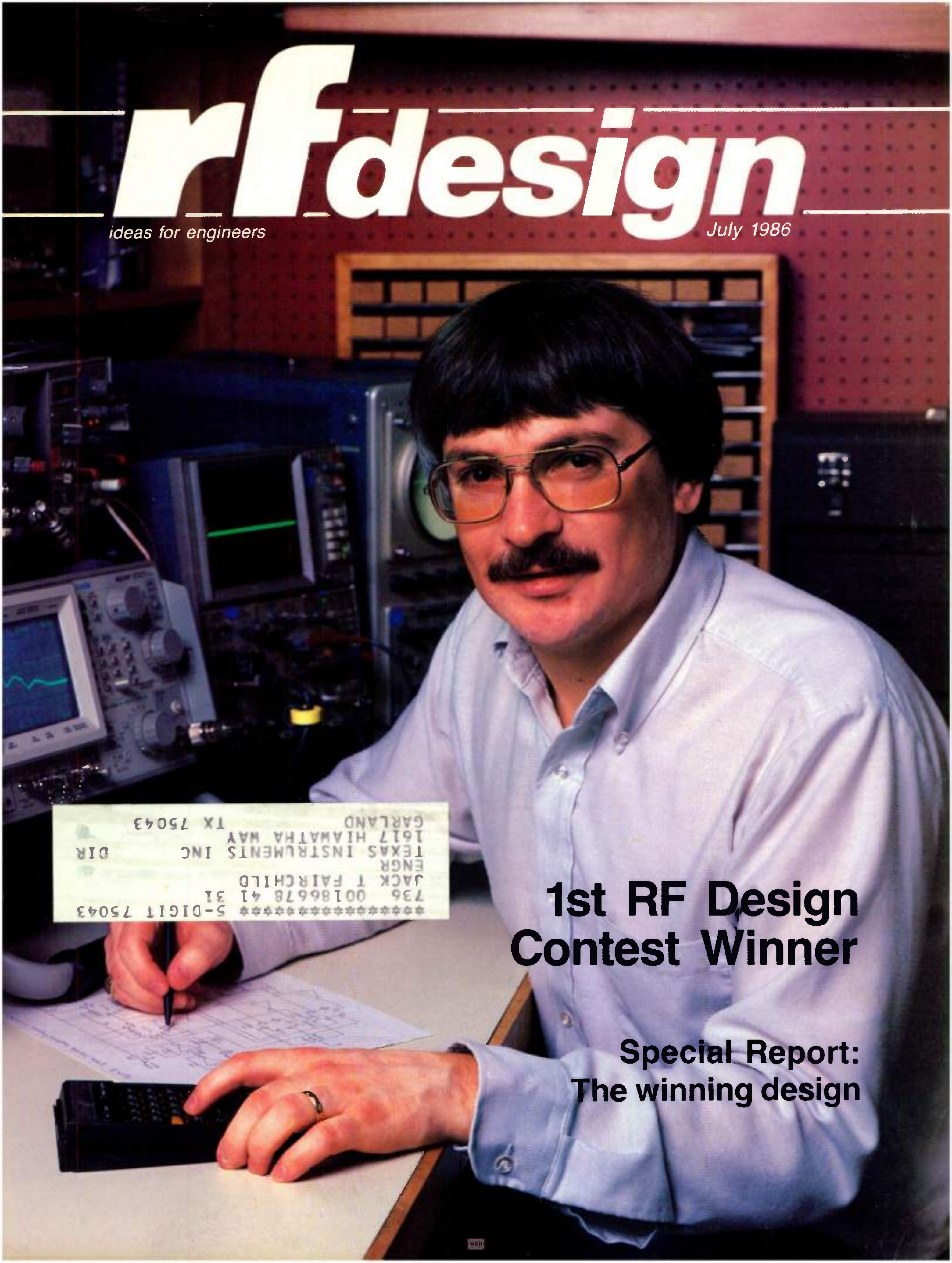
rf design

ideas for engineers

July 1986



1st RF Design Contest Winner

Special Report: The winning design

***************** 5-DIGIT 75043
736 001866478 41 31
JACK T FAIRCHILD
ENGR
TEXAS INSTRUMENTS INC DIR
1617 HIAWATHA WAY
GARLAND TX 75043

For off-the-shelf custom and specialty RF products, our name stands out.

Amperex/Philips produces a full line of Ceramic Strip-Line Transistors, Leadless Semiconductors, Linear Wideband Amplifiers, and Pin Diode Drivers for RF applications.

Ceramic Strip-Line RF Transistors. Low noise, low impedance devices for thru-hole and surface mount assembly applications, featuring all-gold metallization systems for ultimate reliability over a wide range of temperature operating conditions.

Linear Wideband Amplifiers. Single stage amplifiers for linear wideband applications up to 400 MHz, featuring all-gold thin film construction. These devices are available in low-cost TO-39 packages for both commercial and military temperature ranges.

Leadless Inverted Devices. High-density surface mountable products, LID's are ideal for designs where minimum capacitance and inductance are essential, and wherever high shock environments exist.

Pin Diode Drivers. Thin film hybrid integrated circuits in hermetically sealed flatpacks, designed for driving PIN diodes in fast microwave switching applications.

When you need reliable RF products from a dependable supplier, Amperex/Philips is the name that stands out. For price, delivery, or technical discussions with our engineers, write or call Amperex Electronic Corporation, Slatersville Division, A North American Philips Company, Providence Pike, Slatersville, RI 02876. Phone (401) 762-9000; TWX: 710-582-6332.

Amperex®

INFO/CARD 1

A New Dimension in Portable, Digital Spectrum Analyzers!

The A-7550 Spectrum Analyzer

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

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

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

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

A Subsidiary of Regency Electronics, Inc

Impressive Standard Features Include:

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

Optional Features Include:

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

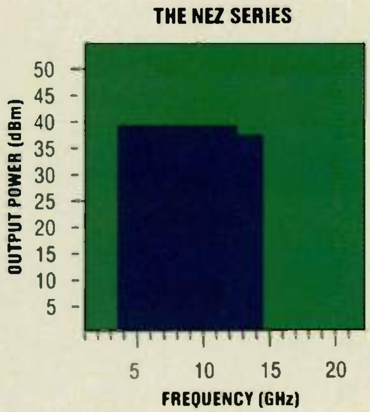
Contact your local IFR authorized distributor for a demonstration.

ifr INC

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

INFO/CARD 2

WRH



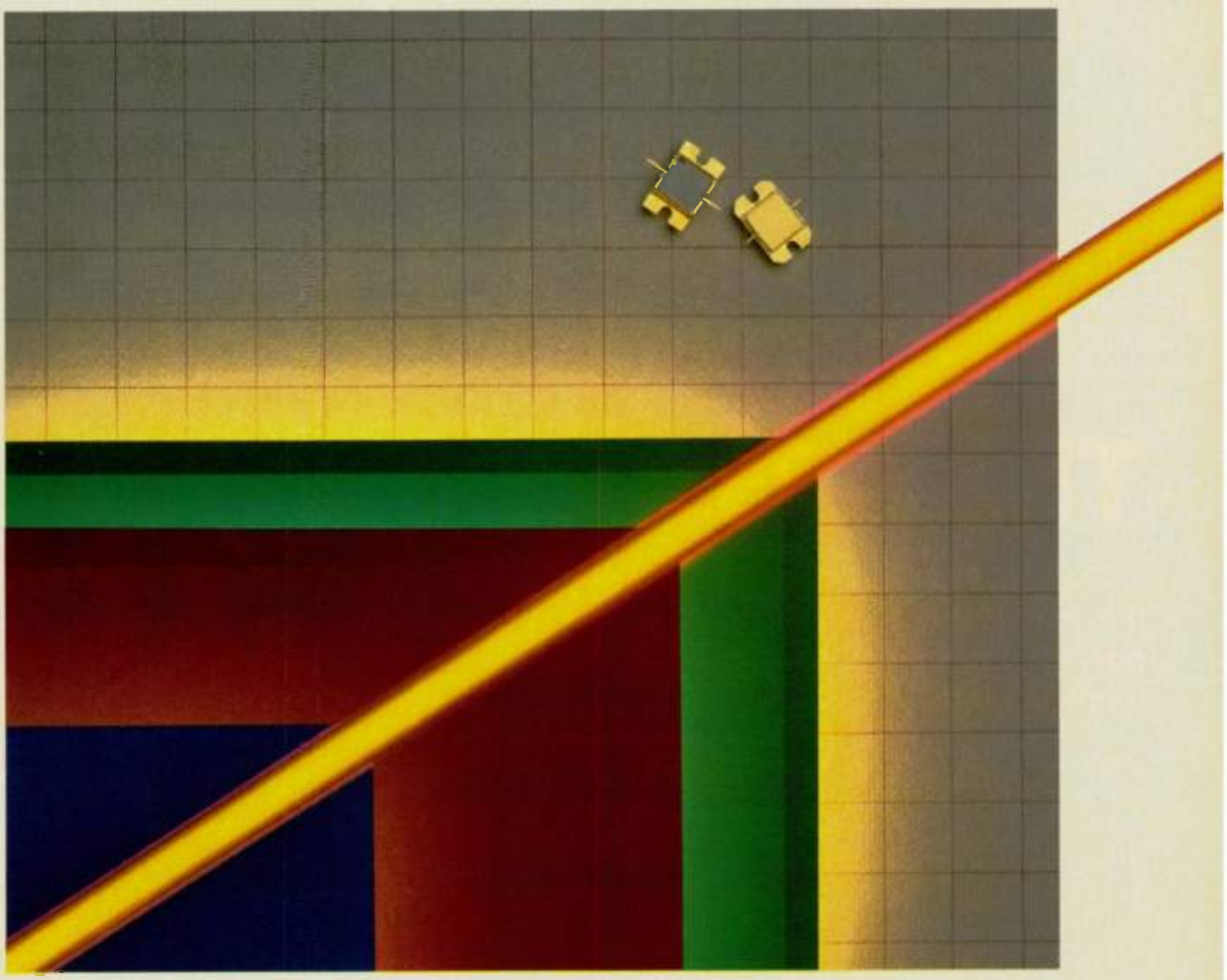
LINEARITY IN POWER GaAs FETs

Produce an amplified signal that's true to the original *at all power levels*. That's what NEZ GaAs FETs do. As an example, the C band FETs in the NEZ series have a third intermod level of 45 dBc—an excellent indication of tracking that straight line to a "T."

While many companies are now playing "Me Too" in GaAs FETs, NEC has been a significant force in bringing this technology to the world market. Such mastery of GaAs FETs has produced a superior linearity that will give your components a similar performance—superior.

These space-qualified FETs are internally matched with P_{1dB} as high as 37.5 dBm, G_L up to 11 dB, and the ability to operate in C through Ku band frequencies. World class GaAs FETs from a world class company—NEC.

MASTERY IN MICROWAVE



NEC

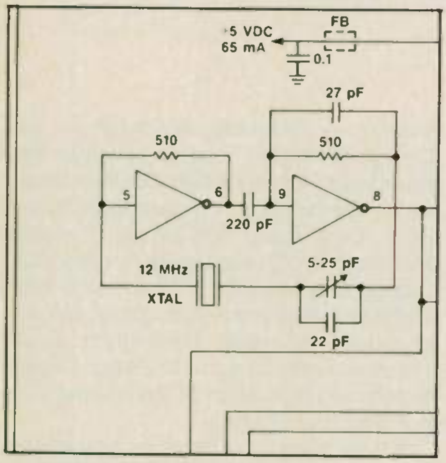
CALIFORNIA EASTERN LABORATORIES
3260 Jay Steet, Santa Clara, CA 95054 (408) 988-3500

Western (408) 988-3500 **Eastern** (301) 667-1310
Midwestern (214) 437-5487 **Canada** (613) 726-0626
Europe 0211/650301

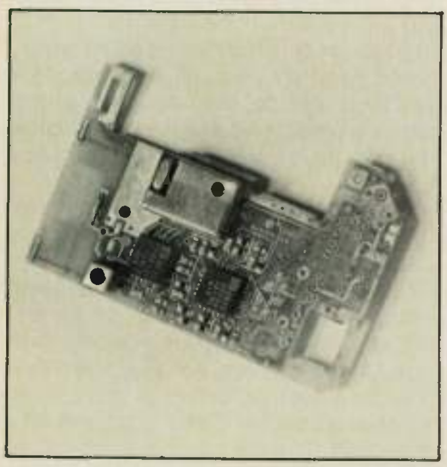
INFO/CARD 3

rf design

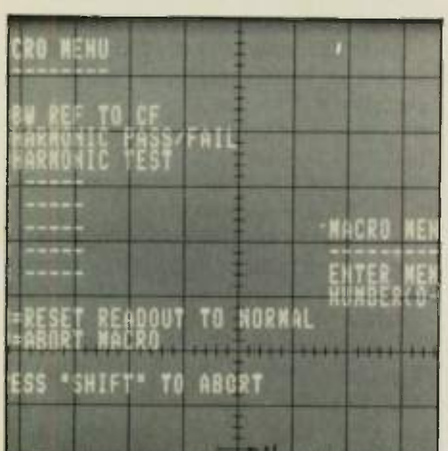
July 1986



Page 40 — Contest Winner



Page 30 — Direct Conversion Receiver



Page 49 — Spectrum Analyzer Macros

Cover

On this month's cover is Dan Baker, winner of the First Annual RF Design Contest. Dan is shown at his bench at Tektronix, where he demonstrated his frequency/amplitude calibrator for *RF Design*. In the foreground is an HP-41CX programmable calculator, donated by Hewlett-Packard Company as First Prize in the contest.

Features

Departments

R.F. DESIGN (ISSN: 0163-321X USFS: 453-490) is published monthly plus one extra issue in August. July 1986, Volume 9, No. 7. Copyright 1986 by Cardiff Publishing Company, a subsidiary of Argus Press Holdings, Inc., 6530 S. Yosemite Street, Englewood, CO 80111 (303) 694-1522. Contents may not be reproduced in any form without written permission. Second-Class Postage paid at Englewood, CO and at additional mailing offices. Subscription office: 1 East First Street, Duluth, MN 55802, (1-800-346-0085). Domestic subscriptions are sent free to qualified individuals responsible for the design and development of communications equipment. Other subscriptions are: $22 per year in the United States; $29 per year in Canada and Mexico; $33 (surface mail) per year for foreign countries. Additional cost for first class mailing. Payment must be made in U.S. funds and accompany request. If available, single copies and back issues are $5.50 each (in the U.S.). This publication is available on microfilm/fiche from University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106 USA (313) 761-4700.
POSTMASTER & SUBSCRIBERS: Please send address changes to: R.F. Design, P.O. Box 6317, Duluth, MN 55806.

No Big Thing.

In fact, this surface mount leadless chip carrier is a pretty small item. Except that ours carries an 8-pole crystal filter (17–250 MHz) – or a clock oscillator (12–30 MHz) – or many comparable variations (from 5–250 MHz). Which is like putting a quality concert hall performance in a telephone booth.

No matter what outfit you're talking to, all the crystal filter talk filters down to performance in space. We're big on performance. Easy on space. If you're having a fit because the other outfits' outfits won't fit . . . send us your specs.

And try our outfit on for size.

SCP

Sokol Crystal Products, Inc.
Where the Impossible Becomes the Ordinary
121 Water St., Box 249
Mineral Point, WI 53565
(608) 987-3363, Telex 467581

INFO/CARD 4

***rf* editorial**

Bring Your Problems to Boston

By James N. MacDonald
Editor

New designs are the emphasis of this issue of *RF Design* and new designs are also the subject of most of the papers to be presented at RF Expo East, Nov. 10-12, Boston. This might be expected from a magazine whose main purpose is to help design engineers exchange information and keep up with new developments.

The program will feature 60 papers of the kind found so useful by attendees at the first two RF Technology Expos, held early this year and last in Anaheim. Since these were the only shows devoted exclusively to high frequency design below the microwave range, we have paid close attention to audience response in determining the subjects *RF Design* readers want covered. Subjects that have proved most popular and been judged most helpful are circuit design, computer aided design, components, filters, oscillators, power amplifiers, receivers and SAW devices. These subjects are included in Expo East, joined by some new ones suggested by past attendees.

In the popular and helpful category are such papers as: An HF Dynamic Range Amplifier Using Feedforward Techniques; A Tactical Miniaturized Crystal Oscillator; A High Performance SAW Filterbank Achieves 80 dB Rejection; Non-Linearity Effects in RF Circuits; HV/VHF/UHF Power Static Induction Transistor Performance; A Practical Approach to the Design of Voltage Tunable Lowpass and Bandpass Filters; Design Considerations for the Development of Internally Matched FETs; Developing Non-Linear Oscillator Models Using Linear Design Tools (CAD); Design and Analysis of Fourth and Fifth Order Indirect Synthesizer Loops; EW Applications of High Resolution Compressive Receivers; and Direct Single-Sideband Modulation of Transmitter Output Switcher Stages.

It is shaping up to be a comprehensive program with many papers of interest for every attendee. The major problem facing attendees will be deciding which of the four papers being presented at any one time to hear. As before, printed Proceedings will be available at the conference to help that decision and provide the information in the sessions that were missed.

Registration materials have been sent to all *RF Design* readers with preliminary information about session subjects. Another mailing will go out soon showing many of the papers to be presented. Registrants are asked to indicate their session preferences, not as a firm selection but as an indication of interest. Attendees will be free to attend any sessions they wish. These early indications of interest will only help conference organizers adjust the physical arrangements according to expected audience size.

Ten of the papers to be presented at Expo East were presented at RF Technology Expo 86 and were among those judged most interesting and useful by those attendees. They are repeated at Expo East for the East Coast engineers who could not make it to Anaheim.

A comment we hear frequently at these shows is that a paper or a discussion with an exhibitor helped an attendee solve a problem he or she had been working on. RF Expo East will offer more solutions to problems. Bring yours to Boston and see what happens!

James N MacDonald

We work to bring the pieces together.
JFW INDUSTRIES INC.
Matrix Switching Systems
Multi-throw
Single pole-thru 48 throw
Solid State or Relay
DC-1500 MHz
Future Products RS-232 & IEEE488
JFW Industries, Inc.
5134 Commerce Square Dr.
Indianapolis, Indiana 46237
(317) 887-1340

INFO/CARD 5

The First First Prize

By Keith Aldrich
Publisher

The cover story in this issue features Dan Baker, a reader of *RF Design* who works for the Television Products Division of Tektronix, and his first-place design in the magazine's first design awards contest.

Because *RF Design*'s competition is the first such event for RF technology, Dan's victory is actually a first for the field — an historic milestone in the recognition of achievement in high-frequency design.

The winning design will be presented by Dan personally in technical sessions at both RF Expos — RF Expo East, November 10-12 in Boston; and RF Technology Expo '87, February 11-13 in Anaheim. At each show, the session in which he presents his paper will feature two additional papers based on contest entries as well.

All this attention given to Dan, his design, and other contest entrants and entries (we'll be publishing at least six more designs in upcoming issues) is part of our continuing mission to bring an increased sense of pride, community, and achievement to RF engineers.

Digital design is no longer the way to society's heart, or at least not the only way. In fact, being a digital engineer exclusively these days is a pretty good way to assure that you're part of the glut. Conversely, being an RF engineer assures that you're part of a precious too few, and much in demand.

Being valued is not the same as being recognized, however, and the RF Design Awards competition will be an annual event from now on, aimed at giving proper credit where credit is so overdue.

As a result of the first competition we look forward to a much wider participation in the second year's contest. Because of increasing manufacturers' support, we expect to be able to award such prizes as a spectrum analyzer and a personal computer to winning contestants. But regardless of what the prizes are we expect that recognition as a winner in the annual RF Design Awards contest will soon become one of the most prestigious honors that can be earned by an RF engineer.

Congratulations to Dan Baker for being the first First Prize winner. Congratulations to every reader, for being part of RF technology.

Keith Aldrich

rf design
a Cardiff publication Established 1978

Publisher
Keith Aldrich

Editor
James N. MacDonald

Technical Editor
Gary A. Breed

Sales Supervisor
Kate Walsh

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

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

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

Advertising Services
Tony Craighead

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

Circulation Director
Pam Greenberg

Circulation Manager
Patricia Shapiro

Circulation Assistant
Michelle Schwinghammer

Production Manager
Madeline Price

Assistant Production Manager
Mary Barr Felker

Artists
Carol Bates, Maurice Lydick, Matt Park, Dave Pieper, Bill Schmitt

Composition
Jay Jarrett
Ellen Wilson

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

President
Robert A. Searle

Vice President
Judy L. Rudrud

Controller
Marvin Laut

Operations Manager
Cherryl Greenman

Member of Business Publications Audit of Circulations, Inc.

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

IEEE-488

There's only one signal generator that's a better value than the 6060A. The new 6060B.

Price, features and performance. Judge the new 6060B by its specifications.
When we introduced the 6060A, it was without a doubt the best signal generator value on the market. With its unique architecture, this fully programmable synthesized RF signal generator offered the RF industry the performance it needed for design, testing and maintenance applications. Yet it was priced well below other generators in its class.

The new 6060B takes this remarkable signal generator another major step ahead.

New wider frequency range.
The 6060B has an even wider output frequency range. Low end coverage is extended to 10KHz for VLF and LF applications and still maintains the capability to output frequencies up to 1050MHz.

Better residual FM and amplitude accuracy.
Guaranteed amplitude accuracy is now ±1.0dB from +13dBm to −127dBm, improved from ±1.5dB. You can rely on precise amplitude control across the frequency range.

Residual FM performance specification has been improved by better than 30% in all bands. It is now guaranteed less than 10Hz rms (.3 to 3KHz) at 500MHz.

Three options now included standard.
We've added three popular options to the standard 6060B model for much less than you'd pay for each separately. Now standard are: Non-Volatile Memory that can store 50 instrument settings up to two years without power, Reverse Power Protection, and Sub-Harmonic External Reference input.

Good news on the bottom line.
Although we've boosted performance and standard features, the 6060B is still priced at a modest **$4995.*** We think that makes it an unbeatable value in general purpose signal generators. Second to none.

For more information about the 6060B, call **1-800-426-0361** or contact your local Fluke Sales Engineer or Representative.

Fluke 6060B

Frequency range	10KHz – 1050MHz
Amplitude range	+13dBm to −127dBm
Accuracy	±1.0dB
Harmonics	<−30dBc
Spurious	<−60dBc
Modulation	AM/FM
IEEE-488 Interface, opt. 488 switch speed	<100 ms, typ.

FLUKE®

*Suggested U.S. price only

IN THE U.S. AND NON-EUROPEAN COUNTRIES: John Fluke Mfg. Co., Inc., P.O. Box C9090, M/S 250C, Everett, WA 98206, Sales (206) 356-5400, Other (206) 347-6100
EUROPEAN HEADQUARTERS: Fluke (Holland) B.V., P.O. Box 2269, 5600 CG Eindhoven, The Netherlands, (040) 458045, TLX 51846
© Copyright 1985 John Fluke Mfg. Co., Inc. All rights reserved. Ad No. 4405-6060

MSC announces a "New Generation" of upright, passivated GaAs Power FETs. Key features include higher linearity, higher operating voltages and improved efficiency.

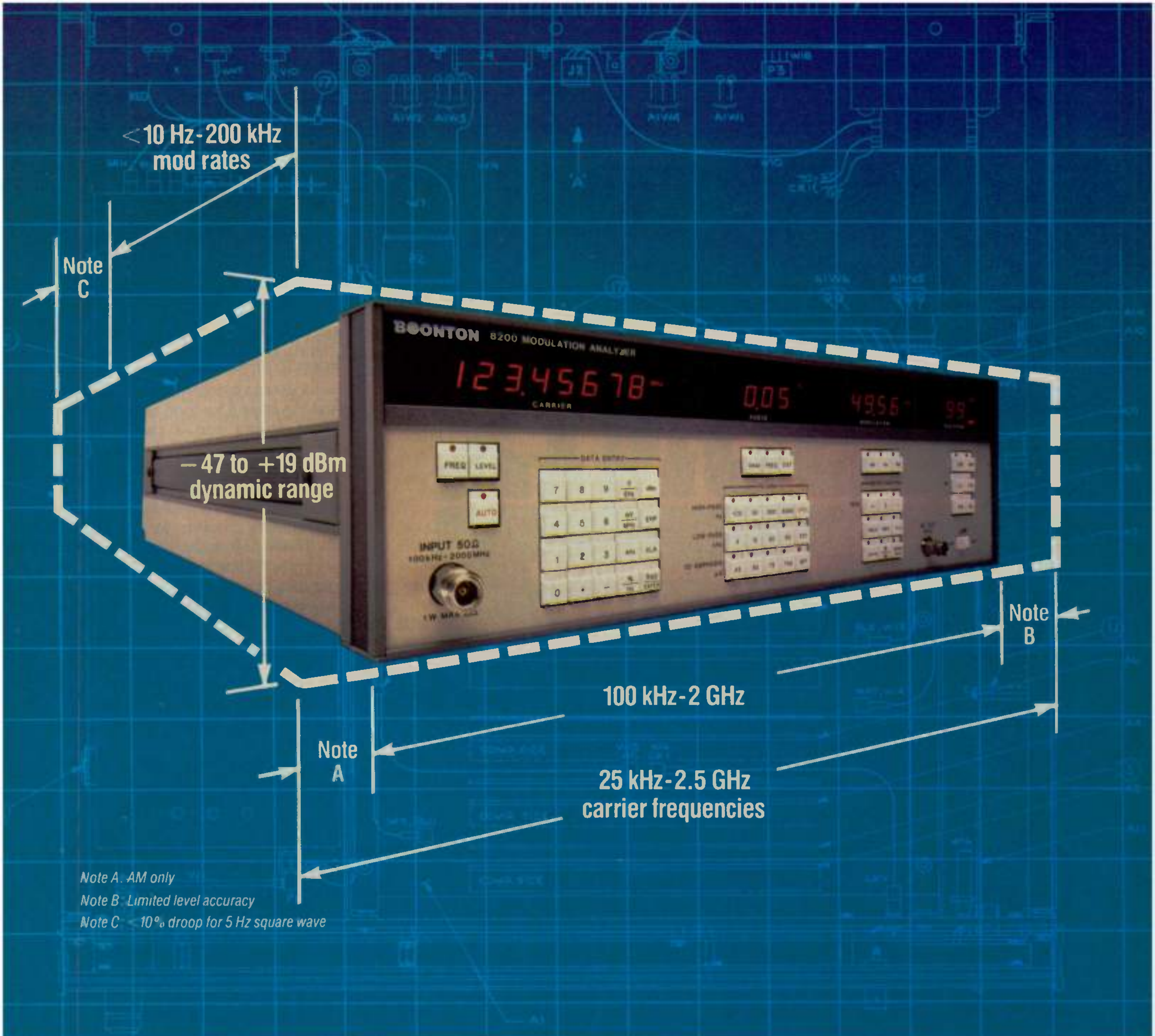
Packaged for commercial as well as high rel applications, these new source-via FETs may be purchased as chips, as well as in discrete or internally matched packages.

A new dimension for MSC, our GaAs product line will soon be expanded to include MMICs, as well as Digital and Linear IC's.

MICROWAVE SEMICONDUCTOR CORP.
A Siemens Company
100 School House Road, Somerset, New Jersey 08873-1276

For more information on the "New Generation" MSC GaAs FETs contact your local MSC representative or call us direct at (201) 563-6447.

INFO/CARD 7



BOONTON RE-DIMENSIONS MODULATION MEASUREMENTS!

BOONTON

Boonton's 8200 Modulation Analyzer out-performs the competition with the widest measurement range by far. Automatic or manual acquisition and display of carrier frequencies and levels. Measures modulation frequencies from <10 Hz to 200 kHz. True peak measurements to 99% a.m. and 500 kHz f.m. with accuracies of 1% of reading. Phase modulation to 500 radians. True rms detection of residuals. Automatic audio distortion measurements from 0.01% to 100% THD or 0 to 80 dB SINAD at baseband frequencies between 20 Hz to 20 kHz. Plus a full complement of low-pass and high-pass filters and de-emphasis networks.

Check with your local representative or contact Boonton directly for the full dimensions of the 8200.

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

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

INFO/CARD 15

WRH

rf testing minus the if's.

Why mix and match the tools you use for rf testing?

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

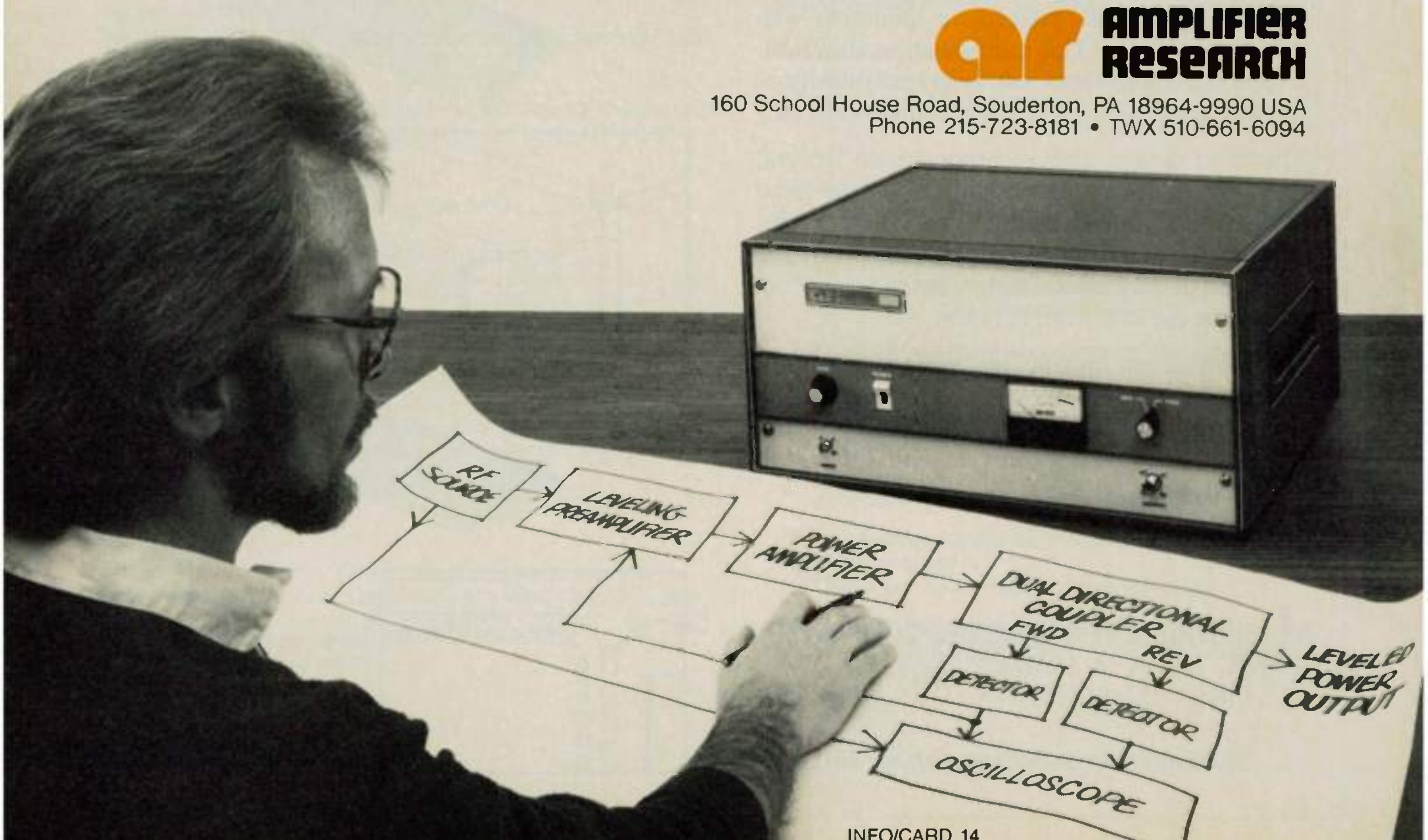
From 1W to 10kW, 10 kHz to 1,000 MHz, in 32 standard models, AR amplifiers give you optimum power, bandwidth, and versatility for your cw, sweep, and pulse requirements. Each model provides instantly available bandwidth without bandswitching or tuning, is completely immune to load mismatch, and won't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

But a high-quality test presumes high-quality test equipment throughout. So we also supply leveling preamplifiers, field sensor systems, fiber-optic telemetry links, matching transformers, directional couplers, and power combiner/dividers.

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

ar AMPLIFIER RESEARCH

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



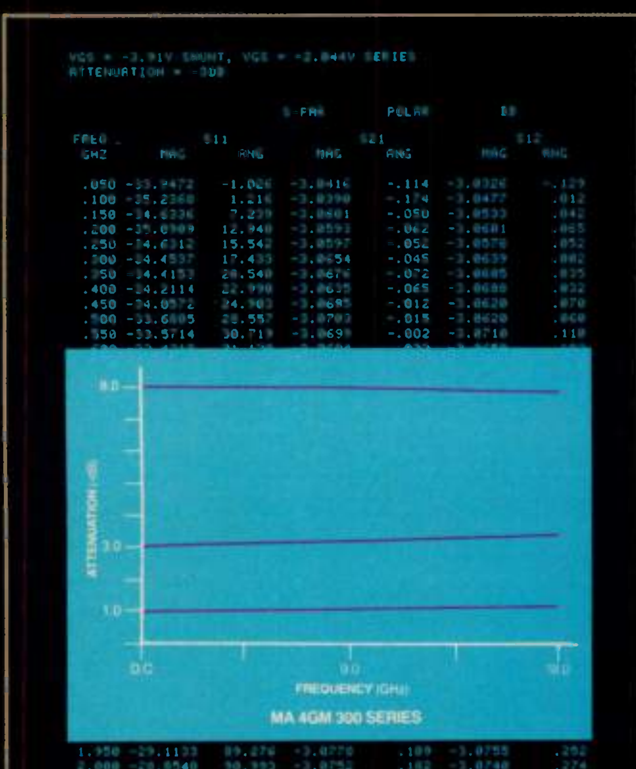
INFO/CARD 14

LEADERSHIP

Low Cost MMIC GaAs FET Attenuators

Broadband performance (dc to 18.0 GHz).

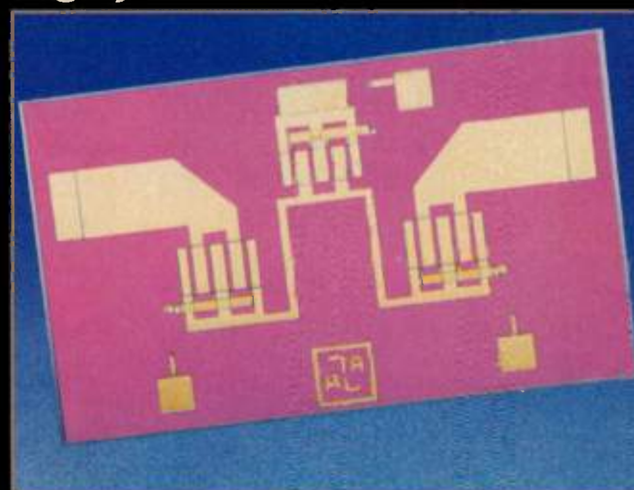
Here is a monolithic matched attenuator with unmatched performance. Variable attenuation levels are attainable between 0 to 20 dB, below 2.0 GHz and 0 to 10 dB above 10.0 GHz, opening unprecedented possibilities in gain control, frequency stability and automatic leveling circuits. Since the chip is analog any attenuation level within the specified range can be obtained. Rated input power for linear attenuation is at + 13dBm with insertion loss only 1.8dB at 18.0 GHz.



Operating temperature attenuation characteristics are truly impressive. From – 55°C to 120°C, maximum variations from ambient are only one half of a dB or less.

In comparison, conventional MIC attenuation shifts over temperature can be as high as 3 to 4dB and require temperature compensation networks that increase component costs and dc drain.

High yields on the wafer.



Extraordinary uniformity of gate geometry across the wafer and from wafer to wafer has provided consistently high yields. The attenuator circuit chip (41 x 66 mils) can be easily cascaded to achieve a wide range of attenuation levels. Users can now utilize attentuator chips throughout all their system requirements increasing circuit integrity and dramatically reducing the high labor costs associated with traditional rf hybrid circuit fabrication.

Put our GaAs Leadership to the test.

M/A-COM MMIC broadband matched and variable, low cost attenuators are in stock *now* offering unprecedented state-of-the-art performance over temperature. Another GaAs breakthrough from M/A-COM.

Write for comprehensive data sheets and pricing to **M/A-COM Advanced Semiconductor Operations,** 100 Chelmsford Street, Lowell, MA 01851 or call JoAnne Dalton at (617) 937-2876.

M/A-COM

INFO/CARD 8

"SWITCH DC TO HUNDREDS OF MHz IN 8x8 to 64x8 CONFIGURATIONS"

It's easy to switch eight DC to 500Mhz inputs to any of eight outputs with our Model 4108 wide-band coaxial relay matrix shown at the left. This miniaturized matrix is completely self-contained, requiring only TTL control signals and DC power.

For larger systems, our Model 4076 can switch 64 signal sources to any of eight outputs under IEEE-488 control with a bandwidth of DC-300Mhz by packaging up to eight 4108 modules in a compact cabinet.

These miniaturized extremely wide-band matrices are perfect for Automatic Test Equipment (ATE) where fast rise time, wide bandwidth data from the unit under test must be connected to any array of test equipment, or in telecommunications where wideband data rates must be connected between modems, transceivers or satellite uplink/downlink terminals.

Experience—We Have It

No matter what kind of high frequency switching system you're buying, it pays to deal with a company who really understands the business. Matrix does. We've been designing state-of-the-art reed relay and semiconductor switching matrices for over 17 years—to the toughest electrical and packaging specs imaginable. Our customers include government agencies, defense contractors, the TV industry, ATE and telecommunications companies and more. So deal with the leader and be sure.

MATRIX
SYSTEMS CORPORATION

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

INFO/CARD 16

MMD®

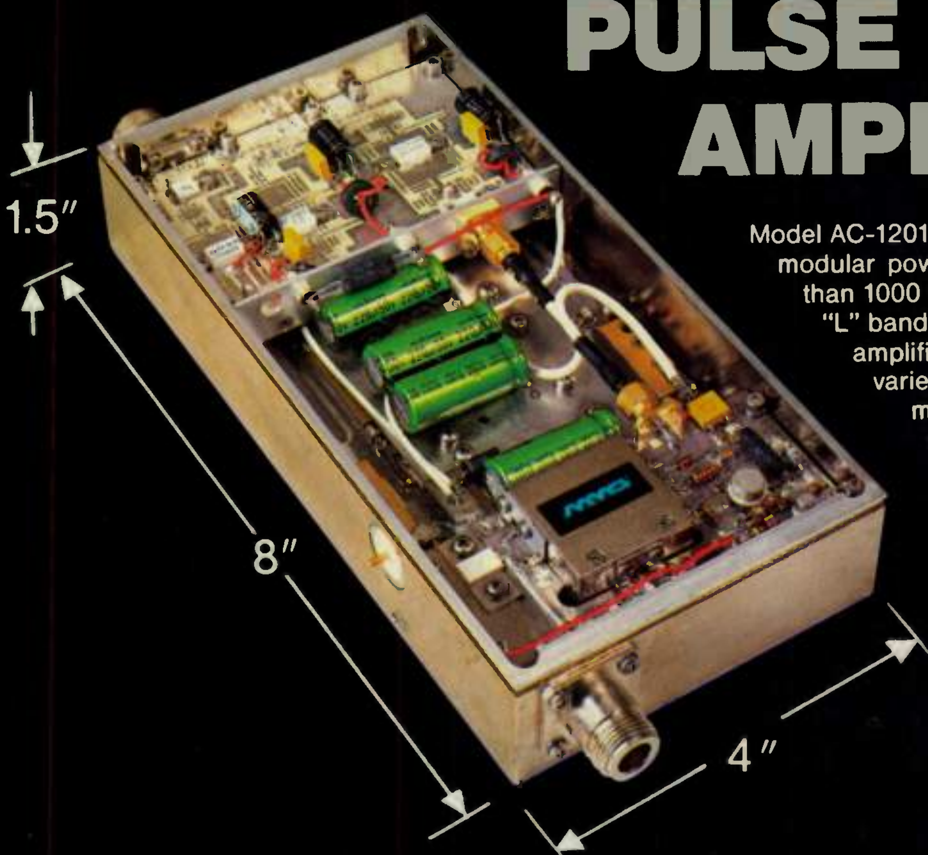
MODEL AC-120140-1000P

"L" BAND

1200-1400 MHz.

1 KILOWATT

PULSE POWER AMPLIFIER

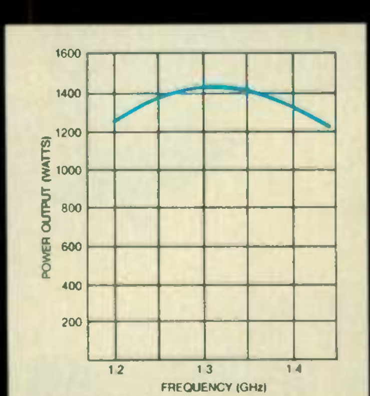


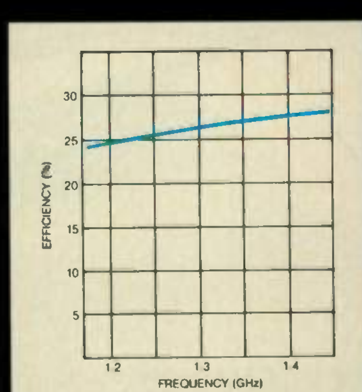
Model AC-120140-1000P is a hermetically sealed modular power amplifier that provides more than 1000 watts of pulsed output power in "L" band, 1200 to 1400 MHz. This compact amplifier module is well suited for a wide variety of high power commercial and military applications. An electrically stable and mechanically compact design makes it easily possible to combine several modules for multi- kilowatt output power.

Incorporation of a 90° quadrature combiner assures predictable 50 ohm system interfaces and superior performance into mismatched loads.

FEATURES

- 30 dB gain.
- More than 1000 watts output into 2:1 VSWR.
- Circulator protected.
- 50 ohm input and output.
- Flat gain vs frequency.
- High efficiency.
- Hermetically sealed.
- Rugged...highly stable.





Please write/phone/telex for additional details and price/delivery information.

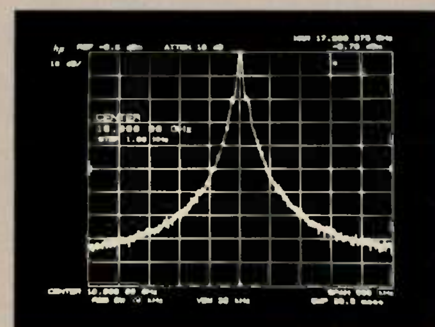
MMD® MICROWAVE MODULES & DEVICES, INC. 500 Ellis St. Mountain View, CA 94043 (415) 961-1473 TELEX 508746

INFO/CARD 17

2 to 18 GHz in 270 cubic inches

WJ-1295-2 Synthesizer

Stability	**10 ppm**
SSB Phase Noise	**dB/Hz**
100 Hz	-60
1 kHz	-60
10 kHz	-70
100 kHz	-95
1 MHz	-125



Phase Noise: Center at 18 GHz

Watkins-Johnson Company Synthesizers

WJ-1247 and WJ-1296	
Tuning Speed (any step)	250 microseconds
WJ-1265 and WJ-1295	
Tuning Speed:	
Step-to-step	250 microseconds
Random Step	
5 MHz	350 microseconds
100 MHz	1.5 milliseconds
Full Band	20 milliseconds

WJ-1247	WJ-1296	WJ-1265	WJ-1295
Frequency Bands in GHz			
2.0 to 4.0	0.5 to 2.0	2.0 to 4.0	2.0 to 12.4
4.0 to 8.0	2.0 to 8.0	2.0 to 8.0	2.0 to 18.0
8.0 to 12.4	8.0 to 18.0	8.0 to 12.4	
12.4 to 18.0		8.0 to 18.0	

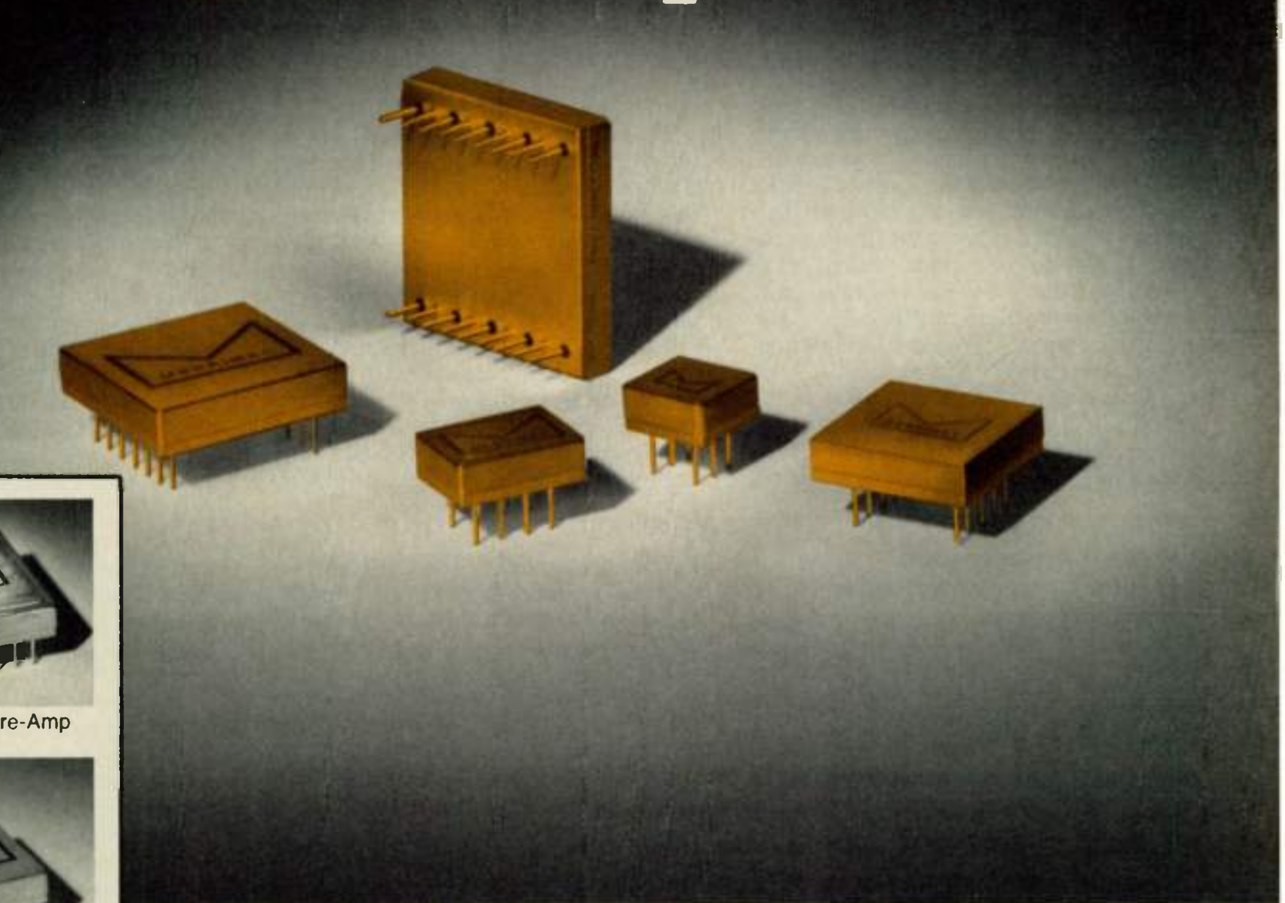
- Excellent for airborne local oscillator applications
- Fast step-to-step tuning for receiver scan operations
- Frequency resolution: 1.0 MHz
- 270 cubic inches
- Excellent phase noise, spurs and stability
- Digital control

Call Watkins-Johnson Synthesizer Applications Engineering, (408) 435-1400, ext. 3506, with your specific requirements.

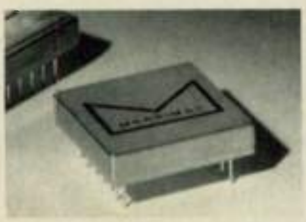
WATKINS-JOHNSON

Watkins-Johnson—U.S.A.: • **California,** San Jose (408) 435-1400; Orange (714) 634-1811; San Diego (619) 296-0173; Ventura (805) 658-6948 • **Florida,** Longwood (305) 774-6227 • **Maryland,** Gaithersburg (301) 948-5954 • **Massachusetts,** Lexington (617) 861-1580 • **New Jersey,** Little Silver (201) 747-6635 • **Ohio,** Fairborn (513) 426-8303 • **Texas,** Dallas (214) 247-1761 • **United Kingdom:** Dedworth Road, Oakley Green, Windsor, Berkshire SL4 4LH • Tel: (07535) 69241 • Cable: WJUKW-WINDSOR • Telex: 847578 • **Germany,** Federal Republic of: Keferloher Strasse 90, 8000 Muenchen 40 • Tel: (089) 35 97 038 • Cable: WJDBM-MUENCHEN • Telex: 509401; Deutschherrenstrasse 46, 5300 Bonn 2 • Tel: (228) 33 20 91 • Telex: (886) 9522 • Cable: WJBN-BONN • **Italy:** Piazza G. Marconi 25, 00144 Roma-EUR • Tel: 592 45 54 or 591 25 15 • Cable: WJ ROM I • Telex: 612278

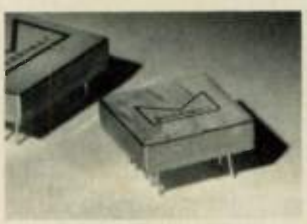
Now Meri-pacs™



1″ sq. Mixer with Pre-Amp



8/10″ sq. Phase Comparator



5/8″ sq. Complex Weight Network

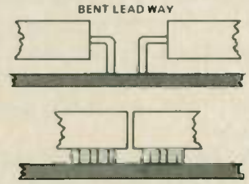
1/2″ sq. Phase Shifter

3/8″ sq. Broadband Mixers

High Performance IF Signal Processing Networks in up to 50% less space

- **Save on real estate and also obtain low profile 0.20″ height package**
- **Compatible package for computerized parts placement**
- **Increase yields by avoiding lead forming**

Merrimac's Meri-pac provides you with a new way to save space in dense PCB requirements for all your IF signal processing needs *up to 3.5 GHz*. **When you have flat packs on your mind — consider Meri-pacs instead** — you'll eliminate wasted space and lead breakage problems. Plus you have the advantage of a package which permits direct insertion into PCB by computer control parts placement.



The *gold-plated* **Meri-pacs** give you not only real estate savings, but also environmental integrity—package is hermetically sealed, seam welded... no solder, therefore no solder balls.

Merrimac's extensive Hi-Rel product experience in RF and IF signal processing is available in every configuration; flat pack, low profile TO cans, relay packages, discrete connectorized SMA or OSP low profile packages, and NOW in new Meri-pac.

Call us on your next project. We want to help.

Merrimac

P.O. Box 986, 41 Fairfield Place, West Caldwell, NJ 07006
201-575-1300. TWX 710-734-4314. TELEX 6853128

INFO/CARD 19

TRW to Build Factory of the Future

TRW's Electronic Systems Group, San Diego, Calif., will invest more than $50 million over the next three years in an Advanced Avionics Manufacturing Facility (AAMF), a highly automated production plant. The new facility is an important step for TRW in establishing itself as a major manufacturer of advanced avionics systems — such as Integrated Communication, Navigation, and Identification Avionics (ICNIA) and the Integrated Electronic Warfare System (INEWS) — programs on which TRW already has important development roles.

The facility, referred to by TRW as the "Factory of the Future," is a vital element of TRW's business growth plans as the company's Electronic Systems Group expands its role from electronic systems development, engineering, and limited run production to full-scale volume manufacturing.

The key to the AAMF is a computer integrated manufacturing system that incorporates computer-aided design, computer-aided engineering, automated testing, manufacturing planning and control systems, automated materials handling, computer-aided manufacturing and extensive robotics.

Robert L. North, AAMF vice president and general manager, said, "The next generation of avionics systems, like ICNIA and INEWS, will be extremely complex. They will incorporate Very High Speed Integrated Circuit Technology and will integrate a wide range of functions now being handled by separate systems.

"In addition to being very sophisticated high-performance systems, they must be reliable, maintainable, and affordable — incorporating current design philosophies, as embodied in TRW's Maintenance and Diagnostic System.

"They have to be manufactured as cost-effectively as possible, and this means heavy investment in robotics, computer controlled manufacturing, and high-tech workers who understand the system and who can perform a wide range of tasks."

The facility will be built on the grounds of TRW's Military Electronics and Avionics Division in the Carmel Mountain Ranch area of San Diego, Calif.

Watkins-Johnson Gets Frequency-Converter Order

Watkins-Johnson Company has received an order valued at more than $2.6 million from the U.S. Air Force's Warner Robins Air Logistics Center, Ga. The order represents a follow-on to an $8.5 million contract received in 1985 and calls for the delivery of frequency converters for the AN/APR-38 radar homing system carried aboard F-4G Wild Weasel aircraft.

Avantek to Open European Manufacturing Facility

Avantek planned to establish an operation in Farnborough, England, this June as its first step in increasing business activities and providing maximum service in Western Europe. At this site the company will initially manufacture microwave amplifiers used primarily for military and defense applications in the United Kingdom and other European Economic Community countries.

Avantek Ltd., a wholly-owned subsidiary of Avantek, Inc., will be located in Frimley Business Park, a new high technology center in Farnborough, southwest of Heathrow Airport. Avantek Ltd. plans to move within the Park from temporary facilities to a new building, now under construction, by year end. The company has options to further expand its activities within the modern business park complex.

"As Avantek enters its second 20 years as the leader in vertically-integrated, microwave-based products, we plan to increase our activities on a global basis and be as close to our wide customer base as possible," Avantek chairman, CEO and president Dr. F. Oran Brigham said. "The U.K. and other EEC countries are extremely important to Avantek's future."

With its initial facilities in England, Avantek will gradually build its manufacturing, engineering and marketing support capabilities to more than 200 people within several years. It's expected that employees located at the Farnborough facilities will be hired locally with few exceptions.

According to Robert Goff, Avantek senior vice president and group executive, Microwave Products Group, "We plan to eventually provide product design, manufacturing and marketing support for a growing number of our microwave products to provide the highest level of customer support and service the United Kingdom and Western Europe." Today, Avantek manufacturers more than 700 different microwave products.

The initial products to be manufactured in England are microwave amplifiers. These and other Avantek microwave products are utilized in defense electronics programs which include electronic countermeasures, communications, surveillance, radars, missiles, avionics, and satellites. Avantek microwave products are found in defense and telecommunications systems throughout the free world.

Under a mutually exclusive charter, Avantek microwave products are sold and serviced in the United Kingdom by Wave Devices, headquartered in London.

Wavetek Forms New Microwave Instrumentation Division

The microwave instrument business units at Sunnyvale, Calif., and Wavetek San Diego have been consolidated into a new entity within Wavetek Corporation to be called Wavetek Microwave, Inc. John Battin, Wavetek president and CEO, has appointed Robert C. Corrao to head the new division as vice president and general manager.

"We plan to be one of the most dynamic and innovative companies in the microwave instrumentation business," noted Battin. "To do so we have combined the resources of our San Diego and Sunnyvale groups, and added to it the research group that we maintain in Seattle, Wash. To head this new division, we have chosen Rob Corrao, who comes to us from Avantek Inc., where he was general manager of a commercial products business unit."

Wavetek Pacific Measurements' current lineup features microwave network analyzers and power meters. Wavetek's Microwave group in San Diego produces a broad line of microwave signal and sweep generators.

Interelement Interactions in Phased Arrays Study Available

Large phased array antennas can be more efficiently and effectively designed, and their performance more accurately predicted, if the effects of mutual impedances on array element excitations, and the role played by multiple reflections and mutual impedances in producing elementary patterns that combine to form the radiated field are understood. The first results of a study of these issues by the National Bureau of Standards are presented in *Interelement Interactions in Phased Arrays: Theory, Methods of Data Analysis, and Theoretical Simulations* (TN 1091).

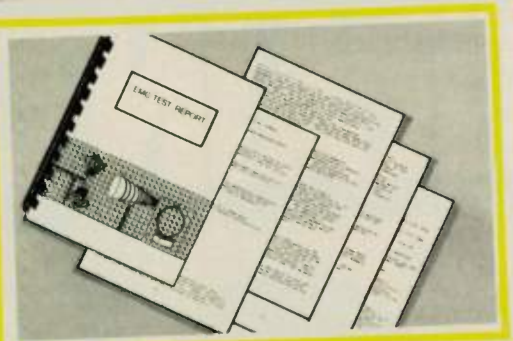
A principal objective of the study is to

How sure are you of your Interference Control?

Instrument Specialties can

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

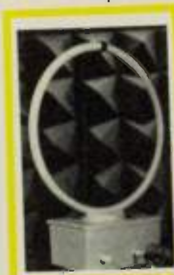
What is Certified Testing℠?

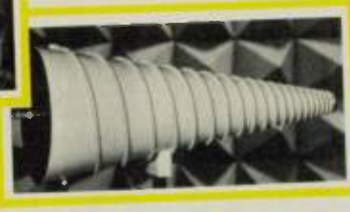


Certified Testing is our name for our automated test program that evaluates the interference control built into the equipment being tested. Available only from Instrument Specialties, it includes state-of-the-art emissions and susceptibility measurements from 20 Hz to 20 GHz up to 20 V/m...RF gasket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

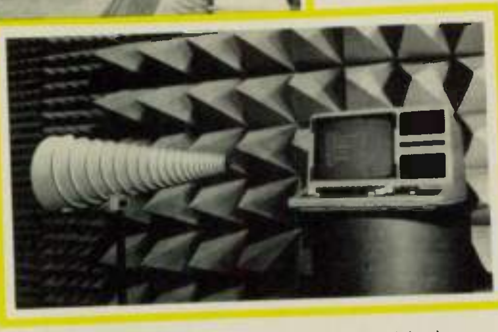
How do we test?

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



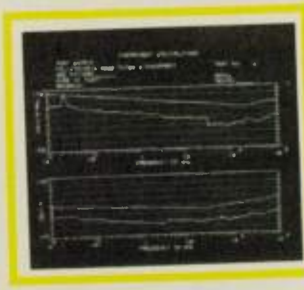


Where do we test?



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

What do you get?



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

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

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

Specialists in interference control since 1944

Yet the Model 1370 HPA contains its power in a mere 5.25 inches of rack space.

At Epsco's RF Division (formerly 3dbm Systems, Inc.), our customers were asking for power amplifiers with higher output, greater gain regulation, multi-octave bandwidths. They wanted thermal stability and high resistance to mechanical stress. And they needed to save as much space as possible.

CREATING THE HPA

The Epsco Model 1370 is one member of a solid-state High Power Amplifier (HPA) family developed in response to those needs. Small, light, self sufficient, and highly reliable, these amplifiers cover a range of frequencies from 2 to 1000 MHz and output power up to 1000W.

The key to their superiority is a sophisticated combination of analog, digital, mechanical and thermal engineering techniques... including advanced power combining... all designed to harness with maximum efficiency the multiple power modules sufficient for the application.

TYPICAL BANDWIDTHS AND OUTPUT POWER LEVELS
2-32 MHz at 1000W
20-100MHz at 1000W
100-500 MHz at 400W
500-1000 MHz at 400W

HIGH POWER EPSCO

With their integrated power supplies and self-contained thermal control systems, these Epsco HPA's are ideal for Class 1 military environments as in jamming, decoy, and set-on operation applications.

Conservative operation of all devices insures long-term reliability and MTBF.

For more information, contact Epsco, RF Division, 31355 Agoura Road, Westlake Village, CA 91361. (818) 889-5200. Telex: 18-3378.

EPSCO

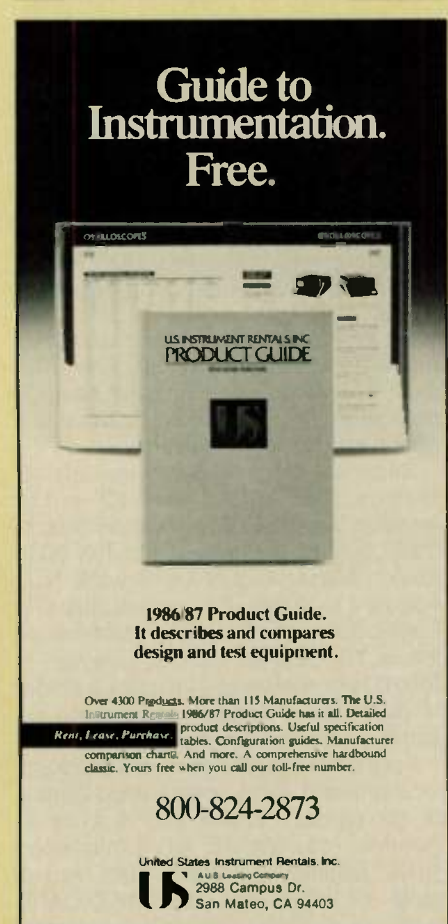
INFO/CARD 21

determine if it will be possible to predict the far-field pattern of a large phased array from measurements of some of its subarrays in the near field. Since many large arrays are too big or immobile to be economically measured using present techniques, the study is intended to solve a major measurement problem. Copies may be purchased for $2 prepaid from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; order by stock no. 003-003-02715-4.

EEsof, TriQuint Introduce GaAS Foundry Design Package

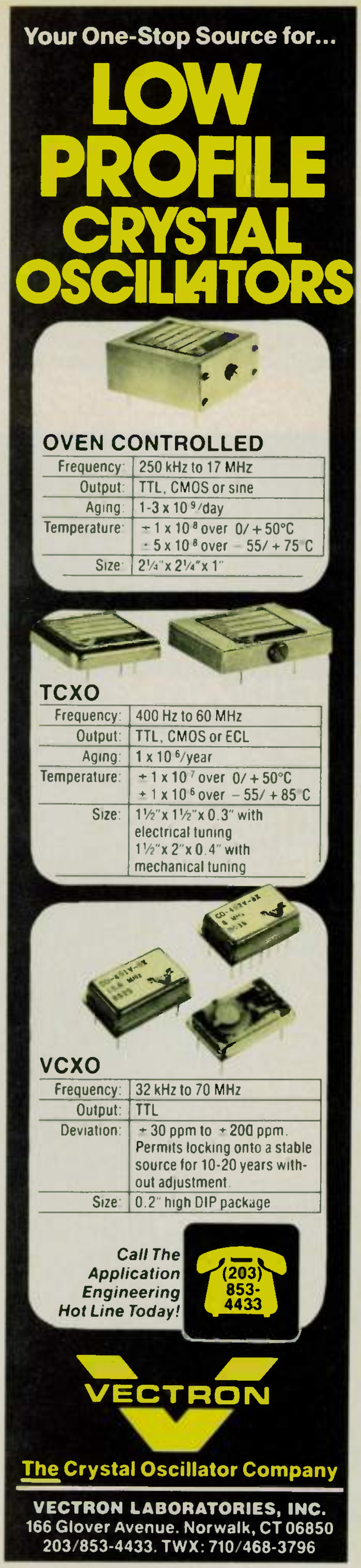
EEsof, Inc. and TriQuint Semiconductor, Inc. have teamed to incorporate TriQuint's GaAs (gallium arsenide) custom MMIC (monolithic microwave integrated circuit) foundry models into Touchstone®, EEsof's program for the design, analysis, and optimization of linear microwave circuits. Together, TriQuint and EEsof have developed a GaAs MMIC element library that allows Touchstone users to simulate microwave integrated circuits using MMIC components that precisely model the actual components available from TriQuint's custom MMIC foundry facility. TriQuint will license the library to EEsof, who in turn will incorporate the models into Touchstone and license the enhanced program to its customers.

"Our introduction of TriQuint's foundry technology into Touchstone provides a bold new direction in the development of GaAs-based MMICs," said EEsof's president, Charles Abronson. "Now microwave IC designers can work with Touchstone to develop MMICs that are accurately based upon sophisticated and fully tested IC device elements available through the GaAs foundry. Engineers will be able to utilize the techniques and accurate models provided by TriQuint's experienced designers along with the ease of use of Touchstone for circuit design," Abronson explained. "EEsof will continue to expand its marketing program to include cooperative ventures with other recognized leaders in the foundry industry."



INFO/CARD 52

INFO/CARD 22



INFO/CARD 23

The Touchstone/TriQuint MMIC element library provides a wide variety of common MMIC components, including MESFETs, diodes, inductors, capacitors, and resistors. The Touchstone software allows users to specify MMIC models in terms of TriQuint's manufacturing data base processing parameters. Moreover, active components (FETs and diodes) can be specified over a wide range of DC bias values.

Such GaAs FET parameters as gate width, drain-to-source voltage, and drain-source current (relative to I_{DSS} — drain current saturation level) can be optimized to achieve desired MMIC circuit performance to 18 GHz. Gate length and the number of gate fingers may be changed as desired. When optimum performance is achieved in the simulation, the physical parameters of the transitor(s) are immediately available to specify the actual device layout.

The TriQuint library will be available as an add-on product to Touchstone in June 1986, at which time EEsof will begin licensing the library to its customers for an additional fee. Documentation that clearly describes the use of the foundry models with Touchstone will accompany the program.

IEEE Press Publishes Modern Spectrum Analysis, II

The IEEE Press, book publishing division of the Institute of Electrical and Electronics Engineers, Inc., has announced the publication of *Modern Spectrum Analysis, II,* edited by Stanislav B. Kesler. This volume, part of the IEEE Press Selected Reprint Series, was prepared under the sponsorship of the IEEE Acoustics, Speech and Signal Processing Society.

The past decade witnessed the emergence of the field of power spectrum estimation as a very active subfield of digital signal processing. Advances in very large scale integration technology have had a major impact on the technical areas to which spectrum estimation techniques are being applied. This second volume of selected reprints on power spectrum estimation complements the first, *Modern Spectrum Analysis,* published in 1978 by the IEEE Press. Since the publication of that first reprint book, there have been many important developments in the field with regard to theoretical approaches, extensions, and applications.

Modern Spectrum Analysis, II (Order number PC01958) contains 456 pages and is priced at $49.50 ($37.15 for IEEE members). For ordering information, circle INFO/CARD #122.

Avantek Offers Semiconductor Design Solutions Seminar

Avantek, Inc. announces the *Avantek RF & Microwave Semiconductor Design Solutions Seminar.* This full-day seminar, to be held in 13 cities in the United States and Europe, is devoted to the technical understanding of modern microwave semiconductor devices and their application to discrete, hybrid and monolithic circuits. The seminar also features the latest computer-aided design and analysis products from EEsof, Westlake Village, Calif., and will include presentations by a guest lecturer from that company.

Avantek and EEsof will present the latest technology in RF and microwave semiconductor products and microwave software for both linear and non-linear design. It will be valuable practical training for any microwave or RF design engineer, whether a new college graduate or a more experienced designer, an Avantek spokesman said.

The program includes background on the device physics and modeling of both silicon and gallium arsenide transistors. Examples of linear amplifier designs using EEsof's Touchstone computer-aided design program during the seminar will include silicon bipolar transistors in gain blocks, multi-stage cascades and feedback amplifiers, and GaAs FETs in low-noise amplifiers. Examples of oscillator designs to be presented include lumped-resonator oscillators (LROs), reflection dielectric resonator oscillators (DROs) and silicon monolithic amplifiers in feedback DROs.

An example of non-linear analysis using Microwave SPICE will illustrate transient analysis, power analysis, and S-parameter vs. temperature analysis of a silicon monolithic amplifier.

Seminars are scheduled on July 15, 1986 in Santa Clara, July 22 in Los Angeles, and July 23 in Newport Beach, Calif.; July 28 in Chicago, Ill.; July 30 in Boston, Mass.; August 1 in Newark, N.J.; August 4 in Tampa, Fla.; and August 6 in Dallas, Texas. The European seminars will follow. The cost for the U.S. seminars is $100.00 per person and includes a binder of materials, a diskette of software examples, lunch and coffee breaks.

For further information on the program, locations and dates in the United States, or to register, contact Janice Little at Avantek, Inc., ms 5Y, 481 Cottonwood Drive, Milpitas, CA 95035-7492. Phone (408) 943-4565 or circle INFO/CARD #121. In Europe, contact your closest Avantek representative.

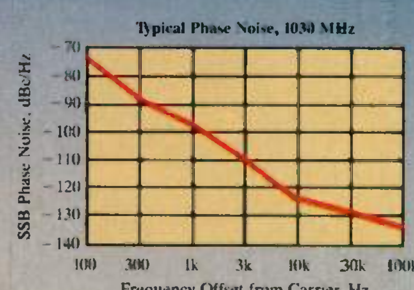
Stable, Compact Reliable and Efficient UHF Frequency Sources.

Small Accomplishment!

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

We cover applications from 150 MHz to 6000 MHz, and offer a wide range of options including temperature compensation, frequency multiplication, voltage tuning, and a variety of modulation formats from linear FM to direct-sequence spread spectrum. We can cover the full −55°C to +125°C temperature range and offer screening to MIL-STD-883 and MIL-S-49433.

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



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

RFM

THE NEW WAVE IN RF

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

INFO/CARD 24

One Antenna Kit with everything, to go please.

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

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

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

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

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

INFO/CARD 25

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

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

A.H. SYSTEMS

Non-Ionizing Radiation Exposure and Public Safety

FCC's Broadcast Rules Represent First Effort in Regulation of RF Radiation Hazards

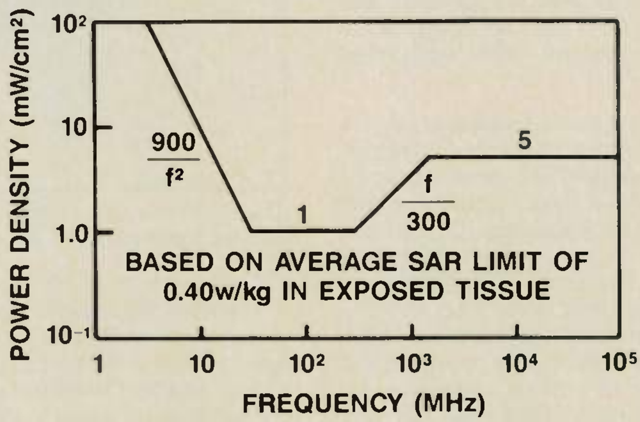
By Gary A. Breed
Technical Editor

This past Jan. 1 Federal Communications Commission Report and Order, General Docket 79-144 went into effect. This is the first federal regulation of its kind, which requires all new or modified broadcast facilities to meet the standards of ANSI C95.1-1982 (1) for human exposure to RF radiation. This rule is the result of six years of study by the FCC, combined with study by the Environmental Protection Agency, concerning the possible hazards and acceptable limits on RF exposure.

The standard which has been adopted by the FCC is shown in Figure 1. The C95.1-1982 standard is based on the absorption factor of human tissue, and the RF level at which damage can occur. With a tenfold safety factor included, the ANSI standard is essentially an inverse of the absorption curve of the human body. Note the high absorption (and low radiation limit) in the 30-300 MHz range, possibly the most densely populated segment of the RF spectrum.

An analysis of the standard also shows that it takes a relatively high power to exceed the limits at a distance of more than a few feet. Broadcasting stations and government communications and radar represent the vast majority of high power RF sources that the public may be exposed to. Other services, such as satellite uplinks, commercial two-way, aviation and amateur radio services, may have sufficient power densities at specific locations to exceed the limits, but their location or intermittent operation makes them minor contributors to any public hazard. The six minute averaged exposure time of the ANSI standard has the effect of eliminating as hazards those systems with short transmissions or low duty cycle modulation.

Figure 1. ANSI C95.1-1982 RF Radiation Exposure Limits.



The Cougar Mountain Study

In May 1985 the FCC and EPA performed a joint study (2) to determine actual radiation levels in an area surrounding a multi-station broadcasting facility. The Cougar Mountain "antenna farm" at Issaquah, Wash., is the location of 10 Seattle-area FM transmitters, and many two-way communications and microwave relay stations. With effective radiated power of 126 to 200 kW each (all polarizations included), the FM stations are by far the largest contributors to maximum power densities in the area.

A brief summary of the study findings shows that many localized areas exceed the present radiation limit, and a person remaining in such a spot long enough would receive radiation in excess of the six-minute-average standard. However, when the measurements are averaged spatially, rather than at a single point, no publicly accessible location exceeded the ANSI standard. Some locations' spatially-averaged levels did approach the ANSI limit (i.e., 0.7 mW/cm^2 vs. limit of 1.0 mW/cm^2), and any future standard with a lower limit would be exceeded.

Other notes in the study included the observation that vegetation, particularly coniferous trees, seemed to be a good RF radiation shield. Also, specific locations could possibly be deemed hazardous, in spite of their spatially-averaged value. Metal objects and household electrical wiring create an "antenna" effect, resulting in areas of concentrated field strength where a person might be stationary for some time. A metal swingset in one yard was another possible point of hazard, with specific spots of high field strength where children might linger. Finally, workers on any of the towers will be exposed to excessive radiation from other towers and methods of cooperation are needed to safely perform tower maintenance.

RF Design *welcomes additional information and comment on public exposure to RF radiation from our readers.*

References

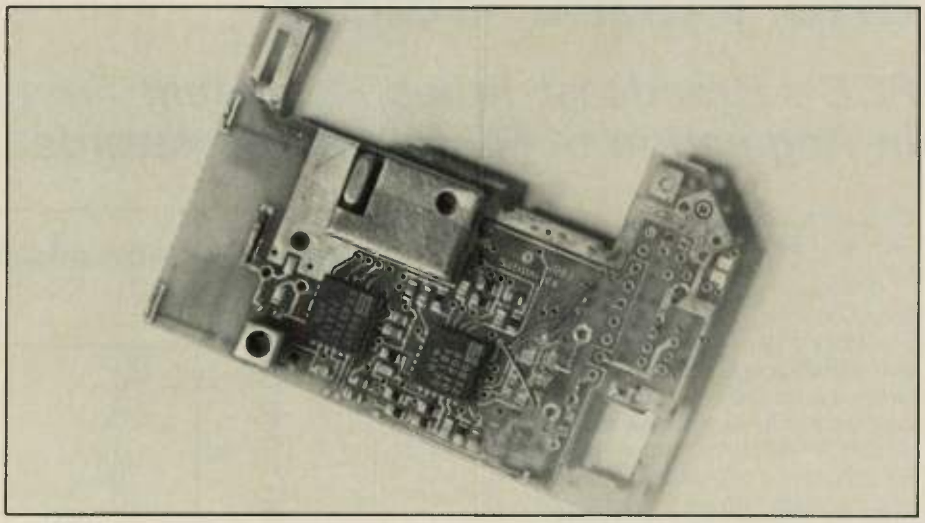
1. "American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz," (ANSI C95.1-1982) I.E.E.E., 1982.

2. "An Investigation of Radiofrequency Radiation Exposure Levels on Cougar Mountain, Issaquah, Washington, May 6-10, 1985," prepared for the FCC by the Electromagnetics Branch, Office of Radiation Programs, EPA.

FSK Receiver Uses Direct Conversion

By David Treleaven and
Doug Wadsworth
Siltronics Ltd.

Data transmission by FM radio link can benefit from a new receiver design approach. Data receivers based on a direct conversion "Zero IF" system offer top performance at lower power and lower cost than regular superheterodyne systems. Although the direct conversion principle has been known for many years, this article shows how new components and techniques allow its performance to become competitive with established methods.



The Siltronics Ltd. SM450 FSK receiver is constructed on a 3" × 2" p.c. board that can be trimmed to 2" × 1.4" size.

A direct conversion receiver (1, 2) is a special class of single-conversion heterodyne system. The incoming signal is mixed with a local oscillator at the original carrier frequency. One of the resulting mixer products is a signal at the modulating frequency. It is filtered out from the unwanted mixer products, amplified, and discriminated to produce the output of the receiver. The operation and performance of a direct conversion receiver depends on high gain and very selective filtering in the audio frequency range.

Direct Conversion for FSK Reception

The direct conversion principle is a general technique that can be applied to single sideband, FM, or even AM under certain circumstances. However, for the reception of Frequency Shift Keyed (FSK) signals only, the system can be substantially simplified by using limiting amplifiers and a digital logic discriminator. While these networks limit the type of modulation that can be accepted, they result in a straightforward and cost-effective receiver.

A direct conversion FSK receiver has a number of basic advantages over a superhet. First, there is no image frequency. Next, most of the gain is at relatively low frequency, resulting in power savings. Also, there is only one frequency source to be set up and controlled (LO), compared to three for a double-conversion superhet (2 LOs and discriminator). The block diagram of a direct conversion receiver for data is shown in Figure 1. This receiver might be used, for example, under the conditions of: 150 MHz carrier frequency, 25 kHz channel spacing, ±4.5 kHz FSK frequency deviation, and an output data rate up to 4000 bits/second.

The incoming signal is directed into two channels where it is mixed *in quadrature* with the carrier frequency generated by a local oscillator. The mixer output signals are separated in phase by 90 degrees and are at a frequency equal to the deviation of the incoming signal. The signals in the two channels are lowpass filtered to provide channel selectivity, then fully limited in IF amplifiers such that the IF outputs can be regarded as digital waveforms. These are digitally demodulated by a phase detector that detects whether channel A leads or lags channel B to give output data in NRZ format. To achieve the desired selectivity, the lowpass filter configuration must be such that the filters pass the FSK frequency deviation of 4.5 kHz while attenuating adjacent (25 kHz) channel signals by about 70 dB.

A fundamental relationship exists between the frequency deviation and the maximum possible output data rate. The function of the digital discriminator is equivalent to sampling the input data with twice the deviation frequency. The sampling theorem defines a maximum data rate of one half the sampling frequency. Since the deviation frequency is 4.5 kHz, the absolute maximum data rate is 4.5 kHz or 9,000 bps. There is, however, substantial signal degradation before this theoretical limit is reached and a practical maximum is 4,000 bps. Higher data rates are obviously possible with larger deviations and correspondingly wider channel spacing and filter bandwidth.

Mixer Products and Spurious Responses

A direct conversion receiver has a much simpler and less troublesome frequency response spectrum than a regular superheterodyne receiver. A superhet receiver can generate sum and difference frequencies for any number of input signals that happen to be applied to the

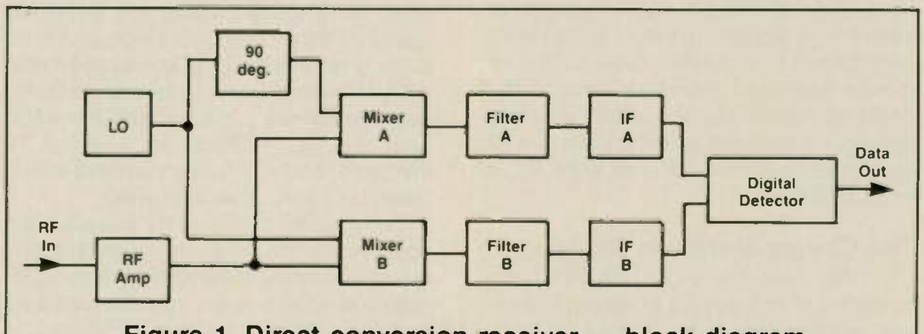
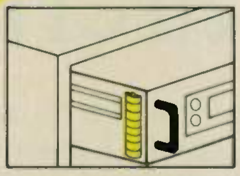


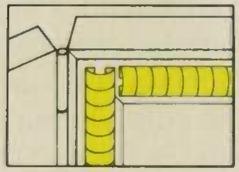
Figure 1. Direct conversion receiver — block diagram

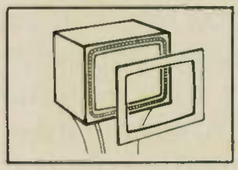
Want to save $10,000?

<u>Heat is on computer manufacturers</u> to comply with FCC emission standards. At stake are amounts of electromagnetic radiation that disrupt communications. Recent FCC test showed that half of 29 models examined failed to meet limits. Agency plans to ask Justice to crack down on offenders with fines of $10,000 for those who fail to comply, and that includes fixing machines already sold.

— as reported by Research Institute of America







Instrument Specialties can help you comply with FCC emission standards and prevent future fines. Our beryllium copper shielding strips, available from stock or custom-designed to your needs, do the job. And they cost a lot less than $10,000!

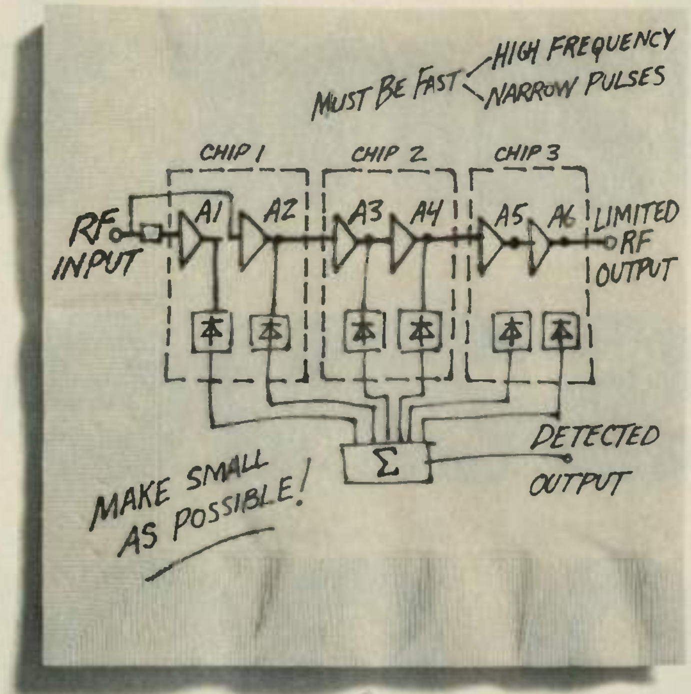
For more information, consultation, and design services, as well as our "Guide to Interference Control", phone and ask for EMC Customer Service. Or, write us at Dept. RF-31.

INSTRUMENT SPECIALTIES COMPANY, INC.

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

Specialists in interference control since 1944

WRH



The best hybrids for radar aren't always hybrids.

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

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

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

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

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

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

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

PLESSEY

Plessey and the Plessey symbol are trademarks of the Plessey Company plc.

INFO/CARD 27

input of the mixer. In addition, the mixer output can also contain higher-order detection products that may introduce unwanted spurious responses.

The most serious of these is the image frequency. Assuming the first LO frequency is higher than the RF, the image frequency is $f_{LO} + f_{IF}$. If a signal of this frequency is picked up by the antenna, and if it reaches the mixer input, it will beat with f_{LO} to produce a difference frequency component equal to f_{IF}. In addition to the image frequency an input signal at f_{IF}, or an input signal at $f_{IF}/2$ doubled by the square-law mixer term, can appear in the output.

Frequency Rage	20-50	Mhz
	138-174	MHz
Power Supply Voltage	1.8-6.0	V
Power Supply Current (5V)	3	mA
Channel Spacing	25	kHz
Frequency Deviation	±5	kHz
Sensitivity	0.2	uV
Selectivity	73	dB
LO Frequency Stability	±10	ppm

Table 1. SM450 performance specifications

In a direct conversion receiver, because the IF is at such a low frequency, image rejection is essentially infinite and general IF leakage is essentially zero.

The frequency component of particular concern to a direct conversion receiver is f_{LO}. Since the local oscillator frequency is on the carrier frequency, LO radiation can conceivably interfere with nearby receivers on the same channel, or feed back to the antenna and interfere with its own receiver. A direct conversion receiver requires good LO radiation suppression and good LO frequency accuracy and stability for reliable operation.

An example of a complete FSK radio receiver based on direct conversion is the Siltronics SM450, a module product. It includes two Siltronics integrated circuits, the S408 and S410 as shown in the block diagram of Figure 2. This receiver example illustrates the foregoing discussion of direct conversion. The S408 IC contains an RF amplifier and two mixers. The S410 contains the filter amplifiers, limiting IF amplifiers, digital discriminator and data output circuitry.

In the complete receiver the collector of the RF amplifier transistor is connected to a load tuned to 150 MHz, and AC coupled to the two mixers. The 90-degree phase separation between the two channels is obtained by matching 45° lead (C-R) and lag (R-C) networks between the LO output and the two mixers.

The lowpass filters are seventh order

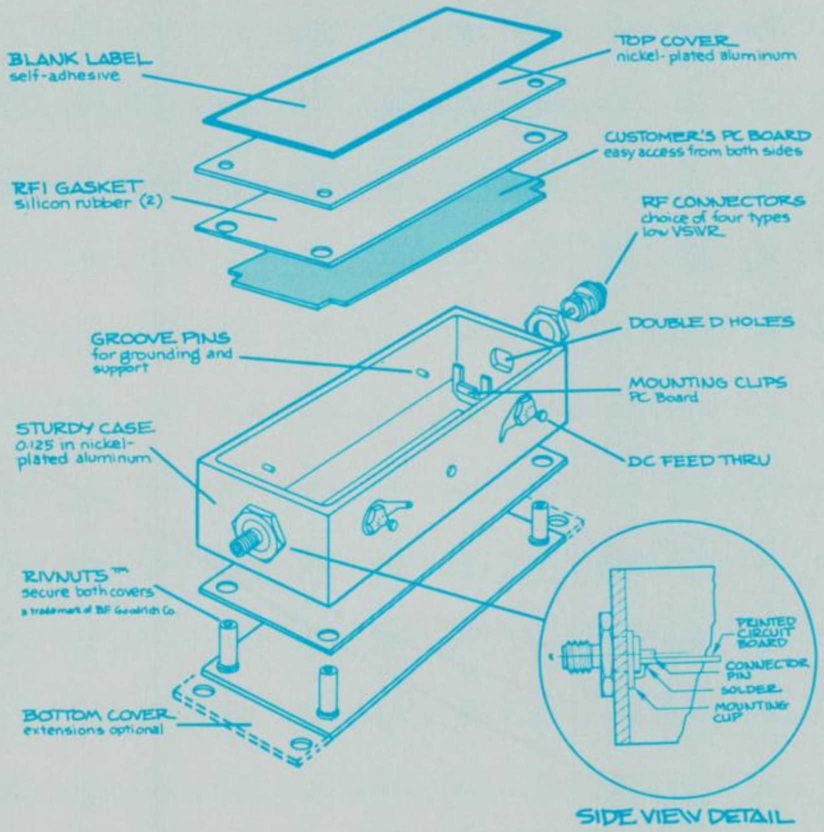
The SM450 FSK Receiver

Siltronics' new FSK receiver for VHF paging (or other data reception) is constructed on a PC board trimmable to 2 × 1.4 in. Small size is achieved by use of custom ICs and the lower parts count required by the direct conversion (Zero IF) method of reception described in the accompanying article.

The module uses two Siltronics ICs specifically designed for direct conversion, the 408 and 410. The 408 contains an RF amplifier transistor, oscillator transistor, two balanced mixers and supporting DC circuits. The 410 has operational amplifiers for the audio filters, limiting amplifiers and the digital detector. The 408 also contains low battery and tone alert outputs.

The SM450 receiver is priced in the $40 range (1000 qty.). For more information circle INFO/CARD #123.

Here's the Secret!



MODPAK™ Shielded RF Housings for Prototypes or Production

Your circuit needs the protection only MODPAK can give. More than 100 standard models to choose from . . . or we will custom-fabricate to your specifications. Send for catalog.

Adams Russell
MODPAK

80 Cambridge St., Burlington. MA 01803 • (617) 273-3330 • FAX 617-273-1921

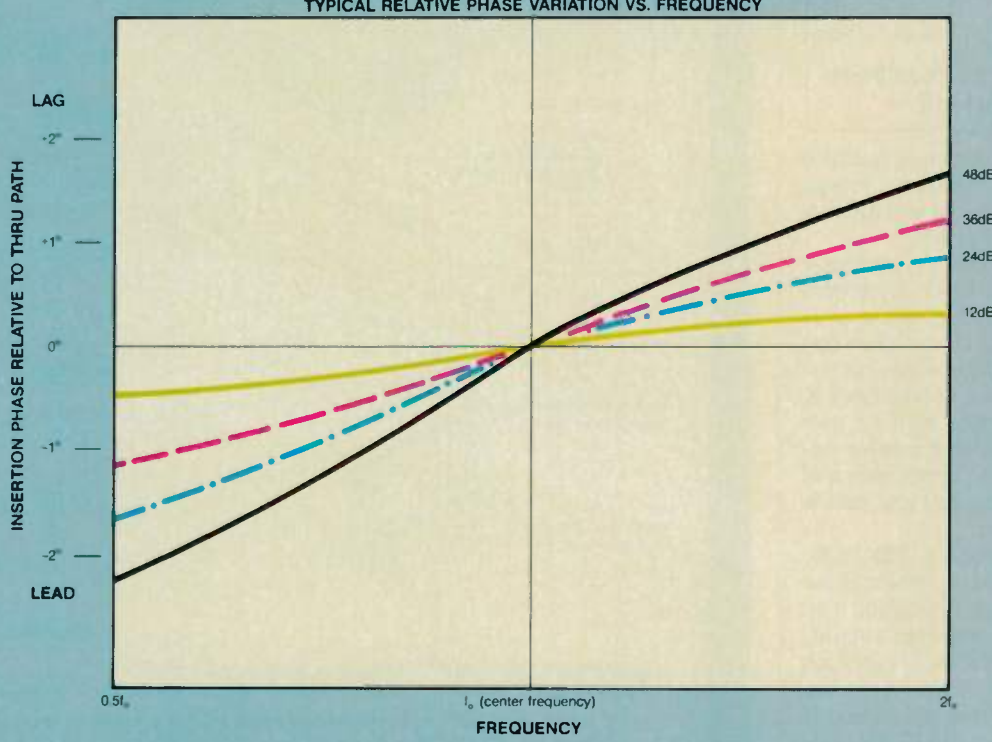
INFO/CARD 28

DAICO PHASE COMPENSATED STEP ATTENUATORS

OPTIMIZED FOR SINGLE FREQUENCY/NARROW BAND APPLICATIONS

- ☐ Range of Center Frequencies: 20 to 70MHz
- ☐ High Speed 25 Nanoseconds Typical
- ☐ Range of Attenuation Values/ Steps: From 0.1dB (LSB) to 32dB (MSB) One Bit (Step) through Eight Bits (Steps)
- ☐ Low Transients 25mV Typical
- ☐ Meets Military Environmental Requirements

TYPICAL RELATIVE PHASE VARIATION VS. FREQUENCY



FEATURES:

- Single +5V Supply Operation
- TTL Control Inputs
- RF Operating Power +10dBm
- 50 Ohm Impedance
- VSWR 1.35/1 Maximum
- Insertion Loss 0.6dB/Bit typical 1db/Bit Maximum
- Dual In-line MIC (Microwave Integrated Circuit) Package

Also Available Broad Band Phase Compensated Step Attenuators and Voltage Controlled Attenuators with Operating Frequencies from DC to 2 GHz.

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

INFO/CARD 29

© 1986 DAICO INDUSTRIES, INC. mp86454

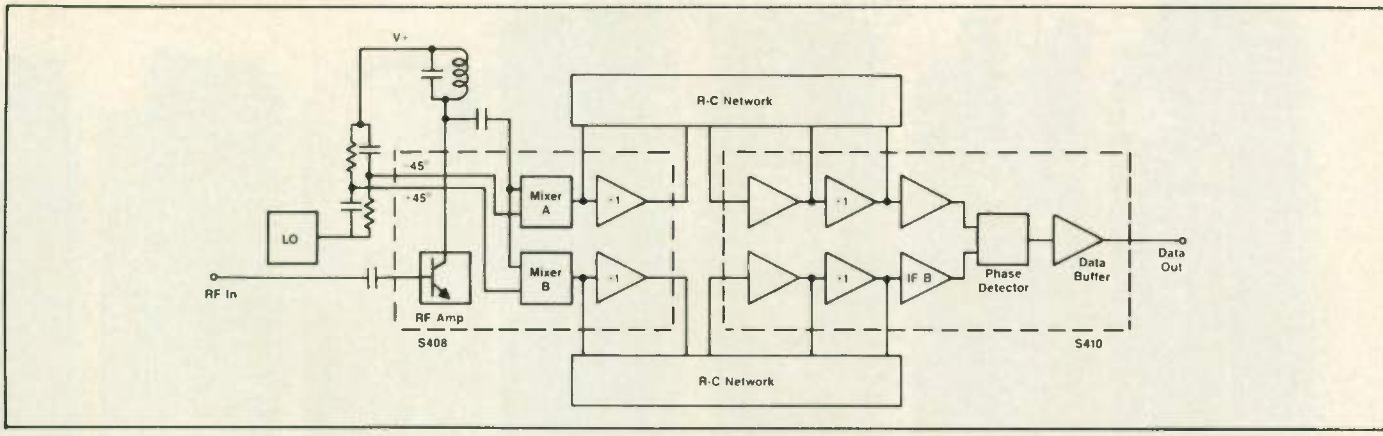


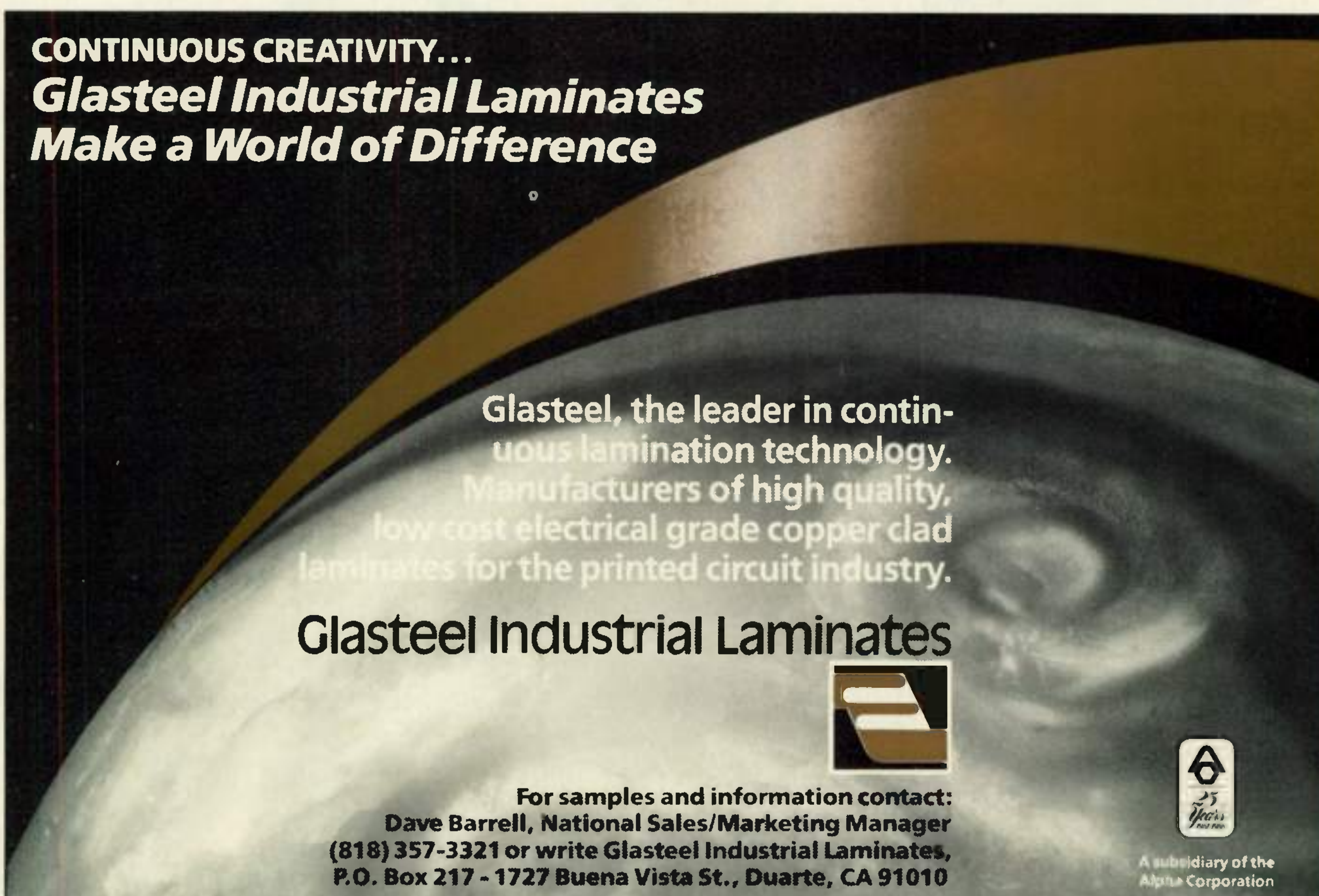
Figure 2. Block diagram SM450 radio receiver module

networks that include a multiple feedback filter with a high gain amplifier and a Sallen and Key filter with a unity gain amplifier. The filter frequency response is shown in Figure 3. Stage gains are controlled by off-IC components up to the inputs of the IF amplifiers. Voltage gains are: RF amplifier 15 dB, mixers 24 dB, active filters 6 dB.

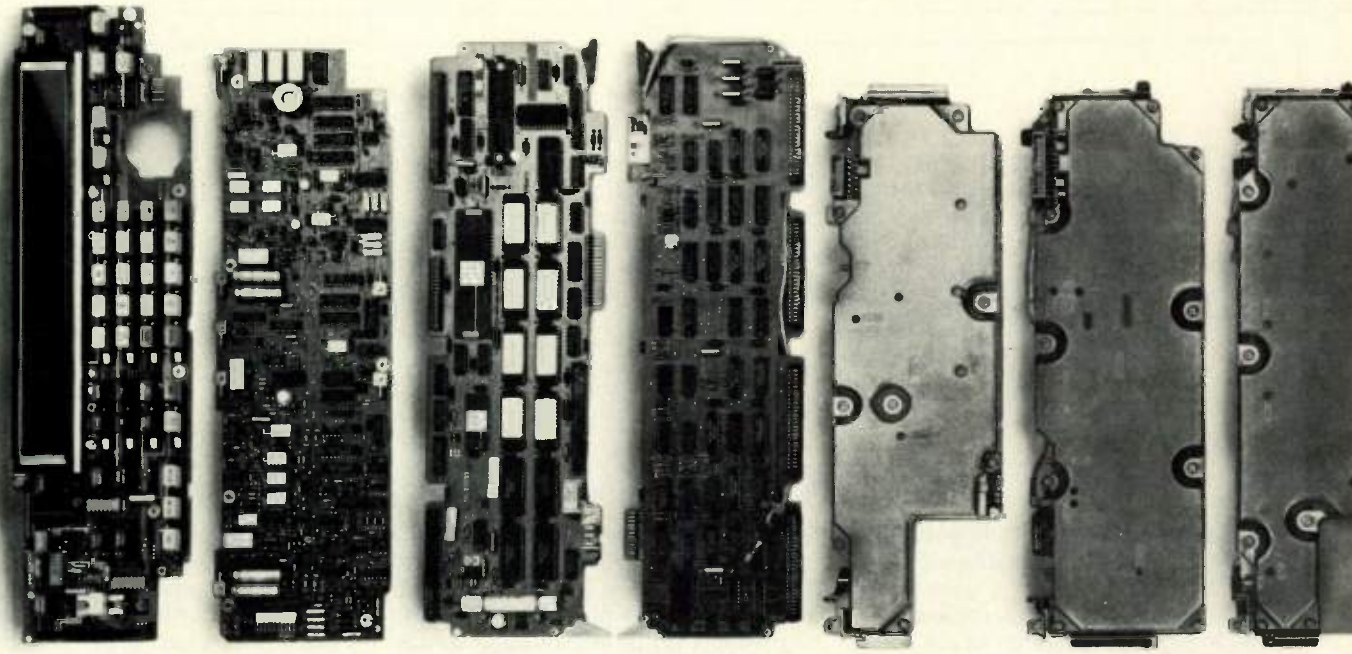
Operation of the system with frequency deviations larger than ±4.5 kHz is possible with appropriate changes to the external filter components. The upper limit is defined by the 1 MHz gain-bandwidth product of the active filter amplifiers and the 50 kHz 3 dB point of the limiting amplifiers. Thus deviations up to approximately ±50 kHz are practical.

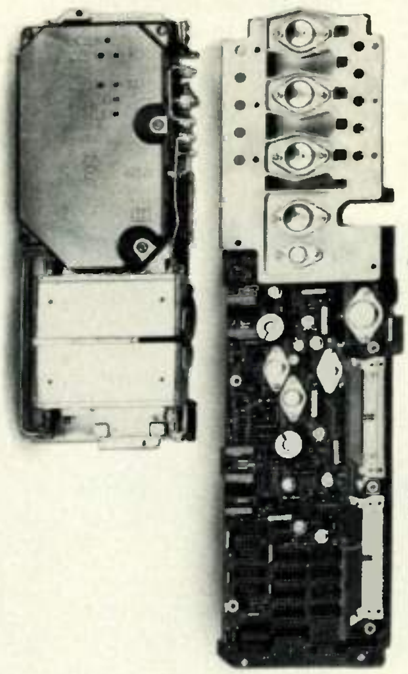
In the photograph of the receiver the LO screen box enclosing the local oscillator circuitry is readily seen. LO frequency accuracy and stability of ±1.5 kHz at 150 MHz is readily attained over a temperature range of −10 to 50°C. LO radiation is more than 40 dB below the level required by the FCC for radio paging receivers, and more than 10 dB below the most stringent European specifications. This level is far below that which might possibly cause receiver self-interference.

For some applications requiring very high selectivity because of high adjacent channel signal levels, a high Q antenna or input RF filter may be required. The parameters listed in Table I apply without the benefit of such a filter.



INFO/CARD 30



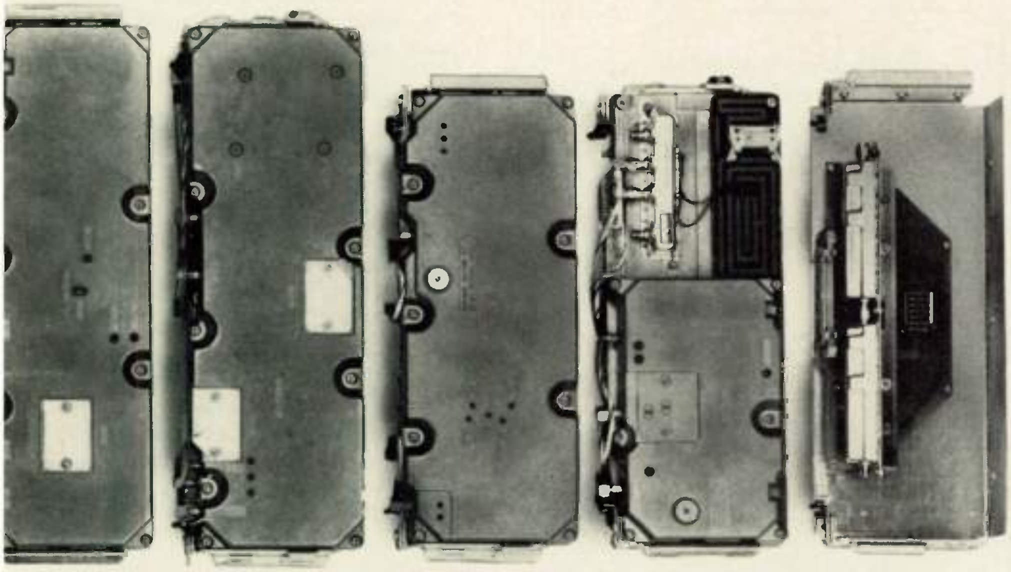


Leave it to Hewlett-Packard to get you up and running fast if your HP 8642A/B RF signal generators ever go down. The do-it-yourself HP On-Site Service Kit does it all.

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

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

14 Get-



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

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

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

HEWLETT PACKARD

INFO/CARD 31

Well Cards For Signal Generators.

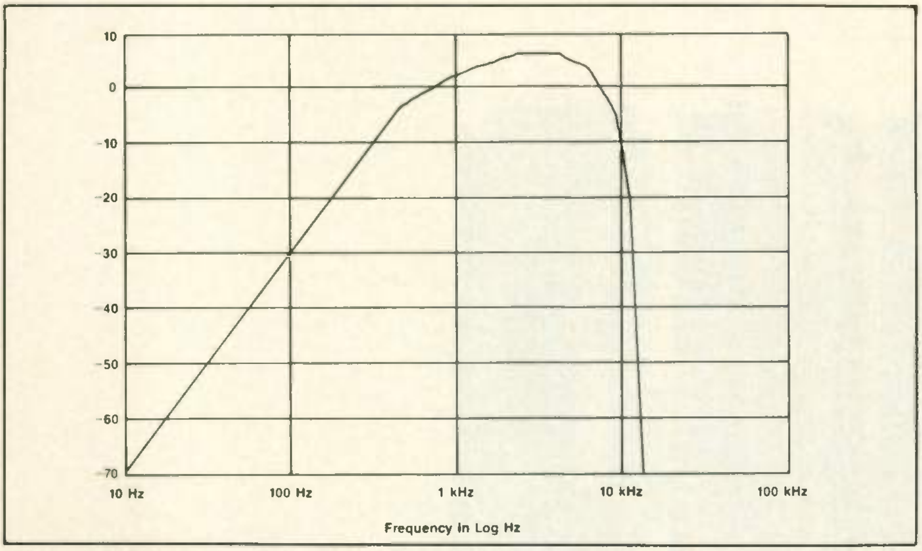


Figure 3. Lowpass filter characteristic

A direct conversion receiver has the following fundamental advantages over a regular superheterodyne receiver:

- Image rejection is essentially infinite. Also, since $f_{IF} = 0$ there is no potential problem with any other IF-related frequency components. IF rejection is very high, IF leakage is very low.
- Lower power consumption is possible because most of the gain is at audio frequencies.
- A number of cost advantages exist. No crystal filters or ceramic filters are required, and only a minimum number of coils. There is no need for IF tuning. There is only one frequency source to control.

References

(1) *An Integrated Circuit VHF Radio Receiver,* I.A.W. Vance, The Radio and Electronic Engineer, Vol. 50, No. 4, pp.158-164, April 1980.

(2) *Fully Integrated Radiopaging Receiver,* I.A.W. Vance, IEE PROC., Vol. 129, Pt. F, No. 1, February 1982.

About the Authors

David Telleaven and Doug Wadsworth have been with Siltronics for over 10 years and have prior experience in microelectronics with major manufacturers. David has a B.Sc. from the University of British Columbia, and is IC Marketing Manager. Doug is Manager of IC Applications, and holds a B.Sc. from McGill University. They can be reached at Siltronics Ltd., 436 Hazeldean Road, Kanuta, Ontario, Canada K2L 1T9. The telephone number is (613) 836-5003.

One of these 404 communications antennas is exactly right for your needs.

Whatever your system requirement—in any frequency band from 25 to 900 MHz...for every conventional or special application...base station, portable or mobile...every conceivable vehicle configuration—you'll find the one best answer without leaving your desk in this new Selection Guide from the industry leader.

***FREE**—comprehensive new 28-page, Professional Antenna Selection Guide.*

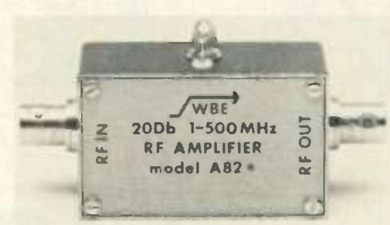
the antenna specialists co.
A member of The Allen Group Inc.
12435 Euclid Ave., Cleveland, OH 44106 • Canada: A. C. Simmonds & Sons, Ltd.

INFO/CARD 32

WBE
BROADBAND EQUIPMENT FOR INSTRUMENTATION AND COMMUNICATIONS

1971 - 1986

15th Anniversary Year



MINIATURE RF AMPLIFIERS

IMPEDANCE: 50 or 75 ohms

RANGE: 1-500 MHz (others available)

GAIN: 20 dB Stable $\pm$.5 dB

POWER REQUIREMENTS: +12 VDC

PRICE: 50 ohm A82A $151.00
75 ohm A82A $161.00

Several catalog models are available. Call with specifications for OEM applications.

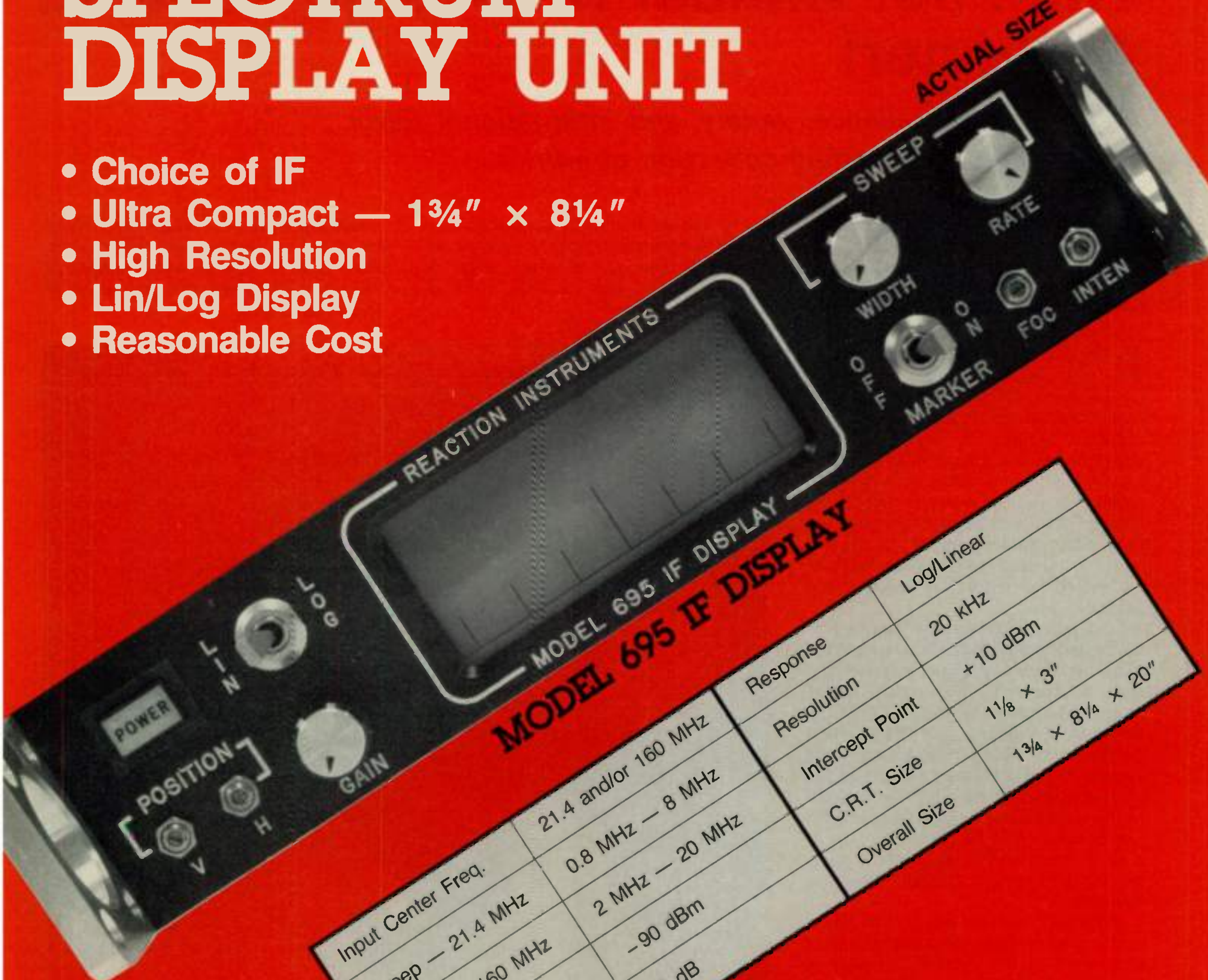
WIDE BAND ENGINEERING COMPANY, INCORPORATED

P.O. Box 21652 Phoenix, AZ 85036
Phone (602) 254-1570

INFO/CARD 33

IF SPECTRUM DISPLAY UNIT

- Choice of IF
- Ultra Compact — 1¾″ × 8¼″
- High Resolution
- Lin/Log Display
- Reasonable Cost



MODEL 695 IF DISPLAY

Input Center Freq.	21.4 and/or 160 MHz
Sweep — 21.4 MHz	0.8 MHz — 8 MHz
Sweep — 160 MHz	2 MHz — 20 MHz
Sensitivity	−90 dBm
Gain Control	60 dB
Response	Log/Linear
Resolution	20 kHz
Intercept Point	+10 dBm
C.R.T. Size	1⅛ × 3″
Overall Size	1¾ × 8¼ × 20″

For further information, please call or write to Marketing Department, Reaction Instruments, 1930 Isaac Newton Square, Reston, VA 22090. PHONE (703) 471-6060, TWX 710 833 9031.

REACTION INSTRUMENTS

INFO/CARD 34

The First Annual RF Design Contest: A Winner!

Engineering excellence, variety, and international flavor highlight an outstanding collection of entries.

When RF Design *decided to sponsor a contest, we didn't have any idea what to expect. We didn't know that one third of the entries would arrive from engineers outside the United States. We certainly didn't foresee that every entry would be a worthy contestant. We also could never have guessed at the wide range of designs that our readers would come up with.*

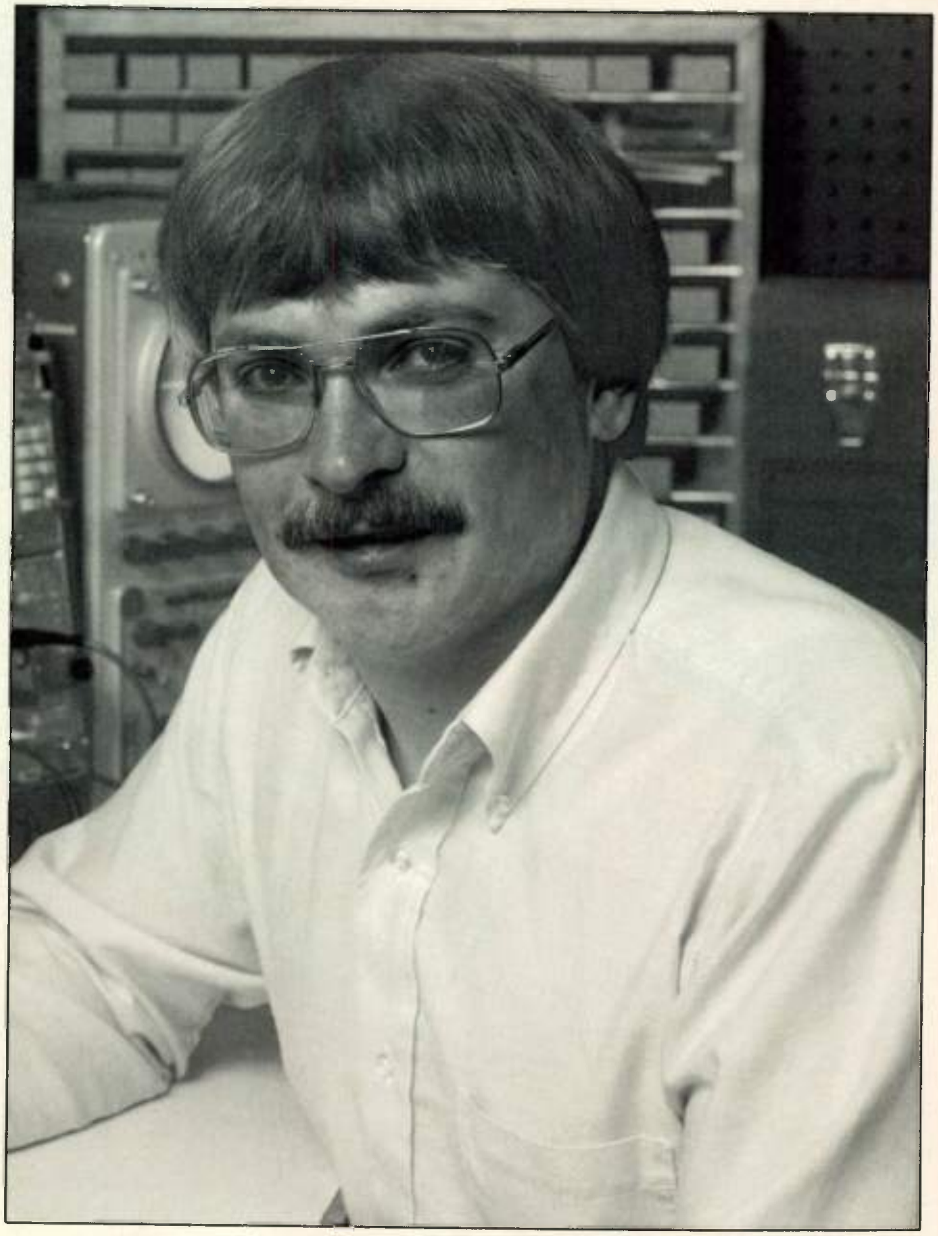
Now we know . . . and we are looking forward to the next contest, which will be announced in a few months. To those of you who didn't enter this year, there is always next time.

In December 1985, *RF Design* made the first announcement of our contest. On December 23rd, we received the first entry from George Dodson of Allied Corporation. Finally, at the April 15th deadline, the final entry arrived from Tom Litty of Milcom International. In between came entries from every corner of the United States and several foreign countries. After receiving all of the contest designs, the judges were confronted with an incredible array of "apples and oranges" variety!

Evaluation of the design entries was performed by the judges according to the published criteria, and after some discussion, a consensus was reached. The judges, *RF Design* Technical Editor Gary Breed, ARF Products Vice President for Development Andy Przedpelski, and Lockheed Senior Research Engineer Jim Mize all noted that the variety represented by the entries made judging very hard. No two designs could be compared side by side, so each had to be judged against the list of criteria, a difficult, subjective evaluation!

In the end, a winner was chosen. Many of the other designs were considered of high merit by the judges, and eight of them will be published in *RF Design*. Al Helfrick's thermally-tuned VCO and George Dodson's TTL compatible RF driver are the first two "runners up" to be published, and can be found in this month's "Designer's Notebook.

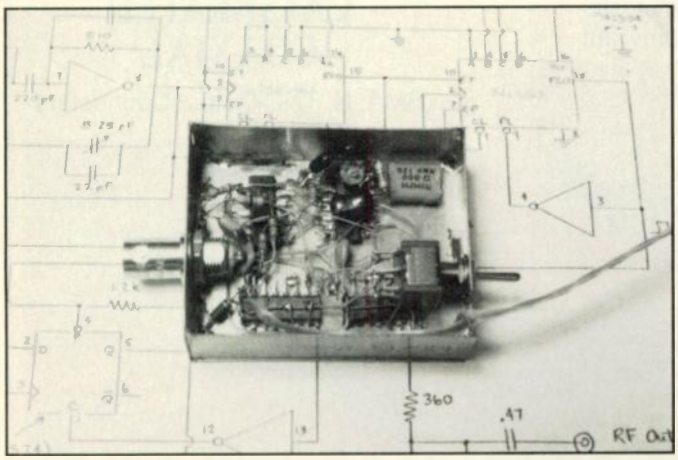
Congratulations to Dan Baker, our winner, and a special thanks to every entrant! Hewlett-Packard supplied the first prize, an HP-41CX programmable calculator. Their support has been greatly appreciated! Our thanks also go to the judges, who struggled with a tough task in evaluating the entries. Next year's contest promises to be bigger, better and even more exciting that this year's *First Annual RF Design Contest!*



The Winner: A Crystal Controlled Frequency and Amplitude Calibrator

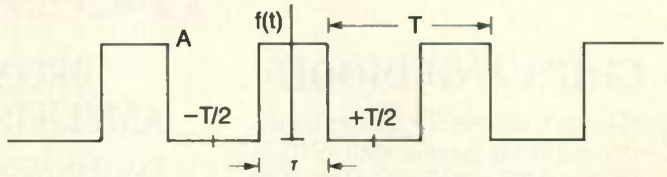
By Dan Baker
Tektronix, Inc.

The motivation for creating this circuit was to provide a calibrator for both amplitude and frequency over a reasonable range of the HF band. Most modern receivers use frequency synthesis and would receive little benefit from a frequency calibrator. However, older receivers and spectrum analyzers need frequency calibration and virtually all receivers would benefit from a broadband amplitude reference. This circuit accomplishes these goals with a simple design that is fundamentally accurate requiring no adjustments.



Construction of the calibrator circuit.

The design is based on narrow-width pulses with 1 MHz and 100 MHz repetition rate. For a theoretical analysis, consider the following time function:



The double-sided Fourier coefficients for this function are:

$$F_n = \frac{1}{T}\int_{-T/2}^{T/2} f(t)e^{-j\omega_o n t}dt = \frac{1}{T}\int_{-\tau/2}^{\tau/2} Ae^{-j\omega_o n t}dt$$

$$F_n = \frac{2A}{\omega_o n T}\left[\sin\left(\frac{\omega_o n \tau}{2}\right)\right] = \frac{A\tau}{T}\left[\frac{\sin\left(\frac{\omega_o n \tau}{2}\right)}{\left(\frac{\omega_o n \tau}{2}\right)}\right]$$

This is of the general form:

$$Fn = \frac{A\tau}{T}\left[\frac{\sin(X)}{(X)}\right]$$

where $X = \dfrac{\omega_o n \tau}{2}$

The familiar [sin(x)]/x function is shown below:

The Hewlett-Packard HP-41CX First Prize Goes to Dan Baker of Tektronix, Inc.

"Wow! I can't believe I won," was the reaction of our winner when informed of his accomplishment. Dan Baker's frequency/amplitude calibrator was chosen as the top entry in the *First Annual RF Design Contest*. From an outstanding group of entries, his was judged the best.

Dan is a senior engineer in the Television Waveform Display Division of Tektronix, Inc. He has been with Tektronix for 12 years, and has made a number of "winning design" contributions to the TV waveform monitor products at TEK, including a patent on an aperture correction circuit and five more patents pending.

Dan received his BSEE (Maxima Cum Laude) from the University of Portland, and is currently working toward his MSEE at Oregon State. He is an amateur radio operator (Extra Class, WA7KRN), and holds a General Radiotelephone License and Private Pilot License. Some outside interests include astronomy, flying, photography and skiing.

He can be reached at Tektronix, Inc., Television Division, P.O. Box 500, M/S W3-100, Beaverton, Ore. 97077-0001.

BROAD BAND NOISE SOURCES

FOR SPACE, MILITARY AND COMMERCIAL APPLICATIONS...

DC-50 GHz

CHIPS AND DIODES

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

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

ALL ARE IN STOCK

DROP IN MODULES FOR BITE

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

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

ALL ARE IN STOCK

BROAD BAND AMPLIFIED MODULES

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

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

MOST ARE IN STOCK

HIGH-OUTPUT:
+10 dBM, 50 ohms
SMA or BNC output

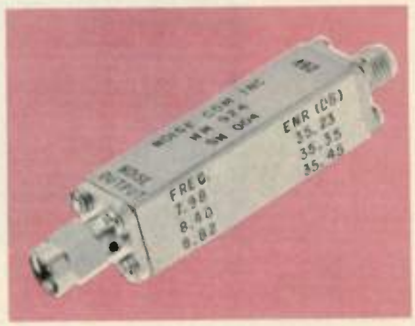
TYPICAL STANDARD MODELS	
NC 1101A	up to 20 kHz
NC 1107A	up to 100 MHz
NC 1108A	up to 500 MHz
NC 1109A	up to 1 GHz
NC 1110A	up to 1.5 GHz

Other frequency ranges
and output levels available

MOST ARE IN STOCK

BROAD BAND PRECISION, CALIBRATED COAXIAL

SMA, N, TNC Output Connectors



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

NOISE/COM

"NOISE IS OUR ONLY BUSINESS"

NOISE COM, INC.
111 Moore St.
Hackensack, N.J. 07601
(201) 488-4144
TWX 910-380-8198

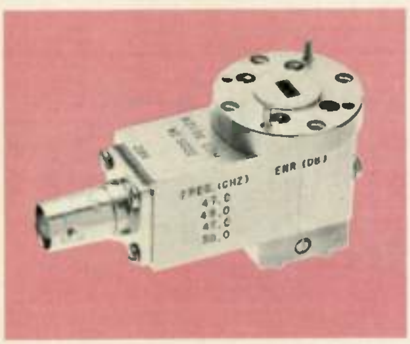
BROAD BAND NOISE SOURCES

FOR SPACE, MILITARY AND COMMERCIAL APPLICATIONS...

DC-50 GHz

BROAD BAND PRECISION, CALIBRATED WAVEGUIDE

WR-22,-28,-42



TYPICAL STANDARD MODELS	
NC 5100 Series	up to 50 GHz 15.5 dB ENR, noise figure meter compatible
NC 5200 Series	up to 50 GHz 21-25 dB ENR, high noise output
NC 5300 Series	up to 50 GHz 21-25 dB ENR, high noise output

For More Information And Quick Response Call:

GARY SIMONYAN @ 201-488-4144

BROAD BAND INSTRUMENTS

115V or 230V Standard
Bench Type or Rack Mounted

MANUALLY CONTROLLED:
+10 dBM Output

TYPICAL STANDARD MODELS	
NC 6101	up to 20 kHz
NC 6107	up to 100 MHz
NC 6108	up to 500 MHz
NC 6109	up to 1 GHz
NC 6110	up to 1.5 GHz
NC 6111	up to 2 GHz

Other standard models available
MOST ARE IN STOCK

PROGRAMMABLE:
IEEE-488 (GPIB), MATE (CIIL)
RS232, etc. +10 dBM Output

TYPICAL STANDARD MODELS	
NC 7101	up to 20 kHz
NC 7107	up to 100 MHz
NC 7108	up to 500 MHz
NC 7109	up to 1 GHz
NC 7110	up to 1.5 GHz
NC 7111	up to 2 GHz

OPTIONAL: Remote variable filters, signal input combiner, 75 ohms output, marker input
Other standard models available
MOST ARE IN STOCK

CUSTOM & HI REL PRODUCTS

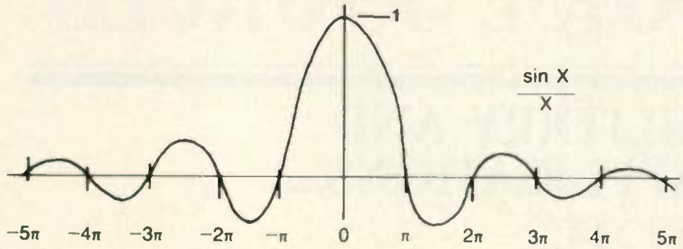
HYBRID FOR SPACE QUALIFIED AMPLIFIED MODULES
10 Hz to 10 MHz, 7 GHz, 9 GHz, 14 GHz etc. Small size and weight
MIL-STD-883, MIL-STD-1547

DC COUPLED AMPLIFIED MODULES
1 volt output into 50 ohms
DC-100 kHz
Low offset voltage
Compact.

NOISE/COM

"NOISE IS OUR ONLY BUSINESS"

NOISE COM, INC.
111 Moore St.
Hackensack, N.J. 07601
(201) 488-4144
TWX 910-380-8198



The function is zero at integral multiples of π. The first zero occurs at:

$$X = \pi = \pi nF_o\tau$$

$$nF_o = \frac{1}{\tau} = \text{first null frequency}$$

A spectrum analyzer or receiver measures the magnitude of $F\omega$. The frequency response $|F_{(\omega)}|$ for a rectangular pulse train is a series of impulses in the frequency domain as follows:

$$|F_{(\omega)}| = \sum_{n=1}^{\infty} \left| 2A\tau F_o \left[\frac{\sin X}{X} \right] \right| \delta(\omega - n2\pi F_o)$$

where $X = \pi F_o n\tau$

$F_o = 1/t$ = the pulse repetition rate.

The envelope of the frequency response is dependent only on the pulse shape and not the pulse repetition rate (F_o). If the pulse is rectangular and of short duration, the resulting response may be quite flat over a portion of the frequency band before the first zero.

The circuit shown in Figure 1 generates a pulse of approximately 8 nsec in duration. The pulse duration is loosely controlled by the propagation delay through the inverter and D flip-flop. A more consistent pulse width could be obtained with a 74S04 instead of the 74LS04. However, as will be shown, this is not necessary to meet the design goals.

An 8 nsec pulse width would provide the following flatness error at 50 MHz.

$$\text{Error} = 20\log\left[\frac{\sin\left(\frac{50}{125}\pi\right)}{\left(\frac{50}{125}\pi\right)}\right] = -2.4\text{ dB}$$

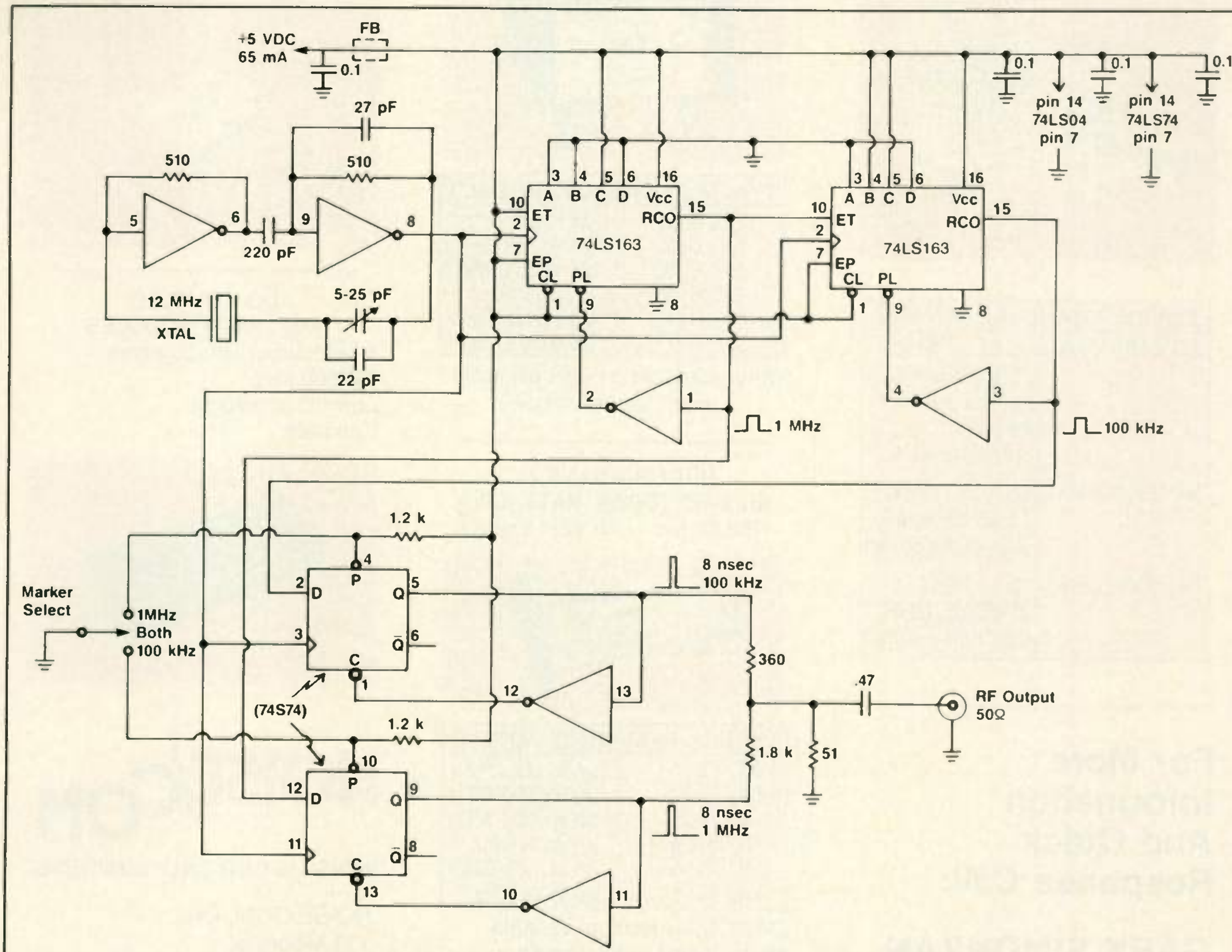
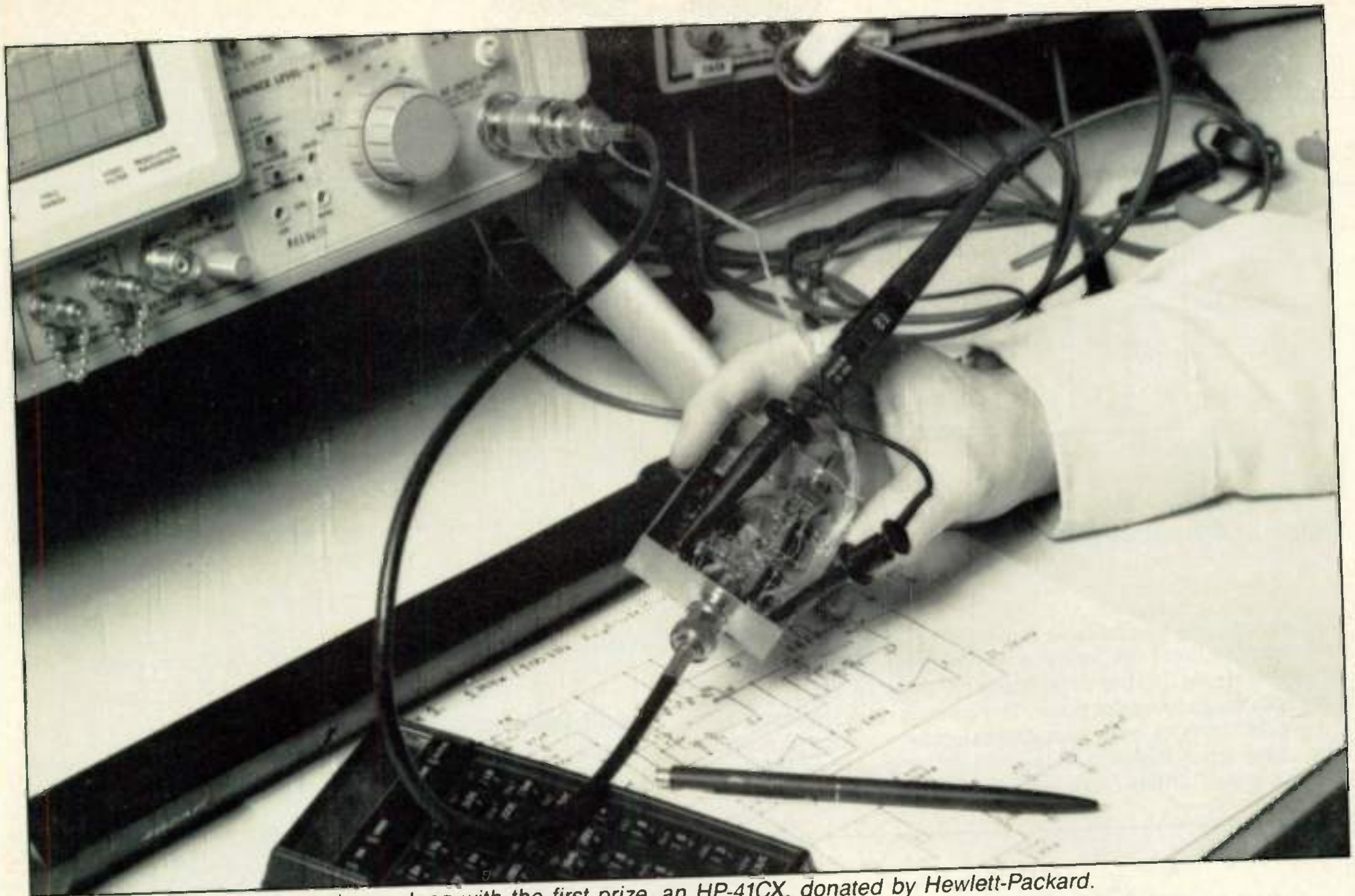


Figure 1. 1 Mhz/100 kHz Amplitude/Frequency Calibrator circuit diagram.



The winning circuit is shown here, along with the first prize, an HP-41CX, donated by Hewlett-Packard.

PIEZO's Mini Wonder.

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

- ☐ Stress compensated (SC) cut crystal
- ☐ Single supply voltage
- ☐ Low power consumption

- ☐ High short-term stability
- ☐ Low phase noise
- ☐ Fast warm up

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

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

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

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

1.98″ × 1.59″ × .98″ (LWH)

PIEZO SYSTEMS

INFO/CARD 36

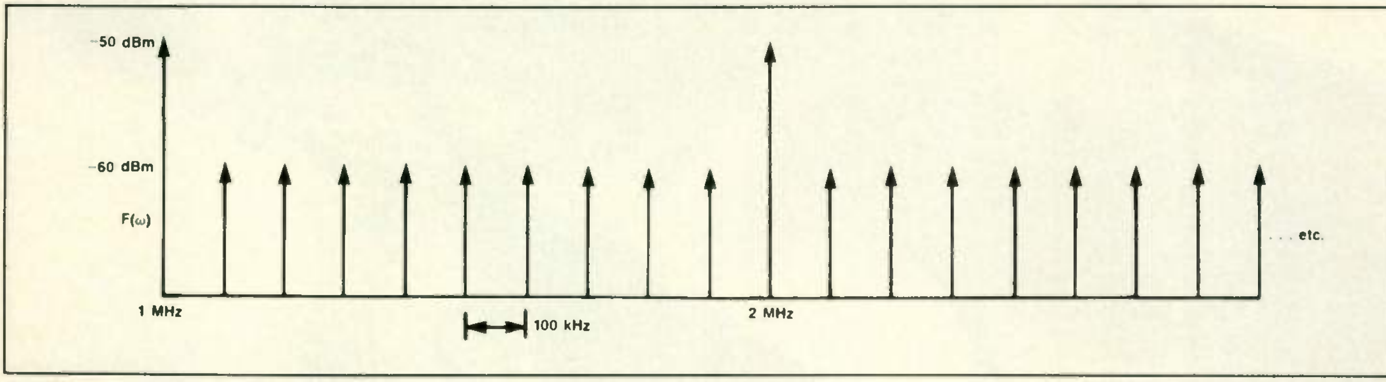
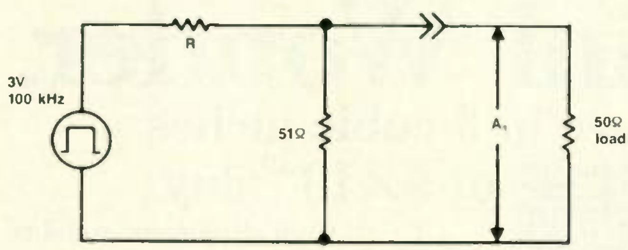


Figure 2. Output spectrum

This is actually a worst case since 1) the pulse is typically narrower and the first zero greater than 125 MHz, reducing the error at 50 MHz, and 2) the D flip-flop is not capable of generating a very narrow rectangular pulse. The pulse is rounded and, due to slew rate limiting, better approximated by a triangular pulse. This spectrum is flatter than the (sin x)/x frequency response and this effect further reduces the amplitude flatness error at 50 MHz. The measured error of the prototype circuit was <2 dB.

$$A_1 = \frac{1}{2F_o\tau}(317\mu V) = 198 \text{ mV}$$

For F_o = 100 kHz and τ = 8 nsec

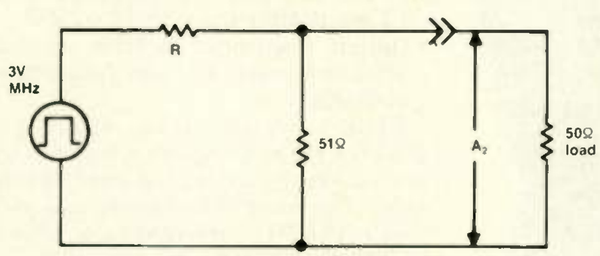


therefore, R = 360Ω

(a) 100 kHz, −60 dBm markers

$$A_2 = \frac{1}{2F_o\tau}(708\text{-}224)\ \mu V(\sqrt{2}) = 42.8 \text{ mV}$$

For F_o = 1 MHz and τ = 8 nsec



therefore, R = 1.8 kΩ

(b) 1 MHz, −50 dBm markers.

Figure 3. Determination of attenuator resistor values.

Circuit Description

To provide markers at 1 MHz and 100 kHz, two programmable synchronous counters are used. Crystals at 12 MHz are readily available and most work well in the TTL inverter oscillator shown. The trimmer capacitor is adjusted to calibrate the oscillator to a frequency standard.

The first counter divides by 12 and the second by 10. The two D flip-flops generate the 8 nsec pulses so that 1 MHz and 100 kHz markers can be generated simultaneously or separately. The 12 MHz oscillator synchronously clocks the two D flip-flops as well as the counters. This allows the 100 kHz pulses to occur precisely coincident with every tenth 1 MHz pulse. This is necessary for proper in-phase addition of the two spectra when both 1 MHz and 100 kHz markers are to be generated.

The desired output power for the calibrator is −60 dBm for the 100 kHz markers and −50 dBm for the 1 MHz markers (Figure 2). This is rather high for most narrowband receivers and the output may need padding for "S" meter calibration. For the 100 kHz spectral components, the required output into 50 ohms is:

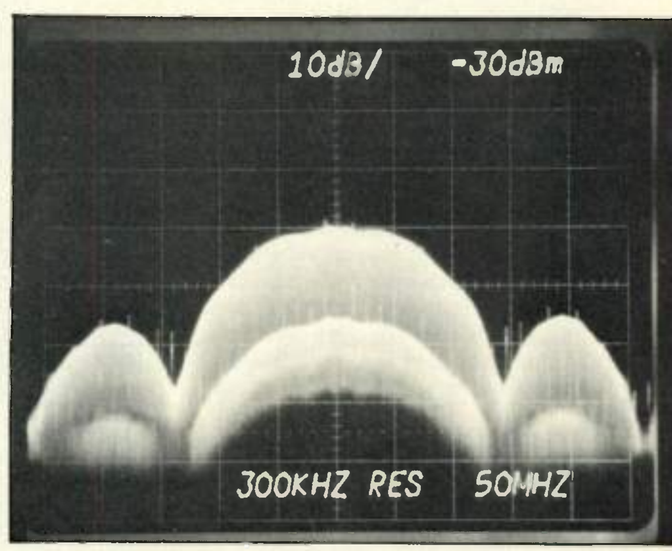


Figure 4. Double-sided (sin x)/x spectrum of the calibrator.

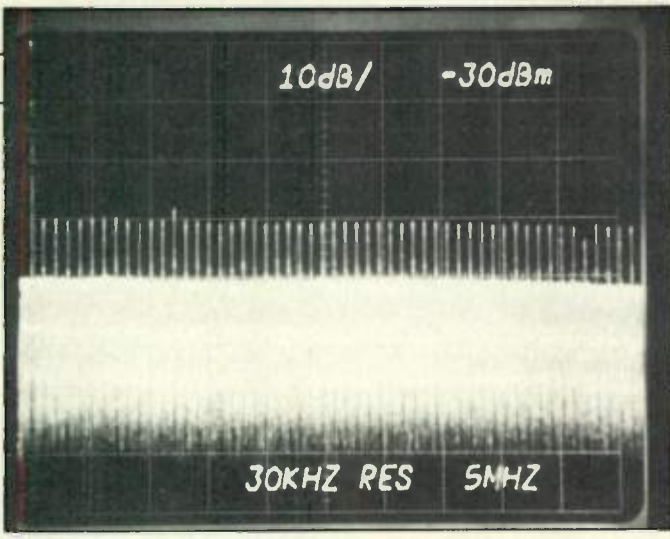


Figure 5. 0-50 MHz markers, showing approximately 2 dB flatness error at 50 MHz.

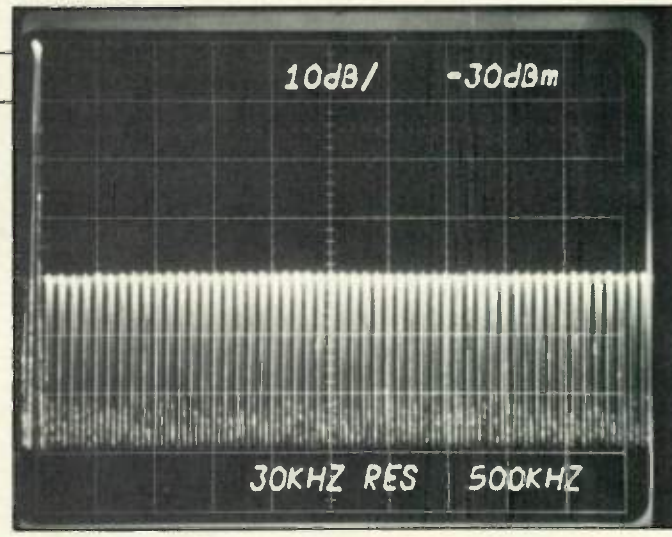


Figure 6. 100 kHz markers, from 0-5 MHz at −60 dBm.

$$-60\ \text{dBm} = 20 \log \frac{V_{Fo}}{224\ \text{mV}}$$

$V_{Fo} = 224\ \mu V_{RMS} = 317\ \mu V$ peak

This requires an attenuator on the output of the TTL flip-flop. The values are then calculated as shown in Figure 3a. It is desired that the 1 MHz markers be 10 dB above the 100 kHz marker amplitudes. The attenuator for the 1 MHz markers is shown in Figure 3b.

Note that when both markers are present, the 1 MHz markers will be 3.3 dB higher than the amplitude when generated alone. This is due to the in-phase addition of the 1 MHz components of both spectra.

Prototype Results

Figures 4 through 8 illustrate the measured results of the prototype. Figure 4 is the double-sided (sin x)/x magnitude response. Note that the first zero is slightly higher than 125 MHz indicating the pulse width is slightly less than 8 nsec.

Figure 5 shows the first 50 MHz of the spectrum and illustrates the predicted flatness error of about 2 dB. Note that the 12 MHz component is too high. This is probably due to crosstalk in the hex inverter. A separate XTAL oscillator would probably eliminate this error at the expense of more parts.

Figures 6, 7 and 8 show a 5 MHz segment of the first 30 MHz. Figures 3 and 4 show the 100 kHz and 1 MHz markers when selected separately. Figure 5 shows the composite calibrator output. Note that the marker amplitudes are about 10 dB different, as predicted. Also note that the 1 MHz markers are about 3 dB lower (Figure 7) when selected individually, as was also predicted.

One note of caution is in order. Receivers have a limited voltage dynamic range at their inputs. Pulses much larger than the ones used in this design can overload a receiver input. If very fine resolution markers are desired using this technique, it would be prudent to consider a chirp or other more complex technique to obtain a flat spectrum with good signal-to-noise ratio.

This circuit provides a cheap, yet quite accurate calibrator of both amplitude and frequency over the 30 MHz HF band. It can serve as a general purpose reference for a general coverage receiver or spectrum analyzer. rf

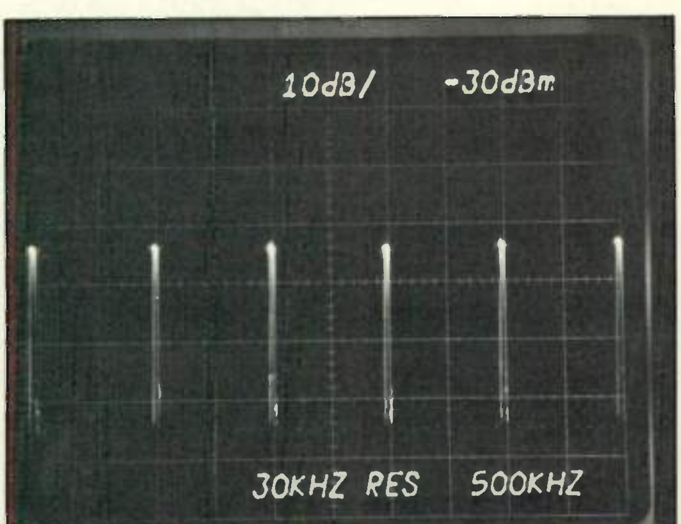


Figure 7. 1 MHz markers, from 1-6 MHz. Note level at about 3 dB below −50 dBm.

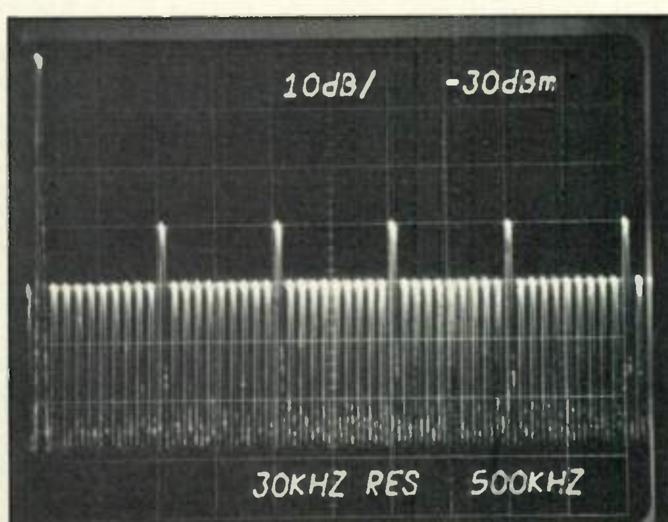
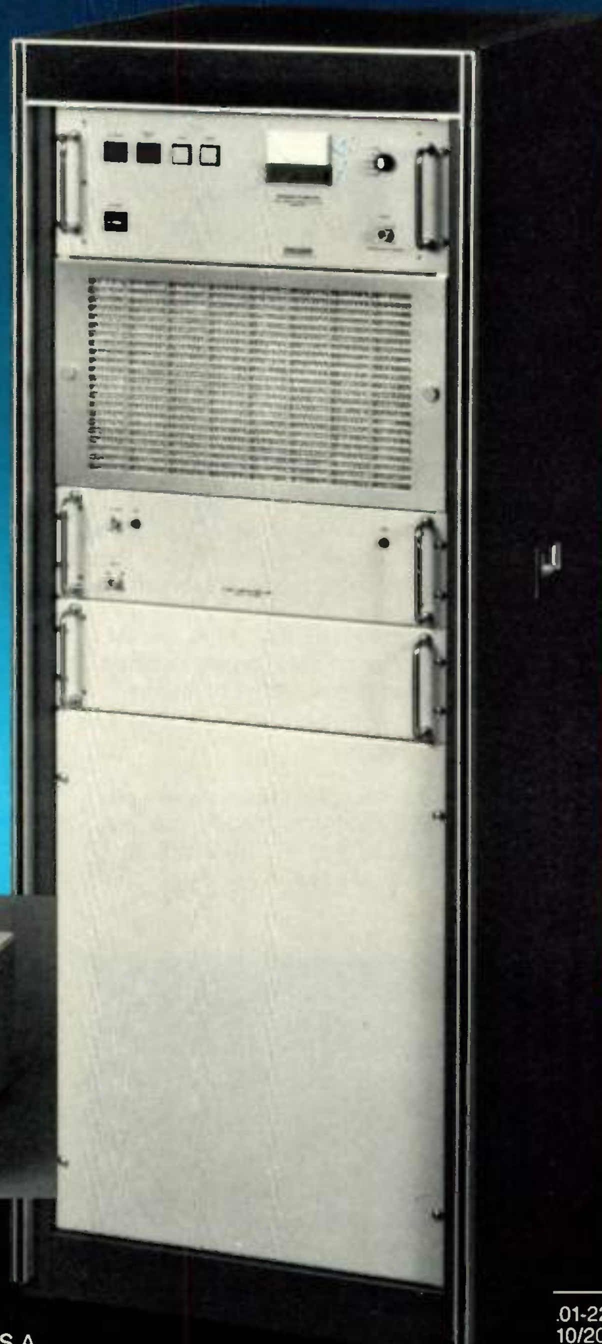


Figure 8. Both markers combined, 0-5 MHz, showing accuracy of amplitude.

HIGH ENERGY RF POWER



Our high standards of manufacturing excellence is your assurance of superior quality in design, versatility and reliability. Choose from our complete line of over 30 laboratory type AC instruments or from more than 40 DC modules for OEM or special projects. Over 16 years of RF Power design and manufacture. If we don't have what you need, we'll design it for you! Send for free catalog.

EMI/RFI TESTING
NMR SPECTROSCOPY
LINEAR ACCELERATORS
MEDICAL RESEARCH
COMMUNICATIONS
FULLY VSWR PROTECTED

2-30MHz
200/400/1000/2000/3500 WATTS

.01-220MHz
10/200/500/
1000 WATTS

MADE IN U.S.A.

KALMUS

Engineering International, Ltd., U.S.A.
21820 87TH SE, WOODINVILLE, WA 98072
(206) 485-9000 TELEX: 24-7028

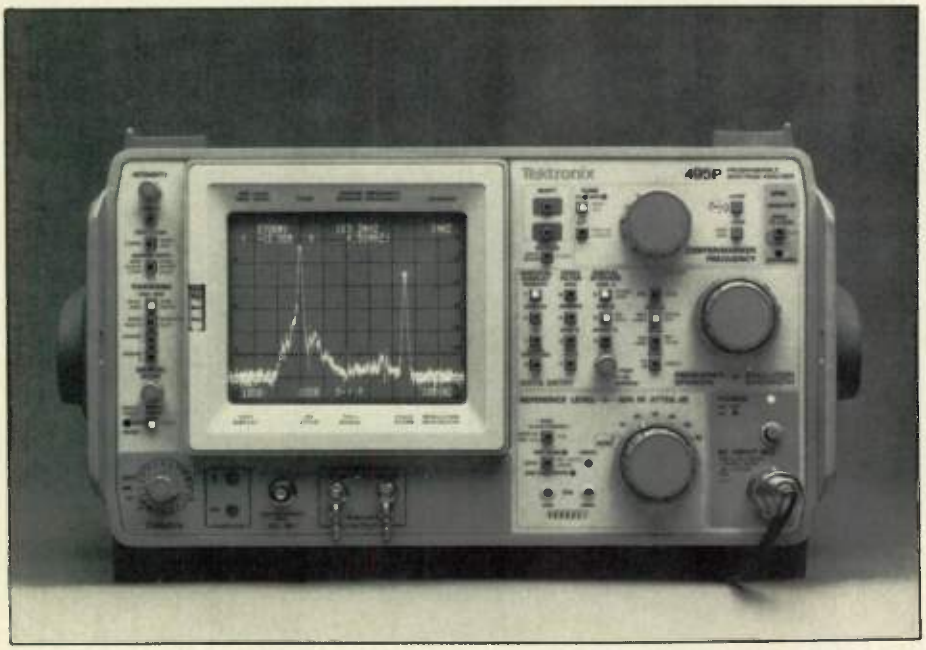
INFO/CARD 37

rf design feature

Macros Simplify RF Measurements

Programmable Test Routines Run Without Host Computer

By Robert Vistica
Tektronix, Inc.



Front panel view of the Tektronix 495P Spectrum Analyzer shows waveform and readout under macro control.

Microprocessor-based instruments are substantially improving both day-to-day and special-purpose measurement capability. The capacity for built-in processing can reduce complex measurements to pressing a single button. Modern spectrum analyzers now offer automatic discrimination and processing of CW, pulse, or spurious signals. There are also automatic occupied bandwidth and signal tracking functions that eliminate the need for constant adjustment.

A new level of capability is being added to instrumentation: "macros," which combine built-in-controlled functions into "macro-functions." These macro functions can be specifically created to perform a complete measurement sequence, such as total harmonic distortion, signal-to-noise ratio, or spectrum surveillance, and can check input signal validity. Measurement results can be displayed on the spectrum analyzer screen (Figure 1).

The benefit of macros is that complex measurement sequences can be downloaded from a system controller for front-panel execution by the instrument. Frequency markers are positioned automatically and marker data is collected, compiled and processed automatically. Besides being done automatically, the measurements are done the same way every time the macro function is executed, resulting in faster measurements with higher repeatability and confidence. Operation is simplified to the pressing of just two or three buttons. This makes the most complex measurement sequences easy.

The Tektronix 495P Spectrum Analyzer can store eight different macro functions in the instrument's memory. A MACRO MENU button is used to display the macro list on screen (Figure 2). A macro function is selected by entering its menu number from the spectrum analyzer keypad, and is then executed automatically (or reinitiated) by pressing the RUN/STOP button.

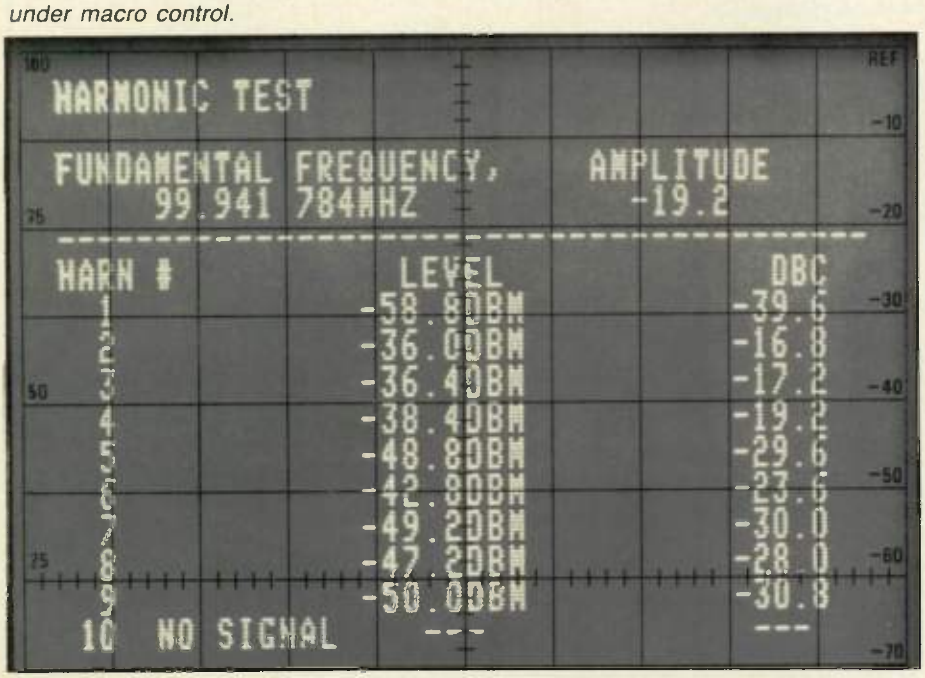


Figure 1. Measurement results displayed on screen.

How Macros Work

A macro is a single computer instruction that stands for a series of operations. For example, the "+" symbol in BASIC is a macro instruction that implements a series of assembly language instructions that cause two numbers to be added together. A BASIC subroutine to multiply complex numbers could also be considered a macro if it can be called by a single label. Fundamentally, however, a macro or macro function can simply be thought of as a program. It is a collection of commands or instructions placed in a certain order to accomplish a specific task.

In a sense, a sheet of written instructions telling you how to set up a harmonic distortion measurement is a macro. It has a macro title, e.g., HARMONIC PASS/FAIL, and an ordered series of instrument setup instructions. A HARMONIC PASS/FAIL macro for the Tektronix 495P Spectrum Analyzer is similar in concept. The major difference, of course, is that the instructions or commands will be in the spectrum analyzer's language and will be executed from the spectrum analyzer's memory.

The instruction: STMAC 2, "HARMONIC PASS/FAIL" tells the spectrum analyzer to store subsequent commands as macro

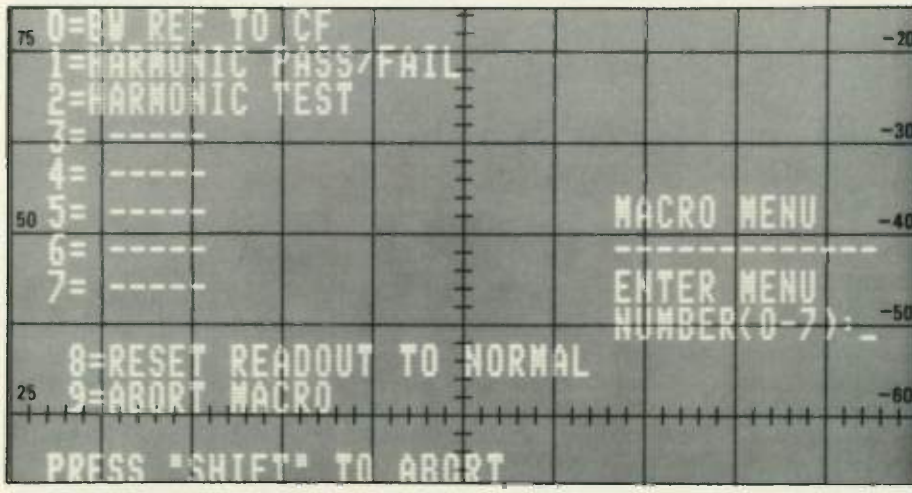


Figure 2. Menu display of available macros.

HARMONIC PASS/FAIL TEST

THIS MACRO WILL DISPLAY "TEST PASSED" IF THE FUNDAMENTAL'S 1ST HARMONIC IS LESS THAN 60 dBc FROM THE FUNDAMENTAL'S AMPLITUDE. IF IT IS NOT, "TEST FAILED" WILL BE DISPLAYED.

```
STMAC 2, "HARMONIC PASS/FAIL"      * store macro #2
MARKER SINGLE                      * turn on single markers
SWEEP                              * take a sweep
MFBIG                              * move marker to peak
IF SIGNAL                          * if signal, then go look for harmonic
   MCEN                            * center marker
   STEP PRIMAR                     * put marker frequency into step size
   MARKER DELTA                    * turn on delta markers
   PSTEP                           * plus step
   SWEEP                           * take a sweep
   THRHLD -60
   MFBIG                           * move marker to peak
   IF NOSIG                        * if no signal, then test passed
   PRINT 1,10 "TEST FAILED"
   ELSE PRINT 1,5, "TEST FAILED"
   ENDI                            * move marker back to fundamental
   MSTEP
   THRHLD AUTO                     * no fundamental frequency was found
ELSE
PRINT 1,2 "NO SIGNAL FOUND"
PRINT 2,10, "MACRO ABORTED"
ENDI                               * done with macro
DONE                               * end macro entry
EMAC
```

Note: This macro will use less than 1/30 of the total available NVRAM.

Figure 3. A simple macro harmonic test.

The Modern Spectrum Analyzer

The fundamental principles of the superheterodyne spectrum analyzer have not changed over the years. Still in use is a swept local oscillator (LO), a mixer, and a narrowband IF amplifier to create spectral displays of input waveforms.

There have been substantial improvements, however. Resolution and dynamic ranges have been enhanced. Second LOs and IFs have extended swept frequency ranges up to 325 GHz. Frequency markers have been added to speed and simplify on-screen measurements.

The most dramatic improvements have appeared in just the last few years. They began with the addition of microprocessors to automatically control some of the more complex functions of spectrum analyzers. Waveform digitizing and storage were also added so that spectra could be stored in digital memory and re-displayed at will, providing clear, stable displays at the slowest scan rates. Also, with multiple memories, several spectra can be stored and called up for comparison.

Of course, with digitally stored spectra and a built-in microprocessor, it wasn't long before spectrum analyzers began to appear with a variety of spectrum search and processing capabilities. Today, spectrum analyzers are appearing with an impressive array of automated functions that simplify complex measurements. For example, the new 495P Spectrum Analyzer from Tektronix offers these major features:

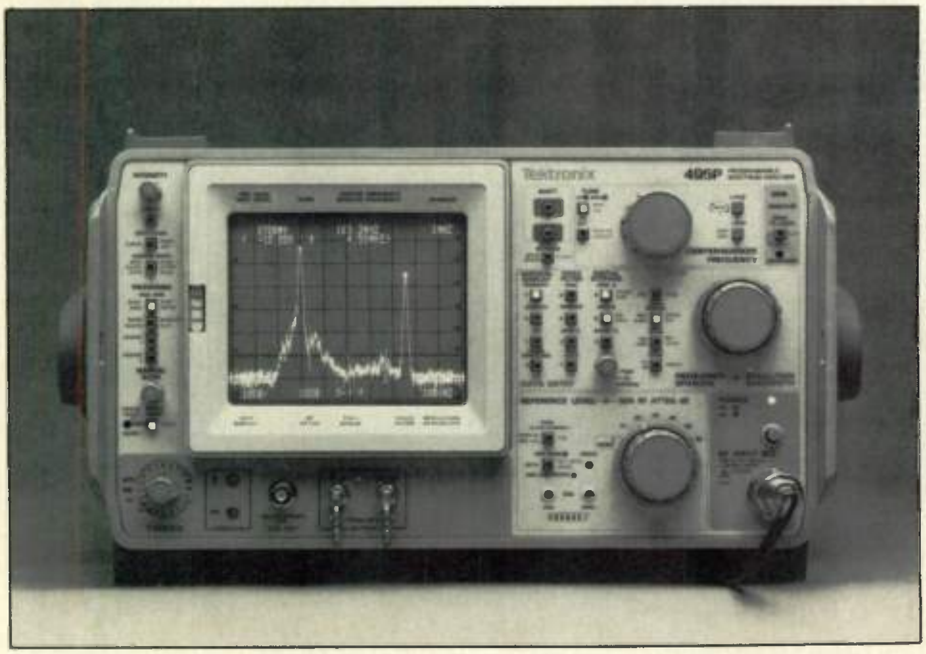
- built-in signal counter
- processing to sort pulsed RF, continuous wave (CW), and other signals
- occupied bandwidth function automatically marks and measures bandwidth
- screen display of HELP information — a manual in memory
- nonvolatile memory for storing up to nine front-panel setups
- front-panel execution of downloaded programs with the 495P option 05

Of the above features, the macro programming option has the highest potential for creating extended measurement power and simplicity. Frequently used or highly complex measurement procedures can be committed to macros and downloaded to the 495P's nonvolatile memory. The macros can then be selected and executed by simply pressing a few buttons on the 495P front panel.

rf design feature

Macros Simplify RF Measurements

Programmable Test Routines Run Without Host Computer



Front panel view of the Tektronix 495P Spectrum Analyzer shows waveform and readout under macro control.

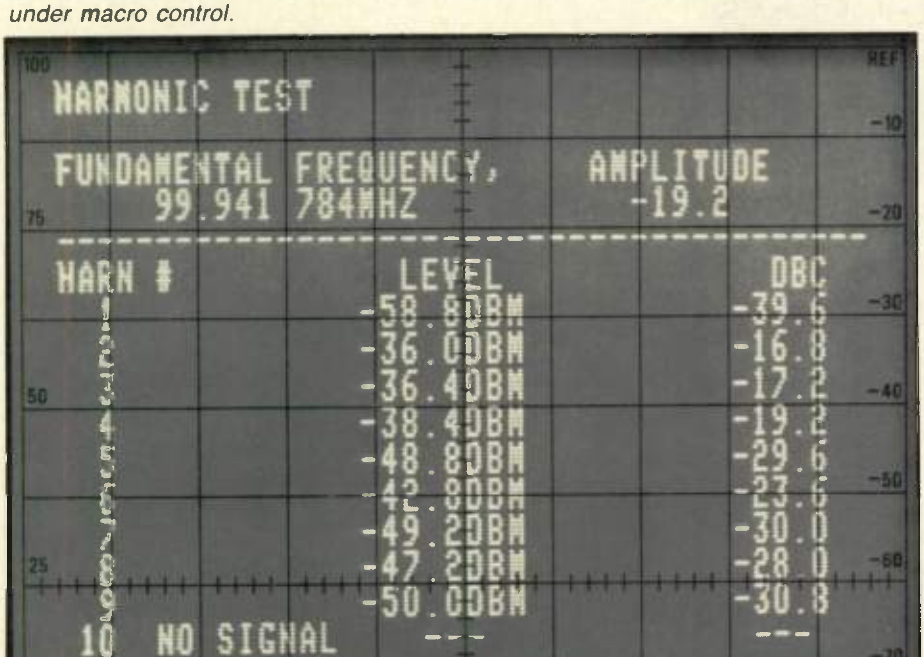


Figure 1. Measurement results displayed on screen.

By Robert Vistica
Tektronix, Inc.

Microprocessor-based instruments are substantially improving both day-to-day and special-purpose measurement capability. The capacity for built-in processing can reduce complex measurements to pressing a single button. Modern spectrum analyzers now offer automatic discrimination and processing of CW, pulse, or spurious signals. There are also automatic occupied bandwidth and signal tracking functions that eliminate the need for constant adjustment.

A new level of capability is being added to instrumentation: "macros," which combine built-in-controlled functions into "macro-functions." These macro functions can be specifically created to perform a complete measurement sequence, such as total harmonic distortion, signal-to-noise ratio, or spectrum surveillance, and can check input signal validity. Measurement results can be displayed on the spectrum analyzer screen (Figure 1).

The benefit of macros is that complex measurement sequences can be downloaded from a system controller for front-panel execution by the instrument. Frequency markers are positioned automatically and marker data is collected, compiled and processed automatically. Besides being done automatically, the measurements are done the same way every time the macro function is executed, resulting in faster measurements with higher repeatability and confidence. Operation is simplified to the pressing of just two or three buttons. This makes the most complex measurement sequences easy.

The Tektronix 495P Spectrum Analyzer can store eight different macro functions in the instrument's memory. A MACRO MENU button is used to display the macro list on screen (Figure 2). A macro function is selected by entering its menu number from the spectrum analyzer keypad, and is then executed automatically (or reinitiated) by pressing the RUN/STOP button.

How Macros Work

A macro is a single computer instruction that stands for a series of operations. For example, the "+" symbol in BASIC is a macro instruction that implements a series of assembly language instructions that cause two numbers to be added together. A BASIC subroutine to multiply complex numbers could also be considered a macro if it can be called by a single label. Fundamentally, however, a macro or macro function can simply be thought of as a program. It is a collection of commands or instructions placed in a certain order to accomplish a specific task.

In a sense, a sheet of written instructions telling you how to set up a harmonic distortion measurement is a macro. It has a macro title, e.g., HARMONIC PASS/FAIL, and an ordered series of instrument setup instructions. A HARMONIC PASS/FAIL macro for the Tektronix 495P Spectrum Analyzer is similar in concept. The major difference, of course, is that the instructions or commands will be in the spectrum analyzer's language and will be executed from the spectrum analyzer's memory.

The instruction: STMAC 2, "HARMONIC PASS/FAIL" tells the spectrum analyzer to store subsequent commands as macro

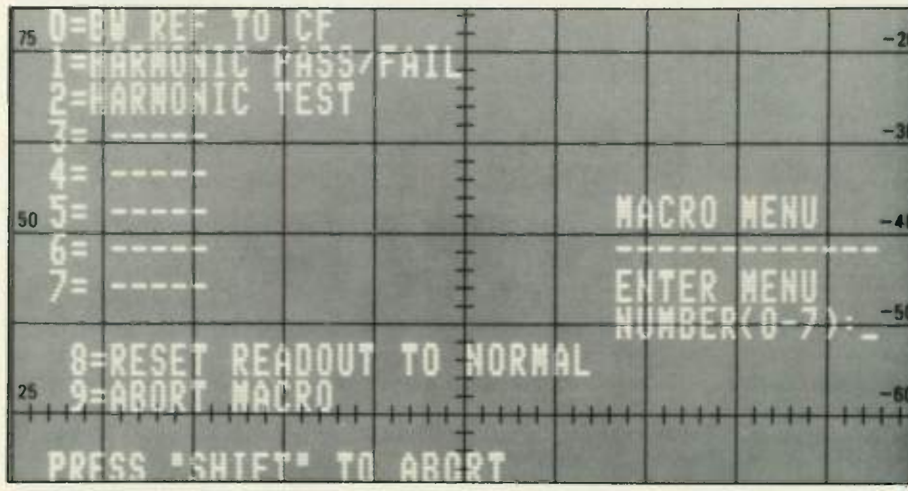


Figure 2. Menu display of available macros.

HARMONIC PASS/FAIL TEST

THIS MACRO WILL DISPLAY "TEST PASSED" IF THE FUNDAMENTAL'S 1ST HARMONIC IS LESS THAN 60 dBc FROM THE FUNDAMENTAL'S AMPLITUDE. IF IT IS NOT, "TEST FAILED" WILL BE DISPLAYED.

```
STMAC 2, "HARMONIC PASS/FAIL"          * store macro #2
MARKER SINGLE                          * turn on single markers
SWEEP                                  * take a sweep
MFBIG                                  * move marker to peak
IF SIGNAL                              * if signal, then go look for harmonic
   MCEN                                * center marker
   STEP PRIMAR                         * put marker frequency into step size
   MARKER DELTA                        * turn on delta markers
   PSTEP                               * plus step
   SWEEP                               * take a sweep
   THRHLD -60
   MFBIG                               * move marker to peak
   IF NOSIG                            * if no signal, then test passed
   PRINT 1,10 "TEST FAILED"
   ELSE PRINT 1,5, "TEST FAILED"
   ENDI                                * move marker back to fundamental
   MSTEP
   THRHLD AUTO                         * no fundamental frequency was found
ELSE
PRINT 1,2 "NO SIGNAL FOUND"
PRINT 2,10, "MACRO ABORTED"
ENDI                                   * done with macro
DONE                                   * end macro entry
EMAC
```

Note: This macro will use less than 1/30 of the total available NVRAM.

Figure 3. A simple macro harmonic test.

The Modern Spectrum Analyzer

The fundamental principles of the superheterodyne spectrum analyzer have not changed over the years. Still in use is a swept local oscillator (LO), a mixer, and a narrowband IF amplifier to create spectral displays of input waveforms.

There have been substantial improvements, however. Resolution and dynamic ranges have been enhanced. Second LOs and IFs have extended swept frequency ranges up to 325 GHz. Frequency markers have been added to speed and simplify on-screen measurements.

The most dramatic improvements have appeared in just the last few years. They began with the addition of microprocessors to automatically control some of the more complex functions of spectrum analyzers. Waveform digitizing and storage were also added so that spectra could be stored in digital memory and re-displayed at will, providing clear, stable displays at the slowest scan rates. Also, with multiple memories, several spectra can be stored and called up for comparison.

Of course, with digitally stored spectra and a built-in microprocessor, it wasn't long before spectrum analyzers began to appear with a variety of spectrum search and processing capabilities. Today, spectrum analyzers are appearing with an impressive array of automated functions that simplify complex measurements. For example, the new 495P Spectrum Analyzer from Tektronix offers these major features:

- built-in signal counter
- processing to sort pulsed RF, continuous wave (CW), and other signals
- occupied bandwidth function automatically marks and measures bandwidth
- screen display of HELP information — a manual in memory
- nonvolatile memory for storing up to nine front-panel setups
- front-panel execution of downloaded programs with the 495P option 05

Of the above features, the macro programming option has the highest potential for creating extended measurement power and simplicity. Frequently used or highly complex measurement procedures can be committed to macros and downloaded to the 495P's nonvolatile memory. The macros can then be selected and executed by simply pressing a few buttons on the 495P front panel.

number 2 with the title of HARMONIC PASS/FAIL test. The next command might be MARKER SINGLE, which would turn on the spectrum analyzer's single market. This would be followed by SWEEP to cause the spectrum analyzer to sweep the input signal and store its digitized spectrum in memory. Then MFBIG would move the marker to the highest spectral peak, the fundamental of the input signal.

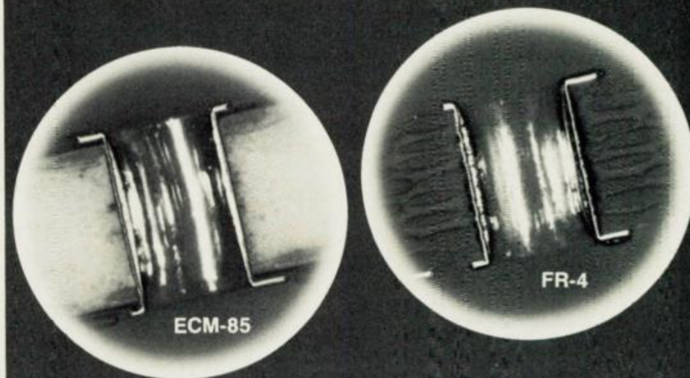
With the fundamental found and defined by a marker, additional commands are executed to turn on a second marker and step it through a search for the second harmonic. the vertical difference between the two markers, one on the fundamental peak and the other on the harmonic peak, provides a relative amplitude reading for the second harmonic. For a simple harmonic test, the level of the second harmonic can be compared to a preset threshold level for a pass/fail decision.

Figure 3 illustrates a macro listing for the pass/fail harmonic test described above. Basically, the test uses the spectrum analyzer's markers to find the fundamental and second harmonic and measure the amplitude difference. In this example, if the second harmonic marker is more than 60 dB below the fundamental, a "TEST PASSED" message is displayed on the spectrum analyzer screen.

MATH COMMANDS	
+PLUS	Add the X and Y registers.
– SUBT	Subtract the X register from the Y register.
* MULT	Multiply the X and Y registers.
/ DIVIDE	Divide the Y register by the X register.
REGISTER COMMANDS	
ENTER	Enter a value into X register.
PUTREG	Put the contents of X register into a setting.
EXCHG	Exchange the numbers in the X and Y registers.
POP	Put the contents o Y register into X register.
BRANCHING COMMANDS	
GOTO	Go to a label.
GOSUB	Go to a subroutine.
RETURN	Return from a subroutine.
LABEL	Label this point in the macro.
IF	If "STATEMENT" then do.
ELSE	ELSE do.
ENDI	End of IF statement.
LOOPING COMMANDS	
FOR	FOR variable =X to Y STEP Z.
NEXT	Next stop.
PRINT COMMANDS	
CLEAR	Clear maco readout buffer.
DSLINE	Display line (affects normal 3-line readout).
PRINT	Print number and/or string.
TEXT	Text mode — normal 3-line, 16-line, or macro readout buffer.
DATA COMMANDS	
MDATA	Store numeric data.
READ	Read data and store into X register.
MRESTO	Restore data pointer.
GENERAL	
DONE	Done with macro execution.
EMAC	End macro entry.
GETWFM	Get current waveform (store waveform in DISBUF).
INPNUM	Input a number from the keypad.
KILL	Delete one or all macros.
MCSTOP	Stop macro execution.
MEMORY?	Return the amount of memory used or remaining memory.
MENU	Display requested menu.
PAUSE	Pause macro execution.
RUN	Start/Restart macro execution.
STMAC	Tell instrument to store the following commands.
STNUM	Store the X register value into a variable.
SWEEP	Start a new sweep and wait for sweep to end.
VAR?	Return the value of a variable.

Figure 4. Macro commands.

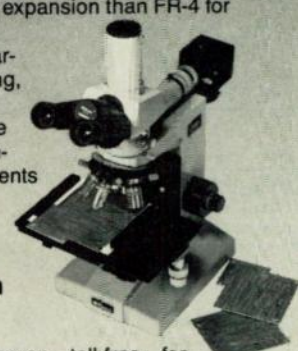
Look Into ECM-85



The FR-4 Alternative

Consistent PTH Quality. Put ECM-85, Cincinnati Milacron's all-glass laminate, up against FR-4 and you'll find it superior in processability and electrical performance. In head to head comparison, ECM-85 consistently provides superior drilled hole quality for PTH applications.

- Lower, more stable dielectric constant and dissipation factor over a wider range of frequencies, temperatures and humidities than FR-4
- Excellent dimensional stability and flatness
- Superior hole quality for both drilled and punched applications
- 20% lower Z-axis expansion than FR-4 for PTH reliability
- Greater safety margins in arc tracking, and high current ignition resistance
- Meets 94-VO flammability requirements



Make Your Own Comparison

Call Cincinnati Milacron—toll-free—for more information, samples, and the name of your nearest ECM-85 approved fabricator. Direct inquiries to:

Steve Hayden or Arlene Bennett
Cincinnati Milacron Marketing Company
P.O. Box 246
Blanchester, OH 45107

1-800-221-7084
(In Ohio, call 513-783-2464)

CINCINNATI MILACRON

INFO/CARD 38

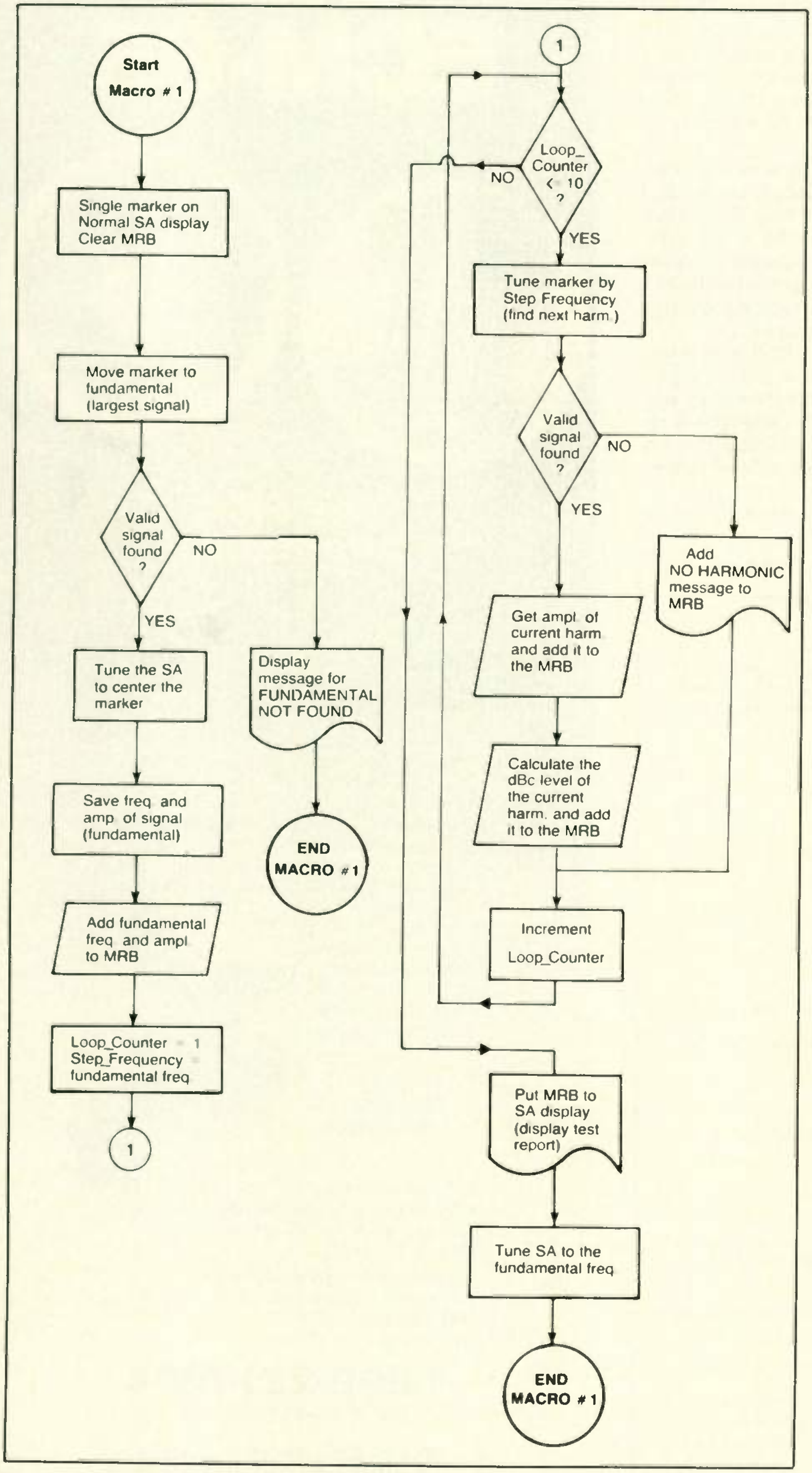


Figure 5. Flow chart for a macro which measures harmonic distortion.

The point of this example is not the detail of the macro code. Much of that can be discerned from the Figure 3 listing. What is important to realize is that a spectrum analyzer macro is a specialized program, similar in structure to a BASIC program. Most of the commands differ from BASIC since they deal with instrument function (SWEEP, MARKER DELTA, THRHLD -60), but there are also some striking command similarities in macro control (IF. . . ELSE, FOR. . . NEXT, GOTO, GOSUB). See Figure 4 for a list of macro commands.

Harmonic Distortion Example

The most important aspect of macros is their potential for extensive measurement capability at the push of a few buttons. Figure 5 blocks out a total harmonic distortion macro that is a substantial extension of Figure 3. The macro searches out all of the significant harmonics of the input signal, testing each signal for validity. That is, does the detected harmonic level meet some preset level criterion for validity? If it does, the harmonic level and amplitude relative to the fundamental (dBc) are measured with the frequency markers and recorded. If the detected harmonic does not meet the level criterion, it is marked as "NO SIGNAL." This is shown in Figure 1, which is an example of results output by this macro.

Checking signal validity is important to measurement accuracy. Noise or a spurious response could be mistaken for a harmonic that is actually missing or suppressed below the noise floor. This would lead to a measurement error which could be significant for signals already having a low total harmonic distortion. To avoid such errors, a threshold level can be set as a criterion for harmonic validity.

The threshold level could be a value that is entered from the spectrum analyzer keypad, it could be determined by one of the built-in marker placement routines, or it could be based on the analyzer's dynamic range. In the latter case, when attempting to validate extremely low-level harmonics, the macro could iteratively compress scan/div while checking the amplitude measurement against the dynamic range limit.

The lengths that can be employed in testing signal validity really depend on the richness of the spectrum analyzer's function and command set. For example, the marker placement and signal find commands on the 495P include:

• MFGIB — move marker to biggest signal on display

• MLTNX — move marker left to next peak

• MFGTNX — move marker right to next peak
• HRAMPL — find next higher peak
• LRAMPL — find next lower peak
• PKFIND — places marker at peak of largest displayed signal
• MVRTDB — move marker right X dB on signal
• MVLFDB — move marker left X dB on signal
• MCEN — move marker and signal to center frequency

In many cases, these commands can be modified by other functions. For example, MVRTDB and MVLFDB operate based on preset dB levels that can be selected or changed.

In some cases it may be desirable to consider only a certain number of harmonics, such as the first three harmonics or maybe the first five. To accommodate such varying requirements, it may be wise to incorporate a query into the macro: HOW MANY HARMONICS? This message would be displayed on the screen when the macro is run, and the program would wait for a number input from the front-panel keypad.

It should also be noted that the 495P front-panel can be adjusted during macro run time, useful in bandwidth measurements. The occupied bandwidth function of the 495P automatically selects the peak of a bandwidth display and moves the markers the designated number of dB down from the peak. The markers also automatically track the designated points if bandwidth varies, such as when adjusting a filter. There may be special cases, however, where the peak of a bandwidth function may not be the desired reference point, such as center frequency. For these cases, a macro could ask that the front-panel frequency control be used to set the marker to the desired center frequency. Once that is done the macro could continue execution — using the front-panel modified occupied bandwidth function — to find bandwidth referenced to the center frequency (Figure 6).

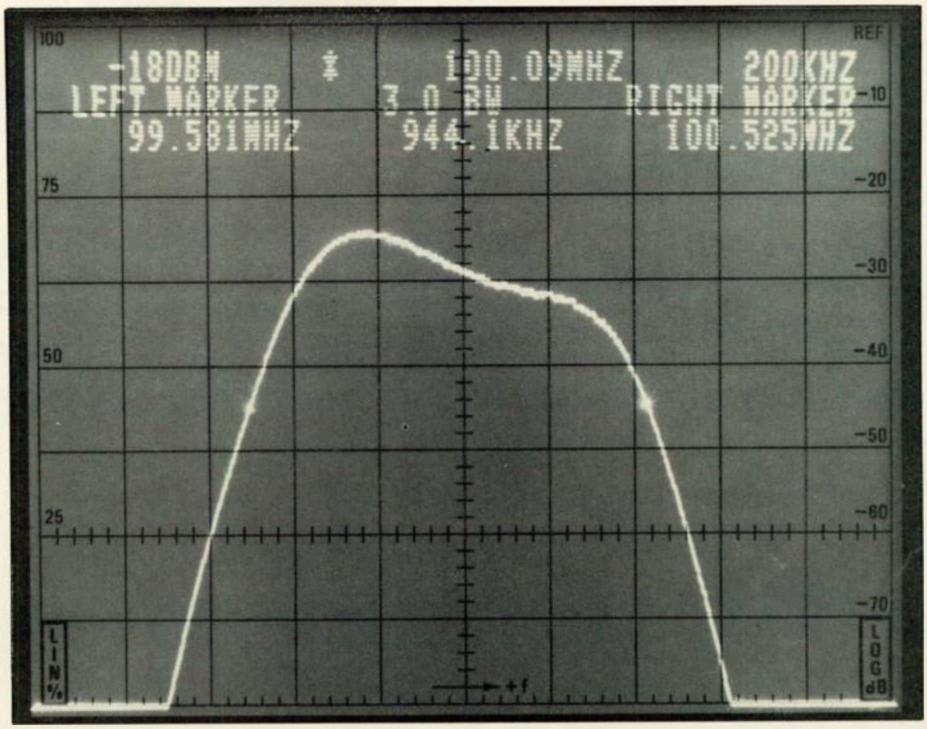


Figure 6. Results of automatic marker placement at −3 dB points to show bandwidth referenced to center frequency.

Creating Macros

Macros for the 495P are created on a computer using any convenient programming language or text editor that generates carriage-return/line-feed terminated ASCII strings. The process is the same as writing any high-level language program, a BASIC program for example. Transfers are done over a General Purpose Interface Bus (GPIB). GPIB interface cards are economically available, along with interface support software, for many computers.

Whatever the computer choice, the major macro requirements are that the macro begin with an STMAC (Store Macro) command and end with an EMAC command. When the macro is transferred to the 495P over the GPIB, STMAC tells the 495P to store subsequent lines as a macro. For example, STMAC 1, "HARMONIC TEST" tells the 495P to store subsequent commands in "macro memory location #1" and give it the title "HARMONIC TEST." EMAC (End Macro), the last line of the macro code, marks the end of macro storage for the 495P.

The 495P can store up to eight macros in instrument memory. This allows a variety of macro measurement functions to be used with the spectrum analyzer, each of which can be selected and executed as desired from the instrument front panel. Since the macros can be run from the spectrum analyzer, a computer is not required after the macros are loaded.

Also, since the 495P memory is nonvolatile, macros are retained even when instrument power is interrupted or turned off. With nonvolatile memory, macros can be loaded from a central macro library. Then the spectrum analyzer can be disconnected and moved back to the test bench or even shipped to a remote test site with specialized macros already loaded.

The macro library concept is important, too, since this allows the spectrum analyzer to be tailored to any set of specialized measurement tasks. Sets of macros can be grouped by categories for filter response testing, carrier and modulation measurements, noise measurements, pulsed RF, antenna sweeps, and many more. Depending on the immediate test needs, the appropriate set of macros is downloaded to the spectrum analyzer.

A set of macros can reduce a series of complex tests and measurements, involving hundreds of front-panel adjustments, to a matter of pressing just a few buttons. In addition, macros can be employed in ATE systems to locally control and precondition the data acquistion, thus freeing the host controller for other tasks. Erroneous setups and accidental omission of procedure steps are eliminated, and since the macro executes the same way each time, high measurement repeatability and confidence is obtained. rf

About the Author

Robert Vistica is a Firmware Engineer at Tektronix, Inc., having spent eight years working with spectrum analyzers. Most recently he designed and implemented the macros for the 495 programmable spectrum analyzer. Bob can be reached at Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077, or by telephone at (503) 627-1855.

Two Contest Entries Emphasize Simplicity

Many of the design contest entries solved a particular engineering problem in a manner best described as "elegant simplicity." Here are two examples which prove that worthy RF designs need not be complex.

A TTL Compatible RF Modulator/Driver

By George Dodson
Circuit Technology

The RF driving signals for lasers require precise control of on/off pulsing, both in pulse duration and turn-on/turn-off times. The circuit shown in Figure 1 was developed to meet the gating specifications in a laser system using a digital control system. The circuit is particularly suited for use in conjunction with high power RF amplifiers driving acousto-optic Q-switches in laser systems where Q-switch timing is TTL controlled.

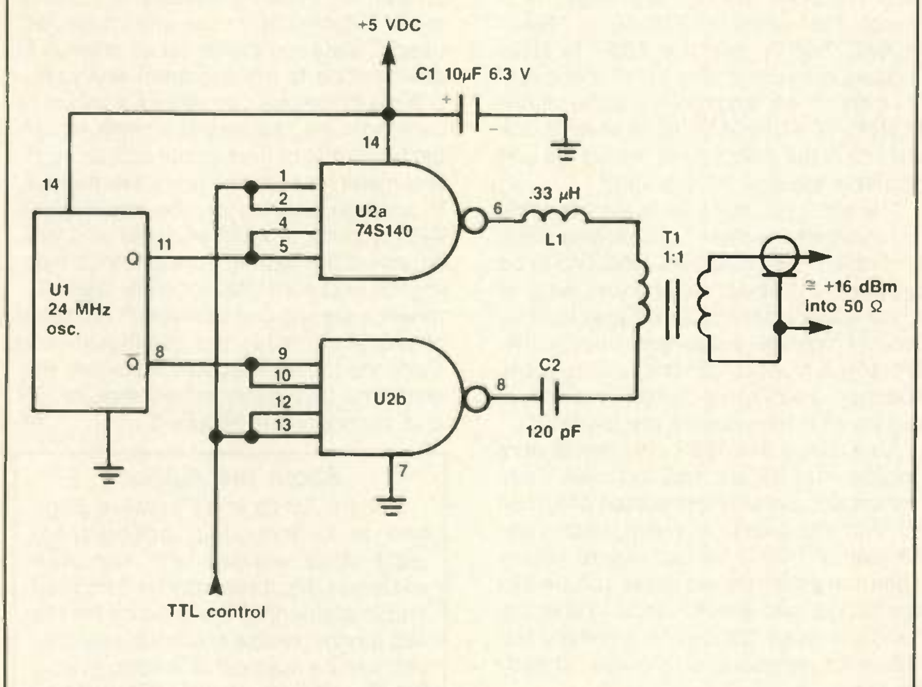


Figure 1. RF Modulator/Driver circuit diagram.

This design uses a 74S140 Schottky line driver to modulate the output of a two-phase crystal clock oscillator and drive a 50 ohm RF output. The circuit provides a +16 dBm output level, enabled by a logical HIGH at the control input. Use of a two-phase clock allows push-pull operation, minimizing feedthrough in the OFF mode.

L1 and C2 act as a low Q bandpass filter, attenuating harmonics and providing a symmetrical sinusoidal output. C2 also provides DC blocking of the T1 primary. The circuit example operates at 24 MHz. The upper limit of operation is limited by the performance of the 74S140 line drivers, approximately 50 MHz. rf

About the Author

George Dodson is proprietor of Circuit Technology, Glendale, CA and is senior engineering consultant to Allied Corporation, Military Laser Products, 31717 La Tienda Drive, Westlake Village, CA 91362. He received his BSEE degree from Worcester Polytechnic Institute.

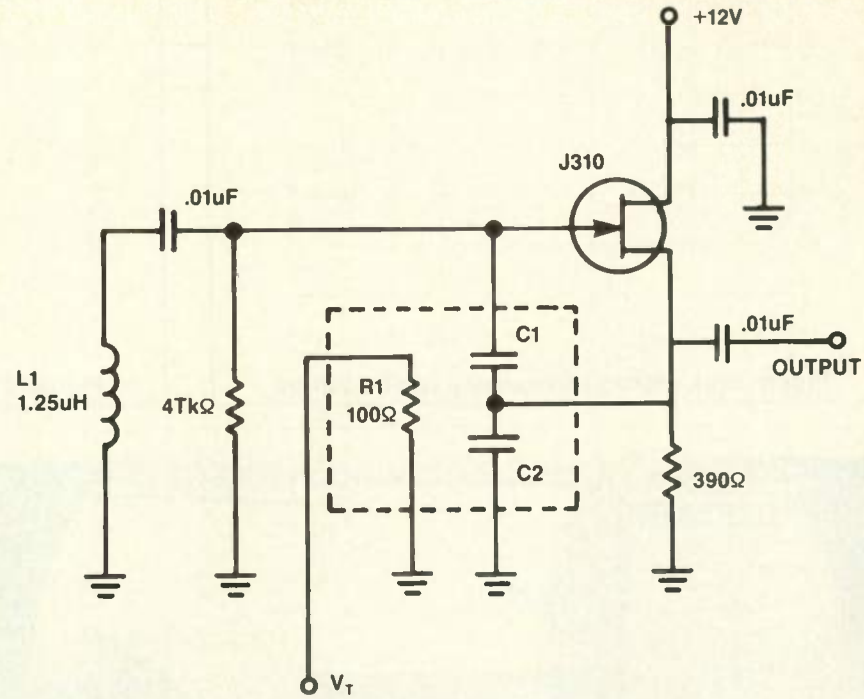
A Thermally-Tuned VCO

By Alfred Helfrick
Dowty RFL Industries

Electronic tuning of an oscillator is almost universally accomplished with a varactor diode. There are, however, some applications where the use of the varactor poses some problems. One such example is a high power oscillator where the high voltage present in the oscillator tuned circuit causes either conduction of the diodes or diode breakdown. Likewise, a pulsed oscillator using a varactor diode can cause a transient frequency shift at turn-on. A high-power or pulsed oscillator frequency can be controlled using heated ceramic capacitors without the problems of a varactor diode.

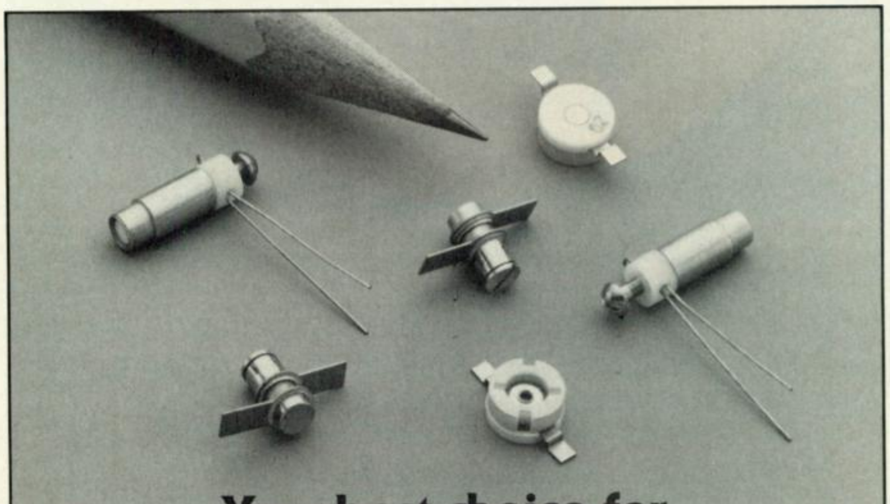
Figure 1 shows an oscillator using a pair of temperature-compensating ceramic capacitors heated with a resistor for frequency control. Although the example circuit operates at a relatively low power level the technique can be adapted to oscillators of practically any power level. For the demonstration circuit, two common N750 ceramic disk capacitors were used. The dipped insulation was removed from the capacitors using a file and ceramic-based resistor sandwiched between the two capacitors. Thermal heatsink compound was used to ensure good thermal contact between the resistor and capacitors. The ceramic resistor was used because of the relatively high power dissipation of this resistor for its small size. A good source of flat ceramic resistors is the DIP or SIP resistance pack where all of the resistors can be placed in parallel.

Figure 2 shows the frequency-voltage and the frequency-time characteristics of the test oscillator. As suspected, the oscillator shows a significant time delay between the applied control voltage and the frequency changes. This limits the applications for such an oscillator and precludes any applications requiring rapid frequency correction. An oscillator of this sort would be suited for the control of industrial heating equipment, where frequency control is necessary because of FCC requirements, but tolerances are loose. Another application is for radar transponders where a high-power oscillator is pulsed but frequency control is loose (0.3 percent).



C1 = 30 pF N750 Cap
C2 = 82pF N750 Cap
R1 = Cermet thin film resistor such as Dale M9340103 series. Resistance depends on control voltage range.

Figure 1. 30 MHz test oscillator diagram



Your best choice for UHF and microwave applications.

Sprague-Goodman Gigaherz Trimmer Capacitors.

Nobody offers a wider selection of single turn ceramics, multiturn sapphire and plastic trimmers for applications in the UHF and lower GHz bands. All feature high Q, great stability, small size and low cost.

For RF applications, our line includes sub-miniature glass and quartz Piston-caps®, plastic Filmtrims® and Ceramic single turn, Mica compression, Airtrim® air dielectric, miniature LC tuners, and Stab-L® metallized inductors.

SPRAGUE GOODMAN

(An affiliate of the Sprague Electric Company)

134 Fulton Ave., Garden City Pk., NY 11040. 516-746-1385. TWX: 510-600-2415. TLX: 14-4533.

INFO/CARD 39

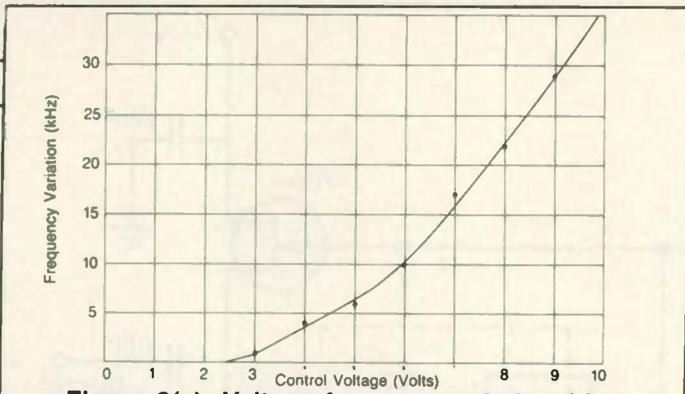


Figure 2(a). Voltage-frequency relationships

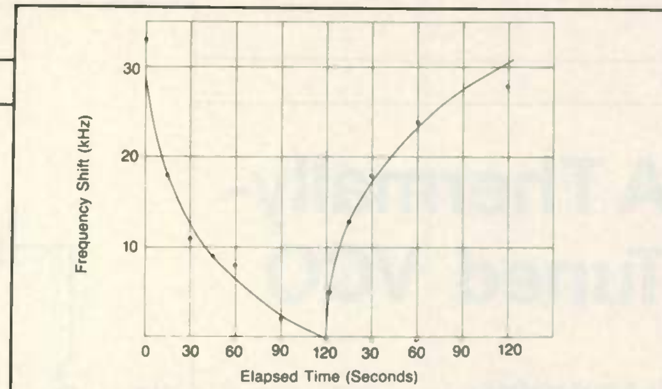


Figure 2(b). Time-frequency dependance

A possible variation of this circuit is to include equal positive and negative coefficient capacitors in parallel and heat the capacitors independently. The oscillator could be configured to have a zero frequency dependence on ambient temperature. The oscillator frequency could be raised by heating the negative coefficient capacitor or lowered by heating the positive temperature capacitor. rf

About the Author

Albert Helfrick is Principal Engineer at Dowty RFL Industries, Inc., Powerville Road, Boonton, NJ 07005. He has a B.S. in Physics from Upsala College and an M.S. in Mathematics from New Jersey Institute of Technology. The thermally-tuned VCO was designed to replace varactor tuning in a pulsed oscillator which exhibited a large "chirp" at turn-on.

COME TO THE PROBLEM SOLVERS IN RF TESTING...IFI

With IFI, finding an efficient, comprehensive RF testing system isn't a problem any more.

For over 25 years, IFI, Instruments for Industry, has been the unequalled leader in producing RF system modules and complete RF testing systems that offer optimum power, broad bandwidth and exceptional versatility.

Whether you need wideband, high frequency power amplifiers, E-field generators and sensors, antennas, TEM test cells or automatic leveling systems, IFI instruments are engineered for long life and trouble-free operation. In fact, for • military and aerospace engineering • defense and space exploration • medical and biological testing, experiments, and treatments • a wide range of communications needs • automotive manufacturing • general lab susceptibility testing and instrument calibration or whatever your particular application ... IFI provides the most comprehensive equipment available to solve your critical RF testing and measurement problems. *IFI, the problem solvers in RF testing.*

1ST IN RF TESTING AND STILL THE BEST

Send for our Data-Pak today!

ifi INSTRUMENTS FOR INDUSTRY, INC.
151 Toledo Street • Farmingdale, N.Y. 11735 • (516) 694-1414

INFO/CARD 40

"If I Grow Up..."

Every child likes to play "grown-up", but no child should have to suffer the very grown-up symptoms of childhood cancer.

To find out how you can help put an end to this killer disease, write to St. Jude, 505 N. Parkway, Memphis, TN 38105.

ST. JUDE CHILDREN'S RESEARCH HOSPITAL
Danny Thomas, Founder

rf products

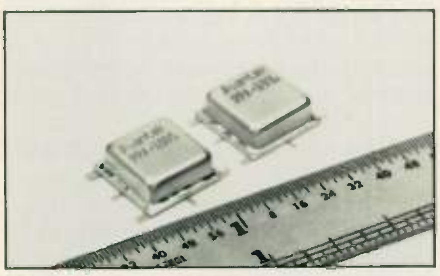
Surface Mount Technology Training Kit

Vector Electronic Company anncunces its new SMT Training Kit designed to introduce design engineers and electronic technicians to surface mount technology. The SMT Training Kit is available in two configurations. The SMT2000 contains, in addition to hardware, over 575 surface

mount components, while the lower-priced SMT1000 is intended for users who already have a supply of component parts. The kit has four elements: SMT devices, prototyping boards, component attachment and interconnection materials, and a comprehensive 50-page manual. The SMT2000 Training Kit is priced at $348.00, while the SMT1000 is priced at $215.50. **Vector Electronic Company, Sylmar, Calif. INFO/CARD #154.**

Surface-Mounted Amplifiers Have Over 11 dB Gain

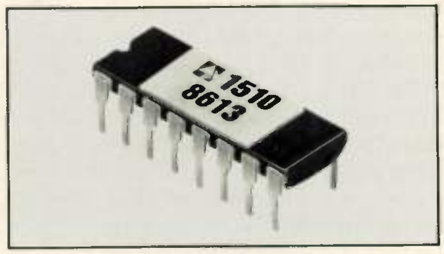
Avantek has introduced two new PlanarPak™ surface-mounted amplifiers having minimum gain of 11.0 dB and typical gains of 12.6 and 12.0 dB respectively over the full 5-1000 MHz frequency range. The models PPA-1005 and 1006 have maximum noise figure of 6.0 dB (5.0



and 4.8 dB typical); 1 dB compressed output powers of +20 dBm and +17 dBm minimum (+21.0 and +18.5 typical) and guaranteed input and output VSWR of 2.0:1 (1.3:1 and 1.2:1 typical). In 1-9 piece quantities, model PPA-1005 is priced at $270 each while model PPA-1006 is $240 each. **Avantek, Inc., Santa Clara, Calif. INFO/CARD #153.**

First Monolithic GaAs OpAmp

The first commercially available GaAs monolithic operational amplifier has been introduced by Anadigics, Inc. The AOP1510 is internally compensated for unity gain stability at 150 MHz, features high gain and phase linearity, and wide bandwidths and fast settling time. Also, AOP1510 provides less than 0.2 dB gain



WAVETEK®

Shock value.

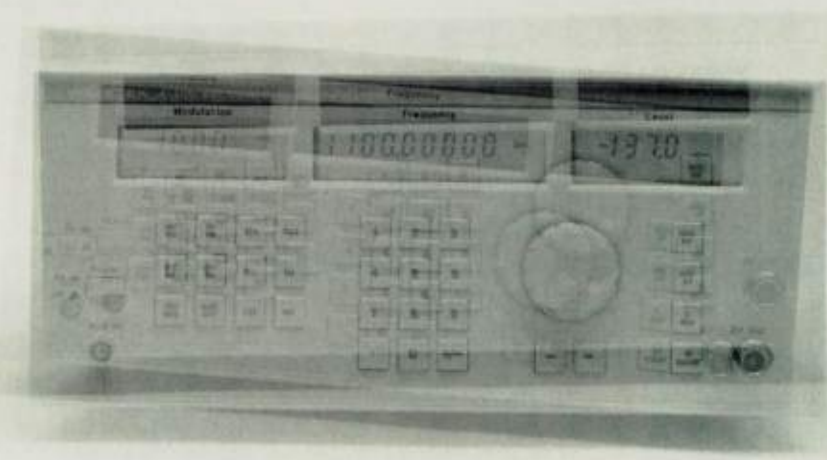
VDE. FCC-A and B. MIL-T-28800 Class 5. The new Wavetek 2500 synthesized signal generator passed these performance tests. And a few more we tossed at it.

Severe vibration. Shock. Extreme temperatures. We put it through more than you ever would. Which is why we offer an optional warranty better than anyone else does.

For a free brochure and demonstration of the only signal generator tuned to your manufacturing needs, call your nearest Wavetek sales office:
Northeast 914 357-5544
Southeast 813 797-1792
Central 317 787-3915
West 619 565-9234

The new Wavetek 2500. *It outclasses everything in its class.*

Wavetek 2500 Signal Generator
Frequency Range: .4 to 1,100 MHz
Output Level: +13 to −137 dBm
Special Introductory Price: $5,495

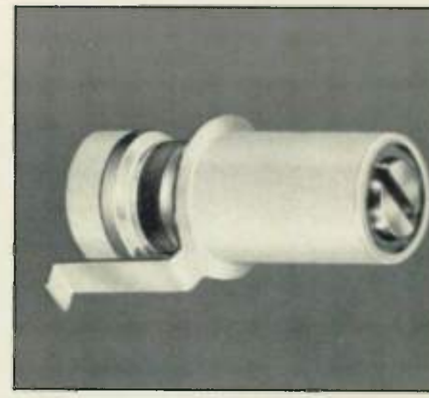


INFO/CARD 41

flatness to 50 MHz (at a gain of +1). Key specifications include unity gain stable at 150 MHz, 70 dB (3000 mV) open loop gain, 30 ns settling time to 1.0 percent, 35 MHz full power bandwidth, and 500 V/μs slew rate. The AOP1510 GaAs OpAmp is priced at $29.00 each in quantities of 1,000. **Anadigics, Inc., Warren, N.J. Please circle INFO/CARD #152.**

Sapphire Precision Trimmer Capacitors

Voltronics Corporation announces its "P" line of sapphire precision trimmer capacitors, with high Q, zero temperature coefficient, and an internal O-ring seal. No flux or cleaning fluid can ever get inside, although sizes are the same as the MIL unsealed styles. The tuning screw does not move in and out, and RF current does not run along it. Sapphire's dielectric constant does not change with frequency, and its loss constant is extremely stable, measuring below 0.0003 up to 10 GHz. There



are three styles of 2.5, 4.5, and 8 pF max in 0.125" diameter, and one 1.2 pF max style of 0.075" diameter. A sample kit, Number 209, can be ordered with any combination of 15 parts for $75. **Voltronics Corporation, East Hanover, N.J. INFO/CARD #151.**

250 MHz 8-Bit DAC is ECL Compatible

Plessey Semiconductors announces a 250 MHz, 8-bit D/A converter designated the SP97618. All data and control inputs are ECL compatible and in most applications require no extra registering or buffering. The SP97618 has inherently low glitch energy, and features differential current outputs, single −5.2V power supply, and 1/2 LSB linearity. Applications for the SP97618 are automated test equipment, digital waveform synthesizers, high resolution graphics and raster graphic displays. The SP97618 is available in a 24 lead DIP priced at $19.72 each (in 1000s), and will be available in surface mount by fourth quarter 86. **Plessey Semiconductors Inc., Irvine, Calif. INFO/CARD #150.**

11 New GaAs IC Logic Functions

GigaBit Logic has announced introduction dates for 11 new standard GaAs logic functions. The new products include:

10G002	Quad Exclusive OR/NOR Gate	3rd Qtr. '86
10G003	AND-OR/AND-OR-Invert Gates	1st Qtr. '87
10G061	4-Bit Synchronous Counter	4th Qtr. '86
10G023	Quad MUX Input D-Flip Flop	1st Qtr. '87
10G046	Quad 4:1/Dual 8:1 MUX	1st Qtr. '87
10G044	3:8/Dual 2:4 Decoder	3rd Qtr. '86
10G030	16X4 Multiport Register File	1st Qtr. '87
10G045	Dual 9-Bit Parity Checker	4th Qtr. '86
10G100	High Speed 4-Bit Adder	1st Qtr. '87
10G101	High Speed Carry Lookahead	1st Qtr. '87

GigaBit Logic, Newbury, Calif. Please circle INFO/CARD #149.

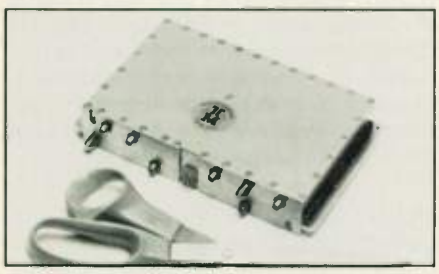
INFO/CARD 42

Step Attenuators are Phase Compensated

A new family of Phase Compensated Step Attenuators is available from Daico Industries. The DA1000 series has 0.1 degree typical phase shift throughout the attenuation range at specified center frequency and only two degrees phase shift across an octave bandwidth. Center frequency can be specified from 20 through 70 MHz with attenuation ranges/steps from 0.1 dB (LSB) to 32 dB (MSB) and one through eight bits (steps) available. The DA1000 series also features a high switching speed of 25 nanoseconds typical with low transients of 25mV. DA1000 series attenuators are available in 14 through 40 pin dual-in-line microwave integrated circuit (MIC) packages. **Daico Industries, Inc., Compton, Calif. INFO/CARD #148.**

Multiple Output Frequency Multiplier

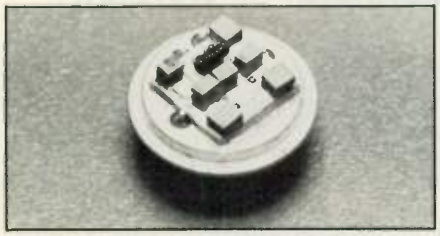
This multiple output multiplier takes three different input frequencies in the 60 to 100 MHz range and provides five different output frequencies. Two are straight multiples of the input frequencies. The



other three are obtained by mixing one of the input frequencies with the output frequency of the preceeding stage, thus providing three output signals to which one of the input signals has been added. For example, if one input signal was chosen as 100 MHz and the other as 50 MHz, the output signals could be 960, 1010, 1060 and 1110 MHz. **TRAK Microwave Corporation, Tampa, Fla. INFO/CARD #147.**

Hybrid Attenuator is Adjustable

Merrimac announces the introduction of a series of miniature hybrid attenuators operating at 10-1000 MHz with attenuation adjustable to 25 dB typical, 20 dB guaranteed. Intended primarily for IF signal processing applications, the new ARET series can be used for signal leveling, as switches or as amplitude modulators. They are available packaged in a TO-8 case, a half-inch square flatpack, or in the "Meripac" low profile package.



Prices commence at $170.00. **Merrimac Industries, Inc., West Caldwell, N.J. INFO/CARD #146.**

Thick Film Manufacturing Services

KDI Electronics has announced the expansion of its Thick Film Microwave Integrated Circuit product capability to include complex sub-assemblies in the fre-

INFO/CARD 43

PRECISION CRYSTAL OSCILLATORS
SERIES 8000

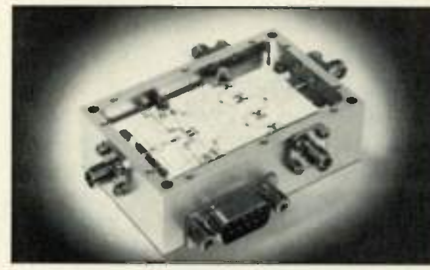
STANDARD FREQUENCY 5.0 MHz
AGING RATE ______ MODEL ER8001 1×10^{-9}/day
MODEL ER8003 1×10^{-10}/day
MODEL ER8005 5×10^{-11}/day
PHASE NOISE ____ SSB 1 Hz BW at 10 Hz offset
MODEL ER8001 . . . 124 db
MODEL ER8003 . . . 135 db
INPUT VOLTAGE __ 12 VDC ± 10% STANDARD
OUTPUT __________ SINE-WAVE 1VRMS INTO 50 ohm LOAD
SIZE ______________ MODEL ER8001 and MODEL ER8003
2" × 2" × 4" H
MODEL ER8005
2.25" × 2.25" × 4.25" H
OPTIONS ________ MANY OPTIONS ARE AVAILABLE TO INTERFACE WITH YOUR REQUIREMENTS

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

For information and prices, send your specifications to:

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

INFO/CARD 44



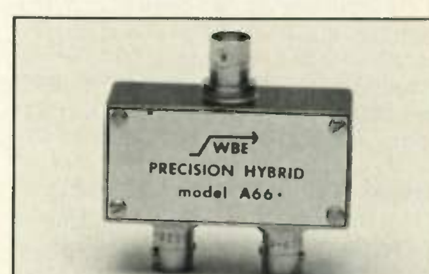
quency range from DC to 5 GHz. The MIC capability ranges from elementary switches to complex functions where elements such as attenuators, dividers/combiners and monolithic drivers are all integrated onto ceramic substrates. All manufacturing is accomplished in accordance with MIL-STD-883. Environmental testing is also available. **KDI Electronics Inc., Whippany, N.J. INFO/CARD #145.**

Signal Processor Operates at 1500 MFLOPS

Model AS72.5-20-20 is a 625 point Spectrum Analyzer subsystem with computational speed equivalent to 1500 Mega FLOPS. Power requirements are less than 20 mW per point. Dynamic range is 50 dB. Frequency range is 60 to 85 MHz. Size is less than 35 cubic inches. It is particularly well suited for high speed signal processing when small volume and low power consumption are required. The processor is manufactured by Thomson-Sintra. Price is $52,000 (1-4 qty.). **Phonon Corporation, Simsbury, Conn. Please circle INFO/CARD #144.**

Hybrid Divider/Combiner Covers 5-1000 MHz

Wide Band Engineering announces the addition of the A66U Precision Hybrid Divider/Combiner to their line of broadband test instruments. The A66U operates in the 5-1000 MHz band. Maximum VSWR



is 1.2:1. Back-back loss is 1 dB max. Isolation with matched input termination is 30 dB and response flatness is ±.25 dB. Maximum Power to input is .5 W and maximum power to output is .25 W. **Wide Band Engineering Company, Inc., Phoenix, Ariz. INFO/CARD #142.**

Software for Antenna Radiation

Eaton Corporation offers a new software program for Antenna Radiation Pattern (ARP) testing. Incorporating a computer into Eaton's EMI system allows faster and more efficient ARP testing. The software supports the HP 9836S Desk Computer, allowing the operator to plan, run and store ARP tests; and retrieve, store and print out test results within minutes. Up to fifteen frequencies in a test group are repeatedly sampled in sequence during a complete turn of the antenna. A real time plot can be observed of the successive readings for each frequency in a test group, as they are collected. **Eaton Corporation, Electronic Instrumentation Division, Los Angeles, Calif. INFO/CARD #176.**

Circuit Analysis and Transmission Line Programs

Microwave Software announces availability of three RF application programs. SCEPTRE is a frequency domain circuit analysis program for the Apple and IBM-PC, featuring a library of active, lumped and distributed elements, a full feature file editor, and a "tweak" mode for sensitivity analysis and fine tuning. SMITHMATCH is an interactive matching network design program for the Apple that brings together a lumped and distributed element library and a detailed Smith Chart. MSTRIP+ is a transmission line analysis and synthesis program for the Apple. Fabricate single and coupled microstrip with near Bryant-Weiss accuracy, single and coupled stripline based on the work of Cohn, and suspended substrate using the Yamashita approach. **Microwave Software, San Juan Capistrano, Calif. INFO/CARD #175.**

Bulletin Board Offers CAE Technical Support

The technical support department of EEsof makes itself available 24 hours a day, 7 days a week with a new electronic bulletin board system. The bulletin board system allows users of EEsof's CAE software for microwave and RF engineers to get instant technical help. Questions about files, program use or software documentation are answered on the system. Additionally, the bulletin board system will be used as a clearing house for information on the EEsof Users' Group, new programs, upgrades and seminar information. **EEsof, Inc., Westlake Village, Calif. INFO/CARD #174.**

"COMPLEX MATCH" Software Optimizes Noise or Gain

COMPACT Software has announced the availability of its "COMPLEX MATCH" software for synthesizing and optimizing matching circuits for both complex and real impedances, based on transistor S-parameters. Matching can be done to optimize gain *or* noise. Using the Yarman/Carlin method (IEEE Trans. MTT, 12/82), matching networks consisting of from 2-12 components can be selected and input, output or interstage matching can be accomplished with or without gain slope considerations. This program stands alone, or can be used in conjunction with Super-Compact PC. Price is $2,500. **Compact Software, Paterson, N.J. Please circle INFO/CARD #173.**

Program Analyzes Analog Circuits

A less-than-$100, graphics-oriented version of its software package, Electronic Circuit Analysis (ECA 2.2) is announced

WAVETEK®

Express checkout.

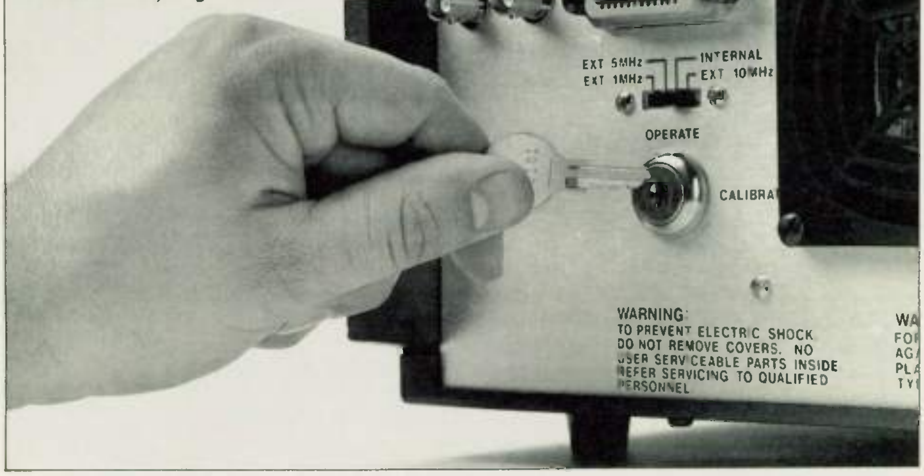
Signal generator calibration and maintenance has never been so easy. Every time you turn on the Wavetek 2500 synthesized signal generator, it automatically tests all its own internal controls and major RF functions.

No need to send it to the lab for complete calibration. Instead, just turn the calibration key on the back to activate AutoCal™, a software-assisted calibration routine. An entire calibration takes fifteen minutes, without removing a panel and going inside. For the lowest possible ownership costs.

For a free brochure and demonstration of the only signal generator tuned to your manufacturing needs, call your nearest Wavetek sales office:
Northeast 914 357-5544
Southeast 813 797-1792
Central 317 787-3915
West 619 565-9234

The new Wavetek 2500. *It outclasses everything in its class.*

Wavetek 2500 Signal Generator.
Frequency Range: .4 to 1,100 MHz
Output Level: +13 to −137 dBm
Special Introductory Price: $5,495



INFO/CARD 45

by Tatum Labs. "EC-Ace" is priced at $95, and is being targeted to electronic and electrical engineers with low operating budgets, hobbyists and engineering students. The package is a "stripped-down" version of ECA 2.2, command driven, with a user interface identical to that of the full-scale package. A 200-page user manual is included. EC-Ace is intended primarily for those who want and need to have circuit analysis software but cannot justify the $450 price charged for ECA 2.2. The program runs on MS-DOS-based microcomputers. **Tatum Labs, Newtown, Conn. INFO/CARD #172.**

Program Aids in Bessel Filter Design

RF Notes No. 3, Vol. 2, is the fourth in the series of design aid programs for RF/analog design. RF Notes 3, Vol. 2, aids in the design of Low-Pass, High-Pass and Band-Pass Bessel response filters to the 7th order. Inputs are in graphical (response curve) form, and the outputs are in schematic diagram form with circuit constants included. Predicted response curves are given, and particular response points can be checked. The price is $85.00 for IBM PC and compatibles with PC/MS DOS 2.1, 128K, and graphics card. **Etron RF Enterprises, Diamond Bar, Calif. INFO/CARD #171.**

Linear Circuit Analysis Program

LCAP is a circuit analysis program for the IBM PC (256K). Written by an RF engineer, it can run an S-parameter analysis or a voltage analysis of any circuit composed of resistors, capacitors, inductors, transistors, and op-amps. Features include full screen editing, unlimited circuit topologies, library of active components, and high resolution graphics. LCAP has been proven in colleges and technical schools. Price is $500, LCAP-87 (8087 version) is $600. **RF Engineering, Norwich, N.Y. INFO/CARD #170.**

Switched-Capacitor Analysis Software

Filter designers with access to an IBM PC or compatible microcomputer now have available to them an analysis program for switched-capacitor circuits. This program, named SCASY, was originally developed in Germany and performs a frequency-domain analysis of switch-capacitor circuits by calculating the loss, phase and group delay versus frequency. The circuit to be analyzed may contain as many as 80 capacitors and up to 20 operational amplifiers, as well as the necessary switches. The currently available PC version is priced at $3,000 and requires the 8087 coprocessor and a hard disk. **DGS Associates, Santa Clara, Calif. INFO/CARD #168.**

Program Synthesizes Matching Networks

Radom Inc. introduces SYNMAT™, a program which uses the synthesis method to design input, interstage and output matching networks for RF/microwave amplifiers. Features include impedance and noise modeling, selection of gain slope, ripple and loss, lumped or distributed solutions, and best match or best noise figure optimization. SYNMAT runs on IBM PC or compatible personal computers. **Radom Inc., Meridian, Idaho. Please circle INFO/CARD #167.**

New Product from M/A-COM Omni Spectra

TNC Mode Free Adapters
VSWR As Low As 1.13:1
dc - 18.0 GHz

Part Number	Description	VSWR Max. dc-4 GHz	VSWR Max. 4-12.4 GHz	VSWR Max. 12.4-18 GHz
3780-2240-00	TNC Jack to SMA Jack	1.10:1	1.20:1	1.30:1
3780-2242-00	TNC Jack to SMA Jack Flange Mount	1.10:1	1.20:1	1.30:1
3782-2240-00	TNC Plug to SMA Jack	1.10:1	1.20:1	1.30:1
3782-2241-00	TNC Jack to SMA Plug	1.10:1	1.20:1	1.30:1
3781-2241-00	TNC Plug to SMA Plug	1.10:1	1.20:1	1.30:1
7082-5016-00	TNC Jack to 7MM	1.04:1	1.09:1	1.13:1
7081-5022-00	TNC Plug to 7MM	1.04:1	1.09:1	1.13:1

M/A-COM

M/A-COM Omni Spectra, Inc.
21 Continental Blvd.
Merrimack, NH 03054
603-424-4111
TWX: 710-366-0674
TLX: 681-7280

Omni Spectra

INFO/CARD 46

RF Switches and Components Catalog

Dynatech/UZ has released catalog No. 8 describing their line of RF Switches, couplers and phase shifters. The catalog includes complete technical data on each product, and also describes the custom manufacturing capabilities available for a customer's unique application. **Dynatech/UZ Inc., Venice, Calif. Please circle INFO/CARD #166.**

Two Data Books: Modular Products and Signal Sources/Filters

Avantek has released their 1986 Modular Products Data Book and the 1986 Signal Sources and Filters Data Book, containing detailed information on all standard Avantek products. Modular products include thin-film amplifiers, mixers and mixer/preamplifiers, switches, attenuators, detectors and couplers. Signal sources and filters include VCOs from 0.3 to 18 GHz, DSOs from 6 to 18 GHz and YIG-tuned oscillators operating to 40 GHz, plus YIG-tuned filters for 2 to 18 GHz. **Avantek, Inc., Santa Clara, Calif. For the Modular Products Data Book, circle INFO/CARD #165, and for the Signal Sources and Filters Data Book, circle INFO/CARD #118.**

Brochure Describes Company's Capabilities

A brochure is available describing the capabilities of Western Microwave, Inc. The company is a supplier of a wide array of microwave technologies including: hybrid thin and thick film MIC assemblies, GaAs FET low-noise amplifiers, and active microwave signal generation components. Signal processing components include A/D and D/A subsystems, filters, multiplexers and channelizer assemblies. **Western Microwave, Sunnyvale, Calif. INFO/CARD #124.**

Application Note on SMA Connector-to-Circuit Attachment

Chomerics has introduced a novel technique for creating repairable interconnections between SMA connectors and thick film hybrid circuits, or between two hybrid circuits. The interconnect utilizes CHO-SEAL® 1215 conductive elastomer press-fit into a plastic clamp which bridges the SMA connector-circuit gap. This field-serviceable assembly gives performance comparable to thermocompression gold wire or ribbon bonds in the 3 to 7 GHz range, and withstands harsh environments without loss of conductivity. **Chomerics, Inc., Woburn, Mass. Please circle INFO/CARD #163.**

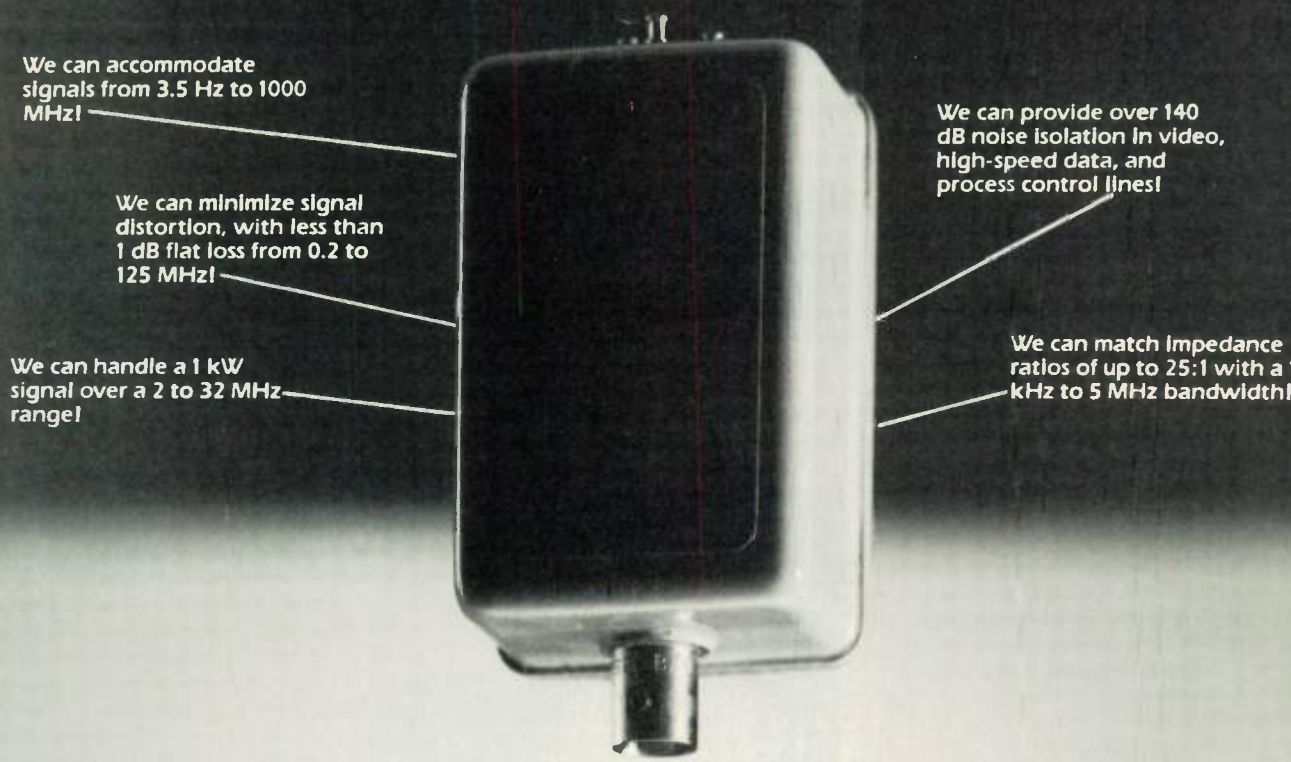
LAN Cable Application Guide

Belden has published a Local Area Network (LAN) Cable Application Guide for design engineers. This brochure explains the characteristics typically used to describe an LAN: It gives details on IEEE standards 802.3, 802.4 and 802.5, computer communications standards adopted by the International Standards Organization (ISO) and it describes 28 different Belden® LAN cables. The cable descriptions also state whether the cable meets the requirements of IEEE 802.3, 802.4 or 802.5. **Belden Electronic Wire and Cable, Richmond, Ind. Please circle INFO/CARD #161.**

INFO/CARD 47

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

(over 400 off-the-shelf models—for immediate delivery!)



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

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

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

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

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

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

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

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

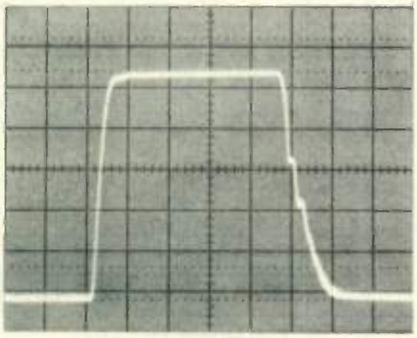
Just call Sales Engineering: 516-671-5700. Or write for our free catalog.

North Hills Electronics, Inc.

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

INFO/CARD 48

NEED FAST LOG RESPONSE?



LOG TECH HAS THE SOLUTION

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

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

SPECIFICATIONS:

Frequency Range
30MHZ—1.2GHZ

Input Dynamic Range
30 to 80 db (Selectable)

Meets Environmental Requirements of MIL-E-5400

WE INVITE INQUIRIES CONCERNING YOUR SPECIAL REQUIREMENTS.

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

INFO/CARD 49

rf opportunities

SENIOR PROJECT ENGINEER

RF CIRCUITRY

Shure seeks a highly qualified Sr. Project Engineer to head-up an Engineering Group dedicated to the development of VHF transmitters and receivers.

Required are 8 years or more RF circuit design experience with demonstrated ability to execute and oversee projects from inception through production.

This key position is part of Shure's long-term commitment to develop and market quality audio and broadcast products.

We offer excellent benefits and salary commensurate with experience. Shure's engineering environment is supportive, stimulating and congenial, stressing research and opportunity for professional growth. Call Collect:

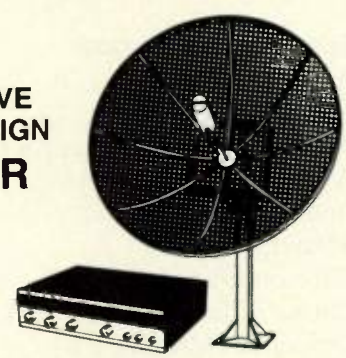
(312) 866-2228
CHERYL YOUNG

Shure Brothers Inc.
222 Hartrey Avenue
Evanston, IL 60202

An Equal Opportunity Employer

SHURE
THE SOUND OF THE PROFESSIONALS®...WORLDWIDE

RF/MICROWAVE CIRCUIT DESIGN
ENGINEER
Colorado



Manufacturer of RF products for TV broadcast, CATV and satellite needs EE's to design new TVRO products for consumer and commercial markets. Experience in RF/microwave circuit design required.

Based in Burlington, Iowa and recognized as an industry leader for 30 years, Winegard Company develops new products at its engineering and research division located in a scenic Colorado mountain community within commuting distance of Denver.

Our medium-sized, stable, independent company offers multiple benefits for its professional employees.

Phone or send resume to Jim Kluge, Winegard Lab, P.O. Box 940, Evergreen, CO 80439. (303) 674-5576

WINEGARD

ENGINEERING/ELECTRONICS

AEL

American Electronic Laboratories, Inc.

We Place Prime Importance On Communications, (And The Ability To Disrupt It!)

For 35 years, the flow of creative communications within the structure of AEL's engineering teams have been vital to our success. It's a major reason for our unsurpassed reputation for leadership in countermeasure technology.

Today, we're working on a variety of defense electronic programs including mobile ground based and aircraft jamming systems for the U.S. Army and Air Force, radar and avionics equipment and a variety of advanced technology antenna and MICs. A heavy backlog of work and resultant growth has created vital engineering openings at our headquarters.

- **STAFF CONSULTANT—TWT—** Requires experience in all phases of the design and development of high power, microwave transmitter sub-systems incorporating Traveling Wave Tubes. Requires 10+ years of experience in high power, microwave transmitter field.
- **STAFF CONSULTANT—Solid State Amplifiers—** Must possess knowledge of high power, wide band solid state amplifiers operating in the 1 to 1000 MHz frequency band. Requires 10+ years of experience working with solid state amplifier technology.
- **DEVELOPMENT ENGINEER—Power Supplies—** Must be well versed in control theory, switching regulator design and circuit modeling. Also requires in-depth knowledge of high voltage power supply development. Experience with power supply packaging including mechanical, thermal and EMI design preferred.

All positions require a BSEE (MSEE preferred) and U.S. Citizenship.

AEL offers excellent potential for career growth, a salary commensurate with experience and a full range of benefits. Qualified applicants should send a resume with salary history/requirements to: **Employment, American Electronic Laboratories, Inc., 305 Richardson Road, Lansdale, PA 19446.** An Equal Opportunity Employer, M/F.

A Subsidiary of AEL Industries, Inc.

RECRUITERS FOR MAJOR AEROSPACE, MILITARY, & COMMERCIAL ELECTRONICS COMPANIES:

- Radar systems
- Signal processing
- Senior Design Eng
- Electronic Warfare
- Transmitter Receiver
- Microprocessor software design
- Circuit design and test
- Microwave Design
- RF/IF processor design
- Airborne Instrumentation

NATIONAL EXECUTIVE RECRUITERS, INC.

8096 N. 85th Way, Ste 102, Dept rf
Scottsdale AZ 85258 (602) 951-2122

Kathi Walsh
Classified Advertising Manager

rf design

A Cardiff Publication

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

Advertiser's Index

NEW — 112-Page Information and Product Catalog

Complete from Abrupt to Zener — 112-pages of designer data to make your life easier and your project trouble-free. Our new catalog will give you the needed information to complete even your toughest projects, by describing our broad base capabilities in silicon and gallium arsenide diodes.

Many of our high performance products are available as standard products or call us and discuss your special designs.

- **Silicon Abrupt Junction Tuning Varactors, 30V to 90 Volts**
- **FLTVAR — Frequency Linear Tuning Varactors**
- **VHF/UHF Hyperabrupt Tuning Varactors**
- **GaAs Tuning Varactors 15V to 60 Volts**
- **Power Generation — Multiplier Varactors**
- **Step Recovery Diodes**
- **Harmonic Generator Varactors**
- **Multi-Chip High Power Generator Varactors**
- **Noise Diodes**
- **Gunn Diodes**
- **Parametric Amplifier Varactors**
- **Control Devices — PIN and NIP Diodes**
- **UHF/VHF PIN Diodes**
- **Power RF Switching**
- **Small Signal RF Diodes**
- **HF Power PIN Diodes**
- **Limiter Diodes**
- **Chip Capacitors**

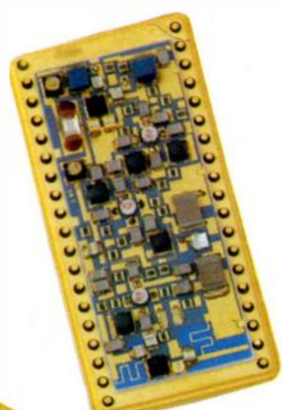
FREQUENCY SOURCES
SEMICONDUCTOR DIVISION
A SUBSIDIARY OF LORAL CORPORATION

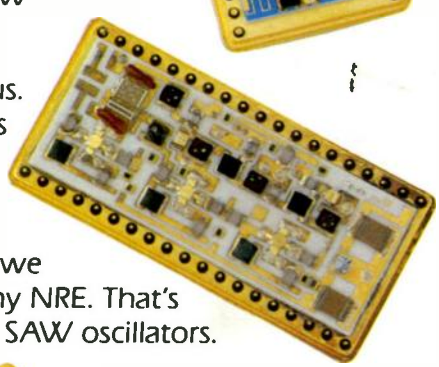
16 Maple Road
Chelmsford, MA 01824
(617) 256-8101
TWX (710) 343-0404

INFO/CARD 50

SAW Questions and Andersens.

Oscillators:





QUESTION: I've heard a lot about SAW hybrid oscillators. When should I consider using one?

ANDERSEN: Any time you need a compact, rugged low noise source in the 100 MHz to 1 GHz range.

QUESTION: What do you mean by low noise?

ANDERSEN: We build SAW hybrid oscillators to phase noise specs of —95dBc/Hz at 100 Hz offset from the carrier to less than —160dBc/Hz at 100KHz.

QUESTION: Are there high NRE costs associated with SAW oscillators?

ANDERSEN: Not with us. We've developed designs for fixed frequency and VCO applications which can cover the entire 100 MHz to 1 GHz range. So we normally don't charge any NRE. That's why we're the leaders in SAW oscillators.

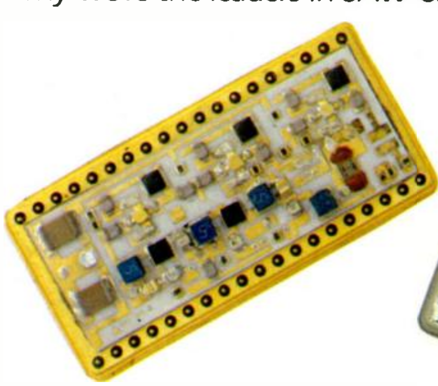
QUESTION: Where are SAW oscillators being used?

ANDERSEN: Our fixed-frequency SAW oscillators are being used in IFF and air traffic control systems, as local oscillators for frequency up/down converters in radar and communications systems, as master clocks for digital communications systems, just to name a few of the applications.

Our SAW VCO's are used in a wide range of Phase Locked Loops including timing recovery circuits for fiber optic data transmission systems where the oscillator reestablishes the timing of the data stream at the end of the fiber optic lines.

QUESTION: How do I get started?

ANDERSEN: Just give us a call. We'll do everything we can to meet your needs. If you simply want more information, send for our handbook on SAW Hybrid Oscillators. Write to Andersen Laboratories, 1280 Blue Hills Avenue, Bloomfield, CT 06002, Phone (203) 242-0761/ TWX 710-4253 2390



ANDERSEN LABORATORIES
A Subsidiary of ANDERSEN GROUP

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

(actual size)

INFO/CARD 51