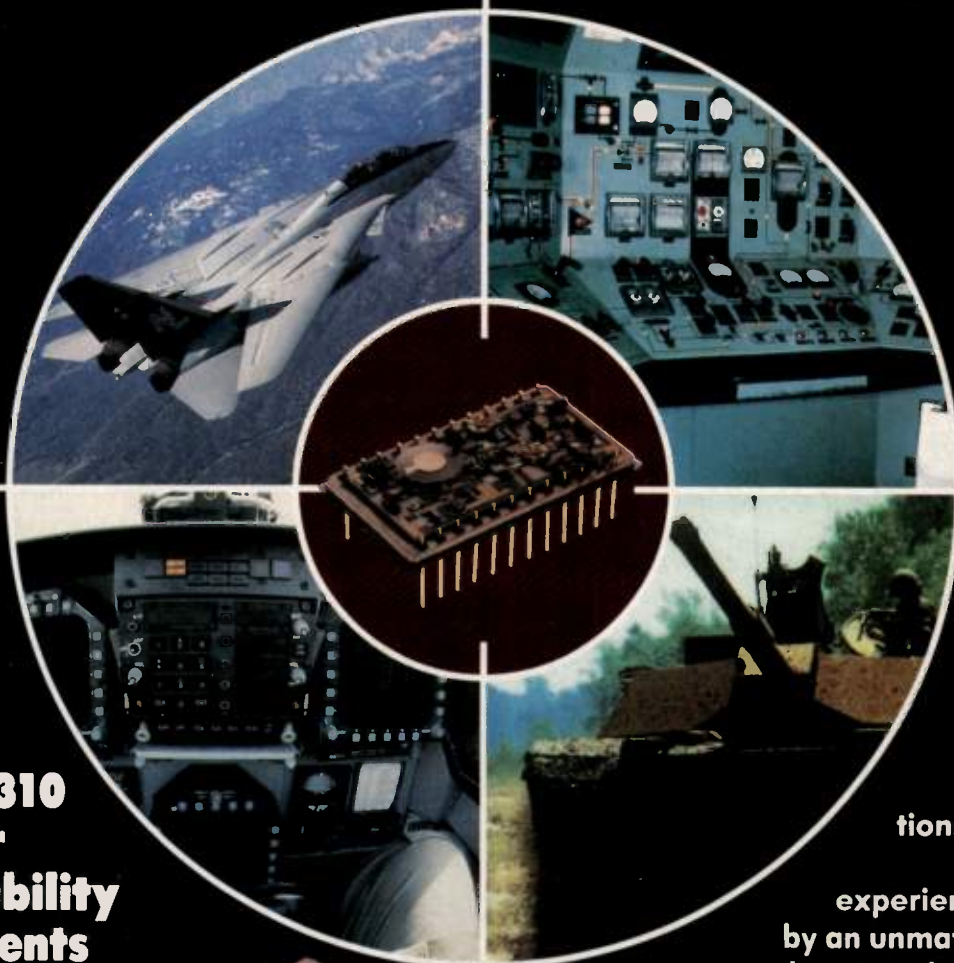
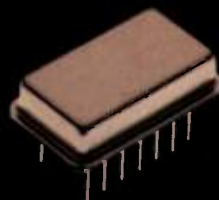
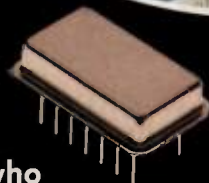
INFO/CARD 1



"Can't Miss" Dependability

Reeves-Hoffman fills your MIL-O-55310 and other high reliability requirements

A long-term commitment to quality has earned Reeves-Hoffman a high degree of customer confidence. Those who depend on us demand high performance and cannot afford component failure. For those needs, Reeves-Hoffman is right on target. ☐ Reeves-Hoffman has provided high-quality quartz crystal products for military and industrial applica-



tions for nearly half a century. This experience is enhanced by an unmatched degree of order control; we are the *only* oscillator manufacturer with in-house facilities for the production of quartz crystals, hermetic seal packages, and hybrid substrates. ☐ In addition to MIL-QPL oscillators, we can also provide you with custom designed oscillators to fit your special requirements. ☐ Whether you need MIL-O-55310 QPL oscillators, or the reliability that a QPL supplier can provide, set your sights on Reeves-Hoffman.



REEVES-HOFFMAN
DIVISION DYNAMICS CORPORATION OF AMERICA

Reeves-Hoffman, 400 W. North Street, Carlisle, PA 17013 USA • Phone 717-243-5929
TLX 265873 RHDV UR • FAX 717-243-0079

Stellar Array of Silicon ICs

Introducing Our Low Cost Line
of High Frequency, High Speed ICs

NEC
NEC Corporation

NEC introduces an extensive line of low cost **RF amplifiers, RF prescalers, high F_t transistor arrays, UHF converters, and demodulators.**

Take the high frequency amplifiers for example. They include a choice of 13 different circuits (see insert). And low prices? Try the UPC1675G or UPC1676G wideband amplifiers. Both are under 75 cents at the 2500 piece quantity. And no external biasing resistors are required.

Most of these ICs are available as chips, or in ceramic, metal, plastic DIP, or plastic surface mount (SMT) packages. Consistent performance and volume delivery are assured by the NEC mass production process.

Call or write today for our free brochure on NEC Silicon ICs. With CEL you get the technology that puts you ahead, and the support that keeps you there.



California Eastern Laboratories

3260 Jay Street, Santa Clara, CA 95054 (408) 988-3500

Western (408) 988-3500 Eastern (301) 667-1310

Canada (613) 726-0626

Europe NEC Electronics GmbH 0211/650301

Wideband Amplifiers

UPC1651,2,3	1.2 GHz at 3 dB down, 18 dB Gain
UPC1654	1.1 GHz at 3 dB down, 19 dB Gain, 10.5 dBm P _{out}
UPC1655	1.0 GHz at 3 dB down, 5.5 dB NF, 18 dB Gain
UPC1656	850 MHz at 3 dB down, 19 dB Gain, 10.5 dBm P _{out}
UPC1658	Low Noise, 1.5 dB NF at 100 MHz
UPC1659	0.6-2.3 GHz, 5 dB NF, 23 dB Gain
UPC1675G	2.1 GHz at 3 dB down, 5.5 dB NF, 12 dB Gain
UPC1676G	1.4 GHz at 3 dB down, 4.5 dB NF, 22 dB Gain

High Isolation, Differential, AGC Amplifiers

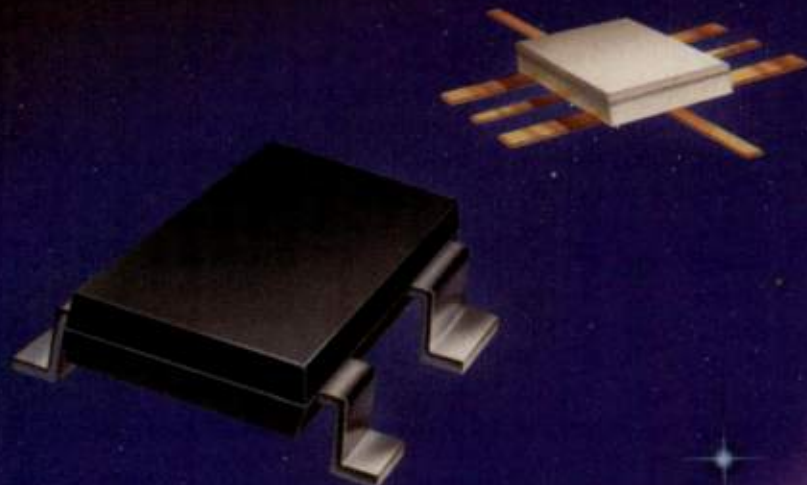
UPC1668	-55 dB Isol at 70 MHz, 14.5 dB Gain, 13 dBm P _{out}
UPC1669	-55 dB Isol at 70 MHz, 10.5 dB Gain, 11 dBm P _{out}
UPC1670	-55 dB Isol at 70 MHz, 7.0 dB Gain, 11 dBm P _{out}
UPC1663,4	Differential, Up to 700 MHz
UPC1476	AGC, 20-600 MHz, 45 dB Gain Control

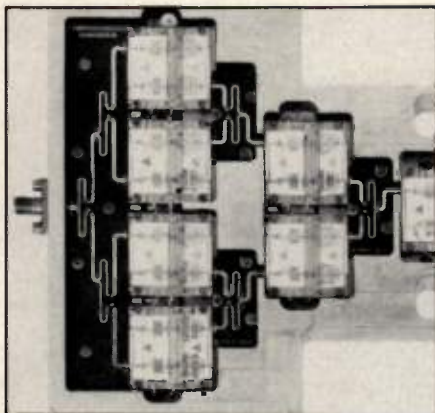
Prescalers — 0.5-2.8 GHz

Transistor Arrays — $F_t = 9$ GHz
Configurable as: Mixers, EXOR/NOR
Gates, Diff Amps, Multipliers

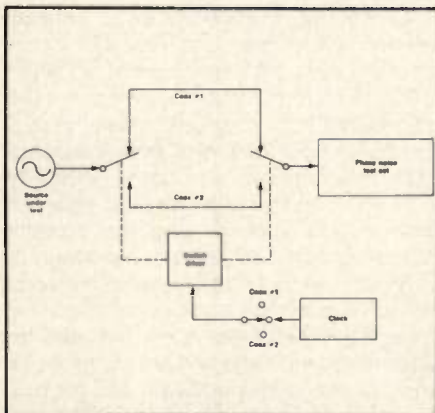
Down Converters — Up to 1.0 GHz

Demodulators — FM and QPSK

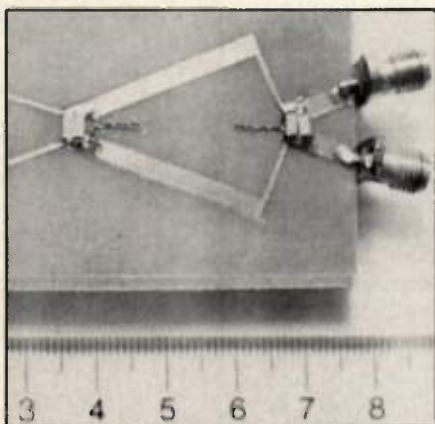




Page 28 — Special Report



Page 38 — Phase Noise Calibrator



Page 49 — Broadband Power Divider

Cover Story

27 Modules Deliver the RF Punch for PLRS

Modular design is carried out to three levels in the PLRS position reporting system — amplifier assembly, three board-level subassemblies, plus thick and thin film hybrid circuits. The assembly is made for Hughes by Microwave Modules and Devices, a young company whose sole business is modular components and subsystems.

Features

28 Special Report — RF “Building Blocks” — The New Approach to Design

Hybrids, modules and subassemblies are different names for the modular components that have become as well known to RF designers as discrete transistors and diodes. This report examines the rise of building block technology and the changes it brings to the role of the RF engineer. — Gary Breed

32 Featured Technology — Specifying High Power Filters

Whether building or buying filters for high power applications, an engineer must consider the important performance factors that lie beyond passband performance. This article notes the electrical and physical characteristics that must be taken into account. — Dick Wainwright

38 Phase Noise Calibrator

A runner-up prize winner in the RF Design Awards Contest, this article describes a method of calibrating and comparing phase noise measuring systems. — Guy V. Love and Kevin Lindell

49 Broadband Miniature Power Splitter

This article describes a new topology for a microstrip power divider requiring minimum board space. This was another runner-up winner in the recent Design Awards Contest. — Peter Vizmuller

58 RFI/EMC Corner — Conductive Plastic Composites Offer Shielding Solution

Among the options for EMI/RFI shielding is the use of conductive plastics. This note covers some of the factors that influence a designer's choice of these materials over coatings or laminates. — Mark Gomez

Departments

- 6 Editorial
- 8 Viewpoint
- 13 Letters
- 14 News
- 21 Calendar
- 22 Courses
- 60 New Products
- 67 New Literature
- 69 New Software
- 69 Classified Advertising
- 70 Advertisers Index
- 74 Info/Card

HIGH POWER COUPLERS



2000 WATTS

.01-250 MHz

- MODEL C1460
- COUPLING 50 dB
- DIRECTIVITY 20 dB
- VSWR 1.15:1

100 WATTS

.05-1000 MHz

- MODEL C1634
- COUPLING 40 dB
- DIRECTIVITY 20 dB
- VSWR 1.2:1

BROADBAND RF COMPONENTS

- Hybrid Junctions
- Power Combiners
- Power to 20 KW
- Frequency .01-2000 MHz

See Gold Book and Microwave & RF Product Directory for Additional Products.



decades ahead

WERLATONE INC.

P.O. Box 47
Brewster, NY 10509
Tel: (914) 279-6187
TWX 510-600-0747

rf editorial

'Building Block' Technology is Coming on Strong



By Gary A. Breed
Editor

With regrets, I have finally accepted the fact that the Renaissance Man is gone from the world of RF. While there are many exceptional RF engineers, the technology has advanced beyond the point where one person can master it all. As a result, the design process requires expertise from different people with knowledge of different areas — power amplifiers, oscillators, modulators, IF circuits.

However, with the present demand for RF engineers, many companies do not have all areas of design represented on their own staff. Some may choose to get by with the available talent, accepting the compromise in overall quality. Others may hire outside consultants to handle a specific design area. A rapidly growing number are buying complete subsystems from specialized companies whose purpose is to do one thing, and do it very well.

This modular approach to design and manufacturing is nothing new. The construction industry has been using pre-assembled doors, windows, and cabinetry for a long time. Automobiles have almost always been assembled from engines made at one plant, body panels from another, instruments from still others. "Building Block" design isn't really new to electronics, either — but it is my observation that it's the hottest thing in the RF industry right now.

A Shortage of Engineers? Talent Can be Purchased

There is a reason for the current high activity in RF modules, hybrids, and other supercomponents. There just aren't enough RF engineers available to meet the design needs of every company. A second reason is cost and competition. Why design a TCXO, log amplifier, or diode mixer when you can buy one that meets your specifications from several different companies that specialize in that type of design? By the time development costs are added up, it may be a lot less expensive (and certainly faster) to use a purchased module.

Of course, the drawback is *control*. Manufacturers are quite used to the purchase of individual components, but when design and manufacturing processes are purchased from suppliers instead of performed in-house, there is an understandable new concern for quality, reliability and delivery. The need for trust between the module supplier and the product manufacturer is extremely important.

Most module companies are teams of entrepreneurs with a particular type of RF expertise. They have seen the need for specialized products and are trying to use their talents both creatively and for profit. A few companies have achieved outstanding reputations, some are just starting. Like most RF companies, they are relatively small, with distinct personalities that reflect their owners and managers. Dealing with such companies is a new experience for some purchasing agents, who have only been involved with individual components from large companies.

Like every other industry, RF is evolving and changing. Because module companies are, in effect, "middle-men," they add another level to the manufacturing chain. If the present trend continues, this intermediate level could become the major force in the RF industry. We'll be watching.

ARM YOURSELF

You're under attack every day...wrestling with design dilemmas...coping with capricious circuits...quelling parasitics, noise, and other "attacks."

Arm yourself against these attacks with the arsenal of information you'll find in the Proceedings from the two RF Expos — *RF Expo East*, held for the first time Nov. 10-12, 1986 in Boston...and *RF Technology Expo 87* held Feb. 11-13, 1987 in Anaheim.

Each book is packed with timely, vital information for the working RF engineer. Practical circuit design papers. Papers on the leading edge of RF technology. Over 50 topics included in each book...including *Cheap CAD*...*Schottky Diodes*...*Medical Applications*...*Power Amplifiers*...among many others. Authored by leading RF experts from Hughes, Rockwell, Plessey, Harris, CCC Compact, Siliconix, EEsof, Motorola, and other prominent companies from around the world.

Proceedings

rf^{technology}expo87

February 11-13, 1987
Anaheim, California

Sponsored by
rfdesign Magazine

Proceedings

rf^{expo}east

November 10-12, 1986
Boston, Massachusetts

Sponsored by
RF Design Magazine

In the battle for better designs, you can be fully equipped. Order one copy, or save 21% over single copy prices by ordering both for \$149 (\$95 single copy price). Fill out the coupon at the right, and mail it today to *RF Design*, 6300 S. Syracuse Way, Suite 650, Englewood, CO 80111. Let *RF Design* and the RF Expos help give you a fighting chance.

Choose Your Weapon

Proceedings of:

- ☐ RF Expo East: \$95 ☐ RF Technology Expo 87: \$95
☐ Both: \$149 (save 21% over single copy prices)
☐ Check enclosed ☐ Bill my: ☐ Visa ☐ MC ☐ Am Ex

Card number

Expiration

Name

Company

Mail stop

Address

City, State, Zip

** Payment MUST be included **

rfdesign

The Engineering Personality



By Keith Aldrich
Publisher

The subject of what kind of person becomes an engineer has been a recurring theme of sociopsychological commentary since engineering first emerged as a profession about the time of the industrial revolution.

Prior to that, the application of new scientific principles had been the sometime avocation of well-read, well-bred generalists, in much the same way that the "renaissance man" wrote sonnets and madrigals. With the "age of enlightenment," today's engineer was born, stereotypically seen as not a very social creature, more comfortable with logarithms than people, less involved with the social or economic implications of an engineering project than would seem justified to social critics.

The subject of the engineering personality and the engineer's role in project structure is again a topic of discussion, with recent announcements by MIT and other schools that they will foster a new element in the training of engineers, to develop their graduates' sense of judgment and responsibility (see Editorial, July). It is hoped that engineering expertise will thereby be brought into the highest levels of decision-making, perhaps averting such tragic and senseless decisions as the one to launch Challenger in January 1986.

As a publisher who has worked with engineering audiences all his adult life without being an engineer, I feel I have some insights into the engineering personality that differ from the usual bromides. I offer them here as my contribution to the current discussion.

- In spite of their professional skepticism, engineers tend to be less jaded or cynical than most people when it comes to assessing other peoples' credibility, sincerity, and motives.

- In spite of a certain shyness about expressing it, engineers tend to feel more unspoiled, childlike enthusiasm about new experiences, places and people than many others, and about their own and others' achievements.

- The practice of engineering is much more akin to the creation of art of several sorts than is often recognized, and the engineer tends to share the artists' sensitivity to such phenomena as musical harmonics and rhythms, shades of color and light, nuances of expression, and *weights of arguments*.

- Engineers by professional training and instinct tend to be superior in sorting through spurious data to spot real facts and fairness.

These characteristics add up, it seems to me, to a relatively clear-headed kind of vision, cognizant of facts but not insensitive to sentiment, conscious of corporate or national goals but not a slave to them. And this sort of vision is, I would think, especially appropriate to the highest level of decision-making.

a Cardiff publication Established 1978
Main Office:
6300 S. Syracuse Way, Suite 650
Englewood, CO 80111 • (303) 220-0600

Publisher
Keith Aldrich

Editor
Gary A. Breed

Assistant Editor
Mark Gomez

Sales Supervisor
Kate Walsh

Advertising:
Western States
Kate Walsh
Main Office

Midwestern States
Kate Walsh
Main Office

Eastern Sales Manager
Joseph Palmer
36 Belmont Rd. S.W. 3
West Harwich, MA 02671
(617) 394-2311

New Jersey & Downstate New York
Carl Goose
RR 1, Box 412, Apt. 1
Hamburg, NJ 07419
(201) 209-4877

Classified Advertising Manager
Bonnie Ward

Advertising Services
Robin Miller

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

Circulation Director
Pam Greenberg

Circulation Manager
Patricia Shapiro

Circulation Assistant
Michelle Schwinghammer

Production Manager
Madeline Price

Assistant Production Manager
Mary Barr Felker

Artists
Maurice Lydick Pam Zegaib
Matt Park Bill Schmitt
Bill Pettit

Composition
Jay Jarrett Ellen Wilson

Published by

CARDIFF
PUBLISHING COMPANY, INC.

BPA

President
Robert A. Searle

Vice President
Judy L. Rudrud

Controller
Marvin Laut

Operations Manager
Cheryl Greenman

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.

DAICO

MILITARY TOUGH

SWITCHES

IF/RF SOLID-STATE



SWITCHES

Number of Throws	Frequency (MHz)	Part Number	Typ/Max. Insertion Loss (dB)	Typ/Min. Isolation (dB)	Max. Switching Speed μ /seconds	Control	Max. dc Power (V/mA)	Max. RF Oper. (dBm)	Package Type
SPST	10-200	DS0050	1.2 / 1.5	62 / 50	0.025	TTL	5 / 150	+10	14 PIN DIP
SPST	400-450	DS0411	0.6 / 1.2	65 / 60	0.5	TTL	5 / 110	+13	14 PIN DIP
SP2T	5-200	DS0492	0.5 / 0.8	52 / 40	20.0	TTL	+5, -15 / 30	+30	14 PIN DIP
SP2T	20-2000	DS0612	1.6 / 2.3	45 / 50	10.0	TTL	+5 / 3	+10	14 PIN DIP
SP2T	200-900	DS0432	0.5 / 0.8	45 / 35	1.5	TTL	+5, -15 / 30	+35	14 PIN DIP
SP2T	500-2000	DS0257	0.8 / 1.5	40 / 35	0.4	TTL	\pm 5 / 25	+10	14 PIN DIP
SP3T	50-500	DS0073	0.8 / 1.0	45 / 40	2.0	CMOS	\pm 12 / 5	+10	0.8 sq 24 PIN
SP4T	10-500	DS0085	0.6 / 0.8	40 / 25	35.0	CMOS	\pm 15 / 6	+10	14 PIN DIP
SP4T	500-2000	DS0259	1.3 / 1.5	50 / 25	0.4	TTL	\pm 5 / 35	+10	24 PIN DIP
SP5T	200-800	DS0475	0.6 / 1.0	50 / 40	1.0	TTL	\pm 5 / 27	+10	24 PIN DIP
SP6T	100-600	DS0506	0.6 / 1.0	56 / 50	1.0	TTL	\pm 5 / 40	+20	38 PIN DIP
SP8T	100-1100	DS0518	1.1 / 1.6	45 / 35	1.0	TTL	\pm 5 / 45	+13	24 PIN DIP
XFER	15-45	DS0097	.5 / 1.0	60 / 50	10.0	CMOS	+5 / 20	+10	0.8 sq 24 PIN
XFER	70-1000	DS0319	1.25 / 1.5	60 / 40	10.0	CMOS	+15 / 15	+10	18 PIN DIP
SPST	20-600	100C1281	1.2 / 1.3	80 / 70	0.5	TTL	+5 / 75	+10	SMA CONN.
SP2T	20-600	100C1282	.8 / 1.2	80 / 70	0.5	TTL	+5 / 110	+10	SMA CONN.
SP4T	20-600	100C1284	1.2 / 1.4	80 / 70	0.5	TTL	+5 / 175	+10	SMA CONN.

DAICO manufactures a multitude of IF/RF solid-state switches to meet your design needs. These include PIN diode, Schottky diode and GaAs FET technologies with integrated drivers in thin-film hybrid MICs for survival in the toughest military environments. Relay switches are available for applications where insertion loss and intermod performance are of primary concern.

SPST blanking switches to miniature SP8T switches are available with low switching transients, fast switching speed, high intercept points, phase matched ports for the most demanding radar, EW, and C³I systems.

Daico switches are available in MIC — including SURFACE MOUNT — and connectorized packages.

Call Daico for applications assistance, custom device information, and a prompt response. Write for catalog.



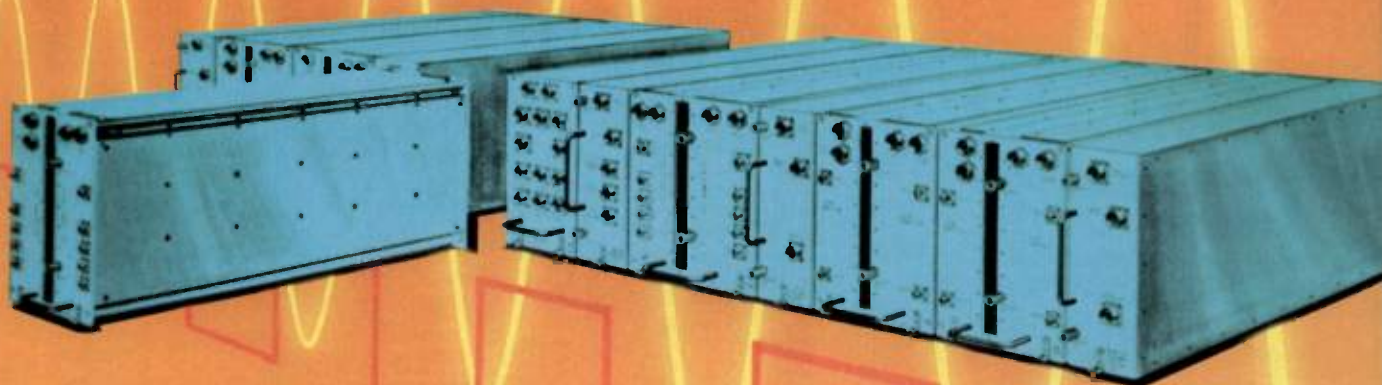
DAICO INDUSTRIES, INC.

2139 East Del Amo Blvd. Compton, CA 90220
Telephone 213/631 1143 TWX 910 346 6741
FAX 213/631 8078

©1987 Daico Industries, Inc. mp87467



MICROWAVE MODULES & DEVICES, Inc.



Inquiries relating to solid-state modules and/or complete transmitters, 1 MHz to 4 GHz, are invited. Applications may involve communications, radar, broadcast, television, avionics, ECM and EW. Power outputs can range from fractional wattage to multi-kilowatts.

**. advanced concepts in
solid - state power
amplifiers reach
beyond today's
technology.**



MICROWAVE MODULES & DEVICES, Inc.

550 ELLIS ST., MOUNTAIN VIEW, CA 94043

(415) 961-1473 TELEX: 508746

DEMO INFO/CARD 7 LITERATURE INFO/CARD 18

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.

Impressive Standard Features Include:

- 10 kHz to 1 GHz frequency coverage, fully synthesized
- 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, compare and peak hold display modes
- 300 Hz and 30 kHz video filters

Optional Features Include:

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



Contact your IFR distributor or representative for a demonstration.

IFR SYSTEMS, INC.

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

rf letters

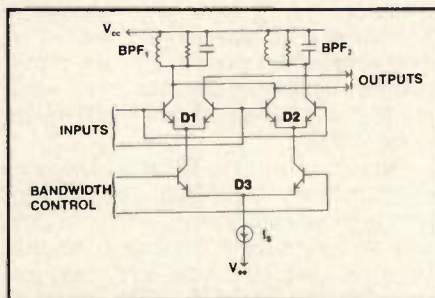
Letters should be addressed to: Editor, *RF Design*, 6300 S. Syracuse Way, Suite 650, Englewood, CO 80111.

Variable Bandwidth IF Correction Editor:

I have discovered an error in Figure 2 of my article, "Variable Bandwidth Intermediate Frequency Amplifier," published in the June issue of *RF Design*.

I regret the typographical error and enclose the correct diagram. (Shown below — Ed.)

Steve Kuh
Motorola, Inc.



Corrected version of variable bandwidth filter design.

Comment on Filter Design Definitions

Editor:

I thought Alan Tam's article an excellent introduction to microstrip filter design. It should be explained, however, that he elected to use a less common way of defining the cutoff frequency of his prototype. Usually the cutoff frequency of a Chebyshev filter is defined as the highest frequency where the response is ϵ dB down, where ϵ is the passband ripple. Mr. Tam's filter is designed to be 3 dB down at the cutoff frequency. This is a minor point unless someone happened to use the normalized coefficients given in the article to design another filter, which might result in an unpleasant surprise.

Methods for generating both types of coefficients (and others) are presented in *Handbook of Electronic Design and Analysis Procedures Using Programmable Calculators* by Bruce K. Murdock (Van Nostrand Reinhold, 1979). This book also contains much other information of interest to RF engineers.

John R. Moriarity
Wavetek San Diego

Hi-Power RF

AMPLIFIERS, TRANSMITTERS, POWER GENERATORS

10-10,000 WATTS! / 2-500 MHz Frequency Range!

**HENRY RADIO
HAS THE PRODUCT
YOU NEED.**

(If we don't have it, we'll make it.)

APPLICATIONS:

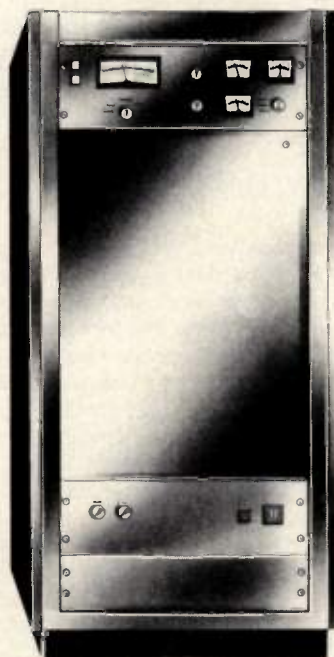
NMR, Nuclear Magnetic Resonance
PLASMA Generation
MEDICAL Applications
NUCLEAR Magnetic Imaging
COMMUNICATIONS Applications



The New, Dynamic

HENRY RADIO

2050 S. Bundy Drive, Los Angeles, CA 90025
TOLL FREE: 1-800-421-6631
In California call (213) 820-1234



PRECISION CRYSTAL OSCILLATORS

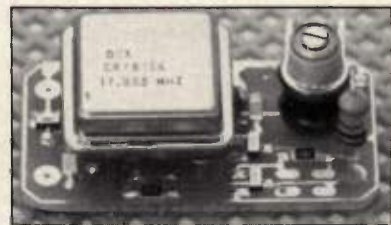
Frequency Range:

8-200 MHZ

Frequency Stability:

**LESS THAN 1 P.P.M.
From -30° C to 85° C**

Aging:	< 2 p.p.m for 6 months < 1 p.p.m for life
Trim Range:	± 6 p.p.m minimum
Fast Warm Up:	< 1 minute from cold
Current Drain (Oven):	< 50 mA @ 25° C
Oscillator Current:	< 30 mA @ 12 VDC
Output Level/Shape:	Per Customer requirement



**HIGH PERFORMANCE
LOW POWER
LOW DRIFT
LOW COST**



CUSTOM DESIGN CAPABILITY

Crystek's innovative engineering group has in-house capability of circuit development/artwork using computer aided design. (CAD/CAM)

This great flexibility allows Crystek to create custom made oscillators to any special customer requirement or specification.

Semi-automated manufacturing methods (surface mount technology) and 100% testing guarantees consistent and uncompromised quality of our product.

Fast turn-around for prototype samples and production quantities at economical prices.

Write or Call Us Today!

Toll Free: 1-800-237-3061

CRYSTEK CORPORATION

DIVISION OF WHITEHALL CORPORATION
2351/2371 Crystal Drive/Ft. Myers, FL
33907

P.O. Box 06135
Ft. Myers, FL 33906-6135
(813) 936-2109 / TWX 510-951-7448
FAXIMILE: 813-939-4226

High-Temperature Superconductors: Excitement in Materials Research

The past half year has seen dramatic changes in the theory and practical use of superconductors. As a start, the first commercial product appeared on the market (from Hypres, Inc., see April 1987 *RF Design*, p. 21) using existing low-temperature technology. At almost the same time, news of high temperature superconducting breakthroughs began appearing in physics journals, then in the public press. Since then, every advance in research has been watched closely to see if it will be the one to bring superconductors into everyday use.

The use of superconductors in commercial applications made big news several years ago when IBM announced full-scale research into Josephson Junction (JJ) technology, with the intention of making a great leap forward in supercomputer performance. Difficulties in JJ development caused IBM to abandon its research, and superconductors were out of the news until Hypres' announcement of a picosecond-speed oscilloscope using

technology based on the IBM research.

Early this year, researchers discovered new ceramic compounds that achieve superconductivity at temperatures above the 4 to 20 degrees Kelvin required for previously known superconducting materials. These materials are primarily rare-earth ceramics of the Yttrium-Barium-Copper Oxide family, which exhibit repeatable superconducting characteristics. Among the developments is the National Bureau of Standards development of a superconducting quantum interference device (SQUID) operating at 81K, above the 77K temperature of liquid nitrogen. The SQUID is the most sensitive device for measuring magnetic field, and operation using liquid nitrogen for cooling makes low cost, ultra-sensitive microwave detectors possible.

Evidence of superconductivity has been reported at temperatures as high as 280K (room temperature is 290K), although the results are not conclusive. Proof of superconductivity involves both vanishing resis-

tivity and the Meissner effect, magnetic flux expulsion from the center of the object. In many of the recent experiments involving temperatures above 100K, the magnetic evidence (or lack thereof) suggests that the samples contain only small volumes of superconducting materials. This was reported by a group from the University of Houston, Lockheed's Palo Alto Research Lab and the National Magnet Laboratory, who observed vanishing resistivity in a ceramic oxide material at 225K. The effect survived thermal cycling over a two week period, another important test, but the small portion of the sample that was superconductive still needs to be isolated.

Superconductivity's RF applications include not only the SQUID detector, but also high efficiency magnets for oscillators and amplifiers (klystrons, magnetrons, etc.), dispersionless delay lines, low noise semiconductors, high efficiency power semiconductors and precision measurement standards.

RF Technology Assists in Plate Tectonics Measurements

Actual measurement of the movement of the earth's crust has confirmed the theory of plate tectonics, which explains how continents move in relation to one another. The June 12 issue of *Science* reports that radio telescopes located at Hawaii, Alaska and Japan have been used in a Very Long Baseline Interferometry (VLBI) experiment using distant quasars as "fixed" reference points. Part of the Crustal Dynamics Project, the team of radio astronomers has determined that Hawaii and Japan are moving away from each other at approximately 8.3 cm per year, and Hawaii and Alaska are being separated at a rate of 5.2 cm per year. The most remarkable aspect of the project is that results were obtained after only three years of measurements, indicating the accuracy of current VLBI techniques.

GE's Two Microelectronics Centers Consolidated

GE announced that its two microelectronic centers located in Research Triangle Park (RTP), NC, and in Somerville, NJ, are being consolidated at RTP. The move is expected to be completed by the end of the first quarter of 1988. The new GE Microelectronics Center charter will

have a dual focus: to serve the application-specific integrated circuit (ASIC) requirements of GE's internal aerospace businesses, and to market its products and services with selected external military contractors and government agencies. The consolidated center will feature a complete ASIC capability, including design, CAD systems, and all the operational functions required to deliver qualified/classified parts, including customer program management and IC development.

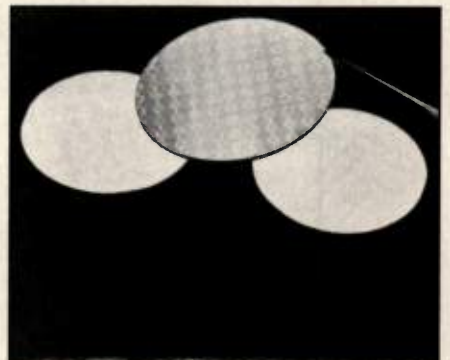
Single Sideband Systems And Circuits

Single Sideband Systems and Circuits is a new book designed to bring radio communications equipment designers, electronic engineers and technicians up to date on the system and circuit design of single sideband radio communications technology. It brings together the expertise of twenty-three recognized authorities from Rockwell's Collins Radio Division to give readers the latest state-of-the-art design information, including audio and RF circuits, digital signal processing, synthesizer design, power amplifiers and many other areas. The book is edited by William E. Sabin and Edgar O. Schoenik. It is published by McGraw Hill Book Com-

pany, 11 West 19th St., New York, NY 10011. Price is listed at \$49.95.

GTE Grows a Transistor

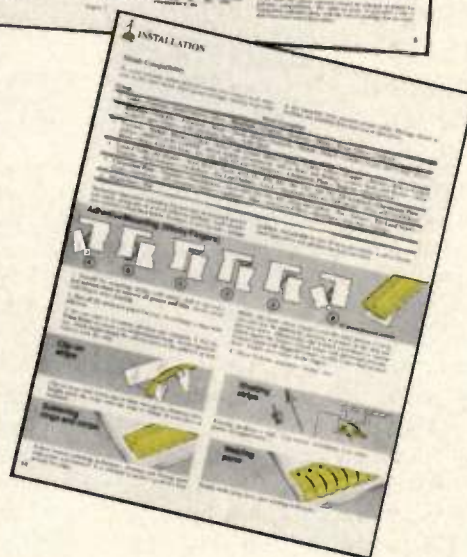
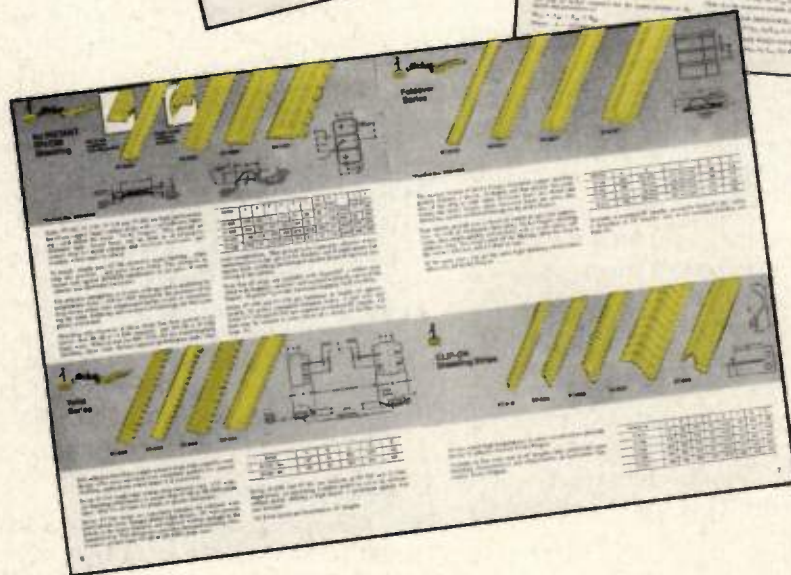
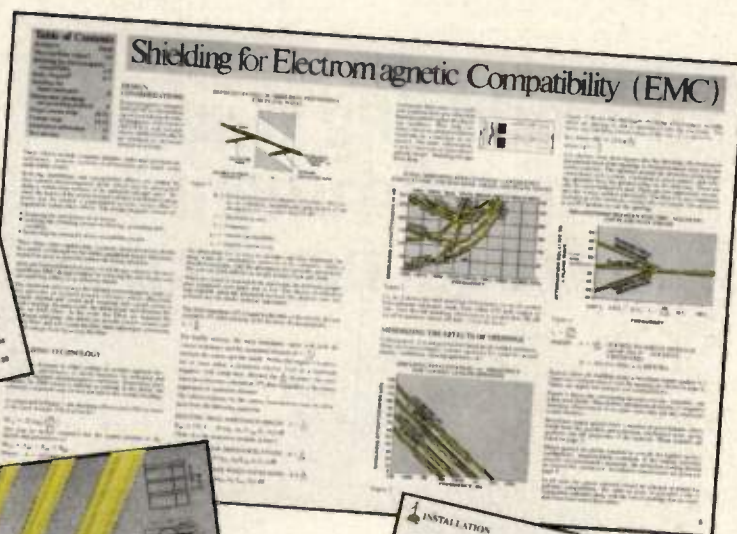
Researchers at GTE Laboratories have developed a way to *grow* a transistor. By combining and heating silicon and the tantalum disilicide, the researchers can



Grown transistors offer high power performance.

simultaneously grow metal connections and silicon crystals, forming a transistor. The connections in the GTE transistor penetrate the entire device, providing a three dimensional form that permits the transistor to excel in high power applications such as pulse switching.

NOW! In one manual— all you need to know about EMC design and products— and it's **FREE!**



If you're involved in designing for EMC—if you're involved in testing and measuring electromagnetic interference—you *need* this manual. For the first time, in one place, you'll find all the data, all the formulas, and all the products you need to meet your interference control problems!

Included are charts, tables, graphs, dimensional drawings, and technical data ranging from a discussion of theoretical design requirements to how to select a specific shielding material.

For your free copy, use the Reader Service Card or write us directly at Dept. RFD-9.



INSTRUMENT SPECIALTIES COMPANY, INC.
Delaware Water Gap, PA. 18327
Phone: 717-424-8510 • TWX: 510-671-4526
Specialists in beryllium copper since 1938

National Security Agency Endorses Rockwell

Rockwell International Corp. has received the National Security Agency's endorsement for a monolithic randomizer integrated circuit. The randomizer is the first device produced under the agency's overtake project in conjunction with its commercial COMSEC endorsement program (CCEP). The device is a digital, monolithic, binary, number generating device

that can be used wherever a high speed, random data stream is required and small size and a single drive voltage are desired. It has been tested and found to have a zero/one distribution statistically unbiased making it appropriate for use in Type 1 products which secure unclassified US government information. More information can be obtained by calling Rockwell International Corp. at (714) 762-2622.

Introducing a small accomplishment in UHF frequency sources!



Our SAW-stabilized frequency sources provide a unique solution to your demanding UHF system requirements. They pack the performance of a fine cavity oscillator into less than a tenth of a cubic inch. Their small size, low power consumption and excellent reliability are made possible by our advanced UHF Quartz SAW technology.

We cover applications from 150 MHz to 6000 MHz, and offer a wide range of options including temperature compensation, frequency multiplication and voltage tuning. We can cover the full -55°C to $+125^{\circ}\text{C}$

temperature range and offer testing and screening to a variety of MIL Standards.

Our SAW-stabilized UHF frequency sources are being used in IFF systems, radar frequency synthesizers, GPS receivers, emergency location transmitters, fiber-optic communications and a host of other UHF and microwave system applications.

Contact us with your next UHF frequency source requirement. You'll find our engineering staff ready to provide you with a custom solution that is innovative, timely and cost-effective.

RFM

RF Monolithics, Inc. • 4441 Sigma Road • Dallas, Texas 75244 U.S.A.
Phone: (214) 233-2903 • Fax: (214) 387-8148 • Telex: 463-0088

INFO/CARD 11

Applied Computation Electromagnetics Society (ACES)

Over the past ten years, computer modeling has matured as a problem solving tool in real world electromagnetic applications. Use of computer modeling has become so routine that sessions at the various professional society meetings deal primarily with new developments. As a result, information exchange is inhibited. ACES has been formed to foster information exchange among computer modelers in electromagnetics. Emphasis is put on computer application issues rather than research and development. Further information on ACES can be obtained from Dr. Richard W. Adler, Code 62AB, Naval Postgraduate School, Monterey, CA 93943. Tel: (408) 646-2352.

Hughes, MBB, and Aerospatiale Join to Bid on Air Defense Program

Derivatives of the battle proven Roland system have been entered by a U.S., French, and West German joint venture for the U.S. Army's Forward Area Air Defense, Line of Sight, Heavy program. Called the Paladin weapon system, the units will incorporate elements of the U.S. Roland air defense system and other components from the European Roland now fielded with the armed forces of France, West Germany and seven other nations. The Western Alliance Air Defense joint venture has been formed by Hughes Aircraft of the U. S., Messerschmitt-Boelkow-Blohm (MBB) of West Germany and SNI Aerospatiale of France to propose the Paladin. Plans call for 50 to 70 percent of the contents of Paladin to be built in the U.S. with the remainder coming from Europe.

Power MMIC Services

Microwave Semiconductor Corporation has announced the availability of GaAs custom circuit design and fabrication services. The services are tailored to meet the demands of customers requiring specialized microwave performance. The foundry services offered use the technology implemented in MSC's GaAs Power FET and standard MMIC line.

Electrospace and Chrysler Announce Merger

Chrysler Corporation and Electrospace Systems, Inc. announced that they have reached a merger agreement under which Chrysler will make an offer of \$27.00 per share for 100 percent of the stock of the defense contractor. The total acquisition of the stock will cost approximately \$376 million. Chrysler has been granted op-

tions by ElectroSpace Systems' four founding shareholders to acquire their approximately 38 percent of the company's outstanding shares. ElectroSpace Systems designs, develops and installs communications and electronic systems and equipment for military and commercial customers.

Watkins-Johnson Acquires Microwave Center

Watkins-Johnson Company has completed its acquisition of the Santa Barbara Microwave Center from Honeywell, Inc. W-J paid approximately \$2 million for the manufacturer of millimeter-wave mixers and oscillators.

AMP and Micro-Coax Join Forces

AMP, Inc., of Harrisburg, PA., and Micro-Coax™ Components, Inc. of Collegeville, PA., have announced agreement to manufacture and market semi-rigid cable assemblies. The assemblies will utilize AMP's semi-rigid crimp Coaxicon™ connectors and Micro-Coax Components' UT™ semi-rigid cable. Available size range of the cable assemblies include cable diameters from 0.0865 inch to 0.141 inch with frequencies ranging from DC to 26 GHz.

Standard Oil Announces New Division

Standard Oil Engineered Materials Company announced the formation of an Electronic Ceramic Division, headquartered in Niagara Falls, NY, to focus on the development, production and marketing of products. The division will invest \$8.5 million in two facilities to produce specialty materials for the microelectronic industry, specifically substrates and planar diffusion sources.

Esterline Sells Product Line

Esterline Angus Instrument Corporation, a subsidiary of Esterline Corporation of Connecticut announced the sale of its Minigraph® analog and event recorder product line to the Dickson Company of Illinois for an undisclosed sum.


General Motors and Siliconix Sign Agreement

The Delco Remy Division of General Motors, along with General Motors Research Laboratories, has signed a contract with Siliconix to develop and produce a new semiconductor power technology. According to Siliconix, the significance of this technology may be compared to MOSFET technology. It is expected to be the basis of a whole family of new devices,

both discrete and integrated circuits, promising major improvements and device efficiency at low cost.

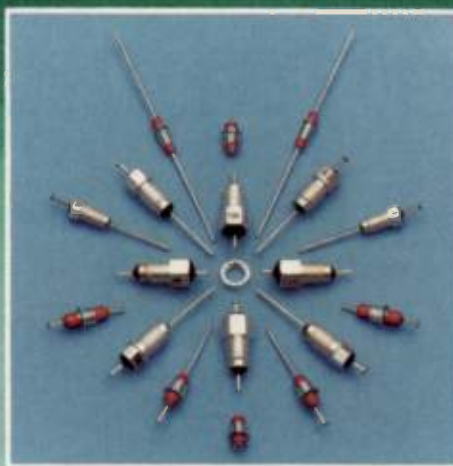
Shipboard DF System Delivered to Paramax

Electromagnetic scientists at Southwest Research Institute (SwRI) have designed and developed an advanced shipboard tactical direction finding system that is claimed to be faster than existing systems

and is strong enough to withstand the stresses of prolonged service atop a ship's mast. The first electronic support measures (ESM) system, designated the AN/SRD-502 was recently delivered under subcontract to Paramax, Inc., a Canadian defense firm, for installation aboard a new class of Canadian Patrol Frigates. It consists of a 16 foot tall antenna, a control unit, an operator unit, and data processing equipment. 

TUSONIX

If you're looking for excellence in
EMI Filters ...



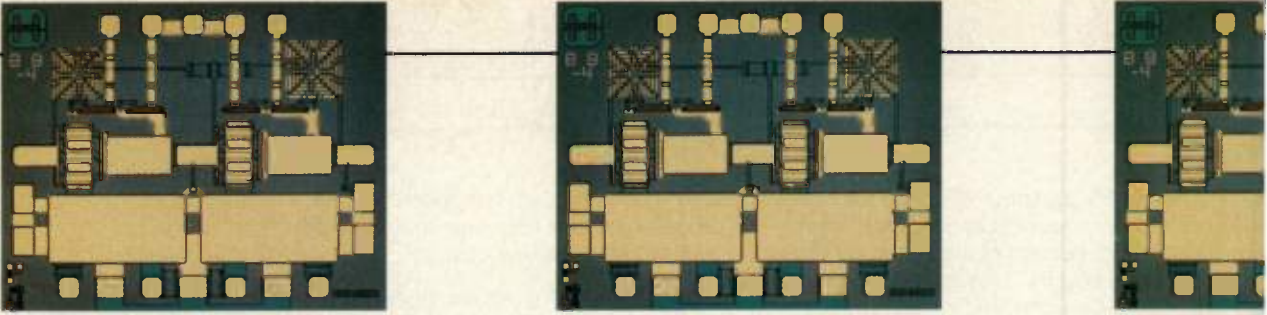
Tusonix has QPL approval on EMI Filters and Filter Caps

These miniature EMI ceramic filters and capacitors are designed to suppress unwanted EMI in applications where small size is critical. Tusonix filters and filter caps cover a variety of voltage, attenuation and capacitance ranges in both solder and bushing mount styles. We have QPL approval and most are available from stock, ready for immediate shipment.

If you're looking for excellence in EMI Filters, Tusonix is your perfect source. Write for our EMI Filter catalog TODAY... or please call us at 602-744-0400.

TUSONIX

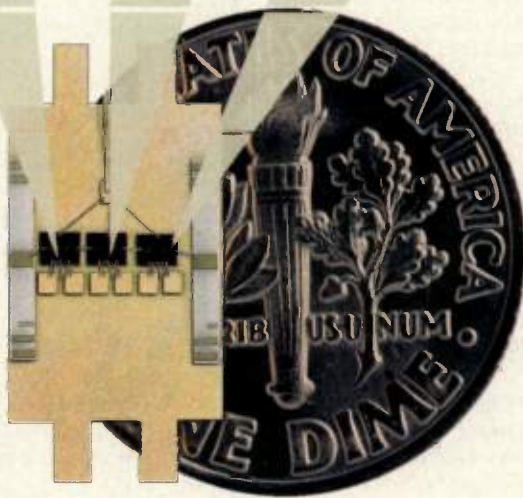
P.O. Box 37144, Tucson, AZ 85740-7144
Phone: 602-744-0400 Telex: (RCA) 299-640
Fax: 602-744-6155



The no-gimmick MMICs: Cascadable, cost-effective, uniform GaAs gain blocks — available now from stock!

*"Hey, here's one supplier who
isn't talking 'blue sky' about
GaAs MMICs!"*

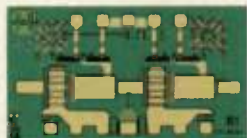
*"Right! Just order from
Harris... they'll deliver!"*



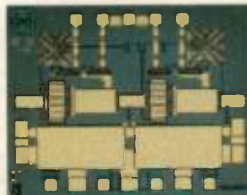
**Small size, easy to use...
lower cost than hybrid designs.**

We think you will be amazed at how much our family of low-cost, gallium arsenide MMIC gain blocks can save in overall system design time and cost. And how they provide uniform performance over wide bandwidths. So you can drop them in wherever utility gain blocks are required.

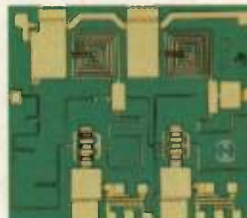
Take our little HMR-10502 GaAs MMIC amp. It provides 10 dB typical gain and 10 mW output power from 0.5 to 5 GHz.



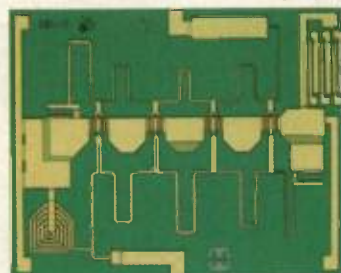
HMR-10502 MMIC



HMR-10503 MMIC



HMM-10610 MMIC



HMM-11810 MMIC

MMICs shown approximately
twenty times actual size.

Or its companion, our HMR-10503. It provides 10 dB typical gain and 10 mW output power from 1 to 5 GHz and includes on-chip decoupling capacitors.

If you need more power and gain, the HMM-10610 is the right choice. It offers 75 mW output power from 2 to 6 GHz with 12 dB gain.

For higher-frequency applications, we offer the HMM-11810 — with 5 dB typical gain and 50 mW output power over the 6 to 18 GHz band.

Since they're directly cascadable, you can combine multiple MMIC chips on the same carrier. They require no tuning, and minimal assembly.

Like all Harris GaAs products, these MMICs offer improved radiation hardness over silicon devices, and are well-suited to applications requiring Hi-Rel Qualification.

And, best of all — *they're available from stock!*

**Consider the
advantage of our
MMICs in your next
microwave system
design.**

Why wait? For GaAs MMIC amplifiers today, there's really only one choice — Harris Microwave Semiconductor. In U.S. phone 1-800-4-HARRIS, Ext. 1501, or (408) 433-2222. (TWX: 910-338-2247) In Canada: 1-800-344-2444, Ext. 1501.

IN GALLIUM ARSENIDE,
THE NAME IS
HARRIS

Harris Semiconductor: Analog - CMOS Digital
Gallium Arsenide - Semicustom - Custom



NOW, YOU CAN HAVE IT ALL!

POWER, SPEED & PRICE.

Up to 4000 watts from 10-500 MHz, and blanking speeds of better than 0.5 μ sec.

The latest MOSFET technology from Kalmus Engineering has made it possible to combine linear power with high speed blanking. Choose from nine different models.

NMR/MRI POWER AMPLIFIERS

**USA
Price
Each**

Model	164 LP,	500 W,	10-86 MHz,	55 dB gain	\$6,990
	166 LP,	1000 W,	10-86 MHz,	55 dB gain	\$8,990
	167 LP,	2000 W,	10-86 MHz,	60 dB gain	\$13,990
	164 HP,	500 W,	80-200 MHz,	55 dB gain	\$7,990
	166 HP,	1000 W,	80-200 MHz,	55 dB gain	\$9,990
	164 UP,	300 W,	200-400 MHz,	55 dB gain	\$5,990
	166 UP,	600 W,	200-400 MHz,	55 dB gain	\$8,990
	164 SP,	250 W,	400-500 MHz,	55 dB gain	\$6,990
	168 LP,	4000 W,	10-60 MHz,	60 dB gain	\$20,990



KALMUS

ENGINEERING INT'L., LTD. USA

21820 87th SE • Woodinville, WA 98072

206/485-9000 • Telex: 24-7028 FAX: 206-486-9657

QUANTITY PRICES CONSULT FACTORY

August 25-27, 1987

9th Quartz Devices Conference

Westin Crown Center, Kansas City, MO

Information: Components Group, Electronic Industries Association, 2001 Eye Street, N.W., Washington, DC 20006; Tel: (202) 457-4930

September 1-2, 1987

Mountain States Electronics Expo

Denver Merchandise Mart, Denver, CO

Information: Darel A. Bennett, Midland Exposition Group, 3699 West 73rd Ave., Westminster, CO 80030; Tel: (303) 426-1634.

September 7-10, 1987

17th European Microwave Conference

Ergife Palace Hotel, Rome, Italy

Information: Microwave Exhibitors of Publishers Ltd., 90 Calverly Road, Tunbridge Wells, Kent TN12UN, England

September 15-17, 1987

Midcon/87

The Ohara Center, Chicago, IL

Information: Midcon/87, 8110 Airport Boulevard, Los Angeles, CA 90045-3194; Tel: (213) 772-2965, (800) 421-6816, inside California (800) 262-4208

September 21-22, 1987

1987 IEEE Bipolar Circuits and Technology Meeting

Hyatt Regency Hotel, Minneapolis, MN

Information: Janice Jopke, BCTM Secretary/Treasurer, 5016 W. 99th St., Bloomington, MN 55437; Tel: (612) 835-6742

September 22-24, 1987

Northcon/87

Portland Memorial Coliseum, Portland, OR

Information: Show Manager, Northcon/87, 8110 Airport Boulevard, Los Angeles, CA 90045-3194; Tel: (213) 772-2965

September 29-October 1, 1987

1987 OEM Design and Integrated Manufacturing Exposition

McCormick Place East, Chicago, IL

Information: Bill Little, Penton Exposition, 122 East 42nd St., New York, NY 10168; Tel: (800) 634-4639, in NY call (212) 867-9191

September 29-October 1, 1987

Ninth Annual Meeting and Symposium, Antenna Measurement Techniques Association

The Stouffer Madison Hotel, Seattle, WA

Information: James R. Otley, 1987 AMTA Symposium, 6682 South 191st Place, Suite E-105, Kent, WA 98023; Tel: (206) 655-7780

September 29-October 1, 1987

Fall National Design Engineering Show and Conference

Javits Convention Center, New York, NY

Information: Monica Viladegutt, Cahners Exposition Group, 999 Summer St., P.O. Box 3833, Stamford, CT 06905; Tel: (203) 964-0000

October 4-8, 1987

ISA/87

Anaheim Convention Center, CA

Information: Paul Albert, Instrument Society of America, P.O. Box 12277, Research Triangle Park, NC 27709

October 13-15, 1987

Scan-Tech 87

Bartle Hall, Kansas City, MO

Information: Don Anderson, AIM, Inc., 1326 Freeport Rd., Pittsburgh, PA 15238. Tel: (412) 963-8588

October 13-15, 1987

19th International SAMPE Technical Conference

Hyatt Hotel, Crystal City, VA

Information: Marge Smith, Business Director, P.O. Box 2459, Covina, CA 91722. Tel: (818) 331-0616

October 19-21, 1987

The Twentieth Annual Connectors and Interconnection Technology Symposium

Franklin Plaza Hotel, Philadelphia, PA

Information: Electronic Connector Study Group, Inc., P.O. Box 167, Fort Washington, PA 19034-0167; Tel: (215) 825-3840

October 26-30, 1987

FOC/LAN 87, Eleventh International Fiber Optic Communication and Local Area Networks Exposition

Anaheim Convention Center, Anaheim, CA

Information: Renee Farrington, Information Gatekeepers, Inc., 214 Harvard Avenue, Boston, MA 02134; Tel: (617) 232-3111

November 10-12, 1987

1987 ITEA Symposium

Park Plaza Hotel, Boston, MA

Information: Howard L. Graves, Raytheon Company, Public Relations, 141 Spring Street, Lexington, MA 02173; Tel: (617) 470-6027

1,239,580 Filters

Lowest prices in America
on small quantities

1 Hz to 100 MHz

1,239,580 standard filter types ☐ Miniature and subminiature sizes ☐ Passive and active types ☐ Telemetry filters ☐ Gaussian, Butterworth, Chebyshev designs ☐ Call or write for free catalog today.

TTE®

TTE, Inc.,
2233 South Barry Ave.,
Los Angeles, CA 90064
(213) 478-8224

1,239,580
STANDARD
FILTER
DESIGNS

FREE CATALOG

R & B Enterprises

Tempest-A Detailed Design Course

September 14-18, 1987, Philadelphia, PA

Electromagnetic Pulse (EMP) Design and Test

October 5-6, 1987, Philadelphia, PA

November 17-18, 1987, Washington, DC

December 7-8, 1987, Philadelphia, PA

Electromagnetic Pulse Workshop

October 9, 1987, Philadelphia, PA

December 11, 1987, Philadelphia, PA

Understanding and Applying MIL-STD-461C

October 20-21, 1987, Philadelphia, PA

November 17-18, 1987, Washington, DC

December 14-15, 1987, Philadelphia, PA

MIL-STD-461C Praxis (Workshop)

October 20-21, 1987, Philadelphia, PA

December 16-17, 1987, Philadelphia, PA

Information: Greg Gore, Director of Training, R & B Enterprises, 20 Clipper Road, West Conshohocken, PA 19428. Tel: (215) 825-1960

Norand Corporation

FCC, VDE, CISPR, and SAE Regulation and Design Criteria

September 1-2, 1987, Cedar Rapids, IA

Grounding, Bonding, Shielding and PCB Design for EMI/EMC

September 15-16, 1987, Cedar Rapids, IA

MIL-STD 461B/C and 462 Regulations and Design Criteria

October 13-14, 1987, Cedar Rapids, IA

RF Susceptibility and ESD Testing

November 3-4, 1987, Cedar Rapids, IA

Information: Bev Reynoldson, Norand Corporation, 550 2nd St S.E., Cedar Rapids, IA 52401; Tel: (319) 846-2415

Compliance Engineering

Compliance Seminars: EMI, Safety, ESD, Telecom

August 25-28, 1987, Atlanta, GA

September 29-October 2, 1987, Orlando, FL

October 27-30, 1987, Boston, MA

December 1-4, 1987, San Diego, CA

Information: Compliance Engineering, 593 Massachusetts Avenue, Boxborough, MA 01719. Tel: (617) 264-4208

Avantek, Inc.

RF & Microwave Semiconductor Design Solutions Seminar

September 15, 1987, Santa Clara, CA

September 17, 1987, Phoenix, AZ

September 21, 1987, Denver, CO

September 28, 1987, Kansas City, MO

October 2, 1987, Ft. Wayne, IN

October 5, 1987, Boston, MA

October 7, 1987, Ft. Washington, PA

October 9, 1987, Atlanta, GA

October 13, 1987, Orlando, FL

October 15, 1987, Dallas, TX

October 19, 1987, Burbank, CA

November 4, 1987, Albuquerque, NM

Information: Janice Little, Avantek, Inc., M/S 3G, 3175 Bowers Ave., Santa Clara, CA 95054. Tel: (408) 970-2139

The George Washington University

Frequency Hopping Signals and Systems

September 9-11, 1987, Washington, DC

HF Communications Technology

September 14-18, 1987, Orlando, FL

November 16-20, 1987, Washington, DC

Spread Spectrum Communication Systems

September 21-25, 1987, Washington, DC

Fiber Optics Technology for Communication

September 22-24, 1987, Washington, DC

Introduction to Modulators and Transmitters

October 5-6, 1987, Washington, DC

High Frequency Spectrum:

New concepts and technologies

October 5-9, 1987, Washington, DC

Introduction to Receivers

October 19-20, 1987, Washington, DC

Modern Receiver Design

October 21-23, 1987, Washington, DC

Global Positioning System: Principles and Practice

November 4-6, 1987, Washington, DC

Wideband Communications Systems

December 7-11, 1987, Washington, DC

Information: Shirley Forlenzo, Continuing Education Program, George Washington University, Washington, DC 20052; Tel: (800) 424-9773, (202) 994-8530

Interference Control Technologies, Inc.

Practical EMI Fixes

September 22-25, 1987, San Diego, CA

MIL-STD-461/462

September 29-October 2, 1987, Washington, DC

Information: Penny Caran, Registrar, Interference Control Technologies, Inc., State Route 625, P.O. Box D, Gainesville, VA 22056; Tel: (703) 347-0030

Integrated Computer Systems

Digital Signal Processing

September 22-25, 1987, San Diego, CA

October 27-30, 1987, Anaheim, CA

December 1-4, 1987, Washington, DC

December 8-11, 1987, Boston, MA

Machine Vision and Image Recognition

September 15-18, 1987, Los Angeles, CA

September 29-October 2, 1987, Washington, DC

October 20-23, 1987, Palo Alto, CA

December 8-11, 1987, Toronto, Canada

Fiber Optic Communication

September 15-18, 1987, Washington, DC

September 29-October 2, 1987, San Diego, CA

November 3-6, 1987, Los Angeles, CA

Hands-On Programming in C

September 22-25, 1987, Washington, DC

September 29-October 2, 1987, San Diego, CA

October 27-30, 1987, Boston, MA

Information: Marilyn Martin, Integrated Computer Systems, 5800 Hannum Avenue, P.O. Box 3614, Culver City, CA 90321-3614; Tel: (800) 421-8166, (213) 417-8888

New!

Symmetrical Shielding Strips (S³) provide bi-directional engagement at severe shear angles!

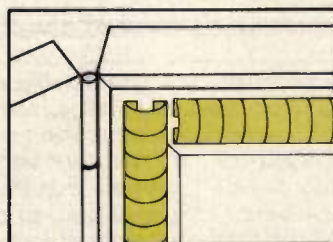
These new symmetrical slotted shielding strips of beryllium copper permit continuous spring contact throughout their length, providing the perfect answer for a variety of shielding requirements.

Three models are available: basic, rivet-mount and double-faced adhesive-mount designs. The basic design consists of low-compression, adhesive-mounted strips. A generous radius profile provides for the greatest incident engagement angle with the lowest force. As with all Sticky Fingers® shielding strips, the self-adhesive tape makes mounting easy and secure.

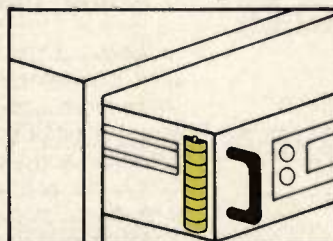
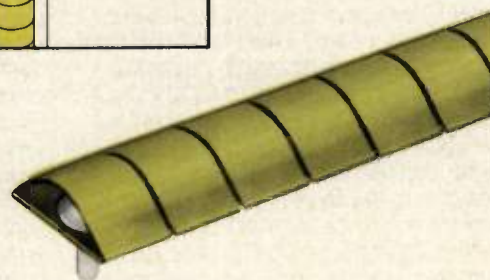
The rivet-mount design incorporates the addition of an integral track, pierced for mounting with nylon push rivets. This configuration allows bi-directional engagement, and is specially designed for slide applications, PC board connections, etc.

The third design also incorporates an integral track-mount design, but employs a double-faced adhesive tape instead of push rivets. This provides for fast, easy field replacement in military applications, especially where high frequencies do not permit the use of mounting holes.

For complete information, including exact specifications, dimensional drawings, etc., on these and other Instrument Specialties shielding strips, use this publication's Reader Service Card. Or write to us directly at Dept. RFD-36.



Adhesive-mounted strips for typical electronic enclosures.



Strips with integral mounting track* and nylon push rivets, for sliding drawer applications.



Strips with integral mounting track* and self-adhesive strip for fast field replacement.



INSTRUMENT SPECIALTIES COMPANY, INC.

P.O. Box A • Delaware Water Gap, PA. 18327
Phone: 717-424-8510 • TWX: 510-671-4526

Specialists in beryllium copper since 1938

*patent pending

BROAD BAND NOISE SOURCES

FOR SPACE, MILITARY AND COMMERCIAL APPLICATIONS... DC-50 GHz

CHIPS AND DIODES

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



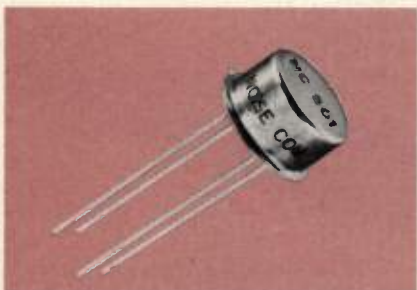
TYPICAL STANDARD MODELS

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

ALL ARE IN STOCK

DROP IN MODULES FOR BITE

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



TYPICAL STANDARD MODELS

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

ALL ARE IN STOCK

BROAD BAND AMPLIFIED MODULES

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



TYPICAL STANDARD MODELS

NC 2101	up to 20 kHz
NC 2102	up to 100 kHz
NC 2103	up to 500 kHz
NC 2104	up to 1 MHz
NC 2105	up to 10 MHz
NC 2106	up to 20 MHz

MOST ARE IN STOCK

HIGH-OUTPUT:

+ 10 dBm, 50 ohms
SMA or BNC output



TYPICAL STANDARD MODELS

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

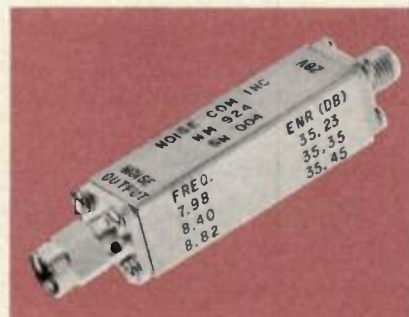
Other frequency ranges
and output levels available

MOST ARE IN STOCK

INFO/CARD 16

BROAD BAND PRECISION, CALIBRATED COAXIAL

SMA, N, TNC Output Connectors



TYPICAL STANDARD MODELS

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

NOISE/COM

"NOISE IS OUR ONLY BUSINESS"
NOISE COM, INC.
111 Moore St.
Hackensack, N.J. 07601
TWX 910-380-8198

For more information and quick
response, call Gary Simonyan at
201-488-4144.

Silicon Hyperabrupt Tuning Varactors

M/A-COM Silicon Hyperabrupt Tuning Varactors are characterized by reproducibility!!!
Because of our proprietary ion-implant process and superior silicon oxide passivation, M/A-COM's HATVs display a characteristic C-V curve that has lot to lot consistency. This homogenous C-V feature is stable within close tolerances, over time and temperature.

Our silicon hyperabrupt tuning varactors are computer tested and we offer off-the-shelf **IMMEDIATE** delivery.

When low cost, lot-to-lot C-V repeatability and prompt delivery are critical, M/A-COM's HATVs deliver. Our HATVs provide the **DEPENDABLE** product performance the marketplace has been waiting for.

For more information, write to: M/A-COM Semiconductor Products, Inc., South Avenue, Burlington, MA 01803.

M/A-COM

CTI PRESENTS

PHASE-LOCKED SIGNAL SOURCES & FREQUENCY SYNTHESIZERS...

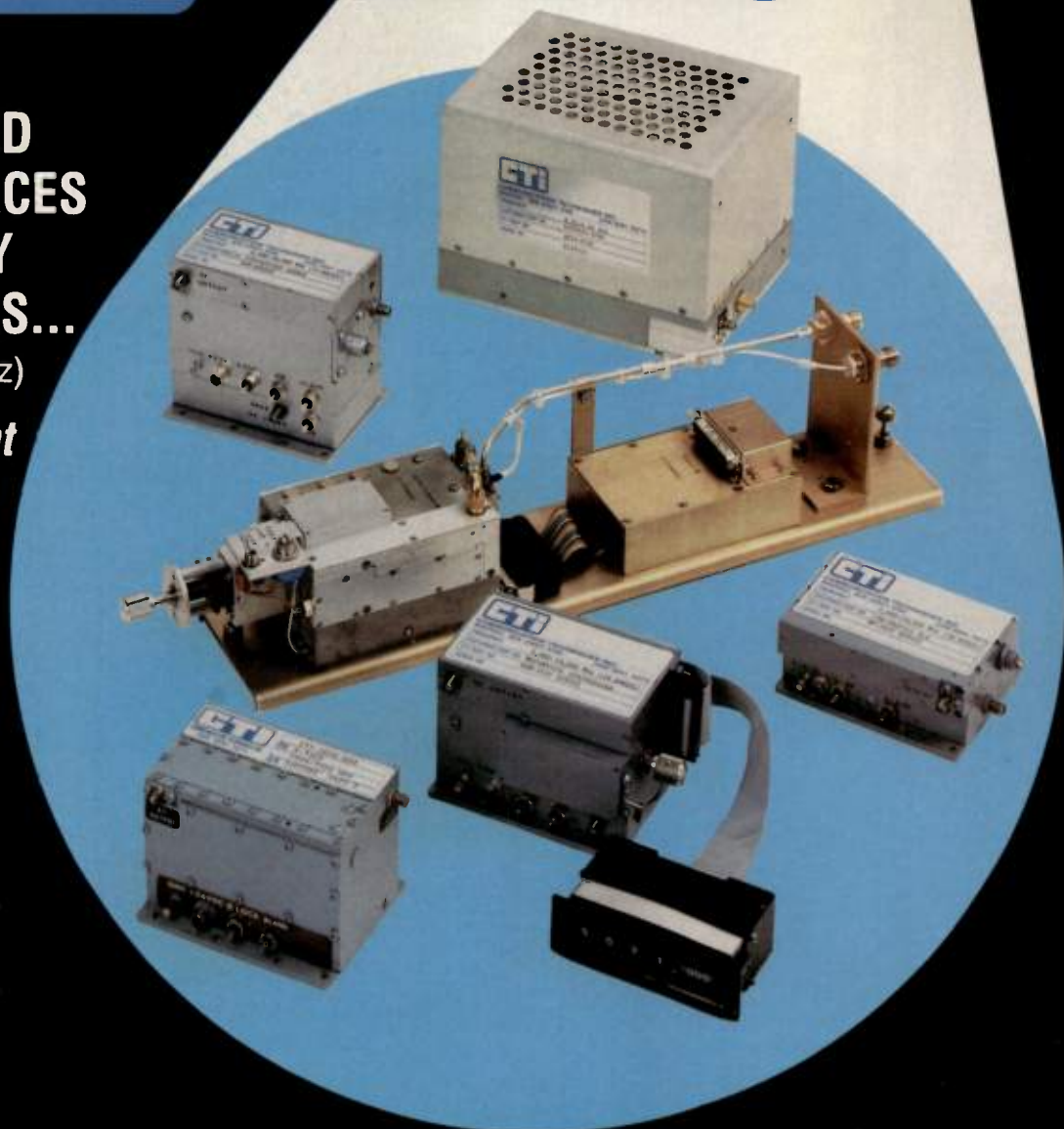
(30 MHz to 21 GHz)

*...When You Want
The Very Best*

Communication Techniques, Inc. has established a world wide reputation as the "Specialist" in Microwave Signal Sources and Frequency Synthesizers for Satellite, Terrestrial Radio and Troposcatter Communications Systems, Radar, Telemetry and Microwave Landing Systems; and the various segments of the Defense Industry.

CTI offers a unique total resource for low phase-noise signal generation over the frequency range of 30 MHz to 21 GHz, in discrete bands. An extensive array of standard catalog items are shown in the table to the right. In addition, CTI can provide customized versions as well as integrated assemblies derived from modifications to the standard product line.

Call or write for our full line catalog.



Model No. Series	Product Line Description
P & MP	Mechanical Phase-Locked Sources; Standard & Low Profile
A & MA	Automatic Phase-Locked Sources; (AGILE)-Standard & Low Profile
XSM & XSMP	Ultra-Low Noise Sources; Locked to 5 or 10 MHz
FMPL	Modulatable Phase-Locked Transmitters; Modulatable 10 Hz to 12 MHz
MX	Frequency Multipliers; High Efficiency-Low Noise to 21 GHz
MFSR	Microwave Synthesizer; Ultra-Low Noise & < 1 kHz Steps
SLSR	Microwave Synthesizer; Moderate-Low Noise & 1 to 10 MHz Steps
DSR & MDSR	Microwave Synthesizer; Low Noise, Small Size & Low Cost-10 kHz Step
PXS & PXSM	Crystal Oscillators; Free Running or Locked to 5 or 10 MHz
C & VCO	Cavity Oscillators; Low-Noise Mechanically or Voltage Tuned
PPC	Converts Magnetron RADAR to MTI RADAR >40 dB Cancellation

COMMUNICATION TECHNIQUES, INC.

9 Whippany Road, Whippany, NJ 07981 • Phone (201) 884-2580 • TWX 710-986-8265 • FAX 201-887-6245

INFO/CARD 19

Modules Deliver the RF Punch for PLRS

Assemblies, Boards and Hybrids — Three Levels of Modularity

The Automatic Position Location Reporting System (PLRS) is a UHF radio network consisting of a transportable Master Station with computers and situation display, in communication with up to 400 Individual User Units. These units may be deployed as manpacks or installed in aircraft and surface vehicles. The Master Station computes and continuously updates the position of each User Unit within 15 meters. The PLRS system is currently supplied to the Army and Marines.

Reliable communication of position data is realized by a unique combination of an anti-jam radio and a sophisticated net management algorithm. To support hundreds of users in real-time, the radio uses a spread-spectrum, pseudo-noise, frequency-hopped waveform with error detection and correction. The net management algorithm monitors all radio links and maintains real-time information on the connectivity. This data is used to reconfigure the network when necessary, as a result of a broken link.

The 100 watt Transmitter Assembly used in the PLRS radio is made by Microwave Modules and Devices (MMD) for Hughes, the system manufacturer. The assembly is an excellent example of how modules and modular construction can be applied to high volume production military hardware. The Transmitter assembly built at MMD consists of three replaceable modules, each with a designated function:


- **Control Module** — This module selects appropriate power output with greater than 23 dB dynamic range, controls both the rise and fall time of the pulse, and protects the amplifier module.

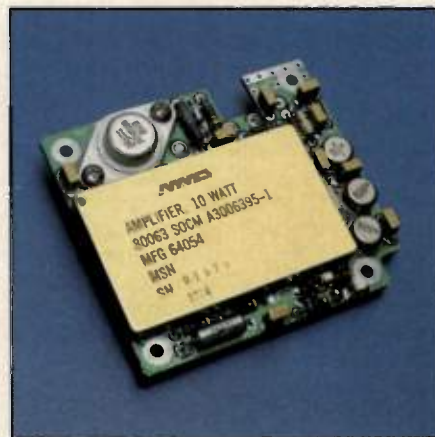
- **Power Amplifier Module** — The UHF PA delivers 100 watts, or another selected level, over the full military temperature range. A PIN diode T/R switch is included in this module.

- **Driver Module** — This module delivers 10 watts of power to the PA module. It is constructed as a combination of

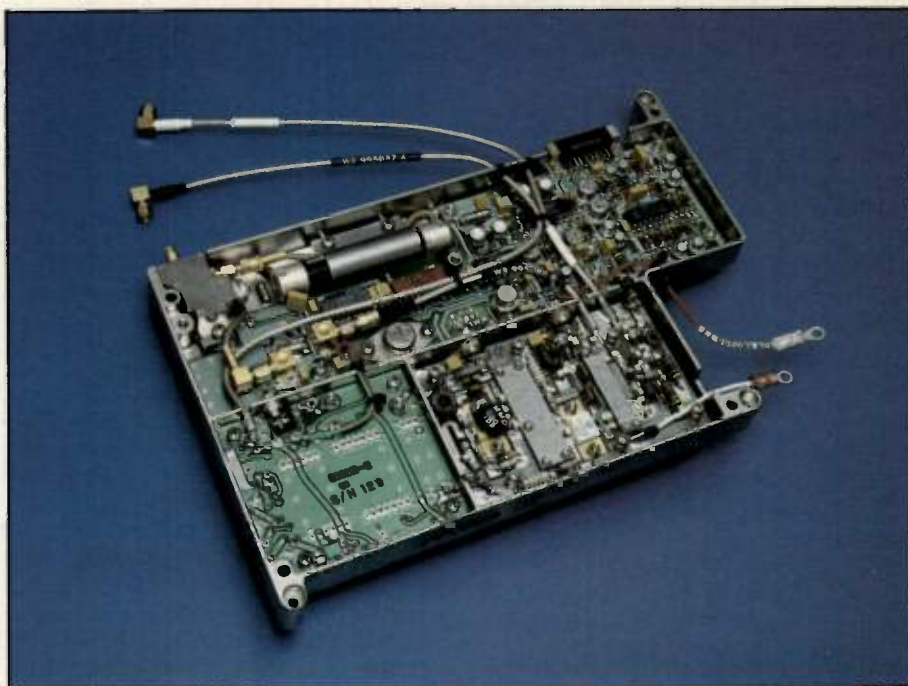
TO39 thin film hybrids and a large thick film plug-in hybrid.

The modules represent an integration of thin film, thick film and printed board technology to achieve an optimum cost/performance tradeoff. Carrying the modular concept even farther, Hughes is able to use the assembly as a power amplifier in other radio systems operating in the military UHF band.

MMD supplies modular RF and microwave power amplifiers for defense electronics and commercial applications. They have delivered amplifiers for communications, radar, avionics and EW systems from DC to 4 GHz, operating from less than a watt to many kilowatts. Microwave Modules and Devices is located at 550 Ellis Street, Mountain View, CA 94043, tel. (415) 961-1473. 



The driver subassembly combines thick and thin film technology.



The amplifier assembly. At the top is the control module, lower left is the driver, and at lower right the power amplifier.

RF "Building Blocks" — The New Approach to Design

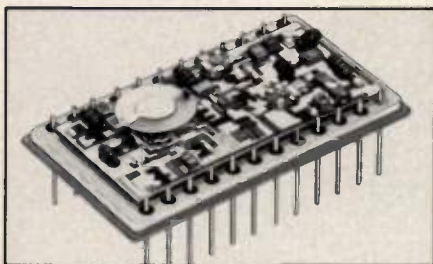
New Super-Components are Changing the Engineer's Role

By Gary A. Breed
Editor

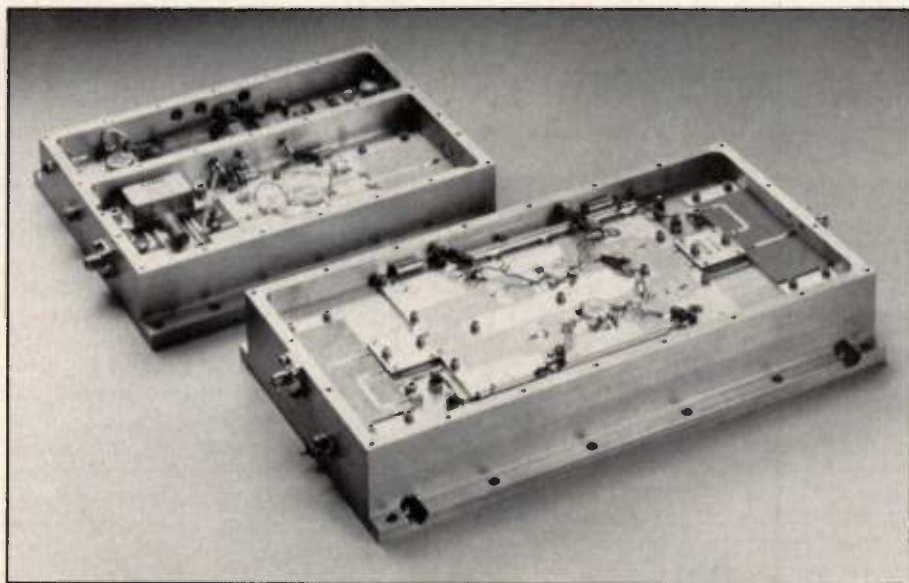
Modules, hybrids, subassemblies, board-level integration — whatever you call them, they are "building blocks" for RF systems and they are the hottest part of the RF industry right now. A look at the advertisements and new product announcements in this magazine (or any other electronics magazine) should prove that point. Although modular circuits have been around for a long time, they recently have become so widespread that engineers generally consider them as if they were individual components like resistors or capacitors.

This report is more of a news story than an update on technology. Many of the rapidly growing companies in the RF industry are in the business of making products best described as building blocks. It really doesn't matter whether their products are thick film hybrids, packaged circuit assemblies or board-level products. They represent functionally complete subsystems, and they are changing the way engineers design RF equipment.

One reason for recent growth in modular components is lack of available expertise. *RF Design* has reported the demand by RF companies for more engineers with analog design abilities (May 1987 issue, p. 57). With this current shortage of designers, companies often find themselves lacking the in-house capability to design



Oscillators are perhaps the most well known hybrid modules. This photo shows the construction of a VCXO from Reeves-Hoffman.



Known best as a transistor and hybrid amplifier maker, TRW RF Devices is now manufacturing these UHF class A amplifiers.

certain types of circuits. When a new technology comes along, the problem is multiplied.

For example, surface acoustic wave (SAW) technology has matured in just the last few years. SAW device manufacturers agree that their greatest difficulty in attracting customers is that engineers lack adequate knowledge in SAW applications. Two companies, Andersen Labs and RF Monolithics, have specifically stated that a major reason they have undertaken modular assembly is to circumvent this problem. By providing their SAW devices in an assembly containing all interfacing circuitry, they have substituted their specialized expertise for the uncertainty of the customer's own engineering staff.

Performance is another major reason for the growth in modules. As RF technology has become more complex, a natural response is to create areas of specialization. Buying a modular assembly gives one company access to the specialized

ability of another manufacturer. As another example, how many companies build their own precision oscillators? Not many. Instead, they buy them from one of the many oscillator specialists. The phrase applied here is certainly, "Why reinvent the wheel?" In just the past two or three years, that principle has been expanded to include power amplifiers, noise sources, IF amplifiers, and entire receiver front-ends. The build-or-buy decision in RF is increasingly "buy."

Cost and Competition

Outside of consumer electronics, RF is not a mass market. The quantities of units produced by RF manufacturers are relatively small. For many years the attitude has been that quality and performance override all other concerns; that people buy equipment for those reasons. Add the desire for complete control over all design and manufacturing parameters and you have a completely engineering-driven sys-



Among the oldest modular components are filters, such as this product from TTE.

tem. For a long time, this system worked well, but there is a definite shift in economic climate that is forcing a change of attitude.

Last November, Hewlett-Packard introduced a new low cost spectrum analyzer. To create that product and sell it at a competitive price, H-P modified its historic 'engineering first' philosophy. The marketplace determined the price range and dictated the design goals for the product. Like another test equipment giant, Tektronix, had done a few years earlier with a new line of oscilloscopes, H-P engineers had to create an instrument within a well-defined framework of time, cost, and manufacturability.

There is another side to the cost equation: manpower. RF engineering salaries are high, and the required support equipment and facilities are expensive. As worldwide competition has grown, companies can no longer justify the cost of designing every circuit in that design. As a result, exercising control over every aspect of design and performance is more costly than ever. Fortunately, competition among module suppliers has developed to the point where quality is generally high in these system components.

Building Blocks Change the Designer's Role

The ability to bypass component-by-component design of amplifiers, mixers,

or oscillators changes the method of circuit design. The RF engineer needs sufficient understanding of these circuits to establish appropriate performance specifications, although he or she won't actually design them. Instead, that engineer must have top-notch ability to *integrate* various subsystems into a working whole. Formerly, the staff engineer had the opposite priorities: circuit design expertise with some system-level familiarity.

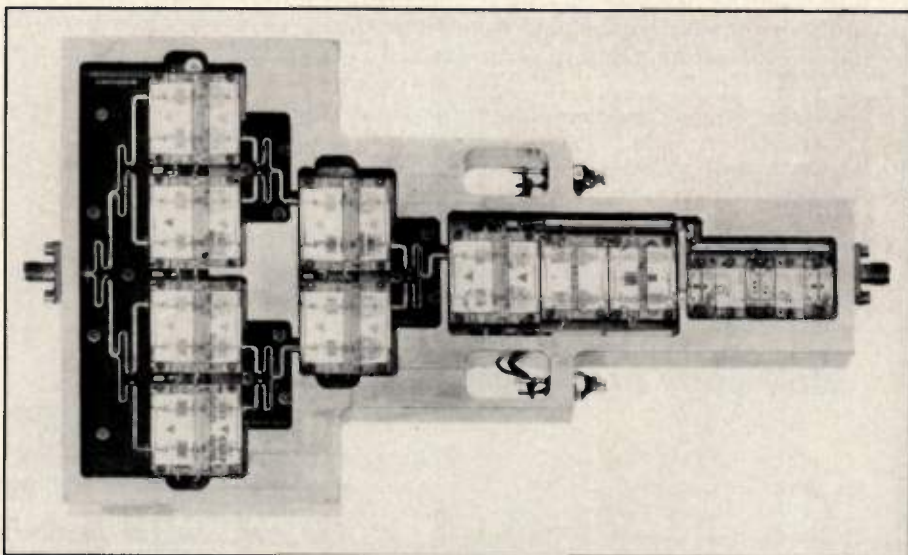
This design process is much less interactive, as it would be under the conventional arrangement where a circuit designer works under a project manager with authority over several subsystem teams. With outside vendors, the process needs to have far more advance preparation. Initially, specifications must be developed for selection of system components, including the compromises in performance that are usually necessary to meet budgets and timetables. Although the design process has always had these first

steps, using outside sources for part of the system makes it very difficult to modify the system or explore different performance options as the project develops.

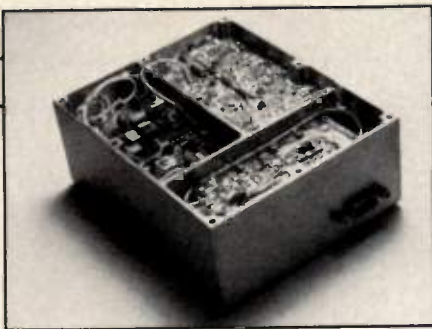
Product Knowledge is a Necessity

Besides the change in planning and specification of a design, modular components require that engineers at the lowest staff level be familiar with available products. If custom or semi-custom assemblies are needed, the capabilities of supplier companies should be well understood. The purchasing department may make the financial arrangements for procuring the modular components, but it is always the engineers who decide exactly what the specifications are, and which companies are most likely to be able to meet them.

This necessary awareness by engineers is in contrast with past practice. Designing with discrete components has involved "generic" resistors, capacitors, and semi-



M/A COM MPD has incorporated amplifier modules into a 20 watt S-Band power amplifier assembly.



This UHF receiver from General Services Engineering can be considered a "module" intended as part of a complete system.

conductors. While preferences for certain manufacturers' products develop as a designer gains experience, these choices do not have to be made for every project. The selection of amplifier, oscillator, synthesizer or mixer subassemblies has to be done "from scratch" every time. An engineer has to be aware of the differences in performance and manufacturing expertise among several potential suppliers.

Right now, the engineers' task is most difficult. The number of companies supplying modular components is growing rapidly, requiring a continuing effort to keep up to date on products and capabilities. Also, firms which manufacture discrete components are incorporating

"value added" assembly of hybrids or boards based on their discrete products. A few examples include: Motorola, which is manufacturing an RF modem board; TRW, offering a line of hybrid and board-level power amplifiers; Piezo Crystal Co. continues to develop new oscillator modules; and Acrian is making UHF-TV and S-Band power amplifier assemblies. All of these companies, known best for their discrete components, have added modular products to their capabilities.

A Gradual Rise to Prominence


"Building block" design is not new. In particular, assembled oscillators, mixers and filters have been around for a long time. What is noteworthy is that the concept has rapidly expanded to include nearly every RF function over the past few years, to the point where modules are replacing discrete designs. The modest collection of modules available only five years ago has grown dramatically, to the point where they are a factor in *all* design decisions.

There is a negative side to the phenomenon, now that it is possible to build complete RF systems by purchasing modular assemblies, interconnecting them



Rather than design an amplifier, engineers have the option of using a broad-band hybrid gain block like this one from the Anzac Division of Adams-Russell.

and applying the proper DC power. There is the danger that engineers will stop *designing* and just pick assemblies from a catalog and put them together in a system. RF engineers have to realize that the process of design should not be less rigorous because modular products are used.

Like all new developments in product technology, the availability of these super-components offers outstanding time and convenience benefits. With proper system planning, maximum performance can also be achieved. But, also like any new development, users of the technology must understand the changes it brings to the process of engineering. 

FINAL CALL FOR PAPERS

RF Technology Expo '88

Anaheim, California, February 10-12, 1988

Your expertise is needed for the best technical seminars in the entire RF universe! In addition to the recognition and respect gained by helping your fellow engineers do their jobs better, as a speaker or session chairman you will receive complimentary three-day full registration and a copy of the Expo Proceedings.

Individual papers and complete three-paper sessions are needed — appropriate topics include:

**Oscillators
Filters
Test Methods
RF System Design
Antennas**

**Mixers
PLLs
Components
Analog Design
RF Switching**

**Modulators
Power Amplifiers
High Speed Digital Circuits
Small Signal Amplifiers
EMI/RFI/EMC**

**Mail your proposals to: Gary A. Breed
Editor, RF Design
6300 S. Syracuse Way, Suite 650
Englewood, CO 80111
Or call with your idea: (303) 220-0600**

THIS YEAR YOU CAN GO TO RF EXPO EAST EXHIBITS FREE.

PROVIDED YOU REGISTER BY OCTOBER 1.

November 11-13... at Boston's World Trade Center...

the RF world will center around RF Expo East...trading the best ideas in RF engineering (in 45 papers, from leading RF authorities around the world)...and showing its best, most recent RF "wares" (in exhibits from more than 100 leading manufacturers of RF components, circuits, instruments, and design aids).

This year you can attend the product exhibits free...just by returning the registration coupon below. **You must return the coupon by October 1, 1987** in order to take advantage of this offer.

For further information on technical sessions and Les Besser's one-day "Fundamentals of RF Circuit Design" course, call Cherry Hughes, *RF Design*, 800-525-9154.

rf expo feast 87

**November 11-13, 1987
Boston World Trade Center**

- ☐ **YES! Please register me for a FREE EXHIBITS ONLY PASS.**
- ☐ **PLEASE RUSH ME A SCHEDULE OF TECHNICAL SESSIONS.**

Name _____

Title _____

Address _____

City _____

State _____

Zip _____

Country (if outside U.S.A.) _____

Phone _____

**Badge should indicate:
(please check one box)**

- ☐ Broadcast, CATV & Video Equipment
- ☐ Instrument & Test Equipment
- ☐ Gov't, Military, Aerospace, ECM & EW Equipment
- ☐ Communications Equipment
- ☐ Components Mfrs.
- ☐ Labs & Consultants
- ☐ Other _____

Return to: *RF Design*, 6300 S. Syracuse Way, Suite 650, Englewood, CO 80111, (303) 220-0600 or 1-800-525-9154.

Specifying High Power Filters

Important Considerations for Filter Design and Purchase Decisions.

By Dick Wainwright
QRS

There are still plenty of engineers who say, "Anyone can design filters, the textbooks are full of tables of element values." That is true, but there are many more pertinent specifications than just *L* and *C* values. Component ratings, not the values, are of fundamental importance in power handling devices. The old saying, "A little knowledge is dangerous," applies to high power filter design — resulting in a lot of smoke testing.

Take a moment to ponder the long list of key terms in the language of high power filter design. Electrical considerations include: Power, *Q*, selectivity, energy storage, modulation, peak-to-average, harmonic content, rejection, EMI, topology, dielectric strength, losses, and so on. Equally important are the mechanical and environmental aspects: heat generation, flow and sinking, contaminants, vibration, salt spray, connectors, altitude, plating, and many others. These terms are but a smattering of the flow of words that haunt every sensible designer of high power devices.

It takes an intimate knowledge and an awareness bordering on paranoia, along with considerable experience, to tackle this area of design. The same understanding is needed when specifying a filter for purchase from an outside vendor. More than one manufacturer has experienced the frustration of losing a bid because of exceptions prudently taken to allow for poorly defined specifications. Many times the user does not know or furnish such important information as:

a) *Harmonic content* of transmitter power output relative to fundamental power.

b) *Connectors* which may be incompatible with specified power and load conditions.

c) *Surface area* available for heat conduction/radiation and availability of cooling air. Assuming that cooling air is available, its rate of flow, pressure and temperature.

Harmonic Order	Level (dBc)	Harmonic Power W _{1/2} kW (Fundamental)
2nd	-18	15.8
3rd	-12	63.1
4th	-21	7.9
5th	-18	15.8
6th	-22	6.3
7th	-21	7.9
(8-13th)		37.8 (total)
Total Harmonic Power = 154.6 watts per kW Fundamental		

Table 1. Typical Amplifier Harmonics.

Selectivity 60 dB/3 dB	Nominal VSWR	Filter Design	Qul for a Given Loss	Energy Storage
1.25	1.2	Elliptic (0.01 dB ripple)	1000	20
1.5	1.35	Chebyshev (0.1 dB ripple)	650	15
1.7	1.2	Chebyshev (0.01 dB ripple)	460	12
—	—	Chebyshev (0.001 dB ripple)	290	—
2.1	1.2	Butterworth	200	10
4.2	—	Bessel	—	—

Table 2. Filter Type Comparisons.

d) Proper *shock and vibration* specifications. A vivid recollection concerns heavy shock and vibration specs along all three axes for an application which, under power, was fixed and indoors!

e) *VSWR* with realistic values. 1.1:1 is not the right specification for a filter which would, in practice, be operating into a load of 2:1 or 3:1, at almost any phase angle.

f) *Other mitigating relationships* which combine to specify an unrealistic design.

Harmonic Content

Typical solid state transmitters of recent vintage can be expected to yield harmonic power levels such as those listed in Table 1. Besides the filter requirements, the system designer may opt to use a ferrite iso-

How Can A Power Meter Be UNIQUE?



Let ANRITSU show you...

*Burg Kenter
813-621-1177*

The **ML 4803 A Power Meter** is no ordinary power meter. Just look at these features, unmatched by any other instrument:

Field Replaceable Sensors To Reduce Downtime

We use an amorphous semiconductor as the element in our thermocouple sensors which allows the element to be quickly and easily replaced in the field.

26.5 GHz Diode and 32 GHz Amorphous (thermocouple) Sensors

Measurements up to 26.5 GHz (diode) or 32 GHz (thermocouple) can be made simply by using *one* sensor. Low VSWRs and fast response times make these sensors highly accurate and precise measuring devices for calibration, R & D or production facilities.

LED Display of "VSWR" and "% Reflected Power" Values

By comparing a measured value to a stored value, the dB difference between the two is used to calculate both "VSWR" and % Reflected Power." These values can then be clearly displayed on the unit's front panel.

30 x 4 Memory

Four values (offset, cal factors, etc.) can be stored in each of the power meter's 30 memory locations for easy recall and manipulation. This is essential in production applications.

Affordable Price Includes GP-IB

GP-IB is usually a costly option for those who require it in ATE or production environments. But not with the Anritsu ML4803A Power Meter ... the cost of this instrument is \$2,825, which includes GP-IB.

Waveguide Sensors to 140 GHz

A series of waveguide sensors extend the meter's frequency range from 17 GHz to 140 GHz over a -30 to +20 dBm measurement range.

For more information on the power meter which is truly unique ... contact ANRITSU today at ...

Anritsu America, Inc.,
15 Thornton Road,
Oakland, NJ 07436,
201-337-1111 (In NJ) or 800-255-7234
Telex: 642-141 ANRITSU OKLD

Anritsu

WE'RE ON THE MOVE. WORLDWIDE.

INFO/CARD 20



OCXO • TCXO • VCXO • TCVCXO Crystal Oscillators

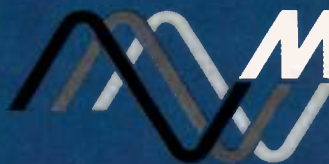
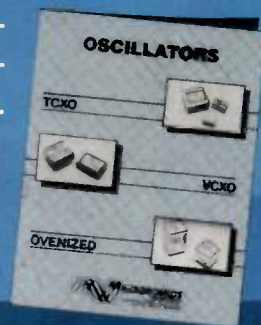
Microsonics has designed and developed standard and custom highly stable quartz crystal oscillators that fulfill literally thousands of space, military, and commercial system requirements over the range of 50 kHz to 1 GHz.

We carefully control each step of the process from in-house quartz crystal fabrication to the final QA-approved tested oscillator. Proprietary CAD capability, component modeling, and product design optimization guarantees fast, accurate design information. Our engineers work closely with you to ensure that you get exactly **what** you want, **when** you want it.

And we've made your task easier when it comes to defining your oscillator needs. Our new 16-page catalog is loaded with helpful information: curves, definitions, design considerations, trade-offs, and complete specifications of typical units. There's even a worksheet you can use as a checklist.

The next step is yours.

Send for your copy.



MICROSONICS
INCORPORATED

A Subsidiary of Signal Technology Corp.

60 WINTER ST. WEYMOUTH, MA 02188-3336
(617) 337-4200 TWX 710-388-6833

©1986



lator at the transmitter output to maintain a well-matched condition. However, most isolators are frequency sensitive, and the result may be excessive heating due to the harmonic energy. Burnout is one possible consequence, as is additional harmonic generation from operation of the ferrite material near its Curie temperature.

Connector Ratings

Most connector manufacturers don't know how much power or apparent power their connectors will safely handle under all possible operating conditions. Current ratings rather than voltage ratings are generally the problem area. Z_0 is of little importance in systems working with very high VSWR values (although, of course, they are related).

The fact is that most filters are reflective devices, producing attenuation by reflection of power back to the source, rather than by absorption. Absorptive filters are generally more expensive and considerably larger than reflective types. However, especially at UHF and higher frequencies, the use of harmonic absorptive filters should be considered.

Cooling Considerations

How much surface area should one allow for the cooling of high power filters? If cooling air is available, what is its pressure and rate of flow? First, we make the following assumptions: 1. The maximum power versus connector type is in the order of 2/3 of the rating of the cable attached, derated appropriately; and 2. A high power filter is normally designed such that the hot surface temperature does not exceed ambient plus 50C, with a heat sinking plate average temperature that is no more than ambient plus 10C (95C maximum). Cooling air, if available, should not exceed an effective temperature of 80C; hence, air speed may be an important consideration as the air approaches the filter hot spots.

In many cases, substantial size fins may be required, but fins are *not* effective in cramped air flow spaces. Convection air currents must be free to circulate if convection represents a substantial portion of the cooling means. Surrounding heat conducting surfaces may need to have rough textures to "wipe" the heat out of the circulating air.

Shock and Vibration

Heavy shock and vibration specifications along all three axes should be studied carefully. The strong G forces should be confined, if at all possible, to the smaller dimensions of the coaxial structure. Minimal forces of no more than

5G (preferred), or 10G maximum (11 m/s standard shock specification) should be applied on the length of coaxial filters of substantial size. In addition, the adequacy of the mounting and supporting hardware is essential.

Electrical Specification

Selectivity, time delay, energy storage, electrical (absorptive) losses and heat

generation go hand-in-hand. Q, the ratio of *Energy Stored per Cycle* to *Energy Dissipated per Cycle* of the applied energy is a critical consideration in the design of all filters in general, and of great importance in high power filters. For a given loss, the required ratio of unloaded Q/loaded Q is different for every filter design. It is not uncommon for certain designs to require inductor unloaded Q val-

Modular Video Distribution Amplifier lets you Expand as Required.



Start off with a single 1X6 channel card in the chassis. Then expand up to 15 separate channels to process 15 different inputs and provide 90 separate outputs.

Simplified controls for each channel provide gain and offset adjustments. The gain is adjustable from -10 to +15 dB, the offset control will remove ± 6 Vdc offset from the output signal. Other gain and offset ranges, as well as automatic level control, are available as options.

Frequency response of dc to 32 MHz is standard; bandwidths of up to dc to 85 MHz are available. This wide range of

operating options makes these units ideally suited for FDM, TDM, telemetry, and wideband pulse applications.

Front panel LEDs provide signal present and overvoltage indications. The intensity of the overvoltage lamp is relative to the signal strength. The threshold level for both detectors is easily adjustable.

For additional details call Gary Gallop at (301) 294-9060. We will be happy to send you complete specifications on our Video Distribution Amplifiers and related products.

APCOM
INCORPORATED

APCOM INC.
625A Lofstrand Lane
Rockville, MD 20850
(301) 294-9060

Now Get Maximum Reliability, Best Price, Prompt Delivery

U.L. LISTED FACILITY FILTERS Now Available Directly From The Manufacturer.

From Fil-Coil, The First Manufacturer To Be Listed As Manufacturer of Facility Filters Per U.L. Spec #1283

These filters are available in two styles, with current ratings from 5 to 225 A, for operation at 277 VAC, 0-60 HZ or 0-400 HZ. They conform to U.L. 1283 and MIL-F-15733.



Also turn to Fil-Coil for:

- QPL Filters to MIL-F-15733/4 and MIL-F-15733/75
- UL, CSA, VDE and other international standard filters.
- Custom Designs to solve your interference problems.
- A Wide Variety of other filters, including power line, communications, screen room, signal line, panel box, telephone line, and EMP protection.



PHONE OR WRITE
TODAY FOR OUR FREE
CATALOG!

800 Axinn Avenue,
Garden City, NY 11530
Phone: (516) 228-9445

International Telex 230199 Swift UR • Domestic Telex 960127 Swift NYK
RFI/EMC EXCELLENCE FOR MILITARY, INDUSTRIAL, AND COMMERCIAL
USERS.

INFO/CARD 23

FAX (516) 228-9064 • CALIFORNIA (408) 372-7447

MILLIONS OF PEOPLE HAVE BEEN CURED OF A DISEASE MOST PEOPLE SEEM TO THINK IS INCURABLE.

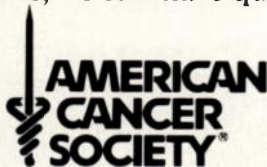
Today, one out of every two people who get cancer will survive.

With early detection and prompt treatment, the survival rate for Hodgkin's disease can be as high as 74%. Childhood leukemia: as high as 65%. Colon and rectal cancer: as high as 75%. Breast cancer: as high as 90%.

As far as we've come, we still have quite a way to go. And for that, we'd like your help.

There's only one place where cancer is a hopeless disease:

In your mind.



Help us keep winning.

ues in excess of 500-1000 and for capacitors, 3500-8000. Even with these values, the engineer may only eke out a responsive design where rejection bandwidths to low loss band edge ratios are small, e.g. much less than 1.2:1 for 40-60 dB rejection. The almost impossible Q values of 2000 or more for coils and over 10,000-15,000 for capacitors may be required, but are unobtainable in practice because of space, moding, or frequency limitations.


The Q of coils increases roughly as the square root of frequency, so high frequency filters generally yield lower losses for the same selectivity and available space.

For a given loss (see Table 2) the unloaded Q required increases substantially with passband ripple (VSWR), complexity (n) and type of filter (Elliptic, all-pole Chebyshev, Butterworth, etc.). Note that Table 2 indicates representative values, not absolutes.

As an example, a 0.01 dB Chebyshev (all-pole) filter required approximately (460/200-1), or 84 percent more Q than a Butterworth filter for a given loss. The Elliptic filter given has twice the energy storage indicating that voltages and currents are roughly 40 percent more than in a Butterworth filter.

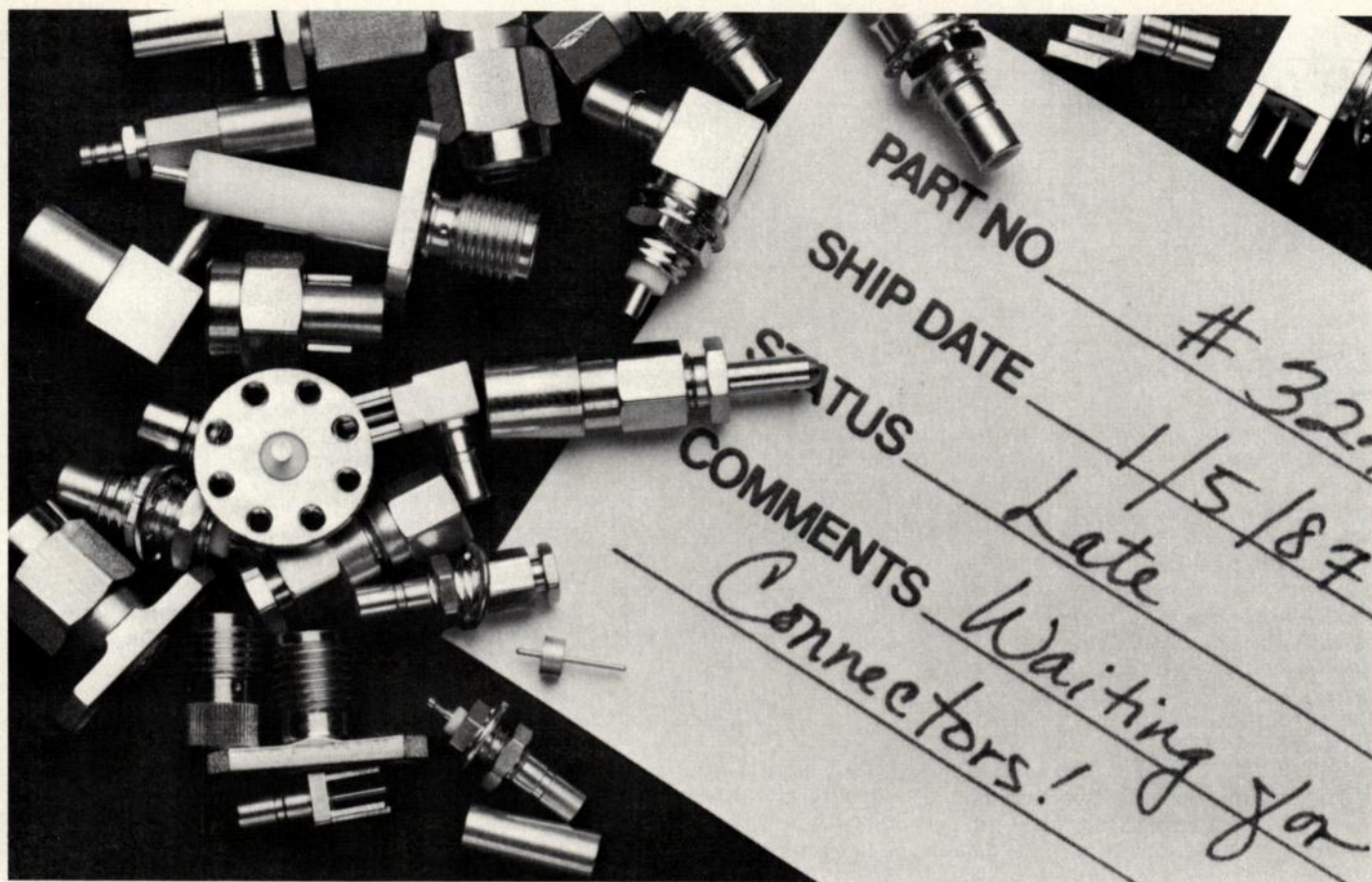
Other Factors

There are several factors that also require consideration in the specification and design of high power filters. These include phase linearity versus frequency in a single filter, or phase matching in filter groups. A ± 5 degree phase matching specification may double the price relative to a non-matching phase unit, to allow for extensive alignment and component selection. Additional work may be required in mechanical construction to assure matching under varying operating conditions.

Humidity is another concern. High humidity, especially when combined with condensation, can present substantial difficulties. Another environmental concern is altitude of operation. Derating may be necessary, and in difficult cases it may be best to pressurize the unit with dry nitrogen or sulfur hexafluoride. Of course, when pressurized, humidity ceases to be a significant problem. 

About the Author

Dick Wainwright has many years experience in filter design as founder and Chief Scientist of Cir-Q-Tel. He is now practicing as a consultant. He can be reached at QRS, P.O. Box 116, Kensington, MD 20895.



SMALL CONNECTORS CAN BE A BIG DEAL

AEP Subminiature Coaxial Connectors

Small connectors can kill a big system if they don't work or aren't there when you need them. AEP can help make sure this doesn't happen to you.

Connectors that work.

Our production standards exceed MIL-C-39012 requirements. 11% of our workforce is in quality control to make sure these standards are met. Need proof? We have shipped 144,000 cable assemblies (with AEP SMB connectors) for the ARC-164 military radio--NO REJECTIONS. We've also shipped almost 150,000 SMA and SMB connectors to a major radio manufacturer--NO REJECTIONS.

Connectors when you need them.

It's easy to get our parts quickly, thanks to our network of stocking distributors and four -week factory delivery of 92 standard items. If you need something unusual, we can generally deliver specials within twelve weeks.

The right connector for the job.

We make hundreds of varieties of SMA, SMB, and SMC connectors--many qualified to MIL-C-39012. Our 7000 series has unequalled performance in micro-miniature size. Do you need 75 ohm connectors? We make them. You can also save time, trouble, and money by letting us build flexible and semi-rigid cable assemblies for you.

If we sound like the kind of connector supplier you'd like to have, call or write for our 120 page catalogue.

We'll probably save you some money, too.

**Applied
Engineering Products**
1475 Whalley Avenue
New Haven, CT 06525
(203)387-5282
Fax: 203/387-7832



Phase Noise Calibrator

By Guy V. Love and Kevin Lindell
Norden Systems

The spectral purity of RF signal sources used in today's radar and communication systems is often the limiting factor in achieving the desired performance. Such spectral purity is usually specified in terms of phase noise, a measurement of the spectral distribution of the random (or regular) wanderings in phase of the ideal sinusoid, by which the source is characterized. The authors earned the runner-up prize of EEsos's Touchstone/RF in the second annual RF Design Awards Contest.

Source manufacturers often assemble their own test sets for measuring phase noise using a few items of standard test equipment, an appropriate source and a few in-house circuits which vary depending on the technique of choice.

In the procurement of low phase noise sources there is a need to assure that measurements made at the vendor's facility, for instance, on test set "A", can be duplicated in the buyer's lab on test set "B". A calibrator that can be used with any type of test set, whose performance is reliable and easily verified, and which is easily transported, has been developed. Its description, details of construction and application follow.

Technique

The basic idea, shown in Figure 1, is to introduce a general type of phase modulator ahead of the phase noise test set. The RF output of the source is switched between two lengths of coax, one of which is slightly longer than the other. This small change in electrical length appears to phase shift the source-under-test at the clock rate, producing a known phase modulation. The spectrum produced is also known, and provides the means of calibrating the phase noise test set.

The calibrator can be turned off to inhibit interference with the noise measurement of the source. The technique is inherently low loss and, being coaxial, is well shielded to assure negligible additive noise or interference. The approach is broadband, and one set of transmission lines can be used over several octaves. The phase deviation produced by switch-

ing between the two lengths of coax is related to the difference in coax lengths, ΔL , by the following equation:

$$\Delta\phi(\text{pp}) \text{ in radians} = 2\pi f \frac{\Delta L}{V_p}$$

where f = frequency of source under test

ΔL = difference in length of cables

V_p = phase velocity of coax cable used, at frequency f .

The phase shift is frequency sensitive varying linearly with frequency as long as phase velocity is constant. It is desirable to keep the phase modulation small so that the spectrum can be predicted from small index approximations and also to provide a calibration commensurate with the noise to be measured. At the maximum frequency of usefulness, determined by the transmission band of RF switches used, the coaxial cables should differ by less than 0.1 radian if small index theory is used.

Operation

In general, and specifically for large phase deviations, angle modulation is a non-linear process, producing an RF

spectrum whose amplitudes are in terms of Bessel functions. However, if the modulation index is kept small (<0.1 radian), the following approximations to these functions can be made:

$J_0(\Theta)$ = carrier amplitude $\cong 1$

$J_1(\Theta)$ = amplitude of first order sidebands $\cong \Theta/2$

and $J_2(\Theta) = J_3(\Theta) = J_4(\Theta)$, etc. $\cong 0$

where Θ is the modulation index, which is equal to the peak phase deviation in radians, and J_n represent Bessel functions of the first kind and order n . Only the first order sidebands are significant, and they are related in amplitude to the carrier by

$$\text{dBc} = 20 \log \Theta/2$$

For example, if single frequency sinusoidal phase modulation is used, with 0.1 radians peak-to-peak: Θ = modulation index = 0.05 radians peak, and $20 \log \Theta/2 = -32$ dBc. In the spectrum, single lines of this value would appear, spaced either side of the carrier by the modulation frequency.

The small angle approximation also permits superposition to be used to predict the spectrum produced by more complex modulation waveforms. Each of

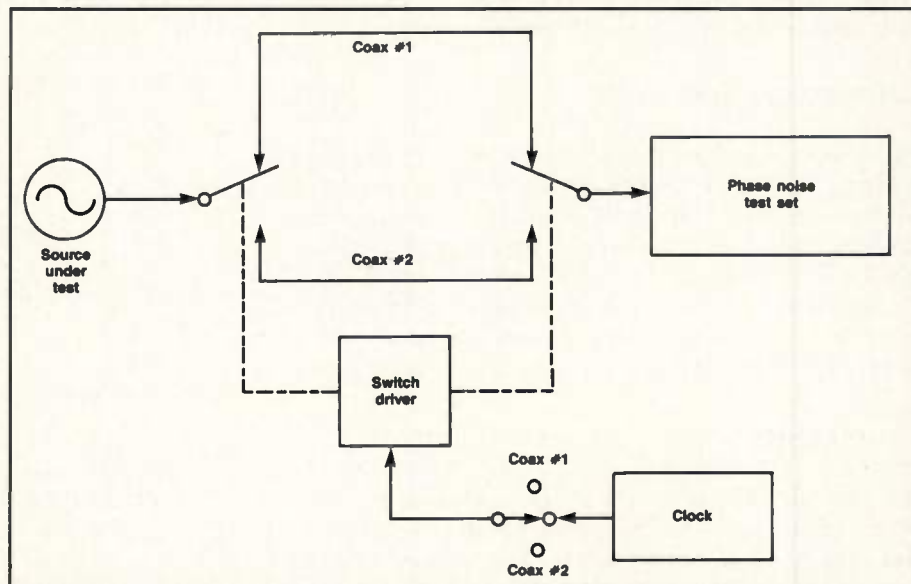


Figure 1. Phase noise calibrator — principle of operation.



You've waited a long time for this 2 GHz signal generator.

For too many years, if you needed a cost-effective 2 GHz signal generator, you had to settle for clumsy, clunky Klystron-based units. Many of which have been around since the last World War.

To achieve any accuracy you needed a counter to set frequency. Then it would drift. And such primitive technology necessitated high maintenance costs.

Of course you could opt for the precision of a synthesizer. It only takes \$20,000 or more.

At last, a true alternative.

The Wavetek Model 2520 puts these past technologies and problems far behind you.

Now you can have a 2.2 GHz synthesized signal generator with all the features and convenience of the popular 1 GHz synthesizers. But, remarkably, at the price of an old-fashioned Klystron generator.

2.2 GHz for under \$8,000.

You've come to expect a lot of performance from your 1 GHz signal generator. Now you can have that same affordable, effective performance in a 2.2 GHz generator with *no compromises*.

Frequency range down to 200 KHz + 13 dBm output power.* Excellent spectral purity. Near field RFI typically <0.1 microvolt. Fast and precise setting of frequency to 10 Hz resolution by keyboard or spin knob. Fully annunciator displays. AM and FM. Pulse modulation with 80 dB on/off ratio.* State of the art GPIB interface.

No compromises.

Pure and simple.

The 2520 accomplishes all this performance without sacrificing simplicity. There's no synthesizer easier to maintain, easier to calibrate. With Autocal you just turn a key and 2520 software helps you through calibration in only fifteen

minutes. Simplicity and state-of-the-art manufacturing techniques provide long MTBF and the durability to stand up to the rigors of everyday use.

Options for your application.

The 2520 offers a wide range of standard features and an even wider range of options to match the instrument to your specific needs. In fact, the 2520 is engineered to make it easy to modify for very specialized applications. Just ask our engineers about it.

Seeing is believing.

We want to show you that the Wavetek 2520 is the best 2 GHz generator available for your testing needs. Contact your local Wavetek Representative or give us a call for a demonstration. Wavetek Indiana, Inc., 5808 Churchman, Beech Grove, IN 46107, 317-788-9351.

*Optional

INFO/CARD 27



WAVETEK®

the Fourier components of the modulating signal then produces its own first order sideband pair around the carrier. For the case of a symmetrical square wave, only odd harmonics exist. The fundamental component (at f_m) produces a pair of lines $\pm f_m$ about the carrier; the third harmonic produces a pair $\pm 3f_m$ about the carrier, and so on for 5th, 7th, etc. The

calibrator uses such a symmetrical square wave phase modulation, switching between the two coax cables whose phase difference is $\Delta\phi(pp)$. The Fourier components of the modulation function are given by:

$$\Theta(n) = \frac{\Delta\phi(pp)}{2} \cdot \frac{4}{\pi n} \quad \text{for } n=1, 3, 5 \dots$$

and zero for $n=\text{even}$

The phase modulation sidebands are then given by:

$$\frac{\Theta(n)}{2} = \frac{\Delta\phi(pp)}{\pi n} \quad \text{for } n = 1, 3, 5, \dots$$

And, relative to the carrier level C, the single sideband levels $L(n)$ are:

$$L(n) \text{ dBc} = 20 \log \frac{\Theta(n)}{2} =$$

$$20 \log \frac{\Delta\phi(pp)}{\pi n} \quad \text{for } n = 1, 3, 5, \dots$$

For the case $\Delta\phi(pp) = 0.1$ radians, the following sidebands are given

$$L(1) = 20 \log \frac{0.1}{\pi} = -29.9 \text{ dBc}$$

$$L(3) = 20 \log \frac{0.1}{3\pi} = -39.5 \text{ dBc}$$

$$L(5) = 20 \log \frac{0.1}{5\pi} = -43.9 \text{ dBc, etc.}$$

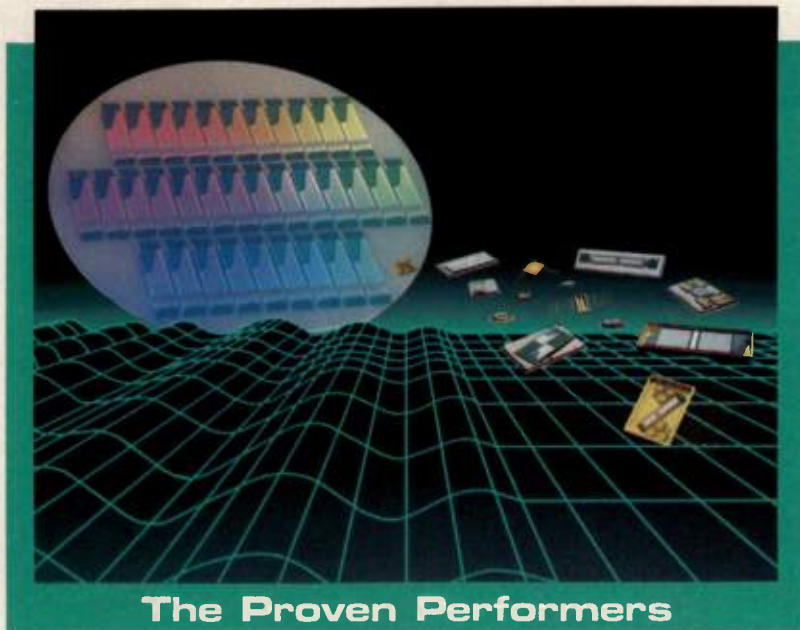
As expected, the sidebands fall as $1/n$, equivalent to -6 dB/octave on a log-log plot of phase noise. The peak values of these line spectra are used to calibrate the plotter output when measuring the phase noise of an unknown source. The choice of clock frequency (fundamental) is not a factor in calibration, and is largely a matter of convenience. It should be high enough to avoid being demodulated by the phase locked loop commonly found in phase noise test sets. It should not coincide with line frequencies or their harmonics, which are often large. An acceptable value is a 100 Hz clock.

Calibration And Sources Of Error

In theory, a careful measurement of the difference in cable lengths, together with an accurate value for cable phase velocity, would yield a close value for $\Delta\phi(pp)$. However, added differential phase shifts in the RF switches, slight but invariable differences in construction, and the uncertainty of the phase velocity, all contribute to errors in this approach. A direct measurement of $\Delta\phi(pp)$ is possible using a network analyzer, or a vector voltmeter.

For use as calibrator, it is the spectral line amplitudes relative to the carrier (dBc) that must be known. As was shown, these vary directly with $\Delta\phi$. A 0.5 dB accuracy in spectrum magnitude requires better

SAWTEK FILTERS...



The Proven Performers

... State-of-the-art SAW devices for signal processing applications that require...

- Steep skirts, high rejection, and compact size.
- Low insertion loss, linear phase, and excellent repeatability.
- Superior RF feedthrough and triple-transit suppression.
- Operating frequency ranges from 10 MHz to 2 GHz.

To meet your requirements, Sawtek produces a selection of discrete components and custom filter assemblies. Our inventory of SAW filters includes Bidirectional, Low-Loss, and Resonator Filters. Sawtek Filters are the ideal choice for high-performance applications such as: digital data transmission, EW, satellite communications, radar, CATV, and PSK to MSK conversion.

Maximize your system's performance. Go with the proven performers... Sawtek Filters. Call us today at 305/886-8860 for an evaluation of your SAW filter application. Or write Sawtek Inc., P.O. Box 18000, Orlando, Florida 32860. FAX 305-886-7061. TWX 810-862-0835.



INFO/CARD 28

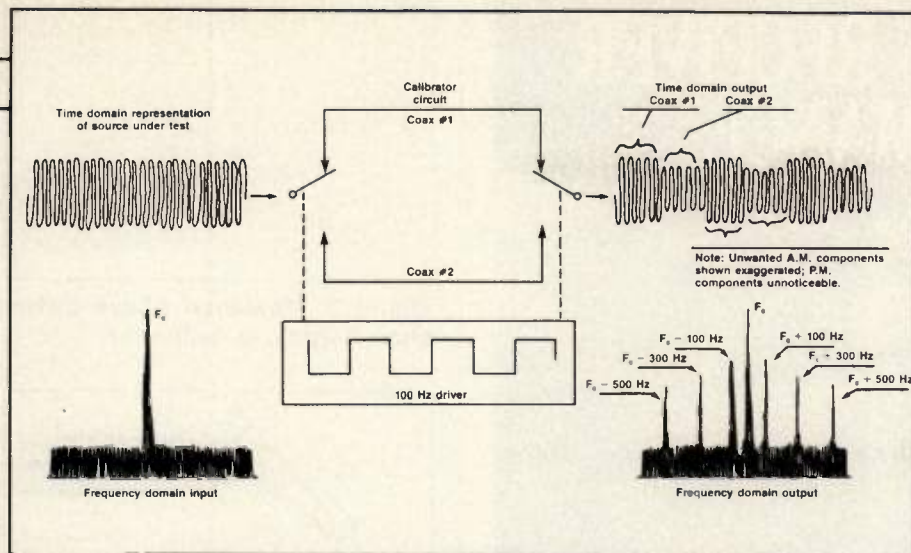


Figure 2. Signal representation in the phase noise calibrator.

than 6 percent accuracy in measuring $\Delta\phi$. If $\Delta\phi$ is 6 degrees, the measurement error should not exceed 0.36 degrees. Since $\Delta\phi$ is the difference of two larger phase shifts, the allowable percent error, in terms of either path length, must actually be much less than 6 percent. Fortunately, absolute phase shift is not needed, and the evaluation of $\Delta\phi$ allows systematic or offset type errors to be differenced out. Still, 0.5 dB accuracy requires considerable

care. A 1.0 dB uncertainty in spectrum content is more easily achieved and may be adequate for many phase noise measurements.

An experimental model of the calibrator was built, and $\Delta\phi(\text{pp})$ evaluated using a network analyzer. The transmission phase angle was measured for each path, using the mode switch to select the path. Included in the path is any phase shift due to the RF switches. It is essential that these

High Frequency Amplifiers . . .

You should also consider price & performance ratios.

Signetics does.

NE5204/5205 Wide-band Amp

- -3 dB bandwidths to 600 MHz
- 20 dB fixed gain block
- Input/Output impedances matched to 50 or 75 Ω
- Noise figure: 6 dB (50 Ω); 4.8 dB (75 Ω)
- No external components
- ★ Military specs available

NE5539 RF Op Amp

- 350 MHz unity gain bandwidth
- 600 V/ μ s slew rate
- 48 MHz full power bandwidth
- Open loop gain: 52 dB
- ★ Military specs available

NE5212 Transimpedance Amplifier

- 14 k Ω differential transresistance
- -3 dB bandwidth to 100 MHz
- Low noise: 2.5 pA/ $\sqrt{\text{Hz}}$
- Single 5 V supply
- ★ Military specs available

See us at RF EXPO EAST
Booths 244 & 246

Call 800/227-1817, ext. 900
for the number of your local
Signetics sales office

Signetics

a subsidiary of U.S. Philips Corporation

Your Broadline Communication IC Supplier

INFO/CARD 29

OEM'S Mini Front? Mini Rear? Mini Flange?

MINI UHF CHASSIS JACKS—WE KNOW WHAT YOU'RE LOOKING FOR AND CAN'T FIND ANYWHERE! OUR RFU-600 SERIES IS EXPANDING EVERY DAY AND NOW IS THE LARGEST AND MOST COMPLETE LINE AVAILABLE FROM ANY SOURCE. WE KNOW YOUR PRODUCT IS GETTING SMALLER, NOT LARGER, AND THE MINI UHF IS YOUR BEST CHOICE IN NEW CONNECTORS.

SPECIAL APPLICATION? CALL US, WE'RE THE CELLULAR SPECIALISTS. WE WANT TO HELP YOU BE #1 BECAUSE YOU'RE #1 WITH US!



RFU-602 RFU-602-1 RFU-603

ALSO AVAILABLE, MINI UHF ADAPTERS AND MALE PLUGS.

- SOLID BRASS CONSTRUCTION
- NICKEL PLATED BODY
- SILVER PLATED JACKS
- TEFLON DIELECTRIC
- SUPPLIED WITH WASHER AND NUT
- DELRIN OR POLYCARBONATE

RF INDUSTRIES
(a division of Celltronics)

10040 Mesa Rim Rd., San Diego, CA 92121, 619-587-0656,
800-233-1728, 800-424-8491 (CA), FAX 619-587-0049, TLX 4993540

INFO/CARD 25

WBE

PRECISION TERMINATIONS



WBE Precision Terminations are available in several connector configurations. When ordering, please state impedance and connector desired.

0-500 MHz VSWR: 1.006:1 max
Price: \$43.00

0-600 MHz VSWR: 1.006:1 max
Price: \$50.00

0-900 MHz VSWR: 1.02:1 max
Price: \$72.00

WIDE BAND ENGINEERING COMPANY, INC.

P.O. Box 21652, Phoenix, AZ 85036 U.S.A.
Telephone (602) 254-1570

INFO/CARD 24

IMPROVE GPS RECEIVER PERFORMANCE

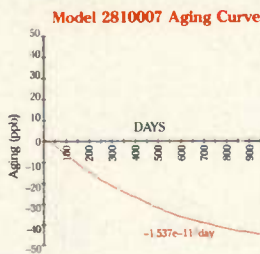
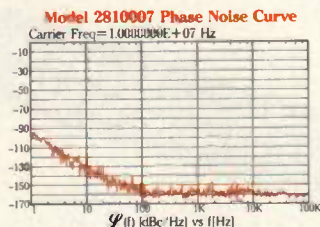


- ✓ SC Cut Crystal
- ✓ Aging Rate: 1×10^{-11} /day
- ✓ Low Phase Noise: > -165 dBc/Hz at 100KHz offset
- ✓ SPC Manufacturing and Hi-Rel capability to MIL-Q-9858A & MIL-I-45208A
- ✓ Allen Variance: $> 5 \times 10^{-12}$ for 1 second average

PIEZO'S LITTLE WONDERS

Merging the latest techniques in SC cut crystal design, compact size, rugged construction and superb performance, Piezo's Little Wonders set the standards in GPS, instrumentation, communications, navigation and airborne systems performance.

Standard output frequencies are 10.00 and 10.23 MHz with special frequencies available. The Models 2810007 and 2850038 demonstrate frequency stability of 4.5×10^{-9} over -55°C to $+71^{\circ}\text{C}$; fast warm-up to within 5 parts in 10^9 of final frequency in 10 minutes; and low power consumption of 1.5 watts after warm-up. The Aging and Phase Noise curves below illustrate the advantages of the Little Wonders:



See for yourself the wonders Piezo can work for your systems and programs. Call our Application Engineers today for more information. Or write to request a copy of our capabilities catalog.



We help make whatever you're making better.

100 K Street • P. O. Box 619 • Carlisle, PA 17013 • 717/249-2151

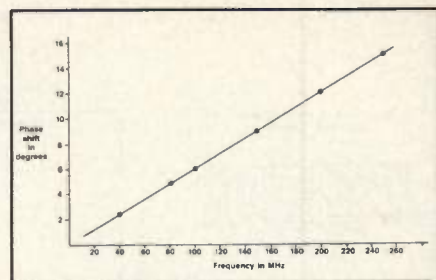


Figure 3. Measured phase difference, $\Delta\phi(\text{pp})$, in calibrator.

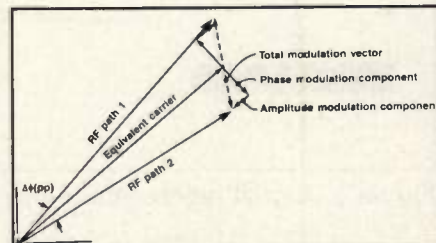


Figure 4. Vector representation of small index phase modulation plus amplitude modulation.

switches exhibit the same phase delay when switched statically as when driven by the clock. Since their phase shift was found to depend on drive level, the RF switches are always controlled by the same drive circuit (a TTL switch driver), the DC voltage (+5 V) is regulated, and mode switching is done ahead of the driver.

While the calibrator was intended for use in the 50 to 200 MHz range, the $\Delta\phi$ value was measured over a somewhat wider range. No dispersion (variation in phase velocity with frequency) was seen, and the data points fell closely in a line, as shown in Figure 3. A best fit straight line averaged the data and facilitated interpolation of values of $\Delta\phi$ at different frequencies. The measured value of $\Delta\phi(\text{pp})$ was found to be 6.1 degrees at 100 MHz, and the first order sidebands were expected to be -29.4 dBc. As a check, the modulated output of the calibrator was observed on a spectrum analyzer. All of the sidebands were greater than expected, with the first pair at -28 dBc. In looking for the discrepancy (about 1.4 dB), it was realized that the spectrum analyzer does not distinguish between amplitude and phase modulation, but measures the spectral energy distribution due to all causes. If AM was present, it could explain the increased sideband levels.

Figure 5 shows how the AM and PM vector components add to produce an increase in the total modulation content. The amplitude difference in the vectors (labeled RF path 1 and RF path 2) represents a difference in the insertion loss through the two paths (including switch losses), while the phase difference in these vectors is the measured phase

modulation. Looking again at the network analyzer results, an amplitude difference of about 0.5 dB in the path losses was measured. The fractional amplitude difference, corresponding to ± 0.25 dB, would be ± 0.03 relative to a unit carrier vector. The measured phase modulation of 6.1 degrees pp translates to be ± 0.053 radians. The total modulation vector is the quadrature addition:

$$\sqrt{(0.03)^2 + (0.053)^2} = 0.061$$

The total peak modulation vector, 0.061, represents about 1.2 dB increase over the expected 0.053 vector for phase modulation alone. This explains most of the 1.4 dB discrepancy in sideband energy as measured with the spectrum analyzer. The remainder is easily within the expected error of measurement. Confidence that the phase modulation component is close to the value that was expected, nominally -29.4 dBc, is important because a phase noise instrument is sensitive only to phase modulation (assuming proper alignment) and is insensitive to AM. An accurate measure of phase angle $\Delta\phi(\text{pp})$ throughout the band, therefore, should be sufficient to establish a useful calibrator.

Construction

Figure 5 is a schematic diagram of that model. IC1 is a clock generator, set to produce four times the desired modulating frequency. IC2 is a dual D flip flop which divides the clock frequency by four, assuring

ing a 50 percent duty cycle square wave with which to drive the RF switches. IC2-b has its *Set* and *Reset* lines tied to a three position manual switch to permit selection of the toggling mode, or either coax line #1 or #2. This enables the coax lines and switch combinations to be characterized on a network analyzer. Also, the calibrator can be left in the test set circuit and disabled to permit phase noise measurements to proceed without calibrator interference.

SW#1 and SW#2 are pin diode type RF SPDT switches, whose passband largely determines the RF range and characteristics of the calibrator. The switches should have a reasonably fast switching time (a few orders of magnitude less than the modulating period) to assure nearly ideal modulation. They should also be closely matched in path loss, together with their coax lines, to prevent excessive amplitude modulation. Coax #1 and #2, constructed of semi-rigid (0.141 OD) 50 ohm coax, are of different electrical length to produce a small phase shift in the frequency range of interest. The switches used were fitted with SMA connectors to allow different coax lengths to be easily accommodated.

The measured value of $\Delta\phi(\text{pp})$ was 6.1 degrees at 100 MHz, as has been mentioned. Using a 100 Hz switching rate, the expected n^{th} order sideband levels are given by:

$$20 \log \left[\frac{\Delta\phi(\text{pp})^\circ}{360^\circ} \right] \cdot \left[\frac{2}{n} \right] \text{ for } n \text{ odd,}$$

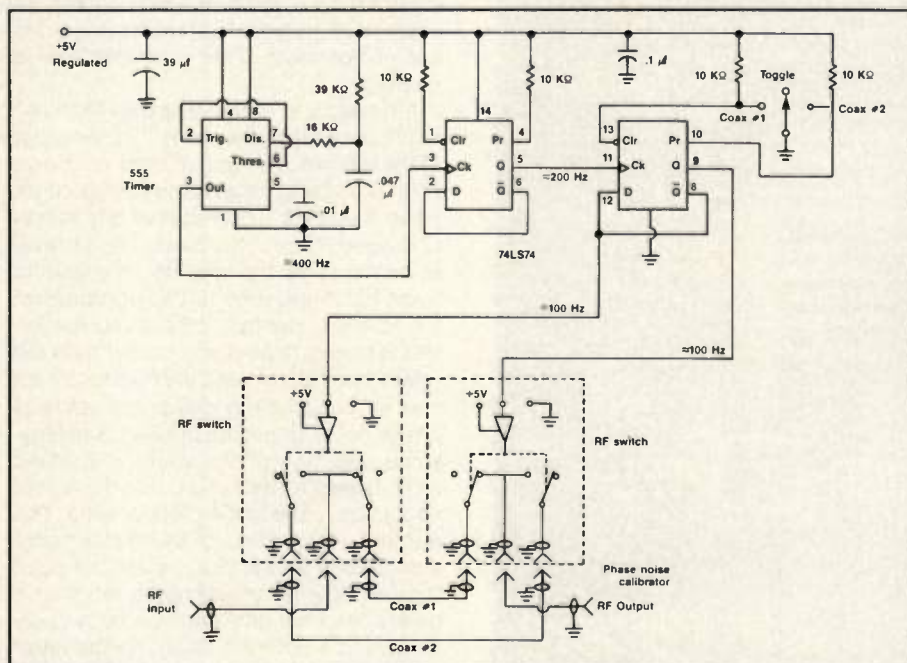


Figure 5. Schematic diagram of experimental calibrator.

Signetics Audio Compandors ...

When audio dynamic range, signal & noise, or modulation index are critical.

NE570/571 General Purpose Compandor

- 110 dB dynamic range
- Compress/Expand/Automatic level control
- Temperature compensated
- Built-in op amps
- Only 3.2 mA typical supply current

NE572 High Performance Compandor

- 110 dB dynamic range
- Independent attack and recovery time
- Low output noise: $6 \mu\text{V}$ typical
- Temperature compensated
- Very low distortion
(0.05% typical at 1 kHz)

NE575 Low Voltage Compandor

- Operates to 1.8 V
- Fully specified at 5 V
- Two built-in op amps in each channel
- 600Ω drive capability
- 0.13% typical THD
- Only 4 mA supply current at 5 V

See us at RF EXPO EAST
Booths 244 & 246

Call 800/227-1817, ext. 900
for the number of your local
Signetics sales office

Signetics

a subsidiary of U.S. Philips Corporation
Your Broadline Communication IC Supplier

and are:

- 29.4 dBc at 100 Hz ($n = 1$)
- 38.9 dBc at 300 Hz ($n = 3$)
- 43.4 dBc at 500 Hz ($n = 5$), etc.

Applications

The calibrator can be inserted after either of the RF sources in a two-source

type phase noise test set. Figure 6 shows the calibrator in series with the voltage controlled reference source (usually an internal component or synthesizer). The modulation rate (clock frequency) must be well above the phase-locked loop bandwidth, or the loop will act to demodulate the phase shift, reducing the spectral content and upsetting the calibration. This is true whether the calibrator is in-

side or outside the loop. In a discriminator-type phase noise instrument there is only one source (the unknown), and, without a locked loop, there is no such limitation on clock frequency.

The calibrator was used to check an HP 11740 phase noise test set, the plotter output of which is shown in Figure 7. A 100 MHz source was used, and the expected calibration spectrum was -29.4 dBc for the first order line at 100 Hz offset, -38.9 dBc at 300 Hz offset, and -43.4 dBc at 500 Hz. Phase noise is defined in terms of the power density on one side (single sideband) of the carrier, so the above line levels should not be doubled (increased by 6 dB) to account for the double sideband nature of the RF spectrum.

As can be seen in Figure 7, agreement with expected values is quite close. The small scale of the plotter output precludes resolution better than 1 dB, and the accuracy goal of ± 0.5 dB for the calibrator appears to be entirely adequate for the purpose. The higher order sidebands continue to fall 6 dB per octave, as is expected. The closeness of the lines on a log plot become so great beyond 1 kHz that the plotting routine never gets down to the source noise floor between lines. Ultimately, the analyzing bandwidth is inadequate and the plotter output beyond 4 kHz is meaningless. A possible source of misunderstanding is whether the calibration levels should be adjusted by 3 dB, just as it is assumed that a noise plot can be reduced 3 dB to account for equally noisy sources, each of which contribute one half of the observed phase noise. No such adjustment of the calibrator level is needed.

It is helpful to realize that the HP 11740 reads out total phase noise, including that of the reference source and the unknown source, making no assumption about relative noisiness. This requires any appropriate reduction in the plotted noise level to be made by the operator, depending upon his knowledge of the noisiness of the source-under-test. If the source-under-test is known to be much noisier than the reference, it dominates the measurement and no reduction in measured value of phase noise should be applied. Similarly, since only one of the sources is being modulated for calibration, no adjustment should be made to the plotted value. The number -29.4 dBc, for the first-ordered sideband is an absolute reference point for the detected phase noise, whether it arises because only one source is noisy or because both are noisy. In the latter case, only the noise plot should be adjusted downward to report the single



FILTER YOUR REQUIREMENTS THROUGH US.

We'll make them work for you.

Caught in a technical trap?
Stumped by tight specifications?
Know *what* you need, but not
how to get it?

Filter your requirements
through us.

For more than 26 years our
design team has been creating
state-of-the-art, custom-designed
RF filters.

Our filters have been launched
into space on the shuttle,
plunged to the ocean depths on
Polaris submarines . . . and

served in hundreds of more
hospitable environments.

We made our name by solving
hundreds of our customers' RF
filter problems . . . individually,
to Mil Spec I-45208 procedures.

That means great ideas and
great performance. Every time.
We're state-of-the-art, but we're
still old fashioned enough to
stake our reputation on every
filter we produce.

The idea of it!

CIR-Q-TEL

Phone: (301) 946-1800

Fax: (301) 946-1874

Telex: (710) 828-0521

10504 Wheatley Street, Kensington, Maryland 20895

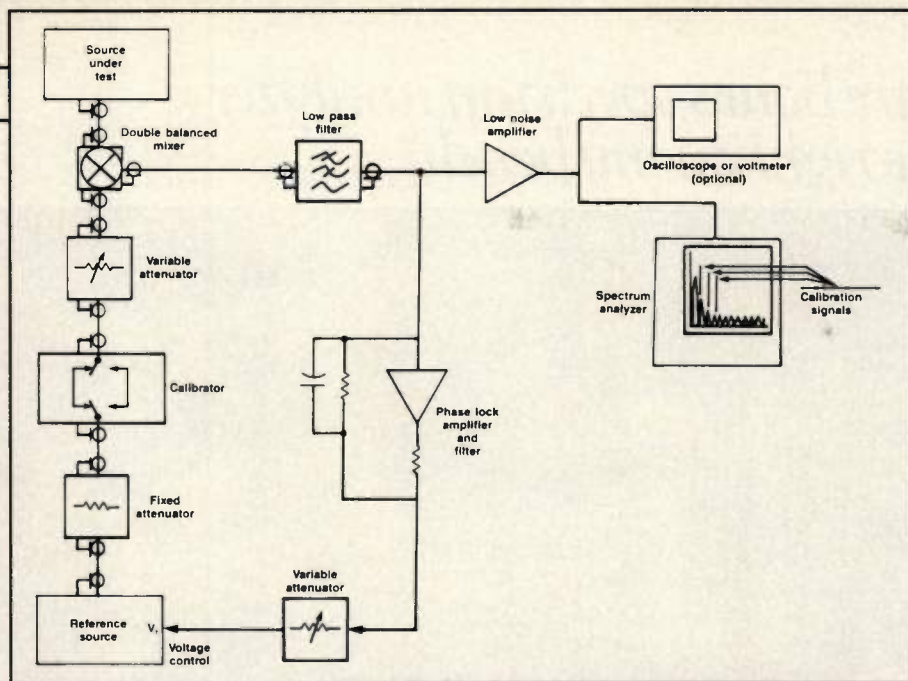


Figure 6. Application of calibrator to a typical phase noise test set.

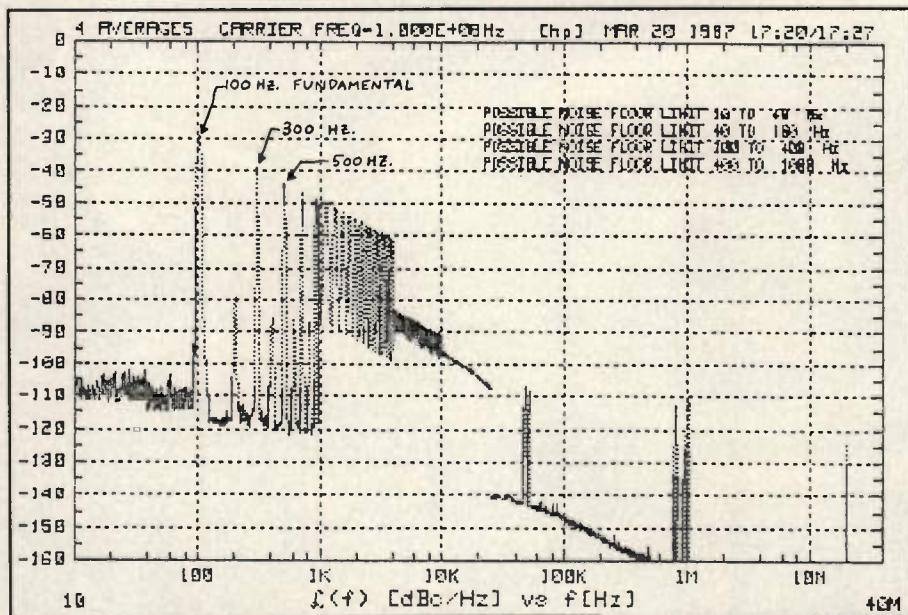


Figure 7. Line spectra produced by calibrator and measured with HP 11740 phase noise analyzer.

source phase noise, and not the calibration of the plot.

Summary

The calibration of phase noise measuring instruments can be established or confirmed using a simple phase modulator, built around the principle of switching between two short sections of coaxial cable. Such a modulator would be placed in series with a source to be measured, and, provided the line difference is less than 0.1 radian at the source frequency, the line spectra which result have a usefully small and easily determined value relative to the carrier. The amplitude of the line spectra can be used to establish the calibration of a phase noise

test set to within ± 1 dB. The technique can be applied over the entire frequency spectrum, subject to the availability of suitable components. Multiple calibrators can be cascaded to provide coverage of a wide frequency range with a single instrument. Norden Systems has filed for patent disclosure on this technique. \square

About the Authors

Guy Love is a senior design engineer and Kevin Lindell is an RF engineer at Norden Systems, Inc., Division of UTC, Norwalk, CT 06856. The authors can be reached at (203) 852-5000 for Guy, and (203) 852-5148 for Kevin.

Low Power IF Integrated Circuits . . .

You normally don't think about performance to power ratios.

Signetics does.

NE602/612 VHF Mixer/Osc

- HF/VHF/UHF mixing with 2.5 mA current
- 18 dB conversion gain at 45 MHz
- 4.6 dB noise figure at 45 MHz
- Built-in oscillator to 200 MHz
- ★ Mil-Spec available in November 1987

NE604/614 FM IF Strip

- 0.27 μ V sensitivity from matched load at 455 kHz
- 0.4 μ V sensitivity with 10.7 MHz (narrow-band)
- Two-stage 90 dB limiting amps with low phase shift
- 90 dB log signal strength indicator
- Quadrature detector for narrow or wide band IF
- 3.0 mA supply current
- ★ Mil-Spec available in November 1987

NE605 FM IF System

- NE602/604 functions combined
- 5.5 mA supply current
- Excellent compact performance

See us at RF EXPO EAST
Booths 244 & 246

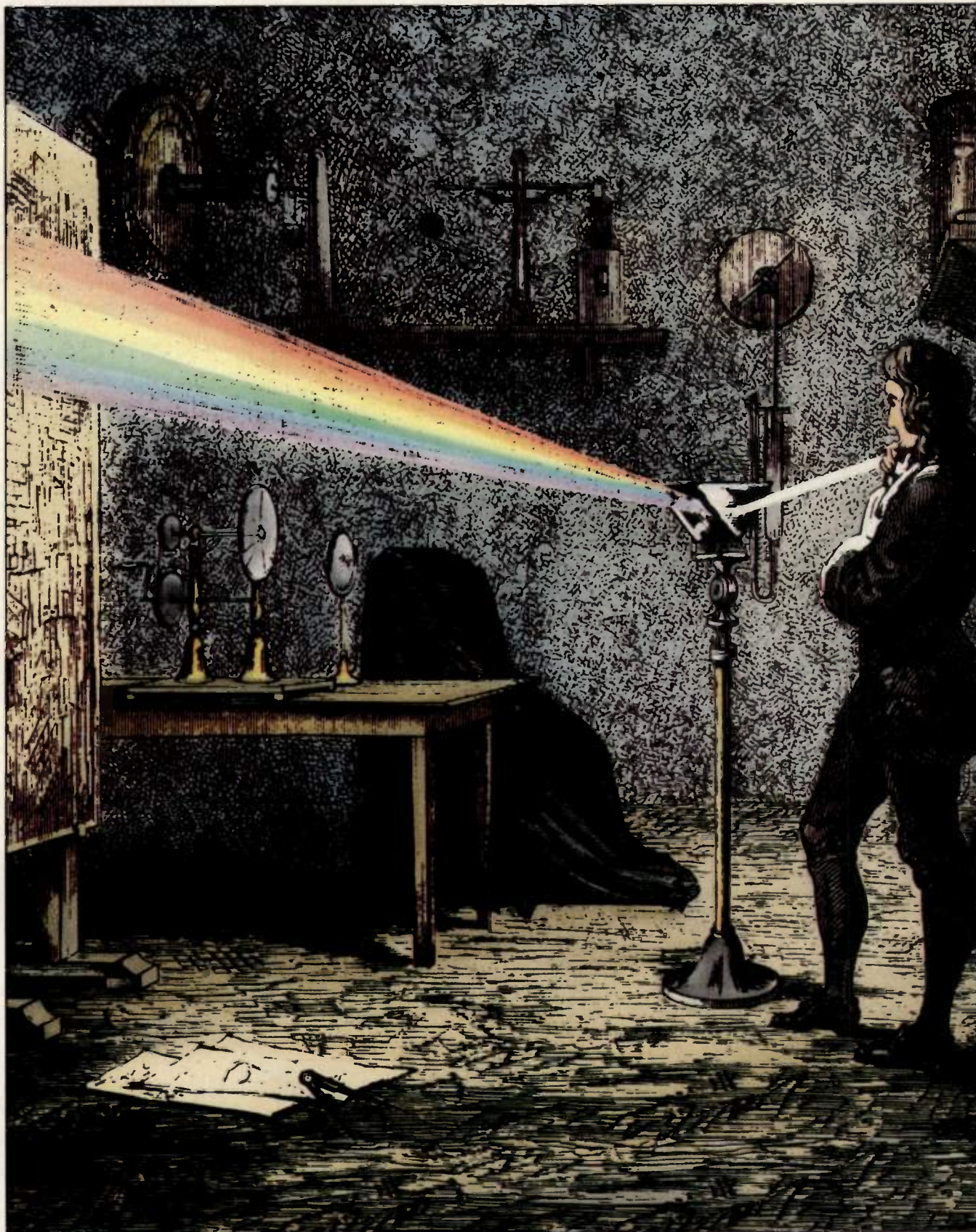
Call 800/227-1817, ext. 900
for the number of your local
Signetics sales office

Signetics

a subsidiary of U.S. Phillips Corporation

Your Broadline Communication IC Supplier

*"I'd settle for a bare bones spectrum analyzer
just to have one right on my bench."*





"Why settle?" At just \$9,690, the HP 8590A Portable RF Spectrum Analyzer is such a good buy that you can afford one for every bench. Yet it's no stripped down, low-tech model.

It's loaded.

You'll find every essential measurement tool in the HP 8590A, plus more of the right bells and whistles than analyzers three times as expensive.



HP 8590A
Portable RF Spectrum Analyzer

And there's a wide frequency range (10 kHz to 1.5 or 1.8 GHz), large amplitude range (-115 dBm to +30 dBm), plus 50 or 75-ohm input. Frequency accuracy runs $\pm(5 \text{ MHz} + 1\% \text{ of span})$.

We take care of the basics with three simply labeled keys: FREQUENCY, SPAN and AMPLITUDE. The entire keyboard is that easy to understand. Press SIGNAL TRACK, for instance, and the analyzer will capture a signal and hold it in the center of the screen—even if the signal is inclined to drift. There are 14 dedicated keys for common functions plus softkeys for over 80 special tasks.

Better still, three optional digital interfaces make the HP 8590A completely programmable for automated production testing. And you can use just about any desktop or HP hand-held computer to do it.

Use the HP 8590A's briefcase handle to carry it anywhere. It weighs just 30 lbs. and slips into all the tight spots. Including the space under your airplane seat. And it's sturdy enough to withstand the rigors of real portability.

Call today for a demonstration or brochure: 1-800-556-1234, Ext. 515. In California call 1-800-441-2345, Ext. 515. Take a look at the HP 8590A; the first full-function analyzer that fits your budget and your bench.

\$9,690: U.S. list price.

*Newton refracts light
through a glass prism, circa 1672.
"The Bettmann Archive."*

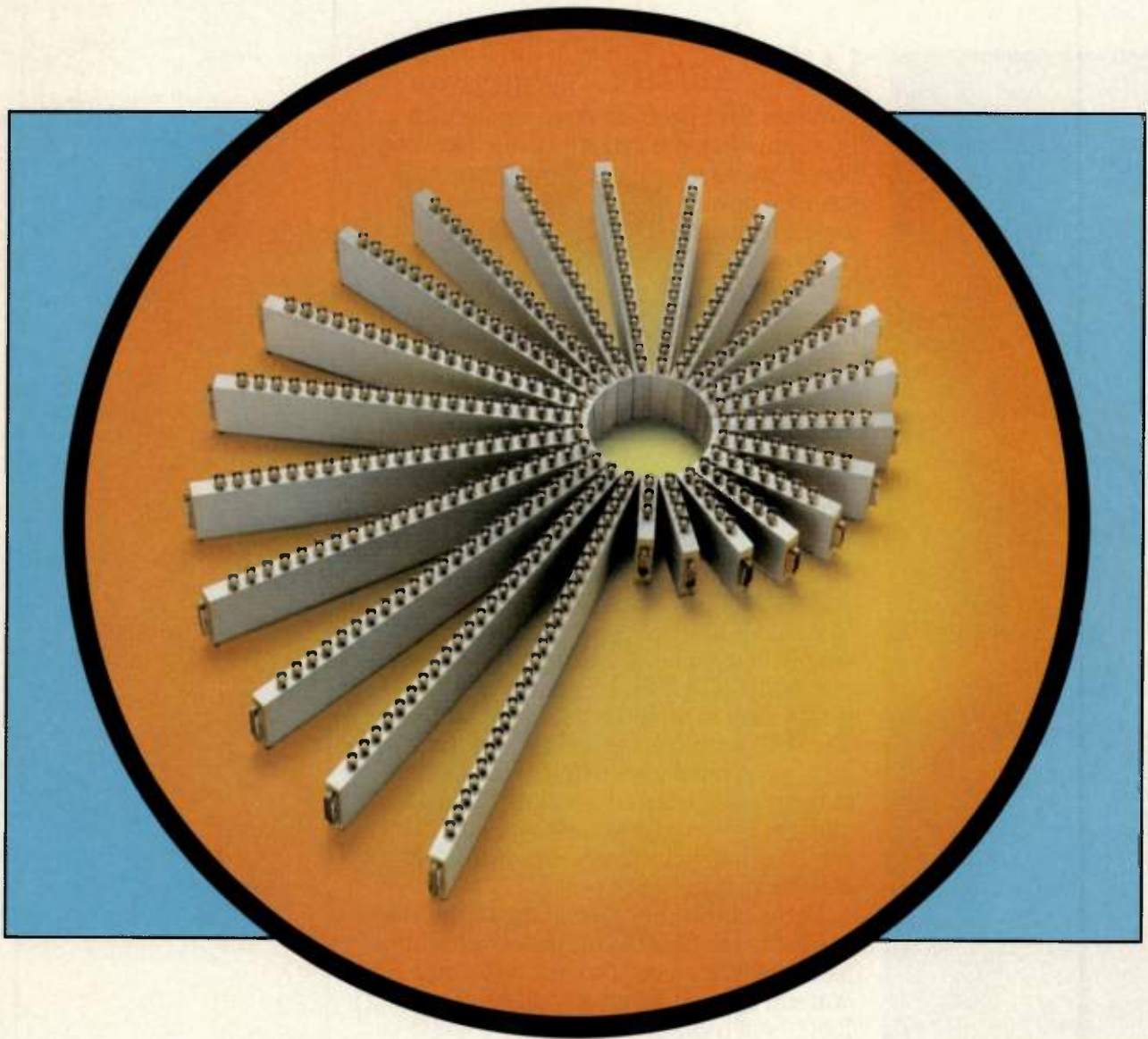
we never stop
asking

"What if..."



HEWLETT
PACKARD

NEED BROAD-BAND COAXIAL RELAYS? FROM 2 TO 24 THROW, MATRIX HAS THE ANSWER



Our versatile 7000 series of coaxial relays have band-widths from DC up to 800 MHz. They're available from 2 to 24 throw. And by using our 9000 series cross-straps, switching matrices of any size can be configured.

Why have Matrix broad-band relays become the industry standard? Because we construct them of precision machined anodized aluminum alloy, all signal shield paths are silver plated, and basic switch elements are hermetically sealed in nitrogen filled gas envelopes with rhodium plated contacts to insure non-stick operation.

The end result is extremely low crosstalk, EMI and VSWR. Another plus, all switchpoints are individually field replaceable.

The units are plug compatible with Matrix 6100A and 1600 Series Logic Modules for compatibility with RS-232, RS-422 and IEEE-488 Interface busses as well as 16 bit parallel.

Non-blocking Matrix configuration may be easily assembled

using our self-terminating relays and 5100A series power dividers. Built-in Video/RF amplifiers allow zero insertion loss designs.

So if you're looking for broad-band relays, it pays to deal with Matrix. After all, we've been designing state-of-the-art reed relay and semiconductor switching systems for over 18 years.

Our customers include government agencies, defense contractors, the TV industry, ATE and telecommunications companies — and more.

Phone: 818-992-6776

TWX: 910-494-4975

FAX: 818-992-8521



MATRIX
SYSTEMS CORPORATION

5177 NORTH DOUGLAS FIR ROAD
CALABASAS, CALIFORNIA 91302

INFO/CARD 35

WRI

Broadband Miniature Power Splitter

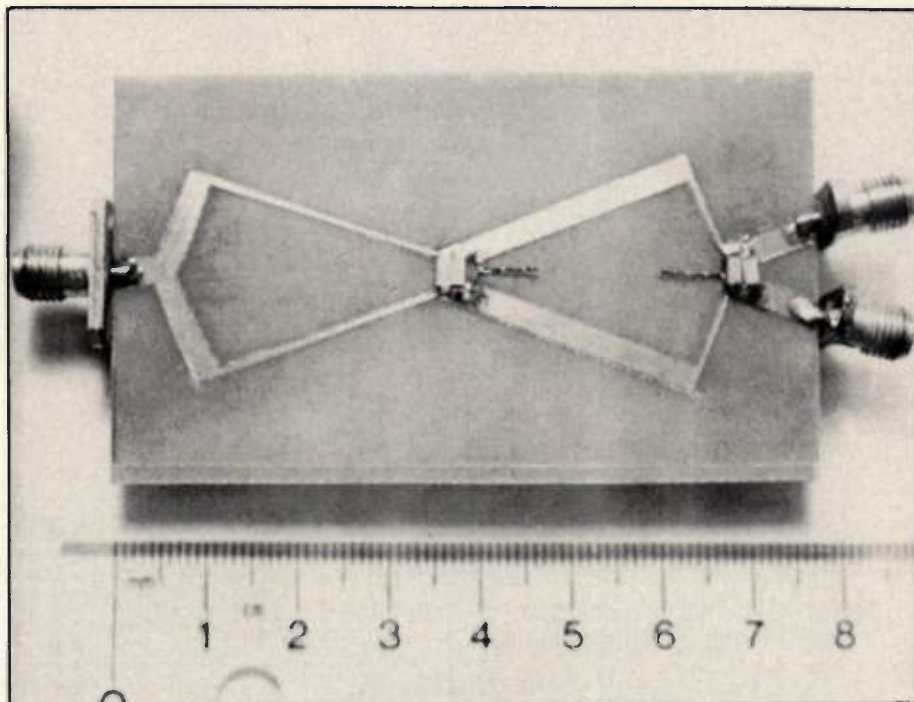
Space-Saving Microstrip Design is Contest Runner-Up

By Peter Vizmuller
Motorola, Ltd.

The frequency range between 500 MHz and 2 GHz presents a challenge for broadband power splitters. Those based on ferrite transformers become difficult to optimize above 500 MHz and broadband power splitters based on conventional microstrip techniques tend to be bulky below 2 GHz. The design in this article illustrates an inexpensive, compact microstrip power splitter that covers an octave bandwidth, yet is smaller than conventional microstrip realization. This design won Peter Vizmuller the Bird Model 4421 RF Power Meter in the RF Design Awards Contest.

The three most important design parameters for a power splitter are input match, output match and isolation. Other performance characteristics, such as amplitude and phase imbalance depend on circuit symmetry and are determined by construction techniques. The input match problem can be reduced to a 100 ohm to 50 ohm impedance transformation, as shown in Figure 1.

In a 50 ohm system, an equal in phase power split will occur if each of the output lines presents a 100 ohm load to the input line at A-A shown in Figure 1. This way the input line will see two 100 ohm loads in parallel, and a 50 ohm input match will be maintained. Each output line has to behave as a 100 ohm to 50 ohm transformer. The simplest impedance transformer is a quarter-wave length of 70.7 ohm transmission line, which forms the basis of the classical Wilkinson power splitter (1). The disadvantage of this impedance matching method is its narrow bandwidth. More sections of quarter-wave lines of varying characteristic impedances improve the bandwidth but make the transformer much longer.



The miniature power splitter.

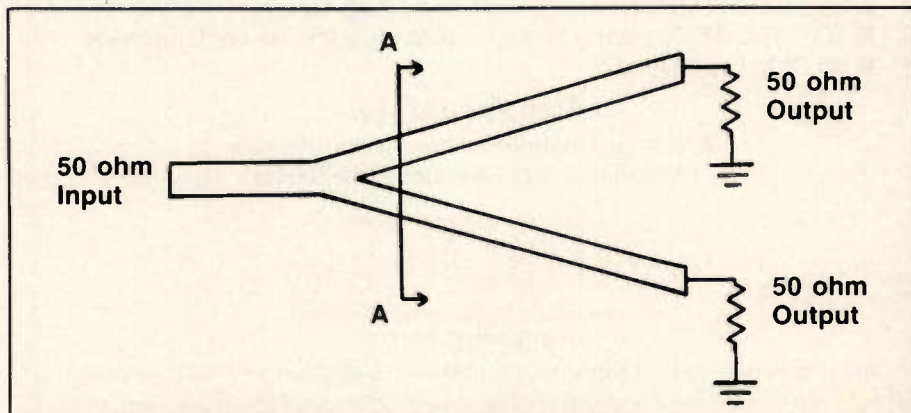


Figure 1. Simplified power splitter.

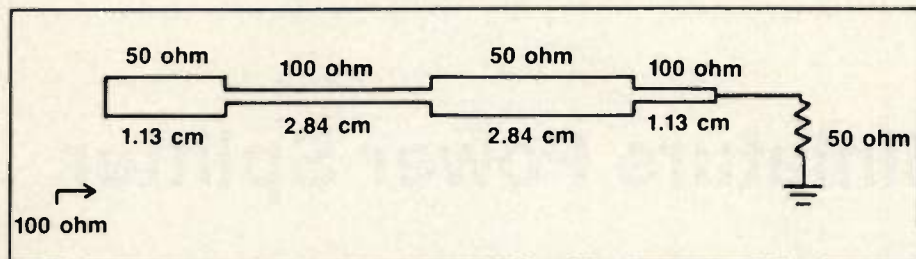


Figure 2. 100 ohm to 50 ohm nonsynchronous transformer.

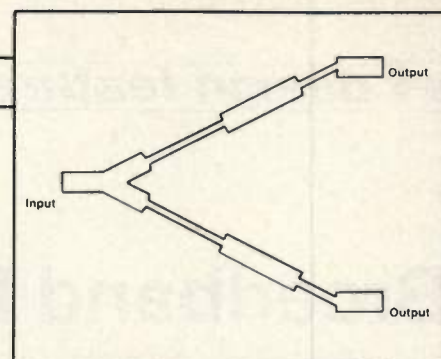


Figure 3. 50 ohm power splitter not corrected for output match and isolation.

AMPLIFONIX ANNOUNCES...



Phase Compensated Step Attenuators

For Single Frequency, Narrow Band Applications

- Frequencies from 10MHz to 150MHz
- Environmental Screening to military requirements available
- Attenuation Values From 0.1dB (LSB) to 32 dB (MSB); One Bit through 8 Bits.

Features

- Single "+" (positive) Supply Operation
- TTL Control Inputs
- +10dBm RF Operating Power
- 50 Ohm Impedance
- 1.5:1 Maximum VSWR
- 0.7dB/Bit typical Insertion Loss — (1dB Max.)
- Many package configurations

Also Available:

- Voltage Controlled Attenuators, Limiters, Amplifiers, and Switches (kHz-2GHz)

Amplifonix

A TECHNICORP CO.

2010 Cabot Blvd. West, Langhorne, PA 19047 • 215-757-9600 • TWX 510-667-0501

INFO/CARD 36

Another approach to this impedance-match problem is the use of nonsynchronous transformers(2), where in matching 50 ohm to 100 ohm source and load impedances, sections of 100 ohm and 50 ohm transmission lines can be used to accomplish the impedance transformation. This is the approach taken for the proposed splitter.

A circuit analysis program was used to design a nonsynchronous transformer to operate between 450 MHz and 950 MHz on glass-epoxy circuit board as shown in Figure 2. The total length of this transformer is equal to the 70.7 ohm single-section transformer, but it covers almost three times the bandwidth. Having obtained the required input match, the next step is to look at output match and isolation. Figure 3 shows the uncorrected power splitter. This splitter provides an equal power split from the input to the output in a 50 ohm system, but the output match and isolation is poor. To improve both, an isolation resistor can be added between the two outputs as shown in Figure 4.

The resistor isolation is accomplished the following way: Assume a signal is fed into one output, terminating the input in 50 ohms and looking at power coming out the other output. The signal that travels from one output to the other via the transmission lines is delayed by 180 degrees due to the quarter-wave length

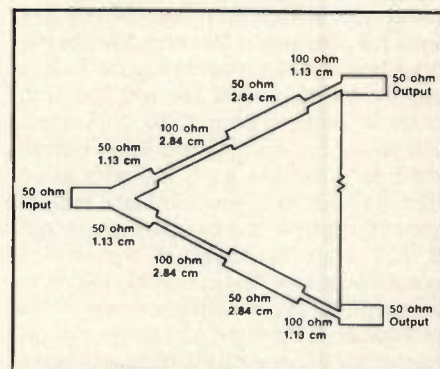


Figure 4. Power splitter with one isolation resistor.

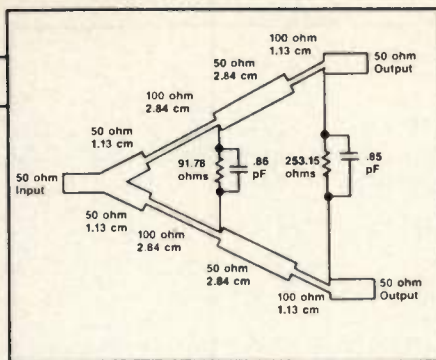


Figure 5. Final splitter configuration.

of each transformer, but the signal which takes the path through the resistor is not delayed, and therefore out of phase with the other signal. Selecting a proper value resistor ensures equal amplitudes for the two signals and therefore signal cancellation at the other output, accomplishing isolation.

Using one resistor achieves isolation over a narrow bandwidth, comparable to a conventional Wilkinson splitter. To increase the isolation bandwidth, two resistors are used as shown in Figure 5. The other resistor improves isolation at higher frequencies, since some of the signal going to the input is shunted to the other side by this resistor, decreasing the phase shift as required at higher frequencies, where the impedance transformers are longer than quarter-wave and would provide more than 180 degrees phase shift without the second resistor.

The splitter as constructed so far, has good input match, output match and isolation, but these parameters do not coincide exactly in frequency. Small capacitors added in parallel to the isolation resistors overcome this difficulty by shifting the output match and isolation curves in frequency, so that all three parameters become centered around a common frequency. Note that any components placed between the two output lines at corresponding points do not affect the input match or power split, since

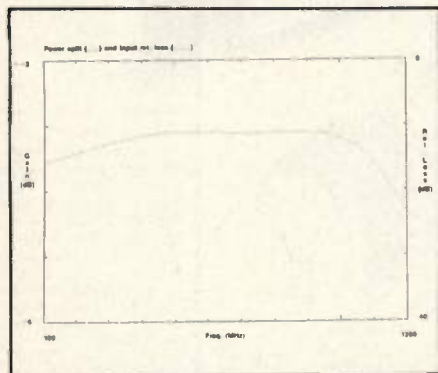


Figure 6. Theoretical performance of the splitter.

signals at corresponding points in the output lines are in phase (when the input is the signal source), and there is no potential difference across a component placed there.

The final resistor and capacitor values were obtained by a circuit optimization program, design criteria was better than 20 dB input and output return loss and better than 20 dB isolation over 450 MHz to 950 MHz. Figures 6 and 7 show the

theoretical performance. The power splitter was then constructed on standard G-10 glass epoxy board, 1.6 mm thick. The transmission lines were folded at their junctions to allow the use of chip isolation resistors; 50 ohm lines were 2.7 mm wide and 100 ohm lines were 0.54 mm wide. Capacitors were realized as short lengths of twisted bifilar wire. Measured performance of this splitter is shown in Figures 8 to 12.

L/S-BAND POWER FETs

Fujitsu's L/S-band family of power FETs is designed for optimum performance in the frequency ranges of 1 to 3 GHz. They provide stable, repeatable, ultra-reliable class A and A/B performance time after time. Their well behaved S-parameters make broad or narrow band matching a snap. For full information call 408-562-1000 or circle the reader service card.



Typical L/S-Band Performance

Device	Freq. (GHz)	P _d B (dBm)	G _d B (dB)
FLL101ME	2.3	29.5	13.5
FLL171ME	2.3	32.5	12.5
FLL351ME	2.3	35.5	11.5
FLL50ME	2.3	36.0	10.0
FLL100ME	2.3	39.0	8.0
FLL200IB-2	2.3	42.5	11.0



FUJITSU
MICROELECTRONICS, INC.

Microwave and Optoelectronics Division

3320 Scott Boulevard, Santa Clara, CA 95054-3197 • (408) 562-1000

TELEX: 278868 FMMO UR, FAX: (408) 727-3194

Trimmer Capacitors from HF through Microwave.



Sprague-Goodman has 'em all.

If you're looking for quality, variety, and easy availability, call (516) 746-1385 today.

**SPRAGUE
GOODMAN**

The First and Last Name in Trimmer Capacitors

Sprague-Goodman Electronics, Inc./An Affiliate of the Sprague Electric Company
134 Fulton Avenue, Garden City Park, NY 11040-5395/516-746-1385/TWX: 510-600-2415/TLX: 14-4533

INFO/CARD 38

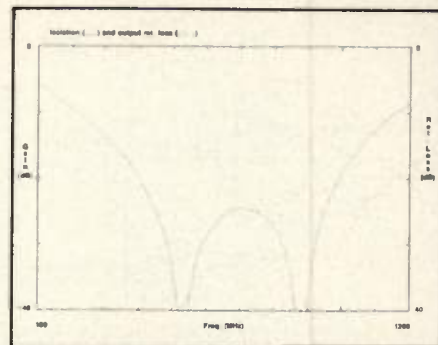
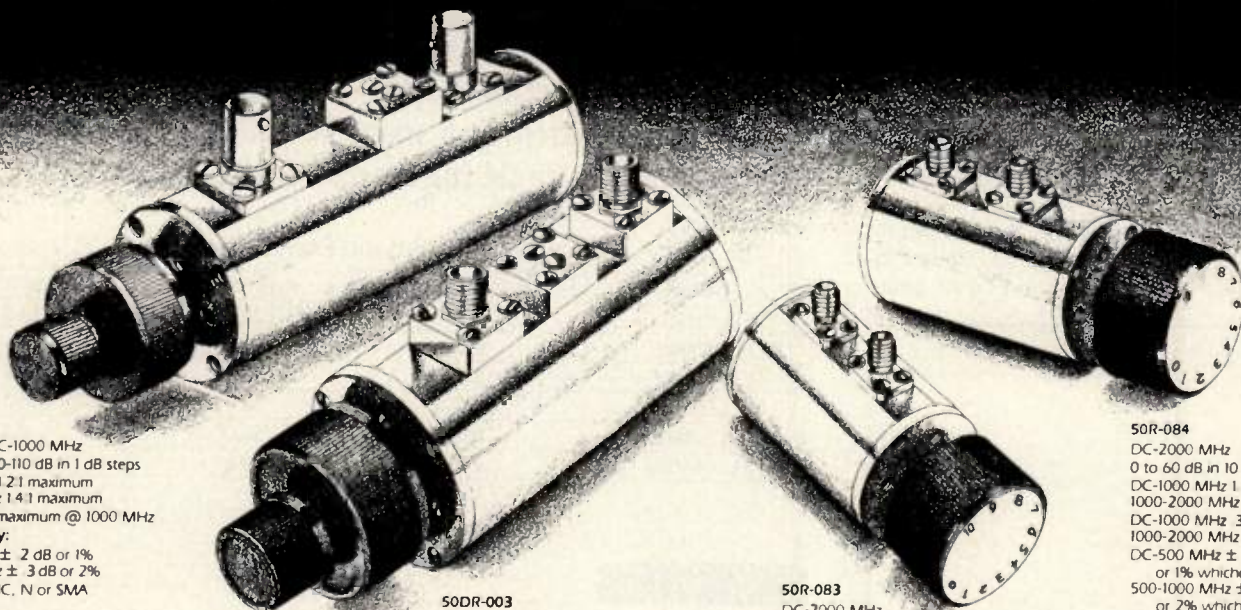


Figure 7. Theoretical performance of the splitter.



Figure 8. Measured input return loss.

ROTARY ATTENUATORS



Model: 50DR-001

Frequency Range: DC-1000 MHz
Attenuation Range: 0-110 dB in 1 dB steps

VSWR: DC-500 MHz 1.2:1 maximum
500-1000 MHz 1.4:1 maximum

Insertion Loss: 5 dB maximum @ 1000 MHz

Attenuation Accuracy:

DC-500 MHz ± 2 dB or 1%
500-1000 MHz ± 3 dB or 2%

Connectors: 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

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



INFO/CARD 39



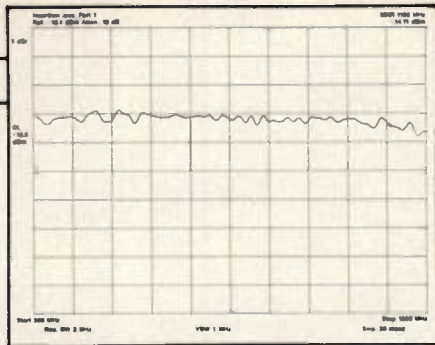


Figure 9. Insertion loss at Port 1.

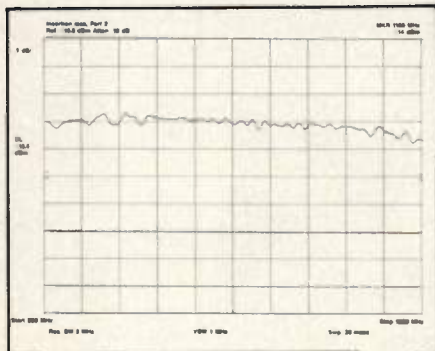


Figure 10. Insertion loss at Port 2.

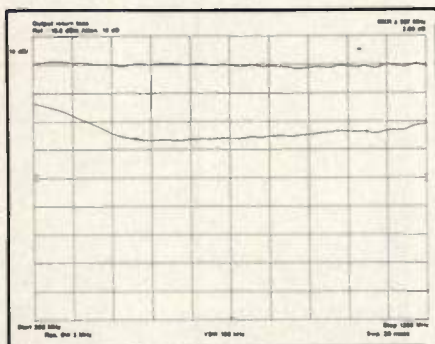


Figure 11. Output return loss.

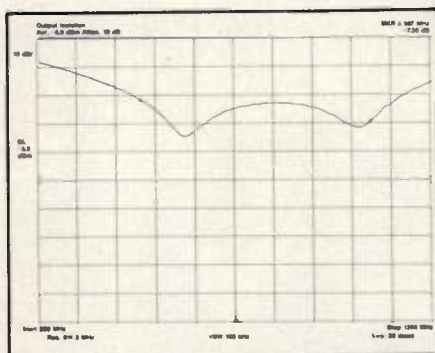


Figure 12. Measured output isolation.

RF Design

FREQUENCY AGILE CRYSTAL STABILITY RAPID FREQUENCY CHANGES LOW NOISE SIGNAL SOURCE



NCMO™ Numerically Controlled Modulated Oscillator DRFS-2250

The **DRFS™-2250 NCMO™** provides the RF communications industry with a cost-effective means to achieve high stability, fine resolution, rapid switchability and low noise signal generation simultaneously.

Two **NCMO™** devices can be cascaded for **nano-Hertz frequency** resolution. Frequency modulation can be effected over the entire tuning range, including cascading over multiple devices. Phase modulation resolution exceeds 0.1 degree. For symmetrical output waveforms, the phase output is configurable to count up during half the period and then down to return to zero.

Input interface circuitry is included to simplify application in the three basic tuning modes; 24 bit direct parallel, 8 bit bus, and quadrature clocked serial.

The **NCMO™** utilizes CMOS technology for low power consumption and is **available now** in surface mount (80 Pin Flatpack and 84 PLCC) packaging. To order or obtain additional information on this revolutionary product line phone us today:

800/782-6266 or INSIDE CALIFORNIA 408/727-5995

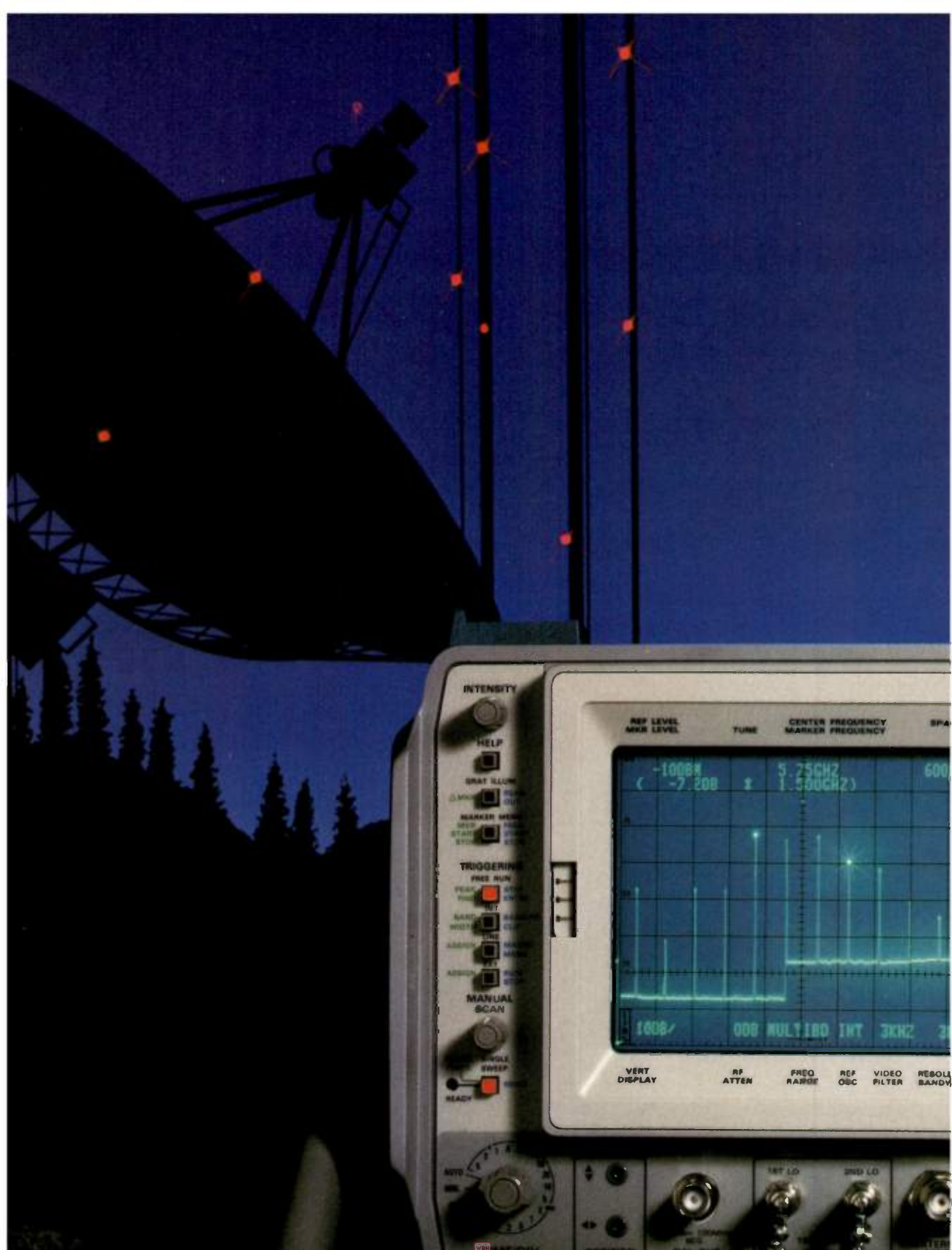
DIGITAL RF SOLUTIONS CORPORATION

3080 Olcott Street, Suite 200D
Santa Clara, California 95054-3209

Patent Pending
© 1987 DRFS

NCMO and DRFS are Trademarks of The Digital RF Solutions Corporation

INFO/CARD 41



BEST IN THE FIELD.

The new Tek 494AP continues a winning tradition: outstanding value for the dollar in portable, field-proven spectrum analysis.

Nobody is as well equipped as Tek to meet your high-performance requirements with economy and ease of use — from 100 Hz to 325 GHz, with up to 90 dB display dynamic range, -130 dBm sensitivity and 10 Hz to 3 MHz resolution.

Twelve Tek 490 Series Spectrum Analyzers range from the 495 and 496 for baseband through UHF coverage to the 494AP for high-

performance microwave and millimeter wave measurements. They are optimized for efficient on-site service — under harsh environmental stress — with features previously restricted to laboratory equipment.

Superior portability isn't at the expense of true laboratory quality. Even at remote monitoring and field service sites you can count on reliable, no-compromise measurements, *no matter what.*

Options add extra performance: Tek waveguide mixers, preselectors, MATE compatibility and 75-ohm input, to name just a few.

Features of the new 494AP include a **built-in precision frequency counter**, down-loadable Macro programming, 10^{-9} marker and center frequency accuracy, multi-band sweep capability, automatic signal tracking and noise normalization.

With TekSPANS[®] software — available for IBM PC, Tek and HP controllers — you can automate complex measurements, including EMI tests.

Get the facts! See the portability and performance that lead the field year after year. Contact your Tek Sales Engineer or call direct: 1-800-TEK-SPEC, Ext. 23. In Oregon, 235-7315, Ext. 10.



**TEKTRONIX 490 SERIES
PORTABLE SPECTRUM
ANALYZERS**

Tektronix

Results

The design objectives of 20 dB return loss and isolation were achieved from 460 MHz to 1030 MHz, bandwidth performance being limited by the input return loss; output return loss and isolation covers a wider bandwidth. Maximum insertion loss measured was 3.4 dB at the higher frequencies, maximum amplitude imbalance was 0.2 dB. The measured prototype is shifted higher in frequency from the theoretical design, probably

because in folding the lines at right angles, the high impedance lines are slightly foreshortened.

Table 1 outlines the performance of a Wilkinson splitter, the author's power splitter and a conventional two-section microstrip splitter of comparable performance (3), all realized on glass-epoxy circuit board, covering the same frequency band (results were obtained by computer simulation). The summary table shows

High Frequency Wide Band Crystal Filters

Our new state-of-the-art crystal filters feature fundamental mode crystals. Designed to achieve wide bandwidths and high stability, these crystal filters are ideally suited for applications in Telecommunication Signal Processing, Transceiver IF, and Satellite Communication Systems.

For over 30 years McCoy Electronics has offered professional frequency control capabilities including the design and manufacture of custom crystal filters for Aerospace, Military and Industrial applications using modern CAD techniques.

ELECTRICAL SPECIFICATIONS

Center Frequency: 50 to 120 MHz
3 db BW: 250 kHz min.
60 db BW: 500 kHz max.
Ripple: 1.0 db max.
Insertion Loss: 8.0 db max.
Source/Load Z: 50 Ω
Temperature Range:
-40 to +85°C

Write for catalog or additional information: McCoy Electronics Company, 100 Watts Street, P.O. Box B, Mount Holly Springs, PA 17065 or call (717) 486-3411, TWX 510-650-3548

McCoy
ELECTRONICS COMPANY
a subsidiary of M&K Technology Inc.

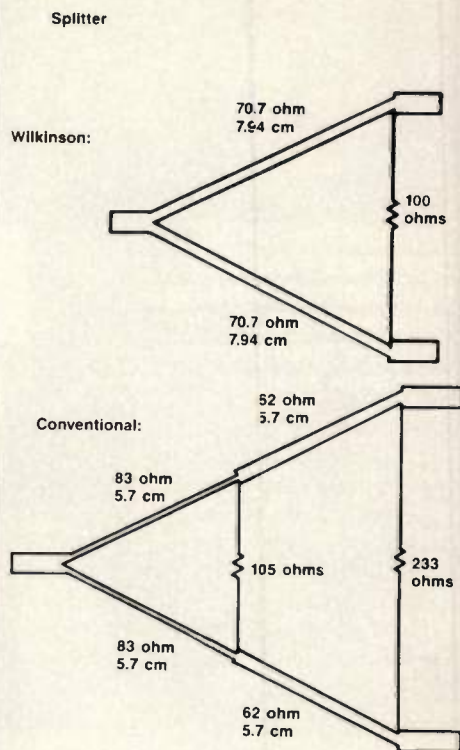
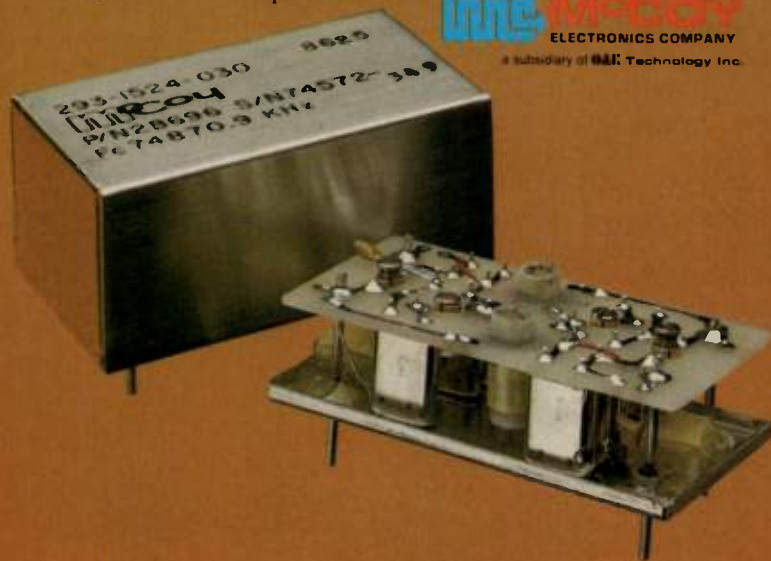


Table 1. Comparison between three splitters.

that the proposed power splitter is more broadband when compared to a Wilkinson of the same length and is 30 percent shorter than a conventional two-section microstrip version of slightly better performance.

Conclusion

This design illustrates how a fresh look at impedance matching coupled with understanding of basic circuit performance can advance the state-of-the-art in microstrip power splitters, to produce an inexpensive, practical broadband device. □

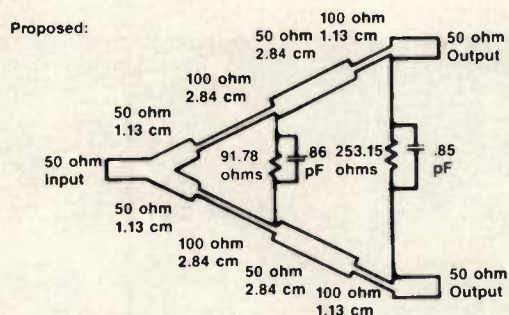
References

1. Howe, H., *Stripline Circuit Design*, Dedham: Artech House Inc., 1974, p.94.
2. Matthaei, G., L., L. Young, E.M.T. Jones, *Microwave Filters, Impedance Matching Networks, and Coupling Structures*, Dedham: Artech House Inc., 1980, p.334.
3. Howe, H. *op. cit.*, p. 105.

About the Author

Peter Vizmuller is a staff engineer at Motorola Canada, 3125 Steeles Ave. E., North York, Ont. M2H 2H6, Canada; Tel. (416) 499-1441 ext. 3693.

	Length (cm)	Bandwidth (MHz)	Bandwidth ratio
Wilkinson:	7.94	200	1.45
Proposed:	7.94	570	2.39
Conventional:	11.40	610	2.49



CAE for
Analog Circuit Designers

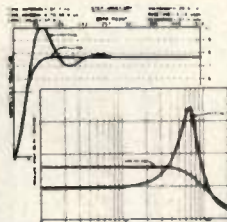
50 TIMES FASTER
than your HP AC Circuit Analysis for your
300, 217, 9836, 9816, 9920, 9845 and 9020

PLUS:

- OPTIMIZATION
- 98 NODES
- TIME DOMAIN
- GROUP DELAY
- RELATIVE PHASE
- NEGATIVE COMPONENTS

- COMPONENT SENSITIVITY
- OUTPUT WAVEFORM for any INPUT
- IMPROVED ALGORITHMS
- COMPATIBLE with HP DATA FILES
- INTEGRATED with FFT and MEASUREMENTS with HPIB
- 6 YEAR TRACK RECORD
- 30 DAY TRIAL

Now
on 4.0



ALSO: FFT WAVEFORM ANALYSIS
• 4 TIMES FASTER than HP
• INTEGRATED into ONE FILE

THREE INTEGRATED MODULES:

AC-CAP AC Circuit Analysis with OPTIMIZATION	\$950.00
S-WAVE FFT Waveform Analysis for Time Domain	\$950.00
PLOTT Time Domain Data Acquisition	\$950.00
Double all prices for 9020 computer version	

COMTRAN INTEGRATED SOFTWARE
FROM

jensen transformers
INCORPORATED

10735 Burbank Boulevard • North Hollywood, California 91601
(213) 876-0059 • TELEX via W.U.I. 650 291 9207 MCI UW
Contact Deane Jensen • Closed Fridays

INFO/CARD 45

Standard to
the Industry Since 1946
RFI/EMC Filters



POWERLINE® FILTERS for high power installations, shielded rooms, communication centers, security areas. Currents from 5 to 2,000 Amperes.

FIL-TEL® FILTERS for secure communication lines, telephone lines and signal lines in Red/Black and Tempest installations.

SUB-MINIATURE FILTERS for your miniaturized electronic equipment.

BAND PASS FILTERS for satellite and communication applications.

CUSTOM FILTERS over 30,000 designs available in a wide variety of voltage and current ratings, mounting and terminal configurations — or custom engineered to meet specific customer requirements.

FILTERED CIRCUIT BREAKER PANEL BOARDS for secure communication installations.

TESTING AND CONSULTATION SERVICES for customized products and systems to meet such requirements as Red/Black, Tempest, EMP, EMC, EMI, FCC, etc.

FILTRON®
FILTRON CO., INC., Subsidiary of Aeroflex Laboratories Inc.
148 Sweet Hollow Road, Old Bethpage, NY 11804 • (516)752-1144



INFO/CARD 44

RF Design

FEATURES

Easily tuned

10 Watt Power

Low VSWR

Rugged



**IMPROVE DYNAMIC RANGE OF YOUR
SPECTRUM ANALYZER**

An Eagle TNF-2 tuneable notch filter allows a 30 dB improvement in dynamic range during harmonic measurements. Simply set the notch at the fundamental frequency and remove attenuation. High Q circuitry assures a deep notch, always better than 35 dB. Low VSWR, low insertion loss (less than 1 dB at 1.0 GHz), easy tuning and fast delivery make EAGLE filters your best choice. Six models provide notches from 9.5 MHz to 850 MHz.

But, EAGLE is more than notch filters. We provide fast delivery on custom LC filters. Do you have a filter requirement in the frequency range of 100 kHz to 2 GHz? Are you faced with long lead times, no qualified source, or lack of vendor interest because of low quantities? Give EAGLE a Call! We are ready to meet your filter requirements.

EAGLE
(619) 728-6000

PO BOX 911 Fallbrook, CA 92028

INFO/CARD 40

Conductive Plastic Composites Offer Shielding Solution

By Mark Gomez
Assistant Editor

Electromagnetic interference is an unavoidable aspect of design engineering. The search for cost effective methods of shielding has brought about various solutions to reduce interference problems. Conductive plastics offer one possible answer to this dilemma. However, plastics can only be used for new designs, while other products may be used to fix or improve existing systems. This article takes a look at a plastic shielding material developed by GE Plastics.

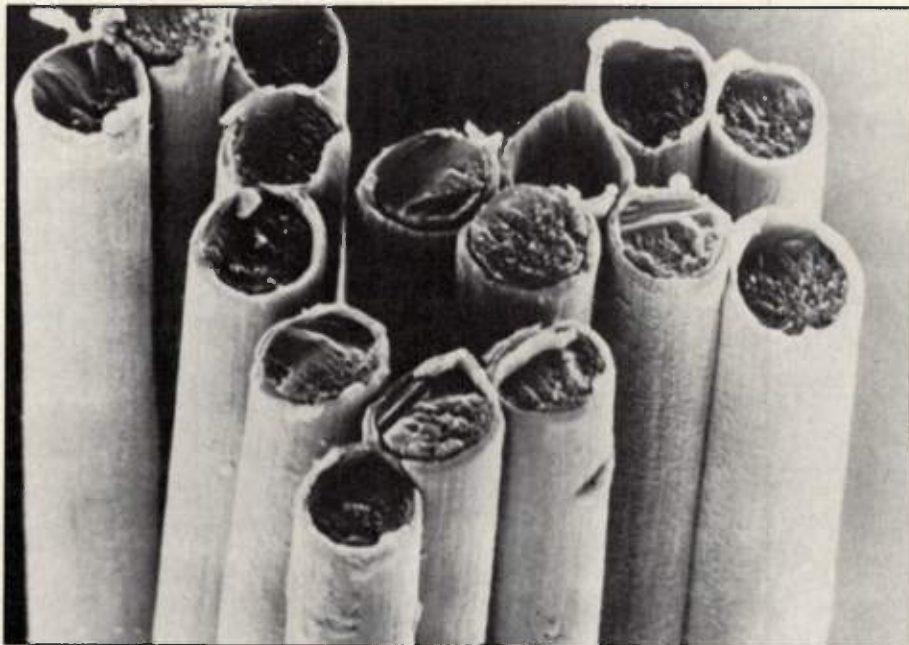
Shielding is defined as the ability of a material to reduce the transmission of propagating electromagnetic fields. It is continually being improved with the development of various fabrics, composite materials, and plastics. Conductive plastic composites are made up of polymer resins that contain electrically conductive additives.

Metal coatings such as metal filled paints and electroless plating have not proved to be effective since they are prone to flaking. Also, aluminum flake and stainless steel fibers used in shielding are relatively expensive and difficult to process. Plastics offer molded-in functionality and usually look better and weigh less than conventional methods.

High performance resins are easy to process and provide uniform and consistent inherent shielding without the need for costly secondary operations. Plastic materials which exhibit equivalent or superior shielding are generally more economical than nickel acrylic painting, electroplating, vacuum metalization or zinc arc spraying.

The Lexan® dB5000 resin series is a thermoplastic introduced by General Electric Plastics designed to provide shielding from EMI and RFI. The Lexan conductive polymer is a combination of bundles of nickel coated graphite fibers and pellets of Lexan resin. The bundles comprise of up to 12,000 quarter-inch-long fibers that become evenly distributed during the melt process, providing the desired shielding level.

A key advantage of the resin is the molded-in shielding for increased design



Nickel coated graphite fibers are combined with pellets of Lexan resin to achieve the desired shielding level.

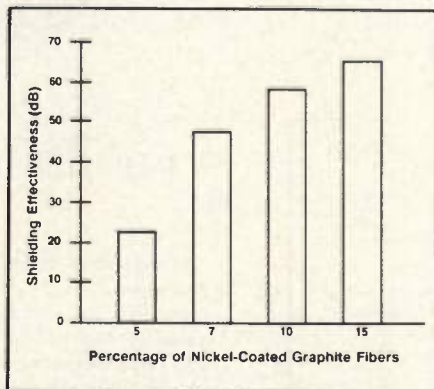



Table 1. Effects of nickel coated graphite fibers on shielding effectiveness.

freedom. Another advantage is that the mechanical and logistic problems associated with line of sight coatings are eliminated. Since the shielding is molded in, it will not flake or peel off.

Varying the loading levels in the Lexan resin/nickel-coated graphite fiber mixture gives the designer greater control over shielding levels, conductivity and cost. For example, a mixture of seven percent nickel-coated graphite fibers in Lexan resin has a shielding effectiveness of about 47 dB, which is greater than a coating of nickel acrylic spray. A 10 percent loading level of nickel-coated graphite fibers increases shielding effectiveness to 58 dB. Table 1 illustrates shielding effectiveness with respect to loading level of nickel-coated graphite fibers.

This method of shielding is fairly cost effective. One manufacturer has priced several shielding methods for an oscilloscope and has determined that at seven percent loading, nickel coated graphite fibers are less costly and provide better shielding than nickel acrylic paint.

For more information from GE Plastics on Lexan dB5000, please circle INFO/CARD #101. 

INTRODUCING EMCO'S NEAR-FIELD PROBE SET.

THE SOLUTION SET.

THE RIGHT TOOL TO SOLVE EMISSIONS PROBLEMS

Locate sources of E- and H-field emissions quickly with EMCO's new Model 7405 Probe Set. Versatile and easy-to-use, this set is a convenient and inexpensive tool for extending the capability of your spectrum analyzer, oscilloscope or signal generator. Using the probe set, you can detect and identify the signal sources that might prevent your products from meeting federal regulatory requirements.

IDEAL FOR CIRCUIT DESIGNERS, EMC AND QC ENGINEERS (SUSCEPTIBILITY APPLICATIONS TOO)

Now, anyone can diagnose radiation problems faster and easier, detecting and pinpointing the source of EMI "hot spots" for prompt correction and compliance.

With input from a signal generator, the probe set also can be used for radiation susceptibility applications.

RUGGED CONSTRUCTION, TWO-YEAR WARRANTY

Made of injection molded industrial grade plastic, Model 7405 probes are durable, light-weight and compact. Alone or with the extension handle, they can be used where larger, more bulky probes can't reach.

The Model 7405 includes three H-field and two E-field probes, a 20 cm extension handle, documentation and a convenient, foam-lined carrying case. The set is also available with an optional pre-amplifier. The entire set is covered by a two-year warranty from EMCO, an industry leader for more than 25 years. So now, for even the most complex set of emissions problems, there's one simple solution set: the Probe Set from EMCO. Call or write for your free brochure.

**FIRST IN QUALITY.
FIRST IN PERFORMANCE.**
1-800-253-3761



The Electro Mechanics Company

Call toll-free between 7:30 A.M. and 4:30 P.M. (CST)

In Texas, call 512-835-4684 Telex: 797627

P.O. Box 1546, Austin, Texas 78767

In Europe, call 08151/89161

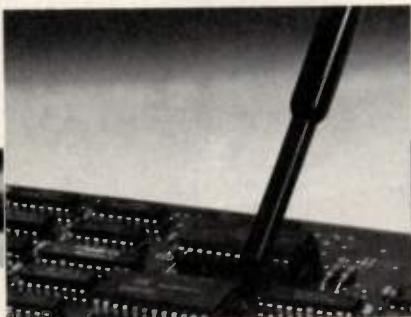
Munchner Str. 2 D-8137 Berg 1, West Germany



904 omni-directional ball probe identifies E-field signals over a broad frequency range



901, 902, 903 loop probes of varying sensitivities to H-field emissions



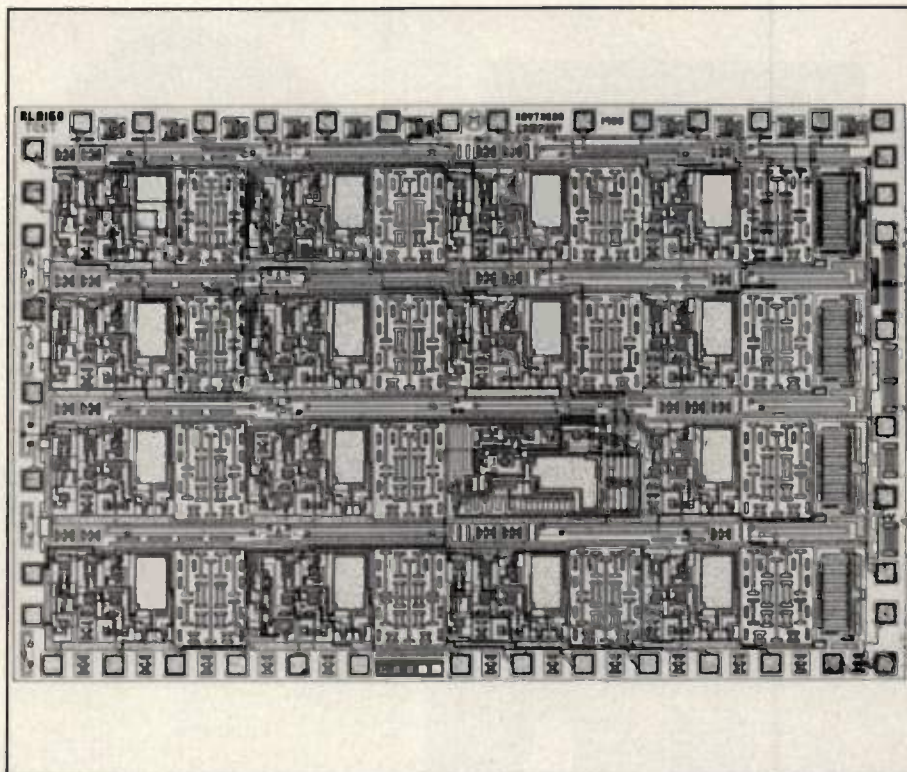
905 stub probe provides measurement near the signal source

Raytheon Offers A Linear Macrocell Array

The RLA160 is a flexible VSLI linear macrocell array that provides the user with the versatility of predesigned programmable analog cells which can be converted into a variety of analog functions such as current sources, voltage references, detector/amplifier circuits, voltage to current sources, data conversion circuits, active filters and various others. With complete isolation, the analog functions can be formed from an interconnect pattern determined by the user. It can replace a circuit board with as many as 15 analog devices of 10 transistors each, 240 binarily-weighted thin film resistors, 10 PNP transistors, 43 NPN small signal transistors, four NPN 200 mA switching transistors and a bandgap voltage reference.

The thin film resistors are made by sputtering silicon-chromium onto the chip. All 240 resistors can track to an absolute temperature coefficient of 5 ppm with a typical tolerance of ± 5 percent each. All the resistors and transistors have double terminations permitting utilization of all the ICs macrocells and up to 80 percent of all individual transistors.

At unity gain, the slew rate is measured at 0.7 V/us and the bandwidth is 2.0 MHz. The input offset voltage is 1.0 mV while the input offset current is 1.0 nA. All the macrocells can be programmed for specific quiescent currents and AC operating conditions. Also sufficient gain can be obtained at specific frequencies which is a



useful feature in the design of filters.

The price of the RLA160 is dependent on the package type, temperature range, cell utilization, and custom test requirements for specific applications. Kits are available from Raytheon to aid a prospec-

tive user in developing prototypes and are intended for designers who want to make a trial application of the RLA160 macrocells in an existing system. **Raytheon Company, Semiconductor Division, Mountain View, CA. INFO/CARD #220.**

750 MHz IF Limiter Discriminator Introduced By RHG Electronics

The Model ICDX750 is a delay line IF limiter discriminator that operates at 750 MHz with a peak to peak bandwidth of 450 MHz while the minimum linear bandwidth is 250 MHz. The ICDX750's wide bandwidth and 20 nsec rise time enables it to handle FM demodulation of high speed pulsed carriers where substantial AM is present. It can also be used to measure the frequency of a pulsed carrier. The unit is rated for an input level of 0 dBm, but is usable down to -10 dBm. A delay line for demodulation, coupled with a constant phase limiter/driver for minimum degradation of pulsed waveforms is employed.

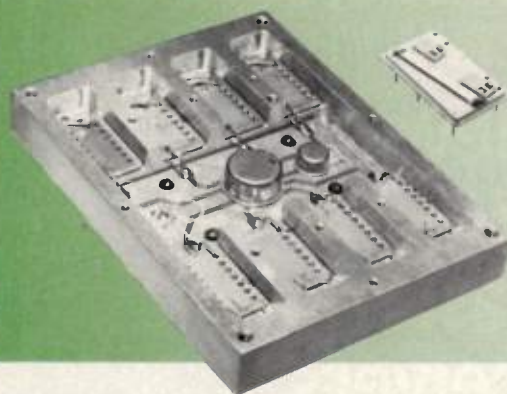
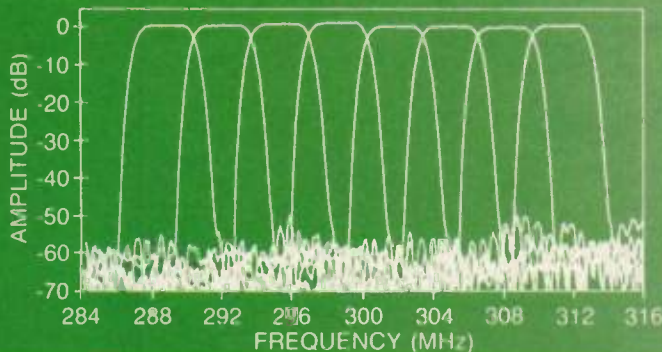
Designed for MIL-E-5400 and MIL-E-16400 environments, the limiter discriminator has an operating temperature range of -54°C to +71°C. It measures 3.53" x 1.50" x 0.47" excluding SMA connectors and weighs 3.7 oz. The specifica-



tions include a frequency accuracy of ± 12 MHz at 25°C and ± 25 MHz above that temperature and a video sensitivity of 10 mV/MHz. The ICDX750 is priced at

\$1535. Other models are available with operating frequencies from 30 to 1000 MHz. **RHG Electronics Laboratory, Inc., Deer Park, NY. INFO/CARD #219.**

SAW Components for Telecom, Radar and Electronic Warfare



SAW Filter Bank for Signal Channelizing Applications

- Small size
- Large dynamic range
- Well defined channel crossover
- Accurate phase tracking

SAW filter banks are available to custom design specifications in the frequency range 100 MHz to 700 MHz with fractional bandwidths as small as 0.1% or as high as 50%. The filter bank can be configured either as 1 input with n outputs or as n inputs with n outputs.

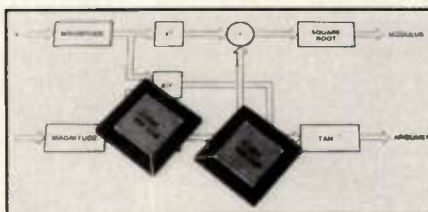
Crystal Technology

1035 East Meadow Circle
Palo Alto, CA 94303 USA
(415) 856-7911 • TWX 910-379-6625

INFO/CARD 48

GaAs MMIC Amplifiers

The UPG100 is a low noise GaAs MMIC and the UPG101 is a medium power GaAs MMIC. Both are internally matched to 50 ohms and operate in the .05 to 3 GHz range. The 100 has a gain of 16 dB with a maximum gain flatness of ± 1.5 dB, typical NF is 2.7 dB while the



the PDSP16330 converts 16×16 bit two's complement or sign magnitude data into 16 bit magnitude and 12 bit phase format. The magnitude may be scaled in amplitude by powers of two. Its applications include radar, sonar and digital radio systems. **Plessey Semiconductors, Irvine, CA. INFO/CARD #217.**

Digitizing Scope With TDR

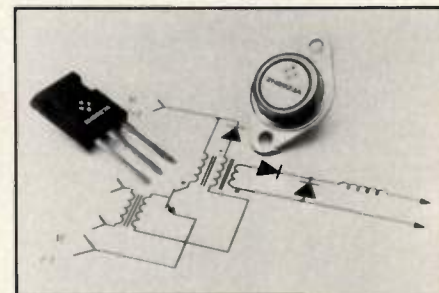
The HP 54120T color digitizing scope has a 20 GHz repetitive bandwidth, a built-in time domain reflectometer (TDR), and four simultaneous acquisition input channels. The features include optional 6 GHz passive probing, 12 bit resolution, .25 ps timing resolution and a 10 ps tim-



ing accuracy. The TDR measures impedance, reflection coefficient and distance from a reference plane. **Hewlett-Packard Company, Palo Alto, CA. INFO/CARD #216.**

Power Switching Transistors

General Semiconductors unveils a series of bipolar power switching transistors that offer a combination of 850 V (V_{CEV}) and a switching speed of 35 ns (crossover time). They also have a V_{CEO} of 400 and 450 V and a maximum saturation V_{CE} of 1 V. These devices are designed to switch the inductive loads characteristic of switching power supplies.



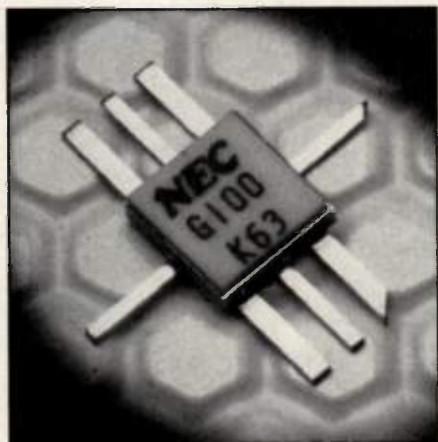
characteristic of switching power supplies. **General Semiconductor Industries, Inc., Tempe, AZ, INFO/CARD #215.**

High Speed Power Driver

The UC3705 power driver uses a high speed Schottky process which allows it to interface between low level control functions and high power output devices. It is compatible with MOSFET and bipolar transistors. The device has a source/sink drive current of up to 1.5 A with a 40 ns rise and fall into 1000 pF. **Unitrode, Merrimack, NH. INFO/CARD #214.**

Tunnel Diode Pulse Generator

The TD-1110A produces an ultra fast pulse with 25 ps rise time, 240 mV



power at 1 dB compression is 6 dBm. The specifications on the 101 include a gain of 14 dB, NF of 5 dB typical, and power at 1 dB compression is 18 dBm typical. The 101 maintains the same gain flatness as the 100. **California Eastern Laboratories, Santa Clara, CA. Please circle INFO/CARD #218.**

Pythagoras Processor

Plessey introduces a device that converts complex cartesian data into polar form magnitude and phase at a 10 MHz rate. Termed the pythagoras processor,

PRECISION REDEFINED...

A New Standard
In 30MHz
Measurement
Receivers...
the VM-7



...in Price and Performance!

History Repeats Itself —

Over a quarter of a century ago, Weinschel introduced the VM-3 30 MHz Attenuator Signal Calibrator...the industry standard for precision attenuation measurements. Now, there's a new standard, the VM-7, utilizing today's technology at yesterday's pricing. The VM-7 provides improved accuracy and performance at the touch of a button. It's a cost-effective alternative for high-priced insertion loss measurement in production, lab or field environments.

Applications Include —

- Insertion loss/gain measurement in the RF, μ wave and mm wave Frequency Ranges
- Calibration of Signal Generators

Unmatched Features —

- Advanced Solid State Triple Down-conversion IF Substitution
- -110 to -127 dBm Sensitivity
- Built-in 30 MHz Calibration Traceable to NBS
- Linear Over 100 dB Dynamic Range
- 0.02 dB/10 dB Accuracy
- Split Second Measurement Results
- ATE Ready, IEEE 488 Bus Compatible

For a demo or details
CALL TOLL FREE
(800) 638-2048.

 **WEINSCHTEL
ENGINEERING**

One Weinschel Lane,
Gaithersburg, MD 20878-4094
(301) 948-3434 • Telefax: (301) 948-3625

rf products *Continued*



amplitude, 4 μ s duration, and 50 kHz repetition rate. It consists of a pulse driver unit and a remote TD pulser head. The unit costs \$1950. **Picosecond Pulse Labs, Inc., Boulder, CO.** Please circle INFO/CARD #213.

2 to 6 GHz MMIC Amplifier Chip

Harris Microwave introduces a dual stage, 2 to 6 GHz, 0.5 micron GaAs medium power MMIC in die form. It is cascable and intended for gain stage applications. DC blocking on the RF output and bypass functions are incor-

porated. The maximum input VSWR is 2:1 while the typical noise figure at 120 mA is 6 dB. **Harris Microwave Semiconductor, Milpitas, CA.** INFO/CARD #212.

GaAs Prescaler

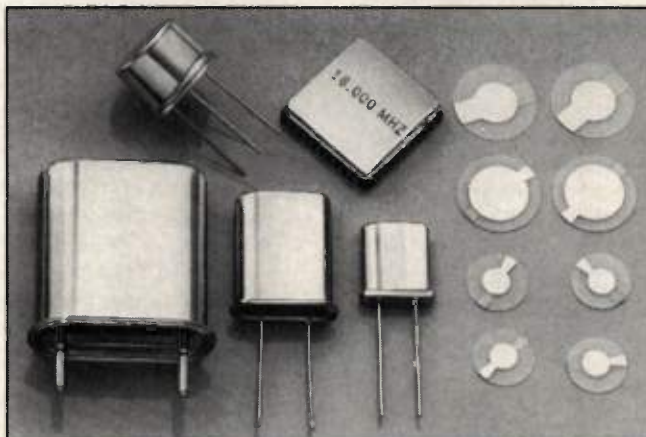
The MFG-8000 Series is a family of dual modulus (1/128, 1/129) high speed GaAs frequency dividers. The devices operate up to 1.6 GHz with a maximum power dissipation of 50 mW. The maximum output current is -5 mA. **Mitsubishi Electronics, Sunnyvale, CA.** INFO/CARD #211.

Microwave Power Meter

Wavetek introduces its 8531 single channel microwave power meter. It is complemented by a broad family of sen-



QUARTZ CRYSTALS



BLANKS

- Processed blanks without base plating
- Blanks custom base plated with silver, aluminum, gold or chrome gold for clock oscillators and miniature filter applications.

SEALED CRYSTALS

- HC-45 or UM-1 miniature packages from 8MHz to 200MHz
- Precision crystals cold-weld or resistance-weld for TCXO and FILTER design applications.

SURFACE MOUNT CRYSTALS

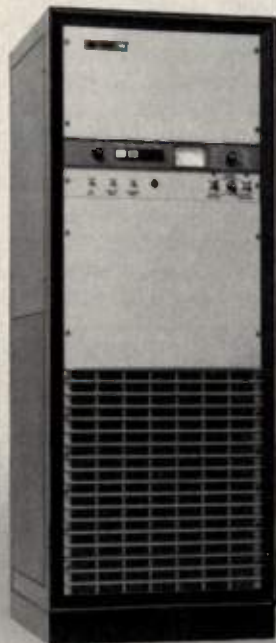
- LCC or any other custom size for surface mounting applications.
- Consult factory for Microprocessor Type Standard Crystals

 **CRYSTALS**

311 NORTH LINDENWOOD DRIVE / OLATHE, KANSAS 66062
PHONE: (913) 764-4544 • TELEX: 910-743-0029 • FAX 913-764-6409

INFO/CARD 50

**Come
where the
power
is.**



Broadband capability from some very powerful amplifiers. Power from one watt to ten kilowatts. Frequencies from 10 kHz to 1 GHz. Gain that's flat and reliable.

For example, our Model 2000L, shown above, delivers 2000 watts minimum cw saturated power over a bandwidth of 10 kHz to 220 MHz. In pulse mode you can almost double that rated output.

We rate most of our amplifiers by minimum power—users can be certain that their 10-watt or 2000-watt amplifier will always deliver at least its rated output at any point in its frequency band.

AR amplifiers are unconditionally stable, immune even to worst-case load mismatch without damage or shutdown. The full bandwidth is instantly available—there's no need for tuning or bandswitching.

Send for our booklet, "Your guide to broadband power amplifiers."

**AR AMPLIFIER
RESEARCH**

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

rf products *Continued*

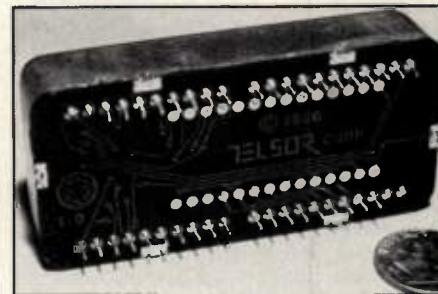
sors including thermocouple and diode sensors for high and low power measurements, low frequency sensors, 26.5 GHz sensors and 75 ohm sensors. The features include one button calibration, user controllable averaging of readings, and is programmable using GPIB format. Error is specified at ± 0.5 percent of full scale in the linear mode or ± 0.02 dB in the logarithmic mode. It can take up to 40 readings per second over the bus. **Wavetek Corporation, San Diego, CA. INFO/CARD #210.**

Portable Spectrum Analyzer

The Spectre 1050 spectrum analyzer offers portability through the use of self contained batteries that operate the instrument for three hours of continuous use. This 1 GHz unit has a line of options that include digital storage, tracking generator and a wideband video detector. **Texcan Instruments, Indianapolis, IN. INFO/CARD #209.**

Interface Reader Module

Telsor introduces an interface Model 2020 reader module. It is capable of multiplexing up to 8 addressable sensors which read 128-bit passive transponders



up to 12 inches away. The device measures 2.6" x 1.2" x 0.7". **Telsor Corporation, Englewood, CO. Please circle INFO/CARD #208.**

L-Band Modular Synthesizer

This OEM instrument is used to generate test frequencies of 1550 MHz to 1850 MHz in 1 MHz steps. Frequency control is provided by parallel TTL and CMOS input levels applied through a 25 pin D type connector. The specification include a phase noise of -85 dBc at 10 kHz, VSWR of 2:1, and a maximum settling time of 50 msecs. A sample of the reference frequency is available for coherent system operation. **Systematix, Lyndhurst, NJ. INFO/CARD #207.**

Custom Filters

1 MHz—26 GHz/LC-Coaxial-Waveguide

Call us If:

- Your need is STRANGE ("shelf item" won't do)
- You need a quote now (within 48 hours)
- You need it on *your* schedule
- You need only *one* (or *many*)

STRANGE filter types:

- Highpass
- Lowpass
- Bandpass
- Bandstop
- Multiplexers
- Networks

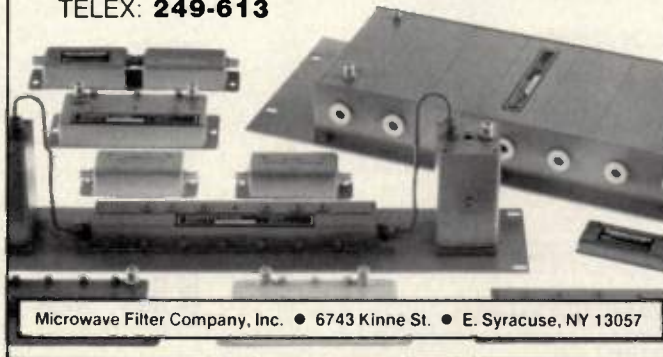
STRANGE applications:

Aerospace, Radar, Broadcast, LAN, Satellite Communications, Cable Television, RF Communications.

Call or write for a quote or our free capability brochure.

1-800-448-1666

Call Collect In NY/AK/HI/CAN: **315-437-3953**
TELEX: **249-613**



Microwave Filter Company, Inc. • 6743 Kinne St. • E. Syracuse, NY 13057

INFO/CARD 51

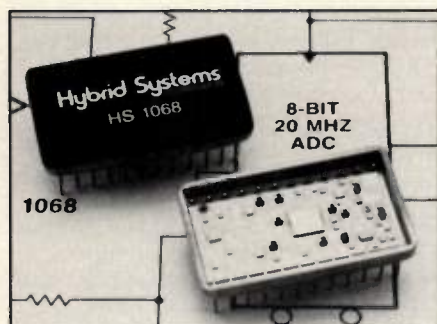
INFO/CARD 52

Quad OP Amp

NSC has released a quad operational amplifier that achieves a 140 dB dynamic range with less than 0.0015 percent distortion. The LM837 has a slew rate exceeding 8V/us, power bandwidth of 140 kHz and is able to drive 600 ohm loads. It has a low input noise voltage of 0.5 μ V. It contains 4 amplifiers and is available in 14 pin dips and molded packages (SO). The price is \$1.25 each in 25,000 unit quantities. **National Semiconductor Corporation, Santa Clara, CA.** Please circle INFO/CARD #206.

8-Bit A/D Converter

The HS1068 is a flash analog to digital converter that incorporates a wideband analog input amplifier, voltage reference and three stage output register into a 1.3"



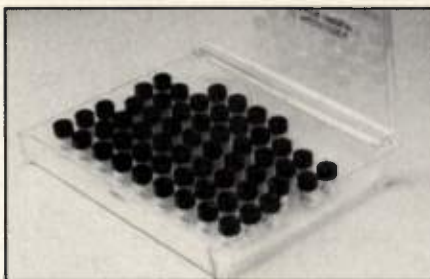
$\times 0.77$ " 24 pin dual in line package. It is an eight bit parallel flash converter capable of digitizing at rates up to 20 MHz. A digital output register provides three state outputs for ease of micro-processor interface. **Hybrid Systems Corporation, Billerica, MA.** Please circle INFO/CARD #205.

GaAs Distributed Amplifier

Texas Instruments introduces a monolithic GaAs amplifier that operates in the 2 to 18 GHz frequency range. The TGA8300 has a typical gain of 6.5 dB with an output power of 18 dBm at 1 dB gain compression. The noise figure is less than 7 dB over the frequency range. It includes on chip metal insulator metal bypass capacitors for the biasing of the amplifier. **Texas Instruments, Inc., Semiconductor Group, Dallas, TX.** INFO/CARD #204.

Capacitor Evaluation Kits

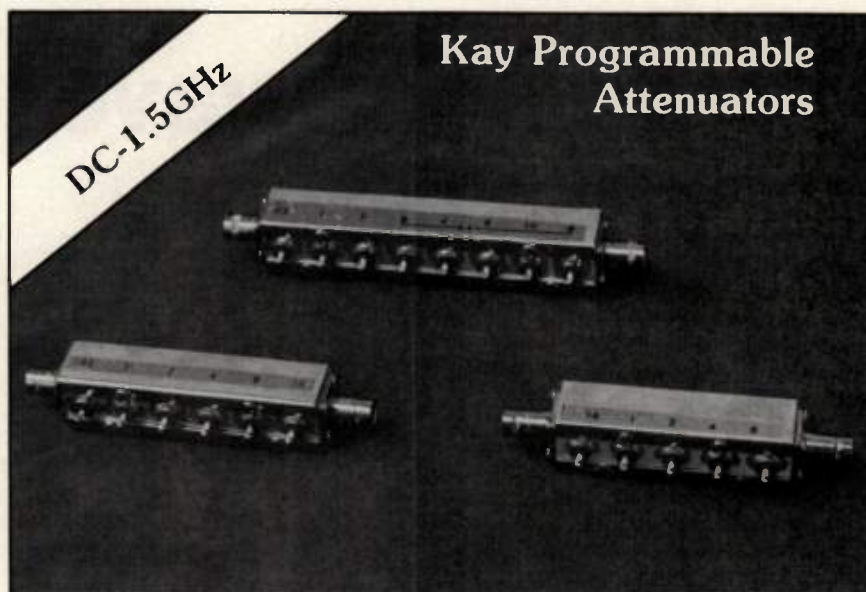
Monolithic ceramic chip capacitor evaluation kits are available from the Delcap Division of American Precision Industries. Each kit contains 25 samples in a range of values and are available in COG and X7R dielectric construction. Standard chip termination is palladium silver with



nickel barrier/solder available as an option. The rated voltage is 50 V. The kit costs \$129.95 for palladium silver and \$179.95 for nicker barrier. **American Precision Industries, Inc., East Aurora, NY.** INFO/CARD #203.

Synthesizer Receiver

Model SR500-F is a UHF synthesized FM receiver that operates at 420 to 470 MHz. The receiver is synthesized at 100



Kay Programmable Attenuators are offered in a variety of frequency and attenuation ranges for applications up to 1500MHz. Substantial discounts are offered on quantity (two or more units) orders.

Model No.	Impedance	Freq. Range	Atten. Range	Steps
P1/4450	50	DC-1000MHz	0-16.5dB	.1dB
P4460	50	DC-1500MHz	0- 31dB	1 dB
P4480	50	DC-1500MHz	0- 63dB	1 dB
P4450	50	DC-1500MHz	0- 127dB	1 dB
P4440	50	DC-1500MHz	0- 130dB	10dB
P1/4457	75	DC- 750MHz	0-16.5dB	.1dB
P4467	75	DC-1000MHz	0- 31dB	1 dB
P4487	75	DC-1000MHz	0- 63dB	1 dB
P4457	75	DC-1000MHz	0- 127dB	1 dB

Kay Elemetrics Corp manufactures a complete line of attenuators which includes Programmable, Standard In-Line, Miniature In-Line, Rotary (Bench and OEM) and Continuously Variable. For a complete catalog and price list or to place an order call Vernon Hixson at (201) 227-2000, Ext. 104.



KAY

Tel: (201) 227-2000, TWX: 710-734-4347

Kay Elemetrics Corp, 12 Maple Ave. Pine Brook, NJ 07058 USA

kHz channel spacings. Bandwidth is 360 kHz while the 12 dB SNR sensitivity is -95 dBm. The SR500-F is available with an analog or digital output. **General Services Engineering, Inc.**, Baltimore, MD. INFO/CARD #202.

Low Frequency Active Transponder

The Eureka 411 is a RF read-write identification device for use in data collection

and identification applications. Up to 115 alpha numeric characters may be read from or written to the tag at a range of up to 39 inches from the interrogating antenna. The activating field is continuous wave at 132 kHz. Data from the tag is transmitted on a 66 kHz carrier using phase shift keying. **Eureka Systems, Inc.**, Englewood Cliffs, NJ. Please circle INFO/CARD #201.

RF & Microwave Filters

100 KHz to 15 GHz

If you have a filter problem we'll provide the solution!

For Military, Communication or Space Application

- Lumped Element
- Helical Resonator
- Coaxial
- Waveguide
- Low Power
- High Power
- Fixed Tuned
- Variable



Give us a call or send us your specifications—we'll do the rest.

LORCH ELECTRONICS CORP.



105 CEDAR LANE, ENGLEWOOD, NJ 07631
(201) 569-8282 TWX: 710-991-9718
A Subsidiary of Vernitron Corporation

Hybrid VCXOs to 100 MHz

Reeves-Hoffman introduces a line of high frequency sine wave VCXOs in a double dip hybrid package. The frequency range is 2 to 100 MHz with power output to 10 dBm. **Reeves-Hoffman Division**, Carlisle, PA. INFO/CARD #200.

30 MHz Measurement Receiver

The Model VM-7 is a 30 MHz receiver designed for applications where precise measurements of RF power ratio are required over a wide dynamic range. It provides measurements over a range of 0 to 127 dBm, a selectable resolution of 0.1, 0.01 or 0.001 dB and an incremental attenuation accuracy of .02 dB per 10 dB. It is priced at \$15,000. **Weinschel Engineering**, Gaithersburg, MD. Please circle INFO/CARD #199.

Power Silicon MMIC Amplifiers

Avantek introduces two 100 MHz to 2 GHz Modamp™ cascable gain blocks intended for use in narrow or broad bandwidth RF amplifier design. The MSA-0520 features +23 dBm power output at 1 dB gain compression and 8.5 dB gain at 1 GHz. The MSA-1023 features +27 dBm power output at 1 dB gain compression, +37 dBm third order intercept point and 8.5 dB gain at 1 GHz. **Avantek, Inc.**, Santa Clara, CA. INFO/CARD #196.

Washable Trimming Capacitors

These miniature trimming capacitors feature internal "O" ring sealing which allow solvent washing. The TZ03 Series capacitance values are from 1.25 pF to 2.3 pF through 10 pF to 120 pF. The capacitors have an axle-less construction that contribute to its stable T.C. and small size. **Murata Erie North America, Inc.**, Smyrna, GA. INFO/CARD #195.

SMT Capacitor Kit

NPO, X7R, and Z5U multilayer ceramic capacitor chips are furnished in Johanson Dielectrics' S-920 SMT prototype kits. It includes 550 capacitors of sizes 0805 and 1206 with nickel barrier terminations. It comes with a chip selector guide and a technical manual entitled *Understanding Chip Capacitors*. **Johanson Dielectrics, Inc.**, Burbank, CA. Please circle INFO/CARD #194.

PTFE Laminate

Rogers Corporation introduces a line of woven glass reinforced PTFE laminates with dielectric constants ranging from 2.4 to 2.6 ± 0.04. Ultralam™ 2000 provides a highly uniform dielectric constant. **Rogers Corporation**, Chandler, AZ. INFO/CARD #193.

CMOS and D-MOS Data Book

This data book from Topaz Semiconductor features data sheets and application tips on lateral N-channel enhancement and depletion mode D-MOS FETs, high voltage vertical N and P-channel D-MOS FETs and high speed CMOS/D-MOS analog switches, multiplexers, and attenuators. It also provides a cross-reference and substitution guide for identifying alternate sources, high performance plug in compatible components plus information on replacing JFETs with D-MOS FETs for significant increases in performance. **Topaz Semiconductor, San Jose, CA. INFO/CARD #189.**

Software Literature

Compact Software has released literature on all its software products, including products formerly sold by Communications Consulting Corporation. Data sheets on Super-Compact revision 1.9 are available with details of all its additional capabilities. Data sheets on the company's line of microwave and RF, IBM PC, and Series 200/300 products called CADEC 4 have been updated. **Compact Software, Paterson, NJ. INFO/CARD #188.**

Technical Note on Pulse Measurement

Pulse Measurements in the Picosecond Domain is a technical note that discusses measurement problems, particularly those with emphasis in the picosecond domain. Oscilloscopes, calibration standards, coaxial cables and connectors, and probes are discussed. Also included is a list of references for extended reading on the subject. **Picosecond Pulse Labs, Inc., Boulder, CO. INFO/CARD #187.**

Application Notes on Mixers

Synergy Microwave introduces a list of application notes and detailed information on surface mount technology for mixers. **Synergy Microwave Corporation, Paterson, NJ. Please circle INFO/CARD #186.**

Microwave Components Fact Sheet

Microwave Data Packet contains detailed fact sheets describing International Microwave Corporation's line of microwave components. Included are photographs, diagrams, descriptions and specifications for GaAs FET amplifiers, bipolar transistors and tunnel diode amplifiers, AGC and log video amplifiers, gunn diode and tunnel diode oscillators, broadband, narrow band and excess noise sources. **International Microwave Corporation, Stamford, CT. INFO/CARD #184.**

Oscilloscope Support Material

Tektronix had released a library of support material for its 2225 50 MHz oscilloscope. The material includes a demonstration video tape, brochure, a booklet entitled *The XYZ's of using a scope* and five technical briefs on oscilloscope measurements. The video tape demonstrates the 2225's dual channel operation, alternate horizontal magnification, 500 microvolt sensitivity and extensive triggering features. **Tektronix, Inc., Beaverton, OR. INFO/CARD #183.**

Surface Mounting Directory

IHS introduce a surface mount directory that enables the user to access over 30,000 devices which includes resistors,

Make the Right Connection.

Everything you need for quality cable assemblies. You can achieve better results in less time for all types of cable assemblies with M/A-COM Omni Spectra tools. Our years of experience in connectors and cable assemblies are built into every cable assembly tool. Call or write today for our new Tools and Accessories Catalog.

- Complete kits for OSM® (SMA), OSSM®, TNC, N and solderless compression crimp connectors.
- Crimping tools, cable benders, torque wrenches, gauges, cutters.
- Free copy of our SMA Assembly Procedures Manual with every SMA Kit.

M/A-COM

M/A-COM OMNI SPECTRA, INC.

Omni Spectra

21 Continental Blvd., Merrimack, NH 03054



Omni Spectra tools are recommended by MIL-C-39012.



ELECTRONIC RESEARCH COMPANY SERIES 8000 PRECISION OVENIZED CRYSTAL OSCILLATORS ARE THE ULTIMATE CHOICE WHERE PROVEN RELIABILITY AND FREQUENCY STABILITY IS REQUIRED. THESE OSCILLATORS ARE IDEAL FOR APPLICATIONS WHERE A PRECISION TIME BASE IS TO BE MULTIPLIED OR SYNTHESIZED REQUIRING A LOW PHASE NOISE SOURCE. ALL ELECTRONIC RESEARCH COMPANY'S OSCILLATORS UTILIZE QUARTZ CRYSTALS MANUFACTURED BY ERC FOR MAXIMUM CONTROL ON ALL PARAMETERS TO INSURE PERFORMANCE SPECIFICATIONS. IF YOUR APPLICATION REQUIRES SUPERIOR OSCILLATOR PERFORMANCE CALL US OR WRITE FOR OUR COMPLIMENTARY CATALOGUE.

erc **FREQUENCY CONTROL PRODUCTS**
electronic research company
7618 Wedd Overland Park Kansas 66204
TVX: (910) 749-6477
Telephone: (913) 631-6700

Teledyne Microelectronics Offers Free Software

"RF Toolbox" is the title of a software package for everyday RF engineering calculations. Features include calculations for cascade noise figure and gain, resistive attenuators, inductive reactance and Q, capacitive reactance and D, resonance and tuning range, VSWR conversions, power level conversions and noise figure measurement. Also included are TSS calculations for DLVAs and TSS calculations with PD gain. The program is user-friendly and provides information on the equations used in the calculations. The software is free and users are entitled to free upgrades for one year provided they are registered with Teledyne. This promotional offer is intended to familiarize RF engineers with the custom hybrid development and manufacturing capabilities of Teledyne. **Teledyne Microelectronics, Los Angeles, CA. INFO/CARD #174.**

Synthesis and Analysis of Coaxial Transmission Lines

Microwave Software Applications introduces software that performs synthesis and analysis of coaxial transmission lines. *Cxline* performs synthesis of dimensions from impedance, analysis of impedance from dimensions, sensitivity analysis of impedance to incremental changes in inner conductor diameter, outer diameter conductor, and dielectric constant. The other functions performed include insertion loss versus frequency calculations for inner and outer conductor loss and dielectric loss effects. Higher-order mode cutoff frequency, capacitance and inductance per unit length, peak power handling of coax cross section and default values of each input parameter can also be calculated. **Microwave Software Applications, Inc., Norcross, GA. INFO/CARD #173.**

System Distortion Simulation

Designer of multichannel linear systems such as television repeaters, cable television distribution networks, microwave television links, and satellite transponders will find DPA-1000's distortion simulation useful in analyzing the interaction between signal to noise ratio and system linearity. DPA-1000 is ideal for frequency allocation studies as it can identify the source of intermodulation distortion in receivers. It calculates the second and third order distortion products arising from non linearity in multichannel systems. Version 1.1 of DPA-1000 read and writes data files compatible with BASIC, Fortran, and Pascal. It is priced at \$3500. **Step Elec-**

tronics, Inc., Campbell, CA. Please circle INFO/CARD #156.

Spice Plus-DEC VAX Interface

Analog Design Tools has integrated its Spice Plus™ program with the DEC VAX. After designing with the Analog Workbench, the simulation can be sent to a remote VAX for the processing. This allows the designer to use his workstation

for the interactive design task, yet free up the workstation for other uses while the VAX is performing the simulation. The price of the remote Spice Plus starts at \$9,500 per MicroVAX. It will work in conjunction with Analog Workbench on Sun and Apollo workstations and with PC Workbench on IBM PC/AT. **Analog Design Tools, Sunnyvale, CA. Please circle INFO/CARD #157.**

Antenna Design

Northrop Corporation's Defense Systems Division, located in sprawling Rolling Meadows, IL just northwest of Chicago, continues to provide innovation and leadership in its role as a major force in the electronic countermeasures industry. Our professionals contribute to the state-of-the-art within a creative, well-managed environment in which individuals are encouraged to develop their capabilities to the fullest, and work in concert as part of winning team. **Positions below require a BSEE, Physics or equivalent, MS preferred.**

Manager: EW Antenna Design

We seek a seasoned professional to spearhead our EW Antenna Design activities. Will be responsible for the design, development and transition into production of Airborne Antenna Systems for ECM applications, and the supervision of a growing unit of design engineers and technicians. Position will have frequent interface with manufacturing and program management. Requirements include a minimum of 12 years experience in airborne antenna design with at least 4 years of project level experience involving budgetary/scheduling responsibilities. Strong management and interpersonal skills are also essential.

Antenna Design Engineers

Participate in the analysis, design, development and testing of Airborne ECM/EW antennas, and the preparation and debugging of a new, state-of-the-art antenna range facility. Positions require candidates with knowledge of phased arrays, monopulse D.F. systems and millimeter wave techniques.

Northrop offers a salary schedule commensurate with level of experience, and a full range benefits program. Interested persons should forward resume with salary specifics to: **James Frasca, Technical Recruiter, Dept. C76, Northrop Corporation, Defense Systems Division, 600 Hicks Road, Rolling Meadows, IL 60008.** An equal opportunity employer M/F/V/H. U.S. citizenship may be required for certain positions.

NORTHROP

Defense Systems Division
Electronics Systems Group

TO MOVE AHEAD IN COMMUNICATIONS, JOIN A LEADER IN THE FIELD.

Harris Corporation is a "Fortune 200" company with \$2.2 billion sales in state-of-the-art information processing, office automation, microelectronic and communication products.

We're the Harris/RF Communications Group with a worldwide reputation for leadership in the design, manufacture and installation of sophisticated HF and VHF/UHF radio communication systems unrivalled for performance, versatility, quality and reliability. We are the world's third largest producer of high-frequency, long-range radios... a major supplier to NATO, U.S. and foreign governments.

Continued expansion and several new product developments have created openings at various levels in an environment where your skills will be challenged, recognized and rewarded.

You'll enjoy the living environment, too.

Rochester offers a low-key modern lifestyle. Freedom from urban pressures and pollution, desirable housing at reasonable rates, a fine school system, extensive year-round cultural and 4-season recreational attractions, renowned campuses for advanced degree study.

Current openings call for a Bachelors degree or equivalent (Masters preferred) and experience in the following areas:

- **Analog and Digital Circuit Design**
- **RF Design**
- **Software Engineering**
- **Digital Signal Processing**
- **Microprocessor Applications**
- **Project Engineering (HF/VHF radio products)**
- **Program Management**
- **Electromechanical Packaging**
- **Applications Engineering**

Please send resume, indicating earnings record, to: Mr. Leo Naioti, Dept. RFD-8 Harris Corporation, RF Communications Group, 1680 University Avenue, Rochester, NY 14610

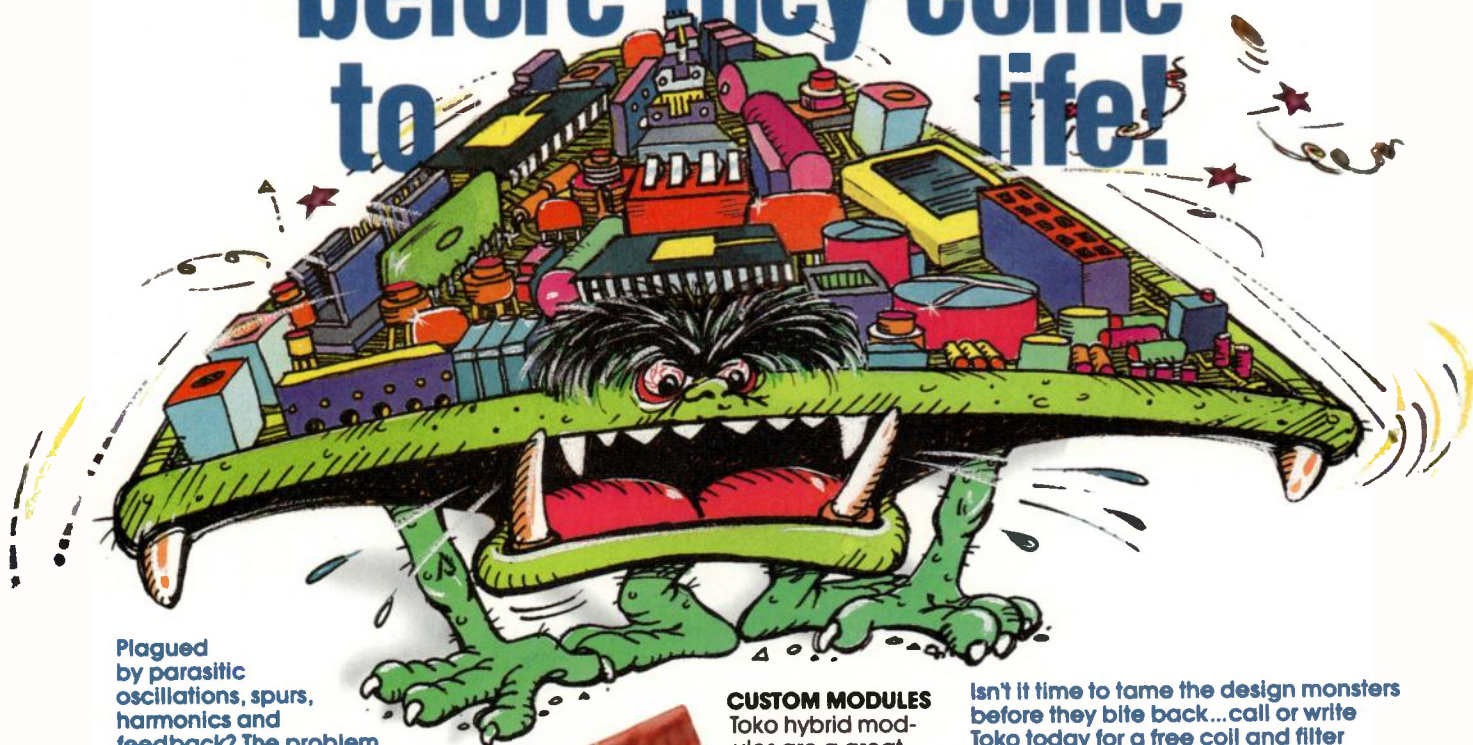
An equal opportunity employer, M/F/H/V



Ad Index

Amplifier Research	64
Amplifonix	50
Anritsu	33
Apcom	35
Applied Engineering	37
California Eastern Labs	4
Cir-Q-Tel	44
Crystal Technology	61
Crystek Corp.	13
CTI Manufacturing	26
Daico Industries, Inc.	9
Digital RF Solutions	53
Eagle	57
Electro Magnetics Co.	59
Electronic Research Co.	68
Fil-Coil	36
Filtron	57
Fujitsu	51
Harris Microwave	18-19
Henry Radio	13
Hewlett Packard	46-47
HI-Q Crystals	63
IFR Systems Inc.	12
Instrument Specialties Co. Inc.	15, 23
Jensen Transformers	57
JFW Industries	52
Kalmus	20
Kay Elemetrics	65
Lorch Electronics	66
M/A-Com Omni Spectra	67
M/A-Com Semi-Conductors	25
Matrix	48
McCoy Electronics	56
Microsonics	34
Microwave Filters	64
Microwave Modules & Devices	10-11
Noisecom	24
Piezo Systems	42
Reeves Hoffman	3
RF Industries	41, 68
RF Monolithics	16
RLC Electronics	2
Sawtek	40
Signetics	41, 43, 45
Sprague-Goodman Electronics	52
Tektronics	54-55
Toko America	75
Trontech	71-72
TTE, Inc.	21
Tusonix	17
Watkins-Johnson Co.	76
Wavetek Indiana	39
Weinschell	62
Werlatone	6
Wide Band Engineering	41

Toko coils and filters attack RF design problems before they come to life!



Plagued by parasitic oscillations, spurs, harmonics and feedback? The problem may not be your design, but the coils and filters you selected. Toko is the world's largest manufacturer of quality small coils and filters, with a selection so large, you're sure to find the right components to neutralize your rf design problems.



SUBMINIATURE ADJUSTABLE AND FIXED

Toko has what you need, so you won't need to compromise... subminiature adjustable coils and transformers, molded coils, radial fixed coils and fixed coils with axial leads. Toko high-Q coils are engineered in sizes from 5mm to 15mm, and inductance ranges from .02 μ H to 500 mH.

CHIP AND ADJUSTABLE SMD

Need to reduce the size of your products or automate production? Toko solves these problems with a wide range of surface mountable coils and LC, ceramic and helical filters in fixed and adjustable configurations. Packaged for automatic insertion and available for reflow or solder dipping.



CUSTOM MODULES

Toko hybrid modules are a great way to simplify design and production tasks. With short lead time,

Toko can develop compact custom modules utilizing a variety of components, surface mounted on a ceramic substrate. One module replaces dozens of components.



FILTERS

For i-f or tuned rf circuitry. Toko filters simplify attenuation of out-of-band signals, while cleanly passing your desired signal. Ultra-miniature ceramic and LC filters at popular i-f frequencies fit tight spaces and tight budgets. With frequencies up to 1.2 GHz Toko helical filters are the right choice for communications transceivers.



ACTIVE FILTERS

If you're advancing the state-of-the-art in digital audio or PCM products you'll appreciate Toko active filters. Especially designed for small size and low distortion, they're also very cost-effective.



Isn't it time to tame the design monsters before they bite back...call or write Toko today for a free coil and filter catalog or a quote on your needs. No matter what Toko coils and filters you choose, you can be assured of exceptionally high quality control at economical prices.

Quality and workmanship that add value and performance to your product.

TOKO
TOKO AMERICA, INC.

(CORPORATE HEADQUARTERS)
1250 Feehanville Drive
Mt. Prospect, IL 60056
(312) 297-0070, Telex: 724372, FAX (GIII):
(312) 699-7864

(Western Branch) 10080 N. Wolfe Rd., SW3-361,
Cupertino, CA 95014
(408) 996-7575, FAX (GIII): (408) 996-7280

(Eastern Branch) 6 Corporate Park Drive,
Suite 307, White Plains, NY 10604
(914) 694-5618, FAX (GIII): (914) 694-6280

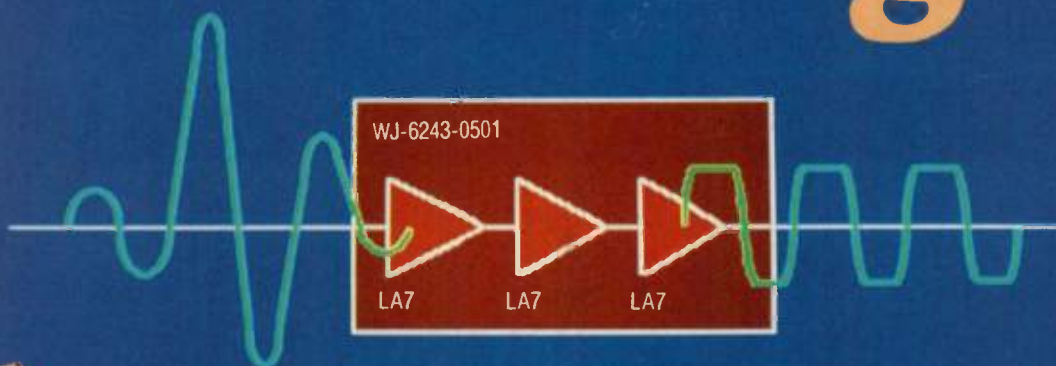
(Southeastern Branch) Executive Plaza,
555 Sparkman Drive, Suite 820-C,
Huntsville, AL 35816
(205) 830-0952, FAX (GIII): (205) 830-5399

For more information on:
Subminiatures, INFO/CARD 58
Chip/SMD, INFO/CARD 59

Custom Modules, INFO/CARD 60
RF & I-F Filters, INFO/CARD 61
Active Filters, INFO/CARD 62

MULTIPAC™

Limiting



Amps

- Cascade them to meet your own design needs
- Customized gain and limiting levels available
- Wide limiting range
- Unique design yields low harmonic distortion

Limiting Amplifiers (Guaranteed at +25°C)

Frequency (MHz)	Model ¹	Description	Gain (dB) (Min.)	Noise Figure (dB) (Typ.)	Power Output at 1-dB Comp. (dBm) (Min.)	VSWR In/Out (Max.)	DC	
							Volts (Nom.)	mA (Typ.)
50-500	6242-0501	LA7/LA7	22.0	9.5	+7.0	2:1	15	108
	6243-0501	LA7/LA7/LA7	33.0	9.5	+7.0	2:1	15	162
	6243-0505	LA7/LA7/LA7	33.0	9.5	+7.0	2:1	15	162
10-1000	6242-0502	LA17/LA17	19.0	7.6	+5.0	2:1	15	110
	6243-0502	LA17/LA17/LA17	28.5	7.6	+5.0	2:1	15	165
	6243-0506	LA17/LA17/LA17	28.5	7.6	+5.0	2:1	15	165
1000-4000	6242-0503	LA45/LA45-1	21.0	10.0	+14.5	2.3:1	15	210
	6243-0503	LA45/LA45/LA45-1	30.0	10.0	+14.5	2.3:1	15	315
2000-6000	6242-0504	KLA62/KLA62	20.0	9.5	+10.0	2.3:1	12	140
	6243-0504	KLA62/KLA62/KLA62	30.0	9.5	+10.0	2.3:1	12	210

Note: 1. These models may be cascaded together for wider limiting dynamic range.

For more information on these excellent products, contact Watkins-Johnson Company, Components Applications Engineering, at (415) 493-4141, ext. 2626.



WATKINS-JOHNSON

Watkins-Johnson Company, 3333 Hillview Avenue, Palo Alto, California 94304-1204

INFO/CARD 64

