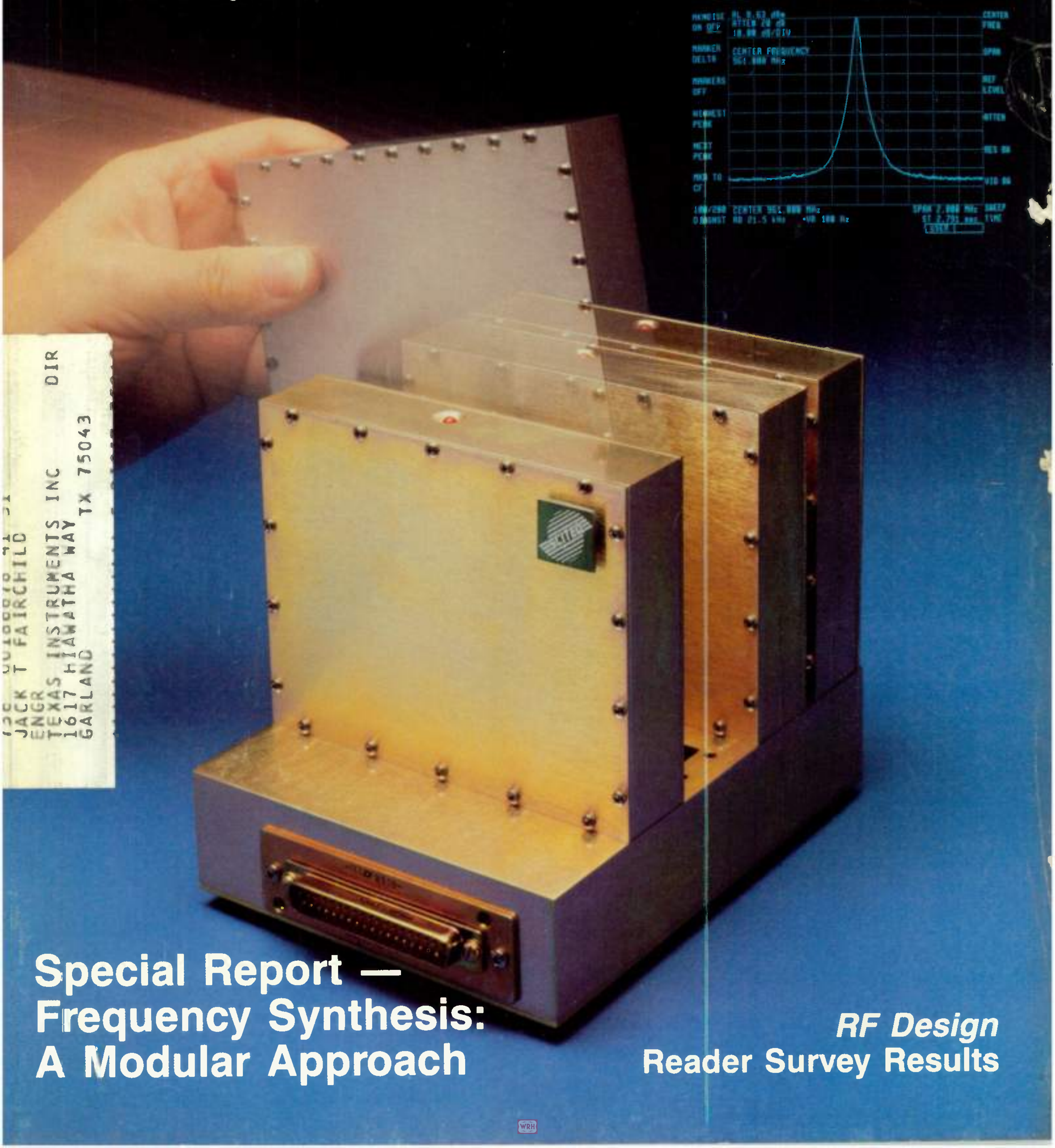
rf design

ideas for engineers

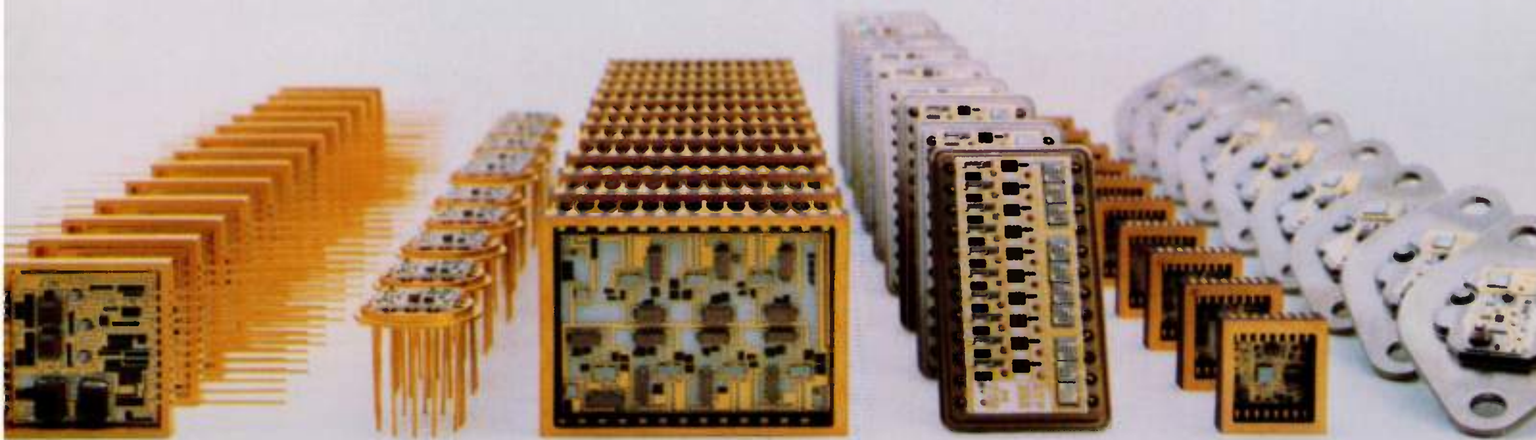
September 1986



Special Report — Frequency Synthesis: A Modular Approach

RF Design Reader Survey Results

When you want custom hybrids to shape up and ship out on-time, one name stands out.



From initial design to volume production, Amperex provides rapid, consistent response for hybrid military applications. We have over 15 years of production experience in thin and thick film linear, digital, and RF hybrid circuits. Amperex hybrids have proven reliability on Copperhead, Sonobouy, C-Sparrow, MK-48, Sgt. York, and B-1, to name a few.

Our engineers will competently and professionally guide your hybrid applications through the transition from schematic design to hybrid prototype in 8-12 weeks. Production of 100's or even 1000's of hybrids per month can commence in our modern 15,000 square foot clean room facility within 12-16 weeks after approval of prototypes.

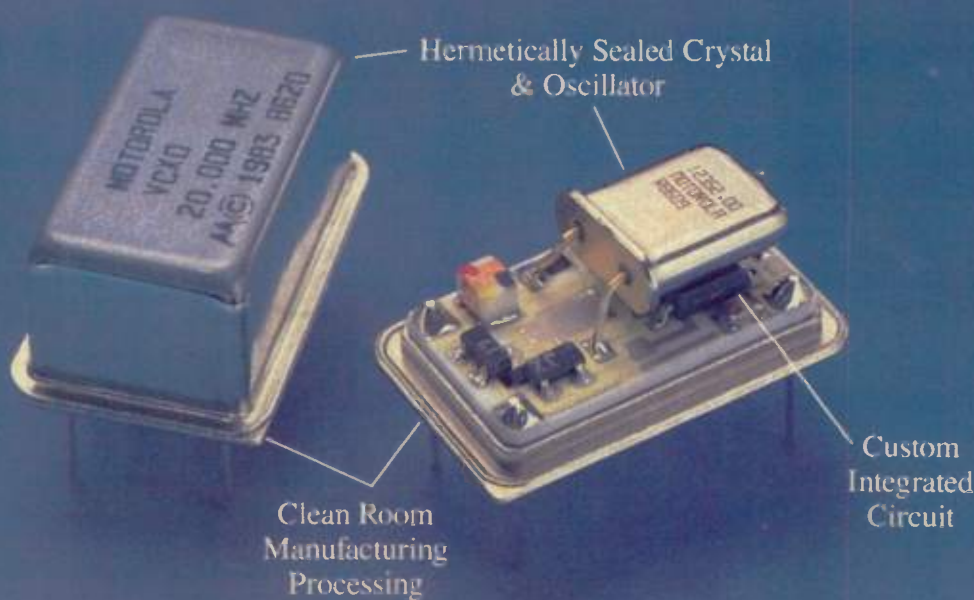
Amperex recognizes the importance of your schedule and cost constraints and places heavy emphasis on on-time deliveries.

When you need custom hybrids for volume, cost-effective military applications, Amperex is the one name that stands out for on-time delivery, proven quality, and dependable performance. For more information, or to request a quotation, write or call Amperex Electronic Corporation, Slatersville Division, A North American Philips Company, Providence Pike, Slatersville, RI 02876. Phone (401) 762-9000. TWX: 710-582-6332.

Amperex®

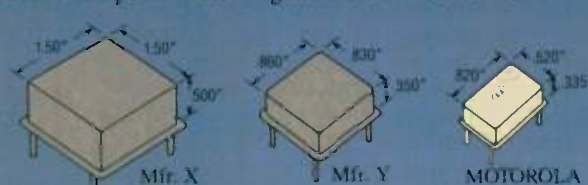
INFO/CARD 1

STEP UP IN PERFORMANCE, DOWN IN SIZE.



Motorola VCXO's Offer a Space Saving Dimension in System Design

Motorola VCXO's not only deliver the reliability and stability your applications demand…they also provide space saving dimensions for greater design flexibility! Hybrid and I.C. component technologies give the Motorola VCXO a space saving size of just .820" x .520" with a .355" seated height. Motorola's new VCXO occupies only .426 in.^{2} of board space compared with some competitive offerings of 2.25 in.^{2} or .714 in.^{2}.



Superior Deviation/Stability Performance

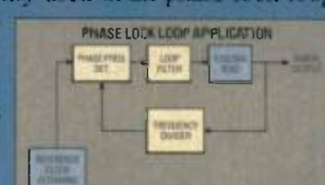
Motorola voltage controlled crystal oscillators are another example of Motorola high performance in a smaller, more efficient design. Motorola VCXO's offer a wide frequency range of 3 to 24 MHz featuring superior frequency stability and deviation sensitivity. Our VCXO's maintain a frequency stability of ± .0025 percent throughout a wide range of conditions: operating temperatures of 0° to +70°C; varying input voltage and load changes; aging; shock; vibration and more. Deviation of ±100 ppm is achieved over a voltage range of 0.5 Vdc to 4.5 Vdc. Wider deviation is optionally available.

Inherent Reliability

Motorola's custom integrated circuit minimizes the number of components, resulting in a VCXO that offers outstanding reliability and consistency from unit to unit. The double hermetic seal with class 100 clean room processing enhances reliability.

Phase-Lock Loop Applications

VCXO's are predominantly used in all phase lock loop applications for communications equipment and analog/digital interface as well as in LAN's and other forms of computer-shared management systems. For phase lock loop applications, Motorola offers a wide variety of reference oscillators to fill your system needs.



Contact us for complete information and samples at the following address: Motorola Inc.—Components Division, 2553 North Edgington Street, Franklin Park, IL 60131. Phone: (312) 451-1000 EXT. 4835. TWX: (910) 255-4619. FAX: (312) 451-7585. TELEX 499-0104.

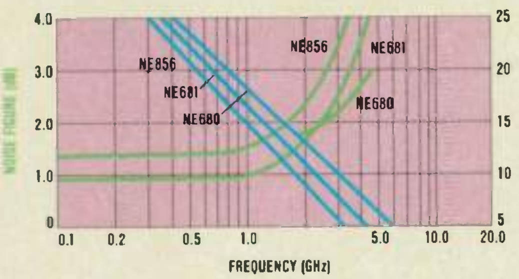
MOTOROLA INC.
Components Division

Motorola Components Division is a broad-based supplier of quality components for the electronics OEM. For more information about specific product lines, contact:
Quartz Bars / Carlisle, PA (717) 249-1456 • Data Clocks, TCXOs, Crystals, Filters, Memory Backup Batteries / Franklin Park, IL (312) 451-1000, Ext. 4835
Piezo-Ceramic Speakers, Annunciators, Filters, Transducers, Displays / Albuquerque, NM (505) 822-8801 • Hybrid Circuits / Ft. Lauderdale, FL (305) 475-5000
NiCd Batteries / Ft. Lauderdale, FL (305) 475-5000 • Printed Circuit Boards / Schaumburg, IL (312) 576-8468

INFO/CARD 2

The Bottom Line In Bipolar Performance Is Value

BIPOLAR PERFORMANCE



It's time for final decisions. The sales pitch has been heard, the data sheets read, the samples delivered. You now sit down by yourself, in your lab, on your test equipment, and see how they *really* perform.

You'll expect, of course, the very best gain and noise figure within your cost constraints. That's why NEC has introduced these new high performance bipolars, NE856 and NE680/681, in SOT23 and Micro-X packages at such reasonable prices...to give you *value*.

For oscillator and gain stage applications the NE856 is an excellent candidate, while the NE680/681 would be the ideal choice for your low noise, high gain requirements. Each of these NEC bipolars uses titanium, platinum, and gold, along with SiO_2 and Si_3N_4 passivation to give you the highest reliability.

Whether you're working in such areas as electro-optics, cellular radio, GPS, or MMDS, you can have that renowned NEC quality. And you'll have it where it counts the most...on the bottom line. *That's value.*

Send for your free NEC bipolar brochure and data sheets. Our comprehensive bipolar line will have what you're looking for... *value*.

Quality Speaks For Itself

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

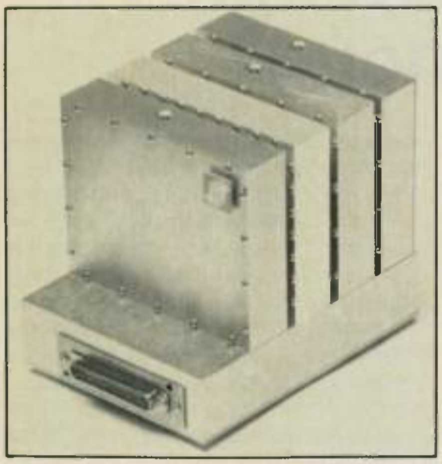
Western (408) 988-3500 **Eastern** (301) 677-1310
Canada (613) 726-0626
Europe: NEC Electronics GmbH 0211/650301

NEC®
NEC Corporation

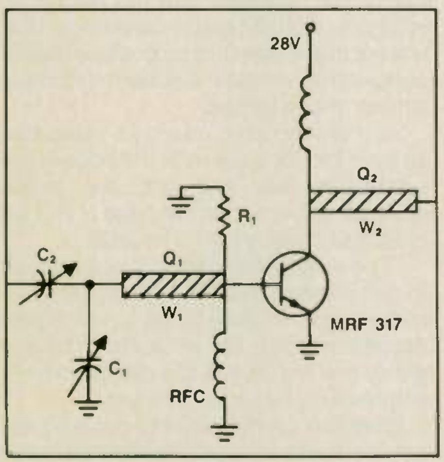
INFO/CARD 3

rf design

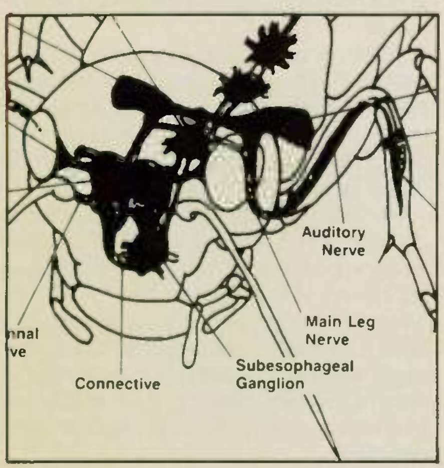
September 1986



Page 29 — Special Report



Page 45 — Q-Factor



Page 74 — Digital Connection

Cover

This month's cover features a new RF synthesizer design by Sciteq Electronics, San Diego, Calif. The synthesizer is most notable for what is missing: it operates in the 500 MHz to 2 GHz range without signal multiplication, crystal oscillator, cavity or mechanical tuning — and consumes only 10 watts.

Features

Departments

R.F. DESIGN (ISSN: 0163-321X USPS: 453-490) is published monthly plus one extra issue in August. September 1986, Volume 9, No. 9. Copyright 1986 by Cardiff Publishing Company, a subsidiary of Argus Press Holdings, Inc., 6530 S. Yosemite Street, Englewood, CO 80111 (303) 694-1522. Contents may not be reproduced in any form without written permission. Second-Class Postage paid at Englewood, CO and at additional mailing offices. Subscription office: 1 East First Street, Duluth, MN 55802, (218-723-9355). Domestic subscriptions are sent free to qualified individuals responsible for the design and development of communications equipment. Other subscriptions are: $22 per year in the United States; $29 per year in Canada and Mexico; $33 (surface mail) per year for foreign countries. Additional cost for first class mailing. Payment must be made in U.S. funds and accompany request. If available, single copies and back issues are $5.50 each (in the U.S.). This publication is available on microfilm/fiche from University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106 USA (313) 761-4700.
POSTMASTER & SUBSCRIBERS: Please send address changes to: R.F. Design, P.O. Box 6317, Duluth, MN 55806.

***rf* editorial**

When 'Well Enough' Isn't Good Enough

By James N. MacDonald
Editor

As we were gathering information for this month's Special Report, which was to have been on Test and Measurement, we learned of Sciteq's new modular frequency synthesizer, the VDS-M. The more we learned about this remarkable design the more impressed we were, until we finally decided to make it alone the subject of the Special Report.

Designed for a major defense contractor, the VDS-M is a radical departure from normal frequency synthesizer designs. One engineer who evaluated it recently told Henry Eisenson, Sciteq president, that the design should not work, but it does a terrific job.

Eisenson has some challenging ideas about the frequency synthesizer business. He divides the frequency synthesizer industry into two parts: instruments and OEM. Instrument frequency synthesizers, he said, can cover wide bands with excellent overall performance and are enhanced by a microprocessor-supported machine/user interface. Such synthesizers are more complex than the average system designer needs, he said.

Hence the concept of the OEM synthesizer, a tailored device that does exactly what is required and no more, using minimum space and power. With few significant exceptions, virtually all OEM synthesizers in the RF and microwave domain depend on architecture and devices that were developed between five and fifteen years ago, he said. There have indeed been refinements during the past decade, but in general the synthesizer industry has made a huge commitment to designs that work and sell, and is unwilling to make new investments as long as the market accepts available products. "This is not an indictment; it's praise of the business judgment and performance of those who manage such product lines. If sales are increasing, why change the product?"

Eisenson said the OEM synthesizer industry has "trained" the market somewhat to accept the capabilities and limitations of these standard products, because competitive models display essentially similar characteristics.

"It then becomes easy to believe that all such products are near the edge of the synthesizer art, and only the astute observer will note that the edge of that art is virtually motionless," he said.

"The synthesizer design process tends to drift into ruts created by commonly accepted practice, dug deeply over the past decade or more. The accepted practices are so well known that it is difficult to force engineering into new territory."

Eisenson claims certain advances will only be made by entrepreneurs because established companies have no incentive to push designs beyond perceived market needs.

"First, a growing market ensures that sales will increase without investment in new technologies (and the risk it entails); the bonus goes not for performance improvement, but for cost cutting. A second factor is customer inertia."

He has demonstrated his faith with the development and introduction of this new frequency synthesizer. The marketplace will be the ultimate judge. But Eisenson's speculation that engineering design can "drift into ruts" is one that all designers might keep in the back of their minds. A complacent engineering team is likely to become a surprised engineering team one day.

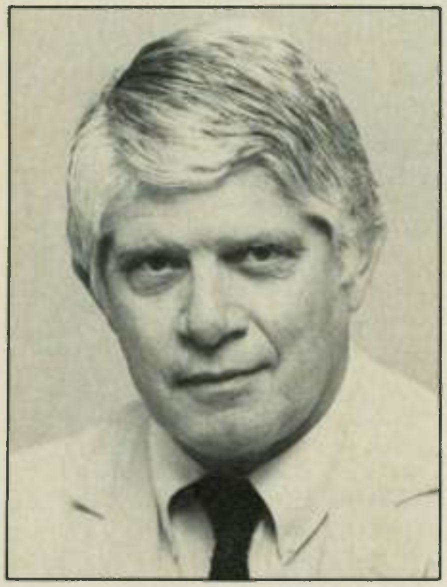
James N. MacDonald

INFO/CARD 55

INFO/CARD 5

rf viewpoint

The Female Solution



By Keith Aldrich
Publisher

In this issue we report response to a survey of *RF Design* readers conducted to determine their demographic characteristics. (See "Profile of the RF Engineer," p. 36.) Among the many questions we asked many of you (thanks for your cooperation, by the way) was the simple one: "Are you male or female?" We didn't exactly have an office pool going, but the staff had some interesting differences in guessing what the answers to this question were going to show. I guessed that women might account for as much as five or ten percent of the RF engineering population by now. Others didn't think so. However, nobody but *nobody* guessed how small the actual percentage is.

The truth is, only one percent of respondents in the survey were women. That's too small a percentage to be reliably projected. It suggests that something like 300 of our 32,000 U.S. subscribers might be women. But the real number could be as little as 100. . .or as "many" as 500.

Whatever the exact statistic, it is startling, even shocking, when one considers two other current realities. . .

1. A substantial number of women students have been reported in recent years at engineering colleges. One of them has been working with us this summer, and she tells us that at Colorado University in Boulder, where she is a sophomore EE major, there may be as many women students as men.

2. There is a critical shortage of RF engineers throughout U.S. industry today, and in fact throughout the world. ("Tell me about it," say you engineering managers who have been trying to hire RF talent. I don't have to prove this one to *you*.)

Surely the same question that occurs to me must occur to any reader who has just read these two statements. *Why aren't more of the new women engineering graduates going to work in the RF industry, which needs new blood so badly?*

It certainly is not true that RF companies have not been hiring *any* new graduates. Our survey shows that almost one out of four of our subscribers is under 30 — indicating that 8,000 of them graduated within the past ten years.

It is also not true that RF engineering jobs don't pay well. *Not a single respondent reported a salary under $25,000 a year* — indicating that starting salaries are at least that, while fully 21.5% of our subscribers have salaries in excess of $55,000.

RF engineering doesn't have a low esteem as a specialization, either, at least among those working in it. Our readers ranked the work as extremely desirable — indicating that they have a high degree of pride when comparing themselves with other engineers.

So what's the answer?

The only one that makes a lot of sense to me is that women graduates aren't fully informed of the opportunities and the advantages in RF engineering. A reverse side of this coin may be that those who should be doing the informing are a little reluctant, perhaps unconsciously, to alter the male atmosphere which has marked the engineering profession since its beginnings in the days of steam turbines and suspension bridges. If there is any such reluctance it ought to be confronted and rooted out as thoroughly as any blight. It is hard to imagine that a country like the Soviet Union would be guilty of not employing such a resource as fully competent, qualified women engineers. If we are going to compete, we cannot be guilty of it either.

I would venture to say that any company which makes a conscious, concerted effort to attract women engineering graduates over the next few years may find a ready solution to its shortage of RF engineers. It may also "steal a march" over competitors who are slow to catch on. Because the march is inexorable. Aside, perhaps, from professional football there are no male professions.

rf design
a Cardiff publication Established 1978

Publisher
Keith Aldrich

Editor
James N. MacDonald

Technical Editor
Gary A. Breed

Sales Supervisor
Kate Walsh

Advertising:
Western states
Kate Walsh
6530 South Yosemite St.
Englewood, CO 80111
(303) 694-1522

Midwestern States
Keith Aldrich
6530 South Yosemite St.
Englewood, CO 80111
(303) 694-1522

Eastern States
Doug Markhouse,
Eastern Sales Manager
167 South Broadway
Hastings on the Hudson, NY 10706
(914) 478-0909 or 4349

Advertising Services
Tami Baird

Editorial Review Board
Alex Burwasser, Ed Oxner
Doug DeMaw, Andy Przedpelski
Dave Krautheimer, 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
Carol Bates, Dave Pieper
Maurice Lydick, Bill Schmitt
Matt Park

Composition
Jay Jarrett
Ellen Wilson

Published by
CARDIFF PUBLISHING COMPANY, INC
BPA
6530 South Yosemite St.
Englewood, CO 80111
(303) 694-1522

President
Robert A. Searle

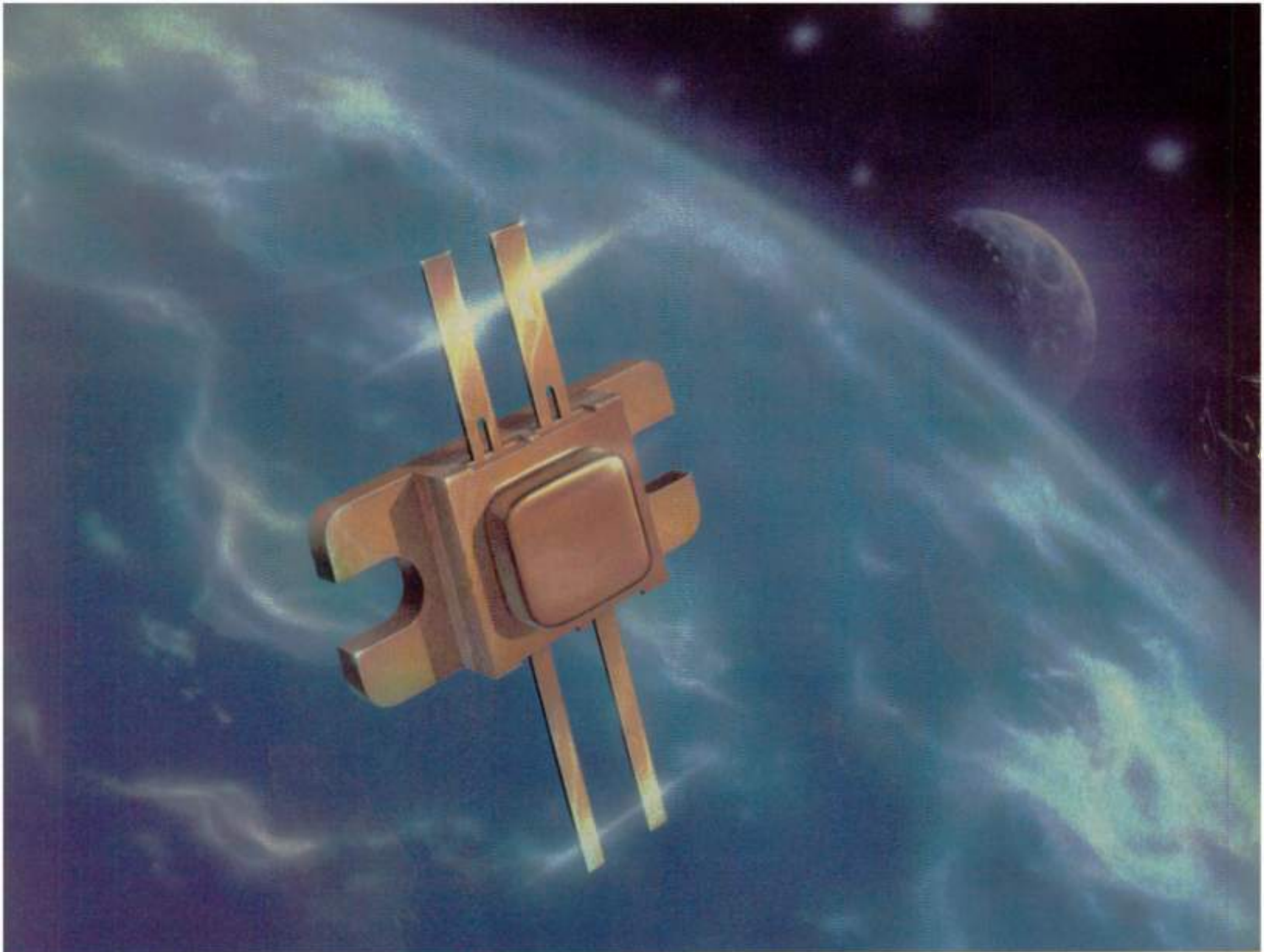
Vice President
Judy L. Rudrud

Controller
Marvin Laut

Operations Manager
Cherryl 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.



PROOF THERE IS INTELLIGENCE IN SPACE.

The Strategic Defense Initiative. A deterrent concept so novel, there are years of research ahead before the best method of implementing it can be agreed upon. But there's one aspect that virtually every major SDI contractor has already agreed upon.

That the UHF pulsed power transistors used in their system evaluations will be from Thomson Components-Mostek Corporation.

It's a smart move on their part considering we have seven years experience developing this type of device to provide the consistent reliability in extreme heat conditions an application like SDI demands.

We perform 100% production testing for die-attach voids. And in our manufacturing process, we use fully-automated wire bond, die sort and die selection techniques to ensure maximum reliability.

In operation, our devices are capable of 500 watts of power under pulsed conditions, or 50 watts under continuous wave. And just as important, they can work at full power with typical junction temperatures at an operating temperature of less than 125° C.

What's more, we can satisfy even the strictest size and weight limitations, either by designing custom packaging or by using your own package.

So if you'd like to know more about our UHF pulsed power or any of our discrete products, write TCMC, Commerce Drive, Montgomeryville, PA 18396, or call (215) 362-8500.

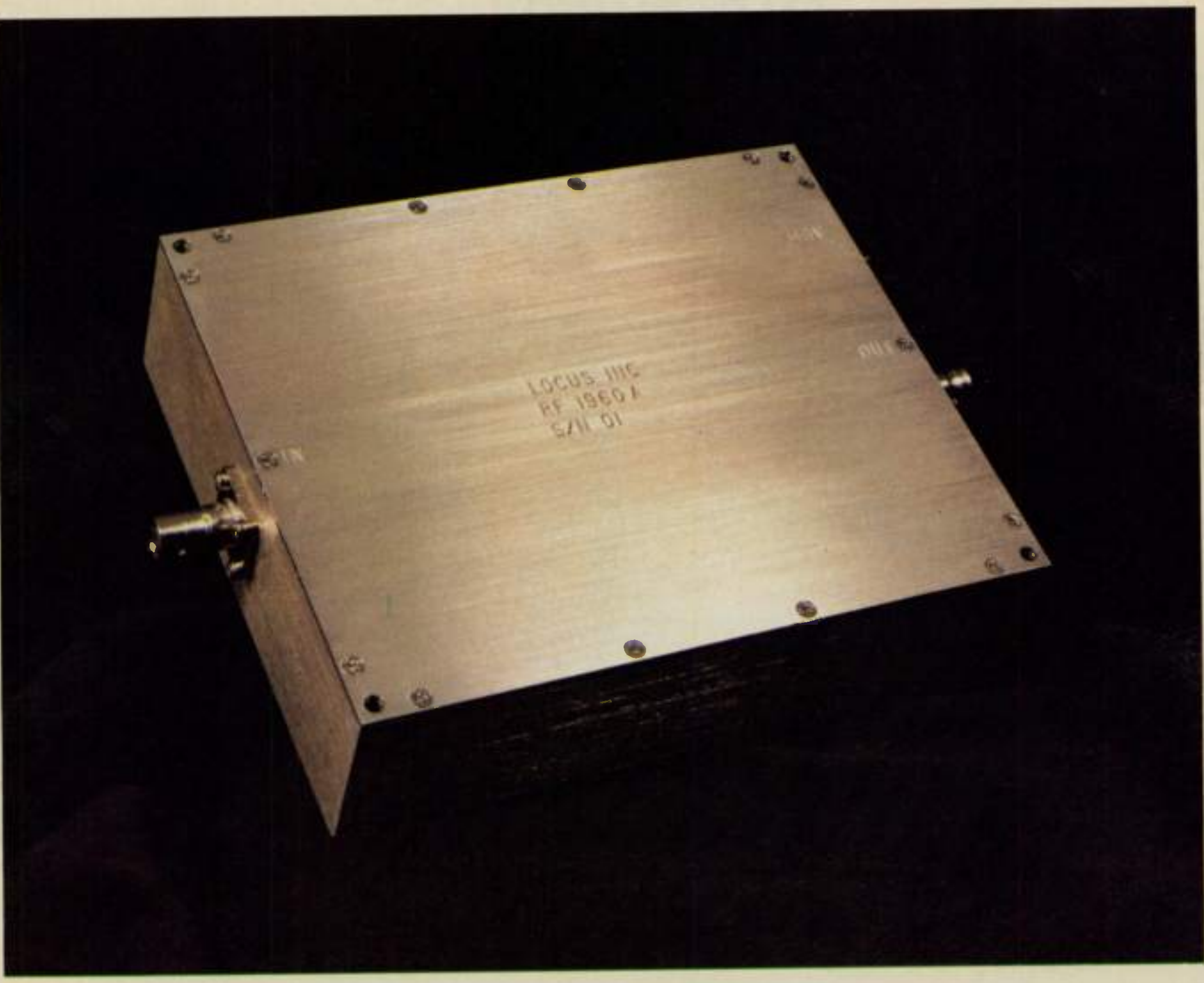
	Configuration	Fo	Pout	Vcc	Pg	PW	DC	Tstg & Tj
SD1564	Common emitter	400-450 MHz	400 Watts	40 Vcc	7.5dB	1ms	10%	Tstg = −65 - +200°C Tj = +200°C
SD1565	Common base	400-450 MHz	500 Watts	40 Vcc	10.0dB	250ns	10%	Tstg = −65 - +200°C Tj = +200°C

Just ask. We have the solution.

THOMSON COMPONENTS MOSTEK

INFO/CARD 7

Increase the dynamic range of your HF Receiving System with this FEEDFORWARD AMPLIFIER

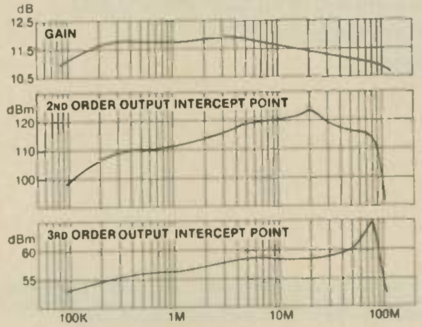


An HF multicoupler, which provides multiple outputs from a single receiving antenna, places severe demands on its amplifier. The problem: extremely high signal density in the HF band.

The amplifier must not add excessive noise to weak desired signals or produce intermodulation products from undesired strong signals - a tough job for traditional amplifiers.

Now, LOCUS, INC. has developed a feedforward HF amplifier that minimizes distortion at the receiving site.

Model RF-1960A Amplifier uses a sophisticated intermodulation cancellation process to achieve the highest possible spurious-free performance with 10 watt dc input power. The unit has a bandwidth of 1 MHz to 80 MHz and provides 11.5 dB gain.



Typically, Model RF-1960A Amplifier offers a noise figure of 6.5 dB, a second order intercept point of +110 dBm and a third order intercept point of +58 dBm. The distortion performance is equivalent to a 100 watt linear unit. Improvements can be expected in all HF antenna preamplifier or antenna multicoupler systems. It's size: 5.0″ x 6.0″ x 1.56″. For more information contact LOCUS, INC., Telecommunications Division, P.O. Box 740, State College, PA 16801 or call (814) 355-7800.

LOCUS, INC.

INFO/CARD 9

We're even better than you think. Absolutely!

Now the 6071A and the 6060B Signal Generators have a guaranteed absolute level accuracy of 1.0 dB.

Whether you need the highest spectral purity (6071A) or are required to do general-purpose testing (6060B), you'll benefit from being able to rely on our improved signal generator accuracy. And, it won't cost you a penny more!

Fluke signal generators are designed for critical applications in the military, defense and mobile communications industries. You'll find them optimized for high-volume production. They're easily integrated, and our fast switching rates will save you production time.

SPECIFICATIONS	6071A	6060B
Frequency	200kHz to 1040MHz	10kHz to 1050MHz
Amplitude	− 127dBm to + 13dBm	− 127dBm to + 13dBm
Accuracy	± 1.0dB (520MHz)	± 1.0dB
Spurious	< − 90dBc (520MHz)	< − 60dBc
Modulation	AM, FM, φM	AM, FM

The unique architecture of these programmable signal generators allows us to emphasize low noise/spurious signals, while reducing expense to you through the use of innovative circuit designs.

You also get superior RF shielding with the 6071A and the 6060B. Our cast aluminum housing and RFI gasket-sealed covers result in low radiated EMI and microphonics.

Whatever your performance needs are, Fluke's family of signal generators offer you an unbeatable value. And, our after-sales support is unparalleled.

Find out what we mean. Call **1-800-426-0361** today or contact your local Fluke sales engineer or representative.

FLUKE®

IN THE U.S. AND NON-EUROPEAN COUNTRIES: John Fluke Mfg. Co., Inc., P.O. Box C9090, M/S 250C, Everett, WA 98206. Sales: (206) 356-5400. Other: (206) 347-6100.
EUROPEAN HEADQUARTERS: Fluke (Holland) B.V., P.O. Box 2269, 5600 CG Eindhoven, The Netherlands, (040) 458045, TLX: 51846.

rf courses

The George Washington University

Spread Spectrum Communications Systems
September 8-12, 1986, Washington, DC

Frequency Hopping Signals and Systems
September 22-24, 1986, Washington, DC

Grounding, Bonding, Shielding and Transient Protection
October 20-23, 1986, Orlando, Florida
December 8-11, 1986, Ottawa, Canada

Radar Systems and Technology
November 3-7, 1986, Washington, DC

Mobile Cellular Telecommunications Systems
December 8-10, 1986, Washington, DC

Wideband Communications Systems
December 15-19, 1986, Washington, DC

Information: Merril Ann Ferber, Assistant Director, Continuing Education Engineering Program, The George Washington University, Washington, DC 20052; Tel: (800) 424-9773

Georgia Institute of Technology

Eighteenth Electromagnetic Window Symposium
September 17-19, 1986, Atlanta, Georgia

Principles of Modern Radar
November 3-7, 1986, Atlanta, Georgia

Phased-Array Antennas: Theory, Design and Technology
November 18-21, 1986, Atlanta, Georgia

Information: Diedre Mercer, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332; Tel: (404) 894-2547

Besser Associates, Inc.

Principles of RF and Microwave Circuit Design
November 12-14, 1986, Baltimore, Maryland
December 15-17, 1986, Santa Clara, California

Information: Ron Rose, Besser Associates, Inc., 3975 East Bayshore Road, Palo Alto, CA 94303; Tel: (415) 969-3400

R & B Enterprises

TEMPEST — A Detailed Design Course
October 6-10, 1986, Philadelphia, Pennsylvania

Electromagnetic Pulse (EMP) Design and Test
October 9-10, 1986, Washington, DC
October 27-28, 1986, Philadelphia, Pennsylvania

Grounding, Bonding and Shielding
October 27-28, 1986, Washington, DC
October 20-21, 1986, Philadelphia, Pennsylvania

Understanding and Applying MIL-STD-461C
October 16-17, 1986, Washington, DC
October 30-31, 1986, Philadelphia, Pennsylvania

Printed Circuit Board and Wiring Design for EMI and ESD Control
October 14-15, 1986, Philadelphia, Pennsylvania
October 20-21, 1986, Boston, Massachusetts

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

rf calendar

September 8-12, 1986
International Test Conference
Sheraton Washington, Washington, DC
Information: Doris Thomas, ITC Executive Secretary, P.O. Box 264, Mt. Freedom, NJ 07970; Tel: (201) 895-5260

September 9-10, 1986
Fourth Symposium on Optical Fiber Measurements
NBS Laboratories, Boulder, Colorado
Information: Douglas L. Franzen, Div. 724.02, National Bureau of Standards, 325 Broadway, Boulder, CO 80203; Tel: (303) 497-3198

September 9-11, 1986
Midcon/86 High Technology Electronics Exhibition and Convention
Dallas Convention Center, Dallas, Texas
Information: J. Fossler, Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (312) 299-9311

September 10-11, 1986
Mid-Atlantic Electronics Design and Production Exposition and Conference
Valley Forge Convention and Exhibit Center, Valley Forge, Pennsylvania
Information: Don Ramey, Conference Coordinator, International Marketing Services Ltd., 1030 South Grange Road, LaGrange, IL 60525; Tel: (312) 354-3900

September 23-25, 1986
Antenna Measurement Techniques Association Symposium
Westin Hotel, Ottawa, Ontario, Canada
Information: L. Forget, 1986 AMTA Symposium, National Research Council, Ottawa, Ontario, K1A 0R6, Canada; Tel: (613) 993-9009

September 29-October 1, 1986
Montech 86 IEEE Conference on Antennas and Measurements
Montreal, Canada
Information: Dr. A. Kumar, Montech 86, P.O. Box 37, Station "A," Montreal, Quebec, Canada H3C 1C5; Tel: (514) 457-2150

September 30-October 2, 1986
Automated Design and Engineering for Electronics (ADEE)
World Trade Center, Boston, Massachusetts
Information: Show Manager, ADEE East, Cahners Exposition Group, 1350 East Touhy Ave., P.O. Box 5060, Des Plaines, IL 60017; Tel: (312) 299-9311

September 30-October 2, 1986
Northcon/86 High Technology Electronics Exhibition and Convention
Seattle Center Coliseum, Seattle, Washington
Information: J. Fossler, Electronic Conventions Management (see address above)

October 7-9, 1986
Connector and Interconnection Technology Symposium
Disneyland Hotel, Anaheim, California
Information: Kent R. Bumpas, Daniels Manufacturing Corp., 11360 Palm Dr., Suite "A," Desert Hot Springs, CA 92240; Tel: (619) 329-2947

Letters should be addressed to: Editor, RF Design, *6530 S. Yosemite St., Englewood, CO 80111.*

Overlapped Microstrip Makes a Simpler Design

Editor:

I read the paper "Microstripline High Power Amplifier Design" by A.K. Tam with a real interest (*RF Design,* Dec. 1985). My intention is to propose an area reducton of the layout at least by half. It can be easily gained by application of my overlapped microstrip (OM) coupler design instead of the branch hybrid as on the Fig. 4. I do understand that Mr. Tam used it only as an easy replacement of a Lange design to make an amplifier feasible in laminate technique. A Lange design is proper for more professional applications and is almost unfeasible using laminate substrate, just opposite from the OM design, which can be manufactured in "kitchen conditions" employing simply a knife, dielectric resin and manual soldering. No Touchstone or Super-Compact is needed.

I am enclosing two reprint copies of my conference papers on the OM design to support my proposal by some background information. The OM lines are a very valuable structure from technological point of view and worthy of deep investigations to be made. If you don't mind I am asking you for some help in getting free samples of laminate substrates and dielectric resin to enable my particular experimental designs.

I would be very satisfied to hear about results gained by some of your readers who would apply my proposal according to the enclosed figure with my notes on it.

Wojciech Marczewski
Polish Academy of Science
Space Research Center
01-237 Warsaw ul.Ordona 21
Poland

Mr. Marczewski's design is described in the Proceedings of the 14th European Microwave Conference, Liege, Belgium, Sept. 10-13, 1984. See the accompanying figure for his modification of Alan Tam's design. — Editor

SPICE, Too, Is Available For PC

Editor:

I enjoyed your May, 1986, articles on CAD. However, the article "Microcomputer Software for the RF Engineer" made no reference to any versons of SPICE. There are at least two very good versions of SPICE for PC-based CAD: PSPICE by MicroSim, an enhanced version of Berkeley SPICE, and ZSPICE, a straight translation of Berkeley SPICE. Any reader interested in either package can contact us for information.

J. Richard Hines
Oholiab Technology
2010 Tulane
Richardson, Texas 75081

Thin Skin Can Shield Effectively

Editor:

I read with interest the April 1986 article "Composite EMI/RFI Shielding" and a subsequent letter to the editor in your June 1986 issue.

I must agree that Figure 1 of the article leaves a lot to be desired. It is quite misleading and confusing since the author mixed units — dBuV/M for the FCC limits and dB for shielding. Apparently, the author had determined that shielding levels of approximately 30 to 45 dB were necessary to meet FCC limits for a specific set of undefined circumstances.

The author of the letter to the editor seems to have missed the point that for thin foils electric field shielding is due mostly to reflection loss, which depends on the ratio of wave impedance to shield impedance. It turns out that a thin shield, even one only a fraction of a skin depth thick offering virtually zero attenuation loss, can provide substantial shielding due to its low shield impedance. One can refer to ASTM ES7-83, "Emergency Standard Test for Electromagnetic Shielding Effectiveness of Planar Materials," to confirm this fact. This document uses a gold thin film standard (thickness on the order of 1×10^{-5} millimeter) for test fixture calibration purposes. The standard has a nominal surface resistance of 5 ohms/square and provides a nominal plane wave shielding effectiveness of 32 dB over the 30 to 1000 MHz frequency range.

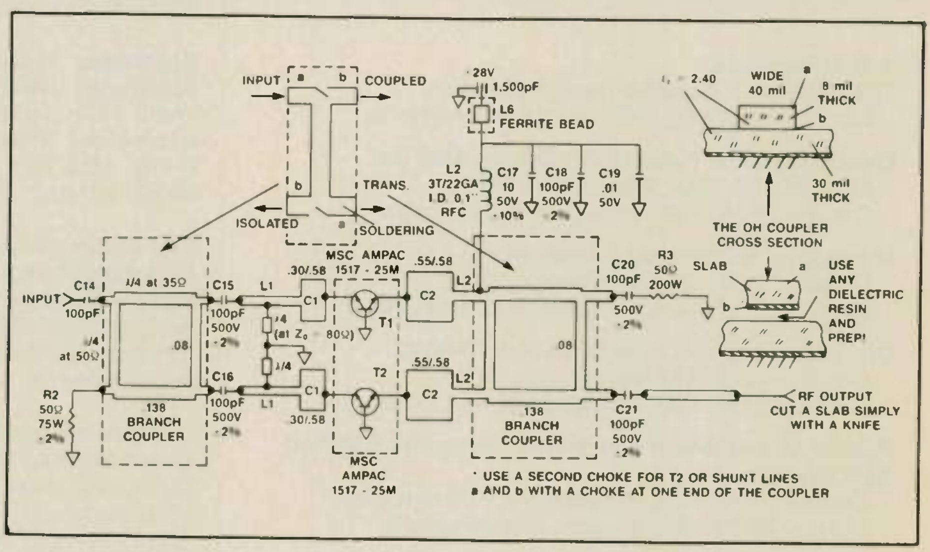
It also turns out that for thin foils which shield electric fields by reflection, lower magnetic permeability is better since it results in lower shield impedance. High permeability materials such as nickel and steel are "poor" for such an application because of higher shield impedances. On the other hand, high permeability materials are preferred for low frequency magnetic, i.e., low impedance, fields. In this situation reflection loss is hard to come by and one must rely on absorption loss, which is enhanced by materials with high conductivity and high permeability.

J.P. Curilla
Staff Research Engineer
DuPont Connector Systems
Camp Hill, PA 17011

Don't Abandon Old Design Tools

Editor:

In the June 1986 issue of *RF Design,* I read an editorial by Mr. Robert Stanton, president of RF Engineering, concerning an earlier article entitled "Coordinate Conversion and SWR Nomogram." I don't



THE OVERLAPPED MICROSTRIP COUPLER DESIGN: 3 dB/90°/50Ω

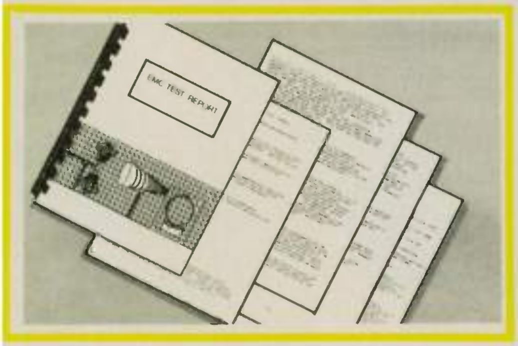
LENGTH ≅ 1.15 INCH

How sure are you of your Interference Control?

Instrument Specialties can

- provide you with Certified Testing℠...
- document with computer print-outs...
- recommend corrections if necessary!

What is Certified Testing℠?

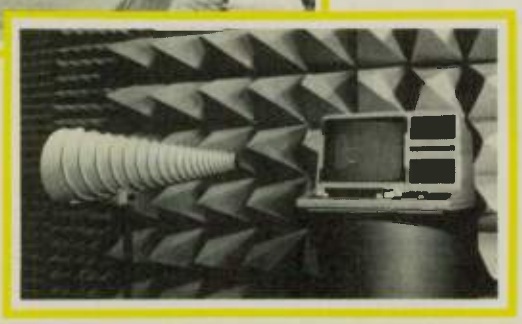


Certified Testing is our name for our automated test program that evaluates the interference control built into the equipment being tested. Available only from Instrument Specialties, it includes state-of-the-art emissions and susceptibility measurements from 20 Hz to 20 GHz up to 20 V/m... RF gasket evaluation... FCC/VDE/CISPR and MIL-STD-461A/B tests... TEMPEST facility measurements per NACSIM 5203 and 5204 requirements ...depending on your needs.

How do we test?

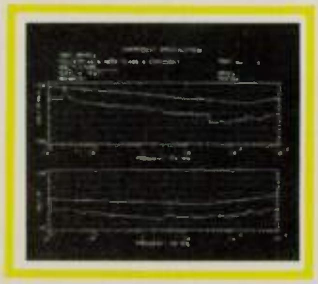
Computer-controlled tests provide customized, precise results, repeatability, and documentation. Shielding can be tested to MIL-STD-285, IEEE 188, NSA, etc. RF gaskets are tested using the SAE ARP-1705 transfer impedence method, to 140 dB. Our computers and proved software, plotters, signal sources, oscilloscopes, receivers, amplifiers and antennas offer a degree of sophistication not available to most manufacturers of Class A and B devices. Few, if any, test facilities in the U.S. have comparable equipment, calibrated and traceable to the National Bureau of Standards!

Where do we test?



Portable equipment is tested in our new shielded enclosures, including semi-anechoic (non-echoing). Commercial tests are confirmed in an open field test site, itself tested in accordance with FCC standards. These superb facilities are available on a daily basis, as is engineering help, if requested. If on-site testing is required, we'll bring our portable laboratory instruments to you.

What do you get?

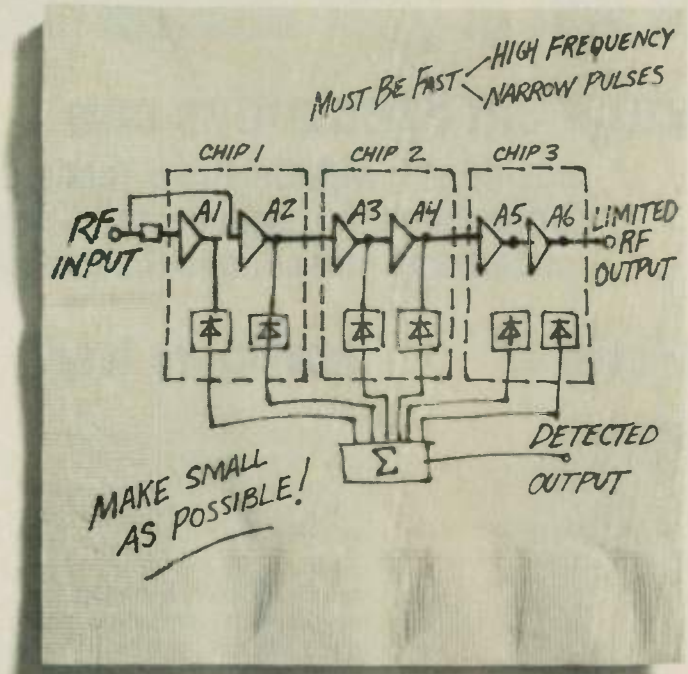


We're told our Test Reports are the best in the industry. More detailed, and clearer, with a continuous sweep of frequency spectrum—not just hand-plotted points. Computer print-outs and documented data meet both FCC and military audit requirements. If desired, we can supply engineering consultation leading to specific recommendations and verification. Of course, all reports are strictly confidential.

For more information on rates and schedule availability, or to discuss your specific needs, phone and ask for EMC Customer Service. Or, write us at Dept. RF-30.

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

Specialists in interference control since 1944



The best hybrids for radar aren't always hybrids.

They're SL2521 Monolithic Log Amps from Plessey. You heard right. Monolithic.

Our advanced 3 micron oxide isolated bipolar process allows us to put Phase, Video and IF limiting functions on a single chip. About one-third the size of bulky hybrids.

So now you can achieve a higher level of performance and reliability with less power than most hybrids. Not to mention a lower price.

Standard features found in the SL2521 include 1.3GHz bandwidth, balanced IF limiting, temperature stability, phase linearity better than 2° (six-stage strip), and pulse handling better than 20ns with 2ns rise times and 6ns fall times. It's the world's fastest monolithic log amp.

And, like Plessey's complete family of monolithic ICs, the SL2521 meets MIL-STD-883C requirements.

In fact, it's the only log amp with guaranteed performance at +125°C, making it ideal for the most demanding radar applications.

So if you still think a radar hybrid has to be a hybrid, we'd like to change your mind. Call Plessey at 800-321-0871 or 714-951-5212. Or write us at Plessey Semiconductors, 3 Whatney, Irvine, CA 92718.

PLESSEY

INFO/CARD 12

feel that Mr. Stanton's attitude of abandoning the old design tools in favor of the new is completely warranted.

Having only two years of RF experience, I would not consider myself a seasoned RF engineer by any stretch of the imagination. Yet in my work, I have been extremely fortunate to hang out with, and be "mentored" by, fabulously experienced RF types, with 25-plus years experience behind them. These veterans could design oscillators or amplifiers freehand, and use nomograms with great success. The nomogram is a powerful, shock-resistant tool for these "old-timers."

Not being an RF veteran, I have chosen different tools. I am equally at ease writing my own software or using a canned analysis program for RF design on a computer. I have never used a nomogram. Yet who is to judge whether my tools are "better" than another's?

When my wife visited her relatives in Japan, she found some merchants performing computations more quickly using an abacus than they could using a calculator.

Do not be so quick to sneer at and abandon the old, simply because something new has arrived. Let each decide for himself which is "best."

Terry Charbonneau
Magnavox Electronic Systems Company
Fort Wayne, Indiana

SAW Windowing Effect on Signal Amplitude

Editor:

We read with interest the article "The Surface Acoustic Wave Filter — Window Function" by Jeff Schoenwald in the March *RF Design*. The article describes the various window functions used to reduce the sidelobe levels. However, we found that this article does not discuss the effect of windowing on signal amplitude which results in S/N ratio degradation (which is quite significant). We have also carried out similar studies at our center and have studied the effect of windowing on signal amplitude also.

O.P. Kaushik
Space Application Centre
Ahmedabad, India

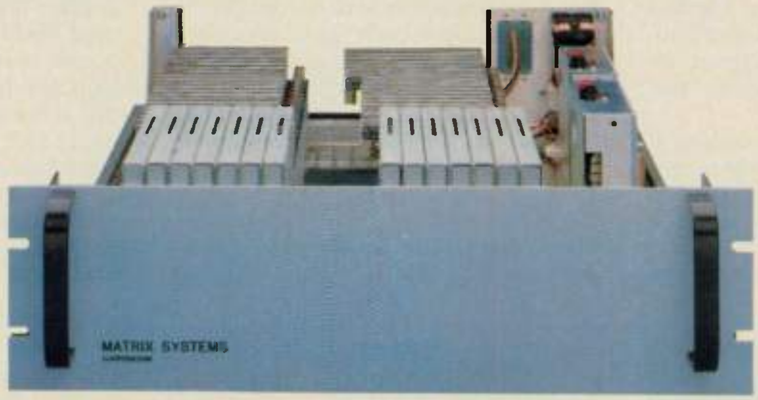
Editor:

Mr. Kaushik's point is well taken. Any window function applied to a transducer reduces the total efficiency in the passband. This is bound to reduce the signal-to-noise ratio. While I have not addressed this subject quantitatively, it is one that merits analysis. I am glad that Mr. Kaushik has done so, since it would add to the readership's further appreciation of SAW filter design.

I would point out that the problem is often ignored by the application of impedance matching networks that often have the effect of improving the efficiency of the device much more than the window function reduces it. As for noise, this is often the result of direct electromagnetic feedthrough between the input and output transducers. Good package design, which cuts off propagation of radiation in the frequency neighborhood of the passband, is often the most sraightforward solution. rf

Jeff S. Schoenwald
Rockwell International/Science Center
Thousand Oaks, California

Matrix Makes Switching as Easy as "OFF" or "ON"



MATRIX MAKES SWITCHING A SNAP

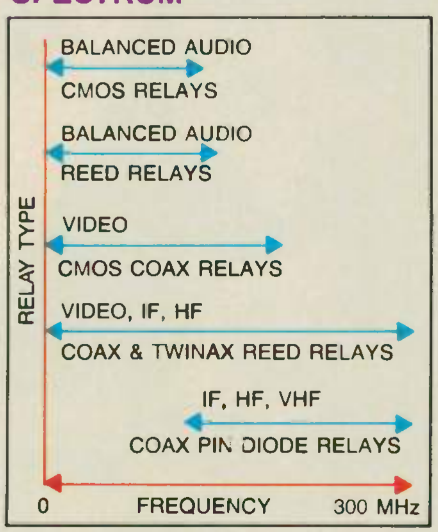
Whether you're switching VHF, HF, IF, video, audio or DC, Matrix Systems makes it a snap. That's because we can tailor a system to your exact needs using Reed, CMOS, or Pin Diode relays. The chart tells the story.

It pays to deal with a company like Matrix who really understands the switching business. We've been designing and delivering state-of-the-art systems for over 15 years to defense contractors, government agencies, the TV industry, ATE manufacturers - and more. Built to the toughest electrical and packaging specs imaginable.

BUILT TO YOUR SPECS

Don't spend months designing a custom switching system when we can do it faster and for far less money. We assume total system responsibility, including computer compatibility, control panel, status indicators, scanning functions and power supplies. We can switch any type of cable system: coax, twinax, triax, common ground, floating ground or twisted pair. And because our systems are modular, repairs can be made in minutes.

MATRIX COVERS THE WHOLE FREQUENCY SPECTRUM



COMPUTER COMPATIBILITY

Just apply a control input from your computer and the system will instantly route your signal to as many points as needed. 16 bit parallel interface is standard, and we also offer IEEE-488 and RS232, all with status feedback.

NEW PRODUCTS

We have a lightweight portable system which is perfect for test, and service. Plus an ULTRA-FAST (microsecond range) pin diode coaxial system.

LEAVE THE SWITCHING TO US

Don't make switching a chore. Make it a snap. Matrix has the answers to your switching problems, no matter how tough they may be.

MATRIX SYSTEMS CORPORATION

5177 NORTH DOUGLAS FIR ROAD
CALABASAS, CALIFORNIA 91302
(818) 992-6776 • TWX 910-494-4975

WHEN IT COMES TO SEMI-RIGID CABLE, WE WROTE THE BOOK.

Next time you need MIL-C-17 QPL-approved semi-rigid coax cable, check with us first. Because nobody else comes close to having as many QPL-approved coaxial cables—flexible as well as semi-rigid—as Times. Over the past 40 years, we've solved more than 10,000 specific problems with our coax cables. And now we've put that experience and knowledge to work for you in a full line of semi-rigid cables that meet or exceed MIL-C-17.

Send for our new catalog today. And when you're ready to buy, give us a call first at (203) 265-8700. You'll salute our selection, competitive price and delivery.

Times Fiber Communications, Inc., Government Systems Division, P.O. Box 384, Wallingford, CT 06492, (203) 265-8700.

TFC

an LPL company

TFC . . . The Defense Connection

INFO/CARD 16

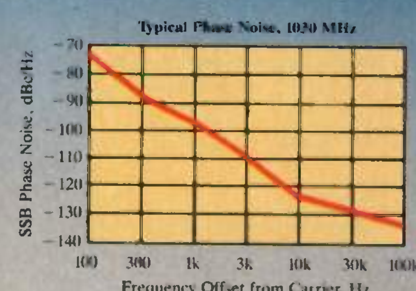
Stable, Compact Reliable and Efficient UHF Frequency Sources.

Small Accomplishment!

Our SAW hybrid oscillators and modular frequency sources provide a unique solution to your demanding requirements. They pack the performance of a fine UHF cavity oscillator into less than a tenth of a cubic inch. Their small size, low power consumption and excellent reliability is 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, voltage tuning, and a variety of modulation formats from linear FM to direct-sequence spread spectrum. We can cover the full −55°C to +125°C temperature range and offer screening to MIL-STD-883 and MIL-S-49433.

Our SAW-stabilized UHF frequency sources are being used in IFF interrogators and transponders, radar frequency synthesizers, GPS receivers, emergency location transmitters, security systems, 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

THE NEW WAVE IN RF

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

INFO/CARD 17

GTE Division Achieves Meteor Burst Communications

Laboratories Division Improves Telephone Digital Sampling Rate

GTE Corp., Westborough, Mass., has conducted the first successful transmission and reception of voice using meteor trail refraction. Using meteor burst communications, engineers at GTE's research and development facility transmitted digitized voice radio signals over the trail of an incoming meteor to a remote receiver site in Maine — a distance of 150 miles.

GTE engineers estimate that digitized voice signals carried over a meteor trail can be used for long-haul communications — 300 to 1,500 kilometers (186 to 960 miles).

"Successfully demonstrating that it's possible to send and receive voice transmissions via meteor trails is a technological milestone that can be further developed for military and commercial applications," said Richard R. Fidler, GTE vice president and general manager for the Strategic Systems Division of GTE Government Systems Corp.

Fidler explained that the most effective military radio communications must withstand jamming, resist signal interception and exploitation, and survive the effects of nuclear blasts. "GTE engineers have determined by mathematical calculations and computer simulation modeling that digitized voice signals sent on meteor burst communication channels may effectively work in these situations," he said.

Meteor burst communication allows radio signals to be transmitted beyond the horizon by scattering them from trails produced by incoming meteors. To achieve an acceptable message transmission rate for meteor burst communication, it is necessary to transmit the speech signals in high-rate "bursts," or tightly queued units of data in a continuous stream.

The theoretical technique for scattering radio signals from meteor trails beyond the horizon was developed in the early 1950s. It relies on the ionization of trails produced by incoming meteors as they hit the upper atmosphere and burn up. Such trails can efficiently scatter a transmitted radiowave beyond the horizon in a narrow cone to the receiver. Meteor-trail lifetimes typically range from a few hundred milliseconds to a second or two, occurring at intervals of several seconds to a few minutes. The trails are produced within the "common volume," the intersection of transmitting and receiving antenna beams.

"GTE's approach to successful meteor burst communication was to greatly compress the digitized voice signals so they could be carried over the brief and intermittent meteor trails," said John R. Herman, GTE engineer who headed the experiment.

The GTE experiment, conducted July 9 by GTE's Strategic Systems Division, used directional antennas and voice recognition equipment for transmission as well as a voice synthesizer at the receiving station. The digitized voice signals were sent 100 kilometers (62 miles) above the earth's surface where they met an ionized meteor trail. The signals were then scattered by the trail to the distant receiving station located about 35 miles northwest of Portland, Maine.

GTE Labs Quadruples Digital Speech Compression

GTE Laboratories, in Waltham, Mass., has developed a technology that greatly increases the number of telephone conversations that can be carried by standard cable or radio communication systems while maintaining high voice quality.

The GTE development represents a major milestone in an intense technological effort by various research institutions over the last two decades to expand by a significant amount the channel-carrying capacities of telecommunication systems while maintaining current voice-quality standards. GTE scientists were able to perfect a method of digitizing speech at a rate of 16 kilobits per second for transmission over telephone circuits. The standard rate for this digital communications method, called "pulse code modulation," is 64 kilobits per second. By permitting four conversations in the bandwidth normally occupied by one, GTE's new invention is four times more efficient. As a result of this development, a single hardware unit could carry 96 channels where

Your One-Stop Source for...

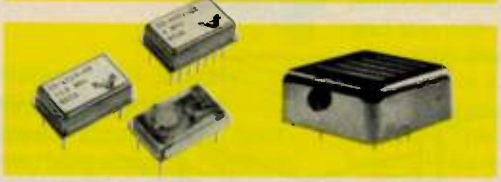
VECTRON

Crystal Oscillators

LOW PHASE NOISE MODELS

	Non-Compensated (XOs)	Temperature Compensated (TCXOs)	Oven Controlled (OCXOs)
			
Frequency:	5 MHz - 1 GHz	1 MHz - 630 MHz	1 MHz - 400 MHz
Output:	+7dBm into 50Ω; TTL, CMOS, ECL and higher level sine optional		
Temp. Stability Options:	±25 ppm over 0/+70°C ± 3 ppm over 0/+50°C ±50 ppm over −55/+85°C	$\pm 2\times10^{-7}$ over 0/+50°C $\pm 5\times10^{-7}$ over −20/+70°C $\pm 1\times10^{-6}$ over −55/+85°C	$\pm 1\times10^{-8}$ over 0/+50°C $\pm 3\times10^{-8}$ over −20/+70°C $\pm 5\times10^{-8}$ over −55/+75°C
Aging:	5 ppm/year (2 ppm/year optional)	1 - 2×10^{-6}/year (depending upon frequency)	1×10^{-8}/day (as low as 1×10^{-10}/day available)
Phase Noise (@ 50 MHz)	1 KHz / 50 KHz	1 KHz / 50 KHz	1 KHz / 50 KHz
Standard:	−125dBc/Hz / −150dBc/Hz	−130dBc/Hz / −145dBc/Hz	−140dBc/Hz / −150dBc/Hz
L2 Option:	−140dBc/Hz / −160dBc/Hz	−140dBc/Hz / −160dBc/Hz	−150dBc/Hz / −160dBc/Hz

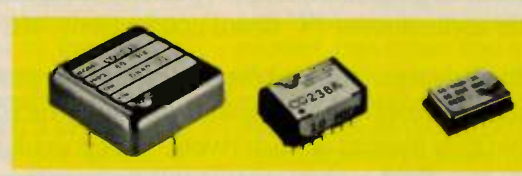
Voltage Controlled Models



	PLL VCXOs	LINEAR VCXOs	VCOs (non-crystal)
Deviation:	±.003% to ±.02%	±.01% to ±1%	±1% to ±33%
Frequency:	to 600 MHz	to 400 MHz	to 500 MHz
Linearity:	±10% to ±20%	±1% to ±5%	±1% to ±10%
Stability: (0-50°C)	±.001%	*±.001% to ±.01%	±.3% to ±1%
	(wider temp. ranges, to −55/+85°C, optional)		

*Higher stability temperature compensated and oven controlled VCXOs also available.

Clock Oscillators (TTL, CMOS, ECL)



	PCB MOUNT	COMMERCIAL DIP (epoxy sealed)	LOW PROFILE DIP (resistance welded)
TTL	1 Hz-100 MHz	16 KHz-100 MHz	16 KHz-100 MHz (QPL'd to MIL-0-55310/16)
CMOS	.01 Hz-15 MHz	N/A	1 Hz-50 MHz (QPL'd to MIL-0-55310/18)
ECL	5 MHz-500 MHz	5 MHz-200 MHz	5 MHz-150 MHz
Accuracy (at 25°C):	±10 ppm, ±15 ppm, ±25 ppm or ±50 ppm (most models also available settable to ±1 ppm via either internal or external variable capacitor).		
Stability:	Standard: ±25 ppm over 0°C to +70°C Option 2: ±50 ppm over −55°C to +125°C Option 5: ± 5 ppm over 0°C to +50°C		

VECTRON

Vectron Laboratories, Inc.

166 Glover Avenue, Norwalk, Connecticut 06850
Telephone: 203/853-4433 TWX: 710/468-3796

The Crystal Oscillator Company

INFO/CARD 20

gence Research Company, 4000 Middlefield Road, Palo Alto, Calif. 94303. Call Wyman Bravard for more information at (415) 856-8200.

High Tech Companies Dissatisfied with Government Trade Actions

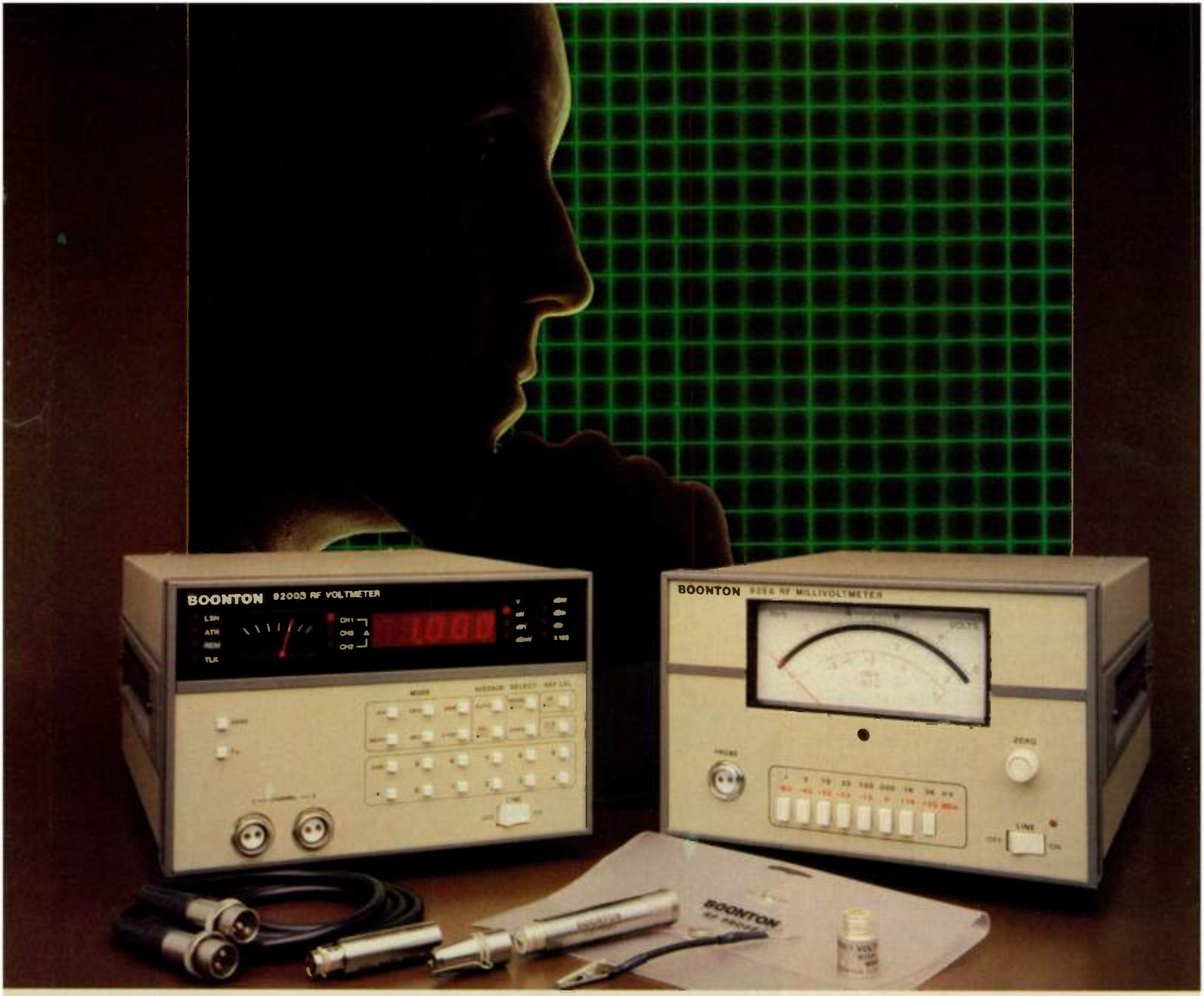
A survey of company attitudes from the equipment manufacturing segment of the high technology industry regarding trade and economic policy as it affects international competitiveness showed that this segment of the high technology industry is becoming dissatisfied with the inability of public policy to help them compete effectively in international markets. The results of this survey by Price Waterhouse, San Jose, Calif., showed that these companies are as concerned today as in 1983 about maintaining their competitiveness in the international marketplace.

Ninety-seven percent believe the ability of the U.S. to compete internationally is an important factor in their economic future. Ninety-one percent worry that the U.S. is in danger of losing its competitive edge in their specific industry. Over half think other countries are taking unfair advantage of U.S. open trade policies. Sixty percent say technology transfer is undermining their competitive position.

All of these responses occurred more frequently in the 1986 survey than in a similar one taken in 1983. An increased number of respondents in the most recent survey rated trade policy as detrimental in promoting economic revenue. U.S. licensing and export restrictions were again cited as barriers encountered by high tech companies trading abroad. Eighty-eight percent said that the interests and problems of companies in their industry are not adequately recognized by the U.S. government.

The 1986 survey indicated that there was increasing support for protectionist or retaliatory approaches to resolving these problems. An additional 16 percent in the 1986 survey supported the U.S. becoming more restrictive in its policies regarding imports. Similarly, an additional 12 percent rated retaliatory restrictive trade policies as "very effective." However, that these views are still held by a minority of those surveyed, indicates that, as in the 1983 survey, high technology companies still do not overwhelmingly favor protectionism.

For more information on policies affecting the high tech industry, contact James M. Coriston, Price Waterhouse, 150 Almaden Blvd., San Jose, Calif. 95113, (408) 282-1200.



WHO DO YOU THINK OF FIRST IN RF VOLTMETERS?

BOONTON

Every brand recognition study proves it. When you think of rf voltmeters, you think of Boonton. After all, we introduced the first sensitive rf voltmeter years ago. Now there's a new generation. Still a choice of high resolution digital and low cost analog models. Still featuring low noise, passive, rms detection with microvolt sensitivity in both unterminated and terminated modes. But now with extended frequency coverage from 10 Hz to 1.2 GHz—to 2.5 GHz with 50-ohm sensor.

A redesigned probe tip mates directly with BNC connectors and accepts all Boonton accessories, including a new convenient ground clip. Detachable and replaceable probe cables available in standard lengths to 100 feet. Special cables to virtually any length.

Choose the digital 9200B and you can store in memory complete calibration data for up to 8 interchangeable probes... low frequency (10 Hz - 100 MHz), standard (10 kHz - 1.2GHz), or 50-ohm (100 kHz - 2.5 GHz). Or add an optional second input channel, GPIB, or MATE interface capability. The analog 92EA is available with a wide choice of meter scales to meet your particular requirements. And both models continue the Boonton tradition for highest accuracy and reliability.

Call your local representative or Boonton directly for full information on the latest generation of rf voltmeters.

Boonton Electronics Corp.
791 Route 10, Randolph, NJ 07869
Telephone (201) 584-1077

Signal Generators ■ Modulation Analyzers ■ RF Power Meters ■ RF Millivoltmeters ■ Capacitance Meters and Bridges ■ Audio Test Instruments

See us at: Midcon, Booth 228, Auto-Test Con, Booth 607, Northcon, Booth 976.

INFO/CARD 22

MMD™ 1.0 W POWER

50 MHz to 2 GHz

BROADBAND AMPLIFIERS

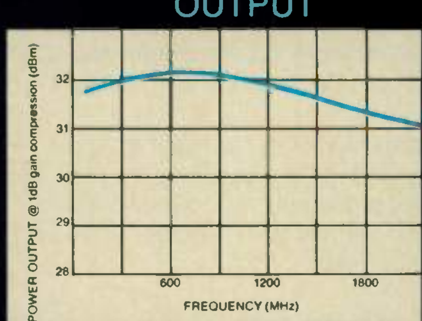
High power, broadband, low-noise performance (−55°C to +71°C) in a "drop-in" package is available from MMD today.

The HPM series of hybrid amplifiers can solve your design problems when space is at a premium and high dynamic range a necessity.

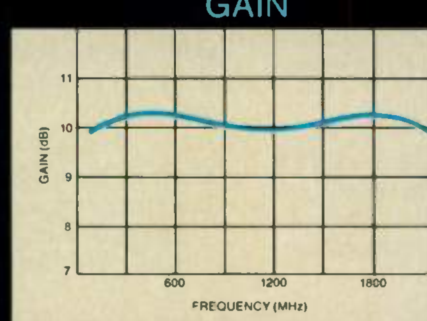
Now available from stock, the HPM-501 (1 watt), HPM-2001 (1 watt), and HPM-1002 (2 watts), offer you unparalleled design flexibility.

Call now for more information or to discuss your custom applications from milliwatts to kilowatts.

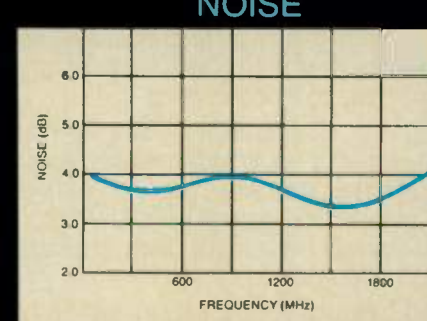
OUTPUT



GAIN



NOISE



Typical performance @ +15V unless otherwise noted

MMD
MICROWAVE MODULES & DEVICES, Inc.
550 Ellis St., Mountain View, CA 94043 (415) 961-1473 TWX 508746

DEMONSTRATION INFO/CARD 24 LITERATURE INFO/CARD 91

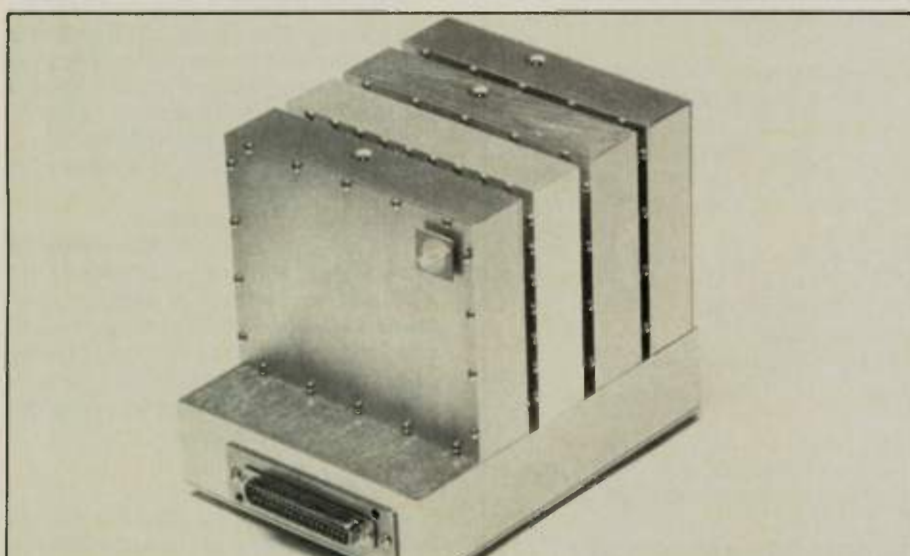
A New Approach to Frequency Synthesis

Sciteq's VDS-M Shatters Accepted Concepts

By Henry Eisenson
Sciteq

Sciteq's VDS-M design project had several goals, including supreme modularity, BITE, simplicity, low power, small size and high reliability. The product consists of four modules mounted on a mother cavity inside which all the interconnections are made. The very small size was made possible by the simplicity of the electrical design. The VDS-M is a phase-lock-loop RF synthesizer with a basic design that is similar to other PLL architectures. Its novelty is in the execution, which exploits advanced devices and techniques that have matured only in the past few years. The general approach improves performance while reducing overall machine size and parts count, which results in better reliability, lower power consumption and less cost.

The VDS-M is made of four modules. Module 1 (reference generator) (Figure 1) uses a SAW resonator to produce the signals required by the RF generator. This module also produces the step size reference for subsequent signal processing. Module 2 (comb generator) (Figure 2) houses a comb generator driven by a 1 W UHF power amplifier. A tubular bandpass filter connects this module to the RF module; it appears as an interconnect in the mother cavity. Module 3 (RF output) includes the VCO and RF signal processing devices. Module 4 (signal processor) uses a combination of programmable dividers, low-noise loop amplifiers and a loop parameter network to accommodate changes in loop characteristics, such as VCO constants and division ratios.



The Reference Generator: SAW Resonators vs. the Conventional Approach

The industry's typical method of building synthesizers in the general category of the VDS-M includes internal reference generation from a 10 MHz or 100 MHz source, with an internal crystal oscillator. This involves multiplication of the reference (and its noise) over very high ratios. Further, the complex circuitry required adds considerably to size, cost and failure rate. Sciteq approached the problem in the light of new surface acoustic wave (SAW) technologies that were simply unavailable when more conventional synthesizers were developed over the past decade. Early in the design process, it was decided to eliminate the expected crystal oscillator and its supporting circuitry.

Advanced SAW resonators were found to have very respectable Qs while operating at frequencies from below 100 MHz to as high as 1.2 GHz. Further, the cost of such a device is lower than the cost of a crystal oscillator and high-ratio multiplication. Several manufacturers offer SAW resonators that could be used in this unit, but the company selected RF Monolithics because a 400 MHz unit was available from that firm without NRE, and the performance of that standard unit met the calculated requirement. Another advantage of the SAW device over a standard crystal oscillator approach is resistance to vibration and shock. When a comb is generated from the output of a crystal oscillator, the BPF must pick a line from a forest of adjacent lines, all close together (100 MHz max.). If a SAW resonator is used, on the other hand, the comb lines can be quite distant and the cost/complexity of the filter is reduced significantly.

The selected approach is shown in the accompanying block diagrams: an internal SAW resonator, operating at 400 MHz, is phase-locked to the 10 MHz reference (Figure 3). That phase-lock circuit uses low bandwidth, and an analog phase detector is used to achieve excellent phase noise characteristics while minimizing the contribution of the reference circuit to the noise performance of the complete unit. The output of the resonator is then multiplied to the desired operating range of the unit, and the required multiple is much lower than would be the case if a crystal oscillator were used. Comparatively, such crystal oscillators typically operate in the 50 to 100 MHz range while the selected SAW resonator runs at 400 MHz. With comb lines that are 400 MHz apart, the task of the BPF is made very simple.

For example, if a 1.6 GHz signal is required, a tubular BPF picks the fourth harmonic. If a 1.2 GHz signal is required, the BPF picks the third harmonic, etc. The

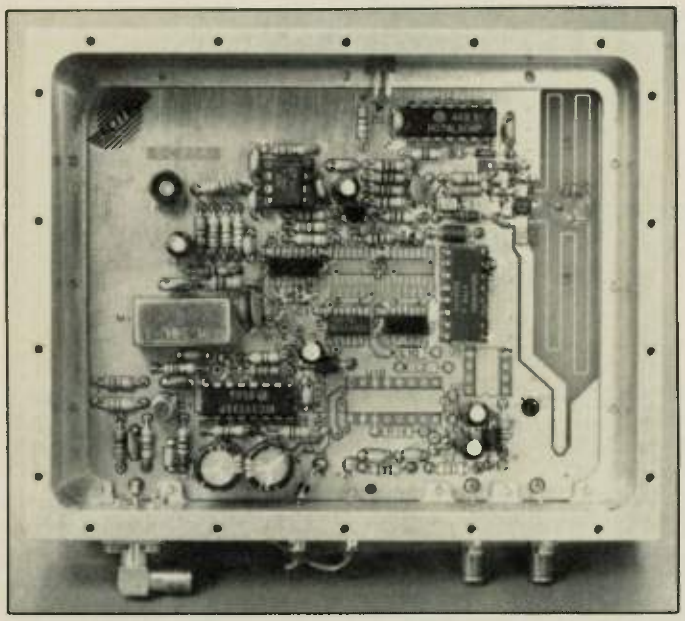


Figure 1. Reference generator module with SAW resonator.

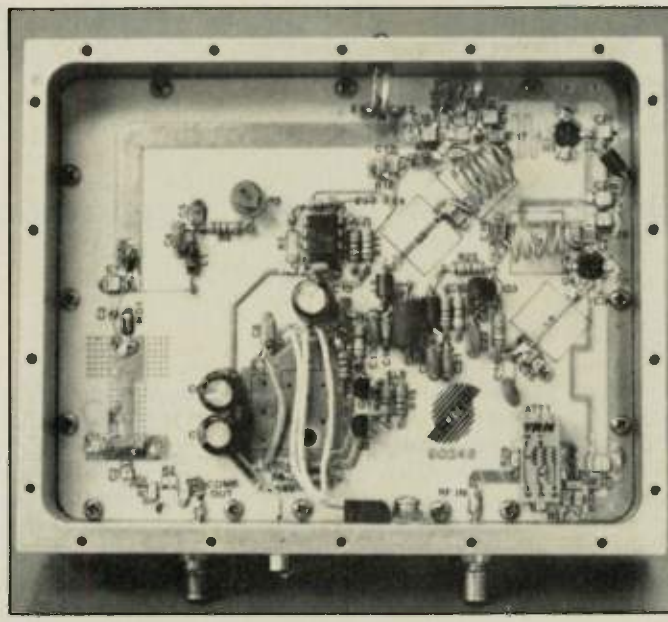


Figure 2. Comb generator module.

tubular BPF was selected because it could double as a replaceable connector between the reference generator module and the RF output module. This starts the synthesis process at a much higher frequency than is otherwise possible, significantly simplifying the overall design and reducing the division ratio (thus favorably affecting noise and vibration resistance). Measured at the final frequency, the noise penalty of the SAW circuit is less than that of its competing crystal oscillator circuit, and low enough to be swamped (>20 dB relative) by the noise from the VCO.

In the VDS-M, one module does all the work of generating the required internal reference; the board within that module is under 4 × 5", and as shown in Figure 1 the circuitry is neither complex nor densely packed. SMD dividers were originally selected to reduce size, but it is now obvious that this precaution was not necessary. That module has sufficient space to house the step size generator as well as the reference generator.

Also within the module is BITE. An out-of-lock detector produces *both* a TTL fault alarm at the interface and a visible LED on top of the module that alerts the technician to the specific location of the fault. This BITE capability reduces MTTR, because a faulty reference generator section can easily be replaced with another without any need for trimming, adjustment or re-alignment.

The characteristics of this reference generator design include:

- the exploitation of advanced SAW devices to eliminate crystal oscillators and reduce required reference multiplication
- a well-designed phase lock between the reference and the SAW
- small size and light weight
- less microphonics and susceptibility to shock/vibration
- low power consumption

The result is an innovative reference generator section that contributes to the VDS-M's combination of excellent performance with simplicity, reliability and economy. In frequency synthesizers that begin development today, this approach will probably be adopted as designers seek similar advantages.

Characteristics of the Sciteq VDS-M

Product	frequency synthesizer				
Manufacturer	Sciteq Electronics, Inc., San Diego, CA				
Designator	Model VDS-M				
Operating Range	500 MHz to 2+ GHz				
Bandwidth	20% standard, 500 MHz available				
Resolution	options: 500 kHz, 1 MHz, 2 MHz, 5 MHz, 10 MHz				
Switching Speed	<1 millisecond				
Spurious	<−60 dBc guaranteed; typically <−70 dBc				
Phase Noise	*offset (Hz)*	*dBc/Hz*	*offset (Hz)*	*dBc/Hz*	
	10	−57	10k	−94	
	100	−80	100k	−110	
	1k	−90	1M	−130	
			10M	−146	
Output Power	+10 dBm ±1 dB nominal				
Output VSWR	better than 1.3:1				
Reference	10 MHz external; internal optional				
Reference Generation	surface acoustic wave (SAW)				
Frequency Control	BCD; external remote control or manual thumbwheel switch				
Power Consumption	less than 10W				
Supply Voltages	+24, −15, +5 VDC				
Mechanicals	four metal modules on base: 6.5" × 5" × 5.5" total				
Connectors	power and control: D-Type; input/output: SMA				
Weight	under 6 pounds complete				
Bite	fault indication by visible alert and electrical signal				

The RF Module

The basic design goals of the VDS-M synthesizer included an unusual combination of simplicity, economy and perform-

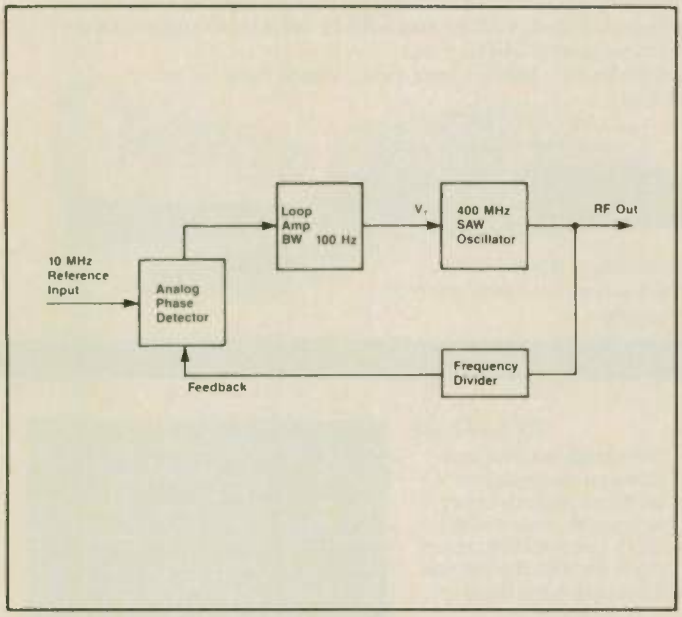


Figure 3. 400 MHz SAW oscillator block diagram.

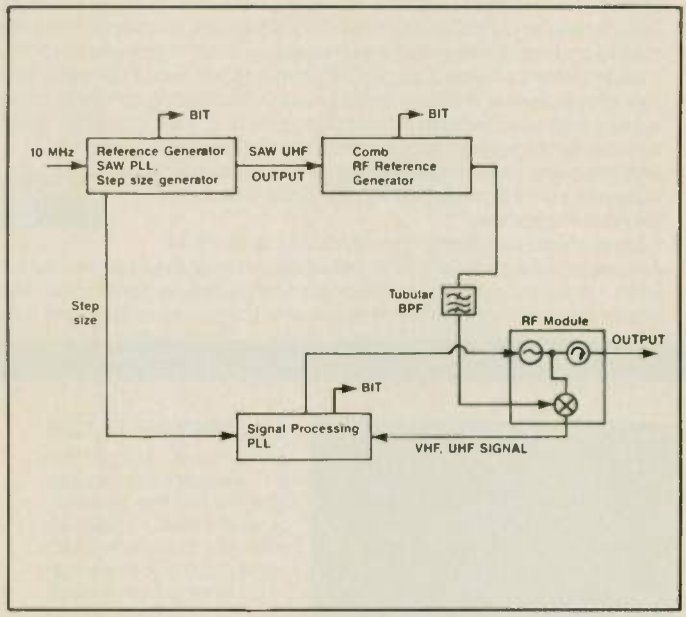


Figure 4. Block diagram of the Sciteq VDS-M frequency synthesizer.

ance. The RF module, then, was critical to the achievement of those goals. It was to house the output oscillator, a mixer and supporting electronics.

If the project were to have followed the beaten path, a cavity oscillator would have been chosen to cover a bandwidth equal to about 10 percent of the center frequency. To maximize the number of applications for which this product would be suitable, the VCO route was chosen. Collateral benefits are many. Elimination of the cavity reduces vulnerability to shock and vibration, and required power is reduced as well. In comparison to a more typical approach, this technique provides increased bandwidth and less microphonics, and results in a smaller and lower-power unit.

A well-designed VCO can demonstrate noise characteristics very competitive with cavities, and noise was the primary criterion by which a VCO was chosen.

The electrical task performed by this module includes generation of the output signal from a VCO and mixing of the output with the reference to produce the down-converted RF output for the signal processing module. The selected VCO can be pulled sufficiently to permit synthesizer bandwidth of at least 20 percent, a figure that has been set as "standard" for the overall unit. In fact, the true bandwidth limitation of the VDS-M is 500 MHz.

Performance of the RF module was ensured by two methods. First, the electrical design was kept simple and in accordance with very recent design ideas. Second, microstrip construction was used to minimize potential signal purity problems. Duroid™ is used in this unit for low-loss signal routing and ease of production. An isolator was added between the VCO and the output port to improve VSWR and to reduce external loading effects upon the VCO.

Considering the requirement for modularity, the optimum result would be an RF module that contains all factors that determine the output frequency of the synthesizer. This would permit changing the output frequency of the synthesizer by replacing only one of the four modules. The customer's logistics and Sciteq's order processing would both be made more efficient if this result were attained. In the end, it was. To change the output range of the unit, the RF module and a tubular filter (that connects the RF module to the reference generator) must be changed. No other adjustments or changes are required.

This degree of modularity is in itself unusual if not unique. Combined with increased bandwidth and reduced susceptibility to mechanical disturbance, low noise, low power consumption and great simplicity, the RF module is considered an overwhelming success. It makes an important contribution to the performance and capabilities of the VDS-M synthesizer.

Signal Processing

This module is the brains of the VDS-M frequency synthesizer. It is basically a PLL control structure that has options and hooks within it to accommodate the requirements of the user, such as switching speed, step size (500 kHz, 1 MHz, 2 MHz, 5 MHz, 10 MHz), frequency control word and other characteristics. It is constructed using SMDs and chip components, with a combination of ECL and FAST devices, and ultra-low noise monolithic amplifiers.

The circuitry was designed to provide a bandwidth of 500 MHz, which is the limit of the product. Such bandwidth should be an "alert" to the competent observer, who will question the capability of the circuitry to support it. In fact, the VDS-M has hardware to compensate for large divider variations and nonlinear modulation sensitivity of the VCO. Taken individually, these issues and their resolution are quite straightforward. Collectively, they pose an apparent problem that has been resolved satisfactorily in the VDS-M.

Implementation of circuitry for low noise performance when dealing with 50 MHz/V modulation sensitivity is a difficult task that requires careful balancing of all variable parameters, and equal care in selecting parts. Even layout must be treated wth extreme care to reduce noise interference that may attack this ultrasensitive VCO control line.

In summary, the signal processing module is critical to the performance of the synthesizer. One of the major advantages of the VDS-M is that this portion of the circuit is in its own module. This permits extreme variability, without disturbing the remainder of the design, to meet the needs of each application. rf

SURFACE ACOUSTIC WAVE TECHNOLOGY

provides performance advantages and design flexibility that have proven invaluable to engineers in need of reliable, reproducible components featuring linear phase, temperature stability, small size, or other SAW characteristics. Increasingly, SAW technology is meeting the exacting requirements of modern systems with high performance bandpass filters, resonator products, delay lines, and other state-of-the-art signal processing components. Sawtek offers the industry's broadest product line and provides the total engineering support needed to make the proper design trade-offs among key parameters in order to achieve the optimum performance available from SAW technology.

Sawtek produces hundreds of standard SAW products for both low and high volume programs in Cable Television, Satellite Communications, Modems, Radar, EW, and many other applications. In addition, Sawtek's custom design capability can provide technical assistance and rapid response to new design and production requirements at frequencies from 10MHz to more than 1GHz. Sawtek also designs and produces subsystems which incorporate SAW components. These include filter banks comprised of cascaded filters packaged in a single assembly, SAW resonator-controlled oscillators, and ovenized components.

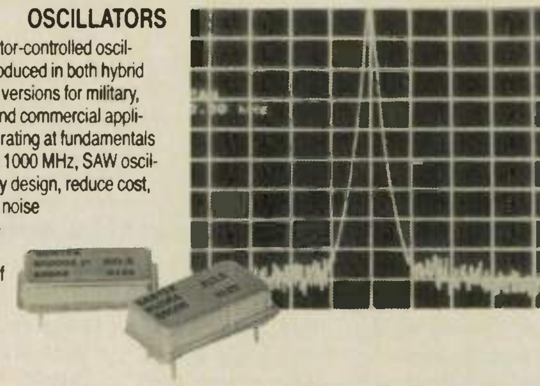
Sawtek maintains a leadership role in SAW technology through the development and production of superior SAW components and a proven track record of delivering these reliable, high performance products on time and at a very competitive price. Product reliability for Sawtek's broad range of military and commercial parts is insured by a watchful quality control program that meets even the exacting requirements of military and space applications.

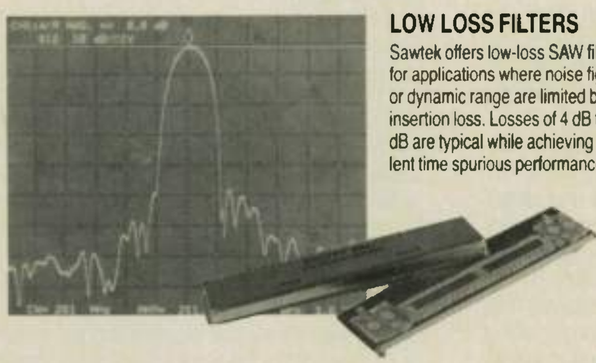
SAW BANDPASS FILTERS

SAW bidirectional bandpass filters are available at frequencies from 10 MHz to 1000 MHz. Fractional bandwidths from 0.1% to 65% are produced with insertion loss that is typically 15 dB to 30 dB with shape factors as low as 1.15:1 and linear phase response.

OSCILLATORS

SAW resonator-controlled oscillators are produced in both hybrid and discrete versions for military, aerospace and commercial applications. Operating at fundamentals to more than 1000 MHz, SAW oscillators simplify design, reduce cost, and improve noise performance through the elimination of multiplier stages.



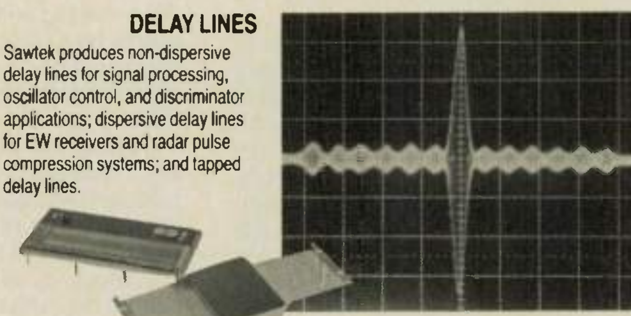


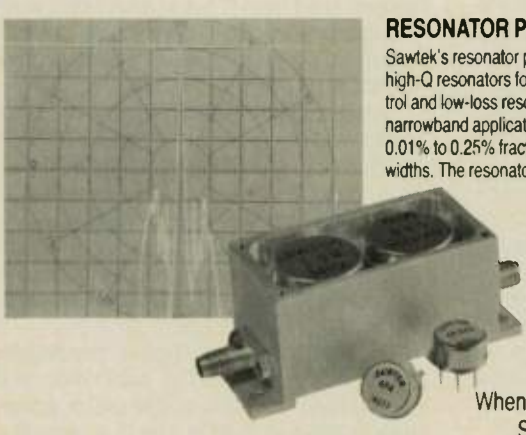
LOW LOSS FILTERS

Sawtek offers low-loss SAW filters for applications where noise figure or dynamic range are limited by filter insertion loss. Losses of 4 dB to 10 dB are typical while achieving excellent time spurious performance.

DELAY LINES

Sawtek produces non-dispersive delay lines for signal processing, oscillator control, and discriminator applications; dispersive delay lines for EW receivers and radar pulse compression systems; and tapped delay lines.



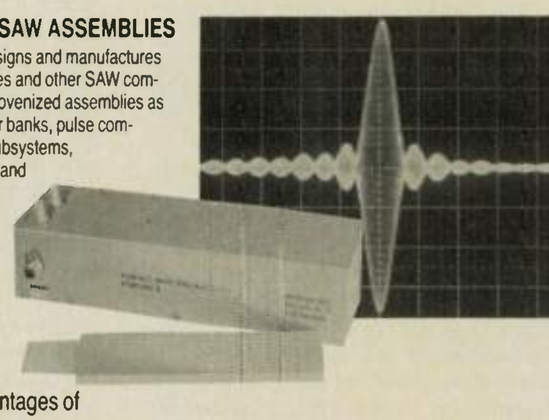


RESONATOR PRODUCTS

Sawtek's resonator products include high-Q resonators for oscillator control and low-loss resonator filters for narrowband applications requiring 0.01% to 0.25% fractional bandwidths. The resonator filters are provided in individual two-pole stages and in custom modules.

SAW ASSEMBLIES

Sawtek designs and manufactures RAC devices and other SAW components in ovenized assemblies as well as filter banks, pulse compression subsystems, oscillators, and specialized signal processing modules.



When your system demands the advantages of SAW Technology... Demand Sawtek.

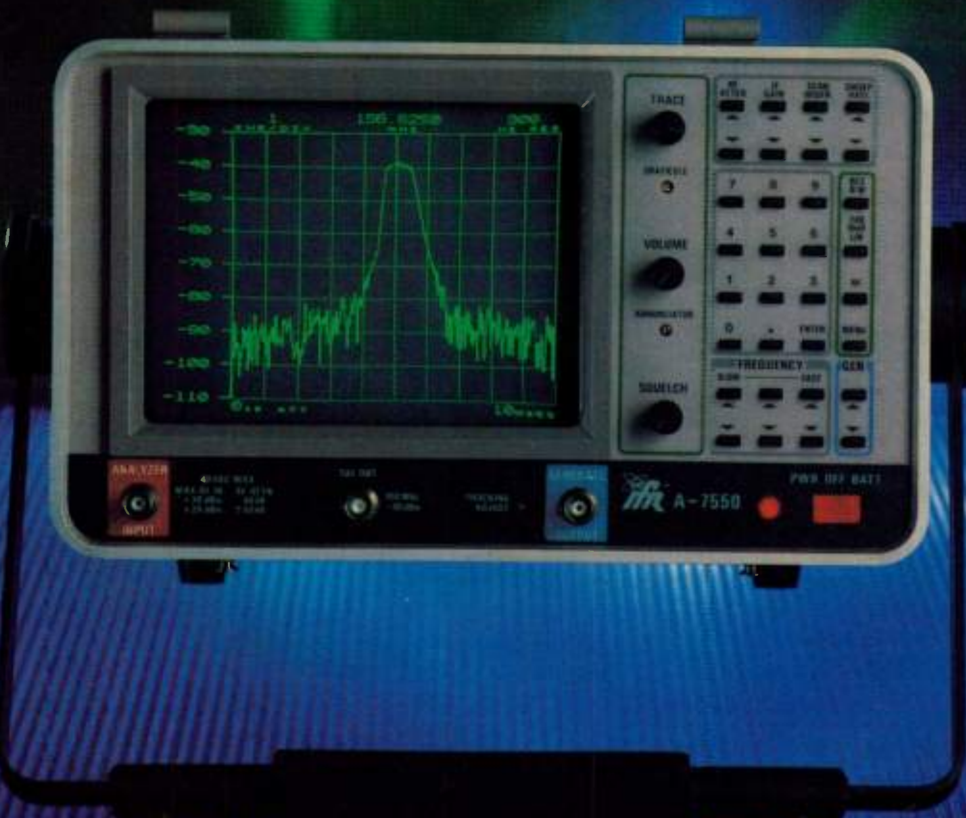
SAWTEK INCORPORATED

Post Office Box 18000 • Orlando, Florida 32860

(305) 886 8860

INFO/CARD 25

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:

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

Optional Features Include:

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

Contact your local IFR authorized distributor for a demonstration.

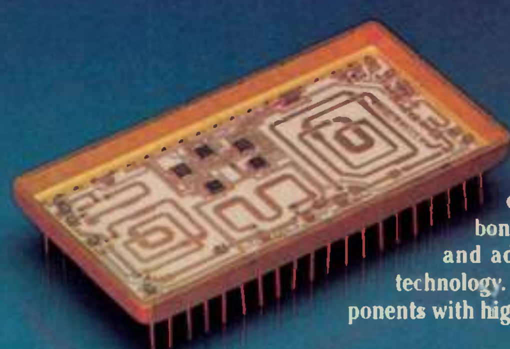
IFR INC

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

A Subsidiary of Regency Electronics Inc

INFO/CARD 26

DAICO HIGH RELIABILITY R.F. MIC STEP PHASE SHIFTERS



Daico step phase shifters combine thin-film microstrip circuitry, automated wire-bonding, computer aided testing, and advanced solid-state switch technology. The results are reliable components with high stability and accuracy.

The following typical characteristics define the range of specifications of parts already developed and delivered to a variety of customers:

Frequency Range:	200MHz to 2GHz (f_0 to be specified)
RF Power Handling:	Up to +20dBm
Insertion Loss:	0.5 to 1dB Per Bit (depending upon frequency)
Insertion Loss Variation:	Compensated to within 0.5dB
Phase Steps:	1 to 6 Bits
MSB Range:	45° to 360° (depending on frequency, number of bits and package size)
Phase Accuracy:	±2°
Control Configuration:	CMOS, TTL, ECL Uncoded, Coded or Latched
Switching Speed:	100 nanoseconds to 10 microseconds (depending on control configuration)

If your system requires cost effective switches, step or voltage-controlled attenuators or step-phase shifters with:

- ☐ Fast switching speeds
- ☐ Low switching transients
- ☐ Phase or attenuation compensation
- ☐ High isolation
- ☐ MIC DIP or Flatpack packaging

Call Daico for a prompt, realistic response.

SURFACE MOUNT PACKAGES SOON TO BE AVAILABLE.

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

INFO/CARD 27

We mass-produce DTOs when few others can

We manufacture Digitally Tuned Oscillators in production quantities. We are currently producing them for the ALQ-161 (B-1B Bomber), ALQ-172 (PAVEMINT) and the ALQ-126B systems at a rate in excess of 100 units a month.

When you need DTO's for your vital military system, come to M/A-COM Omni Spectra for quality, performance and delivery to your specifications.

- *2-18 GHz* ■ *Broad bandwidths* ■ *10-12 bit tuning*
- *Frequency accuracy to ± 5 MHz*

M/A-COM

Omni Spectra, Inc.

2626 South Hardy Drive, Tempe, Arizona 85282
(602) 966-1471 □ TWX 910-950-1296 □ TELEX 668-332

M/A-COM Omni Spectra also produces VCOs, DROs, Amplifiers (GaAs FET), and multi-functional assemblies

INFO/CARD 28

Profile of the RF Engineer

A Survey of Readers Reveals a Fast-Growing, Well-Paid Specialization.

By Keith Aldrich
Publisher, RF Design

The "typical" U.S. reader of this magazine is a male in his late thirties with a BSEE and six years' experience in RF engineering who thinks the work is an "extremely desirable" specialization. He earns more than $45,000 a year working in R&D or product design for a company which employs more than 4,000 people, but only 600 at the location where the reader works. He uses a PC computer to help him design military and aerospace systems in the MHz frequencies — and he likes his language BASIC.

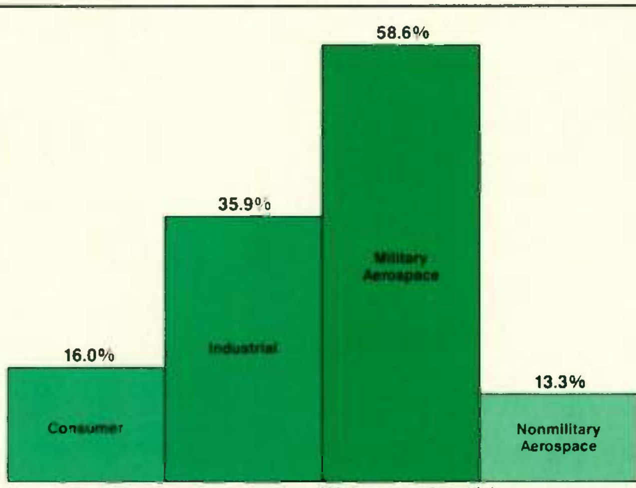
Like most composite pictures, this demographic profile will bear a striking likeness to many individual readers, even though many others will also differ from it in significant respects. The sketch is drawn from more than a dozen means, medians and majorities, based on response to as many questions in a recently completed mail survey of *RF Design* readers in the U.S.

Questionnaires were mailed in the survey to almost 3,000 readers who represented an every "nth" sample of about 32,000 U.S. subscribers, and almost 600 questionnaires were returned. The response illuminates many facets of the emerging community of RF engineers which have lurked somewhat in shadow. Some of the detail is eye-opening.

For instance, 58.6 percent of readers reported that they are working mainly in "military/aerospace" applications (Figure 1) — as opposed to only 35.9 percent in "industrial," 16 percent in "consumer," and 13.3 percent in "nonmilitary aerospace." Prior to the survey many analysts had supposed that the majority of RF engineers were employed in the industrial and consumer sectors with only a minority in military and aerospace. The supposition was based largely on the public visibility of such industrial and consumer applications as cellular radio and cable TV. However, the opposite is true. Roughly two out of three readers work either in military/aerospace or nonmilitary aerospace. They cited the following specific applications, among many others . . .

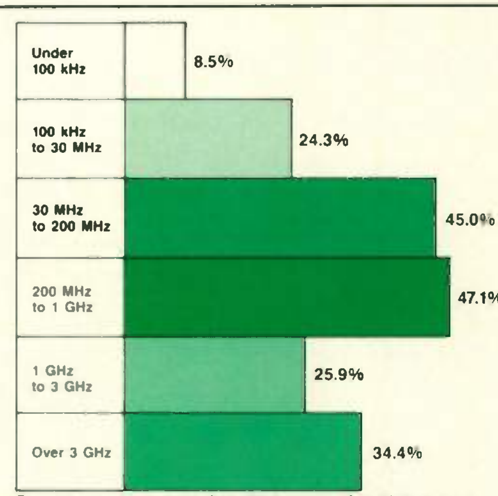
- Airborne platform phased array antenna
- Airborne radars
- Airborne receiver front end
- Aircraft collision alert system
- Communications equipment for military
- Components and multiplexers for satellite
- Electronic warfare systems
- Flight remote control system
- Jammer and simulator VCO
- L-band mobile satellite terminal
- Military identification systems
- Radar and missile systems
- Satellite up-down links
- Telemetry for tracking from aircraft

Another surprise came in response to a question which asked readers to "in-



Percentages add to more than 100 because of multiple answers.

Figure 1. "Indicate the one or two application areas in which you mainly work."



Percentages add to more than 100 because of multiple answers.

Figure 2. "Indicate the one or two frequency ranges in which you mainly work."

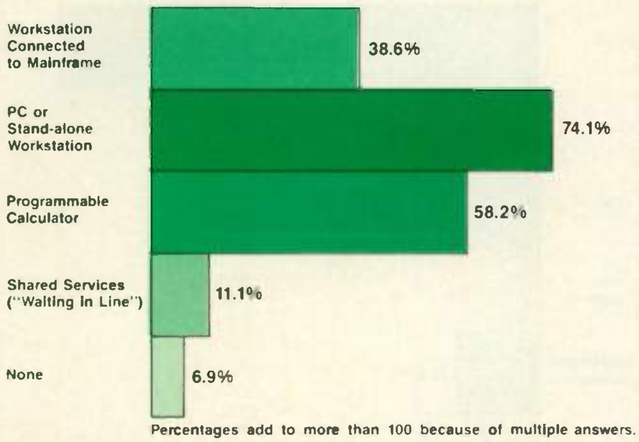


Figure 3. "Indicate (all) the types of computer resources available to you (for CAD/CAE)."

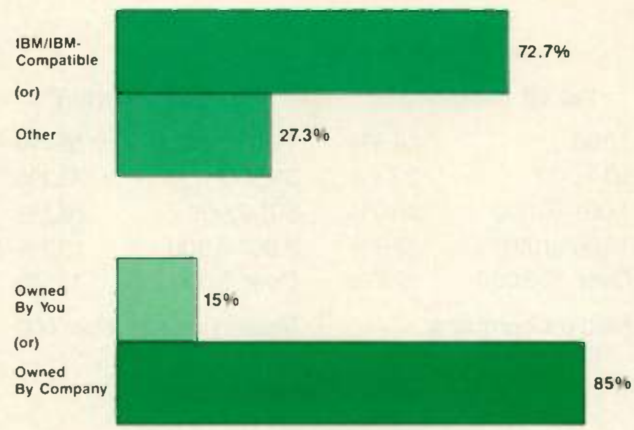


Figure 4. "If you use a PC at work is it. . ."

dicate the one or two frequency ranges in which you *mainly* work" (Figure 2). As expected, the greatest concentration of readers work in the Megahertz bands (45 percent in the range from 30 to 200 MHz and 47.1 percent in the range from 200 MHz to 1 GHz). The unexpected surprise: the next most popular range was the top one, "over 3 GHz." More than one out of three readers (34.4%) cited the microwave frequencies as a major area of their work even though *RF Design's* editorial focus is on frequencies below 3 GHz. The phenomenon probably reflects a growing number of applications in which it is necessary to get from lower frequencies to higher ones or vice-versa, as in uplinking and downlinking for satellites. We welcome letters from readers whose work emphasizes both higher and lower frequencies, telling us about the applications.

Good news for CAD vendors came in response to a question which asked readers to name all the types of computer resources they have available for computer-aided design (Figure 3). Answers revealed that 74.1 percent of readers use a "PC or stand-alone workstation" — substantially more than the 58.2 percent that use the more traditional programmable calculator. Obviously, many engineers use both, but a large number seem to prefer the PC or workstation. In addition, 38.6 percent of readers use a "workstation connected to mainframe." Only 11.1 percent of readers have to "wait in line" to use a shared-service computer, and only 6.9 percent have access to none of the foregoing resources.

Of the overwhelming majority of readers who use PCs (Figure 4), 72.7 percent use IBM or IBM-compatible PCs. Hewlett Packard machines of several models are used by half of the remaining 27.3 percent. BASIC programming language is preferred by 69 percent of the PC users. Just 15 percent of PC users use their own machines, as opposed to PCs owned by their companies.

How RF engineers feel about RF engineering was gauged by a question which asked respondents to rank the work "as a specialization in the engineering field" on a scale of one to five, with five being "extremely desirable" (Figure 5). Almost 90 percent of respondents ranked the job either four or five (overall averaged rank 4.17), indicating a high degree of professional pride on the part of RF engineers. This finding is in striking contrast to the image surrounding RF work just a few years ago, when digital microcircuits were all the rage and electronic magazines all but ignored RF technology. The self-esteem felt by RF engineers today almost surely reflects an increased respect accorded by the general engineering community.

In terms of their companies' organizations, readers work mainly in research and development (50%) and product design (40%), and 30.4 percent of them are engineering managers (Figure 6). Other technical functions, such as production engineering and quality assurance, are

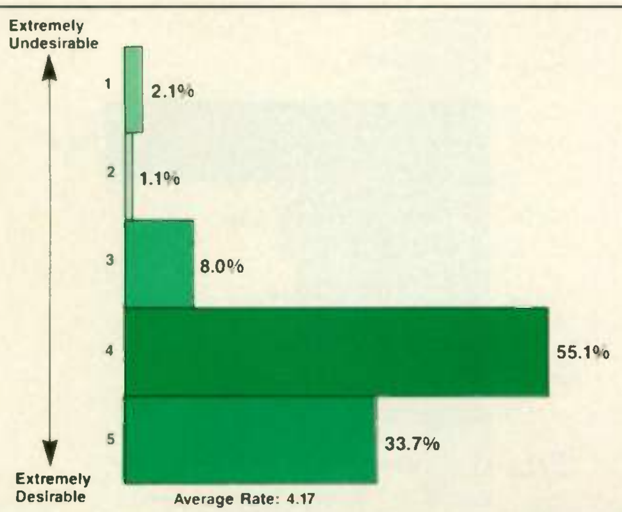


Figure 5. "How do you rate RF engineering as a specialization in the engineering profession?"

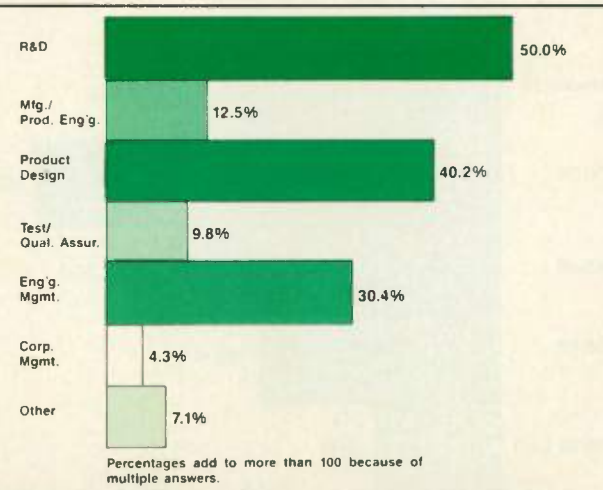


Figure 6. "Indicate the one or two areas of your organization's operations in which you mainly work."

"at all locations"		"at your location"	
1-100	14.3%	1-50	16.4%
10-1,000	23.1%	51-500	32.1%
1,001-10,000	29.9%	501-2,000	26.7%
10,001-100,000	29.9%	2,001-5,000	13.3%
Over 100,000	2.7%	Over 5,000	11.5%
Median company size: 4,000		Median location size: 600	

Figure 7. "How many people are employed by your company?"

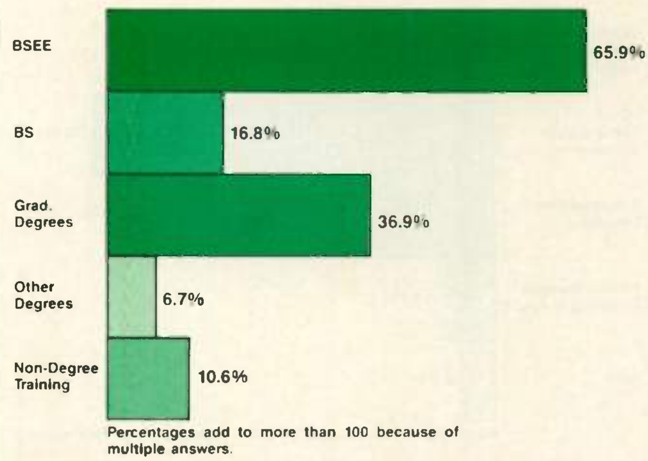


Figure 8. "Indicate the degrees or other training you have received."

performed by small percentages of readers.

The companies or institutions which employ RF engineers tend to be large (Figure 7). Only 14.3 percent of readers work in companies with as few as 100 employees, while two-thirds work for companies with more than 1,000. The median size of the location where the reader works, however, is only 600.

Nine out of ten readers have degrees (Figure 8) and for 65.9 percent the degree is a BSEE. BS degrees in other fields are held by 16.8 percent, with majors in physics and mathematics predominating. Graduate degrees are also held by 36.9 percent of readers, and a third of those are the MSEE. Among the 10 percent of readers who do not have degrees, technical schools and various armed services are mentioned most often as the source of training.

Readers were asked whether their training included any RF or microwave subjects and 78 percent of them said yes. They named 101 schools where such RF training was received. Among those mentioned most often were. . .

- University of Southern California
- University of California, Los Angeles
- University of California, Berkeley
- University of Illinois
- University of Massachusetts
- University of Texas, Austin
- University of Missouri, Rolla
- Stanford University
- University of Colorado
- Massachusetts Institute of Technology
- Johns Hopkins University
- Newark College of Engineering
- Penn State

Age and experience questions indicate a youngish population with recent, rapid growth (Figures 9 and 10). Over half the readers are under 40, and 22.9 percent are under 30. The ages suggest a recent influx in the field. The suggestion is borne out by response to the experience question, which indicates that 45 percent of readers have been in RF engineering less than five years. Many readers apparently began their engineering careers in other specialties; while the median RF experience is 6 years, the median total engineering experience is 12 years.

RF engineers are well paid, and overwhelmingly (99%) male (an editorial on the latter subject appears on page 8). The median salary is over $45,000 per year, and not a single reader reported a salary of under $25,000, no matter how young. Fully 21.5 percent of readers earn in excess of $55,000.

Amateur radio enthusiasts in the profession may be surprised to learn that only 33.8 percent of the respondents said they were hams. Apparently, amateur radio is not the activity that motivates most people to enter the RF engineering field.

Where do RF engineers come from? The results of this survey have raised questions while they provided answers. Perhaps a future *RF Design* survey will help complete this description of the RF engineer. rf

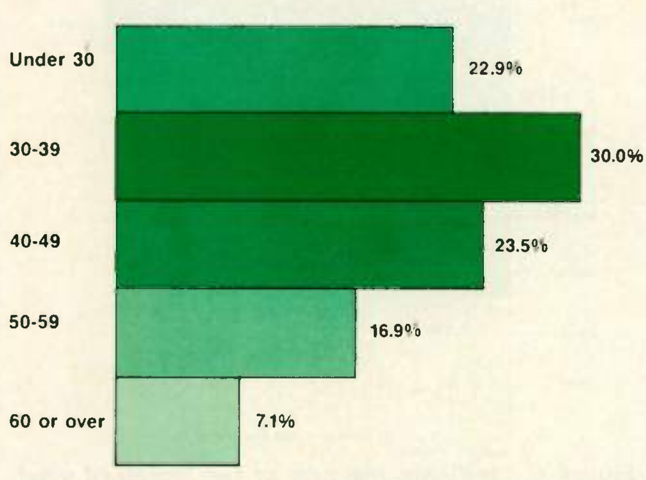


Figure 9. "What is your age range?"

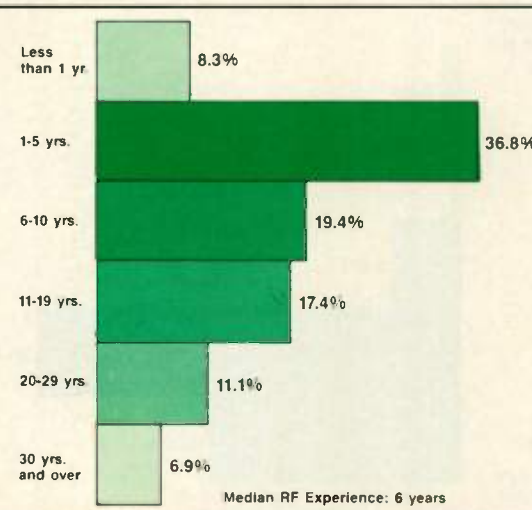
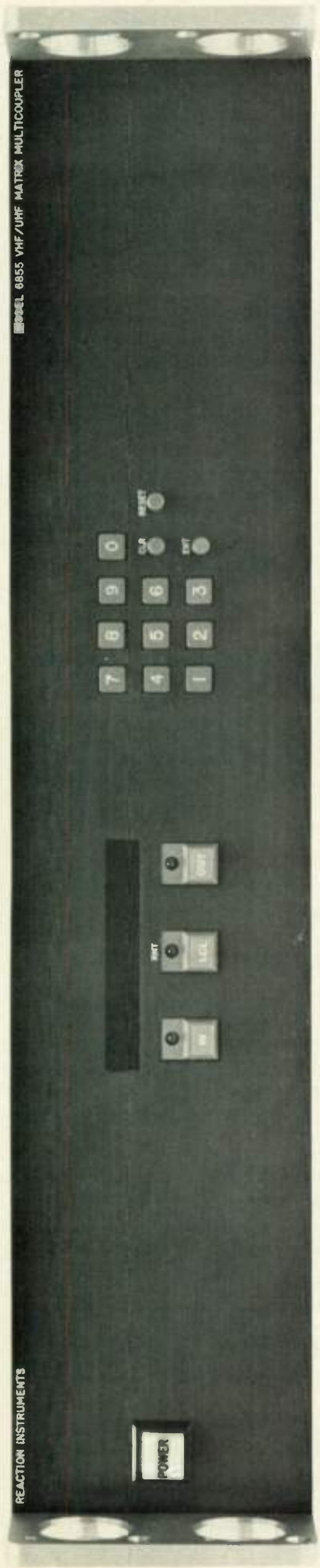


Figure 10. "How many years work experience do you have in RF engineering?"


MODEL 6855 VHF/UHF MATRIX MULTICOUPLER
REACTION INSTRUMENTS
POWER

Choose Alan precision attenuators for performance, service and value

You are assured of premium performance when you select Alan precision attenuators. We have been manufacturing reliable attenuators to meet the highest standards of commercial and military requirements since 1971. These devices deliver thousands of hours of accurate attenuation, low insertion loss, flat frequency response and low VSWR.

Our service provides you convenience. You receive price and delivery information on standard items immediately. Quotations on custom designs are given in 48 hours or sooner. Schedules are kept. Delivery is prompt. Our wide selection of products covers virtually all microwave/RF applications. Here is a brief description of our standard attenuator line:

Programmable
Three series, 15 models, attenuation up to 127 dB

Rotary
Six series, 36 models, attenuation up to 130 dB

Cam Actuated
Two series, 8 models, attenuation up to 130 dB

Manual Switch
Six series, 17 models, attenuation up to 102 dB

Fixed
Four series, 10 models, attenuation up to 60 dB

Continuously Variable
Two series, 17 models, attenuation up to 40 dB

All of our attenuators must pass rigorous tests under our Quality Assurance Program. The criteria for these complies with MIL-Q-9858A and MIL-STD-45662. In addition, many of our attenuators are qualified under MIL-A-3933D and MIL-A-24215A.

We offer performance, service and products at competitive prices for greater value. Specify Alan precision attenuators from either our standard line or we can custom design to meet your requirements. We want to prove we are your best source. Contact us today.

Alan

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

Manufacturers of...

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

INFO/CARD 61

Calibrating RF Test Fixtures

A Method of Reducing Uncertainty in Network Analyzer Characterization of Components.

By D.W. Hughes and C.T. Rucker
Georgia Tech Research Institute, and
R.K. Feeney and D.R. Hertling
School of Electrical Engineering,
Georgia Institute of Technology

Many users of network analyzers desire to make measurements on devices clamped in a calibrated test fixture (1-4). Some manufacturers offer elaborate fixture assemblies with insertable standards and the appropriate software to calibrate the ensemble, but more often the particular fixed loads, sliding loads, shorts, opens and thrus necessary to calibrate such a fixture are unavailable. This article describes a method to more easily use a test fixture by extending the calibration plane from the "normal" calibration position to the desired location within the fixture itself.

The technique is illustrated using the Hewlett-Packard 8510A network analyzer and an HP 11608A transistor fixture. Obviously, other measurement hardware can also be employed. A diagram of a typical test configuration appears in Figure 1 and a procedure to calibrate this equipment is summarized below. It should be emphasized that successful use of the technique described here requires that the transmission lines integral to the fixture be well matched to the test cabling shown in Figure 1. Any significant discontinuities in the fixture transmission lines or connectors require additional analysis to remove their effects (5).

Step 1 — Instrument Calibration

Remove the test fixture from the cable ends and calibrate the network analyzer-cable combination using the coaxial shorts, opens, sliding loads and fixed loads commonly available. For the particular hardware described above, the HP 8500A 7mm calibration kit contains the appropriate standards.

Upon completion of this step, the equipment will be calibrated at the cable ends as illustrated in Figure 2. It is possible to verify this calibration by measuring the standards used for the original calibration itself. If everything is working properly, traces similar to those presented in Figure 3 will be observed.

Step 2 — Fixture Calibration

Connect the test fixture to the cable ends in preparation for extending the calibration planes from their present position at the cable ends to the interior of the fixture. Two different ways of doing this extension are offered.

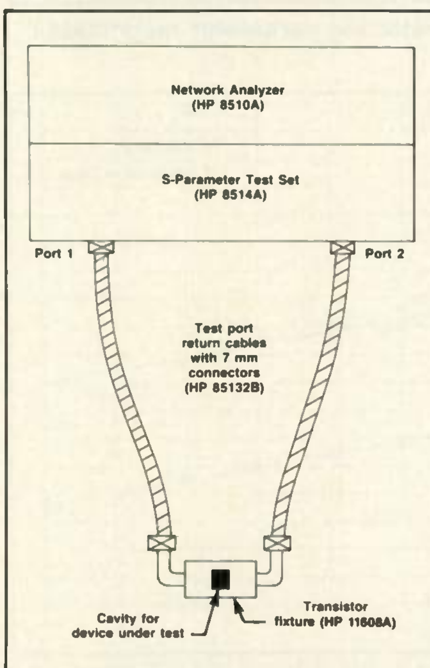


Figure 1. A typical test configuration.

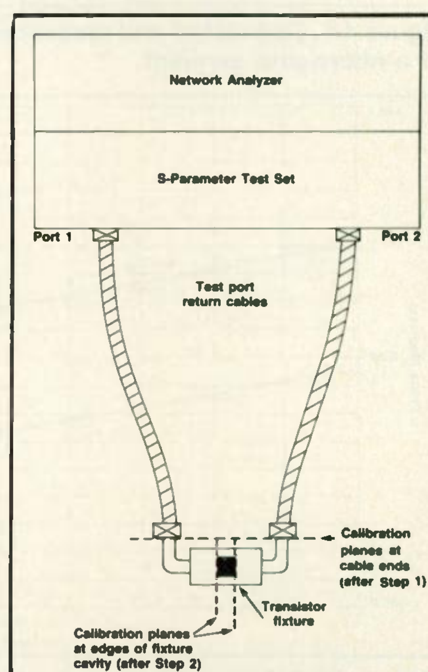


Figure 2. Location of calibration planes.

Frequency (GHz)	S_{11} magnitude	S_{11} phase	S_{21} magnitude	S_{21} phase	S_{12} magnitude	S_{12} phase	S_{22} magnitude	S_{22} phase
1.0	0.02	79.22	1.00	-8.85	1.00	-8.85	0.02	79.22
2.0	0.03	70.93	1.00	-17.71	1.00	-17.71	0.03	70.93
3.0	0.05	62.33	1.00	-26.55	1.00	-26.55	0.05	62.33
4.0	0.06	53.64	1.00	-35.40	1.00	-35.40	0.06	53.64
5.0	0.07	44.91	1.00	-44.23	1.00	-44.23	0.07	44.91
6.0	0.09	36.16	0.99	-53.06	0.99	-53.06	0.09	36.16
7.0	0.09	27.40	0.99	-61.88	0.99	-61.88	0.09	27.40
8.0	0.10	18.64	0.99	-70.70	0.99	-70.70	0.10	18.64
9.0	0.11	9.86	0.99	-79.52	0.99	-79.52	0.11	9.86
10.0	0.11	1.08	0.99	-88.35	0.99	-88.35	0.11	1.08
11.0	0.11	-7.72	0.99	-97.19	0.99	-97.19	0.11	-7.72
12.0	0.10	-16.53	0.99	-106.04	0.99	-106.04	0.10	-16.53

Table 1. Scattering parameters for a thru transmission standard.

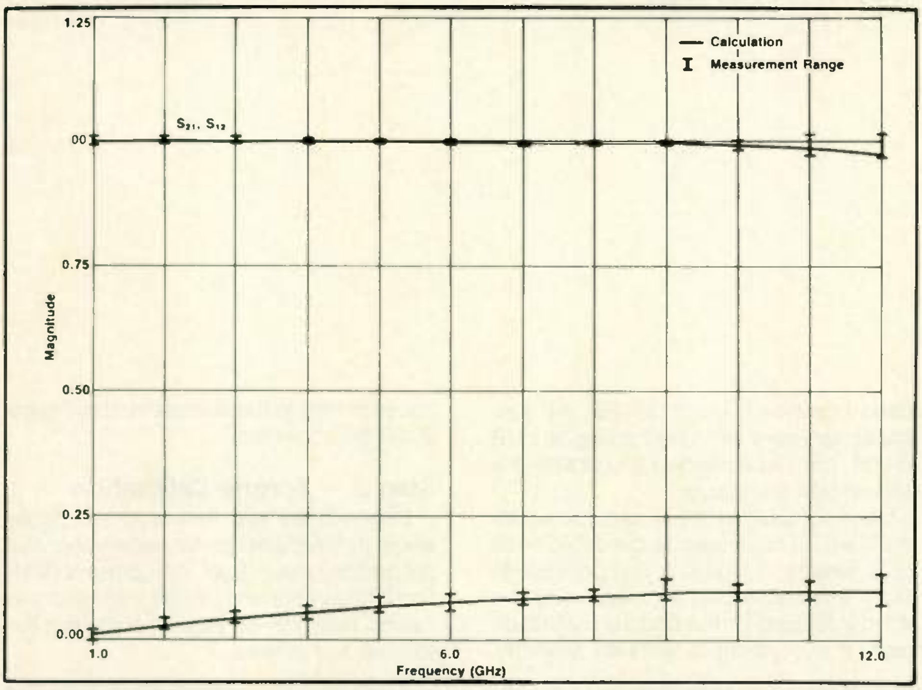


Figure 4A. Calculated and measured scattering parameter magnitudes of a microstrip element.

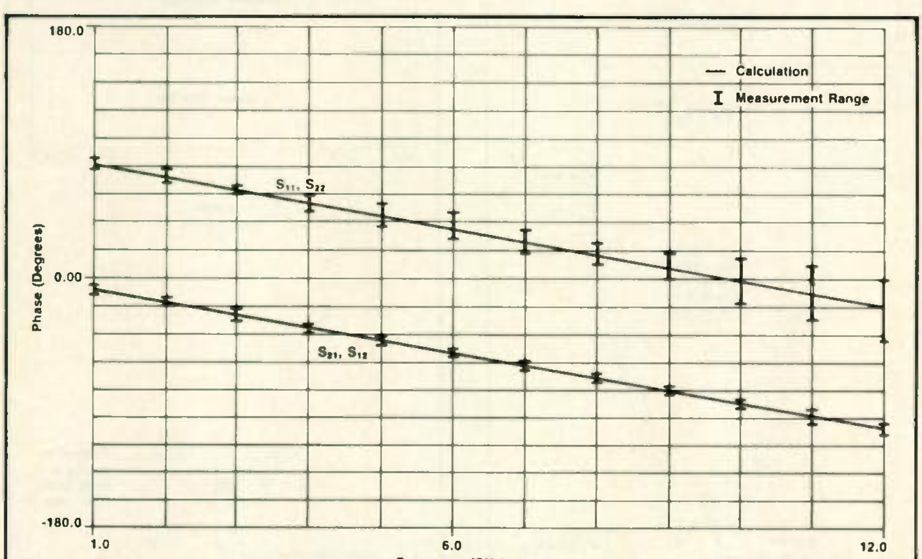


Figure 4B. Calculated and measured scattering parameter phases of a microstrip element.

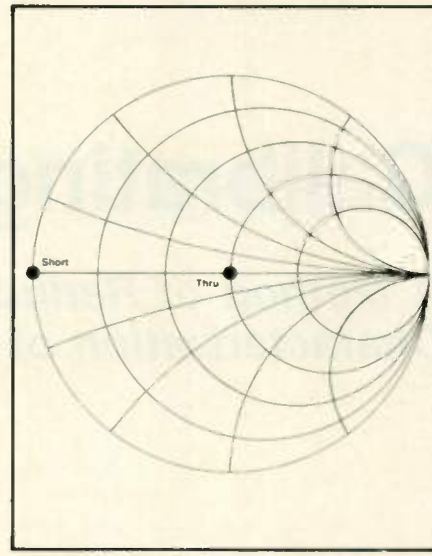


Figure 3. Smith chart traces for ideal short and thru.

Option 1: Place a properly sized shorting block in the cavity normally reserved for the device under test and observe the S_{11} response. Note that instead of seeing a dot representing the short as in Figure 3, the trace makes a lengthy excursion around the Smith chart. This is a consequence of the phase delay experienced by the signal in traveling from the present calibration plane at the port 1 cable end through the fixture to the initial edge of the shorting block and back again. A similar phenomenon is apparent when looking at the port 2 reflection parameter, S_{22}. Now, by adjusting the network analyzer to extend both of the port 1 and port 2 calibration planes, each of the respective traces can be collapsed to a dot. This indicates that the two calibration planes are now coincident with the corresponding edges of the shorting block, as desired.

Option 2: Position a thru transmission standard in the cavity normally reserved for the device under test. Hewlett-Packard supplies a thru line which exactly fits into the HP 11608A test fixture used in this example. Alternatively, such a thru can be fabricated by using a section of microstrip transmission line mounted on a rigid substrate. In either case, the port 1 cable end is now connected to the port 2 cable end by a well-matched transmission line containing no significant discontinuities. Moreover, the thru line insert described above can be easily and accurately modeled with a microwave computer program. For example, the microstrip line element available in Touchstone™ has been found to adequately represent the insertable thru. A scattering parameter matrix calculated using Touchstone for such a thru appears in Table 1. Notice that the angular component for each of the S_{21} and S_{12} entries in the table represents the electrical length of the thru insert at the corresponding frequency. Thus, it is a simple matter to extend both the port 1 and port 2 reference planes until the electrical lengths of the thru insert as measured by the network analyzer are identical to the electrical lengths found with the Touchstone simulation.

Regardless of whether option 1 or option 2 was exercised in Step 2, the calibration planes have now been extended from the cable ends to the desired locations inside the test fixture. The results of these port extensions are illustrated in Figure 2 and the fixture is now ready for use.

Results

Port extension experiments have been performed using both option 1 and option 2. The values of the resulting port extensions determined with these two independent methods agree to within about 0.5 percent. As a further check, a section of microstrip has been placed in a system calibrated as discussed above and measured with a network analyzer. The same piece of line has been simulated using Touchstone and the similarity between the measured and calculated responses is apparent from Figure 4.

This procedure to calibrate a microwave test fixture connected to a network analyzer does not require a comprehensive set of calibration standards sized to the fixture cavity. Instead, it depends upon extending the reference planes from calibrated cable ends to the interior of the test fixture itself. In order for this technique to be used successfully, it is necessary that the test fixture feature transmission lines well matched to the auxiliary cabling.

Acknowledgments

It is a pleasure to acknowledge the capable assistance of Mike Harris at the Georgia Tech Research Institute and Bill Kwan at Hewlett-Packard during the preparation of this article. rf

About the Authors

David W. Hughes, Ph.D., is Senior Research Engineer, and Charles T. Rucker is Principal Research Engineer at the Georgia Tech Research Institute. Robert K. Feeney, Ph.D., is Professor, and David R. Hertling, Ph.D., is Associate Professor in the Department of Electrical Engineering. They can be reached at these departments, Georgia Institute of Technology, Atlanta, GA 30332.

References

1. R.Q. Lane and G.L. McCollum, "A New Self-Calibrating Transistor Test Fixture," *IEEE MTT-S International Microwave Symposium Digest,* p. 99, 1979.
2. B. Manz, "Three-Firm Collaboration Yields New 'Standard' Test Fixture," *Microwaves,* Vol. 21, No. 8, p. 19.
3. R.Q. Lane, R.D. Pollard, M.A. Maury and J.K. Fitzpatrick, "Broadband Fixture Characterizes Any Packaged Microwave Transistor," *Microwave Journal,* Vol. 25, No. 10, p. 95, October 1982.
4. R.D. Pollard and R.Q. Lane, "The Calibration of a Universal Test Fixture," *IEEE MTT-S International Microwave Symposium Digest,* p. 498, 1983.
5. G. Elmore, "De-Embed Device Data with a Network Analyzer," *Microwaves & RF,* Vol. 24, No. 12, p. 144, November 1985.

The Q Factor of Microstrip Matching Networks

A Numerical Design Method for Determining Strip Length as a Function of Q

By P. Gonord, S. Kan and J.P. Ruaud
Institut d'Electronique Fondamentale

The Q factor of an impedance matching network incorporating microstrips has a bounded value. The authors describe methods of numerically evaluating strip lengths as a function of Q, using a 162 MHz Class C amplifier as a design example. First presented at RF Technology Expo 86, the work has since been revised to include the second method using voltage reflection coefficients. The original paper and the additional analysis have been combined in this article.

Microstrip has long been associated with microwave passive or active circuit design since at such frequencies a certain length of strip can be made to behave as a capacitance or inductance according to its physical dimension with respect to the electrical wavelength (λ). When designed as a transmission line, it can also be used for impedance transformation or matching between an active device and its source and load impedances.

The expressions relating impedance variation along a line terminated by a load other than its characteristic impedance (Z_o) are rather simple, but their numerical evaluation requires complex hyperbolic or circular function manipulations which are still performed graphically. Now that pocket computers incorporated with high level programming facilities such as the BASIC language are available, the time has come for every circuit designer to do the calculations by machine with greater accuracy and less time consuming effort.

In RF Class C power amplifier design, one often encounters low input and output transistor impedances. The simple method using 2-element LC components to match them to the 50Ω source and load impedances results in poor harmonic rejection and power efficiency (Figure 1(a)). General practice consists of increasing the Q of the matching network by adding an inductance in series with the transistor's input/output impedances as shown in Figure 1(b).

In high frequency operation, the required inductance is rather small and its precise value becomes difficult to achieve using

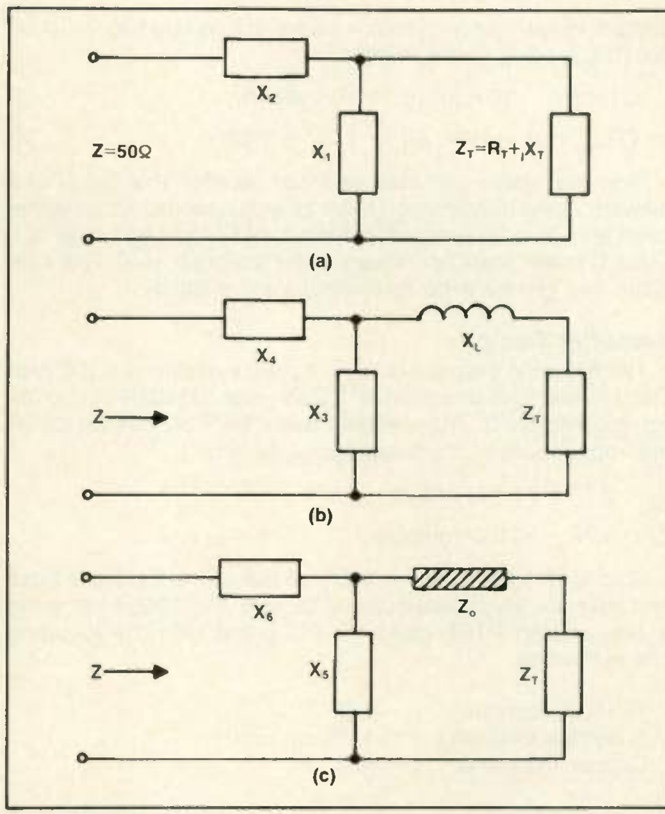


Figure 1. Basic network using X_1, X_2 to match the input/output impedance Z_T of a transistor to 50 Ω (a). Matching network incorporating an inductance to reduce harmonic frequencies (b). Inductance replaced by a microstripline with a well defined Q at high frequencies (c).

a conventional coil. For this reason, most practical VHF/UHF amplifiers adopt microstrip to replace this lumped constant.

In the literature (1-4), the designers often choose a certain length of strip and then try to match the transistor to the source or load with the aid of the Smith chart. This method is rather empirical and the Q of the network is either undefined or cannot be determined accurately. The following shows how the quality factor is related to the circuit parameters as well as strip lengths in a practical design.

Design Procedure

With reference to Figure 1(c), let the microstrip of length ℓ and characteristic impedance Z_o replace the lumped constant of reactance X_L of Figure 1(b). From the general low loss line equation, the normalized input impedance of the microstrip is:

$$Z_{in} = \frac{Z_T + jT}{1 + jZ_T T} = r_{in} + j\,x_{in} \quad (1)$$

where $T = \tan\beta\ell$, $\beta = 2\pi/\lambda$ and

$Z_T = (R_T + jX_T)/Z_0 = r + jx$

By definition, $Q = x_{in}/r_{in}$.

We can then deduce the strip length as a function of x, r and Q, giving:

$$\ell = \frac{1}{\beta}\arctan \frac{(1 - x^2 - r^2) \pm [(1 - x^2 - r^2)^2 - 4(Q^2r^2 - x^2)]^{1/2}}{2(rQ + x)} \quad (2)$$

Since ℓ is real, the expression under the square root must be positive, leading to the relation:

$$Q^2 < [(r - 1)^2 + x^2]\,[(r + 1)^2 + x^2]/4r^2 \quad (3)$$

$$\text{or, } Q^2_{max} = [(r - 1)^2 + x^2]\,[(r + 1)^2 + x^2]/4r^2 \quad (4)$$

From the above expressions it can be seen that the Q of a network using transmission lines as inductances has an upper bounded value. In practice, the input and output networks of a Class C power amplifier require a Q of the order of 10. This condition can generally be met without any difficulty.

Amplifier Design

The following example is taken from the design of a 100 Watt Class C amplifier operating at 162 MHz for ^{31}P NMR in-vivo imaging experiments. The power transistor MRF 317 has the following impedances at the rated output power:

$Z_T = 0.77 + j\,1.4\ \Omega$ (input)

$Z_T = 1.77 - j\,1.0\ \Omega$ (output)

Strip widths were chosen equal to that of the transistor base and collector leads, respectively 5.2 mm and 3.935 mm, using a copper clad PTFE glass (5) PC board with the following characteristics:

Dielectric constant	$\varepsilon_r = 2.55$
Substrate thickness	h = 1.52 mm and
Copper thickness	t = 35 μ

Z_0 was first calculated as a function of the strip widths W (6, 7) then strip lengths vs. Q as determined by equation (2) were tabulated as shown in Tables I and II. For our amplifier, choosing Q = 13 for both the input and output networks led to strip lengths of 4.2 and 11.4 cm, respectively. The latter were etched on a PC board designed to accommodate the power transistor as well as the matching capacitors (8) (Figure 2).

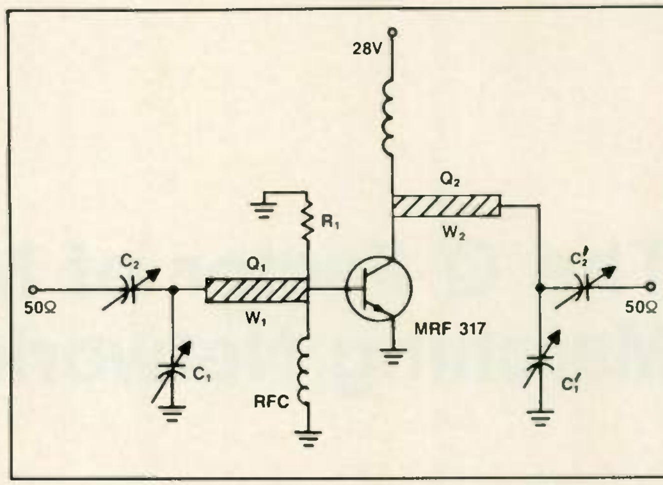


Figure 2. Typical Class C amplifier incorporating microstripline in the input and output matching network. R_1 (18Ω) was inserted to improve transient response. It can be omitted for CW operation.

Design Results

The Class C amplifier constructed has a power gain of 10 dB at 100 watts output and about 7 dB at 127 watts. The measured 3 dB bandwidth ΔF was 8.0 MHz, which is in very good agreement with the theoretical value of 8.1 MHz evaluated from the formula (9):

$\Delta F = F\,(\sqrt{2} - 1)^{1/2}/Q$

where F is the operating frequency. The second solution for the strip length (ℓ_2) was discarded due to its impractical dimension. One means of reducing the required strip length consists in increasing Z_0, which implies the reduction of the strip width. As an example, halving the output strip width leads to a required strip length of only 6.8 cm instead of the actual 11.4 cm. This can be achieved in detriment to the current handling capacity of the strip.

An Alternate Approach

Since the publication of the preceding analysis (10) the authors have proposed another approach to the above problem, based on the voltage reflection coefficient method. Although the formulation is entirely different, the numerical results are identical to those obtained from the previous procedure.

With reference to Figure 3, let us derive the line input impedance Z_{in} in terms of the voltage reflection coefficient ϱ_{in} at a distance ℓ from the termination impedance Z_t. Assuming a low loss line, we have:

$\varrho_t = |\varrho|\,e^{j\phi} = (Z_t - Z_o)/(Z_t + Z_o)$

$\varrho_{in} = |\varrho|\,e^{j\theta} = (Z_{in} - Z_o)/(Z_{in} + Z_o)$

$$\text{where } \theta = \phi - 2\,(2\pi f \sqrt{\varepsilon_r}\,\ell)/C \quad (5)$$

and C = velocity of light,

ε_r = dielectric constant of PC board substrate.

We then find that:

$$\begin{aligned} Z_{in} &= Z_o\,(1 + \varrho_{in})/(1 - \varrho_{in}) \\ &= Z_o\,(1 - |\varrho|^2 + j2\,|\varrho|\,\sin\theta)/(1 + |\varrho|^2 - 2|\varrho|\cos\theta) \quad (6) \\ &= R_{in} + j\,X_{in} \end{aligned}$$

188 variable RF coils. At very affordable prices.

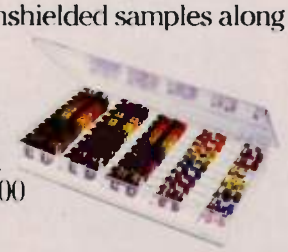
If you need variable inductors in the range from .05 uH to 1100 uH, no one gives you a wider selection than Coilcraft. And no one gives you lower off-the-shelf pricing!

Coilcraft tuneable RF coils are designed to meet MIL specs. They feature compact 10mm or 7mm packaging, optional shielding, and one-piece construction for maximum stability.

For special inductance or Q values, we'll custom-build coils to your specifications and still save you money!

For all the details on Coilcraft tuneable RF coils or our other inductive devices, call 312/639-6400.

Experimenters Kits. Choose kits covering the range from .0425 to 1.5 uH or from .70 to 1143 uH. Kits include shielded and unshielded samples along with detailed specifications. Each costs $60, applied against your first order. Call 312/639-6400 to order.



Chip Inductors

Current Sensors

Power Inductors

Axial Lead Chokes

Coilcraft

1102 Silver Lake Rd., Cary, IL 60013

INFO/CARD 32

by definition,

$Q = X_{in}/R_{in}$ and from (6), we derive

$Q = 2|\varrho| \sin\theta/(1 - |\varrho|^2)$, then

$Q_{max} = 2|\varrho|/(1 - |\varrho|^2)$.

The required microstrip length for a given Q is then given by (5), which reads:

$\ell = (\phi - \theta)\, C/4\pi f\sqrt{\varepsilon_r}$ where the first two values of θ are:

$\theta = \sin^{-1}(Q/Q_{max})$ and $\pi - \sin^{-1}(Q/Q_{max})$.

Numerical Example

In accordance with the previous example, the same data are used here to illustrate the present method:

Transistor impedance	$Z_t = 0.77 + j\,1.4$ ohms.
Characteristic impedance	$Z_o = 43$ ohms.
Dielectric constant	$\varepsilon_r = 2.12$
Center frequency	f = 162 MHz

From these data, the following values were first calculated:

$|\varrho| = 0.9648$
$\phi = 3.0764$ radians
$Q_{max} = 27.9$

Choosing Q = 13, we obtained:

$$\theta = \begin{cases} 0.4839 \text{ radian} \\ 2.6576 \text{ radians} \end{cases}$$

The required strip lengths are either

$\ell_1 = 4.2$ cm (retained), or

$\ell_2 = 26.2$ cm (discarded)

These are identical to those obtained by the first method.

The 100 Watt Class C amplifier built from these data has a measured bandwidth in very good agreement with that calculated. This kind of design is particularly well suited for high frequency operation (short microstrip length) and high power (low input/output impedance, hence high achievable Q). However, other design criteria also can be met simply by choosing appropriate values of Z_o and ε_r.

References

1. Kurt P. Schwan, *Microwaves*, p.59, Dec. 1975.
2. Harlan Faller, *Microwaves*, p.48, Jan. 1974.
3. H.C. Lee and G. Hodowanec, *AN-4025*, RCA Solid State Division, Sommerville, N.J.
4. Dick Brubaker, *AN-419*, Motorola Semiconductor Products Inc., Phoenix, Ariz.
5. Di-Clad 527, Type FL-GXN, Keene Corporation, Chase-Foster Division, Newark, Del.
6. H.A. Wheeler, *I.E.E.E. Trans. M.T.T.*, p. 280, May 1964.
7. H. Sobol, *Electronics*, p.112, March 20, 1967.
8. Midget Trimmer type 422 and Standard trimmer type 463. ARCO Electronics, Commack, N.Y.
9. F. Terman, *Electronic and Radio Engineering*, Chapter 12, Section 12-2, McGraw-Hill Book Company Inc.
10. P. Gonord, S. Kan and J.P. Ruaud, "The Q Factor of Microstrip Matching Network in RF Class C Amplifier Design," *Proceedings of RF Technology Expo 86*, p. 433.

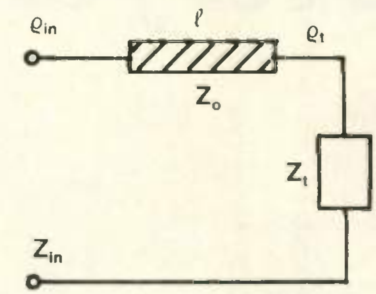


Figure 3. Illustration of parameters, voltage reflection coefficient method.

Q	ℓ_1(cm)	C_1(pF)	C_2(pF)	R_{in}	X_{in}
28_{max}	15.2	18.8	4.1	1.53	43.30
20	7.3	47.5	7.9	0.90	18.05
13	4.2	82.7	14.8	0.81	10.59
10	3.0	112.8	25.2	0.79	7.95
	ℓ_2(cm)				
20	23.1	6.4	3.1	5.2	103.7
13	26.2	2.7	2.9	13.6	176.1
10	27.4	1.3	2.9	23.4	223.8

Table I. Transistor base lead width = 5.2 mm, $Z_0 = 43\Omega$.

Q	ℓ_1(cm)	C_1(pF)	C_2(pF)	R_{in}	X_{in}
15_{max}	16.4	14.0	5.2	3.53	52.0
13	11.4	24.8	7.3	2.4	31.3
12	10.1	29.2	8.4	2.2	26.9
10	8.0	39.2	11.1	2.0	20.0
	ℓ_2(cm)				
13	21.3	7.3	4.2	6.6	86.3
12	22.6	5.8	4.1	8.4	100.4
10	24.7	3.6	3.9	13.2	131.8

Table II. Transistor collector lead width = 3.935 mm, $Z_0 = 52\Omega$.

About the Authors

P. Gonord, S. Kan and J.P. Ruaud are staff/faculty members at the Institut d'Electronique Fondamentale, Batiment 220, Universite Paris XI, 91405 ORSAY CEDEX, France. The Institute is an Associate Laboratory of the Centre National de la Recherche Scientifique.

Anomalous Behavior of Reed Relays

The Discovery of an Unusual Impulse Response in Low Impedance Precision Circuits.

By Colin Gyles
Data Precision Division,
Analogic Corporation

Unwanted responses in precision circuits can present the designer with significant challenges, since the effects may be small and the source of the response may be unclear. The author's experience in solving such a problem is an interesting piece of electronic "detective" work, resulting in the discovery of a small, but significant, effect on circuit performance due to the material used in reed relay contacts.

A 50 ohm, 7 section attenuator containing 14 reed relays (Figure 1) was found to exhibit a step response as shown in Figure 2. Note that after the initial fast edge there is a final slow rise of about 3 percent of the 7 volt step.

In order to observe this small effect, the scope sensitivity is raised such that the level prior to the step is outside the display range of the scope and hence this effect might be attributed to scope overload recovery. After all, the same result was seen for any attenuation level, even in the zero dB attenuation case where the circuit consists of just 14 relays in series and the load.

Suspecting the relays, the circuit of Figure 3 was set up with a 100 mA current step passed through a closed relay contact, observing voltage across it. The recorded results are shown in Figures 4 and 5 for different time scales. Note the initial high amplitude overshoot due to the inductance of the contact followed by a long tail having an initial amplitude of about 30 mV and a time constant of about 400 ns. Again, one might suspect scope overload recovery from the inductive spike, but this was ruled out by two experiments:

1) The rise time of the generator was

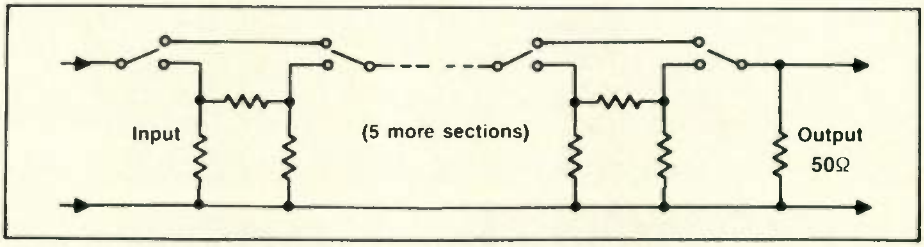


Figure 1. Seven-section 50 ohm attenuator.

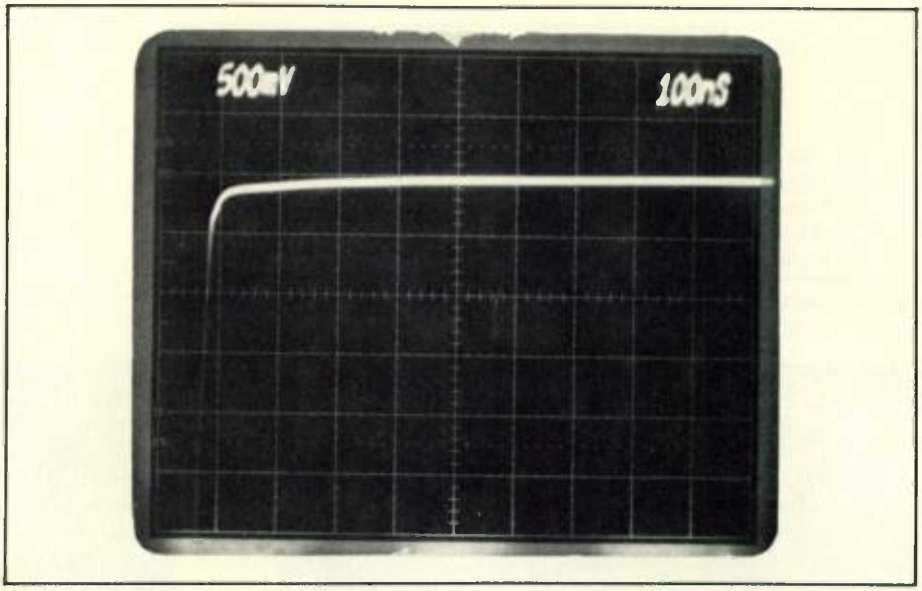


Figure 2. Attenuator step response.

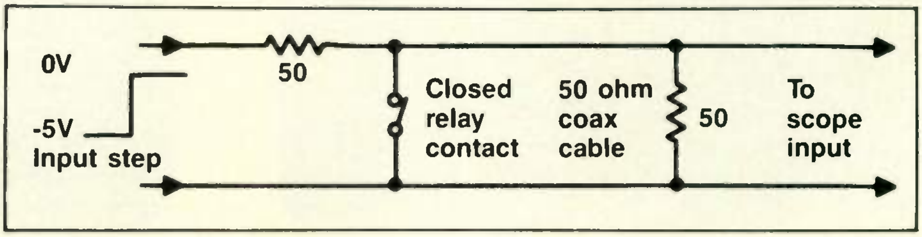


Figure 3. Relay test circuit.

Manufacturer	Part No.	Amplitude (mV)	Time Const. (uS)
Coto	9000-0024	30	0.5
Gordos	4705S	40	0.5
Gordos (Hg wet)	847c-1	15	0.7
Hamlin	721C05-30	20	1
Standex	TG102-1-5	25	1
Teledyne	172	30	0.5

Table I. Measurements of tail amplitude and time constant for different types of reed relays.

increased until the output waveform was totally within the scope display range as shown in Figure 6, with the long tail still present.

2) The relay contact was replaced by a piece of copper wire the same length as the relay contact with the result shown in Figure 7. Note the complete absence of the long tail after the inductive overshoot.

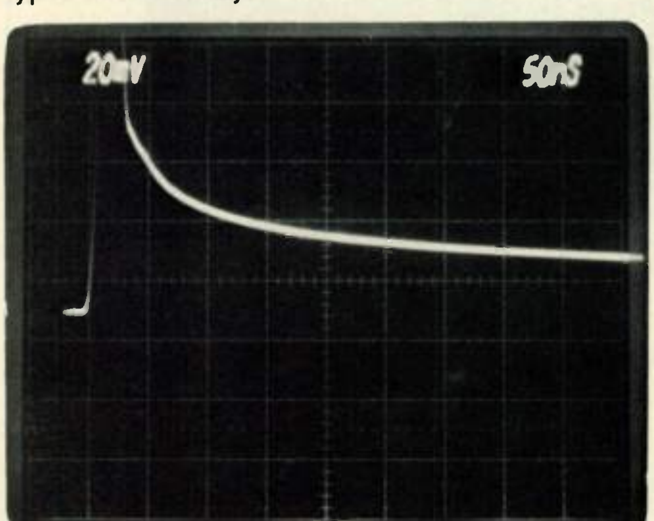


Figure 4. Long tail (50 nS/div.).

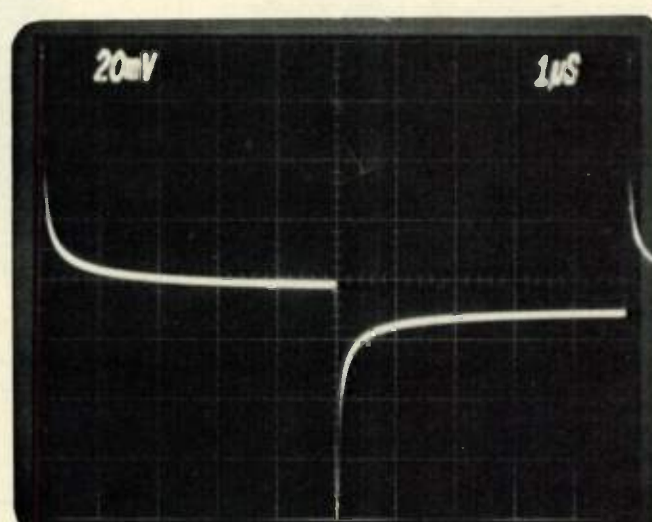


Figure 5. Long tail (1 µS/div.).

The reed relay used in the above tests was a Coto 9000-0024. However, *any* reed tested exhibited the same phenomenon with the measured results shown in Table 1. Repeating the test with armature type relays with contact arms made of a non-magnetic material, typically beryllium copper, gave results the same as copper wire. One armature type relay that did exhibit a long tail, the Teledyne 172, was found to have leads that are magnetic, presumably a nickel alloy wire to facilitate the glass to metal seal used.

Thus, the attenuator with 14 Hamlin #721C05-30 relays exhibiting this behavior, generated a tail amplitude of 14 × 20 = 280 mV, causing the above problem.

Possible Causes

Initially it was suspected that some type of thermal EMF generator at the contact or another metal to metal interface might be the cause. In order to eliminate contact EMF a relay was broken open and one of the contact arms soldered into the circuit of Figure 3. A four wire type measurement was made in that the scope

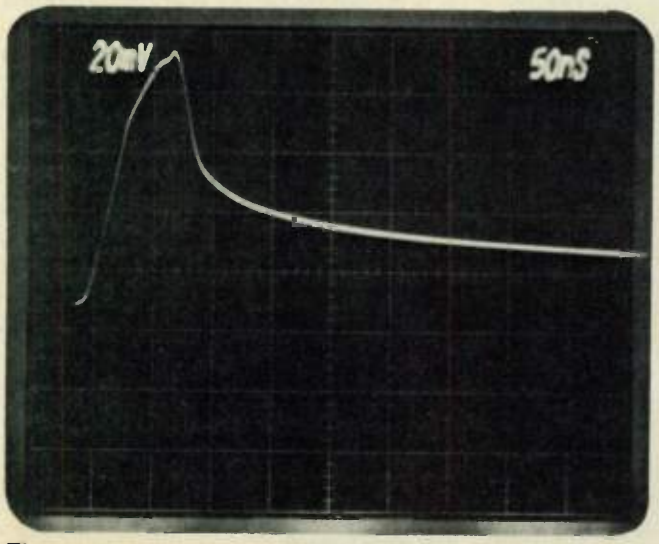


Figure 6. After increased generator rise time.

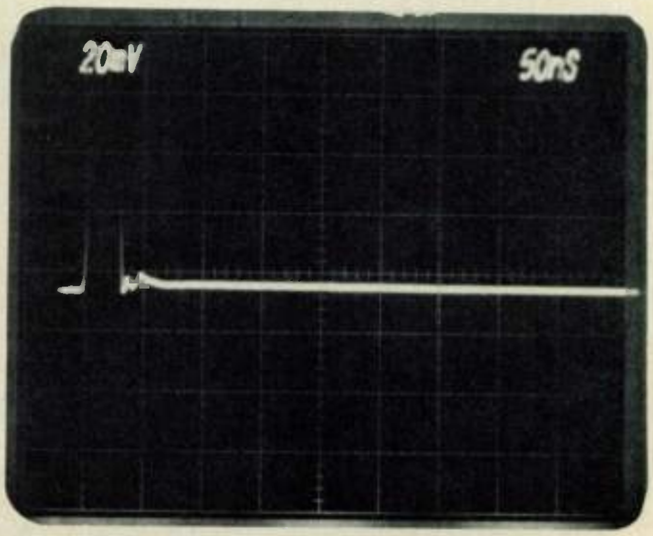


Figure 7. Replacing reed contact with copper wire.

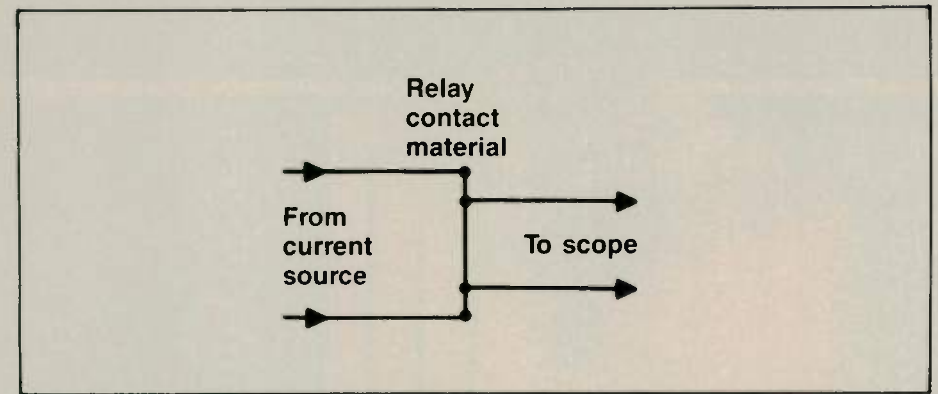


Figure 8. Four-wire connection to contact material.

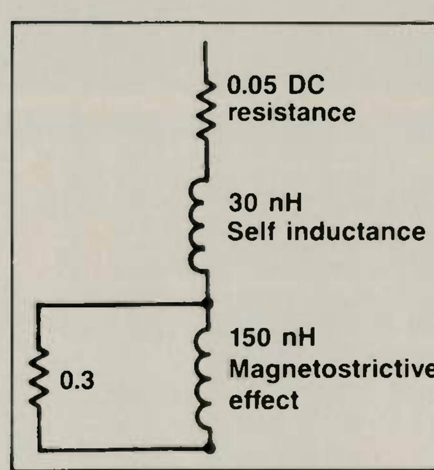


Figure 9. Equivalent circuit of reed relay contact.

sensing leads were soldered "inside" the current supply connections as shown in Figure 8, where the measurement excluded any current carrying metal to metal junctions. The results showed the same long tail, proving the effect to be due to the material itself. The same test was made with a piece of wire lead from the Teledyne 172 relay, with the same result.

The cause of this anomaly can probably be attributed to magnetostriction; the change in dimension of magnetic materials under the influence of a magnetic field, and the reciprocal thereof. Consider the positive transition in the circuit of Figure 3, where the current is switched off from a constant value. When the constant current is flowing through the conductor a magnetic flux is generated that changes the physical dimensions of the material. When the current is switched off the flux is removed and the material returns, slowed by inertia, to its original state. During this time the stresses in the material generate a magnetic flux which produces an EMF in the opposite polarity to that which caused the original distortion.

For simplicity, the special case of the current being switched off is considered. However, any change in current exhibits this phenomenon. In general then, if there is a current change and hence a magnetic flux change in the material, its dimensions change, slowed by inertia. The stresses generated during this time produce an opposing magnetic flux and back EMF. Figure 9 gives an equivalent circuit of the reed relay contact that approximates the measured response. rf

About the Author

Colin Gyles is Principal Scientist at the Data Precision Division of Analogic Corporation, Electronics Avenue, Danvers, MA 01923. Mr. Gyles holds an HNC degree from London University and has been with Data Precision for seven years.

IN THE WORLD OF GaAs MMIC'S
ONE STANDS ALONE...
CGY-40
The performance advantages of GaAs FET technology are now available in a low cost — surface mount MMIC. The CGY-40 MMIC offers the design engineer superior performance with a minimum of design effort. Input and output matched into 50 ohms, this device offers broadband performance, low noise figure and a high intercept point. AGC operation can be acheived via bias control on the RF input.
The CGY-40 is ready for your receiver, IF amplifier or power amplifier driver applications now.
Typical performance data for the CGY-40 is summarized below:
BANDWIDTH
200 MHz — 3 GHZ (3dB down, VSWR = 2:1)
NOISE FIGURE
3 dB 800 — 1800 MHz
GAIN
9 dB 800 — 1800 MHz
POWER OUT
+ 17 dB @ 1 dBc POINT
3rd ORDER INTERCEPT POINT
+ 33 dBm (CALCULATED FROM TWO TONE MEASUREMENTS)
For technical and price/delivery information contact your local MSC Representative or contact the factory at 201 469-3311
MSC
MICROWAVE SEMICONDUCTOR CORP.
A Siemens Company
100 School House Road, Somerset, New Jersey 08873-1276

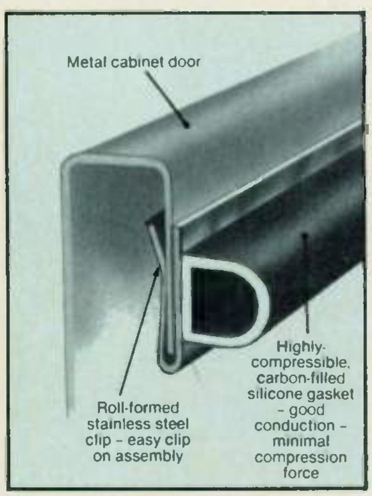
INFO/CARD 37

Expensive EMI/RFI shielding is now obsolete!

Pawling's CLIP-STRIP™ and new MESH-CLIP™— simple, cost-effective and they work.

CLIP-STRIP™– the proven performer

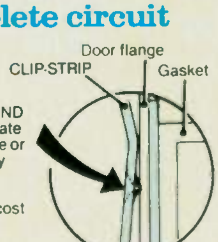
It's simple, cost-effective and it works. You won't have to redesign doors to include expensive grooves, hooks, holes or slots for gasket attachment. Just push Pawling's CLIP-STRIP™ onto the sheet metal flange found on most digital equipment doors and, instantly, you have an EMI/RFI shield that is functional and cost effective.



How it works

CLIP-STRIP™ is a carbon-filled silicone bulb gasket permanently affixed to a durable stainless steel clip. The conductive, compressible bulb seals the gap between the door or side panels and the structural frame, thus reducing escape or entrance of EMI/RFI.

POSI-GROUND™ "teeth" complete circuit

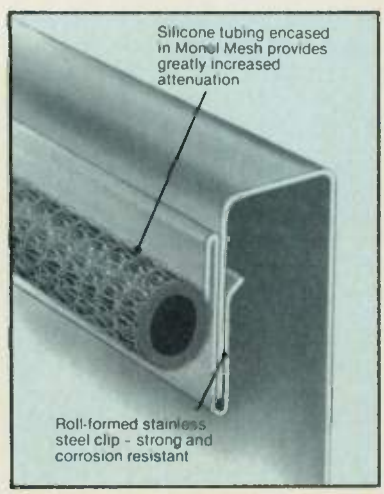


CLIP-STRIP™ is equipped with POSI-GROUND™ "teeth" that penetrate nonconductive painted surfaces. These "teeth" make contact with the conductive structural metal and create a complete conductive circuit.

CLIP-STRIP™– the durable, cost-effective EFI/RFI shielding solution.

MESH-CLIP™– the high attenuation performer

MESH-CLIP™ is the latest innovation in Pawling's breakthrough line of EMI/RFI shields. MESH-CLIP™ is designed for high attenuation/high performance applications and like CLIP-STRIP™, it is simple, cost-effective and it works.



Why it's new

Based on the original CLIP-STRIP™ concept, MESH-CLIP™ features a high-grade silicone rubber tubular core gasket encased in Monel Mesh. The Monel Mesh provides a dramatic increase in attenuation, is highly reliable, and cost effective. MESH-CLIP™ also features POSI-GROUND™ "teeth", a rolled stainless steel clip and "push-on" assembly.

MESH-CLIP™ is the EMI/RFI shield for cost-effective, high attenuation applications.

Contact our shielding specialists

For specifications or more information on Pawling's MESH-CLIP™ and CLIP-STRIP™, contact

Pawling Corporation
EMI Shielding Products Division
157 Charles Colman Blvd., Pawling, NY 12564.
Phone: 914-855-1000 Telex: 646720
FAX: 914-855-1139

PAWLING CORPORATION

INFO/CARD 38

Automotive EMC: It's a Matter of Safety

SAE Addresses the Problems of Interference Prevention as Use of Automotive Electronics Grows.

By Gary A. Breed
Technical Editor

Every new model of car, truck or other vehicle that rolls off the automotive industry's assembly lines has more electronic control, monitoring and display functions than the previous model. As one of the fastest growing applications of any technology, automotive electronics has required a parallel growth in attention to electromagnetic compatibility (EMC), the prevention of interference to or from these electronic systems.

The Society of Automotive Engineers (SAE) has responded to the need for EMC performance and testing standards through its Electrical and Electronic Systems Committee and its subcommittees on Electromagnetic Radiation and EMI Standards and Test Methods. This article provides a look at some of the problems addressed by these groups, and the standards resulting from their work.

Automotive electronics have two problem areas in the realm of EMC. The first is that the mobile nature of vehicles exposes them to every possible outside source (or recipient) of RF interference (RFI). The other is the presence of internal generators of electromagnetic energy: ignition systems, alternator/regulator systems, brush-type DC motors and high-current power distribution. When the more common aspects of EMC are added to the list, the scope of the automotive engineer's task becomes formidable.

SAE Standard J551 (1) contains the limits and test methods for radiation from vehicles (20-1000 MHz). The standard originated in the late 1940s to address the problem of ignition noise interference to television receivers. Since that time it has been amended to reflect the changing uses of communications equipment, and is currently configured to emphasize potential interference to Land Mobile radio services.

Standards for radiation have been coordinated with the American National Standards Institute (ANSI) Committee C63 on Radio-Electrical Coordination, and the International Special Committee on Radio Interference (C.I.S.P.R.). Together with FCC Rules and Regulations, Part 15 and others, the subject of radiated interference from vehicles is well covered, although there remains additional work to be done in this area, particularly at lower frequencies (see Figure 1).

Internal Interference

On-board electrical and RF interference is generated by many items of normal automotive equipment, and can be transmitted by either radiation or conduction to other equipment that may be susceptible to interference. Before an automotive EMC engineer can begin to consider outside sources of RFI, he has to be certain that all of the components that make up the finished vehicle are compatible with one another.

The first priority of any EMC consideration is a component essential to operation of a vehicle, such as an engine controller, voltage regulator, electronically controlled anti-skid braking system or other required items. These must be protected in two ways: Minimize their susceptibility to electrical or RF interference; and design the devices so that a failure will not result in a hazardous situation. Minimizing susceptibility is primarily a matter of cost for added shielding, filtering higher-rated components and additional testing. The design factors for the "failure mode" challenge the engineer to make sure that a failure is not dangerous to the vehicle's operator and passengers. For example, the SAE notes that for an anti-skid braking system, the failure of the control should return the system to normal braking, with no chance of a dangerous "lock-up."

Recognizing these needs, the automotive industry has established tests which subject the various components and systems to pulses, transients and RF which might be experienced in a normal operating environment. The various devices are "graded" according to their safety aspects, with the least important having the lowest required susceptibility standards.

Susceptibility to Outside RFI Sources

Defining the level of protection needed to avoid interference from outside RF sources is at best an educated guess. There are a number of high power RF sources that a vehicle might be exposed to, such as broadcast transmitters, radar installations and commercial or military communications installations. Land mobile and amateur radio equipment may be located within the vehicle, operating at power levels in the hundreds of watts.

SAE J1113 (2) contains the recommended measurement procedures for susceptibility testing. This, too, is an evolving standard, begun in 1972. Automobile companies have invested significant resourc-

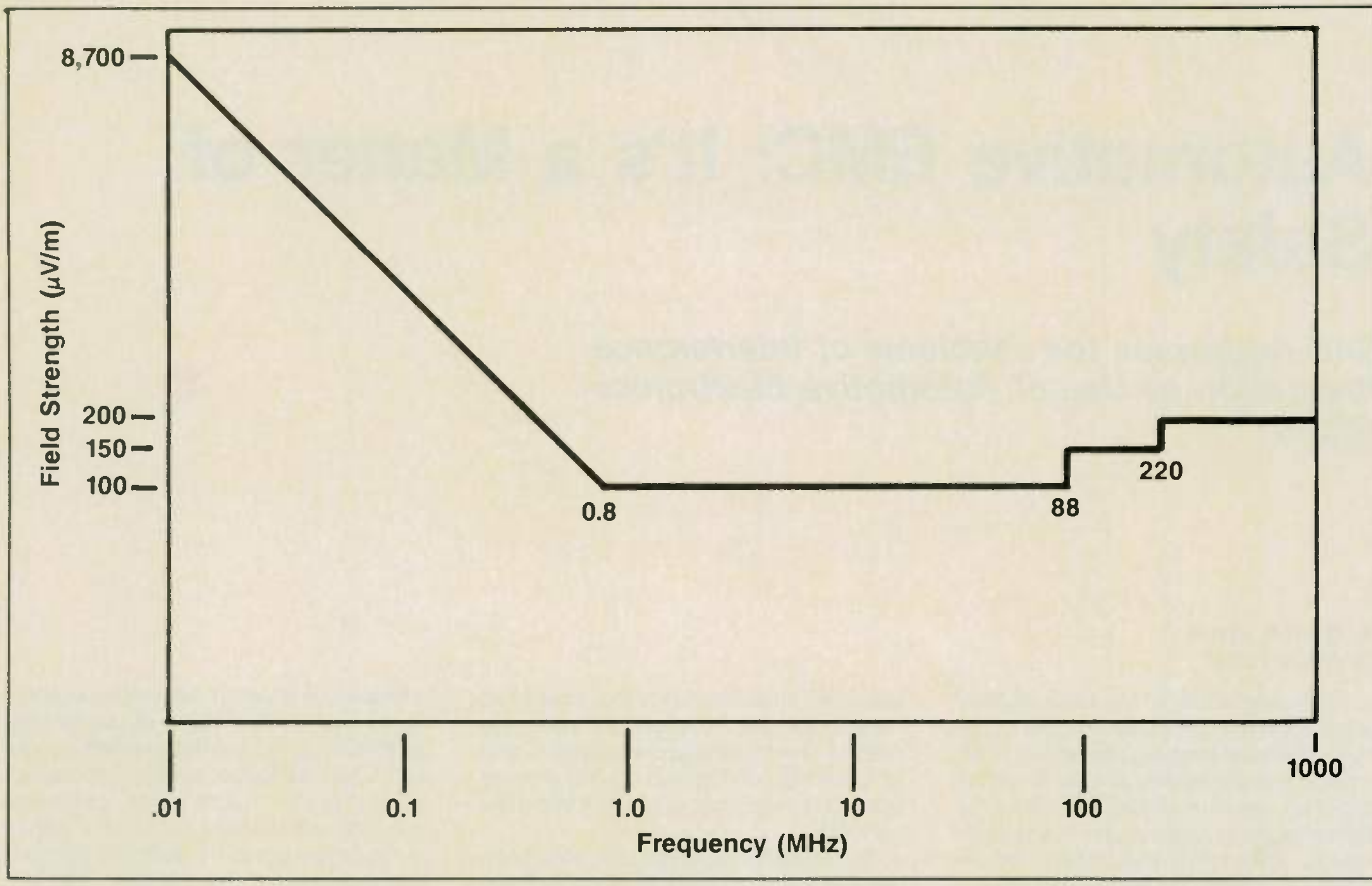


Figure 1. SAE proposed Electromagnetic Radiation (EMR) standard for vehicles and internal combustion engines.

es into facilities to perform such testing. For example, Ford Motor Company's test facility (3) has an anechoic chamber for 20 MHz to 18 GHz testing and a transverse electromagnetic wave (TEM) cell covering 60 Hz to 20 MHz. RF power generation equipment is available up to 10,000 watts from 0.5 to 100 MHz, decreasing through VHF and UHF to 100 watts in the 12.4 to 18 GHz range.

These facilities contain all of the necessary dynamometers, cooling and exhaust handling equipment to operate a vehicle while under test. With this test capability, virtually any conceivable power/frequency combination can be created. The difficulty remains in determining the field intensities, polarizations, orientations and antenna configurations that will subject a test vehicle to "real world" approximations.

Such attention to test facilities and methods offers some assurance that motor vehicles are being built which are not going to be dangerously affected by electrical or electromagnetic phenomena which might be encountered during their travels. However, there are just a few areas that are still under investigation.

Low frequency radiation standards are not firmly established. Interference to AM radios, amateur radio, some navigation equipment and other communications in the low-MHz range is an unresolved problem. Most of these communications systems employ AM (including SSB) modulation, making them more susceptible to pulse (ignition) noise than FM land mobile services at VHF frequencies. AM broadcasters, specifically, are in the process of re-thinking the old "we have to live with it" attitude toward vehicle ignition and other low frequency noise sources (4), and will certainly be vocal in their desire for quieter autos.

The operation of land mobile (two-way, cellular and public service) and amateur radio equipment within a vehicle presents special problems. Installation methods, frequencies and power levels can be widely varied, as can antenna placement and wiring arrangements. There really is no guarantee that such an installation will not cause a disruption or malfunction of electronic equipment in the vehicle. Reports of problems are common, from motors racing or shutting off to erroneous speedometer operation. Until some means of modeling and testing for such close-in interference sources is in use by the automotive industry, users of mobile radio equipment must be very careful to do a complete operational test of the vehicle under all expected operating conditions. rf

References

1. SAE J551 "Limits and Methods of Measurements of Electromagnetic Radiation from Vehicles and Devices (20-1000 MHz)," Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, Pa. 15096.

2. SAE J1113 "Electromagnetic Susceptibility Procedures for Vehicle Components (Except Aircraft)," SAE (above address).

3. Gary F.E. Vrooman, "Vehicle Level EMC Testing Methodology and Correlation," Ford Motor Company, available through SAE.

4. Charles T. Morgan and Michael C. Rau, "The NAB AM Improvement Project," *Proceedings, 40th Annual Broadcast Engineering Conference (1986)*, National Association of Broadcasters, 1771 N Street, N.W., Washington, D.C. 20036.

SPECIAL
MAIL BID SALE

TEC

Test Equipment Corporation

ELECTRONIC TEST EQUIPMENT
RENTALS, SALES AND LEASES

MAIL BID SALE

SAVE ON HUNDREDS OF ITEMS!

MAKE US AN OFFER WE CAN'T REFUSE!

TERMS & CONDITIONS

1. BIDDING PROCEDURE: Mail Bids must be postmarked no later than 12:00 pm, Sept. 26, 1986. Verbal bids will be accepted through 5:00 pm, Sept. 26, 1986. All bids must specify lot number, description and amount bid.

2. NOTIFICATION OF AWARD: The high bidder by lot number will be notified by telephone within 48 hours of bid closing.

3. CANCELLED LOT OFFERINGS: All lots are subject to prior sale. Notification to high bidders of nonavailability will be made within 48 hours of bid closing.

4. WARRANTY: All items will carry a minimum of a 90 day warranty on all parts and labor. All items will be calibrated to manufacturer's original specifications. **EXTENDED WARRANTY:** A low-cost extended warranty is available for most sale items. Call toll free 1-800-227-1995 for details.

5. BIDDERS NON-OBLIGATION CLAUSE: Any winning bidder, upon notification of award shall have the unilateral option of canceling his/her bid. TEC will then notify the next highest bidder, who will also have that option.

6. TERMS OF PAYMENT: Upon approval of credit, a company purchase order will be accepted. Payment terms on P.O.'s will be net 10 days unless otherwise agreed upon. Visa or MasterCard or C.O.D. are alternative methods of payment.

7. DISCLAIMER: Every effort has been made by Test Equipment Corporation to ensure the accuracy of this publication. However, Test Equipment Corporation is not liable for printing errors and reserves the right to refuse any bid due to typographical error.

Anritsu ME 538

Microwave Link Analyzer (MLA) System

Includes Transmitter and Receiver

LIST $23,190

AVAILABLE FOR IMMEDIATE SALE!

$17,500

Lot #	Mfg.	Model #	Description	List $	Min Bid
1	Amplifier Research	40A12	Amplifier 20KHZ-12MHZ 40W	2275	450
2	Amplifier Research	700A	Amplifier 8-450KHZ 700W	3100	650
3	AEL	F3002	Detector Crystal	400	50
4	AEL	F3003	Crystal Detector	400	50
5	AER	12000	Hybrid 3 DB	295	50
6	AER	D-10	Detector	185	30
7	AFD	29205	Slotted Line	650	100
8	AHA	P255	Probe Hi Voltage	525	150
9	AHS	SAS200	Antenna Log Periodic		200
10	AHS	SAS200	Antenna Biconnical		200
11	Ailtech	125-11	Oscillator	17,900	2500
12	Ailtech	13508	Mixer .1-1GHZ TNC	1500	100
13	Ailtech	13509	Mixer 3.6-4.2GHZ Type N	1735	575
14	Ailtech	13630	Amplifier IF	1210	300
15	Ailtech	13635	Converter	950	100
16	Ailtech	13650	Amplifier IF	1210	200
17	Ailtech	186	OSC PI 200-500MHZ 50 watts	6625	1200
18	Ailtech	186M	OSC PI 200-500MHZ 50 watts	6625	1200
19	Ailtech	7380	Monitor Noise Figure 70MH	9250	1925
20	Ailtech	7511C	Meter Noise Figure	5375	1495
21	Ailtech	7514	Meter Noise Figure	7750	2395
22	Ailtech	7615	Noise Source .01-1.5GHZ	1195	395
23	Ailtech	7617	Noise Source 12.4-18GHZ	2775	850
24	Ailtech	Dml05A	Antenna Dipole	1110	300
25	Alfred	105	Attenuator 4-8GHZ	480	100
26	Alfred	1151	Attenuator/Sampler 1-2GHZ	570	125
27	Alfred	1152	Attenuator/Sampler 2-4GHZ	600	150
28	Alfred	1153	Attenuator/Sampler 4-8GHZ	650	175
29	Alfred	5010	Amplifier TWT 10W 1-2GHZ	9000	1995
30	Alfred	5020	Amplifier TWT 10W 2-4GHZ	9000	2195
31	Alfred	5020	Amplifier TWT 20W 2-4GHZ	9000	2395
32	Alfred	5030	Amplifier TWT 20W 4-8GHZ	9500	2695
33	Alfred	5053	Amplifier TWT 8.0-18.5GHZ	12,000	3500
34	Alfred	50786	Coupler 8.2-12.4	640	150
35	Alfred	631D	Oscillator 1-2GHZ	2150	500
36	Alfred	641K	Oscillator 8-12.4GHZ	4275	1150
37	Alfred	656K	Oscillator 10-15.5GHZ	2625	750
38	Alfred	6600	Oscillator Sweep MF	3000	900
39	Alfred	6612ED	Oscillator 4-8GHZ	2500	700
40	Alfred	E101	Attenuator 1-2GHZ	530	125
41	Alfred	E102	Attenuator 1-2GHZ	620	130
42	Alfred	E103	Attenuator 2-4GHZ	530	145
43	Alfred	E105	Attenuator 4-8GHZ	530	150
44	Alfred	S1122	Coupler 4-8 10DB	350	100
45	AME	7000	Adapter J to APC7	725	250
46	Amer. Optical	No Mod	Microscope Stereo	1546	350
47	App. Micro Systems	68000	Emulator Pod Assembly	2195	750
48	App. Micro Systems	ES1800	Emulator Satellite MF	10,045	6000
49	App. Micro Systems	ES1800	Emulator Satellite MF	8545	4500
50	App. Micro Systems	ES1800-A115	or Satellite MF	11,245	8200
51	Andrews		Tower - Antenna 60Ft.	12,000	2500
52	ARR	229 CPR187B	Transition Flange	180	150
53	ARR	3414	Attentuator 0-30DB	340	100
54	ARR	3434	Attenuator 0-30DB	220	75
55	ARR	4436	Attenuator 0-30DB	220	75
56	ARR	4674	Attenuator Variable N	220	75
57	ARR	5414	Attenuator Var. 2-6GHZ	300	100
58	ARR	6414	Attenuator 7-11GHZ	350	125
59	ARR	660B	Termination CMR 229	150	100
60	AXM	EX-855	Printer Video	595	450
61	Ballantine	1010A	Oscilloscope 15MHZ 2CH	695	295
62	Ballantine	1066B	Oscilliscope 20MHZ 2CH	950	450
63	Beckman	1000	Meter MEGOHM	3050	900
64	Beckman	3020	Generator Line Noise	2875	850
65	Beckman	3021	Generator Line Noise	2410	725
66	Biomation	K100D	Analyzer Logic	13,200	3995
67	Biomation	K100D-32	Analyzer Logic	14,800	4295
68	Biomation	K102D	Analyzer Logic	16,900	4995
69	Bowmar	271B2	Error Rate Test Set	2150	950
70	Bird	100A	Element 25-60MHZ 100W	75	50
71	Bird	100H	Element 100W 26-60MHZ	48	35
72	Bird	10E	Element .4-1GHZ 10W	48	40
73	Bird	2500H	Element 2-30MHZ 2500W	75	50
74	Bird	275-1	Element 275-450MHZ 1W	75	50
75	Bird	50E	Element 400-1000MHZ 50W	75	50
76	Bird	50H	Element 2-30MHZ 50W	75	50
77	Calif. Inst.	1001T	PWR Source AC 1KW	3880	1850
78	Calif. Inst.	351A	Power Source AC 1PH	2080	550
79	DAP	248	Meter Multi RMS	385	100
80	DCE	1184	Transition WR137-CMR 229	240	75

Lot #	Mfg.	Model #	Description	List $	Min Bid
81	Dranetz	2010	Probe Current 600V 100A	312	250
82	EIP	548A	Counter 10HZ-26.5GHZ	7900	4895
83	EIP	928	Microwave Source 1-18.6G	26,450	15,000
84	ELO	MTS-2	Test Set Modem	795	495
85	Fluke	2200A	Scanner Board Low Level	355	225
86	Fluke	2200A	Isothermal Input Connect	145	95
87	Fluke	2240B	Datalogger	5995	1895
88	Fluke	7261A	Counter Universal Timer	1405	560
89	Fluke	8125A	Meter Multi	3595	950
90	Fluke	8300A	Meter Multi	3500	800
91	Fluke	887AB	Meter Volt Diff AC/DC	5160	750
92	FXR	AA01N	Attenuator 1DB	35	15
93	FXR	AA06T	Attenuator 6DB	35	15
94	FXR	AA12N	Attenuator 12DB	35	15
95	FXR	AB30N	Attenuator 30DB	35	15
96	FXR	AB50N	Filter	60	20
97	FXR	AFF-0	Attenuator 0 DBM	65	25
98	FXR	AH15N	Attenuator DC 18GHZ	65	25
99	FXR	AJ50F	Attenuator Var. 2-12GHZ	200	60
100	FXR	AJA97	Attenuator Var. 8-12GHZ	200	60

EIP Microwave 928

Microwave Frequency Source

1 - 18.6 Ghz

LIST $23,500

$11,500

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
101	FXR	AV50N	Attenuator Step	220	70
102	FXR	AV5FN	Attenuator Step	220	70
103	FXR	AW10N	Attenuator 0-5DB	275	85
104	FXR	AWA90	Atten. 6-9-12-15-18-21 BNC	465	50
105	FXR	AWC08	Atten. 3-6-9-12 DB BNC	325	50
106	FXR	C2232	Coupler J Band	1130	375
107	FXR	C312A	Tuner E H WG-J	165	80
108	FXR	C601A	Adapter J-N	120	50
109	FXR	C601B	Adapter J-N	145	75
110	FXR	C610C	Coupler Directional	250	110
111	FXR	C622A	Tee Hybrid WG J	235	100
112	FXR	C623B	Bend E Waveguide	100	40
113	FXR	C624B	Bend H Waveguide	100	40
114	FXR	C638	Horn Microwave	100	40
115	FXR	C641A	Switch J Waveguide	785	295
116	FXR	CB58N	Coupler Dir 1.5-3G	150	60
117	FXR	D2-4	Power Splitter	80	35
118	FXR	D34TN	Power Splitter	80	35
119	FXR	DP-4	Tee	165	70
120	FXR	E151A	Attenuator 60-90GHZ	320	150
121	FXR	E175A	Attenuator 60-90GHZ	320	150
122	FXR	E410X	Meter Freq. 60-90GHZ	865	325
123	FXR	E501A	Termination 60-90GHZ	165	65
124	FXR	E610	Coupler 60-90GHZ	645	295
125	FXR	E620A	Tee Series 60-90GHZ	165	80
126	FXR	E621A	Tee Shunt 60-90GHZ	165	80
127	FXR	E622A	Tee Hybrid 60-90GHZ	275	120
128	FXR	E624B	Bend H 60-90GHZ	165	80
129	FXR	E630C	Short 60-90GHZ	345	100
130	FXR	F314A	Phase Shift 90-140GHZ	760	275
131	FXR	F501A	Termination 90-140GHZ	215	95
132	FXR	F620A	Tee Series 90-140GHZ	235	110
133	FXR	F621A	Tee Shunt	235	110
134	FXR	F622A	Tee Hybrid 90-140GHZ	550	195
135	FXR	F623A	Bend E 90-140GHZ	260	125
136	FXR	F631A	Short 90-140GHZ	555	210
137	FXR	F650A	Short 90-140GHZ	555	210
138	FXR	FL150	Filter	125	50
139	FXR	FV160	Filter	125	50
140	FXR	G105A	Slotted Line WR-5	1795	600
141	FXR	G163A	Attenuator 140-220	1380	400

Lot #	Mfg.	Model #	Description	List $	Min Bid
142	FXR	G313A	Tuner E-H 140-220GHZ	1500	450
143	FXR	G314A	Phase Shifter GHZ	900	300
144	FXR	G413A	Meter Freq.	1245	425
145	FXR	G620A	Tee Series 140-220GHZ	305	120
146	FXR	G621A	Tee Shunt 140-220GHZ	345	125
147	FXR	G622A	Tee Hybrid 140-220GHZ	690	210
148A	FXR	G623A	Bend E 140-220GHZ	260	95
148B	FXR	G624A	Bend H 140-220GHZ	260	95
149	FXR	G635R	Transition	245	80
150	FXR	G650A	Short 140-220GHZ	555	175

EIP Microwave 578

Microwave Counter

10 Hz - 26.5 Source Locking

LIST $10,750

$5295

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
151	FXR	G752D	Coupler WG G	820	285
152	FXR	H157A	Isolator G Band	790	250
153	FXR	H601B	Adapter	120	50
154	FXR	H601C	Adapter G-NF	120	50
155	FXR	H621A	Tee Shunt WG G	240	75
156	FXR	H622A	Tee Hybrid WG G	275	85
157	FXR	H623B	Waveguide Bend E	180	65
158	FXR	H624B	Waveguide Bend H	180	65
159	FXR	HA05T	Filter HP	125	50
160	FXR	HA10N	Filter HP	125	50
161	FXR	HA15N	Filter HP	125	50
162	FXR	HA15T	Filter HP	125	50
163	FXR	HA20N	Filter HP 2GHZ	125	50
164	FXR	HCN90	Filter	125	50
165	FXR	HD10N	Filter HP 1GHZ	130	50
166	FXR	HD20N	Filter HP 2GHZ	130	50
167	FXR	HD60N	Filter HP 6GHZ	130	50
168	FXR	HW02N	Mixer	100	35
169	FXR	HW90N	Tee Monitor	210	75
170	FXR	K2058	Detector K Band	450	200
171	FXR	K610A	Coupler 3DB K Band	1400	750
172	FXR	K623B	Bend 90 K Band E Plane	100	40
173	FXR	K638AF	Horn Std. Gain 18-26.5GHZ	395	225
174	FXR	LA03N	Filter LP .3GHZ	80	30
175	FXR	LA04N	Filter LP .4GHZ	80	30
176	FXR	LC04N	Filter LP 400MHZ	110	35
177	FXR	LV04N	Filter LP	110	35
178	FXR	M175A	Attenuator 50-75GHZ	445	150
179	FXR	M622A	Tee Hybrid 50-75GHZ	210	70
180	FXR	M638A	Horn WG 50-75GHZ	345	150
181	FXR	N210A	Detector X Band	140	60
182	FXR	N300A	Tuner DBL Stub /-10GHZ	165	60
183	FXR	N311A	Tuner E H	980	250
184	FXR	Q103A	Slotted Line 33-50GHZ	1035	295
185A	FXR	Q151A	Attenuator Var. 30-50GHZ	510	175
185B	FXR	Q175A	Attenuator 33-50GHZ	405	125
186	FXR	Q501A	Termination 33-50GHZ	140	65
187	FXR	Q620A	Tee Series 33-50GHZ	140	65
188	FXR	Q621A	Tee Shunt 33-50GHZ	140	65
189	FXR	Q622A	Tee Hybrid 30-50 GHZ	210	80
190	FXR	Q623B	Bend E 33-50GHZ	115	45
191	FXR	Q624B	Bend H 33-50GHZ	115	40

Hewlett Packard 141T

Spectrum Analyzer

Main Frame

LIST $4100

$2250

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
192	FXR	Q625A	Twist 33-50GHZ	165	60
193	FXR	Q630C	Short 33-50GHZ	230	80
194	FXR	R101B	Slotted Line 1-2GHZ	2215	450
195	FXR	RPA04	Switch H Band	350	100
196	FXR	S05MN	Short Adj .5-3GHZ	65	20
197	FXR	SF11N	Tuner Coax DBLSLUG	140	75
198	FXR	SF15T	Line Stetcher	110	35
199	FXR	SR05N	Line Stretcher	110	35
200	FXR	SR150	Line Stretcher	110	35
201	FXR	TA5FN	Termination 0-10GHZ	65	30
202	FXR	TA5MN	Termination 0-10GHZ	30	10
204	FXR	TA5MT	Termination 0-10GHZ	30	10
205	FXR	TC5FN	Termination 0-10GHZ	30	10
206	FXR	TD5MN	Termination 0-10GHZ 100W	225	95
207	FXR	TS5MN	Termination	50	25
208	FXR	W622A	Tee Hybrid WG H	165	60
209	FXR	W624B	Bend 7-11 H Plane	120	45
210	FXR	X207A	Detector BNC	300	95
211	FXR	X211A	Detector BNC	300	95
212	FXR	X601B	Adapter X Band	75	25
213	FXR	X610A	Coupler WG 3DB	530	195

Lot #	Mfg.	Model #	Description	List $	Min Bid
214	FXR	X610C	Coupler 10DB	530	195
215	FXR	X620A	Tee Series WG X	140	50
216	FXR	X621A	Tee Shunt WG X	140	50
217	FXR	X622A	Tee Hybrid WG X	165	65
218	FXR	X623B	Bend 90 DEG E	85	35
219	FXR	X624B	Bend X Band H Plane	85	35
220	FXR	X625A	Twist X Band 5 IN	115	45
221	FXR	Y501C	Termination	85	35
222	FXR	V601C	Adapter WG-N 12.4-18	112	40
223	FXR	Y623B	Bend 90 P Band E Plane	100	40
224	FXR	Y624B	Bend 90 P Band H Plane	100	40
225	FXR	Y625A	Twist KU Band	180	85
226	FXR	Y628B	Bend E Plane KU	85	35
227	FXR	Y638A	Horn Std Gain 12.4-18GHZ	300	135
228	FXR	Y641A	Switch	500	195
229	G-E	2030RO	Terminal Data w/Modem	2250	650
230	Gould	222	Recorder Strip 2CH	4985	1725
231	GRC	1644A	Bridge MEGOHM	3743	1250
232	GRC	1666	Bridge DC Resistance	4195	1325
233	Honeywell	1883A	Recorder Pl .05-.5	365	100
234	Honeywell	1884	Recorder Pl	600	175
235	Honeywell	1885	Module	600	175
236	HewPack	00693	Filter LP 8GHZ	100	50
237	HewPack	11540A	Stand Waveguide	60	30
238	HewPack	11581A	Attenuator Set	525	195
239	HewPack	11582A	Attenuator Set	650	250
240	HewPack	11582A	Attenuator Set	760	325
241	HewPack	11605A	Arm Flexible	2135	795
242	HewPack	11661B	Module Frequency Ext	5400	1750
243	HewPack	11689A	Filter Low Pass	280	100
244	HewPack	11694A	Transformer 3-500MHZ	205	60
245	HewPack	11720A	Modulator Pulse 2-18GHZ	3250	1950
246	HewPack	11720A	Modulator Pulse 2-18GHZ	3250	1950
247	HewPack	11869A	Adapter RF Plug-In	405	200
248	HewPack	1220A	Oscilloscope 500KHZ 2CH	990	395
249	HewPack	130C	Oscilloscope	1065	300
250	HewPack	1402A	Amplifier Vertical	675	225
251	HewPack	140A	Oscilloscope	800	300
252	HewPack	140T	Display Section	3500	1500
253	HewPack	141T	Display Section	4100	2495
254	HewPack	1423A	Time Base	485	195
255	HewPack	1607A	Analyzer Logic	4600	1900

Lot #	Mfg.	Model #	Description	List $	Min Bid
256	HewPack	1611A	Analyzer Logic	7200	2900
257	HewPack	1615A	Analyzer Logic	8500	3200
258	HewPack	16451A	Adapter Dielectric Test	300	100
259	HewPack	1645A	Analyzer Data Error	4465	1650
260	HewPack	17400A	Preamplifier Hi Gain	1400	395
261	HewPack	17401A	Preamplifier Med. Gain	550	175
262	HewPack	17404A	Recorder Pl DC Bridge AMP	545	175
263	HewPack	17500A	Amplifier	600	195
264	HewPack	17505A	Amplifier	1050	295
265	HewPack	17506A	Amplifier	800	240
266	HewPack	1804A	Amplifier Vertical 4 TRCE	2600	750
267	HewPack	1805A	Amplifier 100MHZ	3135	950
268	HewPack	180TR	Display	3210	965
269	HewPack	18140C	Breakout Box	505	325
270	HewPack	181T	Oscilloscope MF Store	4130	1650
271	HewPack	1825A	Time Base	2600	750
272	HewPack	197A	Camera Oscilloscope	1495	300
273	HewPack	204C	Oscillator	815	325
274	HewPack	204C	Oscillator	730	295
275	HewPack	205AG	Generator Audio	400	150
276	HewPack	207H	Univerter	2300	695
277	HewPack	214A	Generator Pulse	3735	995
278	HewPack	230B	Amplifier Power	1290	695
279	HewPack	236A	Oscillator Test	1400	425
280	HewPack	302A	Analyzer Wave 20HZ-50KHZ	2195	650
281	HewPack	310A	Analyzer Wave 1KHZ-1.5MHZ	2695	795
282	HewPack	312A	Analyzer Wave 1KHZ-18MHZ	7500	1995
283	HewPack	313A	Generator Tracking 1K-18M	2255	675
284	HewPack	3320A	Synthesizer	4400	1750
285	HewPack	3320B	Synthesizer	6500	2250
286	HewPack	3330B	Synthesizer	9475	2950
287	HewPack	3336B	Generator/Synthesizer	6300	2495
288	HewPack	334A	Analyzer Distortion	3100	950
289	HewPack	3400A	Meter Volt RMS	1650	495
290	HewPack	3400A	Meter Volt RMS Opt.01	1690	525
291	HewPack	3403C	Meter Volt True RMS	4000	950
292	HewPack	3403C	Meter Volt True RMS	4405	950
293	HewPack	3406A	Meter Volt Sampling	3000	900
294	HewPack	340B	Meter Noise Figure	2650	795
295	HewPack	3421A	Data Acq/Control Unit	2690	1495
296	HewPack	342A	Meter Noise Figure	2700	795
297	HewPack	3435A	Meter Multi	800	250
298	HewPack	343A	VHF Noise Source	360	125
299	HewPack	3450B	Meter Multi	5600	1400
300	HewPack	3455A	Meter Volt	5400	2195
301	HewPack	3462A	Meter Volt	5100	1550
302	HewPack	3465B	Meter Multi	750	275
303	HewPack	3490A	Meter Multi	3600	995
304	HewPack	349A	Noise Source UHF	725	250
305	HewPack	3550A	Transmission Test Set	2200	650
306	HewPack	3551A	Transmission Test Set	3500	1400
307	HewPack	3556A	Psophometer	1840	550

Hewlett Packard 853A

Spectrum Analyzer Mainframe

LIST $5550

$3895

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
308	HewPack	774D	Coupler Dual	800	295
309	HewPack	775D	Coupler Dual Directional	800	295
310	HewPack	779D	Coupler 1.7-12.4GHZ	1075	450
311	HewPack	786D	Coupler 960-2110MHZ	800	295
312	HewPack	787D	Coupler 1.9-4.1GHZ	800	295
313	HewPack	788C	Coupler 3.7-8GHZ	1000	325
314	HewPack	789C	Coupler 8-12.4GHZ	1350	435
315	HewPack	796D	Coupler 960MHZ-2110MHZ	675	210
316	HewPack	797D	Coupler1.9-4.1GHZ	675	210
317	HewPack	8640B	Generator Signal	10,802	4800
318	HewPack	8640B	Generator Signal	11.455	5150
319	HewPack	8640B	Generator Signal	11,807	5395
320	HewPack	8654A	Generator Signal	4850	2250
321	'hewPack	86601A	RF Section	6800	2750
322	HewPack	86602B	RF Section	7400	2950
323	HewPack	86602B	RF Section	9650	3850
324	HewPack	8660C	Generator Signal Synth	18,610	7450
325	HewPack	8660C	Generator Signal Synth	18,860	7550
326	HewPack	8660C	Generator Signal Synth	18,400	7350
327	HewPack	86631B	Modulator PI	600	195
328	HewPack	86632B	Modulation Section AM/FM	3400	1350
329	HewPack	86633B	Modulation Section AM/FM	3400	1350
330	HewPack	86634A	Plug-In Modulation Sect'N	2700	895
331	HewPack	8690A	Oscillator Sweep	4500	825
332	HewPack	8690B	Oscillator Sweep	7500	1100
333	HewPack	8691A	Oscillator 1.0-2.0GHZ	6100	1800
334	HewPack	8692A	Oscillator 2.4-4.0GHZ	6500	1950
335	HewPack	8693A	Oscillator 4.0-8.0GHZ	5900	2100
336	HewPack	8693B	Oscillator 4.0-8.0GHZ	7200	2400
337	HewPack	8694	Oscillator 10-15.5GHZ	5900	1750
338	HewPack	8694A	Oscillator 8.0-12.4GHZ	5800	1600
339	HewPack	8694A	Oscillator8.0-12.4GHZ	4855	1495
340	HewPack	8694B	Oscillator 8.0-12.4GHZ	7300	2650
341	HewPack	8698A	Oscillator .4-11/11-110MH	3550	995
342	HewPack	8698B	Oscillator .4-11/11-110MH	4500	1350
343	HewPack	8732B	Modulator Pin 1.8-4.5GHZ	1710	495
344	HewPack	8733A	Modulator Pin 3.7-8.3GHZ	1850	550
345	HewPack	8734A	Modulator Pin 7-12.4GHZ	1850	550
346	HewPack	8734B	Modulator Pin 7-12.4GHZ	1850	550
347	HewPack	8735B	Modulator Pin 8.2-12.4GHZ	1850	550
348	HewPack	8740A	Test Set Transmission	2750	850
349	HewPack	8750A	Storage Normalizer	2355	950
350	HewPack	8903A	Analyzer Audio 20HZ-100KH	6620	4600
351	HewPack	8970A	Meter Noise Figure	10,300	6900
352	HewPack	908A	Termination 50 OHM	100	50
353	HewPack	909A	Termination 50 OHM	175	85
354	HewPack	934A	Mixer Harmonic	495	195
355	HewPack	938A	Frequency Doubler	8600	1995
356	HewPack	940A	Frequency Doubler	8600	2495

Hewlett Packard 8559A

Spectrum Analyzer

Plug-in RF Section, 10 Mhz-18 Ghz

LIST $10,920

$6250

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
357	HewPack	G281A	Adapter G to N	190	95
358	HewPack	G347A	Noise Source WG	1320	295
359	HewPack	G370C	Attenuator WG 10DB	110	50
360	HewPack	G375A	Attenuator Var. 0-20DB	660	150
361	HewPack	G382A	Attenuator Var.	3080	695
362	HewPack	G485B	Detector Adj WG	110	50
363	HewPack	G532A	Meter Frequency	2180	450
364	HewPack	G750D	Coupler Dir WG	110	50
365	HewPack	G752A	Coupler G Band 10DB	905	225
366	HewPack	G752C	Coupler G Band 10DB	905	225
367	HewPack	G752D	Coupler G Band 20DB	905	225
368	HewPack	G810B	Slotted Section WG	770	150
369	HewPack	G845A	Tee Hybrid WG G	110	50
370	HewPack	G870A	Tuner Slide Screw	800	160
371	HewPack	G910A	Termination	300	75
372	HewPack	G914A	Load Moving WG G	250	65
373	HewPack	G920A	Short Adj WG	225	50
374	HewPack	H281A	Adapter H-N	140	50
375	HewPack	H347A	Noise Source	1250	350
376	HewPack	H370C	Attenuator	100	50
377	HewPack	H375A	Attenuator Var. 0-20DB	225	65
378	HewPack	H382A	Attenuator Var.	2475	525
379	HewPack	H424A	Detector Crystal H Band	380	85
380	HewPack	H485B	Detector Adj	100	50
381	HewPack	H486A	Thermistor Mount	410	125
382	HewPack	H532A	Meter Frequency	1980	425
383	HewPack	H532A	Meter Frequency	1980	600
384	HewPack	H752A	Coupler 3DB 7.05-10.0GHZ	820	250
385	HewPack	H810B	Slotted Section	700	175
386	HewPack	H870A	Tuner Slide Screw	800	200
387	HewPack	H910A	Termination	240	100
388	HewPack	H914A	Moving Load	650	150
389	HewPack	HX292B	Adapter H-X-WG	210	95
390	HewPack	J281A	Adapter J Band	160	60

Hewlett Packard 8555A

Spectrum Analyzer

Plug-in RF Section

LIST $11,825

$6995

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
391	HewPack	J347A	Noise Source	1200	295
392	HewPack	J370C	Attenuator WG 10DB	125	50
393	HewPack	J370D	Attenuator WG 20DB	125	50
394	HewPack	J375A	Attenuator Var. 0-20DB	450	140
395	HewPack	J382A	Attenuator Var. 0-50DB	2475	750
396	HewPack	J485B	Detector Adj	110	50
397	HewPack	J486A	Thermister Mount 100 OHM	420	125
398	HewPack	J532A	Meter Frequency	2200	650
399	HewPack	J750D	Coupler	100	50
400	HewPack	J750E	Coupler 30DB J	100	50
401	HewPack	J752A	Coupler 3DB	1130	350
402	HewPack	J752C	Coupler 10DB 5.30-8.20GHZ	1130	375
403	HewPack	J753D	Coupler WG J 20DB	1130	395
404	HewPack	J810B	Slotted Section J	915	195
405	HewPack	J840A	Tee Series WG J	100	50
406	HewPack	J841A	Tee Shunt WG J	100	50
407A	HewPack	J870A	Tuner Slide Screw	725	185
407B	HewPack	J885A	Phase Shifter	2805	695
408	HewPack	J910	Termination WG J	365	95
409	HewPack	J914A	Load Moving	575	150
410	HewPack	K382A	Attenuator Variable	2475	1250
411	HewPack	K486A	Thermistor Mount 18-26.5G	580	295
412	HewPack	K532A	Meter Freq. 18-26.5GH	1540	650
413	HewPack	K532A	Meter Freq. 18-26.5GH	1540	950
414	HewPack	K752C	Coupler 10DB 18-26.5GHZ	825	425

Hewlett Packard 8565A

Spectrum Analyzer

Opt. 100 - .01 to 20 Ghz

LIST $28,575

$14,150

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
415	HewPack	K815B	Slotted Section K Band	695	250
416	HewPack	K870A	Tuner Slide Screw 18-26.5	725	295
417	HewPack	K870A	Tuner Slide Screw 18-26.5	725	425
418	HewPack	M375A	Attenuator M Band	250	100
419	HewPack	M382A	Attenuator Variable	2250	575
420	HewPack	MP292	Adapter M P WG	210	95
421	HewPack	MP292B	Adapter M P WG	210	95
422	HewPack	MP292B	Adapter M P WG	210	135
423	HewPack	MX292	Adapter M X WG	270	125
424	HewPack	MX292A	Adapter M X WG	270	125
425	HewPack	MX292B	Adapter M X WG	270	125
426	HewPack	NK292A	Adapter	210	95
427	HewPack	NK292A	Adapter M X WG	210	95
428	HewPack	NP292A	Adapter	210	105
429	HewPack	P281C	Adapter Waveguide/Coax	360	275
430	HewPack	P347A	Noise Source 12.4-18GHZ	1100	350
431	HewPack	P370C	Attenuator Fixed	100	50
432	HwePack	P370D	Attenuator 20DB 12.4-18G	100	50
433	HewPack	P375A	Attenuator Var. 0-20DB	715	210
434	HewPack	P382A	Attenuator Variable	1485	450
435	HewPack	P424A	Detector Crystal KU Band	340	110
436	HewPack	P486A	Thermistor Mount	460	145
437	HewPack	P532A	Meter Frequency	1155	350
438	HewPack	P752A	Coupler 3DB	680	225
439	HewPack	P752C	Coupler 10DB	680	250
440	HewPack	P752D	Coupler Directional	680	275
441	HewPack	P870A	Tuner Slide Screw	830	250
442	HewPack	P885A	Phase Shifter P Band	2655	795
443	HewPack	P910A	Termination	225	80
444	HewPack	P920B	Short Adj. WG KU	560	180
445	HewPack	P932A	Mixer Harmonic	885	295
446	HewPack	R382A	Attenuator Variable	2470	750
447	HewPack	R422A	Detector Crystal	800	250
448	HewPack	R422A	Detector Crystal	845	295
449	HewPack	R486A	Thermistor Mount	640	350
450	HewPack	R486A	Thermister Mount	640	295
451	HewPack	R532A	Meter Freq. 26.5-40GHZ	1540	525
452	HewPack	R752C	Coupler 10DB R	890	275
453	HewPack	R752D	Coupler 20DB 26.5-40GHZ	890	325
454	HewPack	R914B	Moving Load	700	220
455	HewPack	S281A	Adapter N-WG 2.6-3.95GHZ	210	95
456	HewPack	S347A	Noise Source	300	125
457	HewPack	S375A	Attenuator Var. 0-20DB	100	50
458	HewPack	S382B	Attenuator Variable	4375	1295

Hewlett Packard 8640B

Signal Generator

01 variable audio OSC
02 internal doubler
03 reverse power protection

500 Khz-512 Mhz (to 1024 Mhz w/opt .02)

LIST $11,500

$6950

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
459	HewPack	S382C	Attenuator Variablew	4375	1550
460	HewPack	S752C	Coupler 10DB 2.6-3.95GHZ	1300	450
461	HewPack	S910A	Termination WG S	475	150
462	HewPack	X281A	Adapter X Band	120	65
463	HewPack	X281B	Adapter X to N	285	90
464	HewPack	X281C	Adapter 8.2-12.4GHZ	335	225
465	HewPack	X347A	Noise Source	1050	325
466	HewPack	X362A	Filter Low Pass	1150	350
467	HewPack	X370B	Attenuator WG 6DB	100	50
468	HewPack	X370C	Attenuator WG 10DB	100	50
469	HewPack	X370D	Attenuator WG 10DB	100	50
470	HewPack	X375A	Attenuator Var. 0-20DB	715	225
471	HewPack	X382A	Attenuator Var. 0-50DB	1485	450
472	HewPack	X421A	Detector X Band	100	50
473	HewPack	X485B	Detector Mount X	460	150
474	HewPack	X532A	Meter Frequency	1155	350
475	HewPack	X532B	Meter Frequency	1155	475
476	HewPack	X750D	Coupler Direct 20DB	100	50
477	HewPack	X750E	Coupler Direct 30DB	100	50
478	HewPack	X752	Coupler 8.2-12.4G	680	210
479	HewPack	X752A	Coupler 3DB	680	210
480	HewPack	X752C	Coupler 10DB	680	225
481	HewPack	X752D	Coupler 20DB	680	250
482	HewPack	X781A	Detector Directional	100	50
483	HewPack	X8108	Slotted Section X	1000	325
484	HewPack	X840A	Tee Series WG X	850	275
485	HewPack	X870A	Tuner Slide Screw	800	250

Marconi 6500

Automatic Scalar Network Analyzer

LIST $8195

$3295

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
486	HewPack	X885A	Phase Shifter	2290	695
487	HewPack	X910A	Termination X Band	235	80
488	HewPack	X910B	Termination WG Fixed	235	80
489	HewPack	X912A	Termination X	100	50
490	HewPack	X913A	Termination X 500 W	100	50
491	HewPack	X914B	Load Moving	535	175
492	HewPack	X916B	Reflection Std WG	100	50
493	HewPack	X920A	Short Adjustable X	100	50
494	HewPack	X923A	Short Moving	510	175
495	HewPack	X930A	Switch Shorting	800	250
496	Hughes	1177	Amplifier TWT 4-8GHZ 10W	7680	3995
497	Hughes	1177H	Amplifier TWT 2-4GHZ 10W	8400	3695
498	Hughes	1177H	Amplifier TWT 8-12.4G 10W	7680	4200
499	Hughes	1177H	Amplifier TWT 12.4-18GHZ	8650	4500
500	Hughes	1177H	Amplifier TWT 8-18GHZ	9470	4900
501	Hughes	1177H	Amplifier TWT 1-2GHZ 10W	9000	3295
502	Hughes	1177H	Amplifier TWT1.4-2.4G20W	8665	4400
503	Hughes	1277	Amplifier TWT 2-4GHZ 20W	9000	4295
504	LAM	LH125A	Power Supply 40V 3A	400	166
505	LAM	LK342A	Power Supply 36V 5.2A	1131	328
506	NAR	1010	Coupler 20DB WG X	620	195
507	NAR	1069	Coupler 12.4-18GHZ 20DB	190	80
508	NAR	1070	Coupler WG X Band	175	75
509	NAR	1220	Isolator 8.2-12.4	250	75
510	NAR	210	Slotted Line WG X		100
511	NAR	22092	Coupler 4.5-8GHZ	350	110
512	NAR	22733	Coupler 4-8GHZ 10DB	350	110
513	NAR	23114	Termination		20
514	NAR	231IN	Meter Impedance		50
515	NAR	23988	Termination		50
516	NAR	2689B	Attenuator Variable		50

Lot #	Mfg.	Model #	Description	List $	Min Bid
517	NAR	300	Termination WG X		50
518	NAR	3000	Coupler	315	100
519	NAR	3001	Coupler .460-.950GHZ	315	100
520	NAR	3002	Coupler .995-2GHZ	315	100
521	NAR	3003	Coupler 2-4GHZ	315	100
522	NAR	3004	Coupler 4-10GHZ	425	150
523	NAR	300C	Termination WG X	165	50
524	NAR	3022	Coupler 1-4GHZ	450	175
525	NAR	3024	Coupler 4-8GHZ	490	185
526	NAR	3032	Hybrid Coax .9-2GHZ	460	150
527	NAR	3033	Hybrid Coax 2-4GHZ	400	125
528	NAR	3035	Coupler Hybrid Coax	525	175
529	NAR	3040	Coupler 240-500MHZ	425	175
530	NAR	3042	Coupler .92-2.25GHZ	350	140
531	NAR	3042B	Coupler .92-2.2GHZ	350	140
532	NAR	3043	Coupler 2-4GHZ 10DB	350	140
533	NAR	3043	Coupler 2-4GHZ 20DB	350	140
534	NAR	3043B	Coupler 1.7-4.2GHZ 10DB	350	140
535	NAR	3043B	Coupler 1.7-4.2GHZ 10DB	350	140
536	NAR	3044	Coupler 4-8GHZ	350	125
537	NAR	3044	Coupler 3.7-8.3GHZ	350	125
538	NAR	3044	Coupler Directional Coax	400	125
539	NAR	3044	Coupler Directional Coax	400	125
540	NAR	3044	Coupler 4-8GHZ	350	125
541	NAR	3044B	Coupler 3.7-8.3GHZ	400	125
542	NAR	3044B	Coupler Directional Coax	400	125
543	NAR	3045B	Coupler 7-11GHZ	250	75
544	NAR	3045C	Coupler 7-12.4GHZ	350	125
545	NAR	3045C	Coupler 7-12.4GHZ	350	125
546	NAR	3045C	Coupler 7-13GHZ	350	125
547	NAR	3202B	Coupler 1-12.4GHZ	500	150
548	NAR	3202B	Coupler 1-12.4GHZ	500	150
549	NAR	340-6	Section St 6IN	100	30
550	NAR	350H	Bend X H Plane	100	30
551	NAR	351E	Bend H Band E Plane	100	30
552	NAR	351H	Bend H Band H Plane	100	30
553	NAR	352H	Bend 90 J Band H Plane	105	35
554	NAR	368NF	Termination	550	175
555	NAR	368NM	Load HP 500W 5KWP	550	175
556	NAR	370NF	Termination	48	20
557	NAR	370SC	Termination	48	20
558	NAR	3712	Attenuator Var. 1-2	775	250
559	NAR	371NF	Termination 2-12.4	225	90
560	NAR	371NM	Termination 2-12.4	225	90

Marconi

White Noise Systems

White noise test sets
including *TF 2091B Noise Generator
*TF 2092B Noise Receiver
Appropriate filters & oscillators avail.

LIST $4700

$1295

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
561	NAR	374NM	Termination DC-13G	125	40
562	NAR	3753B	Phase Shifter 3.5-12.4GHZ	2000	600
563	NAR	376MN	Termination 40 Watt	95	35
564	NAR	379	Sliding Load WG	70	30
565	NAR	4001	Coupler Dir. .6-1.25	200	60
566	NAR	4014C	Coupler 4-8GHZ SMA	139	45
567	NAR	4015C	Coupler 7-12.4OSN	164	60
568	NAR	4016	Coupler 12.4-18 SMA	200	60
569	NAR	4032B	Hybrid 1-2GHZ SMA	125	45
570	NAR	4034C	Hybrid 4-8GHZ SMA	139	45
571	NAR	4036C	Hybrid 12.4-18 SMA	156	60
572	NAR	4371M	Termination SMA-M	100	40
573	NAR	4799	Attenuator Var. 4-18	450	135

Philips 3212

Dual Channel Oscilloscope

25 Mhz

LIST $1195

$495

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
574	NAR	4903	Tuner	175	60
575	NAR	5073	Coupler 1.7-4.2	1075	350
576	NAR	5601	Adapter X-APC-7 WG	110	40
577	NAR	613A	Adapter Coax	195	60
578	NAR	615	Adapter WG-Coax L	450	135
579	NAR	70469	Attenuator 0-69 DC-12.4GH	1600	400
580	NAR	705	Arrenuator Step 0-30DB	2100	630
581	NAR	732	Attenuator Variable	1500	350
582	NAR	733	Attenuator Variable	1500	350
583	NAR	768	Attenuator DC 11GHZ 20W	140	80
584	Orionics	FW304	Splicer Fusion	18,500	14,000
585	Orionics	LAS400	Local Alignment System	5800	4000
586	PER	40-15	Pwr. Sup. 28V 40V 100A 15A	600	195
587	PER	40-3	Pwr. Sup. 28V 40V 100A 15A	750	195
588	PER	TVR40	Pwr. Sup. 28V 40V 100A 15A	600	195
589	PHI	3212	Oscilloscope 25MHZ 2CH	1195	495
590	PHI	3214	Oscilloscope 25MHZ 2CH	1495	595
591	PHI	3262	Oscilloscope 100MHZ 2CH	2995	995
592	PMI	1038	Analyzer Auto Network	6525	2195
593	PMI	1038R	Display	2855	600
594	PMI	1038%	Display	2855	850
595	PMI	1038S	Display GPIB	3815	1295
596	PMI	1038V	Vert Log Amp/Mem	1715	450
597	PMI	1038V	Vert Log Amp/Mem	1825	495
598	PMI	15176	Detector 1MHZ 18GHZ	560	195
599	PMI	15237	Detector 1MHZ 18GHZ	475	150
600	PRD	116A	Termination WG X	35	25
601	PRD	1205	Isolator WG G	325	100
602	PRD	1208	Isolator WG-KU	275	95
603	PRD	1208	Isolator 12-18GHZ	275	95
604	PRD	131A	Termination	40	20
605	PRD	132A	Termination K	40	20
606	PRD	1400	Attenuator Var. S	240	70
607	PRD	153BF1	Attenuator Var. K	325	100
608	PRD	154-A	Attenuator Variable	70	30
609	PRD	156A	Attenuator J	100	40
610	PRD	156B	Attenuator J	100	40
611	PRD	159B	Attenuator		60
612	PRD	161	Attenuator WG 10DB		50
613	PRD	162B	Attenuator Variable	125	60
614	PRD	170B	Attenuator Var. J	325	100
615	PRD	175B	Atten Prec. S Band	375	125
616	PRD	175B	Attenuator Var. G	375	125
617	PRD	187A	Attenuator Var.	245	75
618	PRD	201A	Slotted Line G	390	115
619	PRD	203D	Slotted Line X	350	105
620	PRD	210A	Slotted Line KU	500	150
621	PRD	211	Slotted Line	500	150
622	PRD	219	Meter Vswr 100M 1G	580	175
623	PRD	303A	Tuner Slide Screw	125	40

Philips 3214

Dual Channel Oscilloscope

25 Mhz, with delayed time base

LIST $1495

$595

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
624	PRD	313A	Tuner E-H K Band	155	50
625	PRD	3302	Susceptance Unit	195	80
626	PRD	3360	Straight Section	50	20
627	PRD	356	Adapter J-N	45	20
628	PRD	356A	Adapter J-N	45	20
629	PRD	408	Coupler X Band	100	40
630	PRD	408S1	Coupler 10DB X Band	100	40
631	PRD	411	Coupler 10DB	395	195
632	PRD	433-20	Coupler 4-8GHZ 20DB	195	80
633	PRD	4410	Coupler 4-10 G 30DB	125	50
634	PRD	4410	Coupler 4-10 G 20DB	125	50
635	PRD	4410	Coupler 4-10 G 10DB	125	50
636	PRD	4410	Coupler 4-10GHZ	125	50
637	PRD	4410	Coupler 4-10GHZ 10DB	125	50
638	PRD	4420	Coupler 4-8 G 30DB	190	75

Philips 3262

Dual Channel Oscilloscope

100 Mhz

LIST $2995

$995

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
639	PRD	4420	Coupler 4-8 G 10DBC	190	75
640	PRD	4420A	Coupler 7-12.4GHZ	190	80
641	PRD	463	Bend X Plane H	40	20
642	PRD	463-A	Bend H Plane X	40	20
643	PRD	475FI	Bend H Plane R	90	45
644	PRD	536	Meter Frequency	1455	600
645	PRD	616A	Detector Adj KV Band	180	65
646	PRD	643	Detector X	85	35
647	PRD	643	Detector	85	35
648	PRD	7805A	Amplifier .05-80MHZ 1KW		425
649	S/A	11A	Adapter X-Band	100	50
650	S/A	12-82	Horn Std. Gain 15.5DB	500	225
651	S/A	4601	Transc'vr Link Alignment	11,730	4800
652	S/A	4604	Station Remote	1805	500
653	S/A	4605-4	Horn Std. Gain J Band	705	275
654	S/A	4605-4	Horn Std. Gain G Band	705	275
655	SIE	160	Termination	50	25
656	SIE	160-1	Termination 1W	50	25
657	SIE	160-2	Termination 50W	50	25
658	SIE	160-5	Termination 5W	50	25
659	SIE	1601F	Termination	50	25
660	SIE	20FN	Termination 20W	90	40
661	SIE	20MN	Termination 20W	90	40
662	SIE	50D	Termination 50W	90	40
663	SIE	5MN	Termination 5W	90	40
664	SLA	106	Tester Hi Pot		250
665	SMG	901304	Detector	250	50
666	SMG	950690	Detector	250	50
667	SOP	P8088	Pod Microprocessor	1995	1050
668	SOP	SA700	Analyzer System	9995	4500
669	SOR	DCR	Pwr. Sup. 300V 1.25A	900	325
670	SOR	DCRB	Pwr. Sup. 150V 3A	900	295
671	SOR	DCRB	Pwr. Sup. 300V 3A	1150	575
672	SOR	DCRB	Pwr. Sup. 300V 8A	2210	695
673	SOR	DCRB	Pwr. Sup. 300V 9A	2210	695
674	SOR	DCRB	Pwr. Sup. 80V 5A	900	325
675	SOR	QR	Pwr. Sup. 36V 4A	400	150
676	SOR	QRB	Pwr. Sup. 15V 2A	350	125
677	SOR	QRD	Pwr. Sup. 20V 4A	550	195
678	SOR	QRS	Pwr. Sup. 60V 1.5A	525	175
679	SOR	SRL	Pwr. Sup. 60V 4A	1250	400
680	SPC	508	Cable Locater System	180	180
681	SPE	24X1	Coupler Dual WG	700	225
682	SPL	PN30	Pwr. Sup. 30KV	2500	350

Lot #	Mfg.	Model #	Description	List $	Min Bid
683	SPL	RHR40	Pwr. Sup. 40KV 3M	1895	600
684	SPL	UHR40	Pwr. Sup. 40KV 3M	1625	550
685	SRC	IQ120	CRT Terminal R5232	400	100
686	SRI	ESH-3	Meter E/Static 30,20,10,5	795	250
687	SRI	ESH-5	Electrostatic VM 0-25KV	795	250
688	SRI	ESH-6	Electrostatic VM 0-30KV	825	300
689	STC	1700A	Analyzer Audio Distortion	3200	1100
690	STG	1604	Module Characterizer	185	100
691	STG	1621A	Module Character	185	100
692	STG	1624	Module Characterizer	285	150
693	STG	16T28A	Module Ganged Adapter	450	195
694	STG	2000	Module Universal	1600	300
695	STG	202	Module Adapter Pal 20 Pin	140	60
696	STG	203	Module Adapter 24 Pin Pal	140	60
697	STG	2100	Module Personality	1250	250
698	STG	2200	Module Personality Pal	1250	250
699	STG	2516	Module Adapter	75	35
700	STG	2532	Module Adapter	75	35
701	STG	27128	Module Adapter	75	35
702	STG	2716	Module Adapter	75	35
703	STG	2732	Module Adapter	75	35
704	STG	PPX	Programmer w/Bral	3600	950
705	STG	PPX	Programmer Prom	3600	950
706	STG	PPX	Prog. Prom Bral + 32K	3600	950
707	STO	95013	Attenuator N 20DB		20
708	STO	95013	Attenuator N 30DB		20
709	STO	95013	Attenuator N 40DB		20
710	SYD	210	Section St 6IN	150	25
711	SYD	67540	Coupler Directional		150
712	SYD	915	Phase Shifter		100
713	SYD	B1010	Waveguide Stand		50
714	SYD	B915	Phase Shifter		100
715	SYD	BH224	Bend H Band E Plane	85	50
716	SYD	BH234	Bend H Band H Plane	85	50
717	TEC		Adapter WR229-CPR229	125	60
718	TEC		Termination CPR229	125	60
719	TEC	101	Adapter CMR 229 to NM	100	50
720	TEC	301	WR229-CMR Flange	450	185
721	TEK	134	Probe Current Amplifier	625	195
722	TEK	200C	Cart Oscilloscope	330	150
723	TEK	200C	Scope Cart	330	150
724	TEK	202-4	Cart Oscilloscope	475	150

Wiltron 610D

Sweep Generator with 6247D RF Plug-In

10MHz to 18.5Ghz

LIST $23,450

$10,095

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
725	TEK	203-2	Cart Oscilloscope	300	100
726	TEK	203-3	Cart Oscilloscope	300	100
727	TEK	204-2	Cart Oscilloscope	475	150
728	TEK	3	Cart Lab	595	175
729	TEK	3	Cart Oscilloscope	595	175
730	TEK	305	Oscilloscope 5MHZ 2CH	2590	950
731	TEK	335	Oscilloscope 35MHZ 2CH	3135	1250
732	TEK	422	Oscilloscope 15MHZ 2CH	1600	250
733	TEK	432	Oscilloscope 25MHZ 2CH	1720	650
734	TEK	475A	Oscilloscope 250MHZ 2CH	4630	3000
735	TEK	521	Vector Scope	8050	2400
736	TEK	522	Vector Scope	9540	2900
737	TEK	528A	Monitor Waveform	2330	1100
738	TEK	528A	Monitor Waveform NTSC	2330	1100
739	TEK	531A	Oscilloscope		100
740	TEK	547	Oscilloscope		100
741	TEK	5A18N	Amplifier DC-2MHZ Dual	795	225

Lot #	Mfg.	Model #	Description	List $	Min Bid
742	TEK	5A24N	Amplifier DC-2MHZ Dual	275	100
743	TEK	5A45	Amplifier DC-60MHZ	495	175
744	TEK	5A45	Amplifier 60MHZ 1CH	495	175
745	TEK	5A45	Amplifier Vertical	495	175
746	TEK	5A48	Amplifier 60MHZ 2CH	1090	325
747	TEK	5B31	Time Base		100
748	TEK	5S14N	Samp. Delayed Sweep 2CH	6085	1800
749	TEK	620	Monitor CRT	1600	450
750	TEK	7403N	Oscilloscope 60MHZ MF	1050	395
751	TEK	7403N	Oscilloscope	1050	395
752	TEK	7603	Oscilloscope 100MHZ MF	3250	1250
753	TEK	7603	Oscilloscope	3250	1250
754	TEK	7603N	Oscilloscope 100MHZ MF	2970	950
755	TEK	7834	Oscilloscope Storage	13,365	6700
756	TEK	7844	Oscilloscope 400MHZ MF	14,995	8200
757	TEK	7844	Oscilloscope 400MHZ MF	15,390	8500
758	TEK	7904	Oscilloscope 500MHZ MF	8510	2800
759	TEK	7A11	Amplifier DC-250MHZ	2970	950
760	TEK	7A12	Amplifier 120MHZ 2CH	900	250
761	TEK	7A14	Amplifier 20MHZ 1CH	500	150
762	TEK	7A15	Amplifier 80MHZ 1CH	680	200
763	TEK	7A15A	Amplifier 80MHZ 1CH	695	225
764	TEK	7A15AN	Amplifier 80MHZ 1CH	695	200
765	TEK	7A16	Amplifier 75MHZ 2CH	1275	375
766	TEK	7A17	Amplifier 150MHZ 1CH	445	150
767	TEK	7A18	Amplifier 75MHZ 2CH	1395	475
768	TEK	7A18	Amplifier 75MHZ 2CH	1395	600
769	TEK	7A18	Amplifier Vert 75MHZ 2CH	1605	625
770	TEK	7A18N	Amplifier 75MHZ 2CH	1395	375
771	TEK	7B50	Time Base	1015	300
772	TEK	7B50A	Time Base	1075	350
773	TEK	7B53A	Time Base Dual	1685	950
774	TEK	7B53A	Time Base Dual	1845	1100
775	TEK	7B53AN	Time Base Dual	1685	450
776	TEK	7B53AN	Time Base Dual	1845	550
777	TEK	7B70	Time Base	675	200
778	TEK	7B71	Time Base Delaying	725	250
779	TEK	7B80	Time Base Triggering	1620	950
780	TEK	7B80	Plug-In Time Base	1725	1025
781	TEK	7B85	Time Base Delaying	1895	1150
782	TEK	7B92	Time Base Dual	3470	1050
783	TEK	7B92A	Time Base Dual	3745	1700
784	TEK	7CT1N	Plug-In Curve Tracer	1585	495
785	TEK	7D01	Analyzer Logic	5200	1500
786	TEK	7D02	Analyzer Logic	4950	2300
787	TEK	7D12	Converter A/D	1775	500
788	TEK	7D13	Multimeter Digital	1280	375
789	TEK	7D14	Counter Plug-In	2100	650
790	TEK	7D15	Counter/Timer Univ 225MHZ	3495	950
791	TEK	7L12	Analyzer Spectrum	10,960	6500
792	TEK	7L5	Analyzer Spectrum	11,070	6750
793	TEK	7M13	Plug-In Readout Unit	1260	395
794	TEK	7T11	Sweep Unit Sampling	5240	1525
795	TEK	9129	Digital Analysis System	9850	5500
796	TEK	9129	Digital Analysis System	13,000	7500
797	TEK	91A04	Module Data/ACQ	7950	2950
798	TEK	91A08	Module Data/ACQ	3985	2300
799	TEK	91A32	Module Data/ACQ	4990	2495
800	TEK	91P16	Module Pattern Generator	3990	2300
801	TEK	91P32	Module Pattern Generator	6990	2700
802	TEK	C-12	Camera Oscilloscope		150
803	TEK	C-30A	Camera Oscilloscope	1375	275
804	TEK	C-30B	Camera Oscilloscope	1445	600
805	TEK	C-4	Camera Oscilloscope	370	195
806	TEK	C01	Comm Pack RS232C	750	225
807	TEK	C4	Camera Oscilloscope	370	195
808	TEK	C5	Camera Oscilloscope	495	150
809	TEK	C50	Battery Pack	250	100

Test Equipment Corporation

1-800-227-1995

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 857 MOUNTAIN VIEW, CA

POSTAGE WILL BE PAID BY ADDRESSEE

Test Equipment Corporation
2232 Old Middlefield Way
Mt. View, California 94043

Lot #	Mfg.	Model #	Description	List $	Min Bid
810	TEK	C51	Camera Oscilloscope	2250	495
811	TEK	C51B	Camera Oscilloscope	2250	495
812	TEK	C52	Camera Oscilloscope	1600	480
813	TEK	C59R	Camera Oscilloscope	1330	395
814	TEK	CA	Plug-In Amplifier 2CH	100	50
815	TEK	DC502	Counter Frequency 550MHZ	1195	395
816	TEK	DC503	Counter Universal	1140	350
817	TEK	DC503A	Counter Universal 125MHZ	1200	495
818	TEK	DC504	Counter/Timer	800	250
819	TEK	DC509	Counter/Timer Univ.	2080	625
820	TEK	DF1	Formatter Display	2350	495
821	TEK	DM501	Meter Multi	770	195
822	TEK	DM501A	Meter Multi	770	325
823	TEK	FG501	Generator Function 2MHZ	850	225
824	TEK	FG504	Generator Function 40MHZ	3025	1150
825	TEK	P6046	Probe Fet Diff	1750	525
826	TEK	P6051	Probe Fet	675	225
827	TEK	P6056	Probe DC to 3.5GHZ	185	65
828	TEK	P6201	Probe Fet	1210	375
829	TEK	P6202	Probe Fet	620	195
830	TEK	P6202	Probe Fet 10X	640	225
831	TEK	P6202A	Probe Fet	680	275
832	TEK	P6451	Probe Data/ACQ	550	195
833	TEK	P6452	Probe Data ACQ/EXT Clock	730	325
834	TEK	P6454	Probe Data Acquisition	265	100
835	TEK	P6455	Probe Pattern Generator	575	195
836	TEK	P6460	Probe Data/ACQ	700	250
837	TEK	PM101	Module Personality 6502	1700	395
838	TEK	PM107	Module Personality	1800	600
839	TEK	PM109	Module Personality	2000	1050
840	TEK	S1	Sampling Head	1325	425
841	TEK	SC501	Oscilloscope 5MHZ	1400	495
842	TEK	SC502	Oscilloscope 15MHZ 2CH	2550	795
843	TEK	T922	Oscilloscope 15MHZ 2CH	995	350
844	TEK	TM504	Module Pwr. Sup. MF	495	295

Lot #	Mfg.	Model #	Description	List $	Min Bid
845	TEX	7272	Meter Signal Level	1275	450
846	TLQ	D54	Oscilloscope		100
847	TLQ	D67	Oscilloscope		100
848	TMM		adapter WR229 CMR229	48	25
849	VTL	MD113	Data Modem	325	100
850	WAE	2200	Noise Source 18-26.5GHZ	335	110
851	WAE	2901	Adapter WG-N	450	135
852	WAE	2922	Attenuator Variable WR229	1950	595
853	WAE	2974	Coupler CMR 229 10DB	1200	360
854	WAE	2994C	Transition CMR229-G	400	150
855	WAE	308C	Attenuator Var. WG-G	420	100
856	WAE	314	Detector Mount Adj	190	75
857	WAE	390-2	Twist WG-G	105	40
858	WAE	401-NF	Adapter J Band	120	50
859	WAE	401-NF	Adapter J Band	120	50
860	WAE	43412	Straight Sect 3	50	15
861	WAE	43422	Straight Sect 6	50	25
862	WAE	454	Termination J Band	135	80
863	WAE	474-3	Coupler 3DB 5.85-8.2GHZ	770	195
864	WAE	5133	90 Deg. Bend H 15.-22.GHZ	70	25
865	WAE	574	Coupler 20DB	220	80
866	WAE	594	Adapter/Transition H-J WG	120	50
867	WAE	601TNC	Adapter TNCF X	155	50
868	WAE	60351	Attenuator WG X	150	50
869	WAE	613	Attenuator WG X	115	40
870	WAE	614	Detector Adj X Band	130	60
871	WAE	632	Bend 90 X Bend E Plane	50	25
872	WAE	657	Hybrid Tee WG X	85	45
873	WAE	670	Coupler Atten 20DB	140	50
874	WAE	674	Coupler Directional	250	75
875	WAE	681	Termination 150W	200	60
876	WAE	694A	Adapter H-X	70	30
877	WAE	699	Horn Std Gain WG X	155	90
878	WAE	7501NF	Adapter M-N(F)	205	65
879	WAE	782	Termination Hi Power P Band	275	95

PLEASE CUT OUT, FOLD IN HALF, TAPE AND MAIL.

Test Equipment Corporation

MAIL BID FORM

LOT # ________ DESCRIPTION ________ BID ________

________ ________ ________

________ ________ ________

________ ________ ________

NAME ________ TITLE ________

COMPANY ________

ADDRESS ________ CITY ________

STATE ________ ZIP ________ PHONE ________

☐ Please charge my credit card

VISA # ________ Exp. Date ________

MASTERCARD # ________ Exp. Date ________

VISA

If you prefer, you may bid by phone, Call

1-800-227-1995

MasterCard

Please indicate your primary equipment usage:
(Check all headings that apply)

General Purpose Test Equipment

1. ☐ Development/Emulation
2. ☐ Logic Analyzers
3. ☐ Microwave/RF
4. ☐ RFI/EMI
5. ☐ Recorders
6. ☐ Scientific
7. ☐ Temp/Vibration
8. ☐ Other ________

Telecommunications Test Equipment

9. ☐ General Telecommunications
10. ☐ Cellular/Mobil Test Equipment
11. ☐ Fiber Optics Cable Fault Location Equipment
12. ☐ Microwave & Satellite Test Equipment
13. ☐ Noise Loading Carrier Equipment
14. ☐ Protocol Equipment
15. ☐ Signaling & Supervisory Equipment
16. ☐ Video Test Equipment
17. ☐ OTDRs
18. ☐ Fiber Splicers

Please indicate your function:

1. ☐ Administrative/Management
2. ☐ Administrative/Purchasing
3. ☐ Engineering Management
4. ☐ Test Engineer
5. ☐ Design Engineer
6. ☐ Calibration/Repair
7. ☐ Field Service
8. ☐ Sales

Please indicate your primary Company Activity:

1. ☐ Manufacturing/Hard Goods
2. ☐ R & D
3. ☐ Repair/Calibration
4. ☐ Service/Communication
5. ☐ Service/Other
6. ☐ Consultant

Please indicate the Industry type:

1. ☐ Communication
2. ☐ Electronic
3. ☐ Medical
4. ☐ Aerospace
5. ☐ Military
6. ☐ Utility
7. ☐ Energy
8. ☐ Transportation
9. ☐ Education
10. ☐ Non-Specific

WRH

Tektronics Lab Oscilloscope Systems

7403N 60Mhz Mainframe,
7A18N Vertical Amplifier
7B50 Timebase

LIST $3450

$500 COMPLETE

7603N 100Mhz Mainframe
7A26 Dual Trace Amplifier
7B53A Dual Timebase

LIST $7000

$2995 COMPLETE

AVAILABLE FOR IMMEDIATE SALE!

Lot #	Mfg.	Model #	Description	List $	Min Bid
880	WAE	832	Bend 90 K Band E Plane	55	20
881	WAE	833	Bend 90 K Band H Plane	55	20
882	WAE	869	Coupler WG K	215	75
883	WAG	W52M1	Switch WG & Manual	150	50
884	WAL	1000	Adapter WG	280	225
885	WAL	2000	Adapter WG	125	95
886	WAV	1084	Generator Sweep	4395	1650
887	WAV	175	Generator Waveform	4950	1500
888	WAV	2022	Generator Sweep0-2.5GHZ	5995	1795
889	WAV	2002A	Generator Sweep 0-2.5GHZ	6895	1995
890	WAV	2002A	Generator Sweep 0-2.5GHZ	6995	2050
891	WAV	3004	Generator Signal 1-520MHZ	5495	1650
892	WAV	3006	Generator Signal 1-520MHZ	5495	1650
893	WAV	3006	Generator Signal 1-520MHZ	5745	1695
894	WAV	3010	Generator Signal 1GHZ	5495	2395
895	WAV	3510	Generator Signal 1-1000M	5495	2995
896	WAV	712DR	Attenuator Flap 0-40DB KU	335	125
897	WIL	610C	Oscillator Mainframe	2200	650
898	WIL	6213D	Plug-In Osc. .01-4.2GHZ	7800	2350
899	WIL	6215D	Plug-In Osc. .01-4.2GHZ	6250	1895
900	WIL	6219D	Plug-In Osc. 2.0-8.0GHZ	6250	2495
901	WIL	6223	Plug-In Osc. 4.0-12.4GHZ	7825	2695
902	WIL	87A50	Bridge Vswr 2-18GHZ	1600	950
903	WIL	87A50	Bridge Vswr 2-18GHZ	2000	1075
904	WIL	97A50	Bridge Vswr .01-18GHZ	1800	1650
905	WIL	97A50	Bridge Vswr AUTOTESTER	2100	1200
906	WMC	H311S	Hygrothermograph	350	175
907	WUG	SPM11	Meter Selective Level	9000	1250

CALL NOW!

(800) 227-1995

OR BID BY MAIL BY USING THE POSTAGE-FREE FORM

TEC Test Equipment Corporation

typical frequency of 5 kHz.

The following excerpt from a letter by the author to *Scientific American* (February 1986) refers to the component layout of the audio version shown in Figure 3:

"The article 'Cricket Auditory Communication,' by Franz Huber and John Thorson (*Scientific American*, December, 1985), describes an auditory-neuron direction finding system that is remarkably similar in concept to an electronic system developed to measure the position of particle beams in the accelerators at the Fermi National Accelerator Laboratory.

". . . In the cricket, the relative external sound pressure on the two tympana is determined by the orientation of the cricket in relation to its chirping mate. The coupling of the two tympana by the tracheal tube apparently makes the conversion from amplitude to phase. The result is that the relative amplitudes of the two input signals are completely encoded in the relative phase of the two output signals. In the cricket, since there is little useful information in the amplitude of the nerve impulses from the auditory receptors, the omega neurons in the prothoracic ganglia must measure the relative phase of the two nerve signals. This is apparently accomplished by the reciprocal inhibition function of the omega-1 cells by a mechanism similar to that of two cross-coupled monostable multivibrators in an electronic system . . .

"The amplitude-to-phase conversion scheme was chosen to measure the beam position as it accomplished the necessary function with a minimal amount of signal processing. It is interesting that genetic selection in the cricket led to a similar result."

Note that the biological implementation of the amplitude comparator is both plentiful and inexpensive. Billions have been produced and the price is in the "dime a dozen" category. With over a million years of development time, the current models experience a MTBF of approximately 1000 hours.

Reference

Scientific American, Feb. 1986, Letters, p. 6.

About the Author

Robert E. Shafer is on the staff of the Fermi National Accelerator Laboratory, Batavia, Illinois. The mailing address is Fermilab MS341, P.O. Box 500, Batavia, IL 60510. Telephone number is (312) 840-3000.

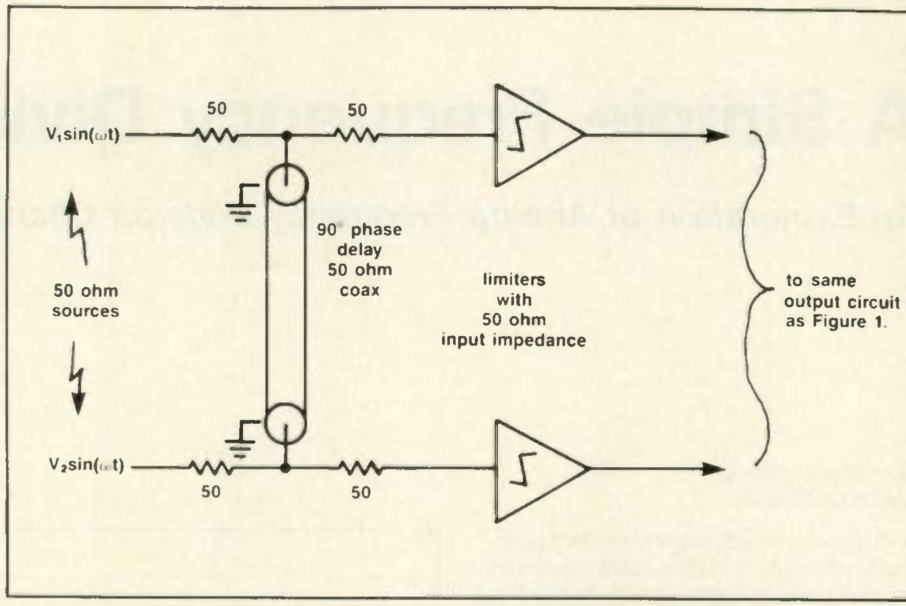


Figure 2. Alternate circuit for Large Dynamic Range Amplitude Comparator.

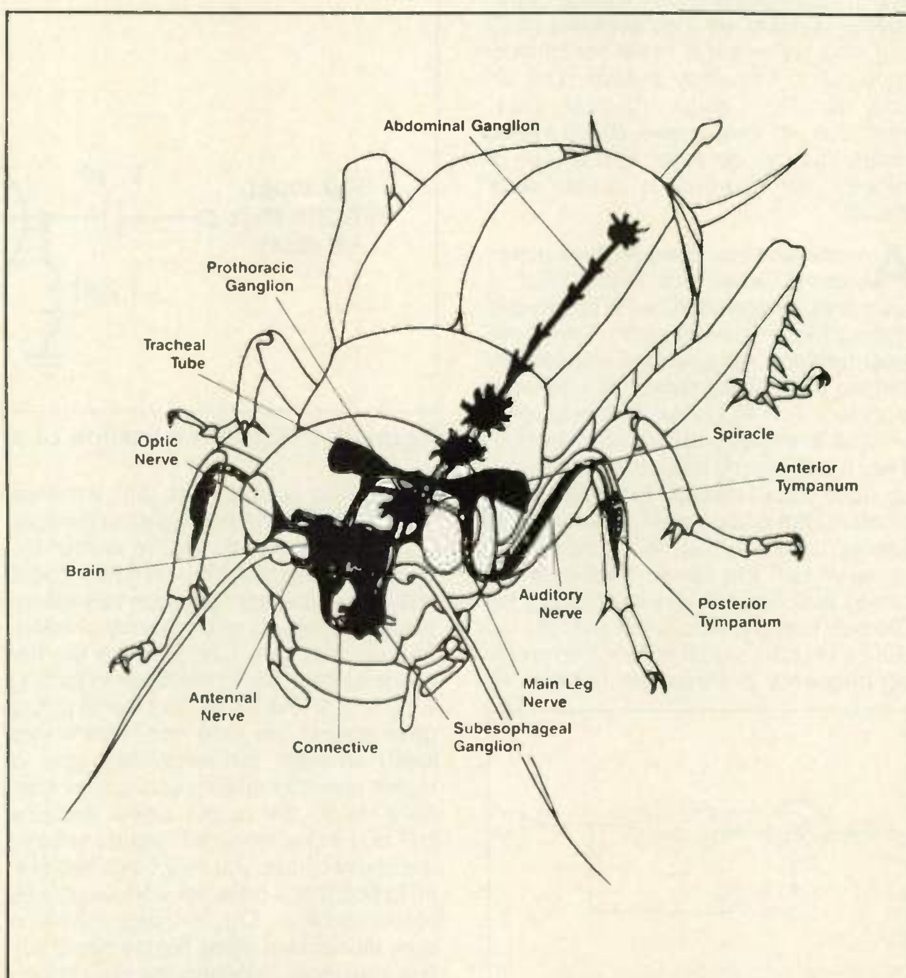


Figure 3. Component layout of audio-frequency amplitude comparator.

A Simple Frequency Divider Circuit

An Exploration of Analog Frequency Division Characteristics.

By Peter Vizmuller
Motorola Canada

Frequency dividers are important building blocks used in synthesizers, frequency counters and spectrum shaping circuits. Although frequency division is normally achieved by digital methods, at VHF and UHF frequencies analog methods of frequency division are also available (1, 2) and may represent a more economical approach to frequency division. This article, an RF Design *Contest entry, describes an inexpensive divide-by-two circuit that can be built "in a couple of minutes with spare parts in your desk drawer."*

Anyone who has designed high power Class-C amplifiers knows that a substantial design effort has to be devoted to ensuring amplifier stability. One of the most troublesome spurious is at exactly half the carrier frequency and is generally present if the input drive level is too high or if the amplifier output is mismatched. If you are designing a power amplifier, this spurious output represents a challenging problem, but if you want to design a frequency divider circuit, this "undesired" signal at half the carrier frequency becomes exactly what you are looking for. The only task is to modify the amplifier circuit so that the signal at half the incoming frequency is enhanced as much as possible. To be able to do that, we need to understand how this signal originates.

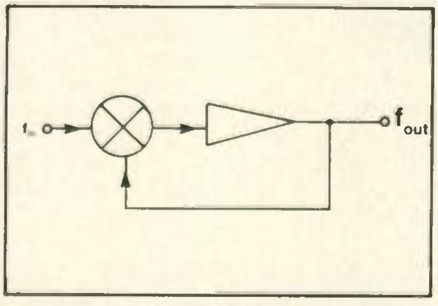


Figure 1. A regenerative divider.

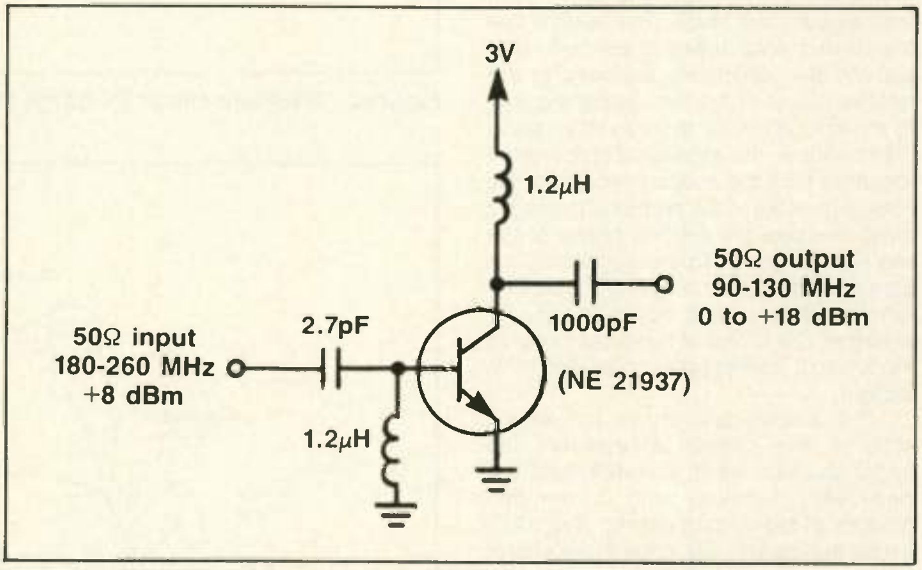


Figure 2. Practical realization of a frequency divider.

Consider the regenerative divider circuit (2) shown in Figure 1. A little thought shows that this configuration has the interesting property of frequency division. Assume that $f_{out} = f_{in}/2$; then the two frequencies combine in the mixer to form $f_{in} \pm f_{out}$ or $f_{in}/2$ and $3\,f_{in}/2$. The signal at $f_{in}/2$ goes around the loop and regenerates itself, provided the amplifier's gain is higher than the mixer's conversion loss. As a result, the output signal contains $f_{in}/2$ and its harmonics. If you try to build the above circuit, you may be disappointed to find that it does not work exactly as theory dictates. The frequency division does indeed take place, but the circuit suffers from other problems, the most important being that the output signal may contain two or more closely spaced frequencies near $f_{in}/2$, rather than the desired signal at exactly $f_{in}/2$.

This can be illustrated as follows: Suppose the incoming frequency is at 300 MHz. Then an output frequency of 150 MHz will regenerate itself in the loop. This is the desired mode of operation. An undesired mode occurs when the output consists of two signals, one at 140 MHz and the other one at 160 MHz. The 140 MHz signal, mixing with 300 MHz, will regenerate 160 MHz and the 160 MHz signal will similarly regenerate 140 MHz. The same argument also applies to other frequency spacings and to more than two signals, provided they are frequency-symmetrical about $f_{in}/2$.

The regenerative divider presented above is not practical (except for very narrow bandwidths), but illustrates the general principles involved in a frequen-

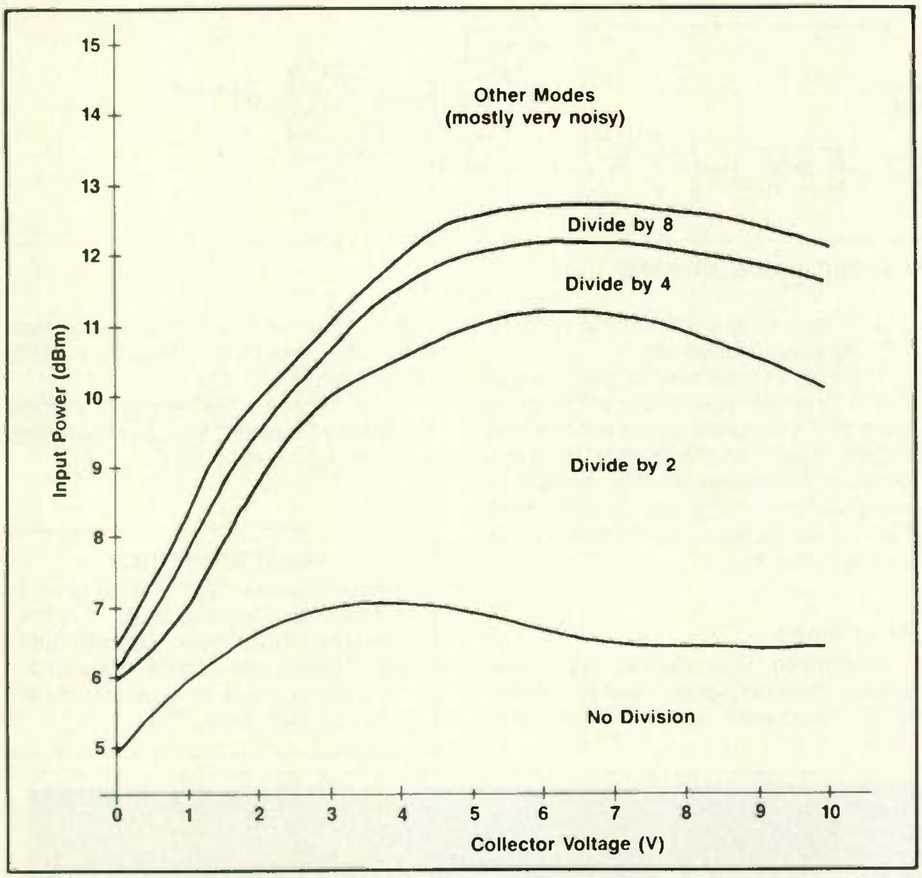


Figure 3. Modes of operation at 203 MHz.

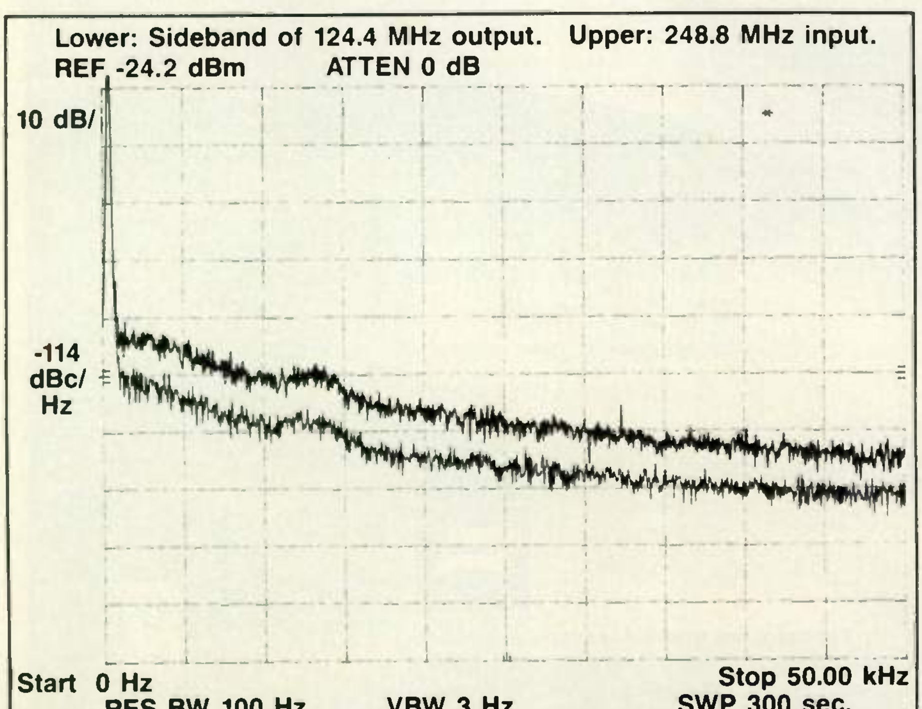


Figure 4. Reduction in sideband noise obtained by frequency division.

cy-division circuit: Any time an amplifier operates in a highly non-linear mode (i.e. as a mixer) and there is a feedback, frequency division can be expected to take place. A transistor amplifier already satisfies two of the conditions since it has gain and internal feedback. If it is made to operate in a highly non-linear mode all three conditions for frequency division will be met. Amplifier operation will be non-linear if the input level is high, the collector supply is low and operation is Class-C. The circuit in Figure 2 shows how frequency division can be obtained using a minimum number of parts.

This is just about the simplest active circuit that can be built, yet it does perform frequency division when the input level is above +7 dBm. The transistor type is not critical (NE21937 is an inexpensive, small-signal RF transistor), the case capacitor and coil determine the frequency of operation, and the collector circuit is not very critical. Frequency division is obtained over a moderate bandwidth of 180-260 MHz with a gain of about 10 dB for a range of input levels from +7 dBm to +10 dBm. Input levels greater than 10 dBm are not recommended, since other modes of operation will be present and the noise level will markedly increase.

This divider circuit is very simple and inexpensive, but has a few disadvantages, including a fairly narrow operating bandwidth, narrow range of input levels and output that is rich in harmonic content. Also, the input and output match are relatively poor to ensure that enough signal is reflected back into the device for regenerative mixing. This means that the circuit is sensitive to source and load impedance variations. Attenuators at input and output would be a good way of maintaining a 50 ohm system. The graph in Figure 3 shows the mode of operation as a function of input level and collector voltage.

To show that true frequency division takes place, one can frequency modulate the input and verify that the frequency deviation of the output signal is one half the frequency deviation of the input. A decrease in side-band noise of about 6 dB can also be observed on the output signal, as shown in Figure 4. If side-band noise reduction is important, two precautions must be taken to avoid AM to PM conversion: Use a limiter on the input signal to eliminate AM noise and make sure that the power supply is clean.

Possible Applications

One interesting use of frequency dividers is in a circuit that is theoretically

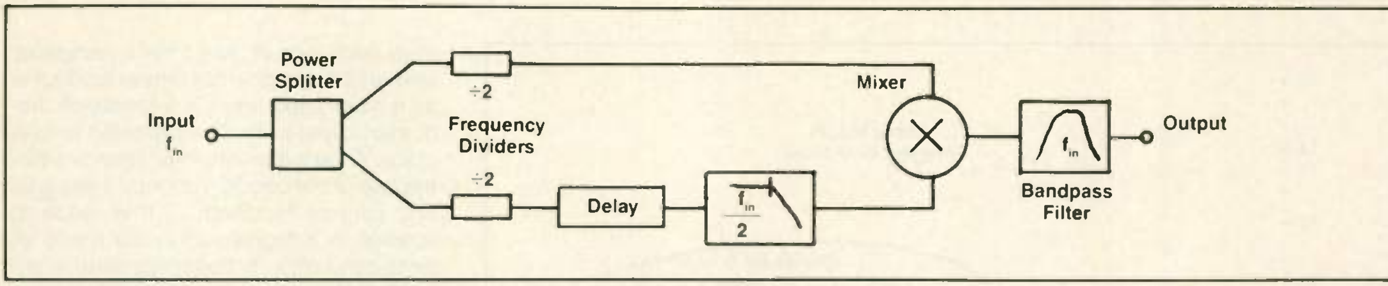


Figure 5. Side-Band noise reduction circuit using dividers.

capable of reducing the side-band noise of the incoming signal by 3 dB, as shown in Figure 5. Each divider drops the side-band noise by 6 dB. When these two signals at $f_{in}/2$ are combined in the mixer the side-band noise increases only by 3 dB since the two signals are not correlated due to the delay used after one of the dividers. The result is a net improvement of 3 dB in sideband noise.

Several assumptions must be met before the circuit can work as described:

1. There is no AM noise on the input signal.
2. The dividers do not introduce any additional noise in the form of phase jitter (3) or wide-band noise.
3. A long delay is available to uncorrelate the noise sidebands.

The above circuit was built with two of the dividers described in this article, using two signal generators as the uncorrelated signals rather than the splitter/delay combination. There was an improvement in side-band noise but it was less than 2 dB. Perhaps an interested reader can improve on these results. rf

References

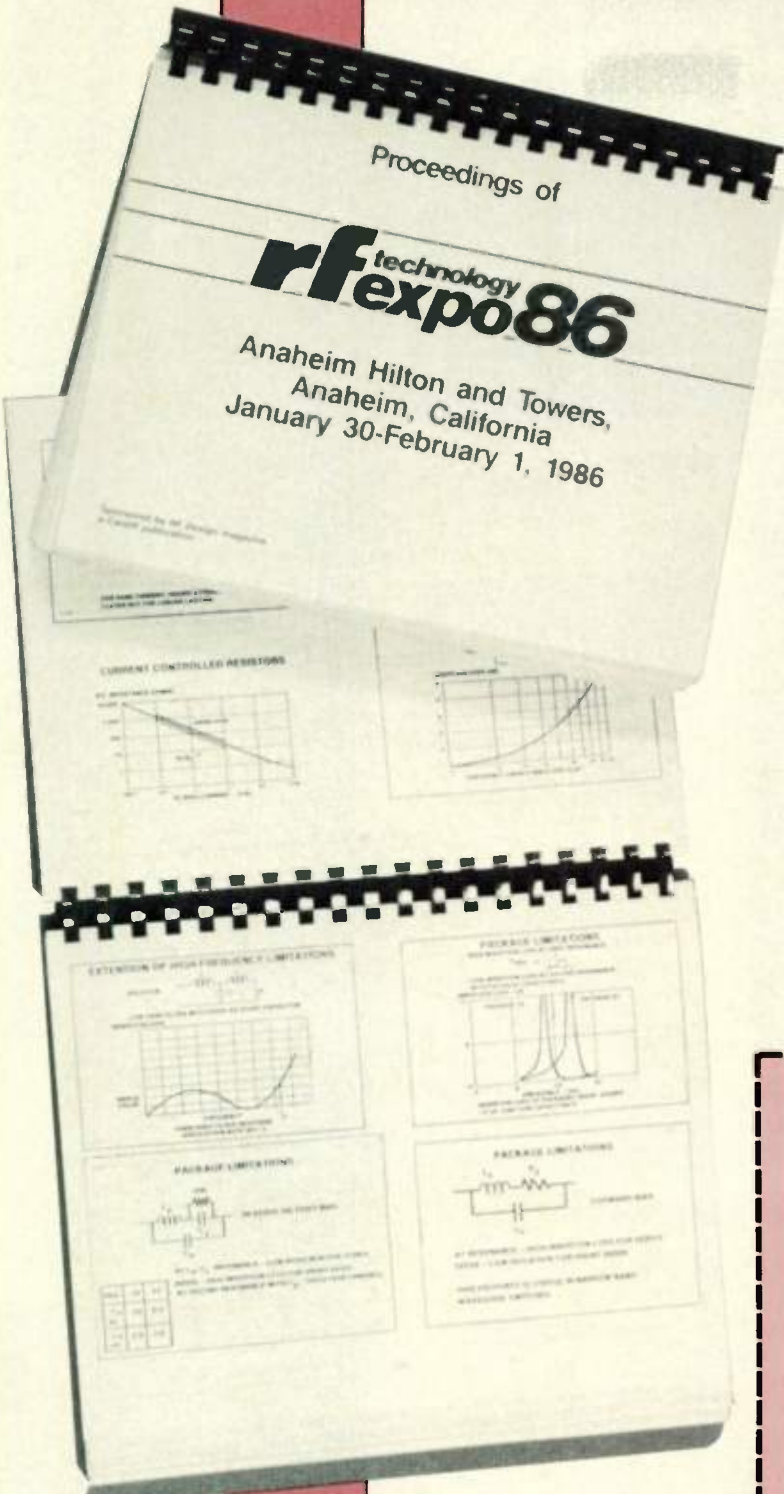
1. Harrison, R.G., Tucker, T.W., "Frequency Division Solves Systems Problems," *Microwave Systems News,* Oct. 1978.

2. Carlson, A.B., *Communication Systems,* McGraw-Hill Co., New York, 1975, second edition, p. 218.

3. Huffman, D., "Extremely Low Noise Frequency Dividers," *Microwave Journal,* Vol. 28, No. 11, Nov. 1985.

About the Author

Peter Vizmuller is a Staff Engineer at Motorola Canada, 3125 Steeles Avenue E., North York, Ontario M2H 2H6, Canada. He can be reached at the above address, or by telephone at (416) 499-1441, ext. 3693.



IF YOU MISSED IT AT RF TECHNOLOGY EXPO 86...

IT'S NOT TOO LATE TO GET ONE NOW.

The "Proceedings" of RF Technology Expo 86 are now available. Included in this 650-page, 3½ pound volume are 67 papers from the technical sessions held at RF Technology Expo 86. These are the papers with information vital to the RF engineering world.

Among the topics included are amplifiers . . . oscillators . . . CAD . . . packaging . . . NMR . . . basic and advanced techniques. These are the topics you asked for, the techniques you need to know, the information you will use over and over again.

Ordering your own copy is easy. Just fill out the order form below and mail it to RF DESIGN, 6530 So. Yosemite, Englewood, CO 80111. The price is $95, and payment MUST accompany the order. You can charge it to Visa, MasterCard or American Express, or send a check or money order. (Price outside the continental U.S. is $100 plus shipping.)

Don't wait to order your copy, as there are only a limited number available. It will be one of the most valuable books in your engineering library.

rf technology expo86

RF Design
6530 So. Yosemite
Englewood, CO 80111

Please send me ________ copies of PROCEEDINGS OF RF TECHNOLOGY EXPO 86 at $95 per copy (shipping included. Outside the continental U.S. $100 *plus* shipping). Please indicate method of payment.

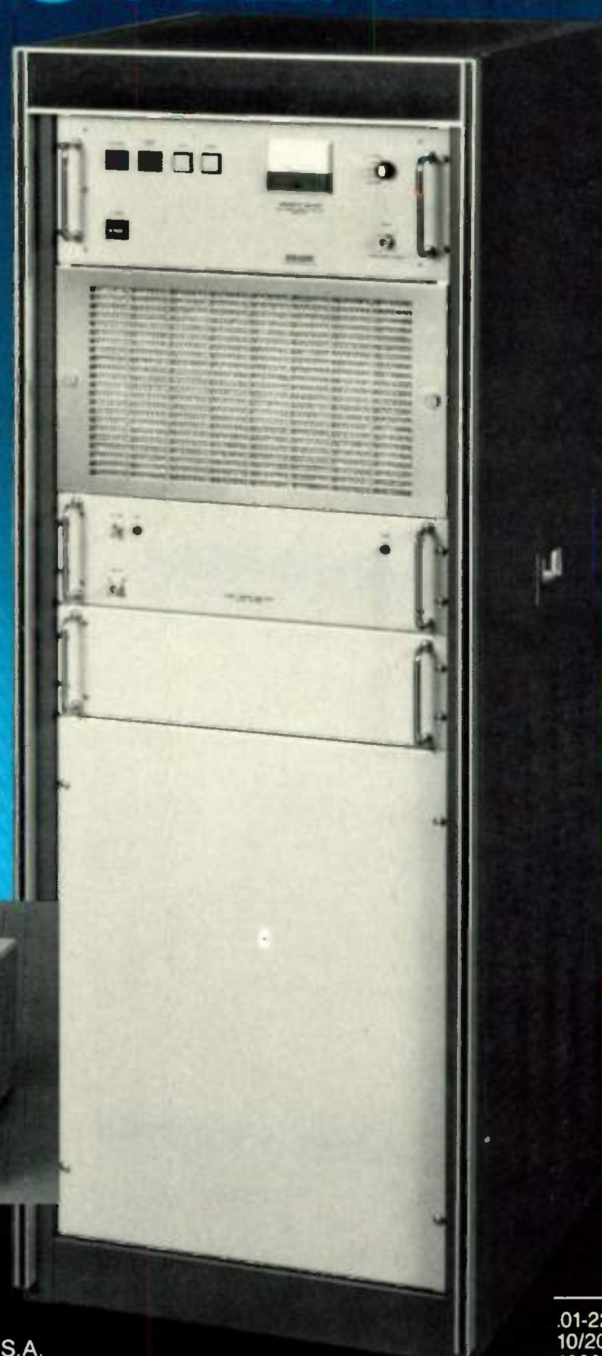
☐ VISA ☐ MASTERCARD
☐ AMERICAN EXPRESS ☐ CHECK ENCLOSED

Card Number: ____________________
Expiration Date: ____________________
Signature: ____________________

Please mail the Proceedings to:

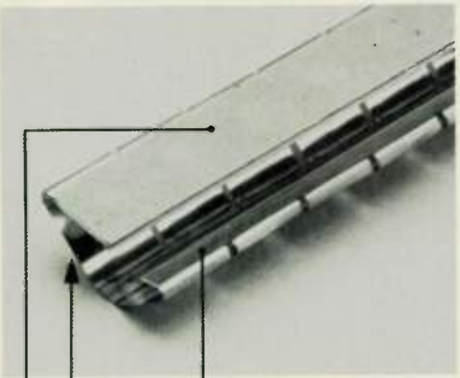
Name: ____________________
Company: ____________________
Address: ____________________
City: __________ State: __________ Zip: __________

RFD 9-86



INFO/CARD 43

New! Soft Fingers For RFI/EMI Shielding

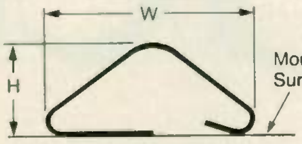


No-Snag Design
Eliminates Finger Breakage

Gentle Slope
Low Closing Force

Pressure Sensitive Adhesive
Fast and Simple Mounting

SOFT FINGERS – beryllium copper shielding gaskets engineered for low closing forces and two-way sliding action with smooth self-cleaning contact surfaces. SOFT FINGERS may be cut with ordinary scissors or ordered to length from the factory to meet your specific requirements. For a free sample, please forward request on your company letterhead.



Available Finger Pitch: 3/8, 1/4, 3/16, 5/32, 1/8
Optional Finishes: Bright Tin, Tin, Tin Lead, Zinc, Nickel

PART NUMBER						
Standard Pitch	**Series**	**W**	**H**	**Length (in)**	**Gap Range**	**Standard Finish**
187	P 32	.32	.10	16	.08-.09	Bright
250	P 37	.37	.13	16	.05-.11	Bright
375	P 60	.60	.22	18	.08-.20	Bright
375	P 80	.80	.30	18	.09-.28	Bright

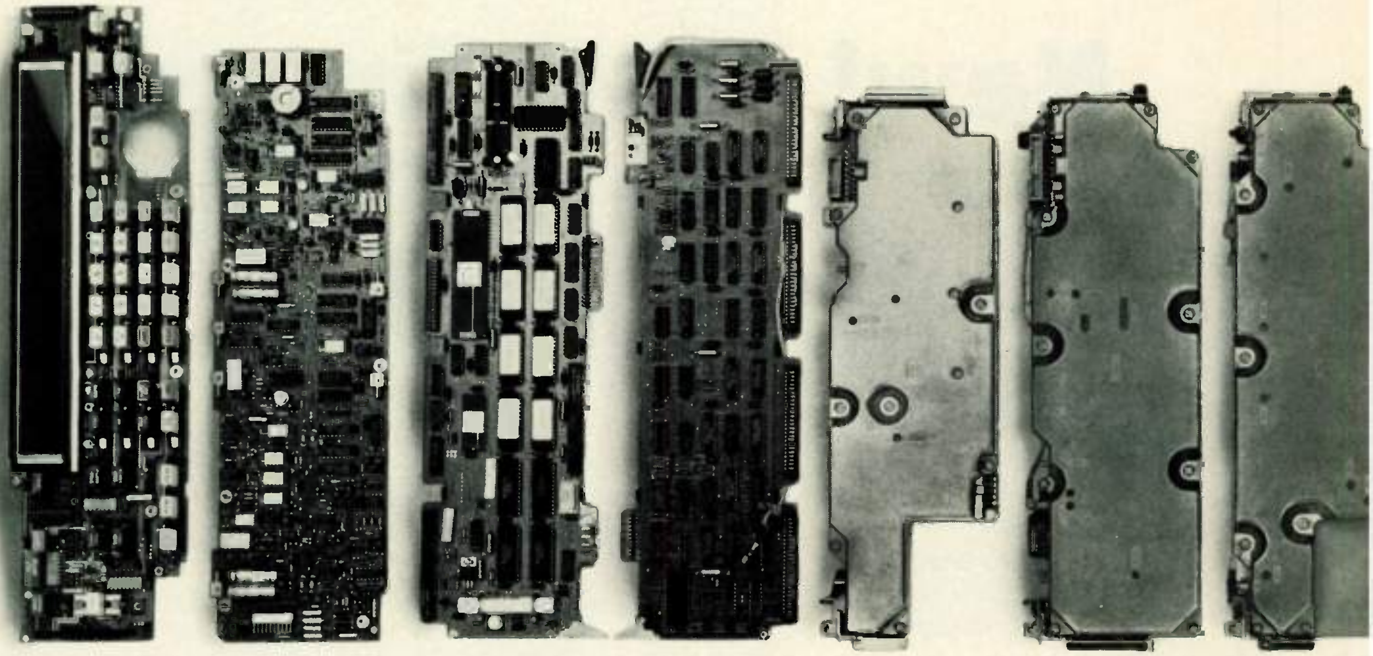
Tech-Etch serves both the commercial and military markets with standard catalog items and custom-designed specialty products – from prototypes through high volumes. Call or write us for all your shielding requirements.

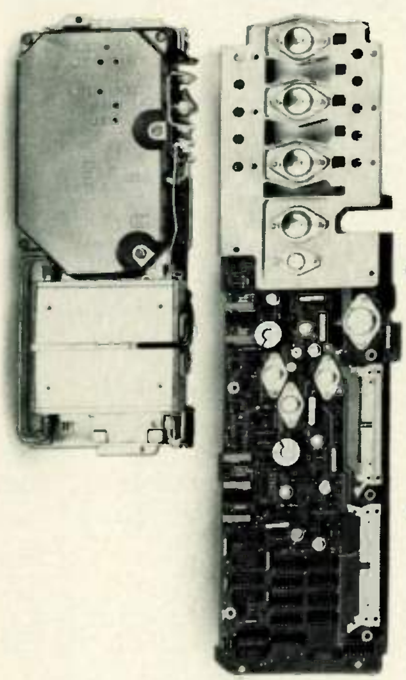
Tech-Etch

Conductive elastomers
Beryllium copper finger stock
Knitted wire mesh
Shielded vents

TECH-ETCH, Inc.
45 Aldrin Road, Plymouth, MA 02360
Telephone: 617-747-0300

EMC SHIELDING DIV.
7341 Anaconda Ave., Garden Grove, CA 92641
Telephone: 714-891-8199



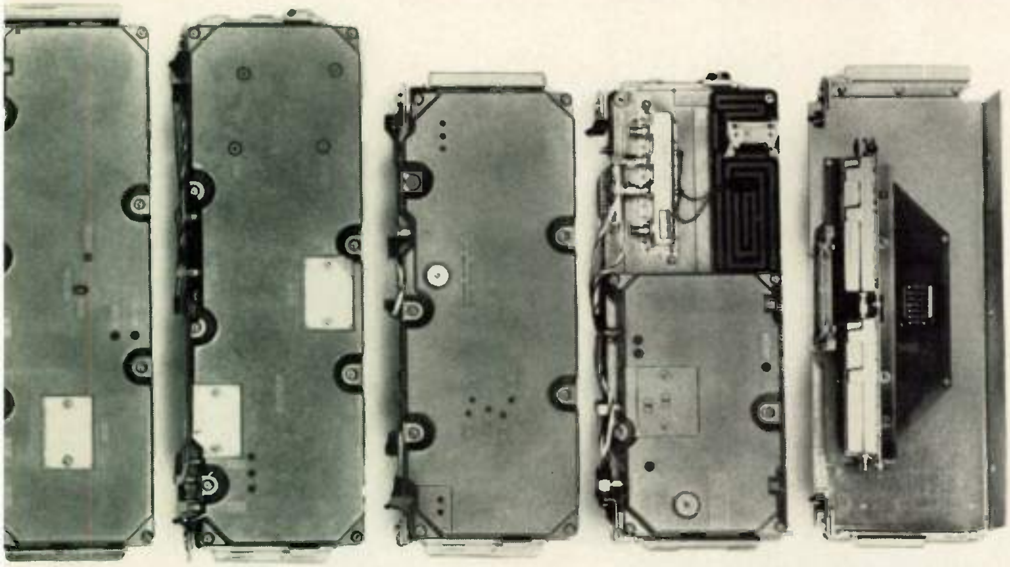


Leave it to Hewlett-Packard to get you up and running fast if your HP 8642A/B RF signal generators ever go down. The do-it-yourself HP On-Site Service Kit does it all.

It comes with enough card-carrying modules for you to cure an HP 8642 signal generator in record time. Usually, less than twenty minutes.

It couldn't be simpler. First, the HP 8642's built-in diagnostics alert you the

14 Get-



moment your measurements are less than perfect. (Not to worry. Actual warranty data cites a healthy 10,000 hours MTBF). Then, push a few buttons; remove the faulty module indicated on the display; and swap it with one from the kit. Recalibrate to original high-performance specs in seconds. Honest.

Why not check out the HP 8642A/B plus the healing powers of the On-Site Service Kit. And get well sooner.

Call 1-800-556-1234, ext. 515 (in California, 1-800-441-2345, ext. 515). Or write 1820 Embarcadero Rd., Palo Alto, CA 94303.

HEWLETT PACKARD

Well Cards For Signal Generators.

INFO/CARD 45

rf software

CAT Software Speeds Development of HP-IB Test Systems

Hewlett-Packard's new Functional Test Manager/300 is a computer aided test (CAT) software package designed to speed development of HP-IB test systems. Based on HP 9000 Series 200/300 Computers running BASIC, HP FTM/300 reduces development by up to 50%; is optimized for test throughput; gives users the flexibility to customize to specific test needs; provides a turnkey statistical quality control (SQC) package complete with reports and graphics; and allows transfer of test data to other computing environments for further test analysis and reporting. **Hewlett Packard, Loveland, Colo. INFO/CARD #148.**

EMI Software Automates VDE, FCC and MIL-STD Tests

New EMI Prequalification Software, usable with Tektronix's 490P Series and 2755P high performance Spectrum Analyzers was created for the IBM PC or compatibles and the Tektronix 494P, 492AP, 495P or 2755P Spectrum Analyzers. The user can expect a high degree of confidence in passing costly verification tests for conducted or radiated emissions. With this software it is also possible to perform quality assurance work for on-going manufacturing compliance. **Tektronix, Inc., Beaverton, Ore. INFO/CARD #147.**

PC-Based FFT Spectrum Analyzer Stores Spectrums

The R411 is a low cost ($888) high performance FFT spectrum analyzer peripheral for IBM PC, XT, AT and compatible computers. Totally turnkey; no programming; simply plug in the hardware, slip in the disk, and start to analyze frequency versus amplitude spectrums on the screen. Use the computer to analyze, store, retrieve and compare spectrums. Features include: FFT software supporting 8087 co-processor speed, FFT sizes from 16 to 1024 points, ability to execute and display a 1024 point FFT every 4 seconds, log or linear scaling for frequency and amplitude, programmable input ranges from 1.6 V to 320 V p-p, spectrum averaging, and sampling rates from 100 Hz to 500 kHz in a 1/2/5 sequence. **Rapid Systems, Inc., Seattle, Wash. Please circle INFO/CARD #146.**

Three University-Developed Programs Are Useful for Industry

LINCAD is a linear circuit analysis and design program for the IBM PC/XT/AT and the Commodore 64/128 that can perform the following functions: graphics of the frequency response of one or two node voltage differences to a monitor or printer for any linear electronic circuit up to 30 nodes; find the voltage difference for any two nodes in magnitude or dB and phase; vary or tune each circuit element to determine its effect on the response of the circuit; frequency may be "tuned" or varied to find a maximum, minimum, or set value of voltage or phase angle; circuit response optimization is possible by changing any circuit element for the desired characteristic; circuit sensitivity to element tolerances, an important design tool, can be found for any or all circuit elements. The price for LINCAD and a manual explaining commands and showing many examples is $49 for the C/64/128, $99 for the IBM/PC/XT/AT, plus $3.50 for shipping and handling.

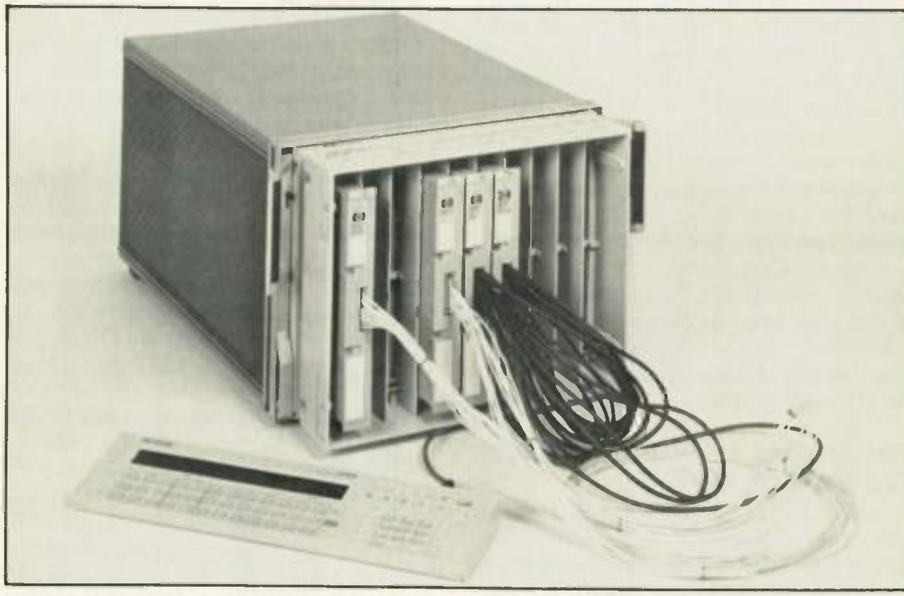
The synthesis ability of CALCAD automates the design of sequential and combinational circuits. Given the minterms and the don't-cares, minimized Boolean expressions with up to eight variables can be obtained in seconds. Sequential circuits with as many as 64 states and 8 input combinations of next states can be synthesized with D flip-flops, JK flip-flops, or flip-flops with a ROM. For analysis, the circuit is sketched, the devices numbered, the inputs are specified and all of these are entered into CALCAD. Timing diagrams can be graphed, various outputs can be stuck high or low for fault analysis, propagation delay effects studied, laboratory experiments conducted, all in an easy manner.

CALCAD and its manual containing all the commands and many examples is available for $179.00 plus $3.50 for shipping and handling.

FFTSA can be used for both digital and analog signals. The spectrum plots of amplitude versus frequency will always be in discrete form. If enough points are taken in the discrete plots an accurate joining of the ends of the discrete lines will reproduce the Fourier Transform of the signal. If the waveform analyzed is a true repetitive wave, the spectrum plot is the Fourier Series amplitude representation of this waveform. The frequency-domain representation of a signal is often more useful than the time-domain since we are interested in the frequency components of a signal for design purposes.

The price of FFTSA for the C/64/128 and its manual is $49.00 plus $3.50 shipping and handling. The IBM/PC FFTSA is $99.00 plus $5.45 tax and shipping as above. **SOFCAD Electronics, Inc., Columbus, Ohio. INFO/CARD #145.**

HP-IB Switch/Test Unit Speeds Interfacing of Test Equipment to Devices Under Test



The HP 3235A Switch/Test Unit reduces test development time of HP-IB production test systems by providing high performance off-the-shelf switching and interfacing to a wide variety of Devices Under Test (DUT). The HP 3235A routes signals between the DUT and the test equipment, such as digital multimeters, counters, signal sources and analyzers. The HP 3235A is intended for medium to large point count HP-IB test systems in electronic computer aided test. The system was specifically targeted at production testing, but it can be used in environmental test, QA and R&D.

Speeds test development

In the past, test station developers have found a limited selection of commercially available switch products to interface their DUT to the test equipment. Some products were either not high enough performance or not good enough quality to put into critical production applications. Sometimes the products were not equipped with the flexibility to do enough of the switching job. So, many test stations have home-brew switching and test system interfaces. An off-the-shelf switch and interface reduces design and documentation costs so you don't build your own. The HP 3235A not only provides an off-the-shelf solution to signal switching and interfacing with a DUT, but it also speeds test system development by reducing the amount of integration, cabling, fixturing and programming the system requires.

An architecture for increased throughput

Combining both switches and instrumentation in one mainframe has allowed HP to increase the throughput in a test system. The HP 3235A chassis is a 10 slot card cage with a high level programming language for fast coding of software. Up to seven 3235E Extenders, each having another 10 slots, can be slaved for a maximum of 2560 two-wire points. BASIC language commands in the mainframe such as IF. . .THEN and FOR. . .NEXT, plus variables and math functions keep computer to switch interactions to a minimum, thereby increasing throughput. The HP 3235A's intelligence includes foreground and background tasks, downloaded subroutines, and it can make pass/fail decisions, too.

Card to card communication is supported by six programmable backplane buses used to ship analog signals or triggers between modules inside the card-cage. This further reduces the cabling and computer interaction necessary for scanning, triggering, and pass/fail decisions.

Faultless connections between test equipment and DUT

Fixturing between the test equipment and DUT typically is a custom design for each system with very little parts and cabling commonality. HP's optional quick interconnect panel now eliminates operator errors when changing test heads for different DUTs. It provides a standardized way to address fixturing and cabling in rack-and-stack HP-IB test systems. Terminal blocks that are separate from the module electronics are provided for each module. Extra terminal blocks can be wired for each application and put into another quick interconnect fixture.

To connect the DUT to the HP 3235A, simply mount the quick interconnect fixture with wiring on the front of the HP 3235A mainframe, lock it in place, and pull the handles up to squeeze the terminal blocks onto the plug-in modules. Feedthrough panels for the Quick Interconnect are available to route cables directly from test equipment to the DUT.

Adaptable for wide variety of testing

The HP 3235A at introduction has seven switch modules available in different topologies and covering the range of low level DC to 1 GHz. In addition, there is a Digital Multimeter module, Digital Input/Output module and a Breadboard module.

The RF switching module switches DC to 1 GHz with better than 55 dB of isolation. VSWR for 500 MHz switching is 1.35. It has two 1 × 4's and one 1 × 3 that are stubless 50 ohm characteristic impedance. Off channels can be terminated in 50 ohms for critical DUT or instrument circuits. For switching signals above 1 GHz, HP's 33111 series microwave relays can be driven by the Digital Input/Output module or the General Purpose Relay module.

More signal integrity built-in

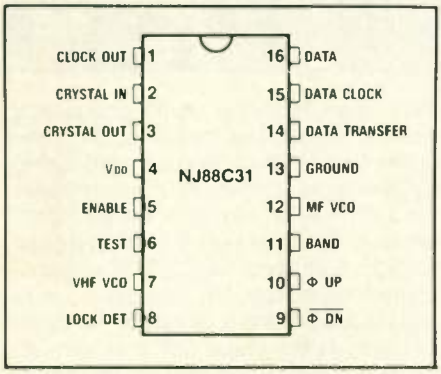
In most production applications continuous performance is mandatory, so the HP 3235A has extensive self tests built into firmware. Also for a "good morning" test, diagnostic fixtures are available for each module to thoroughly test out the relays, Digital Input/Output lines, and Digital Multimeter. Because both self tests are executed in firmware, test developers send only one simple command.

Prices: HP 3235A Mainframe, $4,400; HP 34550A Control Panel, $550; Option 590 Quick Interconnect, $750; HP 34520A Digital Multimeter, $2,550; HP 34522A Digital I/O, $1,100; HP 34505C RF Multiplexer Module, $1,100; Coax Modules, $1,300 to $1,850; Low Frequency Modules, $1,200 to $1,550.

Availability is 4 weeks ARO with deliveries starting in September. **Hewlett Packard, Loveland, Colo. INFO/CARD #176.**

Single Chip CMOS Synthesizers Offer High Performance, Low Cost

Plessey Semiconductors introduces the first pair of complete single chip synthesizers fabricated in Plessey's high performance 2-micron CMOS process. The NJ88C30 and NJ88C31 are complete low-cost VHF (phase lock loop) PLL synthesizers, each incorporating reference oscillators and dividers, a two modulus prescaler, 4-bit register and a 12-bit programmable divider. Manufacturers of cellular radios that require 200 MHz operation and military low frequency radio that need 175 MHz will find the NJ88C30 an excellent solution. The NJ88C31 was designed for AM/FM and car radios with very low power requirements, and a 125 MHz MF/VHF dual frequency operation. The NJ88C31 provides a 4.5 MHz microprocessor clock drive output, and features a lock detect and band switching output. The NJ88C30 features serial programming and no need for an external prescaler. Other applications for the NJ88C30 are sonar bouys and mobile radios.



Samples of both products are available now. The NJ88C30 in ceramic DG 14-pin package is priced at $6.78 each, and in the plastic DP 14-pin package at $4.80 each (quantities of 100). The NJ88C31 is $4.80 in 1000-piece quantities for the plastic DP 16-pin package. Both products are available now in small outline plastic surface mount packages. **Plessey Semiconductors, Irvine, Calif. Please circle INFO/CARD #175.**

Micro-Miniature High Rel Relay is Less Than Cm³

The class 7 Miniature high reliability industrial grade relay offers choice of SPDT and DPDT, mechanical life expectancy more than 100 million operations, and two Form "C" bifurcated contacts (gold clad silver-palladium). Rated for low level to 2.0 amp switching, it requires only 0.155 square inch circuit board space, permitting a mounting density of more than six relays per square inch, with a footprint compatible with 0.1 inch (2.54 mm) grid arrangement. It conforms to FCC Part 68-1500V peak surge resistance. **Magnecraft Electric Company, Northbrook, Ill. Please circle INFO/CARD #173.**

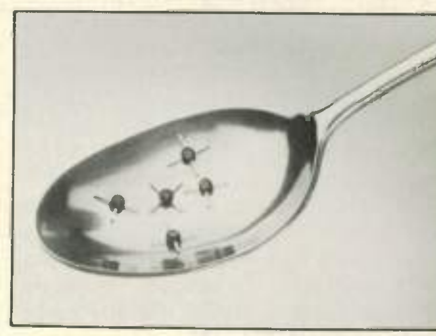
Variable Capacitors Are Configured For Automated Assembly

A new series of surface-mount ceramic dielectric trimmer capacitors known as CERA-TRIM is available in capacitance ranges from .6 to 2.5 pF through 5.0 to 25 pF. The specially formulated High-Q ceramic dielectric enables CERA-TRIM to operate from DC through microwave frequencies at temperature ranges of 55°C to 125°C. In addition, CERA-TRIM's sealed construction renders it impervious to solder fluxes, cleaning solvent and most

other manufacturing, atmospheric and environmental conditions. Assuring complete compatibility with automated tuning requirements, CERA-TRIM incorporates the Johanson square drive tuning mechanism for positive non-slip, tamperproof tuning adjustments. CERA-TRIM was configured especially for automated index and placement and is completely compatible with existing tape and reel and cartridge installation techniques. Its special alumina housing provides incredible mechanical strength and ruggedness and excellent electrical properties in a package-size of .165 (W) × .180 (L) × .090 (H) for outstanding efficiency. CERA-TRIM also withstands installation solderability requirements of 270°C for 20 seconds. **Johanson Manufacturing Corp., Boonton, N.J. INFO/CARD #171.**

NPN Bipolar Transistor From HP Housed in Microplastic Package

The new HXTR-3121 is the first in a series of plastic-packaged RF transistors from Hewlett-Packard Company. This silicon, NPN-bipolar transistor is designed for use in applications up to 4 GHz, and



will prove an ideal low-priced alternative to ceramic microplus-style packaged devices now in use. Offering improved performance over SOT-23-packaged or plastic-stripline devices, the HXTR-3121 will provide users with low noise and high gain over its entire dynamic range. It features +19 dB typical gain at 1 GHz with an associated noise figure of 2.1 dB.

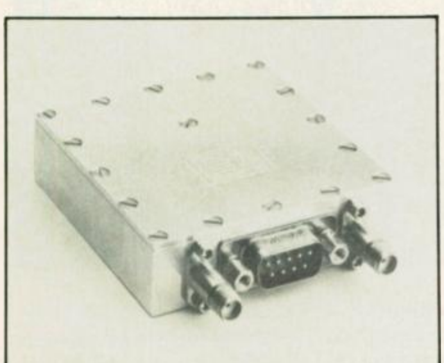
Customers will be able to design the transistor into their products with minimum circuit and PC-board redesign because of the 100-mil diameter of the HPAC-100P, the HXTR-3121's plastic package. Package leads have been finished with a 95/5 percent tin-lead combination that provides excellent solderability with standard assembly processes. **Hewlett Packard Co., Palo Alto, Calif. Please circle INFO/CARD #170.**

Low Cost SMA Attenuator Sets Aid Lab Testing, Breadboarding

Elcom Systems, Inc. announces the availability of two new sets of 50 ohm coaxial SMA attenuators suitable for lab testing or breadboard use. Each set contains a 3, 6, 10 and 20 dB attenuator. They are available in calibrated or uncalibrated models. Attenuation accuracy is 0.5 dB from DC to 1000 MHz, and 1 dB from 1000 MHz to 1500 MHz. VSWR is less than 1.35:1 at 1500 MHz, averaging 1.2:1 over the band. They can dissipate 0.5 W CW or 1 kW peak power. The design uses gold and silver connectors and high reliability MIL resistors in a Mil plated housing. The calibrated set, Elcom Systems Model AT-50-SET/SMA costs $76.00, and the uncalibrated set, Model AT-51-SET/SMA costs $60.00. Also available in type TNC, N, or BNC connector, and in 75 or 90 ohms impedance. **Elcom Systems, Inc., Boca Raton, Fla. INFO/CARD #169.**

Automatic Attenuator is Programmable

A new TTL compatible attenuator that automatically adjusts signal strength to accommodate system requirements, the Model EP 120 flat pack, operates at frequencies from 750 MHz to 4.5 GHz. It is

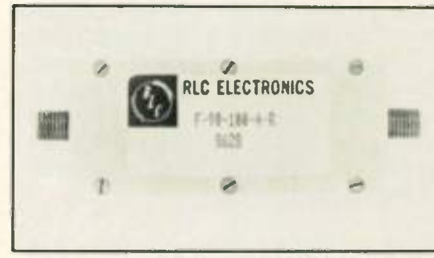


designed for a variety of communications applications where attenuation values must be increased or decreased to compensate for varying signal strengths.

The programmable feature of this new attenuator permits engineers to speed design and simplify receiver/transmitter circuits while assuring signal output or reception at optimum levels. The attenuator uses six independent sections with values of 2, 4, 8, 16, 32 and 58 dB. Accuracy is ±2 dB or 5%, whichever is greater, and can be improved if required. Operating current is 200 mA and maximum insertion loss is 5.9 dB. Switching speeds are in the nanosecond range, with internal drivers controlled by 74/5407 ICs operating at 15 volts. **EMC Technology, Inc., Cherry Hill, N.J. INFO/CARD #168.**

Custom Wide Band Filters Cover Many Uses

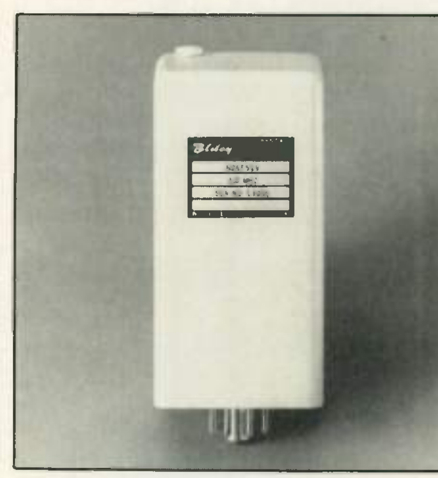
A series of custom wide band high pass filters allows versatility suitable for use in a wide variety of operations. Cut-off frequencies of the F-90 series start at 20 MHz and cut-off frequencies of the F-100 series start at 1500 MHz. Upper pass band frequencies are as high as 18 GHz. Distributed and lumped component tech-



niques offer excellent VSWR in the pass band, low insertion loss and outstanding rejection. These filters are available in a number of sections ranging from 2 through 6 for the F-90s and 2 through 5 for the F-100s. They are built in accordance with MIL-E-5400 Class 1A environment and units are available with SMA (female) connectors. Prices start at $220.00 in unit quantities and are available from stock to 8 weeks. **RLC Electronics, Inc., Mt. Kisco, N.Y. INFO/CARD #167.**

Oven Controlled Crystal Oscillators Provide Excellent Frequency Stability and Time Base Reference

N26F is a new oven controlled crystal oscillator designed for applications requiring high stability at operating environments as low as −20°C available in a 4 to 10 MHz range. Standard frequency is 5 MHz. Mechanical frequency adjustment



within 1×10^{-8} is standard; electrical tuning is optional. Stability ranges include $\pm 5 \times 10^{-9}$ at 0°C to 50°C, and $\pm 1 \times 10^{-8}$ from −20°C to 70°C. At a 50 ohm load, standard output is sinewave 0 dBm minimum. Sinewave as high as +7 dBm is optional, as are TTL and CMOS. Single sideband phase noise has a floor of −140 dB/Hz. Standard power supply requirement is +24 VDC, 6 watts maximum at turn-on. 10 to 30 VDC voltages are optional. **Bliley Electric Company, Erie, Pa. Please circle INFO/CARD #166.**

HF Transmitting Dipole Guarantees Optimal Communication Reliability Over Any Distance

A new, self-tuning HF Dipole is a transmitting antenna covering the frequency range 2 to 30 MHz and handling a transmitter power of 1 kW. The HX 002 ensures optimal communication reliability over any distance despite its overall length of only 10 m. Ranges up to 1000 km are particularly worth mentioning, because at these problematic distances the excellent radiation characteristics resulting from the favorable shape of the radiator, integration of the lowloss tuning network into the antenna and the high-grade balun take on special significance. The fully automatic, adaptive control of the tuning network of the HF Dipole HX 002 fulfills demands of modern communications systems like fast change of frequency and continuous matching — even with altered conditions in the antenna's near field, when soil conductivity fluctuates, for instance. Nonvolatile tuning memory is updated after each tuning correction, so the tuning time of the antenna is continually and automatically minimized. In an adapted state a change of frequency takes just 60 ms; a tuning correction is typically accomplished in 2 s, the VSWR at the antenna input then being 1.3. **Rohde & Schwarz, Munich, Germany. INFO/CARD #165.**

TEMPEST

(těm′pĭst) n:

A furious agitation, commotion, or tumult; uproar

If TEMPEST is your problem, we can help.

IRT Corporation is a leader in TEMPEST Engineering, Testing and System Assessment/Development.

- Testing Facilities
  - Automated/Manual Testing
  - Certified Engineers
  - Lot Sample Testing
- Engineering
  - Complete Product Support
  - Design/Development/Production
- Documentation

For additional information call or write IRT Corporation, 3030 Callan Road, San Diego, CA 92121; (619) 450-4343, Telex: 69-5412

IRT Corporation

INFO/CARD 68

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

FREE CATALOG

INFO/CARD 69

Now there are low-cost EMP simulators! Both damped-sine and exponential waveforms.

For hardening electronic subsystems.

This modular benchtop system eliminates the need to buy or build a huge million-dollar simulator to generate EMP and lightning effects on small to medium-size communications and data-processing gear, cables, and antennas.

These new Elgal simulators are offered in a convenient range of plug-in modules for direct and indirect cable injection to 20kV. Both exponential-decay and damped-oscillation waveforms are available. Other Elgal equipment delivers up to 2.5MV for high-altitude-burst EMP simulation.

Built in Israel by Elgal Electronics, a major supplier to the Israeli defense effort. Call or write Amplifier Research, exclusive USA and Canada distributor, for further information.

ar AMPLIFIER RESEARCH

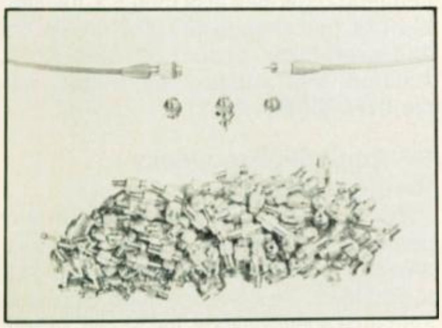
160 School House Road, Souderton, PA 18964-9990 USA • Phone 215-723-8181 • TWX 510-661-6094

8291

INFO/CARD 70

New Wideband Op Amp Features High Output Current

The new CLC203 op amp provides designers with a unique combination of wide bandwidth (160 MHz), high output current (200 mA), excellent DC specifications (0.5 mV input offset voltage), and good settling performance (0.2% in 15 ns). In higher resolution A/D systems, for example, the CLC203 may improve system accuracy through its tighter settling performance and may eliminate an offset voltage adjustment "tweak" due to its much-improved DC performance. With these performance advantages, the CLC203 is an excellent upgrade for systems using the original CLC103. The CLC203 is in volume production and readily available through Comlinear distributors. The 100-pc. price of the industrial version (AI) is $135; the 1-pc. price is $167. **Comlinear Corp., Fort Collins, Colo. Please circle INFO/CARD #164.**



Microminiature Coaxial Connector Line Allows Fast Assembly Without Tools

A remarkable miniature coaxial connector line, the B-Series and C-Series, provide rapid assembly with no special tools. This unusual line is designed for small and large quantity commercial, industrial and O.E.M. users. Assembly is accomplished in seconds. The coaxial cable may be trimmed with nothing more than a razor and simply screwed into the connector plug to complete the cable assembly. Nevertheless, these unique precision parts provide excellent cable retention and high reliability without soldering and crimping. The miniature line consists of plugs, jacks, panel mounts and adaptors. The outer diameters of the B-Series Connectors are less than 1/4 inch, employing #10-32 threads with overall lengths as small as 1/4 inch. The outer diameters of C-Series Connectors are 1/8 inch, employing #4-48 threads with overall lengths less than 1/4 inch. The bodies, pins and sockets are gold plated brass, and the insulating inserts TFE Teflon. **Microtech, Inc., Boothwyn, Pa. INFO/CARD #163.**

High-Performance MODAMP™ Silicon MMICs Available in Plastic Package

Six Avantek high-performance MODAMP silicon MMIC amplifiers are available in low-cost, 85 mil plastic packages. These MODAMP MMICs are cost-effective, general purpose, cascadable gain blocks designed for use in both narrow and broad bandwidth IF and RF amplifier applications. At 1000 MHz, models MSA-0185, -0285, -0385, -0485, -0785 and -0885 feature typical gains from 8.0 to 23.0 dB with 1 dB compressed output power from +1.5 to +12.5 dBm. Excellent uniformities in performance are produced by the ion implantation and self-alignment techniques used in the fabrication of these devices. **Avantek, Inc., Santa Clara, Calif. Please circle INFO/CARD #162.**

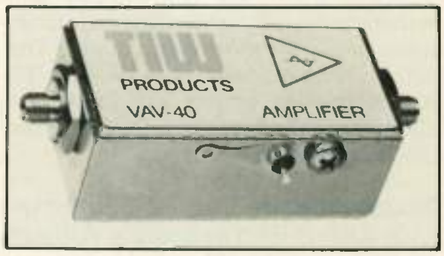
Oscillator Replaces Discontinued HP Model

Austron, Inc. has developed a replacement for the discontinued Hewlett Packard 10811 crystal oscillator. Austron's Model 1111 is both a mechanical and electrical replacement. A number of the Model 1111 pre-production units were sent to Hewlett Packard for testing and were found to exhibit phase noise performance superior to that of the HP10811 inside 10 Hz. The phase noise specifications are −120 dBc/Hz for 10 Hz offsets and −160 dBc/Hz for 10 kHz offsets.

The standard Model 1111 operates at 10 MHz, although other frequencies, input voltages, tuning ranges and various mechanical configurations are optional. It stabilizes to 5×10^{-9} of its final frequency after only a 10-minute warmup and its aging rate is better than 5×10^{-10} after a 24-hour warmup period. The Model 1111 generates output voltages of 0.55 ± 0.50 Vrms in a 50 ohm load and 1.0 ± 0.2 Vrms into a 1 kilohm load, exactly the same voltage specifications as the HP 10811. The frequency stability is better than 4.5×10^{-9} from −55 to +71°C and better than 2.5×10^{-9} from 0 to +71°C. The output frequency changes less than 5×10^{-10} for a ±10% load change into 50 ohms. Price and availability: $1,500; 60 days ARO. **Austron, Inc., Austin, Tex. Please circle INFO/CARD #161.**

RF Amplifier Frequency Range Increased

TIW Systems, Inc. has increased the operating frequency range of their Model VAV-40 variable gain RF amplifier to 0.1 to 500 MHz. Designed to meet high performance specifications, the Model VAV-40 features 20 dB on-board adjustable gain, a 20 to 40 dB gain range, and a 3.5 dB noise figure. Typical compression is +14 dBm, with +22 dBm optionally available.



The VAV-40 operates over a temperature range of −20°C to +75°C. Power supply voltage can be either +15 VDC or +24 VDC, with power supply current of 130 mA or 155 mA. The unit is 1.250 × 1.020 × 2.500 inches in size and weighs 5 ounces. Standard SMA female connectors are furnished, with other types available on special order. **TIW Systems, Inc., Sunnyvale, Calif. INFO/CARD #160.**

High-Speed DMOS FET Has Ultralow Feedback Capacitance And Low On-Resistance

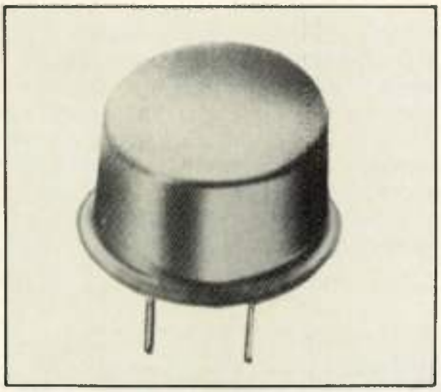
The new Si2400 enhancement-mode FET is a high-speed switch designed for military and industrial instrumentation and fabricated with the company's recently refined DMOS process. The Si2400 is the first FET available that combines 1 ns switching with low on-resistance (8 ohms typical at 15 V). These features, combined with the device's ultralow feedback capacitance (2.5 pF maximum), make this an ideal switch for precision instrumentation such as automatic test equipment and oscilloscopes, as well as choppers, analog switches, A/D and D/A converters, and multiplexers.

A similar device, the Si2200, is included in this new family. Also featuring 1 ns switching, the Si2200 offers an on-resistance of 16 ohms typical for a 15 V input voltage. The device family also includes a diode protected gate, which protects the device from stress over a wide input voltage range.

The Si2400 and Si2200 are available in the hermetically sealed TO-72 package. Samples are available from stock, and production quantities are available in 8 to 10 weeks ARO. Pricing begins at $3.80 each in 1,000-piece quantities. **Siliconix, Inc., Santa Clara, Calif. Please circle INFO/CARD #159.**

10 To 500 MHz RF Transformer Fits Into 0.36 In. Diam. TO-5 Case

A micromin 0.36 in. diam., 0.25 in. high metal TO-5 case houses this new TO-75 wideband RF transformer. The 10 to 500 MHz unit, with a 1:1 impedance ratio, provides isolated primary and secondary



windings and may be operated as low as 12.5 ohms at the primary. Price for the TO-75 is only $3.95 each in 10 to 49 quantity and each unit carries Mini-Circuits' one-year guarantee. **Mini-Circuits Laboratory, Brooklyn, N.Y. Please circle INFO/CARD #158.**

Phase Shifter Has 2 GHz Performance and Smaller Size

Merrimac Industries, Inc. has extended the frequency coverage of the popular PSEF series of electronic phase shifters.

INFO/CARD 59

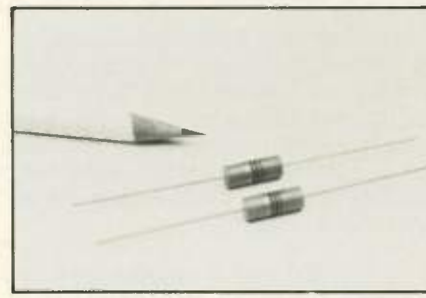
INFO/CARD 60

The new smaller flatpack units, PSEF-3A series, can be ordered with center frequencies between 500 MHz and 2 GHz, with minimum bandwidths of 10%. Each provides continuous adjustment of phase between 0 and 180 degrees, using a 0 to 30 VDC control voltage. Inputs up to 0 dBm can be accommodated with a maximum insertion loss of 3 dB.

The PSEF-3A series are designed for high reliability using wire bonded construction and are hermetically sealed in flatpacks measuring just 3/8" by 1/2" to maximize use of available space. Prices commence at $150.00, plus set-up charges for small quantities. Deliveries within 8 weeks. **Merrimac Industries, Inc., West Caldwell, N.J. INFO/CARD #157.**

Molded Inductor Meets MIL-C-15305

The IM-8, a MIL-style inductor designed to meet requirements of MS90540 (MIL-C-15305, Grade 1, Class A) is designed to provide an inductance range from 1100 μH to 3600 μH. The IM-8 is protected by a covering of flame-retardant molded epoxy. It has a rated DC current from 57 mA to 78 mA. Standard tolerance is ±5%



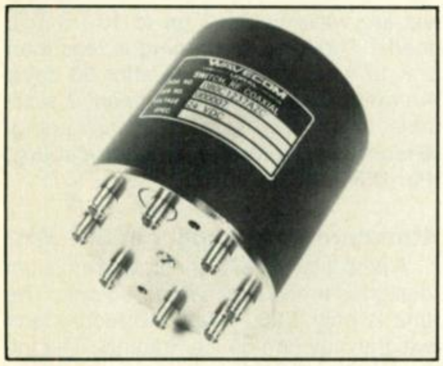
with tolerances down to ±1% available on request. Available in bulk or tape and reel packaging, the IM-8 is one of seven MIL-style inductors available from Dale over a range from .10 μH to 100,000 μH. Typical price for an IM-8 (10% tolerance, 1500 μH) is $1.29 each in quantities of 1,000. Delivery is from stock to 6 weeks. **Dale Electronics, Inc., Yankton, S.D. Please circle INFO/CARD #156.**

Flexible Electrical Conductive Adhesive Cures At Room Temperature

A new, versatile, two component, nickel modified elastomer system features high electrical conductivity, superior bonding strength and chemical resistance for EMI/RFI shielding as well as bonding and sealing applications. This unique compound is both highly electrically conductive and tough, abrasion resistant and flexible. Master Bond EP30C cures at room temperature or more rapidly at elevated temperature with a convenient 5 to 1 mix ratio by weight. It is remarkably resistant to thermal cycling and chemicals including water, inorganic salts, alkalis and acids as well as many organic chemicals over the exceptionally wide temperature range of −60°F to more than 250°F. EP30C is 100% reactive and does not contain any solvents or diluents. Adhesion to metals, glass, ceramics, wood, vulcanized rubbers and many plastics is excellent. Additionally, the cured elastomer has high dimensional stability. EP30C has a Shore A hardness of 92 and a Shore D hardness of 56. Volume resistivity is 0.03 ohm-cm. EP30C is a light flowing paste and can easily be applied in thin and thick cross sections. Available in pint, quart, gallon and 5 gallon containers. **Master Bond, Inc., Teaneck, N.J. INFO/CARD #154.**

Up To 45 Selectable RF Paths With New Matrix Switch

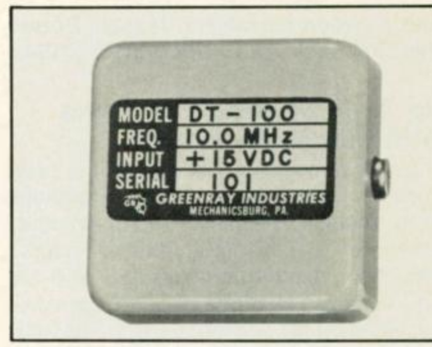
Using a single matrix switch it is now possible to channel microwave signals from multiple transmit and/or receive antennas to and from a variety of filters, amplifiers, spectrum analyzers and so on — up to 10 separate devices, interconnected in up to 45 different ways. The new switches are available in seven configurations, with the number of I/O channels ranging from 4 to 10, and the number of selectable paths ranging respectively from 6 to 45. The switches feature SMA connectors and latching-reset actuation as standard and a frequency range from DC to 18.5 GHz. Other performance parameters are: max. VSWR, 1.5:1; max. insertion loss, 0.5 dB; min. isolation, 60 dB; switching speed, 15-20 milliseconds; choice of 4 solenoid voltages (6, 12, 24 or 28 VDC); and operating temperature from −50°C to +100°C. Options available include internal termination, indicator circuits, TTL logic, BCD control and other actuation modes. Guaranteed for 1,000,000 cycles per switch position, the new matrix switches are available in 8 to 10 weeks from order. Prices begin at $910. **Wavecom Div. of LORAL Corporation, Northridge, Calif. INFO/CARD #155.**



Digitally Compensated Crystal Oscillator Aproaches Ovenized Stability

The Model DT-100 Digitally Compensated Crystal Oscillator (DCXO) is setting a new standard for commercially available temperature compensated oscillators. The

DT-100 offers frequency vs. temperature stabilities approaching those of ovenized oscillators while consuming only a small fraction of the input power required to operate an oven. The DT-100 is on frequency instantly, eliminating the lengthy wait for an oven to stabilize. By using thick film hybrid modules, it is possible to package the DT-100 in a relatively small 2 × 2 × 1" can, making this unit attractive as a plug-in replacement for existing TCXs or OCXOs to upgrade system performance. The DT-100 can be ordered at any frequency between 3 MHz and 30 MHz. Over the operating temperature range of −55 to +85°C, the frequency stability is typically ± 1 × 10^{-7} max. The unit requires a power supply of +15 VDC ± 10%



and typically draws 13 mA input current (20 mA max.). The output is a symmetrical square wave to drive up to 10 LS TTL loads. The long term aging is less than 2 × 10^{-9} per day average after 30 days. An external frequency adjustment is available to offset at least 10 years aging. **Greenray Industries, Mechanicsburg, Pa. INFO/CARD #152.**

Miniature X8 Multiplier at 560 MHz

A new miniature X8 multiplier is custom designed to the user's requirements. The unit is only 1.28 × .71 × .49 inches and weighs only one ounce nominal. The following specifications are guaranteed from

−55°C to +85°C: Input frequency, 70 MHz ± .35 MHz; output frequency, 560 MHz ± 2.8 MHz; RF power input, +5 dBm ± 5 dB; power output, +10 dBm minimum; output bandwidth, 1%; harmonics, −60 dBc maximum. **TRAK Microwave Corporation, Tampa, Fla. INFO/CARD #153.**

Technical Ceramic Dielectrics In 100,000 Variations

Technical ceramic dielectrics now are available in a broad range of ceramic dielectric shapes, sizes and formulations. . .extruded, pressed and cast. Ceramic formulations developed over a 50-year period are available in more than 100,000 variations in capacitance values up to 1 mF and up to 40 kV voltage ratings. Stringent quality assurance is maintained from material blending to firing. **Tusonix, Inc., Tucson, Ariz. Please circle INFO/CARD #151.**

Stripline Bidirectional Coupler Offers High Isolation

This new stripline bidirectional coupler is designed for applications requiring high isolation specifications. Model FC3804-1 operates from 500 to 1000 MHz. Its 30 ± 1 dB coupling value combined with 25 dB minimum directivity gives the unit high isolation specifications. VSWR is less than 1.1:1 and insertion loss is less than 0.15 dB over the band. The unit measures 3" × .55" × .38". **Sage Laboratories, Inc., Natick, Mass. INFO/CARD #150.**

Transient Digitizing Oscilloscope Has 6 GHz Bandwidth

Billed as the world's fastest programmable, transient digitizing oscilloscope, this 6 GHz instrument is designed for work in particle physics, high-power lasers and high-speed digital communications systems. The new high-performance Tektronix 7250 Transient Digitizing Oscilloscope features a 50 ps risetime and 5 V full scale sensitivity. It is fully programmable via GPIB; RS-232 interface is also available. It has 14 sweep speeds from 1 μs/div to 50 ps/div and programmable sweep delay. Sinusoidal (Rossi) sweep capability up to 3 GHz by external generator is also offered. Instrument triggering is external with a 50 ns pretrigger signal required + or – slope. Trigger level is programmable from 50 mV to 10 V in two ranges. Peak-to-peak trigger jitter is 100 ps or less. The instrument's performance is based on scan conversion techniques. Its digitizer offers 11 bits vertical resolution by 9 bits horizontal resolution. Fifteen waveform acquisitions can be stored in internal memory. An optional memory module allows up to 31 waveforms to be stored within the instrument. An internal battery provides memory backup for five years. Waveform processing capabilities include target defect correction and static and dynamic corrections to 1 percent, as well as filtering and smoothing. The instrument has on-screen cursors for waveform measurements including risetime/falltime and pulse width. Price for the 7250 Transient Digitizing Oscilloscope is $85,000. Deliveries will begin in December. **Tektronix, Inc., Beaverton, Ore. Please circle INFO/CARD #149.**

Polarad Catalog Includes US-Built Instruments

Rohde & Schwarz — Polarad's 468-page 1986 Catalog of Measuring Instruments and Systems offers detailed information on the firm's full line of test instruments. For the first time the catalog includes instruments built in the United States, like the new Microwave Synthesizer Models 308-309. **Rohde & Schwarz — Polarad, Inc., Lake Success, N.Y. Please circle INFO/CARD #139.**

Kilovac Corp. Catalog Shows First Miniature PCB Relays

Kilovac Corporation has published a new comprehensive catalog on its sealed, high voltage printed circuit board and high voltage RF relays, the K80 and K40 Series. The K80 board relays are the industry's first high voltage and high current miniature relays designed for PCB mounting. The K80 Series relays will isolate 8 kV and carry up to 10 amps continuous current. Moreover, they occupy up to 47% less board space than high voltage reed relays. The K80 Series is available in Form A, B and C contact arrangements. Applications include safety interlock switching, surge protection and other high voltage switching.

The compact K40 Series of High Voltage Vacuum Relays is specifically designed for high power RF communications equipment, such as frequency-agile antenna couplers. Weighing only one ounce, the 0.5"D × 2.25"H K40 Series isolates 10 kV, carries 15 amps continuous current at DC with derating for operation up to 32 MHz. Contact arrangements include Forms A, B, C and latching. Kilovac's new catalog provides detailed information on: power switching applications, RF derating, part number selection, QPL cross-reference, comparison to high voltage reed relays; and mounting styles. **Kilovac Corp., Santa Barbara, Calif. INFO/CARD #138.**

Short Form Catalog Includes Operating Characteristics

A 28-page short form catalog outlines the operating characteristics of all Kyocera electronic components available from stock. Products covered in this comprehensive catalog include multilayer ceramic radial, axial, and two-pin DIP capacitors, CK05 and CK06 capacitors, SIP and DIP resistor networks, clock oscillators, resonators and piezoelectric transducers, as well as surface mount chip capacitors, chip resistors, chip variable capacitors and chip potentiometers. The catalog contains ordering information, electrical specifications, dimensional data, part marking and packaging details for each. **Kyocera Northwest, Inc., San Diego, Calif. INFO/CARD #137.**

Training Manual Covers SMT Design

SMT PLUS's Surface Mount Design Manual covers in depth all topics pertaining to SMT design, including trends of SMT packaging and design analysis, SMT product selection and analysis, SMT substrate and packaging selection and thermal properties, SMT package specifications, SMT land pattern generating guidelines, SMT design considerations for testing, SMT design considerations for assembly, CAD and manual design techniques, and SMT design rules. Per copy price: US $350.00 plus delivery charges and taxes where applicable. Multiple copy purchase discounts available. **Surface Mount Technology PLUS, San Jose, Calif. INFO/CARD #136.**

Brochure Describes III-V Epitaxial Services

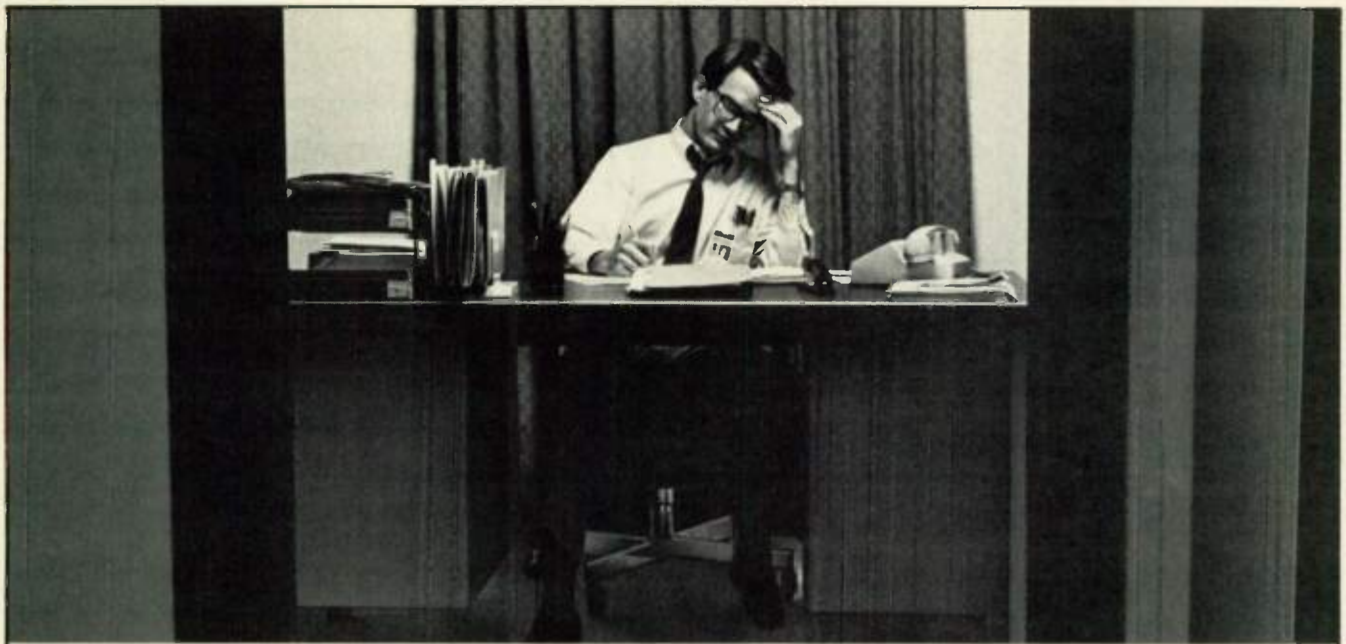
A new 8-page, four color brochure available from Epitronics Corporation describes the company's capability to supply custom and semi-custom gallium arsenide (GaAs) and gallium aluminum arsenide (GaAlAs) epitaxial services. The brochure, entitled "III-V Epitaxial Services," provides a thorough overview of the epitaxial services available from the company. Beginning with a discussion of the company's quality control program, the brochure features a description of the production processes, product characterization, quality assurance, customer support and documentation programs. Instructions for requesting a quotation or placing an order for services are included. **Epitronics Corp., Phoenix, Ariz. INFO/CARD #127.**

Catalog Highlights Isolators, Switches, Multiplexers

This 56-page catalog provides comprehensive and detailed information on Teledyne Microwave's component products. Products highlighted include ferrite isolators and circulators, coaxial switches, and filters and multiplexers. Voltage controlled oscillators, GaAs FET amplifiers, MIC subsystems, BAW delay lines and gain equalizers are also briefly discussed. Complete specifications, drawings, application notes and facilities information is provided. New products shown include switch matrices, switch attenuators, high frequency switches, broadband isolators and circulators and integrated ferrite products. **Teledyne Microwave, Mountain View, Calif. INFO/CARD #134.**

Catalog Features Military Connector Equivalents

E.F. Johnson Company Components Division has released a new 36-page catalog covering the company's entire line of JCM subminiature coaxial connectors, commercial-grade equivalents of military SMA, SMB and SMC connectors that cost up to 50% less. Johnson Catalog 312 contains complete mechanical, electrical, material and performance specifications, including dimensional drawings for each JCM connector product. Included are screw mating JCM-A and JCM-C connectors, snap-fit mating JCM-B connectors, and JCM cable assemblies. In addition, the catalog contains connector assembly instructions, mounting hole dimensional layouts, cable specifications and design formulae to use in determining connector specifications. Available locally through Johnson distributors, JCM connectors meet MIL-C-39012 performance specifications, except for materials used. JCM-As and JCM-Cs are made of machined brass; JCM-Bs of machined brass or die-cast zinc. This one difference provides MIL-grade performance for commercial applications while costing 30-50% less than the SMA, SMB and SMC military versions. **E.F. Johnson Company Components Division, Waseca, Minn. INFO/CARD #132.**



"Ideas Won't Keep..."

"Something must be done about them." **Alfred North Whitehead, Philosopher and Mathematician**

At Northrop DSD, we value the potential born with each new idea. As a DSD engineer, you'll have the chance to pursue new and unique ideas while tackling some of the most challenging projects in avionics electronic countermeasures. You'll have the opportunity to work with a team of progressive thinkers, recognized as experts within the industry. And, you'll get the satisfaction of seeing key projects through, from concept to reality.

We have the following positions available:

ADVANCED SYSTEMS ENGINEERS

Threat Analysis/EW Techniques Development

BSEE or equivalent. Experience with radar/missile threat analysis; IR guided missile threat analysis; radar/missile/ECM/IRCM hardware testing/evaluation; monopulse countermeasure analysis; IRST/FLIR system analysis and vulnerability assessment.

RF Systems Design and Analysis

BSEE or equivalent. Experience in angle of arrival receiver design for interferometric systems; multipath signal processing concept development; advanced EW systems, RF, IF, video & digital signal processing development.

Threat Modeling and Simulation

BSEE or equivalent. Experience in ECM/active IRCM digital computer modeling/simulation; integrated EW system operation analysis and performance assessment, real time hardware-in-the-loop IRCM simulation.

Systems Engineers-Project Development

BSEE or equivalent. Analyze hardware/software trade-offs; develop simulations/modeling for electromagnetic signal analysis; solve EMI, EMC and EMP related problems. Requires background in requirements definition and functional operation of complex hardware/software systems.

ELECTRONICS ENGINEERS

Antenna Design Engineers

BSEE or Physics or equivalent, MS desirable. Requires knowledge of phased arrays, monopulse D.F systems and millimeter wave techniques.

Sr. Project Engineer: Receiver Technology

Experience (12+ years) with receivers including project management and staff supervision. Knowledge of broadband receivers, video processing, digital signal processing, high speed log amps, filters, signal characterization, microwave integrated circuits, hybrids, and surface mount technology required.

Advanced Technology Engineers

MICROWAVE: Active and/or passive microwave and millimeter wave integrated circuit design for components and integrated subsystems. Prior computer-aided design experience required.

RECEIVERS: Conceptual design, fabrication, and test of receiver systems for ECM/Elint applications. Familiarity with systems architecture, signal processing, channelized, set-on, and micro-scan techniques desirable.

Qualified candidates are invited to send resume with salary requirements to: **Supervisor staffing, Northrop Corporation, Defense Systems Division, 600 Hicks Road, Rolling Meadows, IL 60008.**
An equal opportunity employer M/F/V/H.
U.S. Citizenship Required.

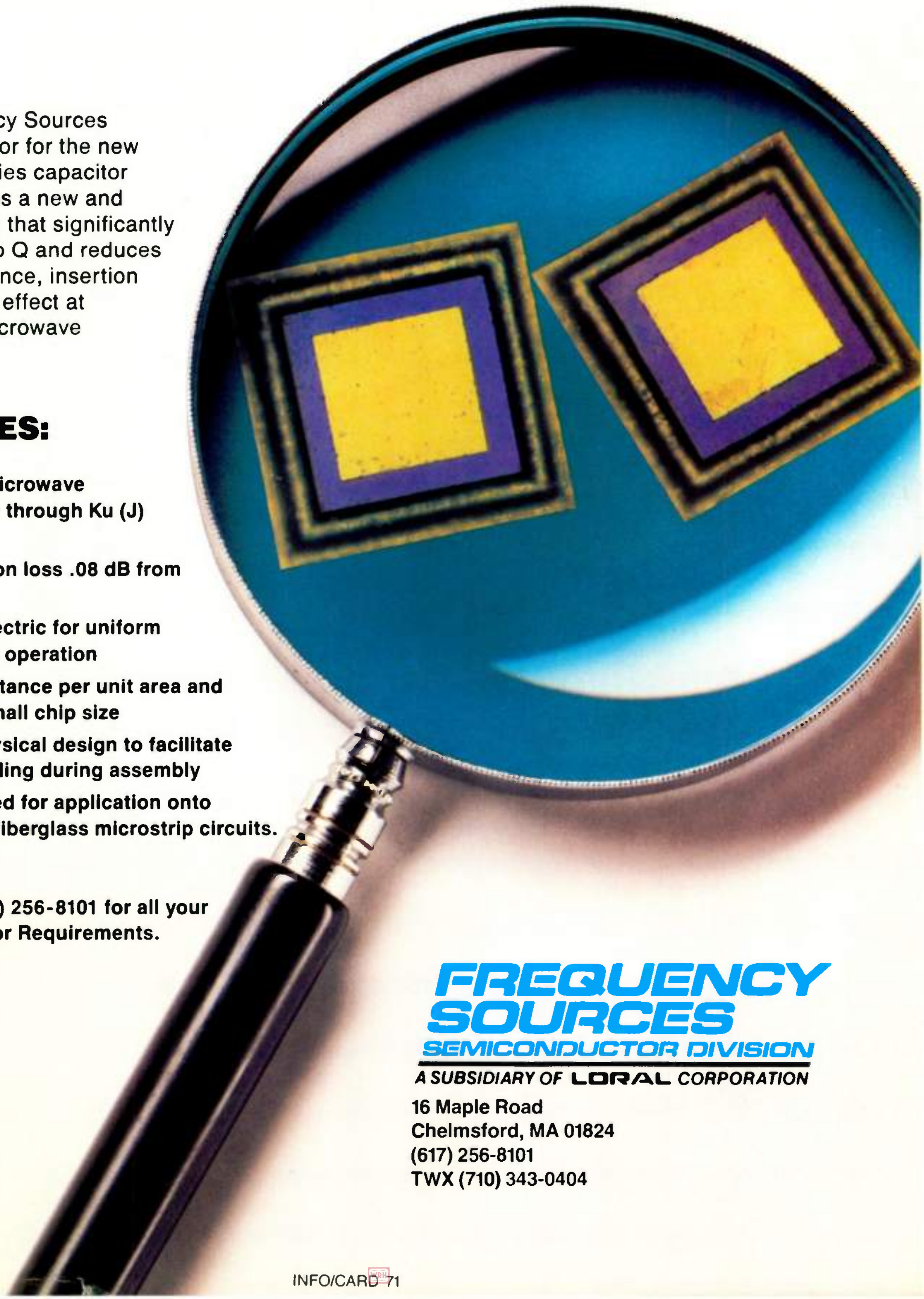
NORTHROP

Defense Systems Division
Electronics Systems Group

Northrop DSD: where the individual thrives... on achievement.

Advertiser's Index

Looking For A High Q MNS Chip Capacitor?



Call Frequency Sources Semiconductor for the new GC86000 series capacitor which features a new and unique shape that significantly improves chip Q and reduces series resistance, insertion loss and skin effect at the higher microwave frequencies.

FEATURES:

- **High Q at microwave frequencies through Ku (J) band**
- **Low insertion loss .08 dB from 2-18 GHz**
- **Nitride dielectric for uniform and reliable operation**
- **High capacitance per unit area and resulting small chip size**
- **Rugged physical design to facilitate easier handling during assembly**
- **Ideally suited for application onto alumina or fiberglass microstrip circuits.**

Call us at (617) 256-8101 for all your Semiconductor Requirements.

FREQUENCY SOURCES
SEMICONDUCTOR DIVISION
A SUBSIDIARY OF LORAL CORPORATION

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

SAW Questions and Andersens.

Dispersive devices:

QUESTION: I'm curious about dispersive devices. Where would I use them?

ANDERSEN: Our matched filters are widely used in digital communications and radar. With pulse expansion/compression you can increase dynamic range without increasing transmitter peak power or sacrificing resolution. They're also used in compressive receivers for real time spectrum analysis with 100% probability of intercept.

QUESTION: What range of bandwidth, dispersion and center frequencies are available?

ANDERSEN: SAW dispersive devices are used for wide bandwidth applications (up to 500 MHz) with dispersions up to 100 μs. IMCON dispersive devices have narrower bandwidths but provide dispersions up to 600 μs (IMCON's have been cascaded to produce dispersions of 10 ms). Center frequencies of Andersen dispersive devices range from 1 MHz to 750 MHz.

QUESTION: If I want to use dispersive devices in my system, what do I do?

ANDERSEN: We can help you specify the devices you need. Or we can supply the entire subsystem (compression/expansion module, compressive receiver, etc.). We've been supplying such systems for over 20 years. And with our in-house hybrid facility we can provide a compact, high performance unit tailored specifically for your system needs.

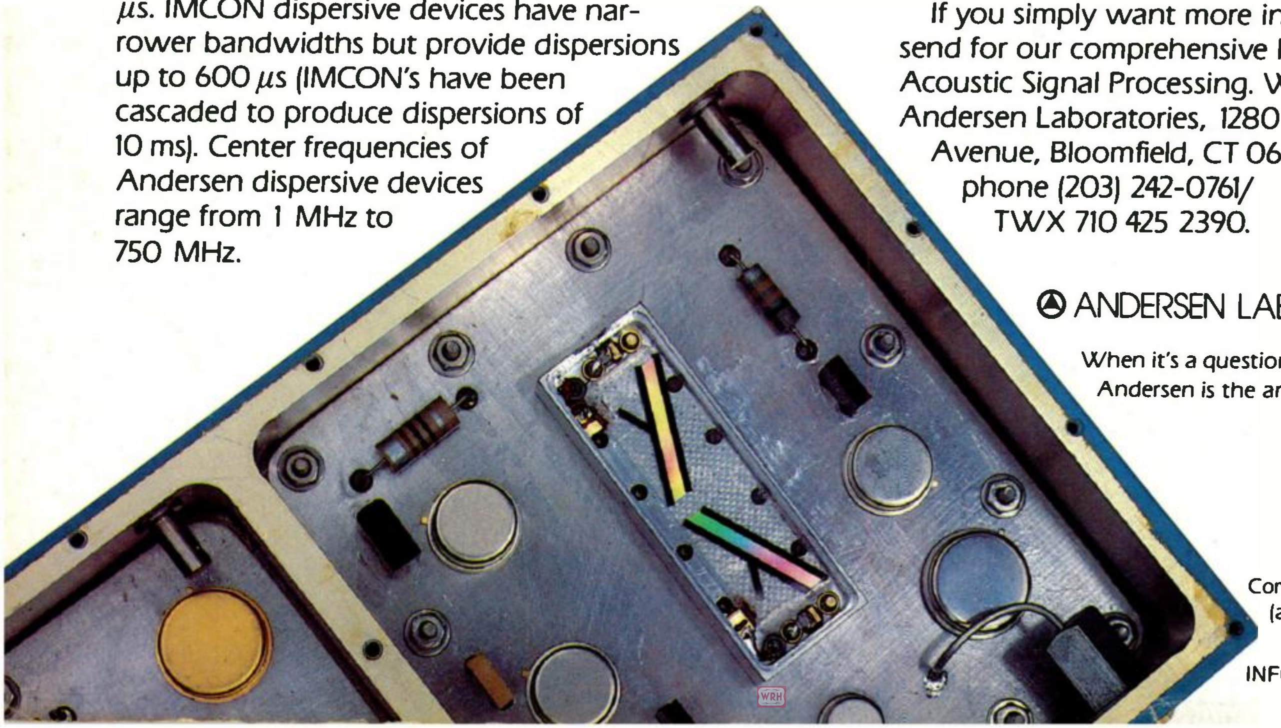
QUESTION: How do I get started?

ANDERSEN: Just give us a call. We'll do everything we can to meet your needs. With our recent major staff increase, we offer one of the largest groups of SAW designers of any U.S. company.

If you simply want more information, send for our comprehensive handbook on Acoustic Signal Processing. Write to Andersen Laboratories, 1280 Blue Hills Avenue, Bloomfield, CT 06002. Or phone (203) 242-0761/ TWX 710 425 2390.

ANDERSEN LABORATORIES

When it's a question of SAW, Andersen is the answer.



Compressive Receiver (actual size)

INFO/CARD 72