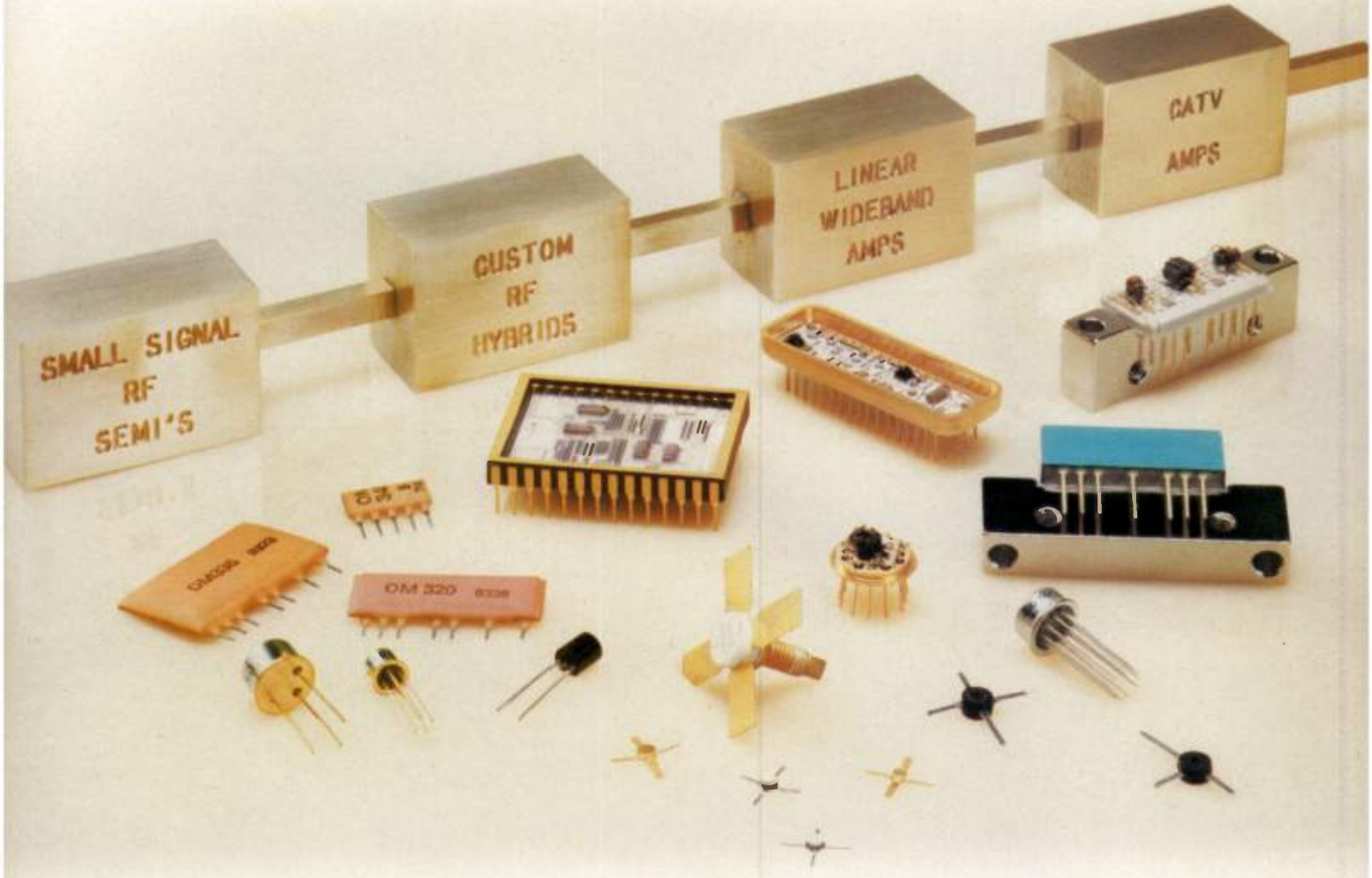
rfdesign
ideas for engineers
November 1985

Special Report:

The New Uses of RF — EMI Susceptibility Testing

In advanced RF products, one name stands out.



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INFO/CARD 2

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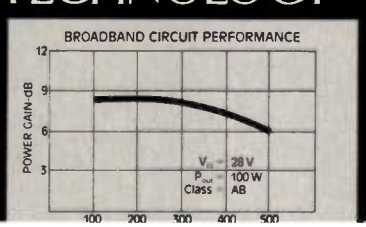

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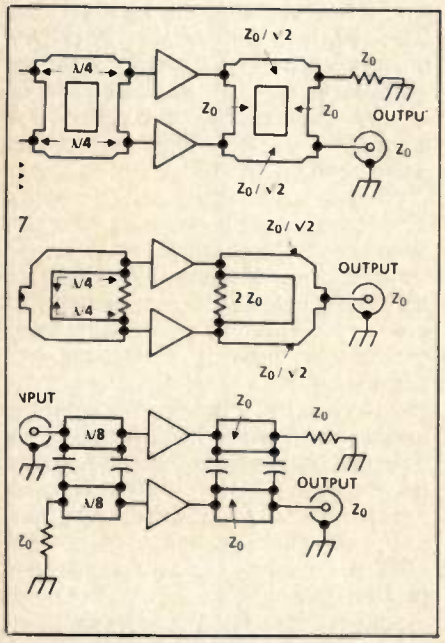
ACRIAN

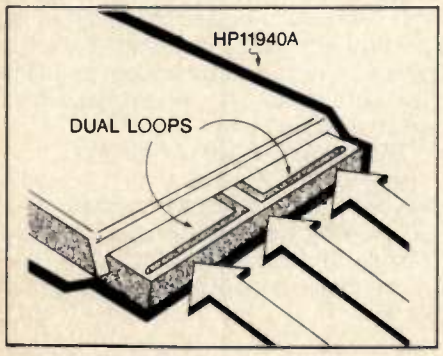
rfdesign

November 1985

The Cavitenna — p.29



Combining RF Power Hybrids — p.43



The Close Field Probe — p.50

Cover

This month's cover shows a test engineer at R&B Enterprises making final preparations for a high-power sweep frequency test of RFI susceptibility. On the lower right is a 2000 watt power amplifier manufactured by Amplifier Research, Souderton, Pennsylvania. The inset photograph shows a postage meter inside the test chamber and the Cavitenna radiator described in the Special Report.

Features

Departments

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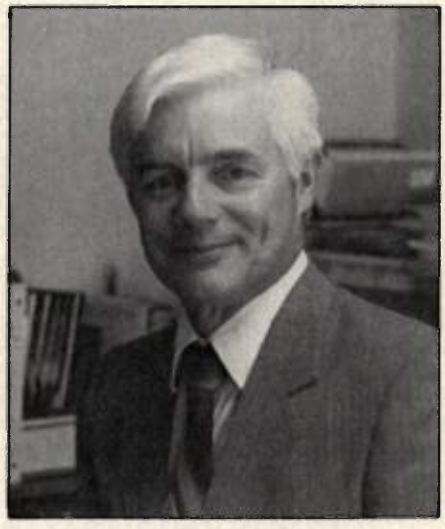
rf editorial

The Glamour Job Of The Future



James N. MacDonald
Editor

Someone in the office wondered what the glamour job of the future would be.

For about the past decade it seems most young people have wanted to be computer programmers or systems analysts. Before that they wanted to be natural scientists and before that engineers. Of course, people respond to public attention directed at certain professions, but there is also a trend toward jobs that seem to be able to solve significant problems and contribute to the improvement of life in general.

The question assumes that computer programming is no longer a glamorous job, and this seems to be the case. It usually takes a few years for a career to lose its glamour. First, the field becomes crowded and jobs are no longer plentiful. Then come reports from new employees that the career is not what they thought it would be and advancement is slow. It is usually a simple case of supply and demand.

Recent glamour jobs have suffered in another way — the conditions that created them have changed suddenly. Engineering students were going to build a better America, then came the reaction against technology in the "back to the basics" movement. Natural scientists were going to save our forests and clean up the environment, but they came up against the reality of economics and a growing population. Computer specialists saw this amazing device as a way to reduce the complexity of the modern world, but it has not gained the necessary wide acceptance. In fact, we may be seeing the beginnings of another anti-technology trend.

There is a pattern in these movements from one career field to another. It is like a pendulum swinging between technology and social service. After WWII a doctor was the thing to be, or a lawyer. In the mid-50s the engineering boom started. The environmental movement got underway in the mid-60s. Computer science took off in the mid-70s.

If the pattern continues, we are ready to start another social service trend. It is logical to expect the pattern to continue. Obviously, past emphasis on either technology or social service has not solved the world's problems, and as disillusionment with one emphasis has set in people have tended toward the other. Perhaps we could combine the two.

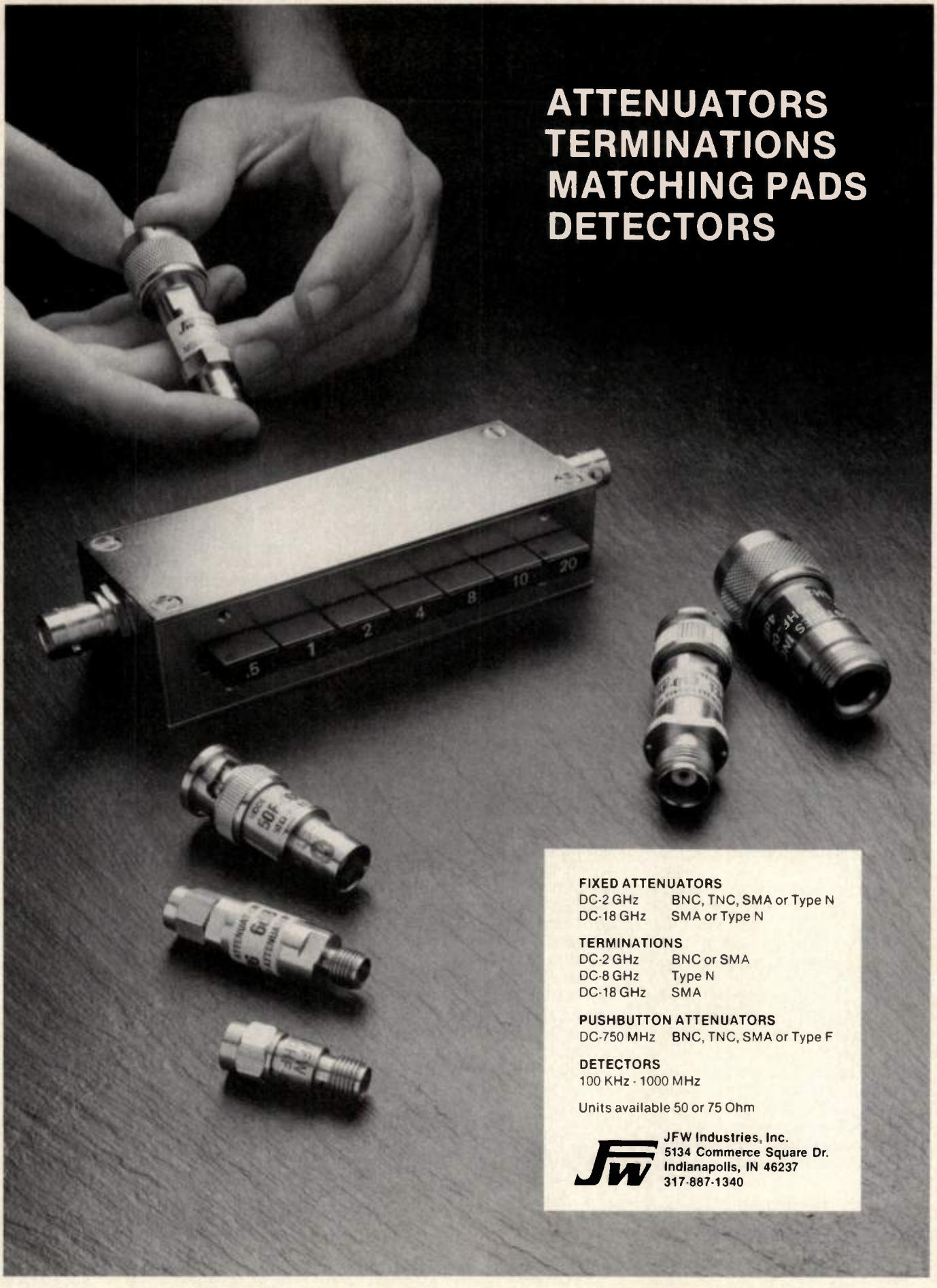
What we have needed since the beginning of the Industrial Age is a way to use the products of technology with an understanding of social needs. RF technology may be the way we will do it. Recently, as in so many similar cases, radio communications were the only contact between earthquake stricken Mexico City and the rest of the world. Ham operators passed messages diligently, for days, asking for no compensation and knowing they could not accept any if it were offered. Their actions demonstrated an outstanding combination of technology and social service.

We see many examples of such a combination. Last month we reported on medical uses of RF technology, uses with astounding possibilities for prolonging health. A news item in that issue noted that drivers with car telephones often reported road hazards, accidents and other serious incidents. Our readers probably know of a number of ways RF technology serves a social need.

RF is a mature technology with a long history of public service. As it expands beyond communications to other uses, RF probably will continue to be guided by that same motivation.

The glamour job of the future? You may be in it.

James N. MacDonald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INFO/CARD 5

rf viewpoint

Will Voluntary Standards Work?

By Gary A. Breed

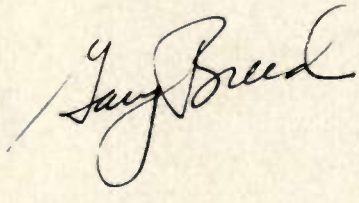
We are witnessing a grand experiment: voluntary regulation of EMI susceptibility in consumer and commercial electronics. (See this issue's RFI/EMI Corner for a report.) Many of us have reacted with joy at the thought of avoiding government intervention. However, further reflection should remind us that we are not just involved with the electronics industry but we are also consumers, taxpayers and concerned citizens. It is easy to be skeptical with millions of consumers, 300,000 ham operators, and hundreds (thousands?) of manufacturers involved in the effort. How can they possibly get together for a project of this scale? Can self-regulation really protect our TVs, VCRs and cordless telephones from interference?

Voluntary regulation is nothing new. Government arm-twisting has been used many times instead of legislation. We can learn from past mistakes such as the attempt at voluntary school desegregation, and the lack of cooperation that resulted in its failure. We must accept, not ignore or fight, our industry's voluntary standards. No one wants the courts to tell the electronics industry how to design their products.

Most of us want this plan to work and our skepticism is tempered with optimism. Electromagnetic compatibility is a young science with few preconceived notions to overcome and all of our accumulated knowledge to help it grow to maturity. Unlike civil rights, EMI susceptibility is principally a technical matter with political and social considerations secondary. There can be no argument about the need for regulation. With so much electronics equipment in use, interference problems cannot be ignored. We have known for a long time that most interference could be eliminated by better design, and Congress finally made it law. Now we need to take the opportunity presented by the FCC's "passing the buck" and use it to develop standards everyone can live with, avoiding the difficult FCC rulemaking process.

Can we predict the success of voluntary standards? Take a look at the pros and cons: Voluntary regulation avoids government bureaucracy but lacks government enforcement; it inspires cooperation among those involved but they have conflicting interests; industry pays the bill but the consumer may lack representation; the high visibility of consumer electronics is an incentive to succeed but the concept remains unproven. With no clear indication of success from this analysis we are left with only one way to make it work — the will and commitment of the people involved.

All of us in the industry need to do our part to keep the commitment alive, to keep compromise ahead of confrontation. The research for this month's Special Report and RFI/EMI Corner made it clear that there is commitment to succeed with voluntary standards. We have been given a chance to show what can be done without the government. Just remember the version of Murphy's Law that says, "Once a job gets screwed up, no amount of patching and fixing will ever make it right." Let's do it right the first time with EMI standards.



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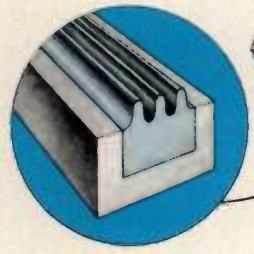

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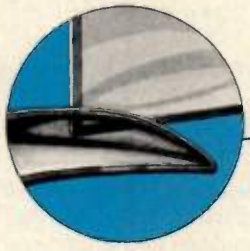

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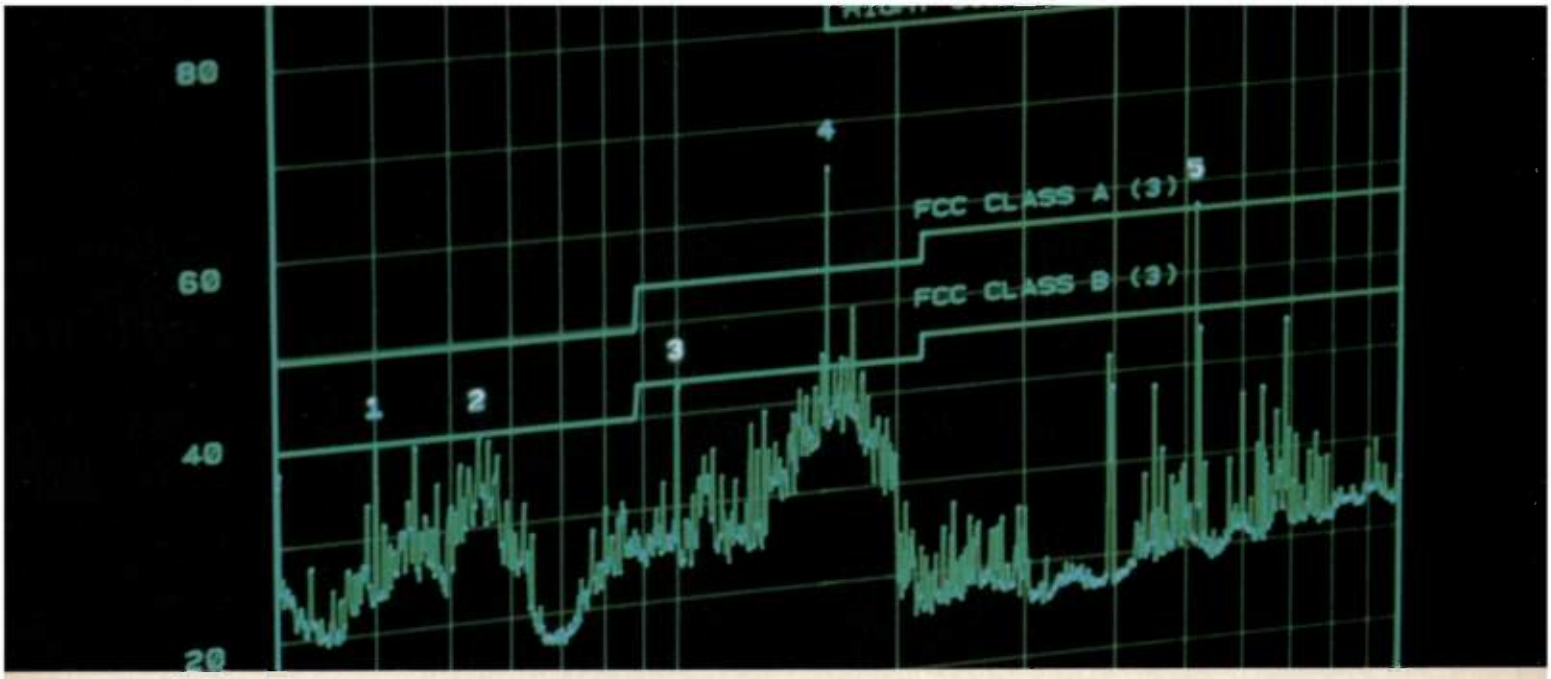

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Using the HP8566B or 8568B Spectrum Analyzer and simple probes, you can quickly locate problem emissions and evaluate potential solutions. These powerful analyzers sweep quickly over a broad 100Hz to 1.5 GHz or 22 GHz frequency range, instantly displaying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

Perform open-site tests with confidence.

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

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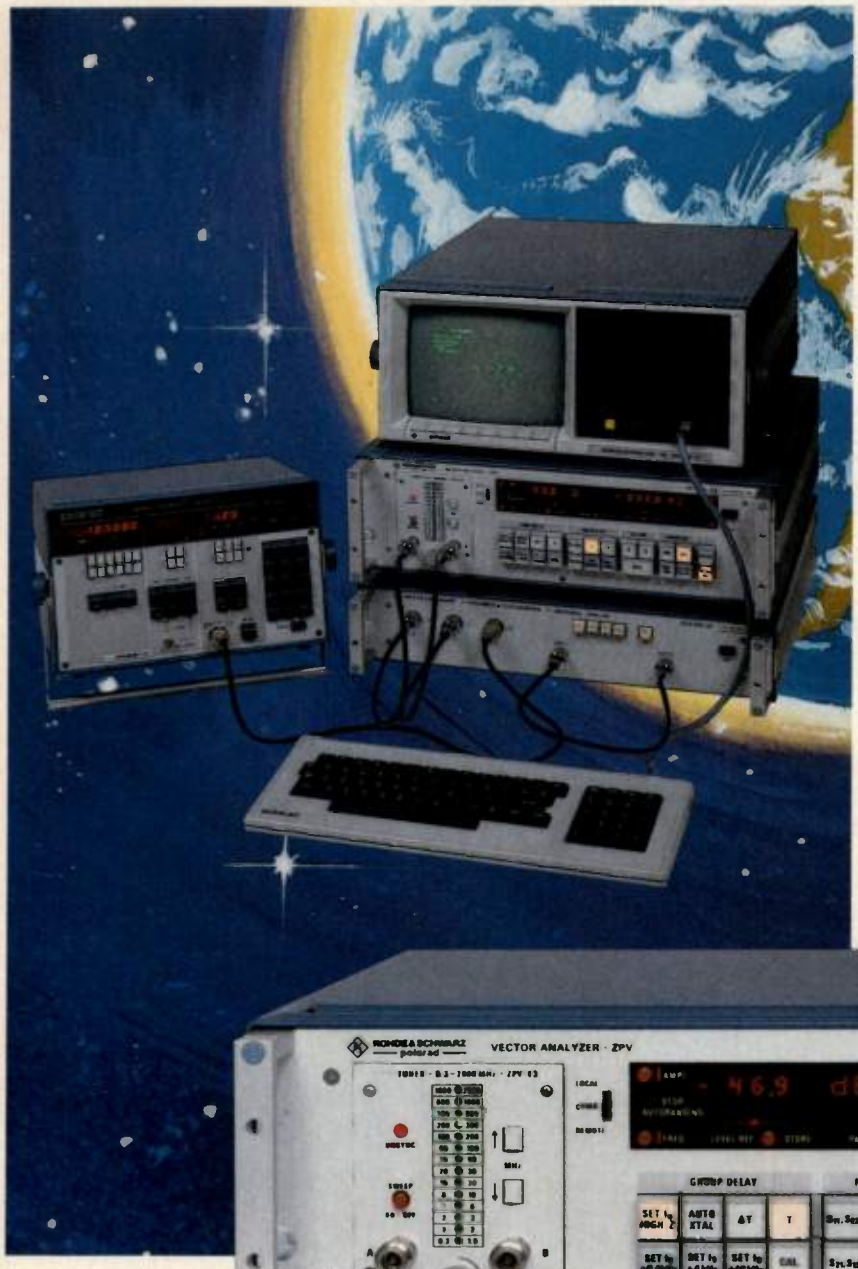
For more information, call the Instrument department of your local HP sales office listed in the White Pages. Or write Hewlett-Packard, 1820 Embarcadero Road, Palo Alto, CA 94303.

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

HEWLETT PACKARD

INFO/CARD 7

New, Low Cost, Programmable Network Analyzer System 10 Hz to 2 GHz



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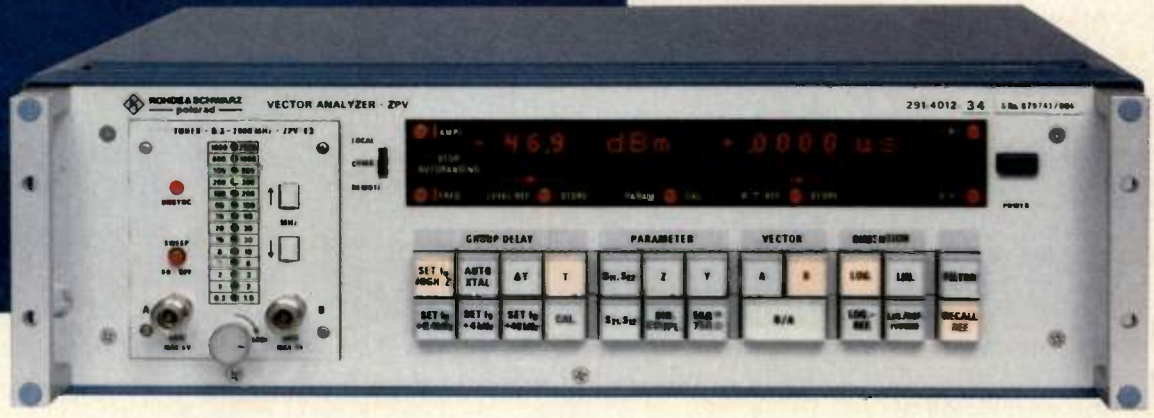
Call or write for literature or a demonstration.



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INFO/CARD 8

rf letters

Editor:

Mr. Aldrich's "note" in the August issue includes a very serious historical error.

The word "electronics" was coined by Dr. Orestes Caldwell who was the first editor of Electronics, published by McGraw-Hill. I believe publication of Electronics began in 1933 or 1934 — long before Emperor Franklin's War (WWII).

Dr. Caldwell later became a major publisher in the electronics field, being the Caldwell half of Caldwell-Clements through the forties and fifties.

Another point of interest: I have been a licensed radio amateur (presently under the call sign K6BH) since 1932 and never heard of a ham who used a crystal set as a portion of an amateur radio station. When I got into radio, in about 1930, the vacuum tube had completely replaced the galena crystal except as a curiosity.

Albert E. Hayes, Jr., Ph.D.
Consulting Radio Engineer

Editor:

I've been reading your editorials for quite a while and appreciate your fine efforts publicizing amateur radio. Being retired and out of the mainstream hasn't prevented me from helping, in some instances, to provide the next generation of RF engineers as indicated by the attached news release. I've also included the information about our 1984 winners.

The Foundation For Amateur Radio is pleased to announce the 1985 winners of the 19 scholarships which it administers.

John W. Gore Memorial Scholarship — $900
James H. Baker, KI4YN — Alexandria, VA

Richard G. Chichester Memorial Scholarship — $900
Eugene S. Reilly, KA8JIG — Cincinnati, OH

Edwin S. Van Deusen Memorial Scholarship — $350
Richard K. Soper, KA2IKV — Syracuse, NY

QCWA Memorial Scholarships — $600 each
Francis P. Horan, KA3CJR — Drexel Hill, PA
Hai T. Nguyen, KA0ALZ — Colorado Springs, CO
Carl E. Puckett, KA7BWC — Great Falls, MT
John E. Schnupp, N3CNL — Ephrata, PA
David J. Schmocker, KJ9I — Oconomowoc, WI
John G. Sullivan, N2DYC — Haddonfield, NJ

QCWA Robert S. Cresap Memorial Scholarship — $500
Douglas Swiatlowski, KA2KMT — Camillus, NY

Radio Club of America Scholarship — $500
James W. Healy, NJ2L — West Hurley, NY

Edmund B. Redington Memorial Scholarship — $500
David Swiatlowski, KA2KLM — Camillus, NY

Young Ladies' Radio League Scholarship — $500
Diane E. Willemin, N8CAY — Elyria, OH

Amateur Radio News Service Scholarship — $500
Michael Krensavage, KA3CUP — Marietta, GA

Columbia (MD) Amateur Radio Association Scholarship — $650
Christine L. Gray, KA3NAK — Elkton, MD

Baltimore (MD) Amateur Radio Club Scholarship — $500
Eric J. Smith, KA3KJO — Silver Spring, MD

Dade Radio Club Tropical Hamboree Scholarships — $500 each
Christopher A. Atkins, KA2QWC — Fort Pierce, FL
David R. German, N4FAD — Sarasota, FL

Lewis W. Wilkinson Memorial Scholarship — $500
Wayne F. Poole, KC4XL, Surfside, FL

These scholarships were open to all Radio Amateurs meeting the qualifications and residence requirements of the various sponsors. The foundation is a non-profit organization representing fifty clubs in Maryland, the District of Columbia and Northern Virginia. It is devoted exclusively to the scientific, literary and educational pursuits that advance the purposes of the Amateur Radio Service.

Announcements of the 1986 awards will appear in the April or May issues of the major amateur radio publications. Additional information regarding the foundation's scholarship program can be obtained from FAR Scholarships, 6903 Rhode Island Avenue, College Park, MD 20740.

Hugh Turnbull W3ABC
Director Atlantic Division, ARRL

Editor:

Your September issue gave me a chuckle when I read every page and arrived at page 42.

On page 14 in the continuation of your "RF News" brief, you announced the surprising demise of Compact Software of Palo Alto, Calif. But, on pages 42 and 43 we are presented with a beautifully stylized advertisement from — guess who?

A telephone call to their advertised number — (415) 966-8440 — brings the interrupt operator!

I hope they gave you a current billing address!!

Another subject: When will the Expo have their speaker lineup ready and have the program ready for mailing? This time I hope to be there!

Ed Oxner
Staff Engineer
Siliconix, Inc.

Compact Software is with us again. See the News section. The Expo '86 program has been mailed and you have probably received it by now. We hope to see you there, Ed. — editor.

Now! A low-compression electronic gasket that also provides environmental protection!

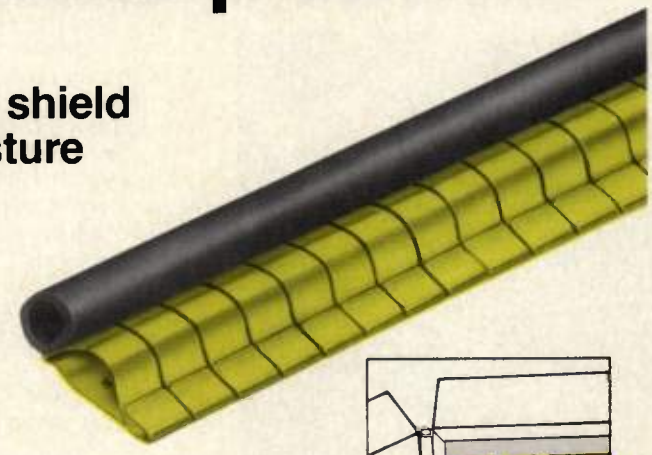
New Instrument Specialties strips shield RFI/EMI; control noise, dust, moisture and chemical contaminants!

These new Sticky Fingers® electronic gaskets combine beryllium copper finger strips with a neoprene rubber seal. Providing shielding characteristics comparable to other Instrument Specialties shielding strips, they also serve as an environmental seal. Thus, they are especially suited to applications where protection against noise, dust, moisture, and chemical contaminants is required as well as electronic interference protection.

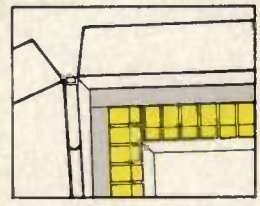
The unique design of these sealing strips permits the use of extremely low compression forces, compared to conventional elastomers, to make contact with the surface of both the environmental and electromagnetic shield.

Complete continuity of the neoprene gasket is assured by using a straight joint coupler, or mitering or butting at corners. No special tools or soldering required. And as with all Instrument Specialties Sticky Fingers strips, installation is fast and secure with the strips' self-adhesive backing. The flexible series provide the same advantages, for use where a continuous shield must conform to irregular shapes and turn tight-radius corners in either direction.

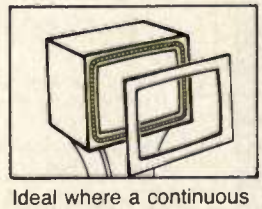
Catalog E³-58 provides complete information, including exact specifications, dimensional drawings, etc., on these and other Instrument Specialties shielding strips. Use this publication's Reader Service Card, or write to us directly at Dept. RFD-23.



Straight strips available: .312, .450, .650 and .950 wide, relaxed position.



Perfect for sealing square and rectangular enclosure/door interfaces.



Ideal where a continuous shield must conform to irregular shapes and turn tight-radius corners.

Flexible series: .345 and .458 wide, relaxed position.

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INFO/CARD 10

Communications Consulting Buys Compact Software

Communications Consulting Corp., Upper Saddle River, New Jersey, has purchased Compact Software from Comsat Technology Products. Ulrich Rohde, President of Communications Consulting, said Compact Software became a division of that company Nov. 7. The name will not change.

Rohde said Communications Consulting will support all existing Compact Software products and will continue to develop a Version 1.8 of Super Compact. He plans to introduce new models into the program later this year.

"A major drawback with available software is that no new models for microwave components have been introduced in 1984 and 85," Rohde said.

He said Communications Consulting has entered into an agreement with MCAD, a German company, to introduce a new generation of programs. Professors Jansen and Wolff, of the University of Duisburg, are helping to develop a library of mathematical models that the user can draw upon as required while running a program. This building block concept, Rohde said, provides powerful programming capability and unlimited growth potential since modules compile themselves as they are called up. It represents a new generation of computer program, he said.

Communications Consulting Corp. may discuss with Les Besser Associates, Foster City, Calif., an arrangement for that company to provide users support for Compact Software's programs. Besser developed COMPACT and was president of the company that developed SUPER COMPACT. That company, Comsat General Integrated Systems, became Compact Software in 1983.

Compact Software's new address is 52 Hillcrest Drive, Upper Saddle River, NJ 07458.

Japan and US are Leading Electronics Exporters

Recent statistical studies show Japan was the largest exporter of electronic communications equipment and components in 1983, with exports totaling $3.6 billion. The United States was second with $2.8 billion. The nearest European country was West Germany, with almost $1.2 billion, followed by France, the United Kingdom and Sweden.

These figures were announced by Benn Electronics Publications as the result of a new series of statistical studies highlighting export opportunities for electronic equipment and components in 30 major trading nations. The *Electronics Import Export Data Companion Series* provides detailed matrix tables of world trade in 11 major categories of electronics equipment and three major categories of electronic components, the company said.

Benn Electronics Publications said the reason for the relatively poor European performance compared with Japan is readily apparent from the detailed country by country data, which show the national origin of imports into each country and the destination of exports. The largest import market, the USA, imports primarily from Japan and such other non-European nations as Taiwan, Canada, Hong Kong and South Korea. The company concludes that Europe is its own major market, while the rest of the world is rapidly being carved up between Japan and the USA.

BEP said the electronics import-export data companion volumes assist in analysis of specific national market opportunities in individual product sectors. For example, the company said the United Kingdom, France and Italy have gained significant shares of the market for radar and navigational aids in the Middle East, with Japan and the US unable to dominate in that region. West Germany and France are the main European transceiver exporters, BEP said, with West Germany supplying Europe and France exporting to Brazil, Malaysia and Singapore.

Japan dominates the world market for radio transmitters with total exports of $445 million in 1983. Its nearest rivals are South Korea, France and the USA, in that order.

Contact Benn Electronics Publications Ltd., P.O. Box 28, Luton, LU2 0ED, for information about the series. Their telephone number is (0582) 417438. The Telex is 827648.

High Technology Management Opportunities Decline

The demand for managers in high technology industries in general will increase only slightly in 1985, according to a survey by Christian and Timbers. Although the 1984 demand was 4.56% higher than in 1983, the company said, the 1985 demand will be only 0.95% above that of 1984. The survey shows overall demand figures strongly affected by retrenchment in the semiconductor industry, where the survey predicts a 12% decrease in demand for managers. In 1984, this sector experienced a 24.6% increase over 1983.

In spite of the overall week managerial outlook, some RF companies show signs of significant growth in the survey. Companies founded since 1975 and making modern telecommunications equipment indicate a 21.3% increase over 1984, compared to 9% last year. The defense electronics industry should have a 7% increase in managerial demand this year, according to the survey, compared to 1.7% last year. However, Christian and Timbers says firms founded before 1975 making middle technology voice communication and two-way communication systems will experience a 7.8% decrease in demand for managers.

The survey consisted of telephone interviews with 76 high technology manufacturing companies with annual sales over $50 million. For additional information contact Christian and Timbers, Inc., 26949 Chagrin Blvd., Cleveland, OH 44122. The telephone number is (216) 464-8710.

New Book Gives Tips for RF Design Consultants

"How to Become a Successful Consultant in RF Design" discusses locating clients, fees, ethics, professional advertising, developing business plans and writing contracts. Author Jack Edwards describes consulting as "the ultimate antidote for overcoming job stagnation or age discrimination." The book is available from Associated Technology, Rt. 2, Box 475, Estill Springs, TN 37330. Cost is $25. For information contact Jack Edwards, telephone (615) 967-9159, ext. 414.

Electrospace to Develop Trailing Wire Antenna Simulator

Electrospace Systems, Inc., Richardson, Tex., has received a contract from the Naval Air Development Center to develop a trailing wire antenna simulator. The simulator will be used to test alternative models of new high power solid state TACAMO transmitters. By accurately simulating the airborne antenna characteristics, the device will permit extensive laboratory testing of the transmitters. For additional information contact Robert Carrel, Execu-

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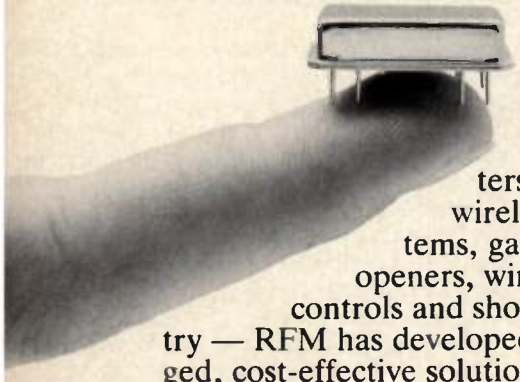


For the many applications that use low-power UHF transmitters under Part 15 — wireless security systems, garage door openers, wireless remote controls and short-range telemetry — RFM has developed an easy, rugged, cost-effective solution to transmitter design.

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

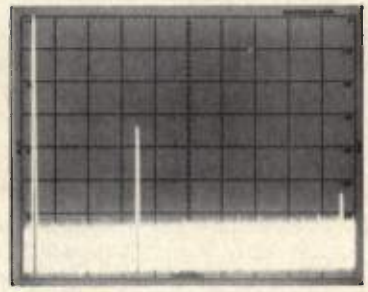
Hybrid oscillators are designed for wireless security products and other remote control devices.

Full operating range.

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

Excellent stability and signal purity.

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



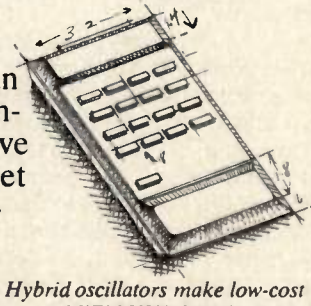
Typical harmonic spectrum of hybrid transmitter.

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

The right options. The right support.

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

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



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INFO/CARD 11

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The CCS-750 system displays signal strength vs. frequency directly, with automatic correction for antenna factors and RF attenuation. And all data can be stored for later use. An IEEE-488 Interface Bus controls signal sources as well as all other test parameters, and facilitates integration with other automated equipment.

CCS-750 Features

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- ☐ Automatic calibration for improved accuracy
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- ☐ Reduced data tabulation time
- ☐ EMI emissions and susceptibility tests per FCC/VDE/CISPR and Mil-Std 461/462 requirements

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INFO/CARD 12

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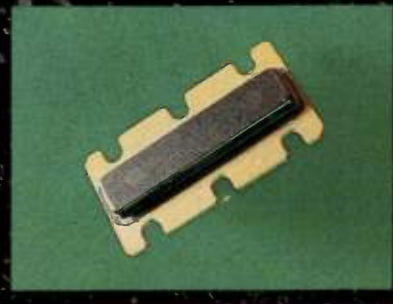
Power Amplifiers
Local Oscillators
Mixer Modules



GaAs FETS—1975
Low Noise and High Power
High Frequency beyond 18 GHz
Power (50 ohm matched,
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Low Cost Packages

BIPOLARS—1945
Small Signal
Power
Pulse Power

DIODES—1930
IMPATT, GaAs Varactor
Si/GaAs Schottky
Beam Lead PIN and Schottky
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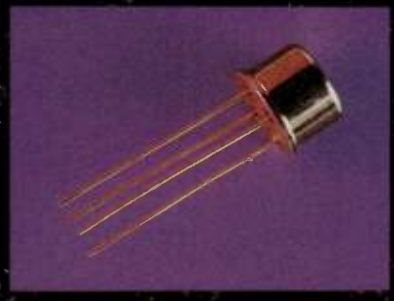

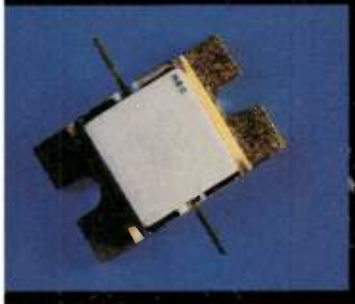

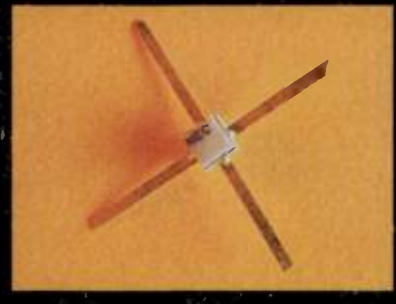

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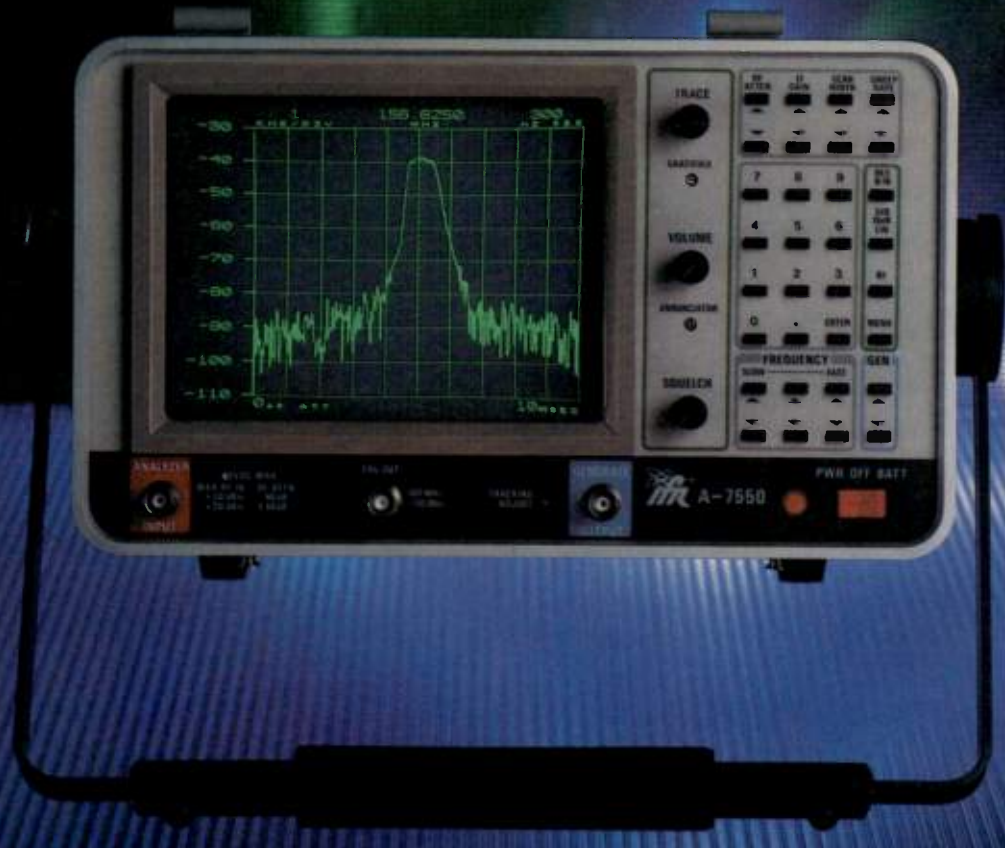
INFO/CARD 13

A New Dimension in Portable, Digital Spectrum Analyzers!



The A-7550 Spectrum Analyzer

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

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

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

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

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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
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- 70 dB dynamic range
- 300 Hz resolution bandwidth
- 16 selectable scan widths
- Accurate center frequency readout
- Direct center frequency entry
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Optional Features Include:

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- RS-232 interface bus
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INFO/CARD 14

tive Vice President, Electrospace Systems, Inc., P.O. Box 831359, Richardson, TX 75083-1359. The telephone number is (214) 231-9303.

Directory Lists Product Certification Programs

The National Bureau of Standards has published a directory of *Private Sector Product Certification Programs in the United States*. The directory contains information on 109 organizations that conduct product certification activities. Designed for federal agencies, the directory may be helpful to manufacturers by furnishing information about certification requirements.

Directory listings include the type and purpose of each certifying organization, nature of the activity, product certified, standards used, certification requirements, availability and cost of service, and other details. Individual copies of SP 703 are available for $8.00 from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402. Order by stock number 003-003-02673-5.

Les Besser, Ron Rose Form Training Company

Les Besser, instructor for the Fundamentals of RF Design course at the RF Technology Expo, and Ron Rose, cofounder of RRD Electronics, formed Les Besser Associates, Inc., Sept. 12. The new company will provide RF/microwave industry training in computer-aided design.

The company will produce videotapes and conduct seminars, internationally on RF and microwave design principles. Rose said videotapes will be produced for three levels of training. They will produce technician level courses in cooperation with the College of San Mateo and CAD/CAE courses and product design courses using the facilities of a local television station. The seminars will be available as open forums and as plant site sessions. Besser will continue his university short courses and other speaking and writing activities.

Advanced Micro Devices Launches Industry Recovery Program

Advanced Micro Devices, Sunnyvale, Calif., anticipating an industry upturn, has begun a positive-action program to accelerate it. AMD president W.J. Sanders III announced at a Sept. 10 annual meeting that the company would introduce a new complex IC every week for the year starting Oct. 1.

"Samples will be available," Sanders said. "There will be data sheets and products on the shelves of distributors.

"Because they offer us freedom from the tyranny of the commodity marketplace, I call them Liberty Chips," Sanders said, referring to the Liberty Ships program of WWII.

AMD is one of the five largest U.S. semiconductor manufacturers. The first Liberty Chip product, introduced in October, is the Am8151 Graphics Color Palette, "an innovative circuit for use in high-resolution graphics devices."

"The downturn that began more than a year ago has become the worst recession our industry has ever experienced," Sanders said. "While I believe that we have now seen the worst of it, there are not yet any solid signs of an upturn."

rf calendar

November 19-22, 1985
Wescon/85 High Technology Electronics Exhibition and Convention
Moscone Center, Brooks Hall/Civic Auditorium
San Francisco, California
Information: Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (213) 772-2965.

January 21-23, 1986
Electrical Overstress Exposition
Anaheim Hilton and Towers, Anaheim, California
Information: Jim Russell, EOE, 2504 N. Tamiami Trail, Nokomis, FL 33555; Tel: (813) 966-3631

January 28-30, 1986
Systems Design and Integration Conference
Brooks Hall, San Francisco, California
Information: Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (213) 772-2965.

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

March 11-13, 1986
Automated Design for Engineering for Electronics West
Moscone Convention Center, San Francisco, California
Information: Show Manager, ADEE WEST, Cahners Exposition Group, 1350 East Touhy Ave., P.O. Box 5060, Des Plaines, IL 60017-5060; Tel: (312) 299-9311.

March 11-13, 1986
Southcon/86 High Technology Electronics Exhibition and Convention
Orange County Convention Center, Orlando, Florida
Information: Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; Tel: (213) 772-2965.

April 8-10, 1986
Test and Measurement World Expo
San Jose Convention Center, San Jose, California
Information: Meg Bowen, Conference Director, Test and Measurement World Expo, 199 Wells Avenue, Newton, MA 02159.

April 9-16, 1986
World Market for Electronics and Electrical Engineering '86
Hannover Fairgrounds, Hannover, West Germany
Information: Hannover Fairs USA Inc., P.O. Box 7066, 103 Carnegie Center, Princeton, NJ 08540; Tel: (609) 987-1202.

May 5-7, 1986
36th Electronics Components Conference
Westin Hotel, Seattle, Washington
Information: Tom Pilcher, Electronics Industries Association; Tel: (317) 261-1592.

June 2-4, 1986
Military Microwave Conference
Metropole Hotel, Brighton, England
Information: Roger Marriott, Microwave Exhibition and Publishing, Convex House, 43 Dudley Road, Tunbridge Wells, Kent TN1 1LE; Tel: 0892-44027.

rf courses

R&B Enterprises
Electromagnetic Pulse Design and Test
November 18-19, 1985, Washington, DC

Grounding, Bonding, and Shielding
November 12-13, 1985, Washington, DC

Understanding and Applying MIL-STD-461B/C
November 14-15, 1985, Washington, DC

EMI and EMP Test Workshops
December 5-6, 1985, Philadelphia (FCC Commercial)
December 12-13, 1985, Philadelphia (MIL-STD-461/462)

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

Interference Control Technologies
Grounding and Shielding
November 12-15, 1985, San Diego
November 19-22, 1985, Bermuda
December 3-6, 1985, New Orleans

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

TEMPEST-Design Control-Testing
December 2-6, 1985, Sunnyvale

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

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

Information: Penny Caran, Interference Control Technologies, State Route 625, P.O. Box D, Gainesville, VA 22065; Tel: (703) 347-0030

Continuing Education Institute
Microwave Circuit Design: Linear Circuits
November 4-8, 1985, Palo Alto, California

Microwave Circuit Design: Non-Linear Circuits
December 2-6, 1985, Palo Alto

Information: Helen Hegnsdal, Continuing Education Institute, 10889 Wilshire Blvd., Los Angeles, CA 90024; Tel: (213) 824-9545

The George Washington University
High Frequency Spectrum: New Concepts and Technologies
November 19-22, 1985, Washington, DC

Electronic Warfare Systems: Technical and Operational Aspects
December 16-20, 1985, Washington DC
March 10-14, 1986, Washington, DC
July 14-18, 1986, Washington, DC

Military Communications Systems
December 2-6, 1985, Washington, DC

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

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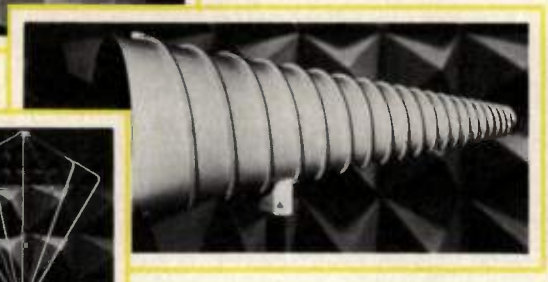
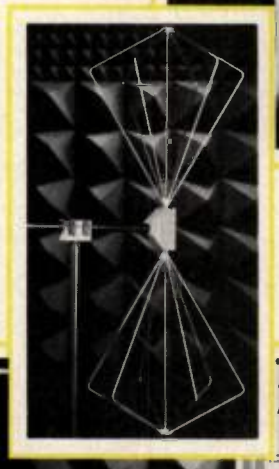




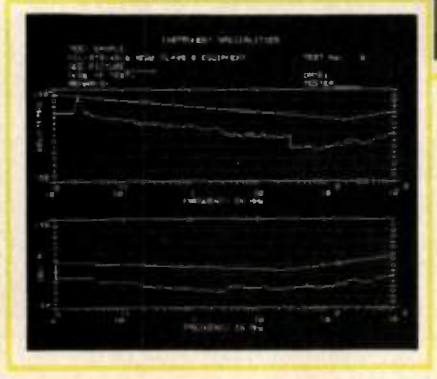
If you're involved with keeping RFI/EMI in or out, you already know about Instrument Specialties. You've probably used our beryllium copper shielding strips...received our engineering help ...even used our new line of ESD devices.

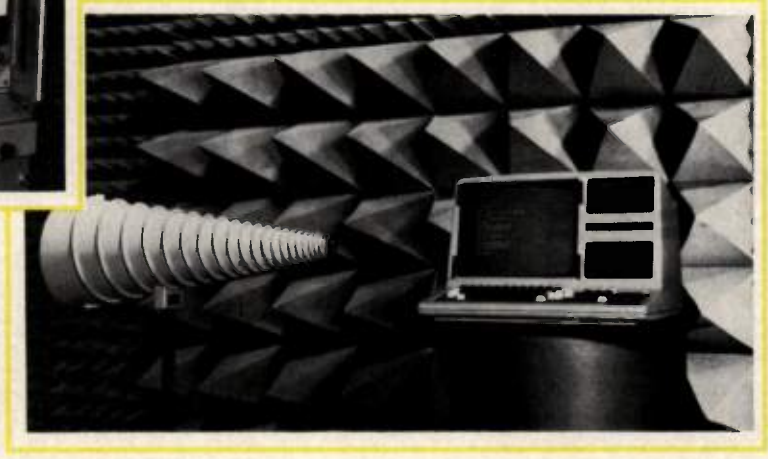
And *now*—the superb EMC testing facilities we use to assure performance of our products is *available to you for the first time.* You now can access the sophisticated equipment you don't have—but *must* have—to secure the test results you need!

State-of-the-art computer-controlled emission and susceptibility measurements from 10 kHz to 1 GHz...RF gasket evaluation...FCC/VDE/CISPR and MIL-STD-461A/B Tests...networks for power line conducted RF emission tests...semi-anechoic shielded enclosure...confirming open field test site...computer-produced hard copy readout of test results—all are yours at Instrument Specialties.

Following testing, you'll leave our facility with the precise documentation you need. In the event you need help to meet required interference specifications, we can supply that as well. All this, from one qualified source!

For more information, rates, and schedule availability, phone us and ask for EMC Customer Service. Or, write us at Dept. EMC-10.





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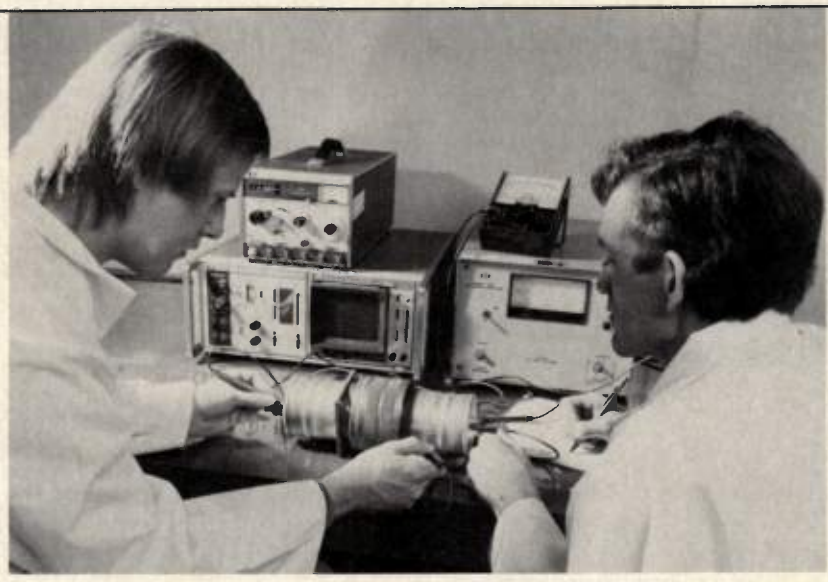
INFO/CARD 16

G & H Technology

ELECTROMAGNETICS LABORATORY



For over a decade, G&H Technology has been a leader in the development of EMP hardened and/or EMI shielded electromechanical components. The knowledge gained from this experience has been employed in the establishment of our advanced Electromagnetics Testing Laboratory in Camarillo, California.

This state-of-the-art facility provides scientific expertise in EMC, EMI, EMP and Tempest testing. From this location, G&H offers a wide spectrum of testing services including:

- Technical Proposal Preparation
- Design Control Plans
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- Failure Analysis
- Test Reports
- Preparation of Specifications

G&H Technology's advanced Electromagnetics Laboratory gives you quality and reliable service whatever your E^3 testing requirements may be.

G&H Technology, Inc.

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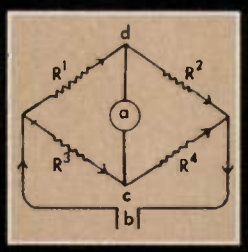
INFO/CARD 17

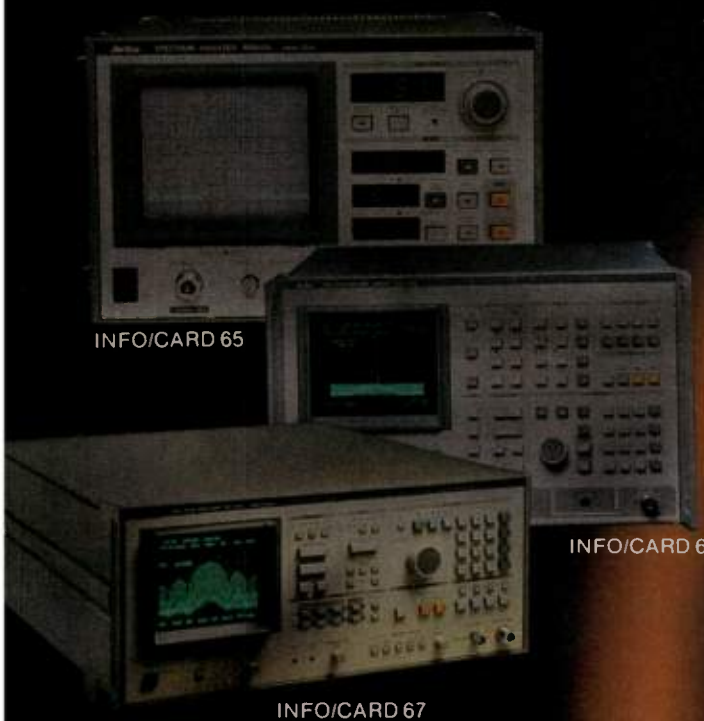
ONE.....can make a difference

In the world of electrical measurement that one was S.H. Christie who, in 1833, devised a bridge, (Wheatstone) to compare electrical resistances, inductance and capacitance.



In the world of SPECTRUM ANALYZERS the ONE that makes the difference is...

Anritsu



INFO/CARD 65

INFO/CARD 66

INFO/CARD 67

The science of measurement has come a very long way from the Wheatstone Bridge. Today, Anritsu offers a full line of Spectrum Analyzers, among them are:

MS610A Portable Spectrum Analyzer (10kHz-2GHz)

MS611A Spectrum Analyzer (50 Hz-2GHz)

MS710A Microwave Spectrum Analyzer (100kHz-90GHz)

Another Anritsu innovation is the new MS560J Network/Spectrum Analyzer (100Hz-300MHz). This highly sophisticated and versatile instrument can be controlled in an ATE environment or provide the control function. It provides the GP-IB (IEEE 488) interface as a standard with PTA and Bubble Memory optional.

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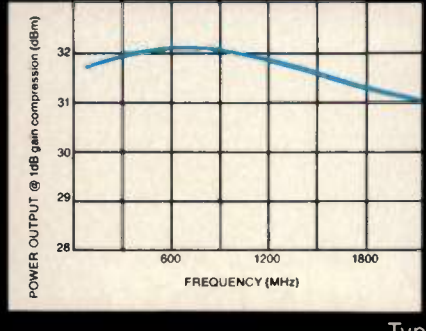
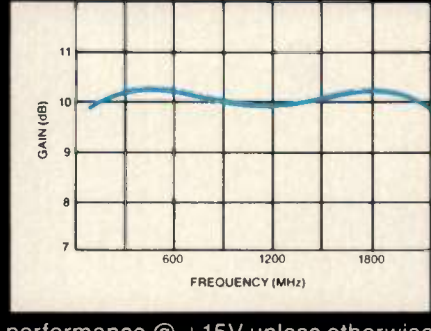
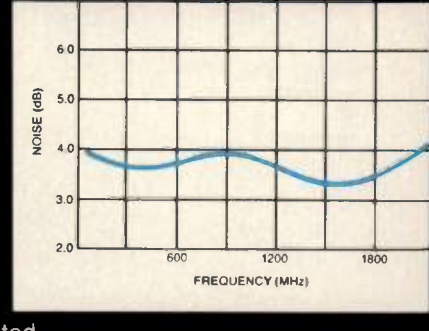


GAIN



NOISE



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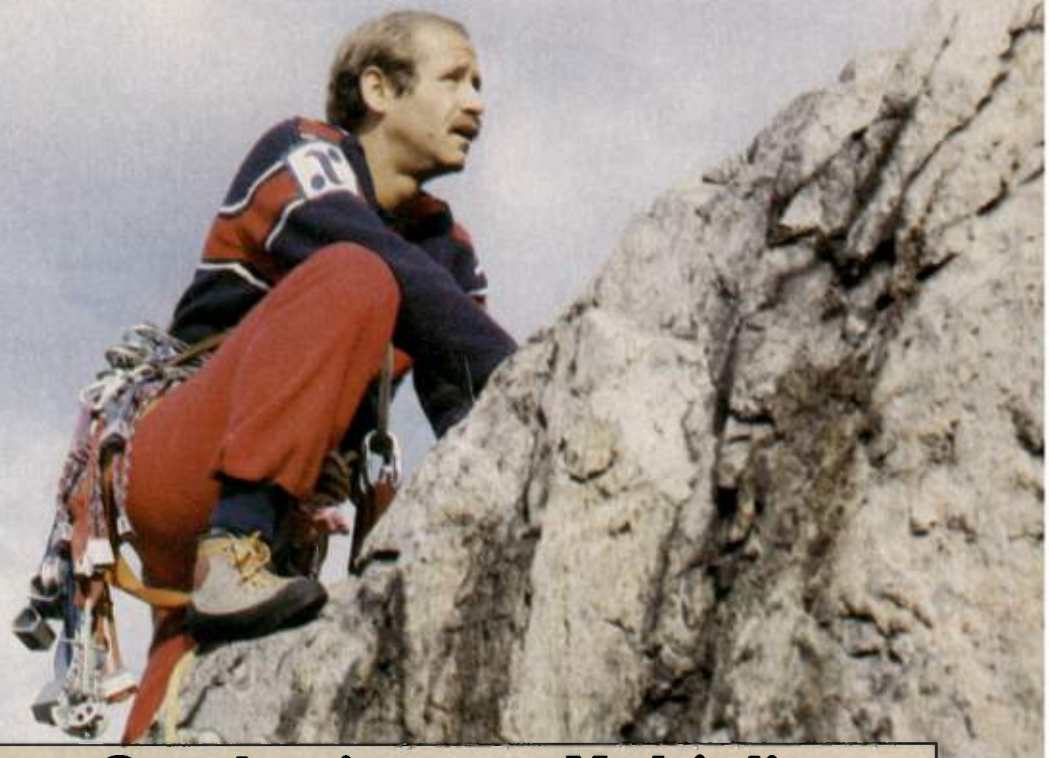

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INFO/CARD 21

EMI Susceptibility: Update on Test Methods

By Gary A. Breed

Earth, air, fire and water. . .this is how science began as the ancient Greeks first sought to explain the world in a rational manner. From the dawn of science, it took 2,500 years until man explained electromagnetic phenomena through Maxwell's equations. In less than 100 years since man first learned about electromagnetic waves, we have reached the point where nearly every wavelength has been put to use, particularly at radio frequencies. Broadcast, military, commercial and personal use of RF is so widespread that maintaining electromagnetic compatibility (EMC) among all types of electronic equipment is an unquestioned necessity. To maintain compatibility, equipment must not radiate unwanted energy and must not be affected by the radiation from other equipment's normal operation. This special report will take a look at the current test methods used to meet the susceptibility standards set forth by U.S. and international governmental agencies and industry committees.

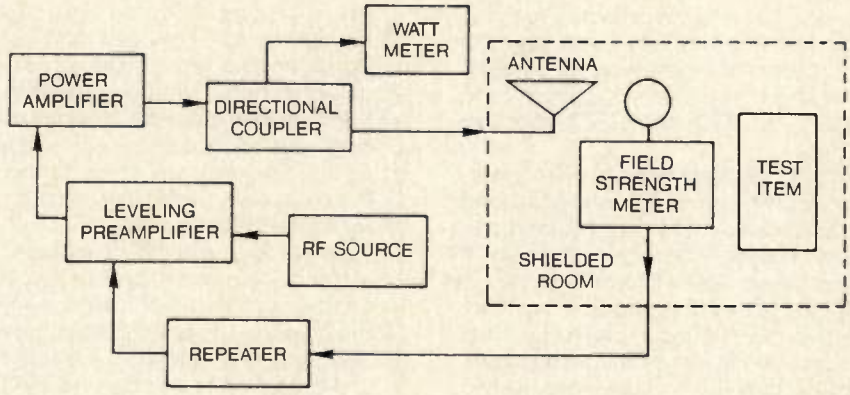


Figure 1. Typical EMI susceptibility test configuration. (courtesy Amplifier Research Corp.)

Testing for electromagnetic susceptibility (EMS) presents the engineer with challenging problems in the practical application of theory. Although the basic principal is quite simple (subject the equipment under test to a known field and measure its response), achieving that known field can be very difficult, and measuring equipment response without interfering with the test process takes effort and care. Fortunately, the entire concept of EMS testing is relatively new, and we can look forward to development of more reliable, accurate and affordable methods.

Let's take a look at some of the current test methods, their equipment requirements, and their relationship to regulations and standards now in use:

Direct Connection. The simplest test procedure consists of coupling the test signal directly to the equipment under test (EUT), whether through the antenna terminals, AC power cord or other connecting leads. Such conducted EMI testing is required by sections CS01-09 of MIL-STD-461B and is the method described in EIA Interim Standard IS-10 (for television tuners). The EIA has contracted with the National Bureau of Standards (NBS) to study conducted EMI through television and VCR power and interconnection leads.

Open-Field Testing. The FCC has long required open-field testing for radiated emissions and has well-established methods for calibration and use of such sites. Although open-field testing seems to have great advantages in accuracy, low interaction of test components, and accommodation of any size object, there are a few disadvantages that all but eliminate open-field testing as a means of EMS measurement. First, in the U.S. and many other countries, test transmitters must be licensed and are limited to operation on a few frequencies. Such testing is susceptible to external signals, confusing the test results. Except for calibration and correlation of test instruments and procedures, open-field testing has limited EMS use.

Anechoic Chambers. Obtaining performance equivalent to open-field testing without the licensing, frequency and interference limitations requires the use of an anechoic chamber. With field intensities up to 300 V/m required for EMS testing (MIL-STD-1385), the containment of the radiated field within a shielded and absorptive enclosure is highly desirable.

Performance of anechoic chambers is limited at long wavelengths, as absorber material must be approximately 0.1 wavelength thick for 10 dB attenuation of reflections. Below 30-50 MHz, anechoic chambers are no longer top performers but remain useful for some applications. At VHF and higher frequencies performance can approach complete absorption of radiated RF. Chambers can be built any size with cost limiting the practical dimensions, although absorber manufacturers such as Ray-Proof, Advanced ElectroMagnetics, Rantec and LectroMagnetics seem to enjoy featuring aircraft-hangar-sized anechoic rooms in their advertising literature.

TEM Cells. Developed by NBS, the transverse electromagnetic (TEM) cell (Crawford cell) is essentially a large size transmission line section in which equipment may be placed for testing. M.L. Crawford of NBS points out that the TEM cell has excellent field uniformity in the test area, creates a high field intensity with low power, and is inherently shielded, but there is a tradeoff between the size of the cell and the upper frequency of use, due to multimoding (1,2). Also of concern in the TEM cell (like other test situations) is the effect of the EUT and interconnecting cables on system performance.

The practical size limit of the EUT is one-third the distance between the center conductor and the outer wall, allowing devices the size of a clock radio to be tested to 300 MHz in a cell 40 cm high, 55 cm wide, and 120 cm long. A TEM cell of this approximate size manufactured by Instru-

ments For Industry Inc. (Model CC-103) will generate a 200 V/m field with only 33 watts of power, and is rated for 1000 watts power input. As part of a testing system measuring direct-radiation EMS of consumer and instrument-sized electronic equipment, the TEM cell is one of the best methods for accurate results.

Shielded and Mode Tuned/Stirred Enclosures. An economical and flexible test location that will accommodate relatively large apparatus is the shielded room. A great deal of effort has been made to study shielded enclosures for EMS testing because of the economy of their use and because MIL-STD-462, RS03 specifies their use.

With the test field radiated by an antenna within the enclosure, reflections and standing waves make accurate and predictable results impossible unless some means are employed to provide more uniform field intensity at the EUT location. A field strength detector placed near the EUT provides feedback to a leveling preamplifier, creating a closed-loop system for regulation of the field intensity, a significant improvement over unregulated sources. However, inaccuracies cannot be overcome by leveling alone; the field variation is too great.

One method of further improvement is to place absorber material in the enclosure to reduce reflections and improve radiated field strength constancy in the test area over the desired frequency span. This technique has been shown to work well with the Cavitenna™, a recent development of Amplifier Research Corporation, which excites the inside of a shielded room as a cavity, using walls or ceiling as a ground plane (3). This new antenna increases the field intensity for a given power level compared to a log periodic antenna placed inside the room.

Another modification of the shielded room is the addition of rotating paddles of reflective material to "stir" or "retune" the modes of the chamber. Over time, the EUT will be subjected to some average field strength and a generally random variation in field polarity. The advantage of the method is that the high fields generated by low power are maintained without the losses introduced by absorbent material. Disadvantages include the low-frequency performance deficiency of all shielded enclosures, due to the lack of low frequency modes within the cavity formed by the interior walls, and the fact that peak fields at the EUT will likely exceed the desired average much of the time. However, this method provides the means for inexpensive "worst case" testing. The EMS community continues to have a high level

RFI Susceptibility Test Equipment

By D.W. Roth
Amplifier Research Corp.

Testing for susceptibility to electromagnetic or radio-frequency interference is required to build a product that will stand up to the harsh interferences it will eventually encounter. Some products aren't bothered by RFI; others may be so seriously affected that they lose or garble information or otherwide cause some catastrophic failure. The extent to which a product is susceptible to RFI determines the extent of its testing.

The product is most often placed in a controlled electromagnetic environment (a shielded room, as shown on the cover, is the preferred test chamber), turned on and then subjected to an RF field which has been tailored to the product under test and to its foreseeable ultimate exposure.

Generating and varying the RF field and recording the effects on the test item's operation through the selected frequency band and power levels is the job of the test lab. Since the task and the test equipment are specialized and not generally needed on a daily basis, it rarely pays a small manufacturer to have an in-house test facility. That is why RFI test labs such as R&B Enterprises in West Conshohocken, Penn., are appearing throughout the world. These labs perform susceptibility, emissions, EMP and other specialized tests for military and commercial equipment manufacturers.

Some small test items, such as hand-held transceivers or calculators, may be tested in transverse-wave (TEM) cells, saving a trip to a shielded-room facility but sacrificing bandwidth and ease of data collection.

Procedure and test equipment

Even though a product may not use the bandwidth of the imposed interference, its power source and/or antenna may pick up and pass along disturbances that could cause unwanted switching of relays or devastating logic anomalies. Therefore, very broad bandwidths are chosen for susceptibility testing, to monitor any unusual effects as the test item runs the interference gauntlet.

The test laboratory usually starts with normally-encountered RFI conditions, both in field strength and in frequency, working gradually up to worst-case conditions to ascertain just how much punishment a test item can take and keep operating satisfactorily. The basic complement of a susceptibility test system is as follows:

A signal source (frequency synthesizer or sweep-signal generator) capable of delivering a signal of one milliwatt or more to the preamplifier;

A *broadband leveling preamplifier* (such as the Amplifier Research Model 999) acting as a control center to receive field-strength signals back from the shielded room and to provide gated pulse output to the power amplifier for pulse testing applications;

A *broadband power amplifier* with good instant-bandwidth and total mismatch immunity. (More than three decades of bandwidth [from 1 MHz to 1 GHz] are instantly available without need for tuning or bandswitching in the "W" Series of amplifiers from Amplifier Research);

An *antenna* particulary suited for use within a shielded room. The Cavitenna® radiator shown in the photo is especially effective within the 30 to 150 MHz range, where other antennas have the greatest difficulty, and has a total range of 30-1000 MHz;

A *field-strength sensor* and repeater system to send information on the field level from the shielded room out to the test engineer. Since the position of the test item in relation to the antenna is changed frequently during the course of testing, field level is affected and must be recorded;

A broadband fiber-optic *telemetering system* to send information from the test chamber on the operation of the test item under varying frequency interference.

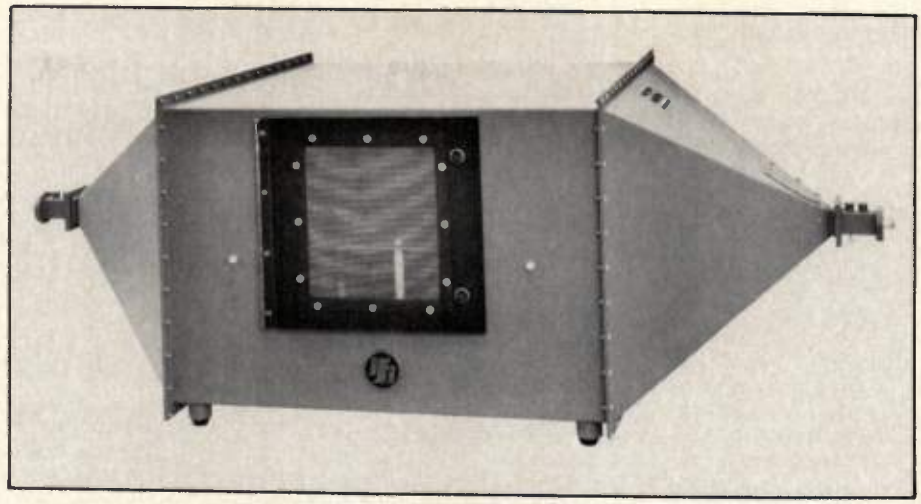
This is the barest outline of an RFI susceptibility test system. Other accessories, including directional couplers, power meters, audio/visual monitors, temperature sensors, etc., may be called upon depending on the type of test item under examination and the type of failure expected from RF exposure.

of interest in the shielded room because of the comparatively low cost and multipurpose nature of the enclosures.

Parallel Plates. MIL-STD-462, RS04 describes test procedures using parallel plates, which generate test fields of high intensity with less power than a normal antenna would require. Recent refinements in technique allow parallel plates, typically used in the HF range, to be used up to about 200 MHz. This test system has problems with radiation, despite the fact that most of the field is confined to the area between the plates. Providing a shielded enclosure around the system adds to the complexity and cost, but effectively meets FCC radiation standards.

Underground Rooms. Another EMS testing development is the use of underground rooms, using the earth as a lossy medium to absorb radiated energy. Despite some practical difficulties, underground EMS test chambers show promise for reasonable cost testing with acceptable accuracy. In areas with existing caves, salt domes, unused mine tunnels, or proper geology for excavation, underground facilities may be implemented quite readily. However, the characteristics of the geologic strata in which the chamber is located determine the ultimate performance of the room in terms of reflectivity of the walls and shielding effectiveness of the overburden.

One effective use of underground facilities is the shielding of parallel plate or triplate line systems. (Tri-plate lines are TEM cells without side walls). These two test systems have good containment of fields between plates, but have significant radiation, requiring shielding to meet FCC standards. If an underground chamber is readily available, the performance of earth and rock as an absorber is sufficient to shield these systems without the high reflectivity of metallic shielding or the high cost of absorber material.



The Instruments For Industry model CC-103 TEM cell (Crawford cell). The test device is placed inside through the access door, where it is subjected to the test field within the self-shielding enclosure.

Equipment Considerations

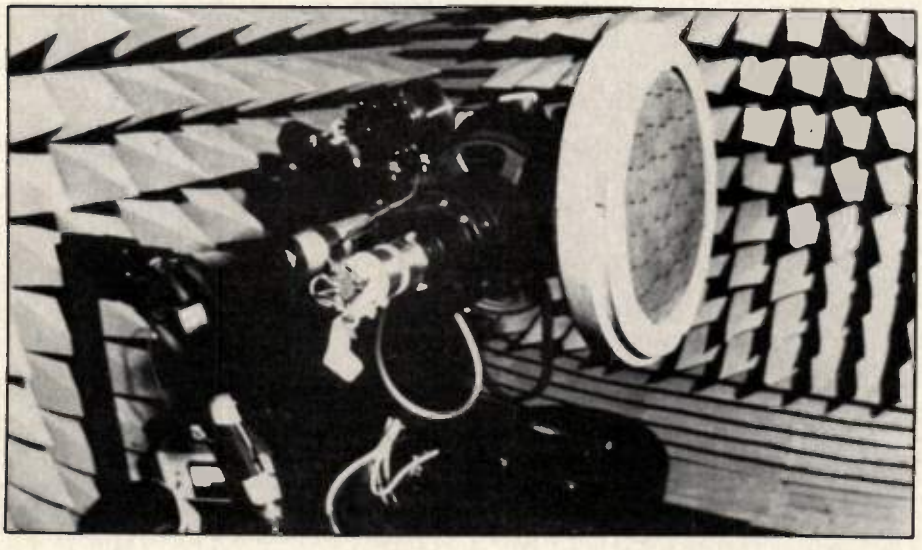
Fig. 1 shows a representative configuration of EMS test equipment. Each item in the test system has equal importance, requiring careful selection to achieve accurate results. The accompanying note "RFI Susceptibility Test Equipment" describes the various pieces of equipment in this configuration.

Additional comments about equipment selection include antennas, which can vary from a long wire within the test enclosure to log periodic types to cavity-exciting devices, such as the Cavitenna. In addition to these radiating antennas, Helmholtz coils are used to generate M-fields and parallel plate radiators are used for E-field testing. Antenna selection is based on the bandwidth and power requirements of the desired EMS test function.

The power amplifier requires careful selection, as wide bandwidth and high power are needed for susceptibility testing. Don Shepherd of Amplifier Research emphasizes correct interpretation of amplifier specifications to be certain that correct power and gain is available over the entire test frequency range and that linearity and mismatch immunity are sufficient for the application.

Tim D'Arcangelis of Instruments For Industry points out another area for caution in amplifier selection: the bandwidth required by the test signal. For example, electrostatic discharge (ESD) testing requirements of the military include a damped sine wave signal with specified envelope characteristics. The ESD test engineer must remember that modulation of a sine wave increases the required bandwidth to accommodate sidebands and harmonics, not just the fundamental frequency.

Finally, the EUT may have to be repositioned within the test chamber and may have to be operated in a manner other than normal. Actuators must be nonconducting and must keep the EUT within an area of uniform field intensity. Control and monitoring cables should be carefully located for minimum interaction with the test field.



Missile seeker antenna undergoing automatic pattern testing in an anechoic chamber. Antenna and chamber designed and manufactured by Rantec Division, Emerson Electric Co., Calabasas, Calif.

It is safe to say that regulations and industry standards are not yet firmly established. Even MIL-STD-462 procedures, around for 10 years, are not the last word since MIL-STD-461B has provisions to modify test procedures as may be needed. The first of the consumer voluntary standards will be released by the first of the year, covering TV and VCR susceptibility (see this month's RFI/EMI Corner for an update). European agencies are also moving toward voluntary standards for consumer goods (see "Update on European EMS Regulations"). To ensure accuracy and reliability of those standards, studies will continue to address the wide range of consumer and commercial equipment.

Testing for EMI susceptibility is a very young science. In the near future we will see new techniques, equipment and facilities beyond the "snapshot" of current work presented here. So much work is going on in EMS technology that it is only possible to show the tip of the iceberg, a few highlights. For more information on specific applications of EMS testing, check with manufacturers of test equipment and EMC testing laboratories. For an in-depth study of EMS test principles, the best starting point is the published research of the National Bureau of Standards.

References

(1) Myron L. Crawford, "Techniques for Measurement of Electromagnetic Radiation and Susceptibility of Electronic Equipment," National Bureau of Standards.
(2) M.L. Crawford and J.W. Adams, "Factors Influencing Radiated EM Susceptibility Testing of Automotive Components," National Bureau of Standards, paper presented June 1978 at SAE Passenger Car Meeting.
(3) Robert D. Goldblum, R&B Enterprises, and Donald R. Shepherd, Amplifier Research Corp., "Advanced Concepts for Vulnerability and Susceptibility Testing," a research report.

Update on European EMS Regulations

By Michael F. Owens
Eurotest Laboratories, Ltd.

In Germany, the only mandatory requirements (civil sector) are specified in VDE Standard 0872, Part 1 through 5. This is only for radio, television and video sets. For all other electronic equipment, there is no standard available at this time and it is up to the manufacturers to design their units to be immune from noise or line disturbances or "Electromagnetic Compatibility Susceptibility (EMV)."

For effective control of the noise problem, manufacturers in the development stage and at equipment installation can take three basic directions:

actions at the noise source,

suppression or reduction of disturbing rate transmission,

elimination of effects of disturbances on the receiver.

The reliability of electronic equipment stands and falls with the control of the electromagnetic interference factor.

To achieve EMV in electronic equipment, only limited interference should be emitted and on the other hand the equipment should be immune to noise effects from the outside.

That means noise radiation of electronic equipment must be under the noise threshold range from 0 Hz to an upper frequency in the GHz range, depending on the project.

EMV — Installation Planning

Installation means various electronic equipment considered as one unit, like a place of manufacturing, a house with all of its equipment or a car. The aim of such an EMV system plan is to provide ways before and during installation of the system to secure the EMV. Suppression at a later date is very costly.

Organization of an EMV System Plan requires definition of requirements, collection of EMV data, analysis regarding interference influence of the individual components, showing basic steps and detailed steps to secure EMV, listing of necessary EMV tests, coordination of subjects concerned, and tests to prove EMC.

EMV testing often is only possible in shielded rooms with high frequency absorbers. Only in the military area are there extensive standards for planning, limit values, test procedures, test equipment and actions. The EMV planning for equipment and systems in this category is mandatory. In Germany these standards are VG-NORMEN 95370 through 95378. EMV standards in the civil area still require a great deal of work, and as mentioned, are only available for radio, television and video sets.

In other international areas, the International Electrotechnical Commission (IEC) published two standards covering EMV. IEC Standard 801-2 covers the area of electrostatic discharge (ESD) with recommended test methods and severity levels. This standard is intended for industrial type equipment, but will likely be used by many worldwide industries. IEC Standard 801-3 covers the area of radiated EMV and gives test methods and test equipment, again intended for industrial control equipment. The aim of these standards is classification of the electromagnetic environment in connection with a "cookbook-style" action catalogue for all types of electronic equipment. With these tools, design engineers, project leaders and contractors should be able to consider EMV by themselves. EMV specialists should then only be needed for protecting very complex and sensitive equipment.

For additional information about European regulations, contact Michael Owens at Eurotest Laboratories Ltd., P.O. Box 262, Mathews Road, East Haddam, CT 06423.

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The Sciteq SCX-256: A *100 MHz* Accumulator

By Gary A. Breed

The Digital Connection features products and techniques with direct application to the design of RF circuitry. This month, a new high-speed digital accumulator from Sciteq Electronics, Inc. is introduced. This device represents a major development in high-speed logic, with clock rates much faster than any previous single-chip device.

Sciteq designs and manufactures frequency synthesizers, specializing in direct-digital techniques. For one MILSTAR application they developed an ultrafast switching synthesizer using 100K ECL which met all electrical requirements but was too large. To reduce space, a custom gate array was designed for the accumulator portion of the circuit, replacing 12 ICs in the original design. The result of that design is the SCX-256.

The accumulator design required a guaranteed clock rate of at least 70 MHz, requiring meticulous attention to every path and junction. Together with Hamilton Avnet's ASIC design center and the fabrication expertise of Motorola, the process of design and prototyping took over three months of intensive work. The result is an accumulator with a typical clock rate over 100 MHz.

An accumulator is a series of adders and latches which add the input number to the previous output sum on every clock cycle, *accumulating* a larger and larger output sum. Fig. 1 shows an 8-bit accumulator with input latches to demonstrate the process. The input word (increment size) is entered via latches and transferred to the adders with an INPUT ENABLE command. Until a new input word is enabled, the adders will increment the sum in steps the size of the input number. This example has a four-MSB (most significant bits) output to mimic the SCX-256's 12 MSB output from a 24-bit input.

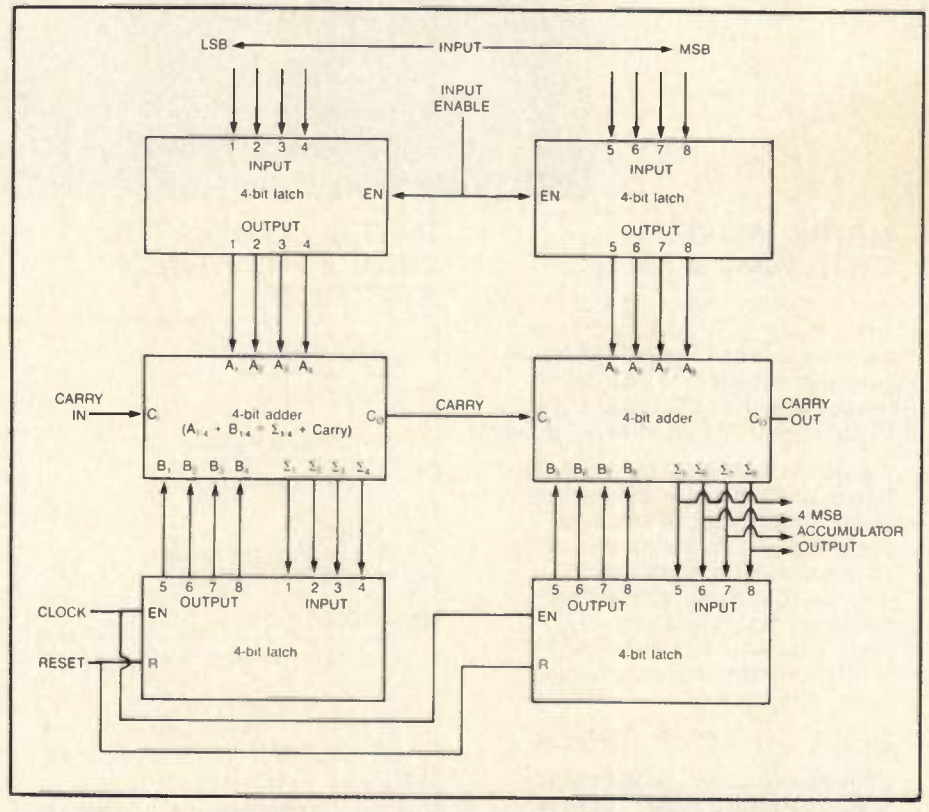

Figure 1. An 8-bit accumulator using 4-bit latches and adders, with registered inputs and 4 MSB output.

Figure 1, above, demonstrates the accumulator process. The input word has been left fixed and the carry functions are not used:

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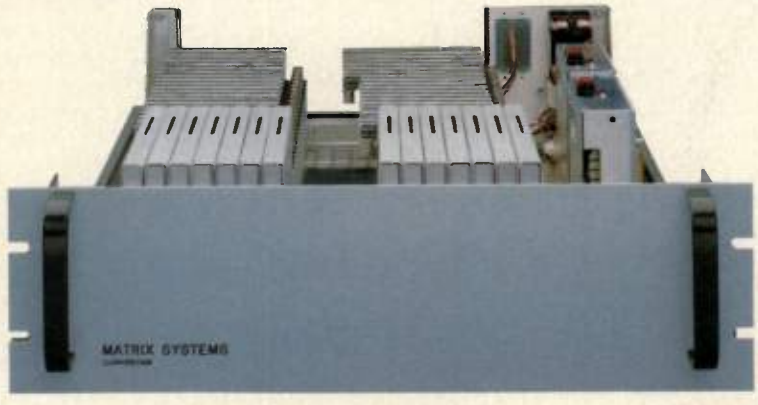

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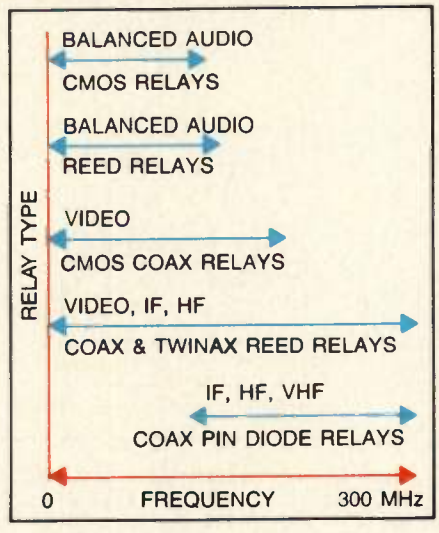

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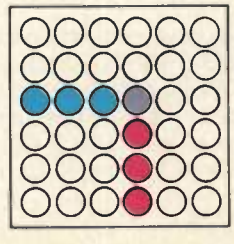

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Start count = 0
Input word = 00101001 (number 41)

Clock Cycle	8-bit Sum	4 MSB Output
1	00101001 (41)	0010 (2)
2	01010010 (82)	0101 (5)
3	01111011 (123)	0111 (7)
4	10100100 (164)	1010 (10)
5	11001101 (205)	1100 (12)
6	11110110 (246)	1111 (15)
7	00011111 (31)	0001 (1)

Note: The sum is really 100011111 (287), but with no carry the 9th bit is dropped: The sum is always the eight LSB (least significant bits).

8	01001000 (72)	0100 (4)

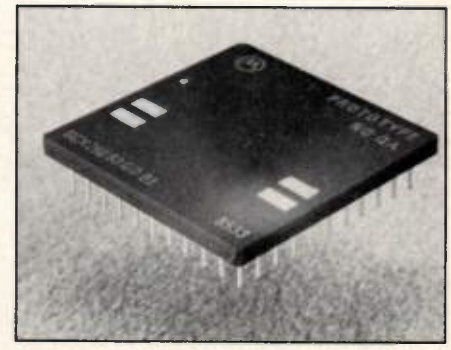
If the four MSB output is used to address a read-only memory (ROM), a sequence of stored values can be recovered at a rate determined by the input word.

Direct digital frequency synthesis uses the sequential recovery of data in ROM. An accumulator such as the SCX-256 generates outputs which address a ROM containing the values of a sine wave in binary form. These ROM values form the input to a digital-to-analog converter (DAC) whose output is a step-by-step approximation of a sine wave at a frequency determined by the input word to the accumulator. The accuracy of the output depends on the resolution (number of bits) of the ROM and DAC. For example, a 512 × 8 bit ROM and an 8-bit DAC with ±½ LSB accuracy will reproduce a sine wave with 0.4% accuracy.

SCX-256 Description

The SCX-256 is a 24-bit ECL level accumulator. The design includes 24 registered inputs with independent loading of the 12 MSB and 12 LSB. Outputs are fully registered 12 MSB of the accumulated sum. Internal adding takes place on the clock rising edge; reset is asynchronous. Transparent latches allow inputs to be loaded either synchronously or asynchronously. Carry input and output functions are available for cascading two or more devices. The SCX-256 requires 750 mA at standard ECL supply voltage. The clock rate is guaranteed to be 70 MHz, with 100+ MHz typical.

Although developed specifically for direct digital synthesizers, the SCX-256 can be used for other fast arithmetic and digital signal processing applications, like digital filters and fast Fourier transform. Although similar functions can be achieved using discrete ECL devices, the SCX-256 will eliminate the critical board layout required for large ECL designs, improving speed and reducing glitches. With the introduction of the SCX-256, Sciteq has given design engineers a lot of performance in a small package. . . and a lot of potential applications. rf



The Sciteq SCX-256 accumulator.

ANSI Committee Studying Voluntary EMI Susceptibility Standards.

Will Soon Release First Report on TV/VCR Immunity

By Gary A. Breed

The 1982 Amendment to the Communications Act of 1934 gave the FCC authority to regulate EMI susceptibility of electronic equipment. Continuing a policy of deregulation, however, the FCC insisted that the parties involved develop voluntary standards. In response to the Congressional mandate for regulation and the FCC's wishes, an ad hoc committee was formed under the aegis of ANSI committee C63. The members of the committee represent manufacturers, testing laboratories, the Electronic Industries Association (EIA) and the American Radio Relay League (ARRL). The first report from this committee on television and VCR immunity is in final draft stage, and should be ready for review by the full C63 committee at their mid-November meeting in Washington. Don Heirman of AT&T Information Systems, chairman of the group, indicated the report should be released by the end of this year.

The committee has been studying TV and VCR susceptibility to interference received by direct radiation or accompanying the desired signal through the antenna lead. Their report will address EIA Interim Standards IS-10, "Immunity of TV Tuners to Internally Generated Harmonic Interference From Signals in the Band, 535 kHz to 30 MHz," and IS-16, "Immunity of Television Receivers and Video Cassette Recorders to Direct Radiation from Radio Transmission, 0.5 - 30 MHz." These two documents represent earlier proposed standards in this area and the committee report is said to contain no major deviation from them. Results of an EIA-commissioned study by the National Bureau of Standards on conducted interference via outside leads may be included in the report. The NBS study has been completed and results should be available for the November C63 meeting.

A spokesman for the FCC expressed satisfaction with the voluntary regulation efforts, noting that the process saves the FCC time and money and should result in standards acceptable to everyone because compromises are being worked out during the process. According to all parties involved, cooperation has been very good despite the diverse interests of the groups represented. One example of compromise is the selection of a statistical "average case" analysis rather than either a lenient model or a worst-case situation.

Some committee members noted the difficulty presented by VCRs, where HF signal processing circuitry is sensitive to radiated interference. TV IF circuits were also mentioned as an area requiring additional engineering to achieve EMI protection. Everyone contacted emphasized the need for continued work, not only on TVs, VCRs and home electronics but in commercial areas. Hugh Turnbull, ARRL Atlantic Division Director, pointed out that cordless telephones, security devices, and other low-power RF devices need attention. Part 15 of the FCC Rules and Regulations covers radiation by these devices, but their immunity to interference has not been addressed. Other users of the RF spectrum, whether they are "closed circuit" or have internal circuits operating at radio frequencies, have potential EMI problems and will require study. Another area the committee must address is Channel 6 interference from Educational FM broadcasters. The FCC recently released revised allocation standards for FM channels in the vicinity of Channel 6 facilities, but has left TV receiver standards to the ad hoc committee.

Eb Tingley of the EIA Consumer Electronics Group emphasized the need for international cooperation to implement new standards. Offshore companies may perform all engineering and manufacturing outside the U.S. and must be aware of new developments. U.S. representatives have been involved in EMI standards discussions in Australia and Europe, sharing the results of work done here and encouraging international development of standards and test procedures.

In its proper role of evaluating only engineering issues, this committee has not addressed the *cost* of achieving EMI immunity. The increase in the price of a TV due to additional shielding is unknown. Line filters, extra bypassing and mechanical redesign will certainly add to the cost of production and consumers must understand the protection offered by these changes. Fortunately, consumer awareness of the nature of interference seems to be improving. Frivolous complaints to the FCC have decreased, and overall interference complaints have not grown at the same rate as the increase in sales of consumer equipment.

It is easy to overstate the significance of this first effort at major voluntary regulation of EMI. It is only a first step, not a set of final standards. Television sets and VCRs may be the largest group of consumer electronics, but with many other devices yet to be examined, work on EMI immunity standards will continue for a long time. Success of this voluntary regulation effort requires industry commitment, international cooperation and consumer awareness. The alternative is a return to the difficult process of FCC regulation, an idea unattractive to everyone involved.

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SAS-200/518	1000 - 18000 MHz	Log Periodic
SAS-200/530	150 - 550 MHz	Broadband Dipole
SAS-200/540	20 - 300 MHz	Biconical
SAS-200/541	20 - 300 MHz	Bicon | Collapsible

MODEL #	FREQ. RESP.	DESCRIPTION
SAS-200/542	20 - 300 MHz	Biconical, Folding
SAS-200/550	.001 - 60 MHz	Active Monopole
SAS-200/560	per MIL-STD-461	Loop - Emission
SAS-200/561	per MIL-STD-461	Loop - Radiating
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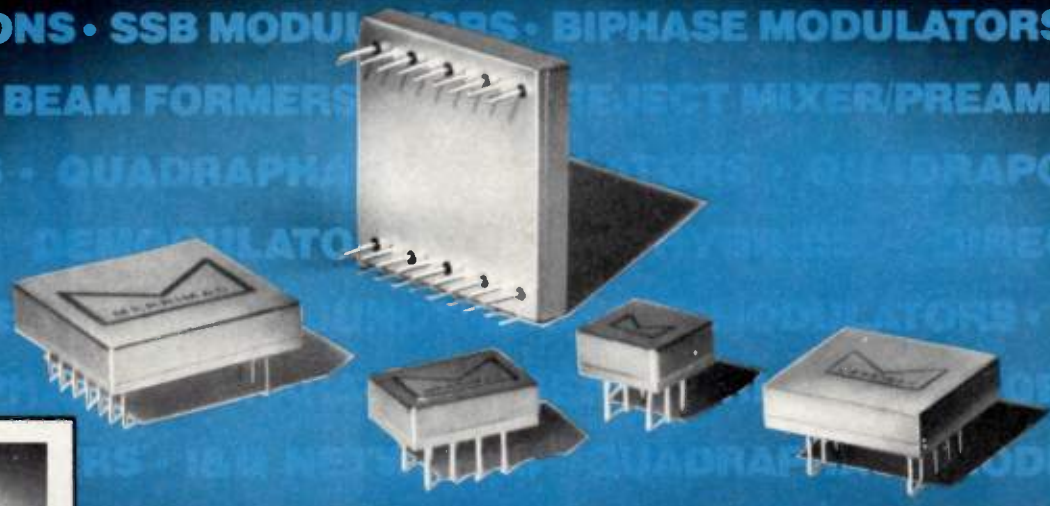

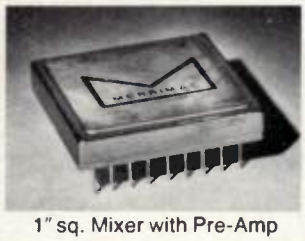

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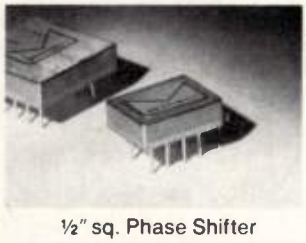

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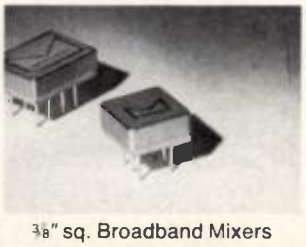

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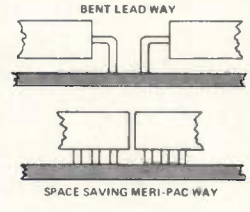

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Excess Insertion Loss at the Input Ports of a Combiner Hybrid

By Earnest A. Franke
E-Systems, ECI Division

Combining circuits for multiple power amplifiers require inputs with proper phase and amplitude relationships. The repair or replacement of circuit components may alter the gain or phase shift characteristics of one portion of the system, causing a change from the original design parameters. This article presents a discussion of the excess losses that are a result of deviation from ideal phase and amplitude of the signals to be combined.

An RF designer measures all the components for a power amplifier consisting of a power splitter, two or more amplifier modules and a power combiner, only to find that the overall gain is less than the sum of the gains and losses of the components. Or, a technician replaces a defective transistor in a paired amplifier and discovers that the total gain is not what he expected, even after assuring himself that separately both halves worked perfectly. Each person expects the total power from a hybrid combiner to be the sum of the inputs after considering any mismatch losses. With an examination of effects of amplitude and phase imbalance, one discovers why the difference power ended up in the isolation resistor connected to the hybrid combiner.

Power Combining and Imbalance

Power combining may be considered on one of two general levels: the device level and the circuit level. Device level combining is accomplished by clustering several devices in a region whose extent is small compared with the operating wavelength. Transistor vendors have continually increased the available output power from a single package until the device is package limited. Combining several transistor dice within the same package eventually runs into problems of impedance matching, concentrated heat dissipation and reactance interaction (power hogging). By directly paralleling two transistors, the resistive part of the input and the output load impedance decreases, yielding a higher Q, lower bandwidth part. The advantage of using a hybrid power combiner centers around the isolation achieved when combining the outputs of the two devices. With power shared by many elements, the summing technique provides more reliability than a single solid state element operating at high power. The stability of combined power transistors is enhanced by this isolation, as the reactive components of one transistor do not affect the other transistor, which is effectively in parallel.

In radio frequency amplifiers formed by effectively placing two transistors in parallel by using hybrid power combiners, there will always be some phase and amplitude imbalance at the input ports when using the typical combiner techniques shown in Fig. 1. Typically, transistors are selectively paired at the factory to limit gain difference at some median operating point and frequency to less than 1 dB. There is also some imbalance due to the type and tolerance of the splitter hybrid. The phase imbalance of the output power of two transistors is a result of component tolerances in the matching networks, process control for manufacturing the semiconductor itself and the fact that several vendors may be second-sourcing the transistor itself. Typically the phase distribution for a part which must be acceptance tested in a wideband circuit is less than ±15°. The use of automated wire bonding and wafer processing has lowered this deviation significantly.

3 dB Hybrid Coupler Performance

Electrical parameters of the hybrid splitter/combiner of concern to the amplifier designer are insertion loss, amplitude balance and phase balance. The insertion or excess loss is the amount of attenuation, in excess of signal coupling losses, of an input signal from a matched source to a matched output termination. The coupling loss for an equal-split hybrid is 3.01 dB.

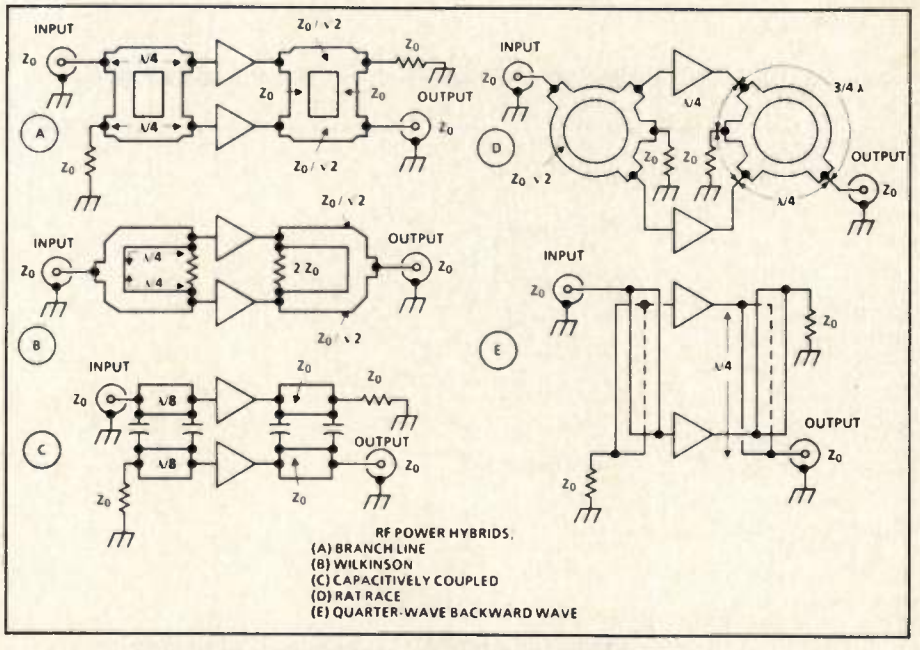

Figure 1. Power Combining using RF Power Hybrids

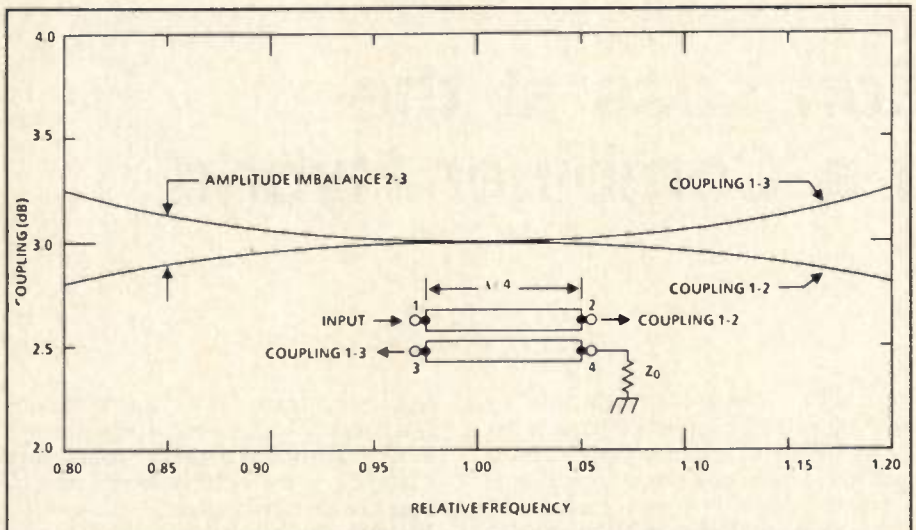

Figure 2. Coupling for a Backward Wave Coupled Hybrid

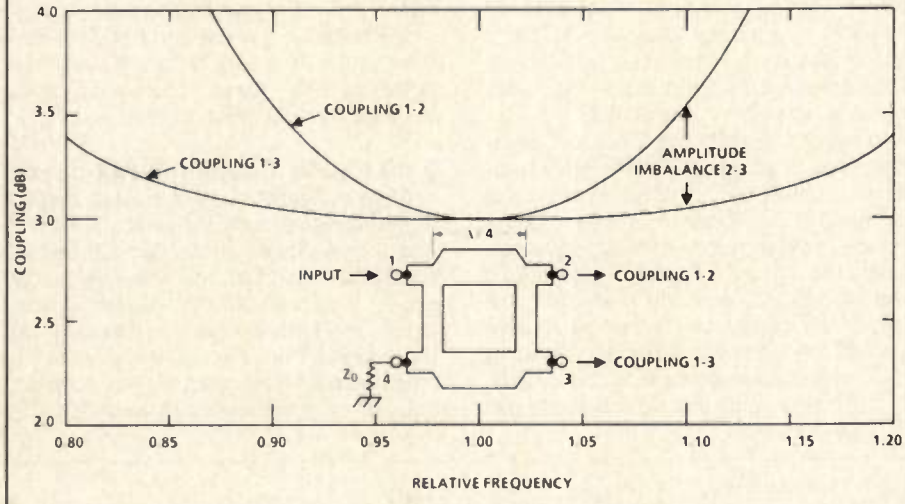

Figure 3A. Coupling of a Single-Section Branch Line Hybrid

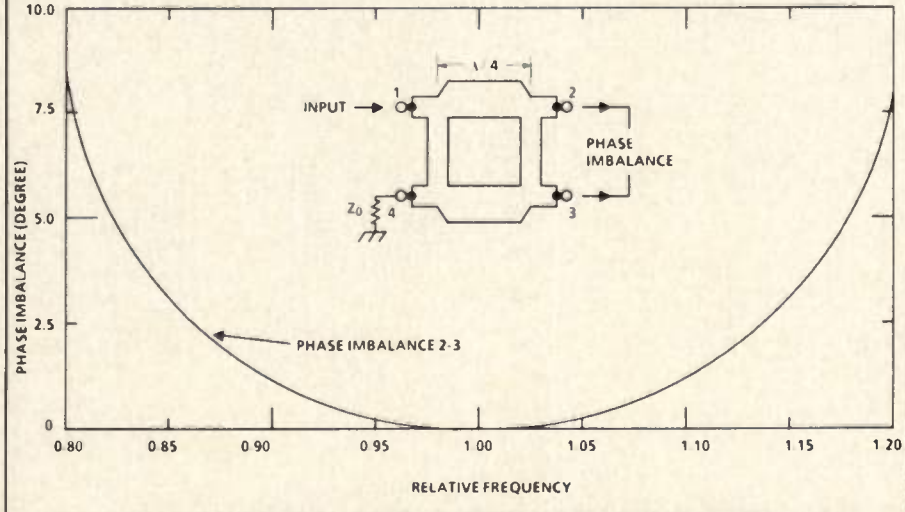

Figure 3B. Phase Imbalance for a Branch Line Hybrid

One-half the input power appears at each output port of a 3 dB hybrid splitter. The amplitude balance is the difference in attenuation between the two output signals when fed from a common input, generally expressed as a maximum variation over the specified operating range. The difference in phase between two output signals fed from a common input is known as phase balance or phase tracking.

Some performance tradeoffs may be made between these parameters. The principal tradeoff naturally deals with simplicity and frequency range. The ability to reproduce a coupler inexpensively in microstripline form on common printed circuit board can be very important. For single frequency applications requiring bandwidths less than 10%, the insertion loss of a manufactured hybrid can be held quite low, with the amplitude balance degrading rapidly away from the center frequency. Octave bandwidth designs typically display slightly more insertion loss but the amplitude balance is held tighter. Amplitude balance may also be improved, at the sacrifice of increased overall loss, by increasing the number of sections contained within each hybrid.

A single-section, quarter-wave, quadrature hybrid for example displays a theoretical amplitude imbalance of 0.44 dB at the upper and lower operating frequencies (Fig. 2) over a 40% bandwidth. The phase balance however, is quite good. Theoretically the outputs remain in quadrature (90° difference) over the above bandwidth. Experimentally the phase imbalance can be held to less than ±1°. The amplitude and phase balance of other 3 dB hybrids is not as good. The popular branch line hybrid (Fig. 3A and 3B) displays an amplitude imbalance of 1.84 dB at the band edges and 8.3° phase imbalance at the same ±20% bandwidth points. The capacitively coupled hybrid formed by two eight-wave transmission lines (Fig. 4A and 4B) has an amplitude imbalance of over 6 dB at the upper operating frequency and nearly 5 dB at the lower operating frequency. The phase imbalance is also quite high, 8.4° at the bottom and 22.3° at the top of the same relative bandwidth.

The rat race hybrid resembles the branch line hybrid with an additional half-wave transmission line added (Fig. 5A). The rat-race is a reciprocal four-port device that can provide two in-phase signals when fed from its sum port and two 180° out-of-phase signals when fed from its difference port. The push-pull output ports differ by a nominal 180° and exhibit an amplitude imbalance of 1.8 dB and a phase imbalance of 13° (Fig. 5B)

over the 40% bandwidth. The equal-phase outputs for an input at port 4 show an amplitude imbalance of 1.7 dB and a phase imbalance of 11°.

An equal-phase hybrid, such as the Wilkinson coupler (Fig. 6) displays excellent amplitude and phase balance over a moderate bandwidth because of its symmetry. Any imbalance is due to construction or termination imperfections.

Excess Insertion Loss

The primary concern of excess combiner insertion loss for amplitude and phase imbalance appears in an amplifier when only one of the two paired power transistors is replaced. The replacement transistor probably will not come from the same wafer lot as the original transistor, nor even possibly from the same vendor. The evidence of amplitude and phase imbalance may be first noted by increased power dissipation in the isolation resistor of the output hybrid combiner. The output power and gain will also be reduced slightly.

The insertion loss due to phase and amplitude imbalance is:

Excess Insertion Loss =

$$10 \log_{10}\left[0.5+\frac{\sqrt{P_r}\,\text{Cos}\,\theta}{1+P_r}\right] \text{dB} \qquad (1)$$

or

Excess Insertion Loss =

$$10 \log_{10}\left[0.5+\frac{10^{\frac{P_{dB}}{20}}\,\text{Cos}\,\theta}{1+10^{\frac{P_{dB}}{10}}}\right] \text{dB} \qquad (2)$$

where

Pr = relative ratio of the input powers
P_{dB} = input power ratio in decibels
θ = relative phase angle between the input signals.

This excess insertion loss also may be broken into two terms to study independently the effects of amplitude and phase imbalance. If the input powers are exactly equal but the phase angles differ, then the equation for the excess insertion loss for phase imbalance reduces to:

Excess Insertion Loss =

$$10 \log_{10}\left[0.5+\frac{\text{Cos}\,\theta}{2}\right] \text{dB} \qquad (3)$$

as shown in Fig. 7. If the two input powers to a hybrid have equal phase angles but unequal amplitudes, then the equation for excess insertion loss due to amplitude imbalance reduces to:

Excess Insertion Loss =

$$10 \log_{10}\left[0.5+\left(\frac{\sqrt{P_r}}{1+P_r}\right)\right] \text{dB} \qquad (4)$$

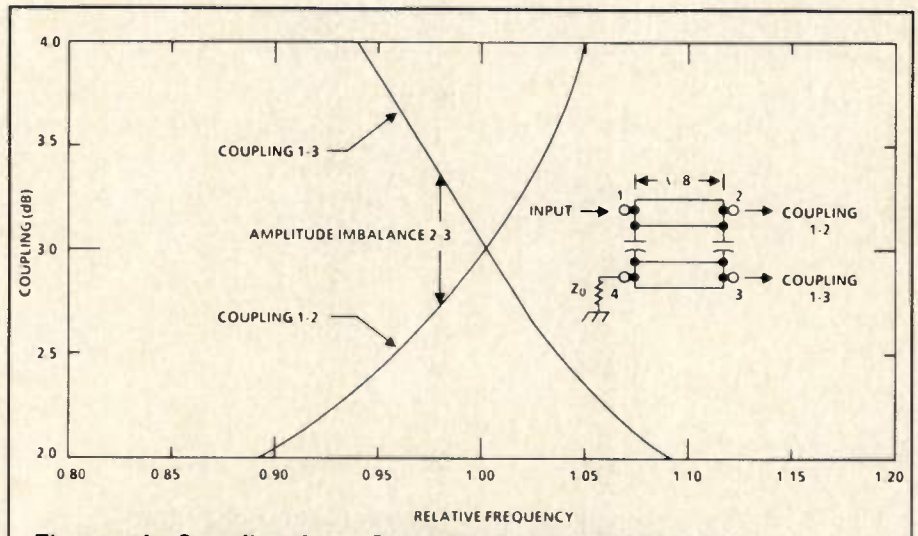

Figure 4A. Coupling for a Capacitively-Coupled Hybrid

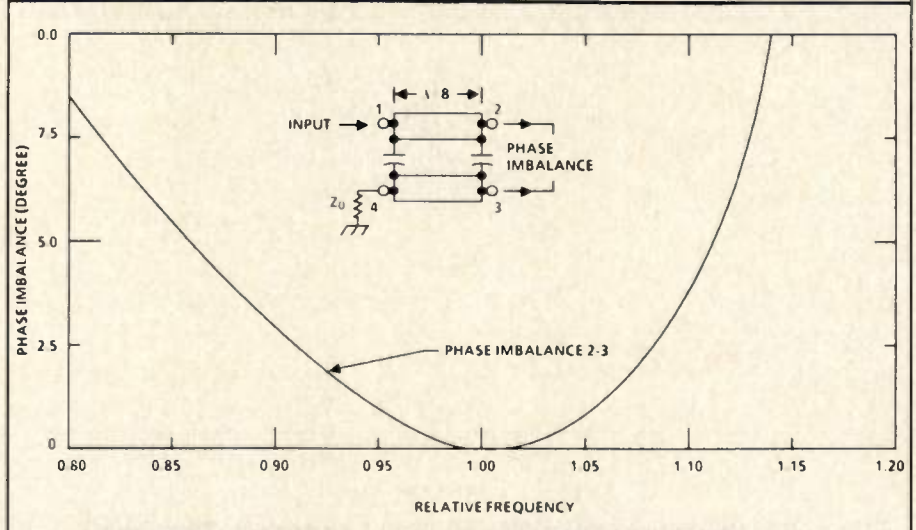

Figure 4B. Phase Imbalance for a Capacitively-Coupled Hybrid

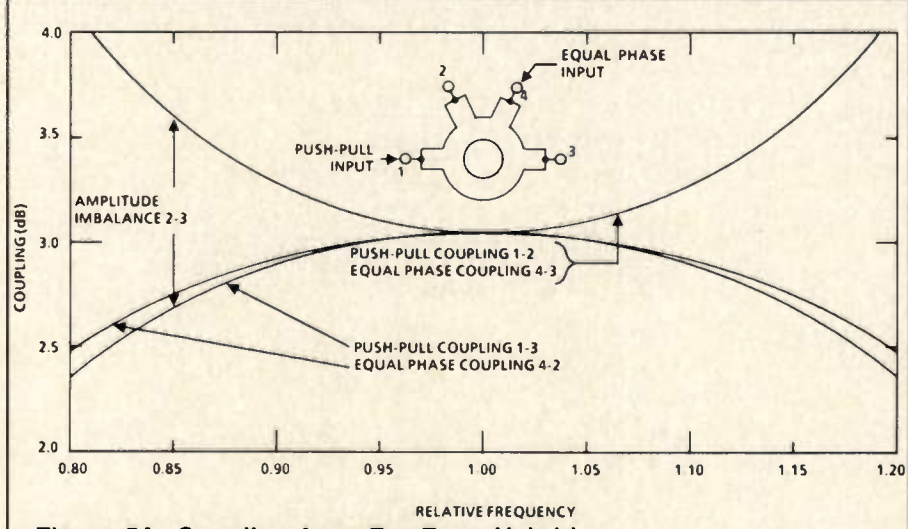

Figure 5A. Coupling for a Rat Race Hybrid

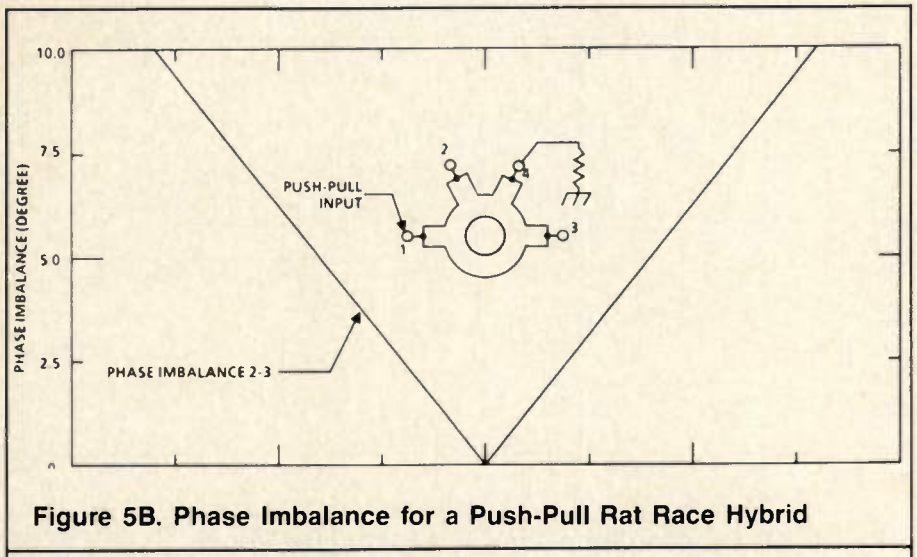

Figure 5B. Phase Imbalance for a Push-Pull Rat Race Hybrid

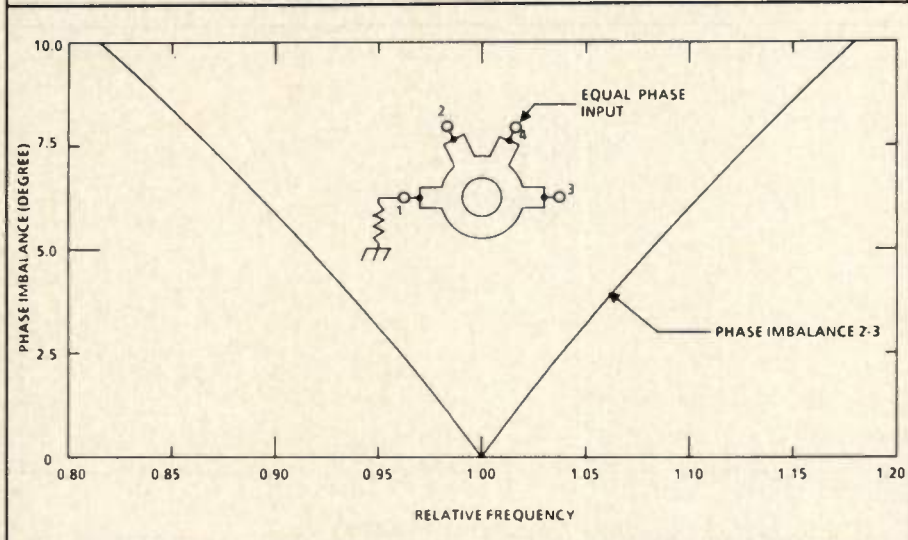

Figure 5C. Phase Imbalance for an Equal-Phase Rat Race Hybrid

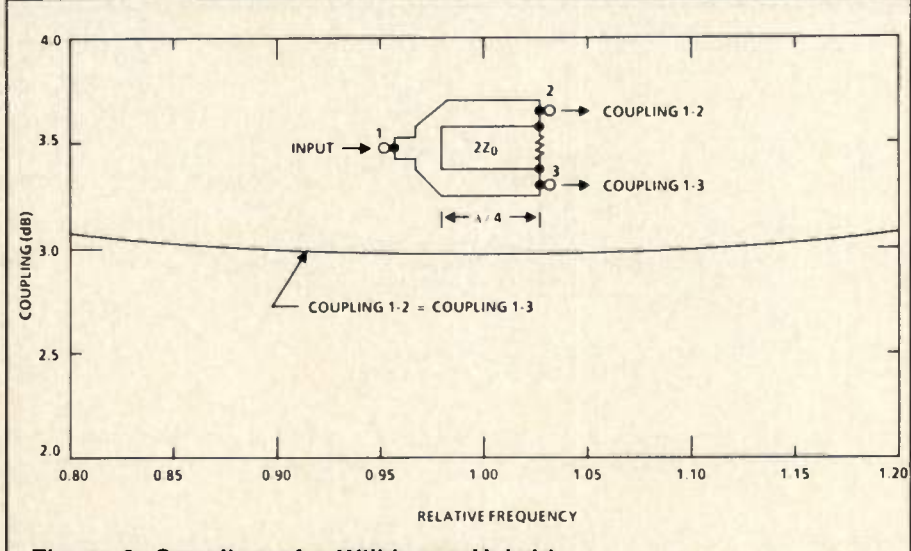

Figure 6. Coupling of a Wilkinson Hybrid

Excess Insertion Loss =

$$10 \log_{10}\left[0.5 + \frac{\sqrt{10^{\frac{PdB}{20}}}}{1 + 10^{\frac{PdB}{10}}}\right] dB$$

as shown in Fig. 8.

Derivation of Excess Combining Loss

The output power for a single input to a 3 dB hybrid combiner is:

$P_{out} = P_{in}/2$ and an output voltage $V_{out} = V_{in}/\sqrt{2}$

The resultant voltage vector V_{out} for input voltage vectors V_A and V_B according to the Argand phasor diagram of Fig. 9A by the law of cosines is:

$$(V_{OUT})^2 = \left(\frac{V_A}{\sqrt{2}}\right)^2 + \left(\frac{V_B}{\sqrt{2}}\right)^2 - 2\left(\frac{V_A}{\sqrt{2}}\right)\left(\frac{V_B}{\sqrt{2}}\right)\cos\theta$$

$$= 1/2\left[V_A^2 + V_B^2 - 2V_AV_B \cos\theta\right] \quad (5)$$

where the angle θ is the relative phase imbalance between the two input voltages.

Using the identity $\cos(180° - \theta) = -\cos\theta$:

$$(V_{OUT})^2 = 1/2\left[V_A^2 + V_B^2 + 2V_AV_B \cos\theta\right] \quad (6)$$

From this equation the resultant output voltage is shown to be composed of two voltages V_A and V_B plus an interference term which is equal to $2\,V_AV_B$ when the phase imbalance is zero. When the phase imbalance is 90° the interference term is destructive.

Next, one input signal is chosen as the reference voltage and the coordinate system is normalized and centered on that vector:

$(V_{OUT})^2 =$

$$1/2\left[\left(\frac{V_A}{V_A}\right)^2 + \left(\frac{V_B}{V_A}\right)^2 + 2\left(\frac{V_A}{V_A}\right)\left(\frac{V_B}{V_A}\right)\cos\theta\right] \quad (7)$$

$V_{OUT}^2 =$

$$1/2\left[1 + \left(\frac{V_B}{V_A}\right)^2 + 2\left(\frac{V_B}{V_A}\right)\cos\theta\right] \quad (8)$$

The normalized output power is equal to the square of the rms voltage across the termination impedance:

$$P_{OUT} = \frac{V_{OUT}^2}{2Z} =$$

$$\frac{1}{4Z}\left[1 + \left(\frac{V_B}{V_A}\right)^2 + 2\left(\frac{V_B}{V_A}\right)\cos\theta\right] \quad (9)$$

The total available input power to the hybrid combiner is:

$P_{IN} = P_A + P_B$

The normalized input power sum is:

$$P_{IN} = \left(\frac{V_A}{V_A}\right)^2 + \left(\frac{V_B}{V_A}\right)^2 \Big/ 2Z \qquad (10)$$

Finally with the ratio of the individual input powers P_A and P_B defined as:

$$P_r = P_B/P_A = (V_B)^2/(V_A)^2 \qquad (11)$$

then the ratio of the output power to the available input power, assuming equal input and output impedances, is:

$$P_{OUT}/P_{IN} = \frac{\frac{1}{4Z}\left[1 + P_r + 2\sqrt{P_r}\ \text{Cos}\ \theta\right]}{\frac{1}{2Z}\ (1 + P_r)} \qquad (12)$$

The excess insertion loss due to amplitude imbalance (P_r) and phase imbalance (θ) is:

$$P_{OUT}/P_{IN} = \frac{1 + P_r + 2\sqrt{P_r}\ \text{Cos}\ \theta}{2\ (1 + P_r)} \qquad (13)$$

Excess Insertion Loss =

$10\ \log_{10}\ (P_{OUT}/P_{IN}) =$

$$10\ \log\left[0.5 + \left(\frac{\sqrt{P_r}}{1 + P_r}\right)\text{Cos}\ \theta\right] \qquad (14)$$

The resultant phase angle (ϕ) of the output signal is simply derived from the phasor diagram (Fig. 9B). The tangent of the resultant phase angle is:

$$\text{Tan}\ \phi = \frac{V_B\ \text{Sin}\ \theta}{V_A + V_B\text{Cos}\ \theta} = \frac{\text{Sin}\ \theta}{(V_A/V_B) + \text{Cos}\theta} \qquad (15)$$

$$\theta = \text{Tan}^{-1}\left[\frac{\text{Sin}\ \theta}{10^{-\frac{P_{dB}}{20}} + \text{Cos}\ \theta}\right] \qquad (16)$$

Typical Losses

Examination of the curves showing excess loss as a function of amplitude and phase imbalance indicates that the loss is low even for moderate differences in amplitude and phase. For an amplitude imbalance P_{dB} of 1 dB the reduction in output power compared to the sum of the input powers is only 0.014 dB (a reduction of 0.33%). A worst case imbalance of 2 dB results in a 0.057 dB loss (1.3% reduction). For a phase imbalance θ of 30° the insertion loss would be 0.30 dB (a reduction of 7.2%).

Let's consider a 100 watt power amplifier module composed of two 50 watt transistors. If we consider a 2 dB power imbalance, the power in one transistor will be +47 dBm (50 watts) and +45 dBm (31.5

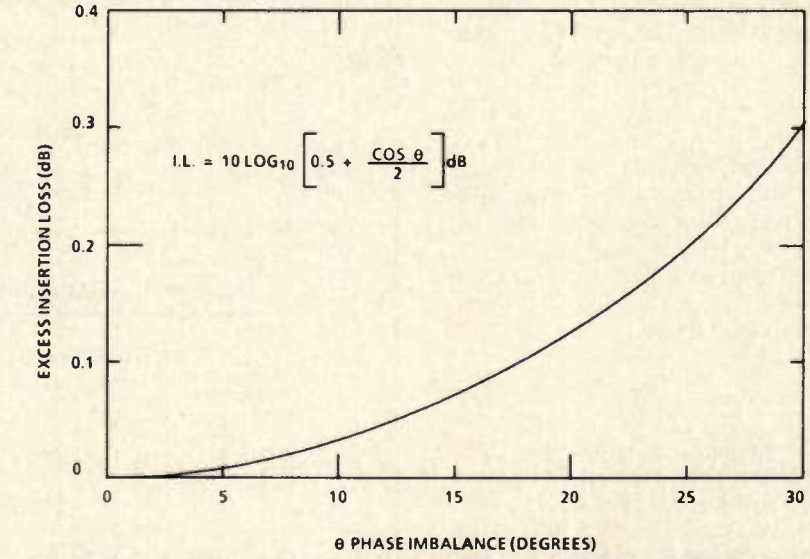

Figure 7. Excess Insertion Loss Due to Phase Imbalance

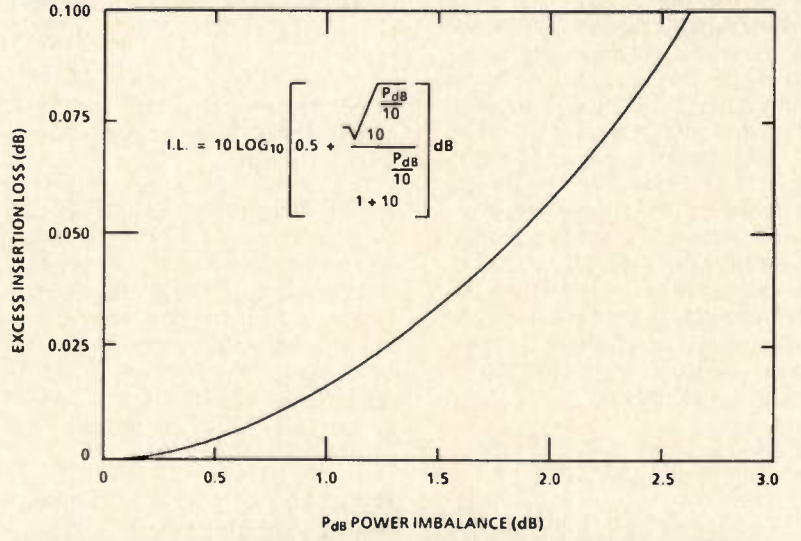

Figure 8. Excess Insertion Loss Due to Amplitude Imbalance

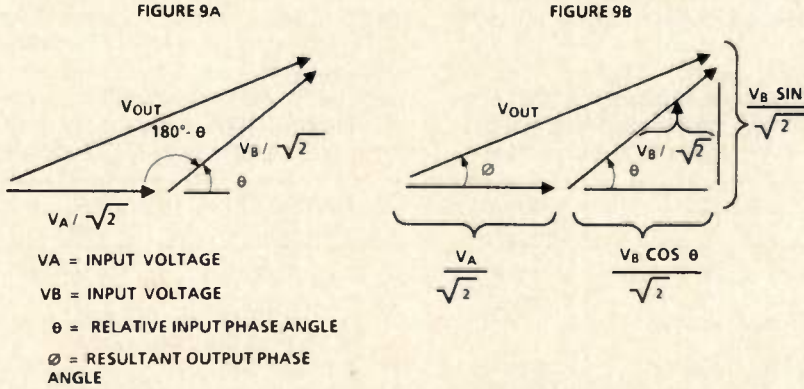

Figure 9. Derivation of Excess Combiner Insertion Loss

watts) in the other. The output power with this amplitude imbalance would be the sum of two powers minus the excess insertion loss due to imbalance:

$$P_{OUT} = P_1 + P_2 - \text{I.L.}\ (P_r) = 80.5 \text{ watts}$$

Approximately one watt from the original sum of 81.5 watts is lost in the isolation resistor because of amplitude imbalance.

Now for the same amplifier let's consider that the two input powers also have a phase difference of 30°. The output power would then be:

$$P_{OUT} = 80.5 \text{ watts} - \text{I.L.}\ (\theta) = 75.1 \text{ watts}$$

Thus, for an amplitude imbalance of 2 dB and a phase imbalance of 30° approximately 6.4 watts of power would be lost out of a possible 81.5 watts of input power to the final combiner, a reduction of 0.35 dB or 8%.

Measured Results

The total losses through a hybrid power combiner consist of the mismatch losses, losses in each path, and excess losses due to phase and amplitude imbalance. Pairs of experimental hybrids (quadrature, Wilkinson, branch-line) were combined to verify the excess losses due to phase and amplitude imbalance. A variable length transmission line was placed in one leg of the coupled hybrid to simulate an unequal amplifier phase delay (Fig. 10). Attenuators were also placed in each leg to simulate unequal amplifier gain. The expected loss just due to attenuators placed in each leg would then be:

$$\text{Loss} = 10 \log_{10} \left[\frac{1}{0.5 \left(10^{\frac{-\text{Atten1}}{10}} + 10^{\frac{-\text{Atten2}}{10}} \right)} \right] \text{dB}$$

where Atten 1 = Attenuation in one leg
Atten 2 = Attenuation in the other leg

The total measured loss was indeed equal to the sum of the insertion loss due to attenuators placed in each leg and the excess insertion loss due to amplitude imbalance.

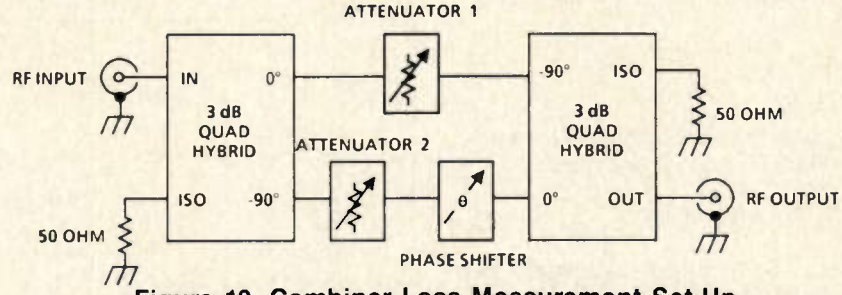

Figure 10. Combiner Loss Measurement Set-Up

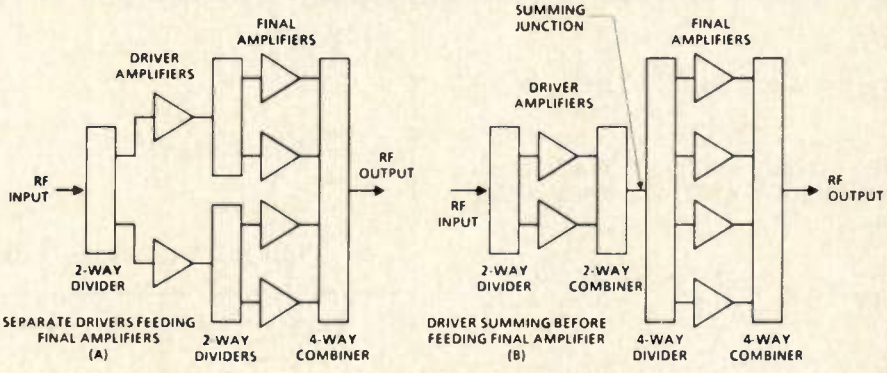

Figure 11. Summing of Gain Stages

Reduction of Insertion Loss Due to Unbalance

The additional insertion loss due to amplitude and phase imbalance following the replacement of one damaged transistor can be minimized in several ways. First, the repair technician could replace both transistors with a paired replacement set that has been matched for gain. Next the design engineer might include a variable phase shift network in one side of the combiner amplifier. If one side of the amplifier were designed to contain less phase shift than the other side, an adjustable phase shifter could be added to account for differing phase delays between the devices. The phase imbalance could be optimized by simply adjusting for minimum detected power at the isolation port of the combiner hybrid.

Finally, excess summing losses can be controlled for long amplifier chains by summing after each stage of amplification as illustrated in Fig. 11. If the driver amplifiers are unequal in gain or phase then this driver output power difference would be further amplified by the final amplifiers before being absorbed in the output 4-way power combiner isolation resistor. By adding a 2-way combiner at the output of the driver amplifier (Fig. 11B) the power is summed before splitting to feed the final amplifiers. Thus, any phase or amplitude difference is absorbed at a lower power level. This design requires an additional 2-way combiner and divider, but the phase and amplitude balance of the drive signal to the final amplifiers is improved. rf

The phase was measured on each of eight UHF amplifier modules. These amplifier modules consisted of two balanced transistors using quadrature hybrids at the input and output. The gain and phase variations reported below are normalized about a collector supply voltage of +28 VDC, a bias voltage of +0.5 VDC, a flange temperature of +25°C, and a power level of 125 watts. (See box below.)

VARIABLE	VARIATION	MEASURED GAIN DEVIATION	MEASURED PHASE DEVIATION
Collector Supply Voltage	+26 to +30 VDC	−0.3 to +0.3 dB	−4 to −3
Base Supply Voltage	+0.4 to +0.6 VDC	−0.6 to +1.0 dB	+4 to −1
Flange Temperature	−40 to +100 C	+0.4 to −1.1 dB	+2 to −4
Power Level	50 to 150W	+0.2 to −0.1 dB	+5 to −2

About the Author

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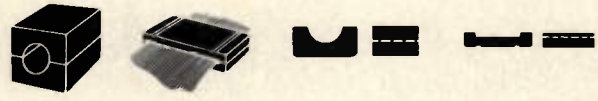
Ferrite Components Suppress EMI

The Simple Solution to Many Interference Problems

Ferrites are capable of suppressing high frequency signals while passing lower frequencies and DC. This property is translated into practical applications by use of ferrite components to eliminate unwanted noise in electronic circuits. Fair-Rite suppressor components are supplied in several different ferrite materials; 73 material is particularly effective up to 40MHz; 43 material between 30MHz and 200MHz and 64 material above 200MHz.

In addition to the beads and sleeves which have become industry standards, Fair-Rite has developed a series of large 1 and 2 piece sleeves, large toroids, and shielding plates. All can be incorporated in new designs; many can be retrofitted to existing equipment. Data processing equipment, which both produces and is particularly vulnerable to EMI, offers a prime opportunity for the use of ferrites as EMI suppressors. Other applications include Switch Mode Power Supplies, communication equipment, as well as other industrial and consumer products employing electronic circuitry.



Split beads and sleeves for bundled or flat ribbon cable permit simple retrofit in problem areas. Precision ground mating surfaces create a virtually complete magnetic path providing effective EMI suppression.

One piece beads, sleeves and toroids offer a wide range of impedance values and a classical approach to interference suppression. Fair-Rite offers an extraordinarily wide choice of shapes and materials, with dimensions from .032″ to 2.400″ diameter, and from .038″ to 1.125″ long.

Round and rectangular multi hole shielding plates are a new concept in connector design. The latter also finds application in DIP configurations. The use of such plates in a connector dramatically reduces the cost per pin for both ferrite and assembly labor.

The NEW 11 hole bead and the 6 hole bead combine high impedances with economy of space and cost. Winding configurations range from 1½ to 4½ turns.

Fair-Rite, the leader in ferrite EMI suppressors, has developed unique capabilities in state-of-the-art shielding ferrites, offering users unparalleled experience in tooling development and the manufacturing process. To assist designers in making full use of our know-how, we offer three ENGINEERING EVALUATION KITS:

The CABLE & CONNECTOR EMI SUPPRESSOR KIT (part no. 0199000002): 13 different large beads and toroids, 1 and 2 piece sleeves, and the new multi hole shielding plates, supplied in Fair-Rite 43 material.

The BEAD-ON-LEAD KIT (part no. 0199000003): 10 different beads on leads, plus two six hole wound shield beads, providing impedances from 68 to 680 ohms typical, measured at 100 MHz. Values from 68 to 200 ohms are available taped and reeled for automatic insertion.

The BEAD, BALUN AND BROADBAND KIT (part no. 0199000001): A selection of 34 cores in 7 different materials offering the designer many options for high frequency circuits.

Each Kit is $25 postpaid against your check or M/O; or, plus shipping when ordered on your PO or letterhead. For prices outside the USA and Canada, please contact our Customer Service Department.

Each Kit comes with its own Engineering Bulletin describing the contents and guiding the designer in the use of Fair-Rite components to solve his EMI problems. Further information on these three kits may be obtained by requesting a copy of the Engineering Notes, Ferrite Components as EMI Suppressors.

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INFO/CARD 27

The Close-Field Probe: A Powerful EMI Troubleshooting Tool

A hand-held probe can find localized emission sources within equipment.

By Mark Terrien
Hewlett-Packard Company

The increasing world-wide regulation of electromagnetic radiation is forcing design engineers to be more concerned than ever about minimizing radiated and conducted emissions. Methods are needed to detect and locate EMI problems during the product-design cycle to avoid costly re-design at the production stage. Unfortunately, many design centers do not have in-house EMI testing facilities and designers have no way of detecting emissions problems early, when they are easiest to fix. Even when such facilities are available, the measurement methods cannot always locate sources of high emissions within the equipment, making it difficult for the designer to solve EMI problems. This article describes the Hewlett-Packard 11940A Close-Field Probe and its use in identification and troubleshooting of EMI problems.

There are a variety of radiating sources in electronic equipment including analog oscillators, digital clocks and microprocessors. The sources and their surrounding metallic support structures directly control the radiation pattern when placed in an unshielded enclosure. When placed in a shielded enclosure, the enclosure itself controls the radiation pattern. In both cases, the task for the troubleshooter is to locate the major radiators in the equipment. However, most EMI testing methods measure total radiated field strengths without determining the physical location of the major radiators. A device that measures radiated emissions with repeatable spatial accuracy would be a powerful troubleshooting tool. With such a device, the circuit designer could identify problem radiators in a new product prototype and the mechanical engineer could evaluate the effectiveness of the enclosures and shields being designed for the new product.

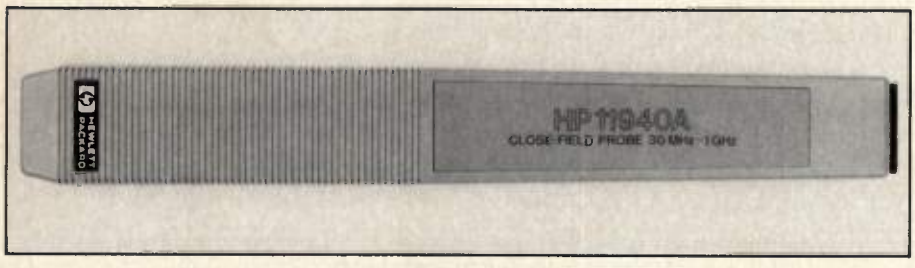

Figure 1. The HP 11940A Close-Field Probe.

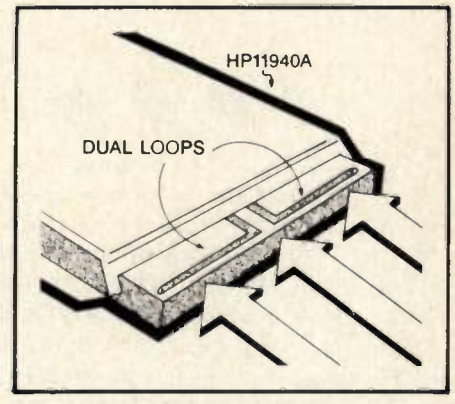

Figure 2. Probe orientation for maximum coupling to the magnetic field.

There are several descriptions in the literature of balanced shielded loop antennas for measuring magnetic fields (1,2,3). These antennas are shielded from electric field components to reduce errors in the output signal from stray capacitive coupling to nearby sources. It is this parasitic coupling that limits the repeatability of the electromagnetic field measurement. The spatial resolution of these antennas is limited because of the size of

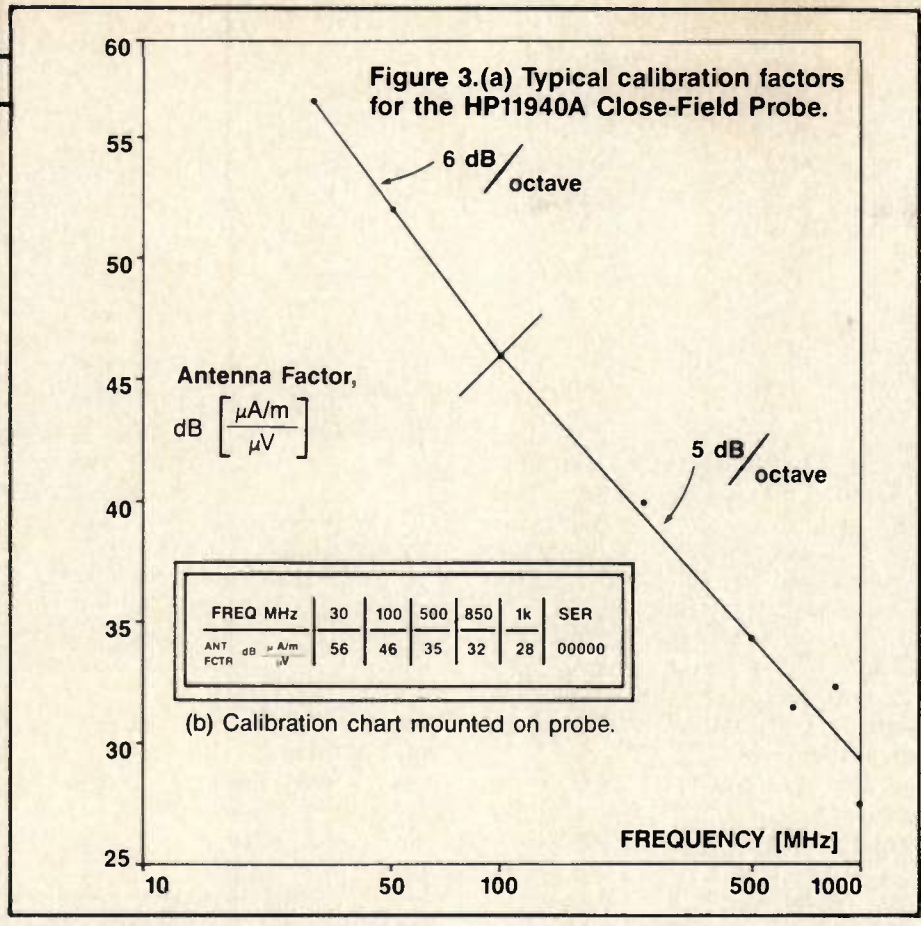

Figure 3.(a) Typical calibration factors for the HP11940A Close-Field Probe.

(b) Calibration chart mounted on probe.

the shield, and the bandwidth is limited by the frequency response of the balun used to match the probe to a measuring instrument's input. Such radiation monitors are also used to measure emissions near an enclosure and when cabled with high impedance, non-metallic lines, the stray capacitive coupling is reduced. However, because radiation monitors rectify the RF voltage for a DC output, frequency information is lost.

A new commercial product for accurately locating emission sources is the HP 11940A Close-Field Probe, shown in Fig. 1. This device is a balanced magnetic field sensor that provides an output voltage proportional to the strength of the magnetic field at its tip. A dual-loop configuration and balun provide rejection of the common-mode currents created by electric field coupling to both of the loops. (Fig. 2.) The balun itself provides 30 dB (typical) of common-mode rejection from 30 MHz to 1 GHz. This common-mode rejection makes the probe insensitive to electric-field components, yielding very repeatable measurements.

Figure 4. Searching for electromagnetic energy leaks at seams of an enclosure.

The Close-Field Probe is supplied with a calibration accurate to +/– 2 dB in a 377 ohm field impedance (see Fig. 3). Using appropriate modeling, this calibration allows the prediction of radiated signal strength at a specified distance from the equipment (4). The probe is small and lightweight making it easy to probe around an enclosure or cabling and accurately locate emission "hot spots." As shown in Fig. 4, the probe tip is held very close to the potential radiating points, such as the seams of the enclosure. When the tip of the probe is on a "hot spot," the radiated field magnetically couples to the probe and produces a larger output voltage.

Since the probe preserves frequency information, it is ideally used with a spectrum analyzer. The spectrum analyzer accurately displays the frequency and amplitude of the emission to help the troubleshooter track down its source. The Close-Field Probe and spectrum analyzer can be used to diagnose EMI problems in these design areas:

1) By the circuit designer on the lab bench.

2) By the EMI test engineer to find emission sources in equipment being tested for the design team.

3) By the mechanical designer to evaluate the relative shielding effectiveness of new enclosures and shielding structures.

The third application requires a tracking generator, whose output signal radiates from a small antenna placed inside the enclosure being tested. The probe is then used to "sniff" along the enclosure's seams and openings in search of electromagnetic energy leaks. This application is described in an article published in the July/August 1984 issue of *RF Design* (5).

The Close-Field Probe can also be used as a localized magnetic field source for locating susceptibility problems on a circuit board. It is a reciprocal device; that is, a voltage fed into the unit will create a magnetic field at the loops. For this application, the maximum input power is 0.5 W with a typical worst-case VSWR of 3:1. The probe can be used effectively by the circuit designer, mechanical engineer and EMI test engineer to troubleshoot EMI problems early in the design cycle and avoid costly re-design.

About the Author

Mark Terrien is a development engineer for EMI measuring equipment at Hewlett-Packard, Signal Analysis Division, Santa Rosa, CA 95401. He has a BS in Physics from the University of Wisconsin (Milwaukee) and an MSEE from the Univeristy of Wisconsin (Madison).

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3. Whiteside, H., and King, R.W., "The Loop Antenna as a Probe," IEEE Transactions on Antennas and Propagation, May 1964, pgs. 291-297.
4. Terrien, M., "Far-field Amplitude Estimation of General Electromagnetic Radiators from Close-Field Electromagnetic Compatibility," Boston, August 1985.
5. Jerse, T., "Low Transfer Impedance — A Key to Effective Shielding," *RF Design*, July/August 1984.

Some Questions You Should Ask Your EMI/RFI Test Equipment Supplier

How long has your company been in the EMI/RFI Testing Equipment business?

The Electro-Mechanics Company has been designing and manufacturing EMI/RFI Test Accessories for over 25 years.

We began with Magnetic Field Instruments and Radio Frequency Antennas for the military. Since the mid-sixties we have been working closely with the military and industry standard setting groups, and EMCO now has one of the broadest lines of Test Antennas and EMI/RFI Test Accessories in the World.

What exactly is your major product line?

EMCO's primary business is Test Antennas for use in Emissions and Immunity (Susceptibility) Testing as required for MIL Standard, FCC, VDE, and CISPR Test Procedures.

Typical Military Antennas for Radiated Immunity (RS) and Emissions (RE) Testing cover the frequency ranges from **30 Hz to 18 GHz**, and are noted in MIL STD 462, Notice 3, Table 1. EMCO currently manufactures **Magnetic Field Loops**, the 41" **Rod Antenna**, **Parallel Strip Line**, both

Biconical Antennas, the **Conical Log Spirals** and the **Double Ridged Guide Antennas** shown on this table.

Antennas which are currently acceptable for use in FCC Volume II, Part 15 Emissions Testing include, **Adjustable Element Dipole Sets**, Broadband **Biconical Antennas** and Broadband **Log Periodic Antennas**. EMCO manufactures all of these separately or can include them as part of an FCC "Class A" and "Class B" **Antenna Test System**.

What differentiates your antennas from your competitors?

One major difference is Calibration. Each Antenna is calibrated using NBS Traceable Testing Equipment, on our own FCC open field test site. Calibration data includes Antenna Factor, Numeric Power Gain, and dBi Gain for each individual Antenna. For Immunity Testing Antennas we include Field Strength measurements in Volts Per Meter, and Radiation Patterns where applicable.

Another difference is Design and Construction. Each Antenna is designed to be durable and long-lasting, yet functional in varied applications, such as in Anechoic Chambers or Outside Test Sites. Antennas and accessories are machined and constructed "in-house" for Optimum Quality Control.

One last difference and maybe the most important, is EMCO's continual Product improvement thru Research and Development. For example, our **Dipole** and **Biconical Balun** design is much improved from the old DM-105 and military designs . . . and we are continually researching and redesigning to make EMI/RFI Testing simpler and more accurate.

What other Test Equipment and Accessories do you offer?

EMCO adds efficiency to EMI Testing with an **Antenna Positioning Tower** (1-6 meters) and an **Equipment Testing Turntable**. Both are suitable for outside or indoor use, come with a standard Digital Readout Controller and are available with **IEEE-488 Bus** Option.

For Conducted Emissions Testing, EMCO manufactures **Line Impedance Stabilization Networks** to satisfy FCC and VDE requirements. Our unique design allows production of as many as 4 separate lines (three phase) in one unit.

Other Related Equipment include: **Signal Rejection Networks**, **Acceptance Networks**, **Magnetic Field Intensity Meters**, **Magnetometers** and **Helmholtz Coil Systems.**

Why should my company buy your EMI/RFI Test Equipment?

The Electro-Mechanics Company is more than just another manufacturer. We realize that in order to grow and help improve EMI/RFI Testing we must constantly forge ahead . . . not live in the past.

As the FCC moves toward better and more Standardized Test Procedures, EMCO is staying close to ANSI (American National Standards Institute), NBS (National Bureau of Standards) and other standards groups so we can keep improving our equipment. Involvement with current and future industry needs also helps us plan for design of new equipment . . . an ongoing process at EMCO.

EMCO is committed to offering Technical Assistance, as well as Test Accessories, to help solve EMI Testing Problems. Part of that Technical Assistance is advice on purchasing only the equipment needed, not kits or systems with unnecessary items. We can also advise on various manufacturers of other complimentary test equipment.

If you have more questions and are looking for Helpful Answers, Call us at (512) 835-4684.

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INFO/CARD 28

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- *SPECTRAL PURITY*
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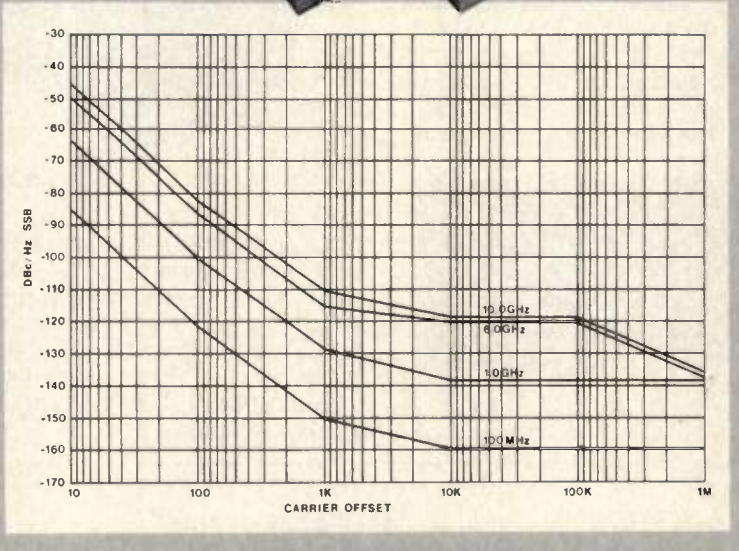

1mHz to 18GHz

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- DIGITAL PLL
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INFO/CARD 29

AMI Analyzer

Electro-Metrics, a divison of Penril Corporation, has announced the latest model in its EMC-25 Series of instruments for measurement of EMI (electromagnetic interference). Designated the "EMC-25 Mark IV," the new instrument incorporates microprocessor control, new bandwidths, and other new features, while retaining the basic 10 kHz to 1000 MHz frequency range of its EMC-25 predecessors. The new instrument features an IEEE-488 (GPIB) interface permitting direct operation from any computer with GPIB capability. Software for testing to various specifications such as MIL-STD-461 is available for popular computers. Bandwidths in the new instrument have been tailored to conform to the August 1984 proposed draft of MIL-STD-462B, and to the October 1984 draft of British DEF STAN 59-41 (Part 3)/2, as well as to ANSI Standard C63.2. An optional rechargeable battery/charger pack provides field operation away from AC power sources. **Electro-Metrics, A Penril Company, Amsterdam, N.Y., INFO/CARD #176.**

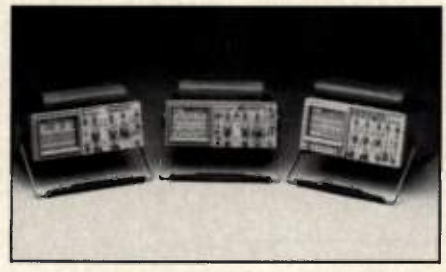
Automatic Transmission Line Analyzer

Systron Donner has introduced a sophisticated portable transmission line analyzer. This rugged, portable system makes automatic two-way attenuation and distance-to-fault measurements on waveguide and coaxial transmission lines from 2 MHz to 18 GHz. The system has four modes of operation: transmission line test mode (fault location), reflectometer mode (VSWR vs. frequency), instructional

mode (operator prompt), and a built-in self-test mode. Other features include: one port operation, foreign signal rejection, IEEE-488 and RS 232 interface, up to 80 dB dynamic range and five remote heads to fit various applications. **Systron Donner Corp., Concord, Calif., INFO/CARD #175.**

Portable Digital Storage Oscilloscopes

Tektronix Portable Instruments Division announced the new 2220, 2230, and 2430 family of portable DSOs. At the top of the family line is the 2430, a fully programming DSO with 150 MHz bandwidth, 100-Ms/sec digitizing speed, and enhanced glitch capture to 2 nanoseconds. Providing midrange capabilities is the 100 MHz 2230 with on-screen cursor measurements and easy-to-follow menus; and at a lower cost there's the 60 MHz 2220. Pre- and post-triggering, enhanced glitch capture (to 2ns in the 2430) and antialiasing features, extensive internal signal processing, and system interfacing capabilities are featured in these instruments. **Tektronix, Inc., Beaverton, Ore., Please circle INFO/CARD #174.**



IF to Tape Converter

A new series of miniature IF to tape coonverters, designated as the 300ITC series, is available from APCOM, Inc. These units are housed in rugged metal cases designed to provide TEMPEST in-

tegrity. Case size is only 3" by 5" by 6". Power consumption is 4 watts and operation is from any external DC source in the range of 8 to 17 volts. Maximum performance is obtained by imageless mixing and by matched group delay equalization. A wide range of frequency conversions is offered. **APCOM, Inc., Rockville, Md., INFO/CARD #173.**

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For further information, please call or write to Marketing Department, Reaction Instruments, 1800 Isaac Newton Square, Reston, VA 22090. PHONE (703) 471-6060, TWX 710 833 9031

REACTION INSTRUMENTS

Subroutine Library for Signal and Image Processing

Quantitative Technology Corporation (QTC) announces the Math Advantage™, a software library of core algorithms for use by engineers and scientists developing numerically intensive signal and image processing applications. The company has developed a library for use in designing satellite image processing or signal processing systems, such as microwave radar tracking systems. The Math Advantage presently runs on over 20 different computers, ranging from the IBM PC to supercomputers. Subroutines in the library can be called from programs written in either FORTRAN or C, using calling conventions which have become the de facto standard set by high-performance computer manufacturers such as Floating Point Systems and Numerix. **Quantitative Technology Corp., Beaverton, Ore., INFO/CARD #172.**

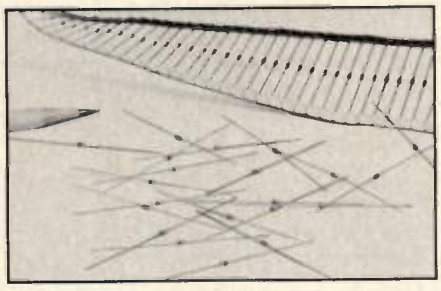
RF Leak Detection System

The Electronic Instrumentation Division of Eaton Corporation has introduced the Eaton 3500 RF Leak Detection System. The model 3500 "sniffer" is designed to locate defects in RF shielding enclosures over a broad frequency range. The system consists of a current generator and a small hand held detector enclosed in a convenient transit case. The Eaton Generator is capable of inducing one ampere of RF current flow in the outer surface of a shielded enclosure; the Eaton Detector will respond to a leakage magnetic field

as low as 0.5 pico tesla. Eaton Corporation holds a patent on this concept. **Eaton Corporation, Electronic Instrumentation Division, Los Angeles, Calif. Please circle INFO/CARD #171.**

Economy HF PIN Switching Diode

Designed for HF low-power applications in communications and test equipment, SDI's new economy PIN RF switching diodes are ideal for band switching, antenna switching matrices and TR or ATR switching. The new type DPJ 0200--034 diodes operate at low-bias conditions, and have a typical resistance at 1 MHz of 0.8 ohms at a forward current of 10 mA, dropping to 0.5 ohms at 5 MHz. Typical capacitances are 1.6 pF at 3 volts of reverse voltage, dropping to 0.9 pF at 20 volts. A minority carrier lifetime of 500 ns permits usage down to 0.5 MHz. Although a twenty-volt breakdown is guaranteed, typical values can be as high as 300 volts. Model DPJ 0200-034 is supplied in a subminiature axial-lead DO-34 glass package, and can be ordered taped and reeled for automatic insertion. **SDI Inc., North Billerica, Mass., INFO/CARD #170.**



Wide Bandwidth Oscillators

Scientific Communications, a manufacturer of electronic surveillance systems, has developed a new series of Wide Bandwidth Oscillators for use in a variety of electronic products and subsystems. There are 19 different models in the SCV series of oscillators which cover the 25 MHz to 26 GHz frequency range. The Wide Bandwidth Oscillators are varactor tuned and have been designed to provide extremely fast frequency tuning with minimal post tuning drift. Normal full band tuning time is 1 microsecond. All come with integral load isolation, voltage regulators, ultra fast settling linearizers, proportional controlled ovens and reverse polarity pro-

tection. They are designed to maintain ±1.0 percent linearity over the combined effects of a −54 to +71°C temperature range, and loads of 2.0:1 VSWR at any phase angle. **Scientific Communications, Garland, Texas, Please circle INFO/CARD #169.**

50-Watt Coax Terminations

Coax terminations that dissipate up to 50 watts in air without a heat sink have been introduced by EMC Technology, Inc. Model 41052 special coaxial terminations are available with either SMA or N type connectors, and may be mounted anywhere space permits on the package without an external heat sink. Measuring 1¾" square by under 5" long, the terminations offer greater design latitude as a result of their mounting possibilities. The new terminations have a maximum VSWR of 1.25 up to 3.5 GHz. All terminations are tested to the same environmental, electrical, and mechanical specifications met by EMC's MIL-C-39012 approved 1 watt Models 4110/4112 terminations, and can be delivered to meet these same qualifications. **EMC Technology, Inc., Cherry Hill, N.J., INFO/CARD #168.**

Ladder Circuit Design Software

Hayward Electronic Systems, Inc. announces it will supply LADPAC, a software package for the design and analysis of radio frequency ladder circuits. Ladder networks are used extensively for electronic filtering and impedance matching. LADPAC will design low pass, high pass, traditional bandpass, coupled resonator LC bandpass, and crystal ladder filters. A special feature is a routine for the design of Pseudo-elliptic low pass filters. The software analyzes networks for transducer gain, impedance match (return loss), phase and group delay. Impedances may be plotted on a built-in Smith chart. A special routine draws and edits the schematics of circuits designed by other LADPAC programs. Enhanced operating speed is available with LADPAC-87, which requires the 8087 co-processor. Computer requirements to run LADPAC are an IBM PC or "compatible," DOS 2.0 (or later), at least one 5.25 inch disk drive, 192 K-Bytes of RAM, and a color graphics adaptor. A dot-matrix printer is recommended. **Hayward Electronic Systems, Inc., Beaverton, Ore., INFO/CARD #167.**

Plated Thru-Holes to Aluminum

Soladyne, a manufacturer of microwave stripline and microstrip circuits for the defense industry, has announced the development of a new technique for copper plated thru-holes to thick, aluminum-

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INFO/CARD 37

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backed PTEE/glass and PTFE/ceramic compositions. According to Soladyne, this process allows microwave circuit board designers to incorporate the favorable temperature and mounting characteristics of thick aluminum as a ground plane with the dielectric constant properties of PTFE substrates. Soladyne has built a dedicated plating line to prcess plated thru-holes to aluminum on microwave circuit boards up to 10"x 14". **Soladyne, San Diego, Calif., INFO/CARD #148.**

500 MHz Modular RF Amplifier

Boonton Electronic's new modular RF amplifier, Model 997000, provides a minimum power output of +19 dBm (2V) with a gain of 30 dB. Frequency response extends from 0.5 MHz to 500 MHz. Harmonics are better than 30 dBc at +16 dBm. BNC and SMA versions are available. **Boonton Electronics Corporation, Randolph, N.J., INFO/CARD #147.**

75-Ohm Coaxial Connectors

For network applications up to 2 GHz, the new cable, panel, and bulkhead-mounted 75 ohm BNC, SMB, and N-Series coaxial connectors from AMP In-

corporated exhibit a VSWR of less than 1.3 and RF leakage is less than –55 dB (–90 dB for N-Series). The nickel-plated outer body houses polypropylene dielectric and gold-plated center contact providing mechanical durability of 500 mating cycles. These connectors can be applied with hand tools or by automatic machines capable of finishing up to 200 cable assemblies per hour. **AMP Incorporated, Harrisburg, Penn., Please circle INFO/CARD #166.**

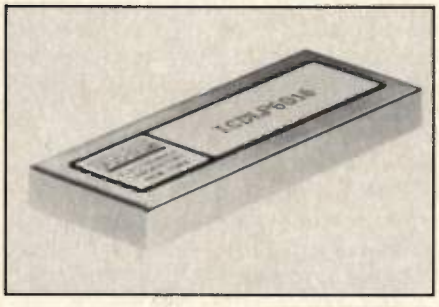
Signal Generator for EMC Applications

A programmable synthesized signal generator with high output power, fast frequency switching and comprehensive modulation capabilities for Tempest testing applications has been introduced by Racal-Dana Instruments Inc. The 9087T covers a 17-octave wide frequency range from 10 kHz to 1.3 GHz. Doublers are not used which ensures that no sub-harmonics are present at the output. The multiloop synthesizer design offers extremely good spectral purity. The output level is controlled in 0.1 dB steps, or by an external DC leveling loop. An output voltage of 2 volts into 50 ohm (+19 dBm) is available across the complete frequency range, allowing high power amplifiers to be driven directly, without the use of intermediate amplifiers. Under GPIB (IEEE-STD-488) control, the generator can settle to a new frequency in less than 1mS.

The Model 9087T was specifically designed for EMC applications and can provide all the features necessary to perform Tempest testing from 10 kHz to 1.3 GHz. Frequencies below 10 kHz can be covered with additional external hardware. **Racal-Dana Instruments Inc., Irvine, Calif., INFO/CARD #165.**

Reduced Size Limiter Discriminator

A new series of high performance limiter discriminators 70 percent smaller than the most advanced thin film hybrid designs previously offered is available from RHG Electronics Laboratory, Inc. Models are catalogued for the ICDL and ICDLP



series of limiter discriminators at six frequencies in the 30 to 750 MHz range. They are packaged in a Kovar housing measuring 2.5"x 1"x .405" (63.5mm x 25.4mm x 10.3mm) and weigh less than 2 ounces (57 grams). The size reduction in the RHG limiter discriminators was attained by rearranging the discrete devices and the thin film resistive elements on a smaller alumina substrate. The devices are hermetically sealed, and operate over the −40 to ×70°C temperature range. **RHG Electronics Laboratory, Inc., Deer Park, N.Y., INFO/CARD #164.**

Lower Cost Diodes from NEC

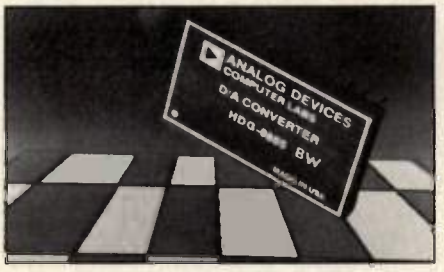
New, low-cost packages for the PIN, Varactor and Schottky diodes are now available from NEC with similar performance specifications as the all-ceramic packages. Prices are, on the average, from 30 to 35 percent below those for previous diodes. The PIN diodes (ND6651-3A) have fast switching times of .5 ns along with the ability to operate at frequencies between 1 and 18 GHz. The Varactor diodes (ND3048, ND3049 and ND3050) have a capacitance of .6 pF, a capacitance ratio up to 15:1, and a quality factor of 4000. Single and double-balanced GaAs Schottky barrier mixer diodes are available in "T" (ND587T-3B) and "Ring" (ND587R-3C) configurations. With a wideband capability at X-band frequencies, these new diodes have a low terminal capacitance ranging from .18 to .26 pF. **California Eastern Laboratories, Santa Clara, Calif., INFO/CARD #163.**

Noise Diode for Stripline or Microstrip Mounting

A new White Gaussian noise diode for stripline or microstrip packaging is now available from Noise Com, Inc. The package measures 0.100"x 0.100"x 0.040" with ribbon flat axial leads 0.020"x 0.005". It is hermetically sealed and ideal for surface or clamp-in stripline mounting. This device, Model ND914, covers the frequency range 10 MHz to 18 GHz, has an output of 30 dB ENR min., breakdown voltage 9-11 volts and operating current of 10 mA typical. It is capable of meeting all the military specifications. Other White Gaussian noise diodes with smaller package sizes are also available. **Noise Com Inc., Hackensack, N.H., Please circle INFO/CARD #162.**

Video-Speed D/A Converters

A series of video-speed digital-to-analog converters (DACs) offering improved specifications has been introduced by Analog Devices, Inc. The new HDG family are the only converters in the 8ns speed class to operate over a full –55°C to +125°C temperature range to suit military applications. The converters dissipate 730mW maximum, and feature a 30ppm/°C maximum nonlinearity. The HDG series feature an internal reference. Applications for the DACs include color graphic displays, raster scan displays, TV video reconstruction, CAD/CAM displays, digital VCOs (voltage controlled oscillator), and process control systems requiring fast settling. Other key performance features include typical power supply rejection ratio of 0.005 percent, supply current of 140mA maximum, update rates to 125 MHz minimum and single –5.2 V power supply operation. The new hybrid converters are offered in 8, 6, and 4-bit resolutions. The HDG-0405 accepts four bits of digital input, the HDG-0605 has six bits, and the HDG-0805 has eight bits. The devices have an output impedance of 75Ω and a low strobe input loading. **Analog Devices, Inc., Norwood, Mass., Please circle INFO/CARD #161.**



Conductive Adhesives for EMI/RFI Shielding

Magne-Bond™ 102-series conductive adhesives for EMI/RFI shielding applications are now available from Yarbrough-Timco Division of Aremco Products, Inc. These conductive adhesives are designed to bond EMI/RFI shielding such as aluminum-silicone gaskets and braided monel over silicone gaskets to assure intimate contact and a conductive path necessary to protect sensitive circuitry. Magne-Bond™ 102-series conductive adhesives are available in 4 compositions: YT-102-1, a silver/epoxy; YT-102-2, a nickel/epoxy, YT-102-4, a silver/silicone. **Yarbrough-Timco, Division of Aremco Products, Inc., Los Angeles, Calif., INFO/CARD #160.**

Electronic Filter Software Program for Personal Computers

The S/FILSYN software program for the design synthesis and analysis of all kinds of electronic filters has now been released for personal computers by DGS Associates. This new edition for personal computers comes in six modules and is

not a restricted version. Several utilities come with the package, including one that allows the construction of templates for the repeated design of filters. The S/FILSYN program runs on any computer with an 8087 coprocessor and a minimum of approximately 320K bytes of memory. A hard disk is strongly recommended. A package of nine small programs is offered for the design of Butterworth, Chebyshev and Elliptic lowpass, highpass, bandpass and band reject filters in passive LC form, or their analog or digital transfer functions. The package includes a small ladder analysis program and a graphics utility and costs much less than the full program. **DSG Associates, Santa Clara Calif., Please circle INFO/CARD #159.**

Video Noise Eliminator

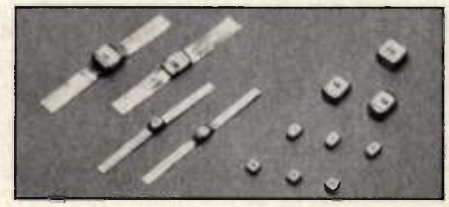
Allen Avionics introduces a new Video Noise Eliminator, model VNE-75, a high frequency Hum Eliminator which will operate up to 20 MHz, and provide a minimum of 45 dB isolation along with no phase or delay distortion. The unit is packaged in an isolated high impact ABS case 2"x 3.25"x 4.38" with BNC connectors for input and output connections. The Hum Eliminator is manufactured in a 75 ohm impedance. **Allen Avionics, Inc., Mineola, N.Y., INFO/CARD #157.**

New VCO Line

MRM adds to its oscillator line with the introduction of Octave Bandwidth VCOs, starting with model MV-1, which covers .5 to 1 GHz with 0 to 10 volt tuning and provides +10 dBm output over a temperature of –50°C to +90°C. Oscillators are available in up to octave bandwidths to greater than 20 GHz. **Microwave Research & Mfg., Inc., Hopedale, Mass., Please circle INFO/CARD #158.**

Ceramic Chip Capacitors

A new line of ceramic chip capacitors for microwave applications is announced by F-TEC (Federated Technology and Electronics Corporation). According to the manufacturer, the multilayer (monolithic) capacitors are usable to 18 GHz with low loss and low equivalent series resistance (ESR). Their capacitance range is from 0.1 to 1000 pF. The standard voltage range



is from 50 to 500 WVDC, and the temperature range is from –55°C to +125°C. Several standard size packages are available in chip, pellets, axial and radial lead configurations. The Q factor is greater than 50,000 at 1 MHz. The dielectric material is magnesium orthotitanite (Ti0 2Mg0), **F-TEC, Piscataway, N.J., Please circle INFO/CARD #156.**

Automatic Telecommunications Test System

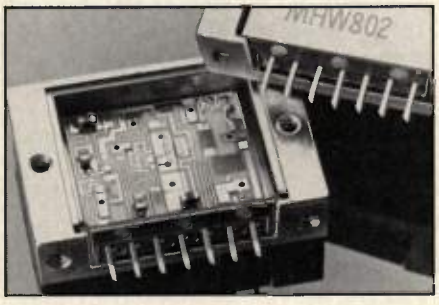
Watkins-Johnson Company has introduced the ADATE WJ-1570 Telecommunications Test System. The system provides automated alignment and performance evaluation of digital and analog single-sideband microwave relay radios and multiline channel-switching systems. It is suitable for either field maintenance or factory acceptance testing. In its standard configuration, the system operates from DC to 6 GHz. It consists of three major assemblies: the main rack assembly,

an umbilical cable assembly and a remote test interface. The remote test interface offers front-end stimulus and measurement capability to both channel-switching systems and microwave relay radios. The remote test interface may be positioned as far as 50 feet from the main rack assembly via the umbilical cable assembly. Sys-

tem software is managed by the industry-standard UNIX operating system. W-J's COLT-II (Conversational On-Line Transistor) provides the ability to easily generate and execute extensive functional telecommunications test and alignment programs. **Watkins-Johnson Company, San Jose, Calif., INFO/CARD #155.**

900 MHz Power Amplifier Modules

Motorola announces power amplifier modules intended for applications in 900 MHz portable cellular radios — the MHW802-1 and MHW802-2. Rated at 2.2 watts output power, the UHF power amplifier modules are ideal for 1.0 watt portables. They provide over 3 dB reserve

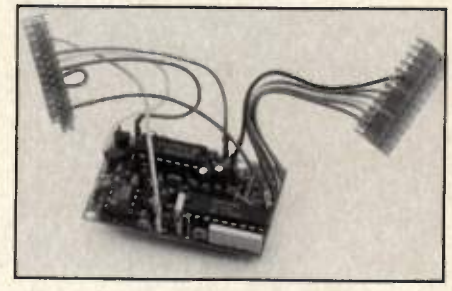


rf products Continued

power to compensate for normal duplex/filter losses. The amplifier operates at a supply voltage of 9.5 Vdc which enhances battery life. Thin film construction provides consistent performance and reliability in addition to guaranteed stability and ruggedness over a wide range of input power and source/load VSWRs. Two models are now available: one covers the domestic band — MHW802-1 (825-845 MHz) and the other is for the European band — the MHW802-2 (890-915 MHz). **Motorola Semiconductor Products Inc., Phoenix, Ariz., INFO/CARD #154.**

Plug-In Encoder-Decoder

Communications Specialists has introduced a direct plug-in encoder-decoder for three popular radios. the TS-32JRC is based on the proven TS-32 programmable encoder-decoder and plugs directly into the JRC JHM-45S50, Sonar FM--2112/FM-2114, and Repco RSM. No modi-



fications to the radio are necessary. The TS-32JRC allows individual selection of all 32 standard EIA CTCSS tones on any of the radios' 16 channel. The send and receive tones may be the same or different on each of the 16 channels. The TS--32JRC is available for immediate delivery from factory stock. **Communications Specialists, Inc., Orange, Calif., Please circle INFO/CARD #153.**

Miniature Metallized Polycarbonate Capacitor

TRW's Capacitor Division has introduced the X441 metallized polycarbonate capacitor for miniature electronics and high-performance circuitry applications. The metallized polycarbonate film construction of the X441 provides low dissipation factor and dielectric absorption, high insulation resistance and very low temperature coefficient characteristics. The metallized construction provides size and weight savings with lead spacing on .200 centers, and the X441 is auto-insertable. **Capacitor Division, TRW Electronic Components Group, Ogallala, Neb., INFO/CARD #149.**

rf literature

New Literature

EMI Shielding Products Catalog

Tecknit is offering a new short form catalog of EMI shielding materials. The 11-page booklet is an illustrated condensation of the manufacturer's 117-page product catalog. A wide variety of shielding materials is listed, including part numbers of standard EMI materials. Brief descriptions, applications information, and specifications of the company's products provide a quick overview for readers. **Tecknit, Cranford, N.J., INFO/CARD #146.**

Ion Beam Milling Services

Ion Beam Milling, Inc. has released a new application note brochure, discussing the process of ion etching in detail. Circuit patterns with greater than 200 microinch metalizations can be delineated with line and space tolerances better than 10 microinches. Cost savings, with improvement in yield and quality can be realized in the processing of tantalum nitride resistors, lange couplers, and tin film spiral inductors. **Ion Beam Milling, Inc., Manchester, N.H., INFO/CARD #145.**

Applications Note from Analog Devices

A new applications guide from Analog Devices, Inc. discusses the operation and applications of the AD654 VFC (voltage-to-frequency converter). Selection criteria for support components is given, such as how to set full scale input voltage and full scale output frequency. The note describes the use of the AD654 in a wide range of circuits, with applications in temperature-to-

rf literature *Continued*

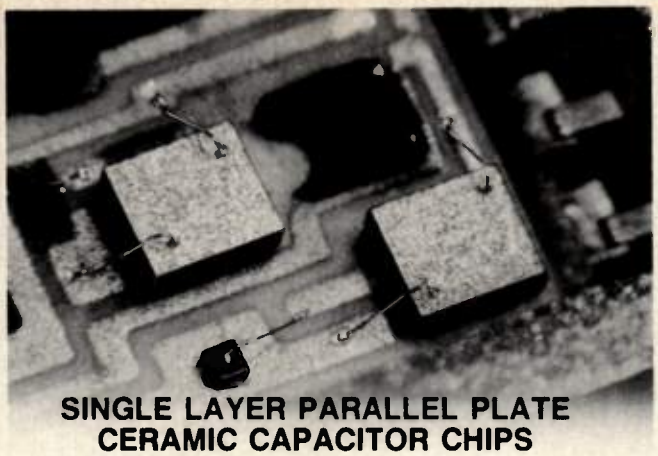
frequency conversion, precision PLL (phase locked loop), F/V conversion, function generators, bipolar VFCs, log-controlled oscillator, clock sources and signal multiplexing. The note includes detailed schematics. **Analog Devices, Inc., Norwood, Mass., INFO/CARD #144.**

Colorado Video Instrument Catalog

Colorado Video, Inc., of Boulder, Colo., has published its 1985-86 short form catalog. Colorado Video specializes in the design and manufacture of instruments using video technology. The catalog features some 29 instruments, including a wide variety of video memory products. Other products include video digitizers, analyzers, micrometers, calipers, multiplexers, test generators, computer digital I/O modules, pseudo-color generators, and freeze-frame television equipment. **Colorado Video, Inc., Boulder, Colo., INFO/CARD #143.**

Micronetics Microwave Components Catalog

Micronetics, Inc. has released a catalog describing its line of Microwave Components. This 24 page brochure details the complete line of coaxial switches, waveguide switches, dummy loads, crystal detectors, bolometers and RF micropotentiometers. The high frequency, high power miniature coaxial switches feature the reliability of 1,000,000 cycles and more. The modular power head waveguide switches cover "L" to "Ku" band. Three standard series of dummy loads are available including medium, high power and liquid cooled. There are 50 watt coaxial mini dummy loads, ultra broadband terminations, and broadband crystal detectors providing low VSWR, high sensitivity and flat frequen-



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INFO/CARD 55

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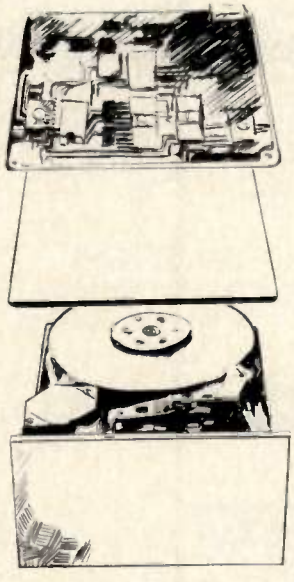

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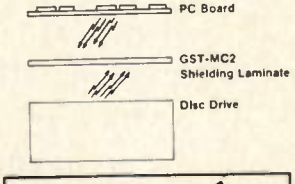

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INFO/CARD 56

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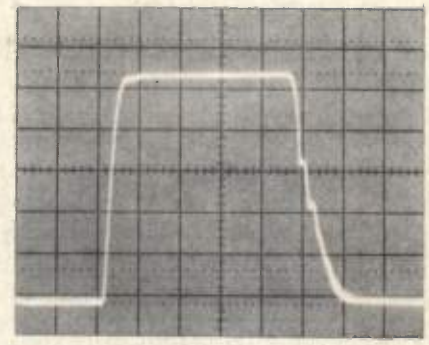

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INFO/CARD 57

rf literature *Continued*

cy response from 10 MHz to 12.4 GHz without bias. Micronetics also has a broad line of microwave and solid state noise components. **Micronetics, Inc., A Quantech Company, Norwood, N.J., INFO/CARD #142.**

EMI Newsletter

R & B Enterprises announces the availability of sample copies of its publication, *Electromagnetic News Report,* (ENR), a bimonthly newsletter on the control of electromagnetic interference (EMI). Subjects covered include equipment design, test techniques, FCC requirements, instrumentation and shielding techniques. Original articles are featured, as well as sections on new products, recently released publications, and a calendar of upcoming events. **R & B Enterprises, West Conshohocken, Penn., INFO/CARD #136.**

Short Form Catalogs from Weinschel Engineering

Weinschel Engineering's short form catalogs covering their line of RF and Microwave Components and Test and Measurement instruments, are now available. Weinschel's Handy Reference Guide to Microwave and RF components is a four page short form catalog featuring comparison tables that list pertinent specifications for their entire component line. A companion to the components short form catalog is Weinschel's four page Quick Reference Guide to RF and Microwave Instruments. It covers the major systems in Weinschel Engineering's Measurement and Calibration Instrument line. **Weinschel Engineering, Gaithersburg, Md., INFO/CARD #141.**

TRW Transformer and Coil Products Catalog

TRW's Transformer and Coil Products Operation has introduced a new, comprehensive catalog featuring their complete line of MIL qualified and industrial products. For ease of reference, the products are grouped in the following categories: Audio Transformers, Power Transformers, Switch Power Magnetics, Pulse Transformers, High Q Coils, and Electric Wave Filters. **TRW Electronic Assemblies Division, New York, N.Y., INFO/CARD #140.**

F-TEC Coaxial Switches

F-TEC, Federated Technology and Electronics Corporation, descibes its complete line of miniature coaxial electromechanical switches in a new 4-page fact sheet. Technical descriptions, features and product performance specifications are provided for each series, as well as a switch products selection guide indicating outline drawings, frequency range selections up to 26.5 GHz and part numbers. **F-TEC, Piscataway, N.J., INFO/CARD #138.**

MIC Brochure

A new brochure is offered by Rogers Corporation covering the technology of Rogers' associated company, Bolriet Technologies Inc. The brochure describes the fine-line capability of Bolriet on substrates of PTFE materials. Bolriet claims the ability to produce one mil wide lines and spaces with a tolerance of ±2 microns, and also offers plated-through holes with a minimum diameter of .005". **Rogers Corporation, Chandler, Ariz., INFO/CARD #137.**

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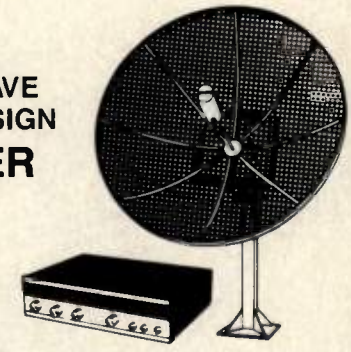

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Yes. Silicon Frequency-Linear Tuning Varactors.

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

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

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

and GaAs Varactors too.

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

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

Write for complete details.

FREQUENCY SOURCES
SEMICONDUCTOR DIVISION
A SUBSIDIARY OF LORAL CORPORATION
16 Maple Road
Chelmsford, MA 01824
(617) 256-8101
TWX (710) 343-0404

INFO/CARD 63

GPIB 488

Why pay more than $6,900 for spectral purity?

100 KHz - 1GHz (SSG-1000)
100 KHz - 2GHz (SSG-2000)

Our competitors would have you believe that you have to spend a lot of money for a synthesized signal generator that will deliver superior spectral purity. Not True!

Using a fundamental oscillator, the Texscan SSG1000 achieves outstanding spectral purity. Its advanced phase lock loop design yields excellent noise characteristics. And the SSG1000's level control, ranging from −137 dBm to +13 dBm in 0.1 dB steps, combined with its extremely low RF leakage lets you accurately test even the most modern receivers.

The SSG1000's versatile AM/FM/phase modulation includes both an internal audio synthesizer, 10 Hz - 99.9 KHz in 10 Hz steps and a fixed 1 KHz source, and both may be mixed to provide complex modulation.

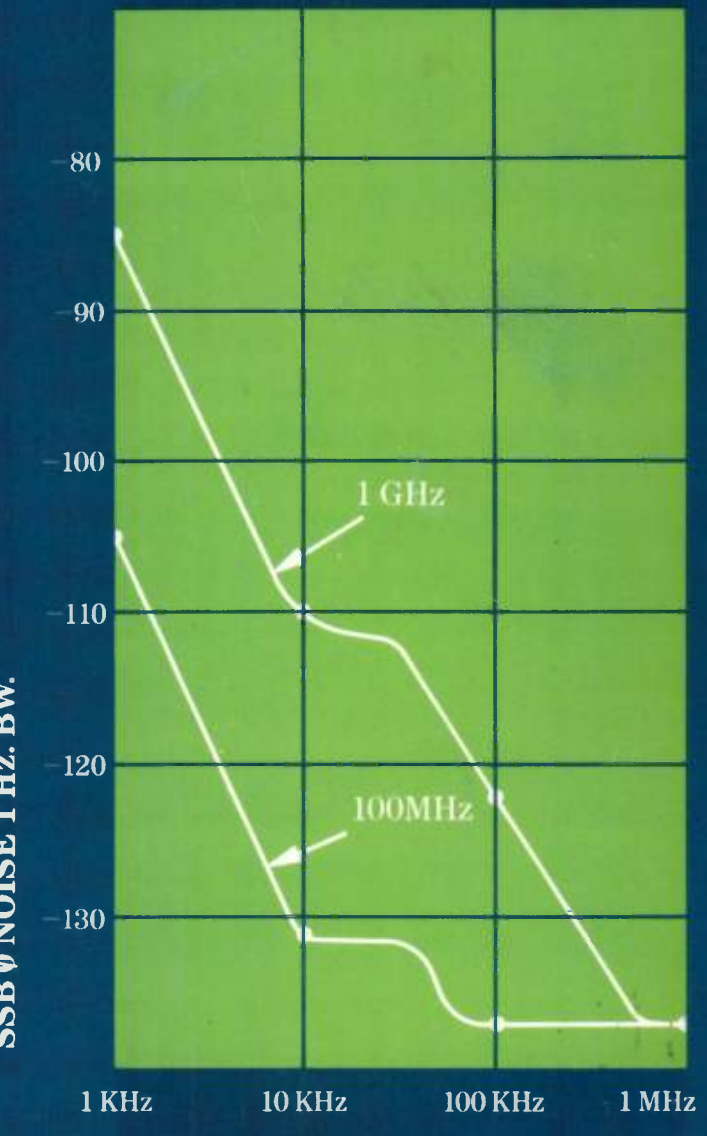
The SSG1000's fast stepping capability lets you investigate the wideband frequency characteristics of the device under test. And its non-volatile memory lets you store up to 10 pre-programmed front panel setups. Plus the SSG1000 includes IEEE-488 bus programmability, and can be ordered with HP-IL* programmability (optional) making it the logical choice for automatic test system use.

The Texscan SSG1000. Only $6,900. Or the SSG2000 for 100 KHz to 2 GHz spectral purity, only $9,450. Why pay more when you don't have to?

Specifications Synthesized Signal Generator

Frequency: 100 KHz - 1GHz (SSG-1000) 100 KHz - 2GHZ (SSG-2000)
Step: 10Hz up to 1 GHz 20Hz 1 to 2 GHz
Stability: 3 parts in 10-9/day
Output: +13dBm to −137 dBm 0dBm (1 - 2 GHz)
Leakage: <0.5 microvolts
Sub Harmonics: None (SSG-1000) −20dBc (SSG-2000)
Harmonic: −30dBc
Spurious: −60dBc (1 - 2 GHz, −54 dBc)
Phase Noise: See Graph
Modulation: AM Bandwidth DC-25KHz 0 - 99% (100KHz - 1 GHz)
FM Bandwidth: DC-25KHz 0-30KHz Deviation
0 Bandwidth: 10Hz - 10KHz 0 - 3 rads
Step speed: <5ms 10 MHz Step <100ms Worst case

*HP-IL is a tradename of the Hewlett Packard Company (optional interface)



Texscan CORPORATION

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