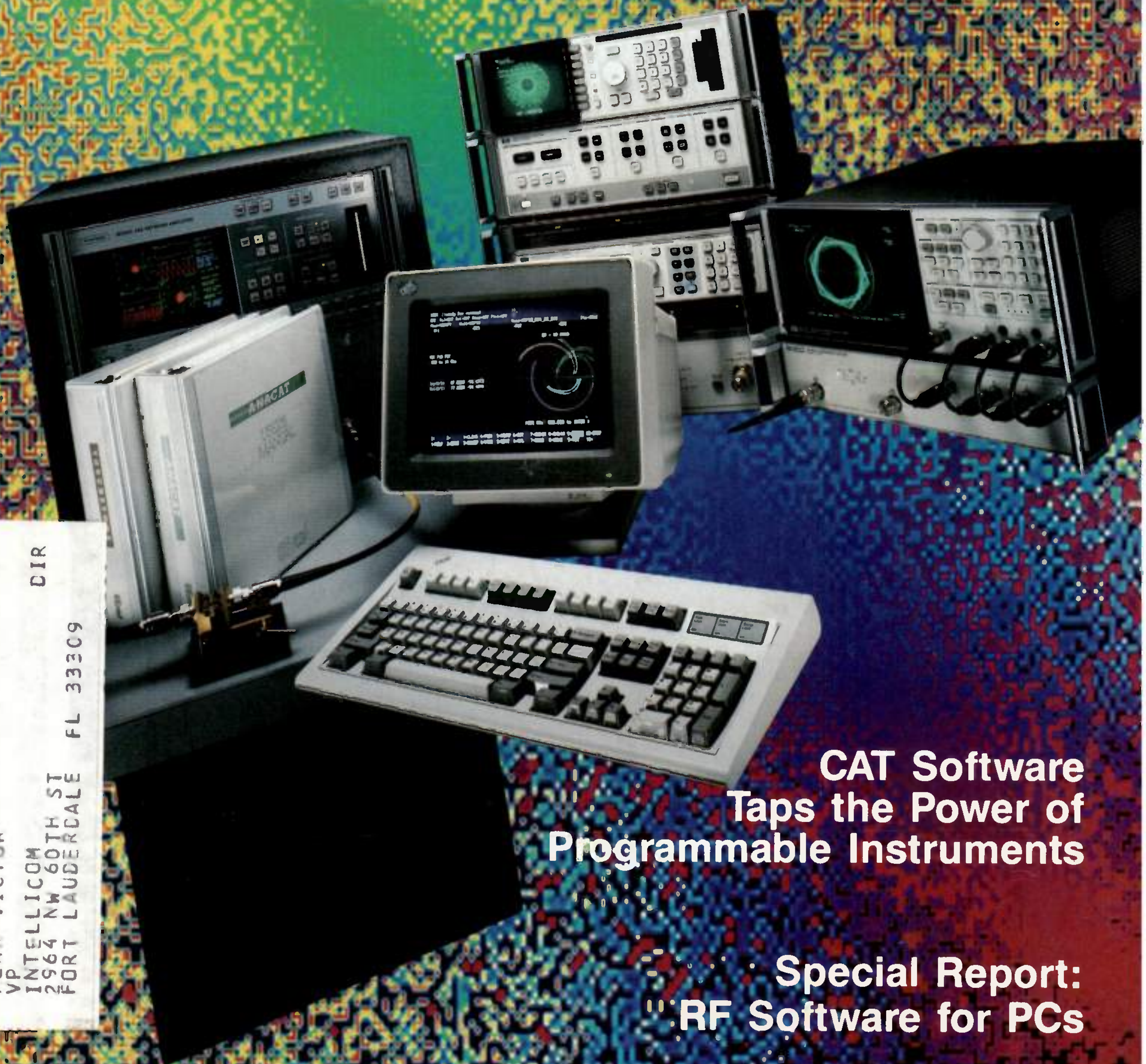
rf design

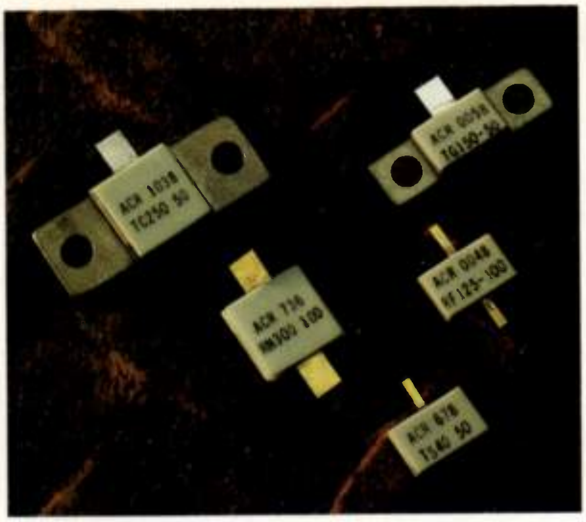
high frequency and analog engineering

September 1987



CAT Software Taps the Power of Programmable Instruments

Special Report: RF Software for PCs



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INFO/CARD 2


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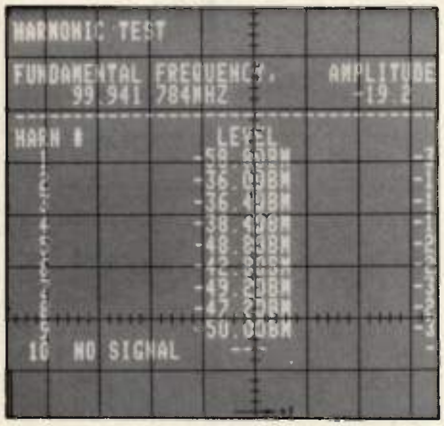
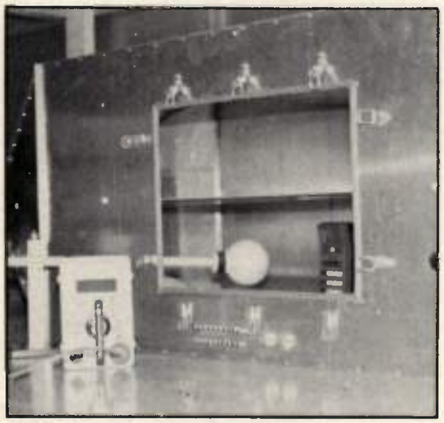
rf design

September 1987

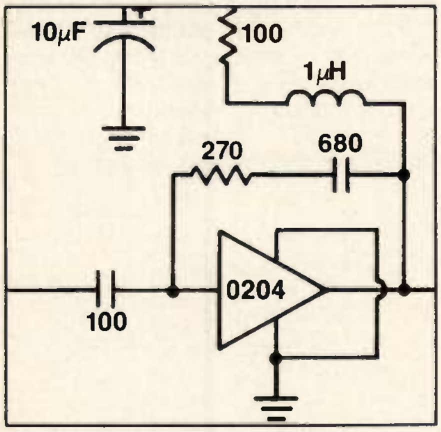


```
HARMONIC TEST
FUNDAMENTAL FREQUENCY.        AMPLITUDE
     99.941 784MHZ               -19.2
---------------------------------------
HARM #              LEVEL
                  -58.8DBM
                  -36.0DBM
                  -36.4DBM
                  -38.4DBM
                  -48.8DBM
                  -42.2DBM
                  -49.2DBM
                  -47.2DBM
                  -50.0DBM
  10   NO SIGNAL     ---
```

Page 39 — Programmable Instruments



Page 52 — EMC Test Labs



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Departments

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rf editorial

The Computer — It's Only a Tool

Gary A. Breed
Editor

Not long ago on late-night TV, I saw one of those movies where a computer ran amok and took over the world. I laughed to myself about the unnecessary fears we once had about computers — taking jobs away from people, becoming smarter than we are, and finally getting rid of us. However, I have again grown uneasy about computers, now that PCs have cloned, networked and bussed their way onto most of our desks.

No, I'm not worried about computers taking over the world. I am concerned for the growing number of people who are allowing themselves to become computer-dependent. Regardless of the profession, many people are replacing their own ability with software. Sure, computers can store the experience and knowledge of the best human minds on any subject. Unfortunately, it is also possible for us to recover and use that information without ever understanding it.

I am worried about the student who got through college by writing term papers using word processing, spelling and style checkers instead of mastering the English language. Now he is an engineer who plugs numbers into design programs without really understanding why they work. He certainly doesn't know which possible design solutions are better than others, he just takes the first one that comes up on the CRT.

What does he do when the power fails? Check your own staff next time the lights go out; see who heads for the door and who pulls out a calculator and proceeds with his work. (The ultimate problem is clearly dead calculator batteries. I have forgotten how to use a slide rule, and I refuse to look up logarithms in my old CRC Handbook!)

Don't get me wrong, computers are terrific! They are incredibly fast, and they're so dumb that they will do whatever we tell them to do. That's why we love them. They are our slaves, taking away the drudgery of repetition and providing valuable information when we want it. They let us do things in seconds that would take a week with pencil and paper. Consider doing an intermodulation analysis to the fifth order with multiple signal sources without a computer and you get the idea.

Computers allow us to spend more time being creative. The RF and analog design software listed in this month's Special Report is not intended to replace engineers with computers. These design aids have been developed to make good engineers even better, by letting them examine more design options, by modeling circuits before building prototypes, and by providing access to the expertise of the authors.

Most engineers understand these points. My concern is for those few who don't follow them — you know who you are. Don't get so dependent on computers that you can't function without them. Computers don't design, engineers do.

Gary A Breed

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M-1

INFO/CARD 5

rf viewpoint

'Megahertzes Never Intended For Transmission'

By Keith Aldrich
Publisher

A couple of months ago, when writing about our newly-expanded charter (covering general analog as well as RF engineering — see July Viewpoint), I mentioned that we would reclassify our circulation to see how many of our *present* subscribers are *already* involved in "non-radio" applications of RF energy. In fact, that very issue had a revised subscriber card, to include such industries as computers and industrial controls for the very first time.

Well, about 18,000 of you have already returned the new card — enough so we can make some judgments about the rest of you as well — and sure enough! We have substantial numbers of readers in the "non-radio" areas. Around 2,000 of you work in computers and data transmission, for instance. That's more readers than we have working in land mobile radio companies! About 1,000 of you are designing industrial controls and power supplies. . . more than those designing video and audio equipment.

These figures confirm what many of you wrote to us, in response to my editorial, all echoing more or less this comment from James Rieger, Naval Weapons Center, China Lake, Calif.: "Congratulations on acknowledging that there's Megahertzes running around out there never intended for transmission!"

We also had three articles submitted — of a very high caliber, according to Editor Gary Breed — which their authors say they would never have sent to us if they hadn't read that editorial. The subjects of those three articles are (1) analog-to-digital converter evaluation, (2) active filter fundamentals, and (3) high-speed op amps. It looks as if you are in for a healthy strain of such topics in your *RF Design* diet.

Apparently there are plenty of you who need and will profit by it. But you don't need to be designing industrial controls for that to be true. Every phase-lock loop has a feedback control circuit, probably using an op amp. The majority of RF instruments today employ an analog-to-digital converter, in order to supply the digital features which make them so increasingly convenient and accurate.

The thrust of our editorial expansion is clearly a right move, even an overdue one. We look forward to a lot of excitement in carrying in out.

Keith Aldrich

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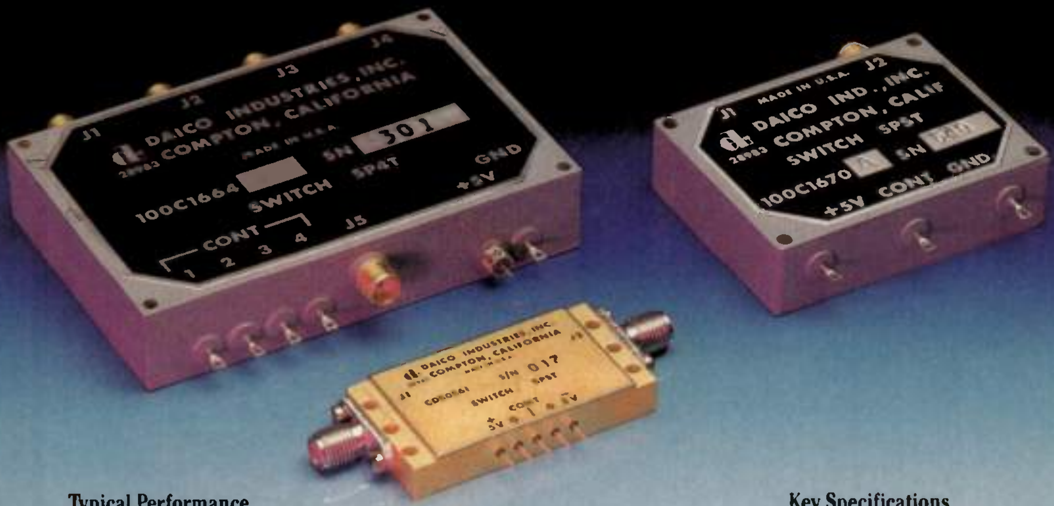

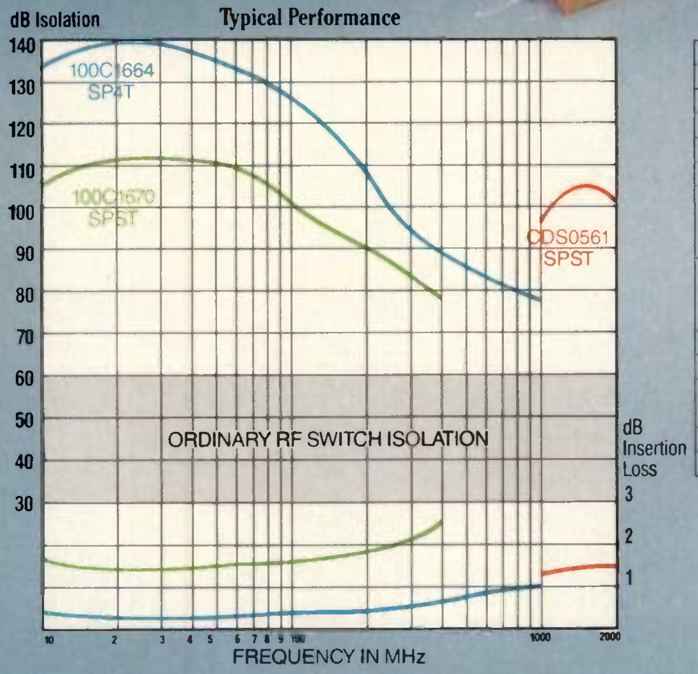

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Control Configuration	1 LINE TTL	1 LINE TTL	4 LINE TTL	—	Logic
Switching Transients	155	10	600	mV	Peak Value
Transition Time	4	2	—	ns	90%/10% or 10%/90% RF
Switching Speed	17	33	400	ns	50% TTL to 10%/90% RF
Insertion Loss	1.5	1.5	—	dB	—
	—	—	0.7	dB	20 - 350MHz
	—	—	1.0	dB	350 - 600MHz
Isolation	106	100	—	dB	—
	—	—	105	dB	20 - 200MHz
	—	—	85	dB	200 - 600MHz
VSWR	1.15 / 1	1.2 / 1	1.1 / 1	—	—
Termination VSWR	1.5 / 1	1.2 / 1	1.1 / 1	—	—
RF Power,	+13.5	+12	+24	dBm	0.1 dB Compression
Operate Max.	—	—	+30	dBm	No Damage
Operating Frequency	1700 - 1900	10 - 100	20 - 600	MHz	—
Operating Temperature	−55 - +125	−55 - +85	−55 - +85	°C	TA

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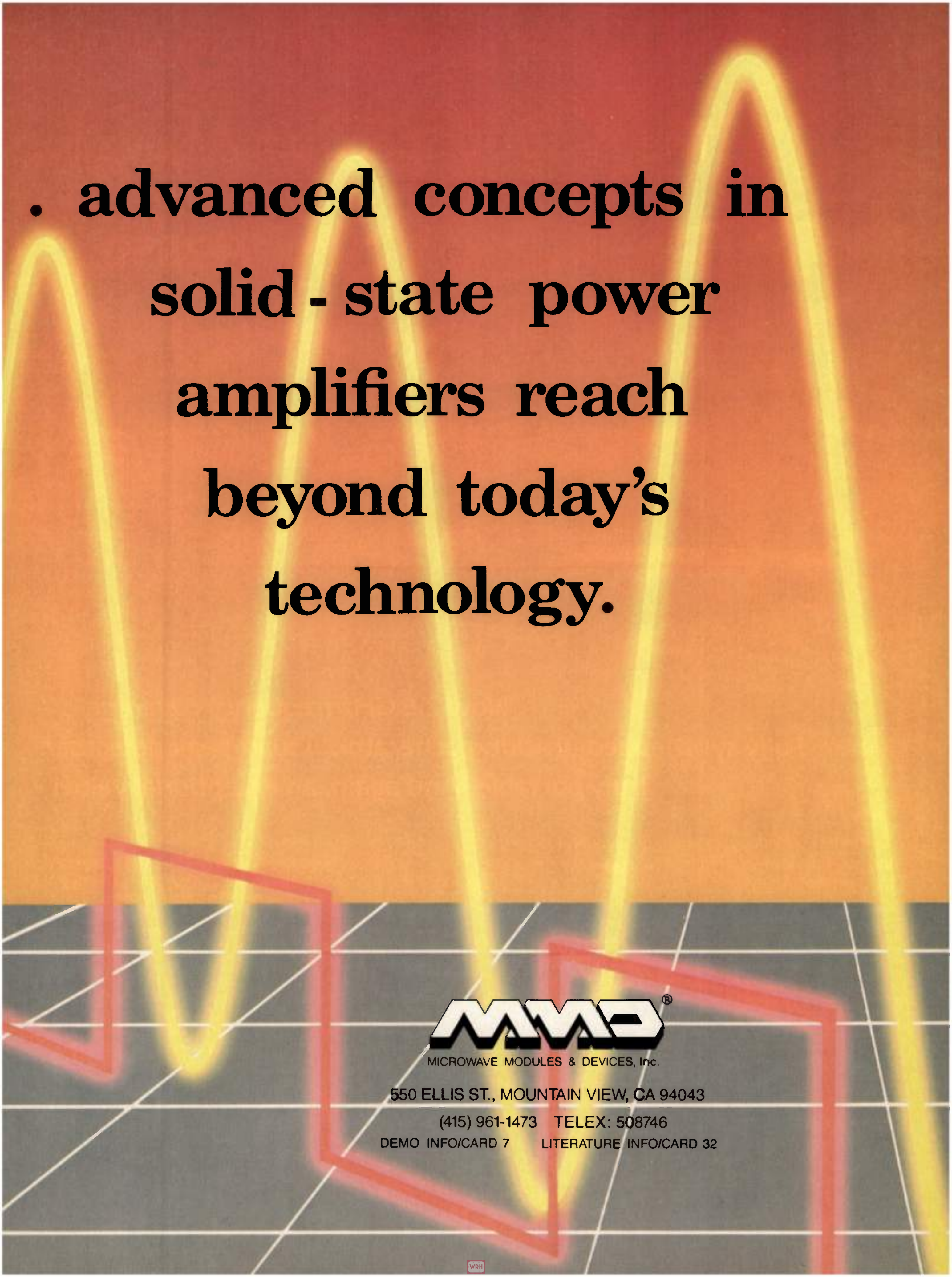

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INFO/CARD 8

rf letters

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

A Different Kind of Spectrum Analysis

Editor:

Remarkable fellow, that Isaak Newton (in the H-P ad). He got red light to refract farther than blue light!

James L. Engle
Phospho-Energetics, Inc.
Philadelphia, PA

We would like to point out this basic error to the artist whose work was used by Hewlett-Packard for their ad ("I'd settle for a bare bones spectrum analyzer. . ."). Unfortunately, he has been dead for almost 300 years. — Editor

A Glitch is Located

Editor:

There is an error in the program listing for "Computer Enhanced S-Parameter Design (February 1987, p. 105). In the subroutine for calculating C1, Line 410 is stated as:

```
410 I2 = −I(1)
```

whereas it should read:

```
410 I2 = −I(4)
```

The subroutine will now calculate C1 = S11 − D*S22.

Joe Catalfamo
Somerset, NJ

There is one more error that readers should be aware of, on page 106. Line 810 should read:

```
810 IF K<1 THEN 1050
```

The "<" was omitted from the listing. — Editor

Another Update on Ladder Network Analysis

Editor:

I have received modifications to my Network Analysis Program (November 1986, *RF Design*) from readers Ronald Derencz and James Hanson, which may be of interest to those with early Commodore 64s, or IBM PCs with Hercules Graphics Cards.

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rf letters Continued

Some early C-64 computers used a different default color scheme which caused an apparent lack of graphics. In reality, the graphics plot was on the screen, but it was drawn using the same color as the background! In order to correct this, Mr. Derencz suggests the following changes:

1) Add the statement,
   POKE P+54272,5 just before NEXT P, in lines 2090, 2100, 2110 and 2120.
2) Line 2120: Delete the statement,
   POKE 1224,79
3) Add a new line 2122 POKE 1224,79:POKE 54272+1224,5
4) Add a new line 2265 POKE V+54272,7
5) Add a new line
   2325 POKE V+54272,2
6) Save the modified program!

These changes will display a green border, yellow insertion loss and red return loss. The colors may be modified as desired by substituting different numbers for the 2, 5, and 7 above.

More and more IBM-PC clones are being sold with the Hercules Graphics Cards (or compatible). This presents a problem in that the network program does not plot with the correct scaling. Mr. Hanson provided the following information:

1) Add the following Hercules setup command within your AUTOEXEC.BAT file:
   HGC FULL SAVE PRINT — You then need to re-boot your machine before running NETWORK4.BAS.
2) Start BASICA or GWBASIC and load NETWORK4.BAS.
3) Examine lines 2090, 2110, 2130, 2150, 2170, 2320, 2370, 2440, 2470, 2480, 2520, 2540, and 2550. Replace the existing scaling factors with new ones per the table below, as appropriate:

Old	New
20	35
30	52
100	113
140	244
150	261
160	278
500	563
600	675

4) Of course, save the modified program!

Since I do not own a Hercules card, I shall forward any requests for technical assistance to Mr. Hanson.

"Thank you for your support."

Ken Wyatt
56 Aspen Drive
Woodland Park, CO 80863

Alan
COLUMBUS, INDIANA

Thomson, GE Make Business Swap

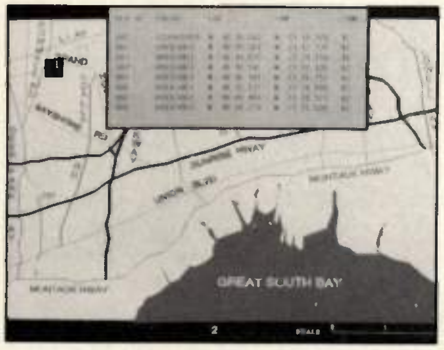
General Electric has agreed to sell its consumer products operation to Thomson S.A. for approximately $800 million plus Thomson's assets in the medical electronic business. Most of the consumer products operation was acquired by GE in its merger with RCA. With this deal, GE will become a major force in medical electronics overtaking Siemens A.G. and Philips by obtaining GGR Medical Corporation of Baltimore, GGR Industries, GGR MeV, and GGR Ultrasonics of France.

Thomson, on the other hand, will obtain a large manufacturing base for video and audio equipment which will be made up of plants in Bloomington, Ind., Indianapolis, Ind., and several Mexican assembly sites. Thomson's share of the deal comprises of GE's operations in 11 countries. Both companies will retain 19.9 percent in the businesses being exchanged. The deal is subject to government approval.

Magnavox Wins AVLS Contract

NAV-COM, Inc., a subsidiary of Magnavox Government and Industrial Electronics Company, has been awarded a contract by the town of Fairfield, Connecticut to install an Automatic Vehicle Location System (AVLS), which is to be used to track the movement and status of police cars and other emergency vehicles.

The system is expected to enhance the safety of field personnel, speed emergency response, ease dispatcher workload, enhance fleet control and management, reduce voice traffic on radio channels and improve procedures for reporting between vehicles and dispatchers. The AVLS provides an automated means for tracking the location and status of moving vehicles at a central location. This is done by equipping each vehicle with a small navigation processor, which tracks its position automatically as the vehicle moves. The vehicles are fitted with a compact navigation processor which determine its geographic position by measuring the distance and direction traveled from a known starting point. This is accomplished with links from speed and heading sensors. The speed input comes from a transducer interface to the vehicles speedometer while the direction of travel is supplied by an electronic fluxgate compass. The vehicle's processor also includes a small receiver that uses signals from orbiting navigational satellites. At intervals, satellite data is used to recalibrate the vehicle's computed position, cancelling out errors that may have accumulated over time. The information from the processor is formatted and transmitted back to the dispatcher station via an existing radio channel where the location of each vehicle in the fleet is shown on a large map display.



Topaz Charts Its Course in DMOS

Double diffused MOS (DMOS) basically involves the diffusion of two types of impurities (N and P types) in areas where conventional circuits utilize only one or the other. It was invented at Signetics in 1968, but has been used in limited applications until Topaz Semiconductor was formed to focus exclusively on DMOS.

At a press conference on July 29, Thomas Cauge, president of Topaz, said that the market for DMOS will more than double over the next three years by expanding applications into low current digital and analog switching equipment. This includes DMOS-type devices now marketed by other companies under other names such as TMOS™ (Motorola), HEXFET™ (International Rectifier) and SIPMOS™ (Siemens). Cauge added that the total available market for all DMOS related devices will grow from $380 million in 1986 to about $443 million this year.

Topaz is now moving to more complex monolithic functions, using a two-layer metal process for wide applications in crosspoint video and RF switching, T-switches, and multiplexers. Also being developed are CMOS/DMOS thick film hybrid circuits which will be utilized in high frequency attenuators and adjustable filters.

Varian and IBM agree on Patent Licensing

Varian Associates, Inc., announced that it has reached an agreement with IBM Corporation which allows each company use of the other's patents in their respective fields of interest. It is, however, limited to an exchange of patent licensing rights in the companies' current business areas. The agreement provides Varian with access to a broad range of patented technology, including developments in such areas as superconductivity and factory automation in device fabrication. Likewise, IBM will have access to Varian's patented semiconductor manufacturing technology for use in its internal chip manufacturing processes.

EEsof Users' Group to Meet at European Microwave Conference

The first European meeting of the EEsof Users' Group will be held in conjunction with the 17th European Microwave Conference at the Ergife Palace Hotel in Rome, Italy, September 7 through 11, 1987. The group will discuss applications, hear technical presentations, and exchange ideas about CAE software and microwave circuit design technology. Representatives from EEsof will be in attendance to answer questions and solicit suggestions for future product enhancement and developments. More information can be obtained by calling Michele Bush-Weller at EEsof, (818) 991-7530 or Helge Pecher, EEsof's European Center, West Germany, (49) 89-8577605.

Europe Sees EMC Boost

A report from Frost & Sullivan forecasts the European EMC market to expand from $194 million in 1986 to $227.5 million in 1987 and $297 million in 1989. *Electromagnetic Compatibility Products and Services Market in Europe* (#E892) analyzes the market by materials, products and services, applications, OEM's and end-users, size, industry structure, and national characteristics. Many of the new opportunities taking shape as the market develops are

Sales of Electromagnetic Compatibility Products & Services from Western Europe.

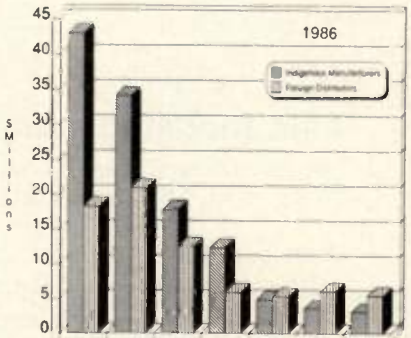
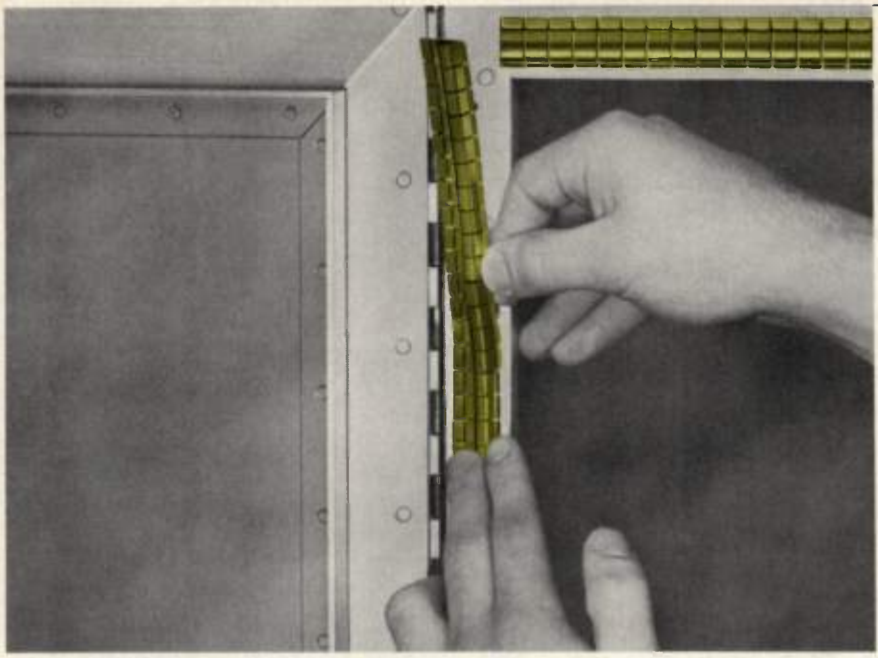


Figure courtesy of Frost & Sullivan.



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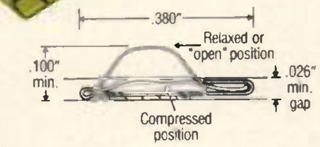

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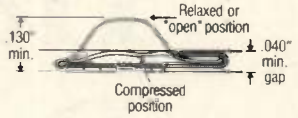
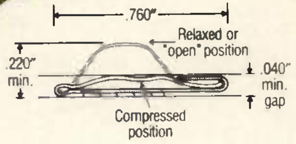


Series 515
.760″ wide



New *sticky fingers*® design resists damage, provides superior RFI/EMI shielding!

Now! Sticky-Fingers beryllium copper shielding gaskets have been made even better! A special, U-shaped end permits the upper part of the strip to slide when enclosure doors are closed, protecting against accidental damage to the strip's fingers.

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Delaware Water Gap, PA. 18327
Phone: 717-424-8510 • TWX: 510-671-4526
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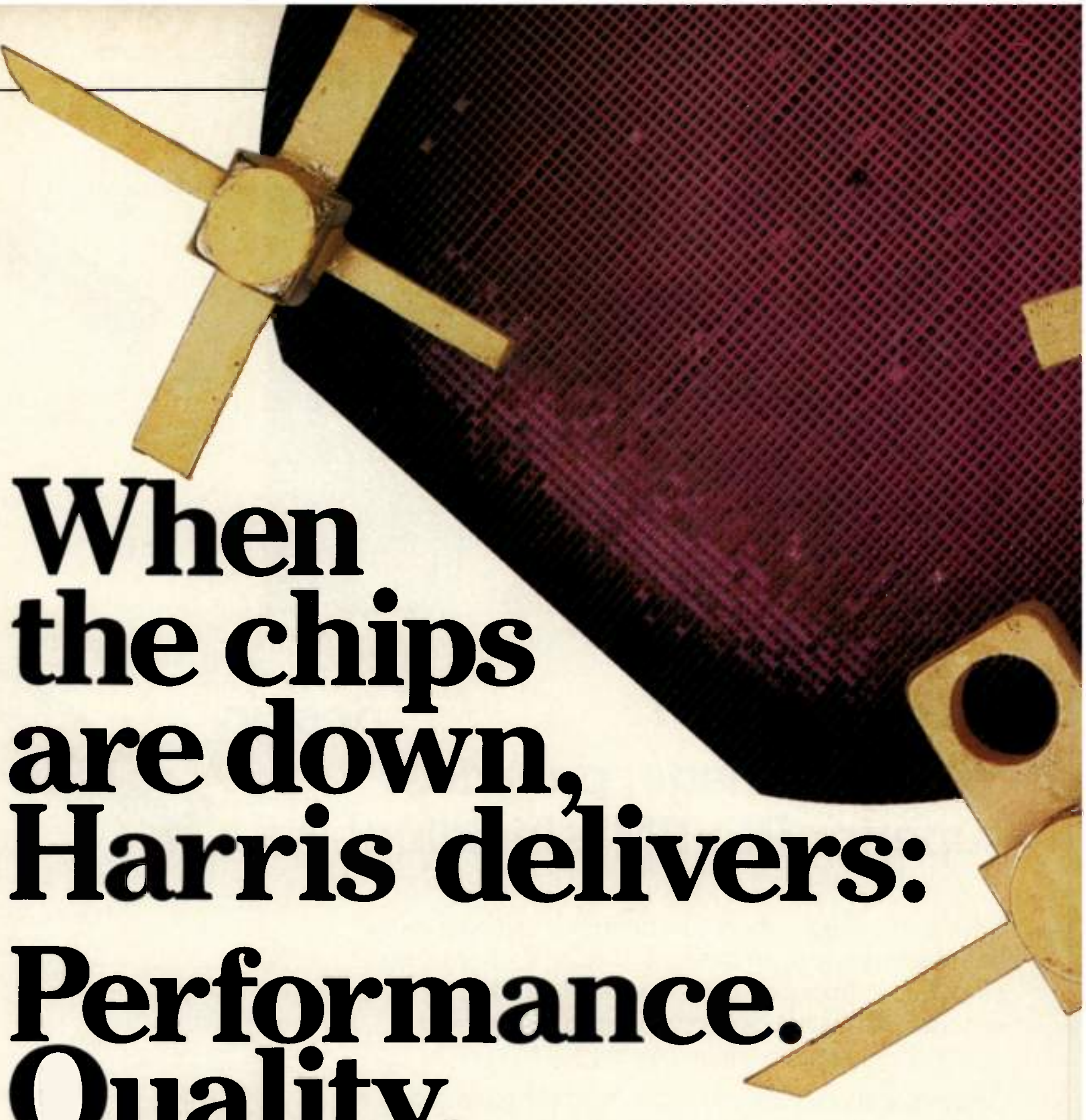
INFO/CARD 13



When the chips are down, Harris delivers:

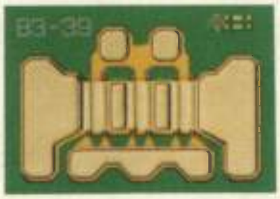
Performance. Quality. Service. Price.

Specify GaAs FETs from Harris... because you can't afford to wait!

You know all gallium arsenide chips are not created equal. So, when you shop for GaAs FETs, you search for the best value. And Harris Microwave delivers!

Delivers value. Selective ion implantation and in-house material growth provide superior uniformity and wafer-to-wafer consistency. Harris GaAs FET chips are uniquely serialized for the ultimate in traceability.

And Harris' metallization system and T-gate structure contribute to excellent bonding and die attach characteristics, as well as providing greater durability and resistance to electrostatic discharge (ESD). This means higher circuit yields for you in production.



Delivers quality. Harris quality certification tests are as rugged as our chips. Every Harris GaAs FET wafer undergoes a battery of tests which exceed the Element Evaluation requirements of MIL-STD-883C, Method 5008, Class B. Higher levels of wafer qualification (including Radiation Tolerance) and screening of packaged devices are also available.

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The best news? Harris FETs are competitively priced — and we intend to keep it that way.

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Contact Harris Microwave Semiconductor, 1530 McCarthy Blvd., Milpitas, CA 95035. In U.S. phone 1-800-4-HARRIS, Ext. 1505, or (408) 433-2222. (TWX: 910-338-2247) In Canada: 1-800-344-2444, Ext. 1505.

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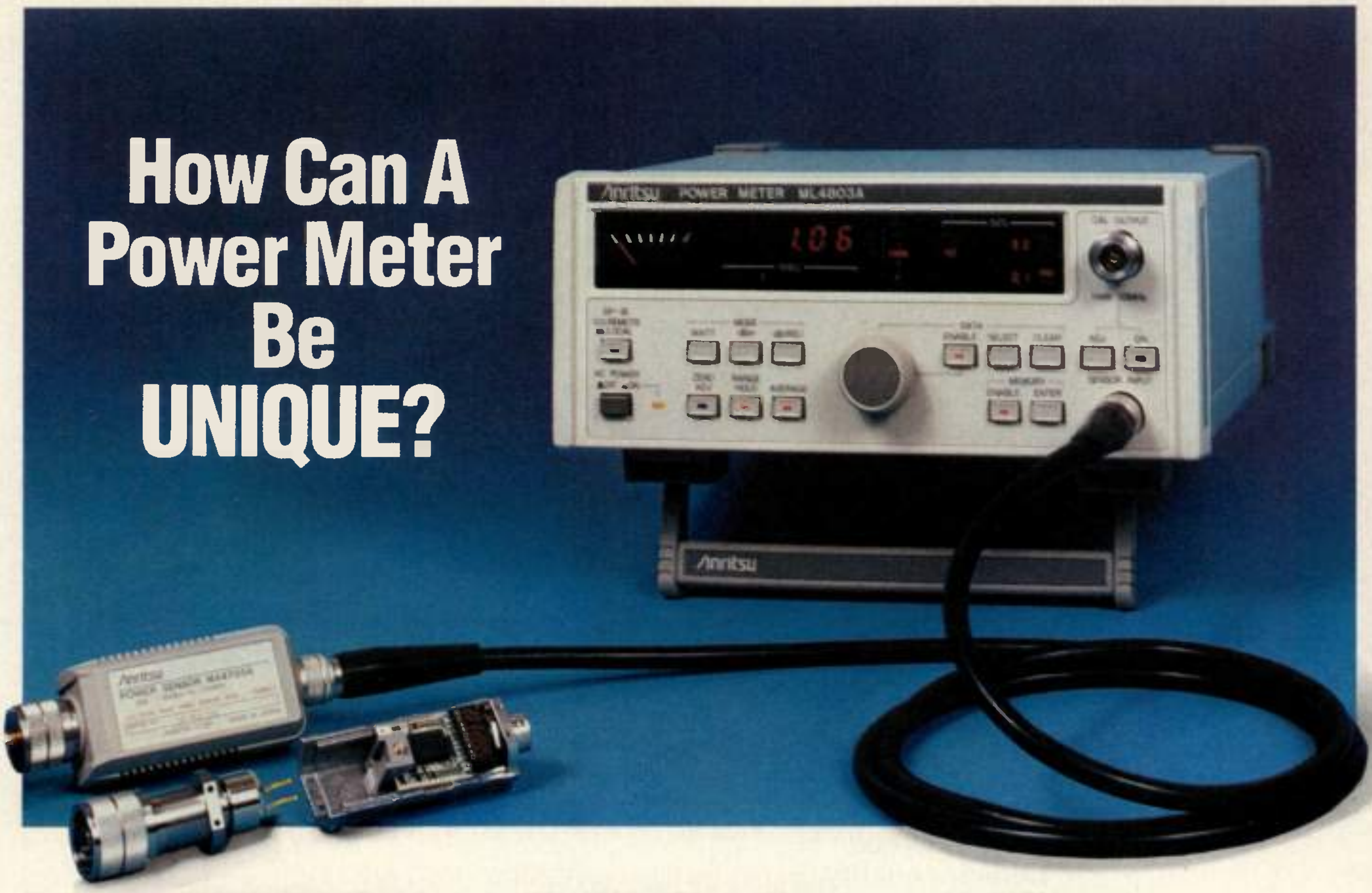

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The **ML 4803 A Power Meter** is no ordinary power meter. Just look at these features, unmatched by any other instrument:

Field Replaceable Sensors To Reduce Downtime

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

26.5 GHz Diode and 32 GHz Amorphous (thermocouple) Sensors

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

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

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

30 × 4 Memory

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

Affordable Price Includes GP-IB

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

Waveguide Sensors to 140 GHz

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

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Oakland, NJ 07436,
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Anritsu

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INFO/CARD 15

in design consultation, and testing and calibration.

Product categories which are predicted to have relatively high market growth rates include materials such as conductive coatings, and conductive polymers. The largest category in terms of sales, filters, and suppressors will maintain its lead going from $39 million in 1986 to $89 million in 1993. The report can be obtained from Frost & Sullivan, Inc. for $2600. Call (212) 233-1080.

Analog Design Tools Joins Marketing Program

Analog Design Tools has joined EDA Systems' Synergy program along with nine other charter members. The Analog Workbench™ produced by Analog Design Tools will become part of EDA Systems' overall electronic design automation framework, called the Electronic Design Management System. Synergy is a cooperative marketing program for CAE products, created to provide customers with a wide selection of electronic design automation tools that take advantage of EDA's Electronic Design Management System Capabilities.

Coaxitube Corp. Produces Cable Assemblies

Coaxitube Corp. has commenced production of semi-rigid coaxial cable assemblies and delay lines at the firm's new Salisbury, Maryland facilities. This includes an RF testing laboratory with capabilities for measuring all types of flexible and semi-rigid cable assemblies in the DC to 26 GHz range.

Soladyne Enhances Testing Capability

By its recent acquisition of a Krautkramer Branson Ultrasonic Immersion Scanner, the Soladyne Division of Rogers Corporation has enhanced its capability to detect lamination flaws in bonded circuit boards. Using the instrument, Soladyne is able to test boards measuring up to 46" × 18" at both narrow band (for detection of very small, deep defects) and broadband (for good image resolution) frequencies.

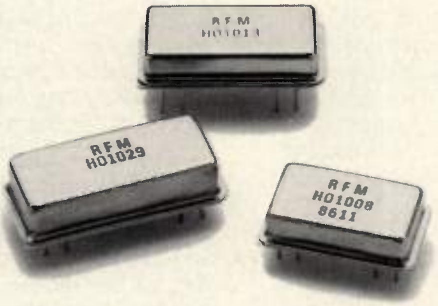
Hytek Forms Military Product Division

Hytek Microsystems, Inc., has formed a Military Products Division aimed at diversification into the large market for hybrid circuits in defense and aerospace applications. The move follows the certification by the Department of Defense of Hytek's Carson City, Nevada facility to the requirements of MIL-STD-1772.

Eaton Awarded $25M

Eaton Corporation has been awarded a $25 million contract by the U.S. Customs Service for the development of a command, control, communications and intelligence (C^3I) system to interdict drug smuggling along the southern border of the United States. The contract calls for the company to provide the government with the most current information-gathering and assessment technology available in its fight against border drug trafficking.

Complementing the Eaton team is Harris Corporation, Government Electronic Systems Division, Melbourne, Florida, which is responsible for the system's broad range of communications technology and digital mapping capability. The system will be designed to receive real-time surveillance information from the nation's exisiting network of civilian and military air traffic control radars, as well



as Customs Service marine radars and other sensing devices. Additionally, extensive intelligence data will be provided through other government agencies.

Keithley Completes Acquisition of Software Company

Keithley Instruments, Inc. has completed its agreement to purchase Adaptable Laboratory Software, Inc.. The action follows Keithley's recent purchase of Macmillan Software, a division of Macmillan, Inc., which marketed ASYST, ASYSTANT+, and ASYSTANT.

Hamilton/Avnet Announces New Facility

Hamilton/Avnet announces the opening of Hamilton/Avnet's new Cable Assembly Facility in Chatsworth, California. The facility stocks Amphenol/Spectra-Strip, Molex, AMP, TRW Cinch, and Winchester Electronics products which are assembled to customers' specifications.

Hughes Receives $300M

British Satellite Broadcasting has reached agreement with Hughes Aircraft Company on a $300 million contact to provide the United Kingdom's first direct television broadcast by satellite. The service is expected to be in operation by late 1989. Hughes will build two satellites for BSB and deliver the spacecraft in orbit.

AEL Awarded Air Force Contract

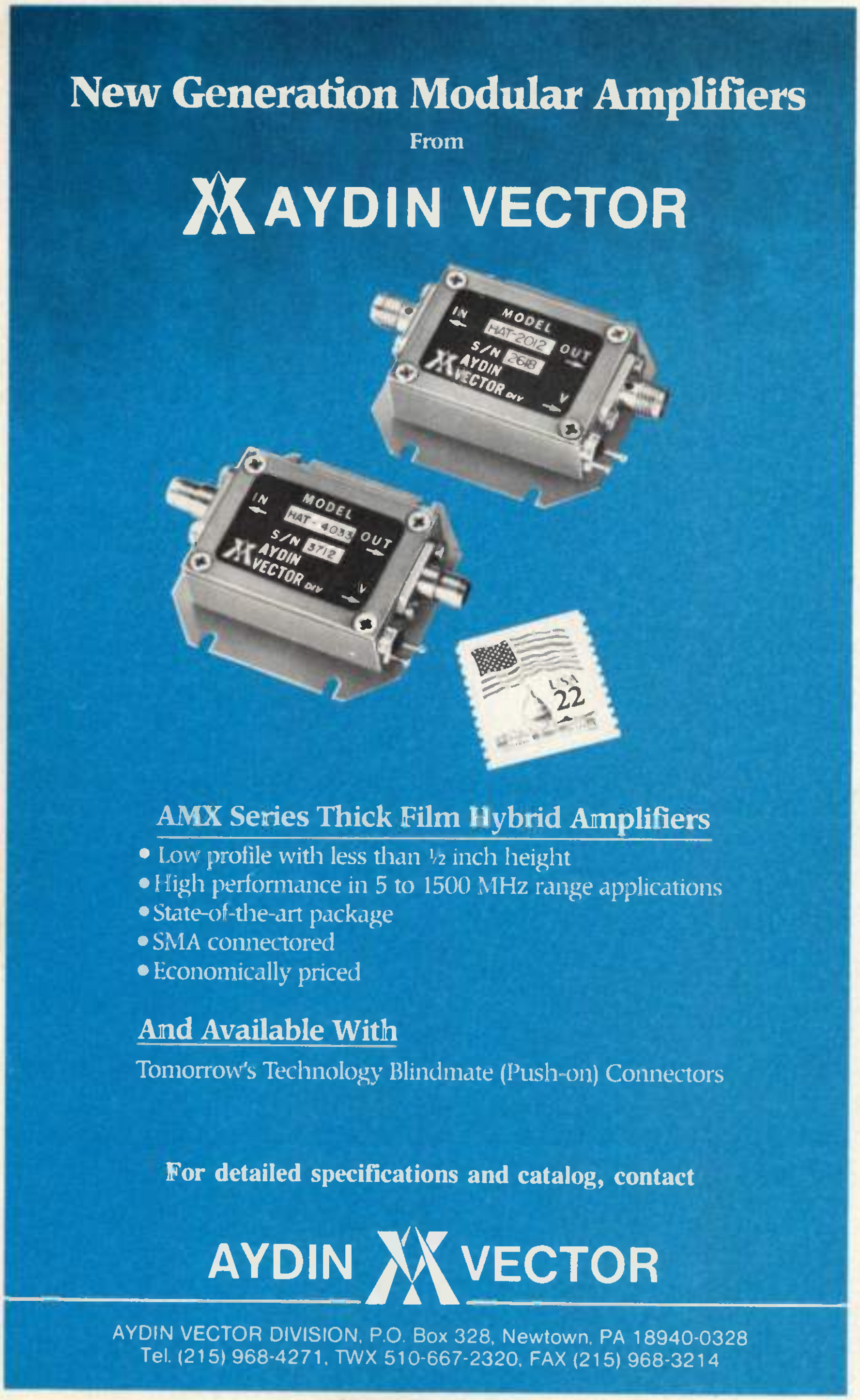
AEL Industries, Inc. announced that its American Electronic Laboratories subsidiary has been awarded a $5.6M contact by the U.S. Air Force to design, develop and produce UHF Satellite Terminal Antenna Subsystems (USTSAS) kits for C-130 and C-141 aircraft. The contract, awarded by the Warner Robins Air Logistics Center at Robins Air Force Base, GA, calls for AEL to produce 833 USTSAS kits with the first delivery scheduled for December 1987.

GE Division Gets Name Change

The commercial segments of GE's semiconductor business became GE Solid State effective August 3, 1987. The division, formerly known as GE/RCA Solid State, is responsible for the design, manufacturing and marketing of GE, RCA and Intersil semiconductors.

C for Programmers

Colorado State University announces a video tape course in C for programmers. The ten 30-minute video tapes are designed to enable experienced programmers to improve their skills in the high level C language. More information can be obtained from Pat Brown, Telecommunications Extended Studies, Division of Continuing Education, Colorado State University, Ft. Collins, CO 80523. Tel: (800) 525-4950.



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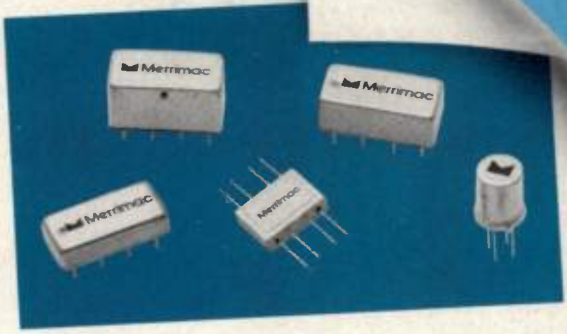

QPL Suffix M-28837	Merrimac Reference Part No.	Operating Freq. Range (MHz)		LO Power dBm	Conversion Loss (SSB) db	Noise Figure dB typ.	Minimum Isolation (dB)				1 dB Comprssn. Point dB typ.	1 dB Desens. Level dB typ.	DC Pola-rity
		RF/LO	IF				L-R	L-I	R-I	for freq. (MHz)			
/1-01S /1-01N	DMS-2-100/57855S DMS-2-100/57855N	0.05-200	DC-200	+4 min. +7 typ. +13 max.	6.5 typ. 8.5 max.	6.5	45 35	40 30	N/A N/A	0.05-30 30-200	+2	0	neg.
/1-02S /1-02N	117A/57834S 117A/57834N	5-500	DC-500	+4 min. +7 typ. +13 max.	7.0 typ. 9.0 max.	7.0	45 35	40 25	N/A N/A	5-50 50-500	+2	0	neg.
/1-03S /1-03N	DMS-2-250/57852S DMS-2-250/57852N	0.5-500	DC-500	+7 typ.	7.0 typ. 8.5 max.	7.0	35 30 25	30 25 20	N/A N/A N/A	0.5-1 1-250 250-500	+2	0	neg.
/1-04S /1-04N	DMS-8-500/57835S DMS-8-500/57835N	RF 2-400 LO 2-500	DC-800	+10 min. +20 typ. +23 max.	7.0 typ. 9.0 max.	7.5	40 35 25	40 35 25	N/A N/A N/A	2-32 32-100 100-500	+16	+14	pos.
/1-09S /1-09N	M119/57836S M119/57836N	1-750	DC-750	+7 typ.	7.5 typ. 8.5 max.	7.5	45 30 25	30 25 20	N/A N/A N/A	1-2 2-375 375-750	+2	0	pos.
/1-10S /1-10N	DMS-4-250/57853S DMS-4-250/57853N	0.4-500	DC-500	+7 min. +13 typ. +17 max.	7.0 typ. 9.0 max.	7.0	45 25	40 25	N/A N/A	0.4-50 50-500	+11	+8	neg.
/1-11S /1-11N	DMS-8-250/57837S DMS-8-250/57837N	1-500	DC-500	+23 typ.	7.5 typ. 9.5 max.	7.5	50 40 30 20	40 30 20 20	25 20 20 20	1-100 100-200 200-300 300-500	+16	+14	neg.
/1-12S /1-12N	DMS-2-25/57838S DMS-2-25/57838N	0.002-12	DC-12	+4 min. +7 typ. +13 max.	6.0 typ. 8.0 max.	6.0	45 40	40 30	N/A N/A	0.002-5 5-12	+2	0	neg.
/2-01S /2-01N	DMF-2A-505/57839S DMF-2A-505/57839N	5-1000	DC-1000	+10 min. +10 typ. +17 max.	7.0 typ. 8.0 max.	7.0	40 30	40 25	30 15	5-100 100-1000	+2	0	pos.
/2-02S /2-02N	DMF-2A-700/57840S DMF-2A-700/57840N	10-1500	DC-1000	+4 min. +7 typ. +13 max.	7.0 typ. 9.5 max.	7.0	30 25 25	30 20 18	N/A N/A N/A	10-600 600-1200 1200-1500	+2	0	neg.
/2-04S /2-04N	DMF-2A-250/57841S DMF-2A-250/57841N	0.5-500	DC-500	+7 min. +7 typ. +17 max.	7.0 typ. 8.0 max.	7.0	40 35	30 20	23 20	0.5-300 0.5-500	+2	0	pos,
/2-05S /2-05N	DMF-2A-250/57854S DMF-2A-250/57854N	0.5-500	DC-500 (IF-1 & IF-2)	+7 min. +7 typ. +13 max.	6.5 typ. 7.0 max.	6.5	35 30 25	30 25 20	25 20 15	0.5-10 10-200 200-500	+2	0	neg.
/7-01S /7-01N	M109/57832S M109/57832N	10-500	DC-500	+7 typ.	7.0 typ. 9.0 max.	7.0	40 35 30 25	35 30 25 15	25 20 15 10	10-50 50-100 100-200 200-500	+2	0	neg.
/7-02S /7-02N	M109/57833S M109/57833N	350-500	DC-500	+7 typ.	7.0 typ. 9.0 max.	7.0	25	15	10	350-500	+2	0	neg.

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INFO/CARD 18

rf courses

Instrument Society of America

Fifth Measurement and Control Technology Short Course
October 5-9, 1987, Anaheim, CA

Information: ISA/87 Short Courses, Instrument Society of America, P.O. Box 12277, Research Triangle Park, NC 27709; Tel: (919) 832- 5599

The George Washington University

HF Communications Technology
September 14-18, 1987, Orlando, FL
November 16-20, 1987, Washington, DC
Spread Spectrum Communication Systems
September 21-25, 1987, Washington, DC
Fiber Optics Technology for Communication
September 22-24, 1987, Washington, DC
Introduction to Modulators and Transmitters
October 5-6, 1987, Washington, DC
High Frequency Spectrum:New concepts and technologies
October 5-9, 1987, Washington, DC
Introduction to Receivers
October 19-20, 1897, Washington, DC
Modern Receiver Design
October 21-23, 1987, Washington, DC
Global Positioning System: Principles and Practice
November 4-6, 1987, Washington, DC
Wideband Communications Systems
December 7-11, 1987, Washington, DC

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

UCLA Extension

Kalman Filtering II
October 26-30, 1987, Los Angeles, CA
Smart Armament/Missile Systems and Technology
October 27-29, 1987, Los Angeles, CA

Information: UCLA Extension, P.O. Box 24901, Los Angeles, CA 90024; Tel:(213) 825-1901; (213) 825-1047; (213)825-3344

Interference Control Technologies, Inc.

Grounding and Shielding
September 15-18, 1987, Washington, DC
October 6-9, 1987, San Diego, CA
October 20-23, 1987, Boston, MA
November 3-6, 1987, Philadelphia, PA
Tempest Design
November 17-20, 1987, Mountain View, CA
Practical EMI Fixes
September 22-25, 1987, San Diego, CA
October 13-16, 1987, Washington, DC
November 10-13, 1987, San Jose, CA
Tempest Facilities
October 20-23, 1987, Washington, DC
MIL-STD-461/462
September 29-October 2, 1987, Washington, DC
RFI Design and Measurement
October 26-30, 1987, Philadelphia, PA

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

Integrated Computer Systems

Digital Signal Processing
September 22-25, 1987, San Diego, CA
October 27-30, 1987, Anaheim, CA
Image Processing and Machine Vision
September 22-25, 1987, Washington, DC
October 27-30, 1987, Palo Alto, CA
November 3-6, 1987, Toronto, Canada
Fiber Optic Communication
September 15-18, 1987, Washington, DC
September 29-October 2, 1987, San Diego, CA
November 3-6, 1987, Los Angeles, CA
November 3-6, 1987, Washington, DC
November 17-20, 1987, Boston, MA
Hands-On Programming in C
September 22-25, 1987, Washington, DC
September 29-October 2, 1987, San Diego, CA
October 27-30, 1987, Boston, MA
November 3-6, 1987, Los Angeles, CA
November 17-20, 1987, Washington, DC

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

Norand Corporation

MIL-STD 461B/C and 462 Regulations and Design Criteria
October 13-14, 1987, Cedar Rapids, IA
RF Susceptibility and ESD Testing
November 3-4, 1987, Cedar Rapids, IA

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

Compliance Engineering

Compliance Seminars: EMI, Safety, ESD, Telecom
September 29-October 2, 1987, Orlando, FL
October 27-30, 1987, Boston, MA
December 1-4, 1987, San Diego, CA

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

Avantek, Inc.

RF & Microwave Semiconductor Design Solutions Seminar
October 2, 1987, Ft. Wayne, IN
October 5, 1987, Boston, MA
October 7, 1987, Ft. Washington, PA
October 9, 1987, Atlanta, GA
October 13, 1987, Orlando, FL
October 15, 1987, Dallas, TX
October 19, 1987, Burbank, CA
November 4, 1987, Albuquerque, NM

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

R & B Enterprises

Electromagnetic Pulse (EMP) Design and Test
October 5-6, 1987, Philadelphia, PA
November 17-18, 1987, Washington, DC
December 7-8, 1987, Philadelphia, PA
Electromagnetic Pulse Workshop
October 9, 1987, Philadelphia, PA
Understanding and Applying MIL-STD-461C
October 20-21, 1987, Philadelphia, PA
November 17-18, 1987, Washington, DC
December 14-15, 1987, Philadelphia, PA
MIL-STD-461C Praxis (Workshop)
October 20-21, 1987, Philadelphia, PA

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

rf calendar

September 29-October 1, 1987
1987 OEM Design and Integrated Manufacturing Exposition
McCormick Place East, Chicago, IL
Information: Bill Little, Penton Exposition, 122 East 42nd St., New York, NY 10168; Tel: (800) 634-4639, in NY call (212) 867- 9191

September 28-October 1, 1987
Ninth Annual Meeting and Symposium, Antenna Measurement Techniques Association
The Stouffer Madison Hotel, Seattle, WA
Information: James R. Otey, 1987 AMTA Symposium, 6632 South 191st Place, Suite E-105, Kent, WA 98302

September 29-October 1, 1987
Fall National Design Engineering Show and Conference
Javits Convention Center, New York, NY
Information: Monica Viladegutt, Cahners Exposition Group, 999 Summer St., P.O. Box 3833, Stamford, CT 06905; Tel: (203) 964-0000

October 4-8, 1987
ISA/87
Anaheim Convention Center, CA
Information: Paul Albert, Instrument Society of America, P.O. Box 12277, Research Triangle Park, NC 27709

October 12-14, 1987
GaAs MAN-TECH Conference
Marriott Hotel, Portland, OR
Information: Wayne Moyers, Pacific Monolithics, 245 Santa Ana Ct., Sunnyvale, CA 94086; Tel:(408) 732-8000

October 13-15, 1987
Scan-Tech 87
Bartle Hall, Kansas City, MO
Information: Don Anderson, AIM, Inc., 1326 Freeport Rd., Pittsburgh, PA 15238. Tel: (412) 963-8588

October 19-21, 1987
The Twentieth Annual Connectors and Interconnection Technology Symposium
Franklin Plaza Hotel, Philadelphia, PA
Information: Electronic Connector Study Group, Inc., P.O. Box 167, Fort Washington, PA 19034-0167; Tel: (215) 825-3840

October 26-30, 1987
FOC/LAN 87, Eleventh International Fiber Optic Communication and Local Area Networks Exposition
Anaheim Convention Center, Anaheim, CA
Information: Renee Farrington, Information Gatekeepers, Inc., 214 Harvard Avenue, Boston, MA 02134; Tel: (617) 232-3111

November 10-12, 1987
1987 ITEA Symposium
Park Plaza Hotel, Boston, MA
Information: Howard L. Graves, Raytheon Company, Public Relations, 141 Spring Street, Lexington, MA 02173; Tel: (617) 470-6027

November 11-13, 1987
RF Expo East 87
World Trade Center, Boston, MA
Information: Linda Fortunato, Convention Manager, Cardiff Publishing Company, 6300 S. Syracuse Way, Suite 650, Englewood, CO 80110; Tel: (303) 220-0600; (800) 525-9154

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FMPL	Modulatable Phase-Locked Transmitters; Modulatable 10 Hz to 12 MHz
MX	Frequency Multipliers; High Efficiency-Low Noise to 21 GHz
MFSR	Microwave Synthesizer; Ultra-Low Noise &<1 kHz Steps
SLSR	Microwave Synthesizer; Moderate-Low Noise & 1 to 10 MHz Steps
DSR & MDSR	Microwave Synthesizer; Low Noise, Small Size & Low Cost–10 kHz Step
PXS & PXSM	Crystal Oscillators; Free Running or Locked to 5 or 10 MHz
C & VCO	Cavity Oscillators; Low-Noise Mechanically or Voltage Tuned
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INFO/CARD 20

Advances in Computer-Aided Test

PCs and Advanced Software Maximize Instrument Capabilities

By Larry Lerner
EEsof, Inc.

Today's test and measurement equipment continues to advance the state of the art in reliability and measurement capabilities, evidenced by Hewlett-Packard's 8510 and 8753 network analyzers, plus the newest entry on the market, the Wiltron 360™ vector network analyzer. These test instruments (pictured on the front cover) address measurements in the RF/microwave range for both active and passive networks over the 100 kHz to 26.5 GHz frequency range, and in the case of the Wiltron 360, up to 40 GHz. Recent computer-aided test (CAT) software such as ANACAT™ 1.1 from EEsof, Inc., has been created to give the RF engineer maximum performance in the calibration, measurement, and management capabilities of this test equipment in the lab.

As little as ten years ago, computer-aided test was confined to the lab where the engineer made measurements with custom-made software programs running on desktop instrument controllers. The process was cumbersome and the results often incomplete. Data had to be manually transferred to simulator programs running on large mainframe computers. The data transfer from test equipment to instrument controllers to programmable software was slow and inexact.

PCs Bridge the Gap

With the advent of the IBM PC™ in 1981 and the subsequent development of software customized specifically for this environment, the requirements for gathering, processing, and measuring test data for use in future simulations were bridged. The PC offered a powerful, portable, and versatile computing environment that could be utilized right in the lab, replacing instrument desktop controllers and the VAX mainframes that provided the early simulations, and lowering the price of an average workstation from the 50-60K range to an affordable 7-10K. As with every other industry, the PC had a revolutionary impact on RF/microwave circuit design and test — from an increase in productivity and creativity for the engineer to huge time and cost reductions in production.

ANACAT 1.1

ANACAT was written from the ground up to maximize the features of the workstation and test equipment pictured below, and the new, upgraded ANACAT 1.1 release has additionally been ported to the 32-bit HP 9000 series 300 computers. It not only commands the full capabilities of the HP test equipment but a full family of network analyzers, including the advanced capabilities of the Wiltron network analyzer. ANACAT provides a flexible and interactive means of controlling the operation of these network analyzers, and for acquiring, correcting, manipulating, displaying, or managing the collected data. This interface provides engineers with a tool to facilitate in-depth measurement of both the pre-design and production test phases of circuit engineering.

The PC version of the program has a DOS interface, full-screen editor for creating and revising files, and color graphics for interactive graphics display. In addition, the program's database readily interfaces with other popular applications such as EEsof's Touchstone® program for circuit simulation, Lotus' 1-2-3™, and Ashton-Tate's dBASE™. New capabilities created for version 1.1 include a new time-domain output feature, macro commands, enhanced view menu, and multi-port measurements.

Measurements and Database Manager

The heart of the program is the measurement database, which is characteristically a task beyond the scope of the automatic network analyzers' firmware. ANACAT takes large amounts of data

ANACAT 1.1 extends the calibration capabilities of automatic network analyzers.

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250C	50 W	1-200MHz	40dB	100-240V	24dB	3,950.00
117CFR	100 W	100-160MHz	45dB	100-240V	35dB	3,495.00
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122C	200 W	10KHz-220MHz	50dB	208-380V	17dB	9,550.00
123CFR	200 W	80-160MHz	50dB	100-240V	35dB	5,850.00
126CR	200 W	225-400MHz	50dB	100-240V	22dB	7,500.00
127CR	200 W	400-500MHz	50dB	100-240V	50dB	8,500.00
163LP	250 W	10-100MHz	53dB	100-240V	23dB	4,900.00
163HP	250 W	80-200MHz	53dB	100-240V	23dB	5,900.00
164SP	250 W	400-500MHz	55dB	100-240V	25dB	6,990.00
164UP	300 W	200-400MHz	55dB	100-240V	25dB	6,990.00
130CF	400 W	80-160MHz	50dB	100-240V	30dB	8,990.00
131CF	400 W	225-400MHz	50dB	100-240V	23dB	18,500.00
128CF	500 W	2-30MHz	55dB	100-240V	16dB	7,250.00
128CR	500 W	2-30MHz	55dB	100-240V	50dB	8,990.00
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164LP	500 W	10-86MHz	53dB	100-240V	23dB	6,990.00
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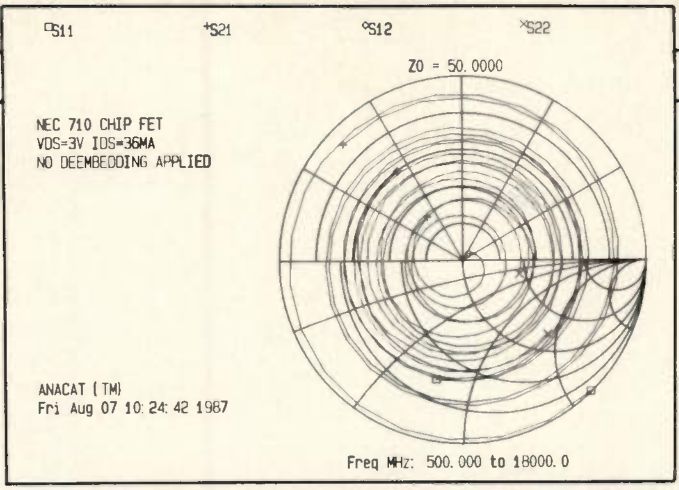


Figure 1. A full, 2-port calibrated measurement of a NEC 710 FET including the test fixture. No de-embedding has been applied by ANACAT at this point to remove the effects of the test fixture.

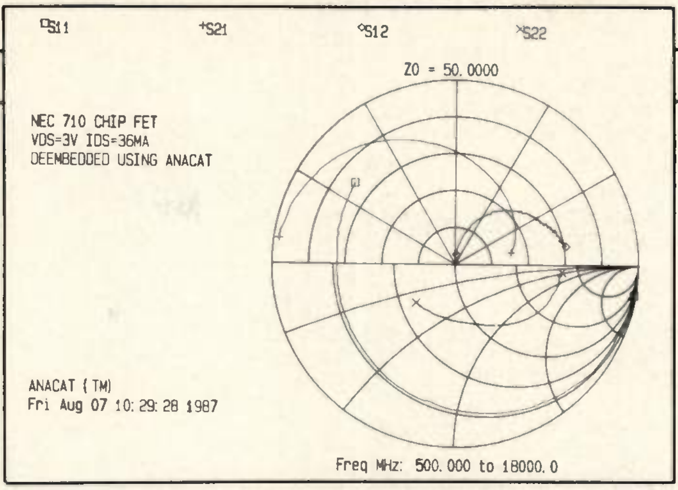


Figure 2. This shows the same NEC 710 FET measurement data from Figure 1, with the test fixture effects removed using the ANACAT de-embedding feature. All four de-embedded FET S-parameters are graphically displayed on a combination Smith-Polar chart.

directly from the network analyzer and stores and manipulates the data in a structured yet flexible database. It's a hierarchical database in which the user can organize measurement data with customized labels, descriptions, and so forth; and the database manager can be readily customized in terms of how the user can organize measurement data.

The database manager lets the user create, delete, and revise test data with a few simple keystrokes. The Lotus/dBASE compatibility opens the door to more direct information exchange. Future product updates will offer a Measurement Data Interchange Format (MDIF) that adds consistency in viewing and flexibility in manipulating the large amounts of stored data in the system.

The database allows the data to be saved and viewed at a later time in such forms as S-, Z-, Y-, G-, and H-parameters. The data is then displayed on a customized selected table or graph in the desired format.

Other features of the program's database are its ability to normalize data in correspondence to any other given measurement and to view calculated parameters relating to the measurement, such as maximum available gain and stability. Using Touchstone, the user can access measurements from the database and apply them either in a simulation or to fit the measured data to equivalent circuit models. Rectangular and polar charts

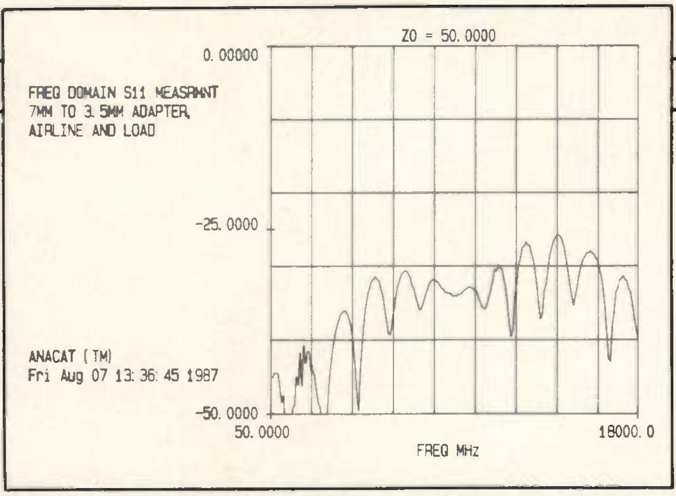


Figure 3. Frequency-domain S11 response of a 7 mm to 3.5 mm adapter, airline, and load combination from 50 MHz to 18 GHz. In the frequency domain, it is not possible to separate the mismatch effects of the 35 mm adapter and airline from the load termination.

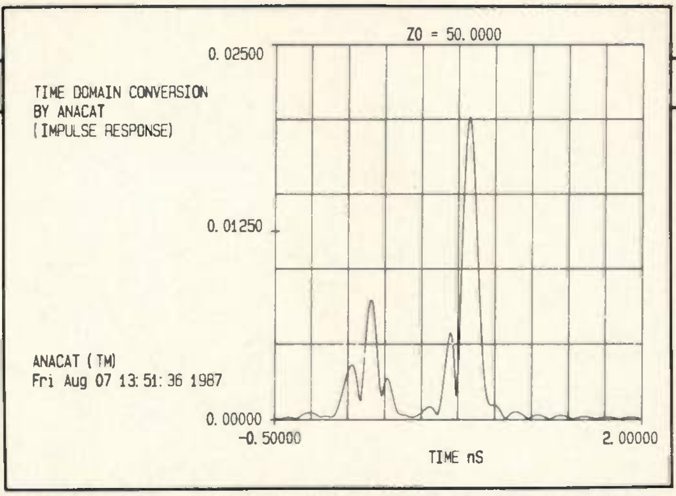


Figure 4. The frequency-domain response is converted to the time domain using ANACAT. Now the effects of the 3.5 mm adapter and airline are readily apparent and easily measured. Position instructions. . . Figs. 1 and 2 need to be adjacent, as do Figs. 3 and 4.

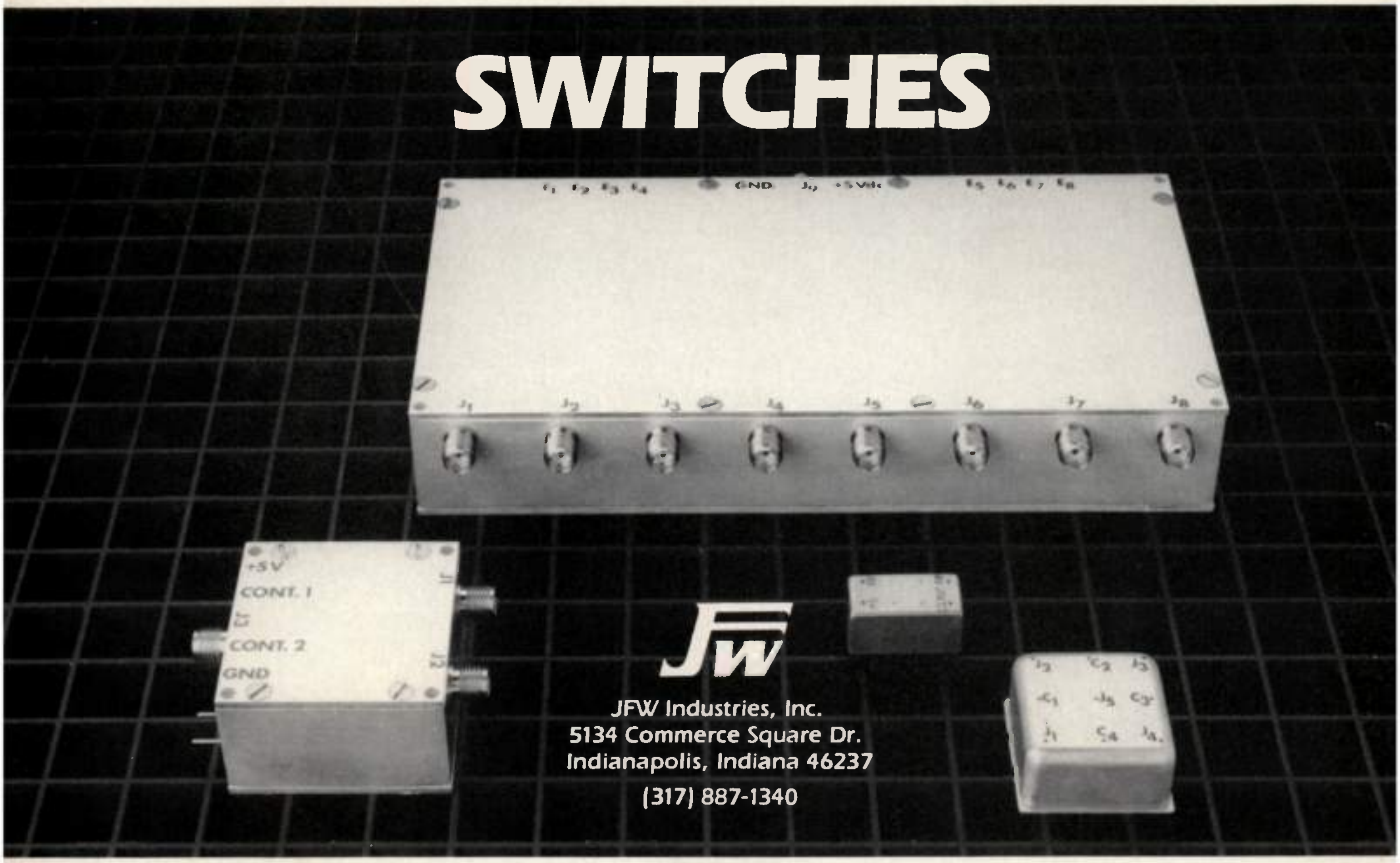
may be customized for comparison of data dispersed throughout the database.

The program will completely define a calibration of the network analyzer system. This is accomplished in an interpretive English language and is easy to understand and modify, providing calibration standards definition using Touchstone-like syntax. Calibration standards are defined using models of coaxial, waveguide, or planar transmission media, and terminating impedances may be expressed in general equation formats.

Using the interactive menus, the engineer can measure customized standards and derive associated network analyzer error coefficients. The definition file standards measurements and derived error terms can be stored and retrieved as needed from the calibration database. Unlike manual operation of the vector network analyzer, ANACAT defines and implements a calibration at any arbitrary collection of up to 512 frequencies.

Embedding and De-Embedding Data

In numerous measurement applications such as for active devices embedded in a planar transmission media, it is difficult to manufacture standards which can, with confidence, be modeled for use in standard error correction. ANACAT enables the engineer to calibrate the network analyzer at a convenient set of reference planes and to then math-



ematically rotate or transform those planes through network descriptions provided by the user. These network descriptions can originate from the program's measurement database, from standard Touchstone S-parameter data files, or can be extracted directly from measurement of unit fixture standards.

For example, if the engineer takes a calibrated measurement from the network analyzer and would like to see how that unit acts when embedded in a hypothetical circuit, ANACAT rotates the calibrated reference planes out or away from the device through the hypothetical networks. Successive application of de-embedding and then embedding operations allows real-time measurement of active devices in hypothetical circuits.

In the case of simulators, most work is done in the frequency domain. But if an engineer wants to understand a circuit physically, then at each juncture of the connected circuit elements it's often advantageous to analyze the circuit in the time domain. Underlying the behavior of the S-parameters with frequency are the cumulative effects of a series of reflected signal waves created at each discontinuity within the circuit. ANACAT allows observation in the time domain of these physical effects in terms of the distance between discontinuities in the circuit, and it lets the user de-embed based on that time-domain information.

ANACAT lets the engineer view any display function as a function of time and to observe time-domain output in either RF or baseband format, for either impulse or step response. The user can de-embed a set of reference planes in the frequency domain by internally converting them to time domain, gating the time domain, and then re-converting to the frequency domain.

The current network analyzers can measure one or two port devices, and that's a limitation. To measure something that has more than two connections necessitates alternate measurements by connecting two ports at a time.

One can mathematically supply three- four- or five-port S-parameters based upon composite measurements for the different two-port connections. ANACAT provides a shorthand way that lets the engineer measure and view measurements of up to six-port devices.

Conclusion

Today's RF engineer has workstations available to him or her that have, in the past few years, dramatically fallen in cost and risen in performance. Information from powerful network analyzers can be easily acquired and manipulated in program databases such as ANACAT for all phases of design and production.

In the future, we will witness the incorporation of artificial intelligence in CAT to produce much more sophisticated and flexible databases and operating systems. The future for RF and microwave design offers unlimited possibilities.

For more information about ANACAT 1.1, contact EEsof, Inc., 31194 La Baya Drive, Westlake Village, CA 91362, tel. (818) 991-7530, or circle INFO/CARD #125.

About the Author

Larry Lerner is manager of CAT development at EESof. He is currently developing interactive test software and is the designer of ANACAT. He holds a BSEE from Harvey Mudd College and an MSEE from Stanford University.

Design Software for Personal Computers

A Complete Listing of RF and Analog Engineering Programs

Radio frequency circuits and related areas of analog design may be the last engineering disciplines to receive widespread computer software support. It isn't that the field has been neglected. Rather, it is the difficulty of creating accurate mathematical models that slowed development. RF design has traditionally been a matter of approximation, refined to a final form through experimentation. The image of RF engineers as practitioners of a "black art" is still strong.

As you can easily tell by the amount of software now available, there is no longer any shortage of computer assistance for the RF engineer! The listing included in this report contains 35 companies and 108 different program packages. There is more available than just this listing, too. A few companies may have been omitted (please tell us about them), and there is plenty of noncommercial software developed by individual engineers and distributed via bulletin boards, magazine articles, or passed along person-to-person.

The wait for RF software has been worth it. Many of the old problems of defining component characteristics, establishing correct transfer function equations and modeling stray reactance have been solved, or at least closely approximated. Designers can now achieve good correlation between software circuit analysis and "real world" performance. This is particularly true in offerings from the eight or ten medium to large sized companies who have invested significant time and money for development.

There are also many small companies who offer low cost software to engineers. Although these programs may not be as sophisticated or have graphics as nice as those from bigger firms, they represent a good dollar value. These programs are usually solutions to a specific engineering problem, and often get used the same way as a reference book. Many engineers find excellent value in having such a reference collection on disk.

Whether from large companies or small, the amount of RF software is growing rapidly, especially programs for personal computers. Now that software designers are achieving good RF circuit models, engineers are gaining confidence in software tools that enhance their design capabilities. The following list (in random order) represents all the RF and analog design software for personal computers that the *RF Design* staff has been able to identify. rf

PC-based RF and Analog Design Software

Analog Design Tools

The *PC Workbench™* simulates the design process from drawing schematics through simulated breadboarding, testing, and performance analysis.

Simukit™ allows the integration of the Workbench with users' simulators and model libraries. **Analog Design Tools, Inc., Sunnyvale, CA. INFO/CARD #160.**

Sofcad Electronics

Linear Circuit Analysis and Design, *LINCAD*, performs design, optimization, frequency and phase graphics, and various other functions.

CALCAD is a logic circuit analysis and design program.

FFTSA and *CONVOLV* are spectrum and signal analysis programs. **Sofcad Electronics, Inc., Columbus, OH. Please circle INFO/CARD #159.**

Thomas H. Stanford Engineering

RFAMP designs RF single stage amplifiers using S-parameters.

MICRO designs asymmetric couplers, end coupled bandpass filters and various other systems for microstrip design. **Thomas H. Stanford Engineering, Escondido, CA. Please circle INFO/CARD #158.**

Microwave Software

Sceptre™ 2.0 is a frequency domain circuit analysis program.

OptiMatch™ 2.0 performs circuit optimization.

SmithMatch™ 2.0 allows the user to analyze or synthesize impedance match networks.

Utilities+™ is a collection of 25 RF/microwave circuit design tools.

MStrip+™ 2.0 is a microwave transmission line synthesis and analysis program. **Microwave Software, San Juan Capistrano, CA. INFO/CARD #157.**

DGS Associates

S/FILSYN™ is structured for the design, synthesis, and analysis of passive LC, active RC, digital and microwave filters, and delay equalizers.

COMBLINE is a filter post processor program that works on a design prepared by S/FILSYN.

SCASY is a program for analysis of linear switched capacitor circuits.

Filter-9 PAC contains nine programs for the design of passive LC filters and transfer of active RC and digital filters. **DGS Associates, Santa Clara, CA. INFO/CARD #156.**

Interceptor Electronics

ALADYN-64 is a circuit analysis program for examining the characteristics of linear and ladder networks. **Interceptor Electronics, Inc., Round Hill, VA. INFO/CARD #155.**

Webb Laboratories

Transcad is a transmission line and waveguide synthesis/analysis package.

Syscad performs link analysis, architecture characterization, optimization, receive and transmit spurious analysis, and frequency source phase noise analysis.

Filsolve performs synthesis on filters in Butterworth, Chebyshev, Bessel, and equal ripple time delay realizations. **Webb Laboratories, North Lake, WI. INFO/CARD #154.**

Multipath

Public Domain & User Supported Software Directory lists approximately 3200 programs which include science, engineering, and math. **Multipath, Inc., Montville, NJ. Please circle INFO/CARD #149.**

RLM Research
Active Filter Design synthesizes and analyzes active filters.
Spice File Conversion Utility Program simulates filters designed with *Active Filter Design* using Spice without having to manually create the input file. **RLM Research, Boulder, CO. INFO/CARD #153.**

Etron RF Enterprises
RF Notes 1 performs general design aids which include image parameter filters, basic stripline design, and basic microstrip design.
RF Notes 2 performs attenuator pad design, impedance matching, inductor design, and capacitor analysis.
RF Notes 3 Vol 1 designs Butterworth filters.
RF Notes 3 Vol 2 is tailored for Bessel filter design.
RF Notes 3 Vol 3 performs Chebyshev filter design.
RF Notes 4 is a network analysis program that creates circuit design with up to 30 circuit sections. **Etron RF Enterprises, Diamond Bar, CA. INFO/CARD #152.**

Hayward Electronic Systems
Ladpac/Ladpac-87 features filter design, circuit analysis, optimization, error trapping, impedance matching, and various other functions. **Hayward Electronic Systems, Inc., Beaverton, OR. INFO/CARD #151.**

BV Engineering
ACNAP is a circuit analysis program.
COMCALC is a communications system design package.
LCFIL performs passive lumped RF filter design.
PCPLOT provides high resolution screen/printer graphics.
BV Engineering Professional Software, Riverside, CA. INFO/CARD #150.

Circuit Busters
Filter synthesizes thirteen topographies of lowpass, highpass, bandpass, elliptic lowpass, and elliptic bandpass filters.
Superstar 3.0 is a general purpose RF and microwave circuit simulation and design tool. **Circuit Busters, Inc., Stone Mountain, GA. INFO/CARD #148.**

Intusoft
Pre_Spice is an interactive circuit analysis program that performs Monte Carlo analysis among various other functions.
Is_Spice performs transfer functions and noise analysis, transfer function sensitivity and curve families, and various other functions.
Intu_Scope is a graphics processor that displays data obtained from Is_Spice. **Intusoft, Rancho Palos Verdes, CA. INFO/CARD #147.**

Microwave Software Applications
SLINE performs synthesis and analysis of single-strip stripline.
MLINE is a software package for the synthesis and analysis of single-strip microstrip transmission lines.
CXLINE is tailored for coaxial transmission lines.
LANGE offers microstrip interdigital coupled software.
SLCUP designs edge-coupled stripline directional couplers.
MSCUP performs design synthesis and analysis of edge coupled microstrip directional couplers.
LEFLTR is a lumped element filter program.
CXLPF designs distributed circuit lowpass filters in coax lines.
MSLPF is for distributed microstrip lowpass filter design with Chebyshev and Butterworth responses.
SLLPF designs distributed stripline lowpass filters with synthesis of electrical and distributed circuits.
MSPCF performs bandpass filter synthesis of parallel coupled lines on microstrip designs.
SLPCF designs stripline distributed bandpass filters using parallel coupled lines **Microwave Software Applications, Inc., Norcross, GA. INFO/CARD #146.**

Tatum Labs
ECA-2 is an analog circuit simulator with AC, DC, transient, and fourier analysis. **Tatum Labs, Inc., Ann Arbor, MI. Please circle INFO/CARD #145.**

EEsof
Touchstone provides an interactive design environment for the analysis, simulation, and optimization of linear microwave/RF devices and circuits.
Microwave Spice is a non-linear, time-domain circuit simulation program.
E-Syn performs automatic synthesis of noise matching, interstage matching, impedance matching, and filter networks.
MiCAD is a microwave mask layout program that converts circuit files created in the simulator program to artwork.
ANACAT is a program for the calibration, measurement, management, de-embedding, and embedding of vector network analyzer data. **EEsof, Inc., Westlake Village, CA. INFO/CARD #144.**

Bishop Graphics
Quik Circuit™ is a software package for printed circuit board design and manufacturing.
Pathfinder™ coupled with *AutoCAD™* (graphics software) provides advanced PCB design. **Bishop Graphics, Westlake Village, CA. INFO/CARD #143.**

T & E Software
Circuit Analysis analyzes linear circuits up to and including 27 nodes at user defined frequencies. **T & E Software, Raytown, MO. INFO/CARD #142.**

Compact Software
Super-Compact® PC does analysis and synthesis over a large range of RF and microwave circuits performs both ladder and nodal circuit analysis.
AutoArt™ PC is an interactive drafting program for microwave circuits.
Sonata is designed for the synthesis and optimization of microwave oscillators.
Linmic+ is tailored for MMIC development and millimeter wave applications.
RF Design Kit™ performs system optimization, WB transformer synthesis, and oscillator design.
PLL Design Kit™ does VCO design, stability analysis, switching analysis, and non-linear analysis.
Communications Design Kit™ is a synthesis and analysis program for analog and digital communication circuits.
Filter Design Kit™ is a software package for the synthesis and analysis of lumped element filters, elliptical filters, helical filters, crystal filters, and interdigital filters.
Complex Match™ performs synthesis and optimization of lumped element or distributed element matching networks.
CADEC 4™ is a general purpose package that performs analysis and optimization on virtually all circuits.
Netcom is a bidirectional HP8510/8753 controller software package that allows total control of the HP network analyzer with IBM PCs with a HP IEEE bus controller card. **Compact Software, Paterson, NJ. INFO/CARD #128.**

Step Electronics
ASM-2000 and *ASM-2500* are translation programs that take the output from *AutoCAD* or *MiCAD* and converts the data

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to commands for pattern generator mask making machines.

ASM-3500 converts the output from *AutoCAD* to *CALMA's GDS-II* database.

DPA-1000 simulates intermodulation distortion in systems.

Super Combline synthesizes the dimensions for combline filters given the electrical and physical requirements. **Step Electronics, Inc., Campbell, CA. INFO/CARD #141.**

Jensen Transformers

COMTRAN is used for the simulation and optimization of active and passive circuits.

AC-CAP performs high speed AC circuit analysis with optimization.

S-Wave does FFT waveform analysis.

PLOTFT with TIMEIN is a time domain data acquisition with frequency domain semi-log scaleable graphics. **Jensen Transformers, N. Hollywood, CA. INFO/CARD #140.**

Design Automation

Class-E Amplifier Design computes steady state repetitive time domain waveforms in a switching mode RF power amplifier circuit of the Class-E topology.

RESOCAD is a program for analysis and design of zero voltage switching resonant DC/DC power converters. **Design Automation, Inc., Lexington, MA. INFO/CARD #139.**

El International

PROSPICE™ is an enhanced Spice circuit simulator which includes pre and post processing for ease of data entry and output. **El International, Inc., Idaho Falls, ID. Please circle INFO/CARD #138.**

ALK Engineering

Ladfil L-C is an LC filter design and evaluation software package. **ALK Engineering, Salisbury, MD. Please circle INFO/CARD #137.**

Analop Engineering

Analop is an RF/microwave circuit analysis and optimization program.

NetSyn-II is a matching filter synthesis program that performs design using lumped elements or transmission lines.

Combline is an automatic synthesis program for designing combline filters with equal diameter round rods. **Analop Engineering, Milpitas, CA. INFO/CARD #136.**

SPEFCO Software

CiAO performs circuit analysis, optimization, and synthesis in the frequency domain. **SPEFCO Software, Stony Brook, NY. INFO/CARD #135.**

Wintek Corporation

smARTWORK is a tool for creating printed circuit board layout.

HiWIRE is a schematic capture program that allows the user to sketch and modify a design during phases of development. **Wintek Corporation, Lafayette, IN. INFO/CARD #134.**

M.C. Horton

BEADLP is used to design bead type coaxial lowpass filters.

COMBCLID performs internal dimensional design of Combline and Capacitively-Loaded Interdigital bandpass filters. **M.C. Horton, Thousand Oaks, CA. INFO/CARD #133.**

OrCAD Systems

OrCAD/SDT is a design tool that designs, prints, and edits electronic schematics. **OrCAD Systems Corporation, Hillsboro, OR. INFO/CARD #127.**

8th Dimension Enterprises

RF Fiter CAD Programs is a set of programs for filter design.

Microstrip Low Pass Filter CAD calculates microstrip parameters for low pass filters from 100 MHz to 26 GHz. **8th Dimension Enterprises, Sunnyvale, CA. INFO/CARD #132.**

Tektronix

Remote Site Monitoring Software (RSM) merges the power of the TEK490P Series portable and 2750P Series laboratory spectrum analyzers with IBM PCs or compatibles.

EMI Prequalification Software performs eight automated EMI tests from FCC, VDE, and MIL-STDs.

TEK-SPANS (Tektronix Spectrum Analyzer Software) enables the user to perform test procedures, analyze, compare data, and perform various other operations. **Tektronix, Inc., Beaverton, OR. INFO/CARD #131.**

Hewlett-Packard

I.Q Tutor is an interactive training package which covers digital communication systems from analog input through modulation, transmission, demodulation, and conversion back into analog.

Signal Simulator System (HP 8770S) is a signal simulator system from DC to 50 MHz for radar, EW, communications, and other systems.

Measurement Automation Software (HP 85160A) simplifies magnitude and phase measurements of devices from 300 kHz to 3 GHz when used with a network analyzer and a desk top controller.

Amplifier Test Software automates the measurements of gain, gain compression, return loss, and standing wave ratio.

Scalar System Software (HP85015B) for the HP 8757/8756 scalar network analyzers provides automated testing of filters, amplifiers and isolators.

Transmission Line Test Software for the HP 8757/8756 network analyzer controls and documents measurements needed to test and troubleshoot transmission lines. **Hewlett-Packard Company, Palo Alto, CA. INFO/CARD #130.**

RF Engineering

NOVA is a circuit analysis program for audio, RF, and microwave frequencies that designs, analyzes, and tunes circuits of various topologies.

SYN can analyze and synthesize RF Cheybshev filters up to the 29th order. **RF Engineering, Norwich, NY. Please circle INFO/CARD #129.**

Technology Services Corporation

Radar Workstation 2.0 (RWS) is a radar engineering software package that performs pulse doppler clutter foldover plots, user specified antenna patterns and various other functions. **Technology Services Corporation, Silver Springs, MD. INFO/CARD #126.**

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IH5352	4ch, 70dB Isolation @ 10MHz	5.00

Video Amplifiers/Buffers		
MAX450	± 12V, 10MHz	$ 2.35
MAX451	Low I_{BIAS}, 10MHz	5.70
MAX452	± 5V, 50MHz	3.00
MAX460	140MHz Buffer, 1500V/µs slew rate, 100mA	19.80
BB3553	300MHz Buffer, 6000V/µs slew rate, 250mA	23.00
BB3554	100MHz Op Amp, 100mA	47.70
LH0063	300MHz Buffer, 6000V/µs slew rate, 250mA	24.00
LH0033	100MHz Buffer, 1500V/µs slew rate, 100mA	14.40

Video Multiplexers		
MAX310	1 of 8, 76dB Isolation @ 5MHz	$ 8.00
MAX311	2 of 8, Differential, 76dB Isolation @ 5MHz	8.00
MAX312	Latched, 1 of 8, 84dB Isolation @ 5MHz	10.00
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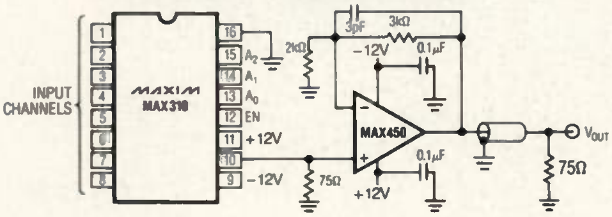
(Prices are for 100-up quantities)

No Insertion Loss, 10MHz 8Ch MUX



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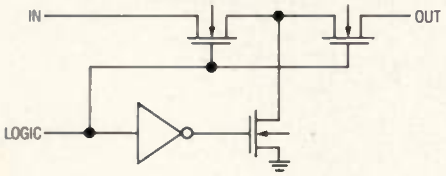

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INFO/CARD 28

Getting The Most Out of Programmable Instruments

Standard Interfaces and New System Software Eases the ATE Engineer's Task

By Cliff Morgan,
Tektronix, Inc.

The last 15 years have seen dramatic increases in the complexity and capabilities of test and measurement equipment. Prior to 1972, most instruments were analog, requiring a skilled operator for operation and measurement interpretation. With the advent of microprocessors, integrated A/D converters and low-cost RAM and ROM, instruments took on a digital complexion, offering immediate advantages over purely analog units. The next logical step (and current manufacturing trend) for digital instrumentation is programmability — instruments that give engineers the flexibility and speed of automatic measurements. This article describes the present state of programmable instrument use, with background on historical developments.

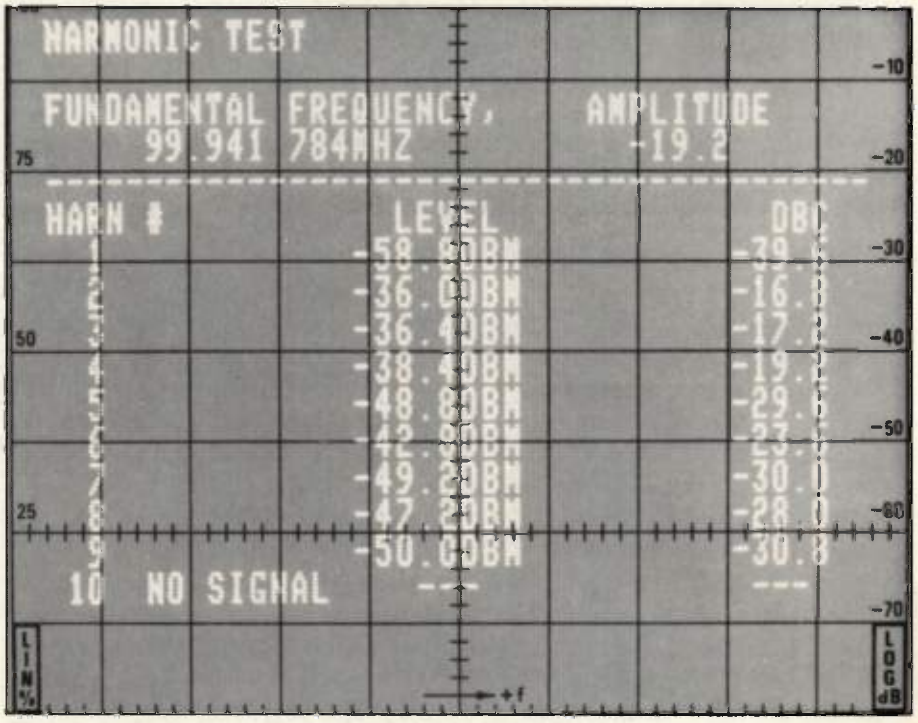
One of the biggest advances in digital instrumentation has been the development of standard interface buses such as IEEE-488 and RS- 232. These buses provide the means for a minicomputer or programmable calculator to control and acquire data from an instrument, then process it into a more usable format. Test results can then be displayed and recorded on a printer, plotter, CRT, or magnetic media.

The electronics industry quickly adopted these interface standards, which provided the impetus to develop fully programmable test equipment. The control of instrument functions via computer ushered in the era of Automatic Test Equipment (ATE). Unfortunately, assembling a system of test equipment is often a complicated task due to variations in programming protocol. Fortunately, there are recent advances and industry trends that should minimize or accomodate these variations and ease the task of system integration.

Types of Interface Buses

Prior to the '70s there were few attempts at standardization. Generally, each manufacturer created its own special interface to connect a particular minicomputer to a specific piece of test gear. To more fully appreciate the test system designer's task, it is helpful to review the development of several common interface buses.

One of the earliest attempts at standardization was Computer Automated Measurement and Control (CAMAC), initiated by the European scientific community primarily for nuclear instrumentation. A large controller was required, and each piece of test gear required a plug-in interface adapter. Although this standard was eventually accepted as IEEE Std. 583-1975, it has seen little use outside of the scientific community.



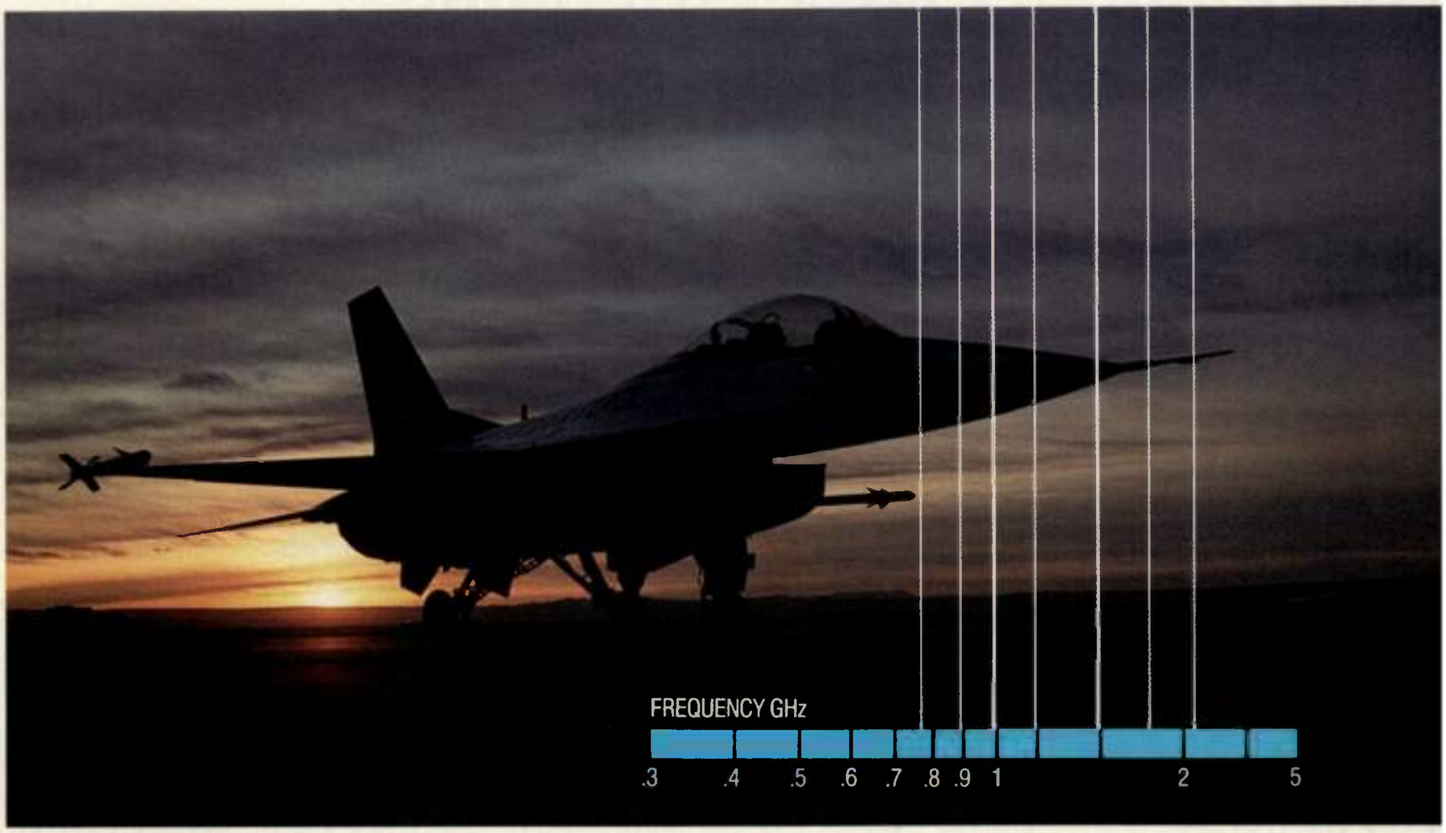
```
HARMONIC TEST

FUNDAMENTAL FREQUENCY,      AMPLITUDE
     99.941 784MHZ             -19.2
-------------------------------------------
HARM #            LEVEL              DBC
  1              -58.8DBM           -39.6
  2              -36.0DBM           -16.8
  3              -36.4DBM           -17.2
  4              -38.4DBM           -19.2
  5              -48.8DBM           -29.6
  6              -42.8DBM           -23.6
  7              -49.2DBM           -30.0
  8              -47.2DBM           -28.0
  9              -50.0DBM           -30.8
 10   NO SIGNAL    ---               ---
```

Figure 1. Sample output of a harmonic test macro.

Another early interface standard, still widely used today, is the RS-232 developed by Electronics Industries Association (EIA). This is a serial interface designed for connecting terminals and other peripherals to mainframe computers. Since it offers no easy means of addressing instruments and since serial mode is inefficient at transferring large amounts of data, it was not intended as an instrument bus. However, most manufactures are providing optional RS- 232 interfaces for test equipment, to allow access over a phone line via modem, or to use laptop computers which include an RS-232 interface as a low-cost, single-instrument controller.

In 1972, Hewlett Packard introduced a bus to interface its programmable test equipment with an instrument controller. The HP bus was a byte-serial, bit-parallel data bus that could support a controller and one or more talkers/listeners. The concept of the Hewlett Packard Interface Bus (HP-IB) was soon endorsed by the



FREQUENCY GHz
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electronics industry and, after some modification, was adopted in 1975 as IEEE standard 488-1975. It was later revised into the present document (IEEE 488-1978). Today it is commonly referred to as either the IEEE 488 bus, HP-IB, or General Purpose Interface Bus (GPIB). The European IEC 625 bus is identical except for the specification of bus connectors.

In spite of the many merits of the IEEE 488 standard, it did not specify the programming protocol used when one device talks or listens to another. Shortly after it was approved, Tektronix, Inc. assembled a Corporate Interface Group to try to standardize the format of commands and message protocol. The result of this committee's work was the Tek Codes and Formats document. The goal of this interface standard was to ensure that any two Tek instruments could easily communicate with each other. Tek's internal standard also served as a starting point for industry-wide efforts to standardize bus message protocol and data format.

IEEE 488.2

While industry was quick to accept the original IEEE 488 standard, the process of standardizing programming protocol has taken longer. The first industry-wide effort resulted in IEEE 728-1982, "Recommended Practice for Codes and Format Conventions for Use with ANSI/IEEE Std 488-1978." The most recent effort at language standardization has resulted in IEEE 488.2, approved in June 1987.

IEEE 488.2 can be thought of as a complement to IEEE 488. It describes standards that address the code, formats, protocol, syntax, and semantic concepts that system integrators have found useful in configuring systems. More specifically, IEEE 488.2 covers the following topics:

- Standard IEEE 488.1 subsets.
- Standard message handling protocols, including error handling.
- Unambiguous program and response message syntactic structures.
- Common commands useful in a wide range of instrument system applications.
- Standard status reporting structures.
- System configuration and synchronization protocols.

While a complete summary of IEEE 488.2 is not possible here, its usefulness can be demonstrated. Users of Tek instruments will recall the ID? query which provides the identity of the instrument queried and the firmware version number. A similar feature is included in IEEE 488.2, the *IDN? query, with the following response:

Field 1 Manufacturer: required
Field 2 Model: required
Field 3 Serial Number: ASCII 0 if not available
Field 4 Firmware level: ASCII 0 if not available

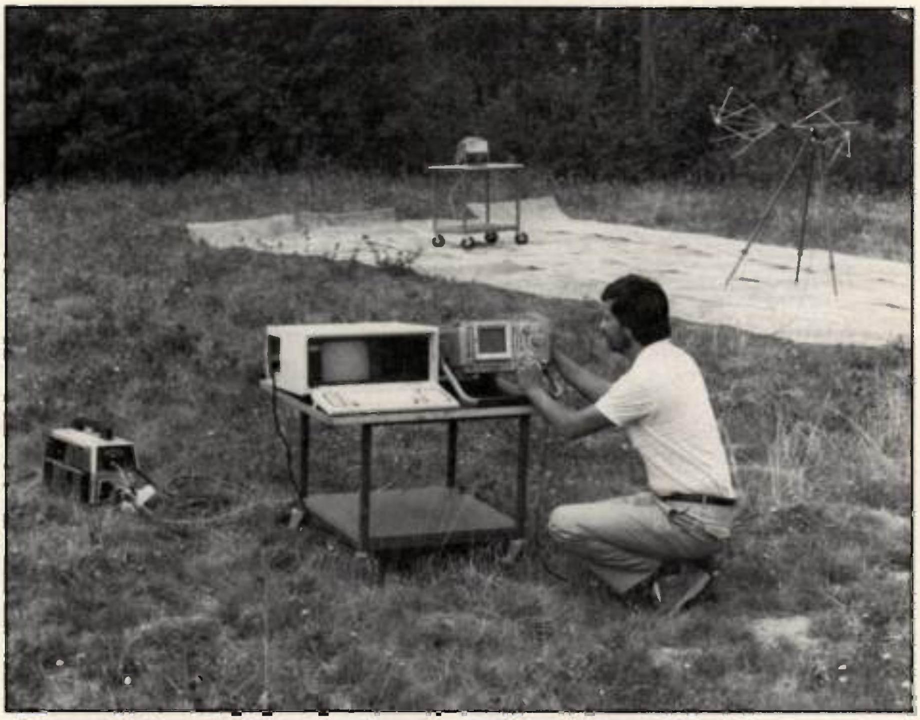

Figure 2. Open-site test system for radiated emissions.

Another useful command in IEEE 488.2 is the *LRN? query (similar to the Tek SET? query). This returns the complete front panel status of the instrument being queried.

MATE/CIIL

In 1976, the Air Force announced a competitive research and development program called Modular Automatic Test Equipment (MATE). The task was to study ATE problems and design an effective management concept to develop, integrate, apply, and control ATE on a total Air Force basis. The need for the MATE concept was created by the rapid proliferation of test equipment, each with its own unique programming language.

MATE is an entire test system made up of a central control computer and several connected automated instruments. Communication between devices occurs using standard interface buses such as IEEE 488. Programming of a MATE system is done using the ATLAS language, the output of which is Control Interface Intermediate Language (CIIL). Even though CIIL is compiled from ATLAS, the Air Force allows CIIL to develop independently of ATLAS. Thus CIIL can grow to accommodate new test instruments and features.

The advantage of MATE/CIIL is that two instruments from different manufactures (e.g. two spectrum analyzers) are programmed using the same such commands. Thus MATE/CIIL, unlike IEEE 488.2, attempts to create a universal language for test instruments.

Instrument manufactures may take one of two approaches to creating MATE compatible instruments: 1) they can add an external Test Module Adapter (TMA) which translates the MATE/CIIL commands into the native language of the instrument, or 2) they can have the instrument's internal firmware recognize the MATE/CIIL commands. The second approach is generally preferred, but may be more difficult to implement.

An increasing trend among leading manufactures is to make instruments multilingual. For example, the Tektronix 2756P (option 45) spectrum analyzer recognizes MATE/CIIL commands as well as Tek Codes and Formats commands. This instrument also recognizes commands from other analyzers in the Tek 490P and 2750P series family of spectrum analyzers, even if not applicable (as one designer stated "it will simply swallow commands without hiccupping").

Instrument Controllers

The system programmer's challenge is not only learning the command language of each test equipment, but also master-

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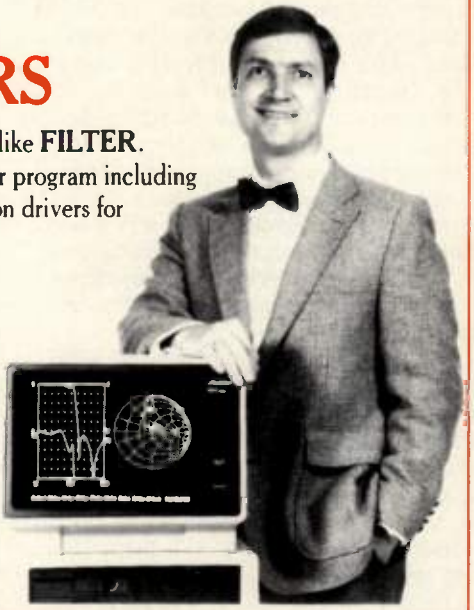

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ing the programming language of the instrument controller. These controllers fall into two broad categories: dedicated instrument controllers and personal computers.

Until recently, most ATE applications were accomplished with minicomputers or instrument controllers such as the DEC PDP-11, HP9836, or Tek 4041. They include standard interfaces and provide the necessary language features to address and control instruments and to properly handle interrupts. Another advantage is the inclusion of BASIC software for signal processing, graphics, and data reduction. These types of controllers continue to be used in both R & D and manufacturing test environments.

One drawback to the dedicated instrument controller is price. A typical controller, complete with required memory and interfaces, can cost more than $15,000. This may not seem significant when compared to more expensive items such as network analyzers or microwave signal sources, but it may push the total system price out of reach. Another disadvantage is that the controller usually is not well suited for general purpose computing such as word processing and spreadsheet analysis, limiting its utility.

Let's contrast this situation to that of the personal computer. A fully configured PC can be purchased for under $3,000. Also, these computers are becoming so ubiquitous that the user may already have access to a PC, eliminating the need for a special purchase. Besides low cost, PCs are supported by a wealth of software and hardware accessories. Thus data that is acquired from a programmable instrument can often be ported to a spreadsheet package for data manipulation or graphic display. With these advantages, PCs are becoming commonplace in automated test environments.

The drawback to using the PC for instrument control is that it was not designed for the application. Where a dedicated instrument controller has special commands to set and query an instrument, the same process on the PC can be cumbersome, particularly when programming is limited to BASIC.

Several manufacturers make IEEE 488/GPIB interface cards for the IBM PC™, including Capital Equipment Co., Tecmar, Ziatech, and National Instruments. When selecting a GPIB card, it is important to choose one that has a good software support (i.e. it must have device drivers for the programming language or applications software being used). For example, National Instruments' PC2 (and PC2A) card, has device drivers for several different languages including MS-BASIC, IBM Complied BASIC 2, Turbo Pascal, and Lattice C.

For those who need a tutorial introduction to programming the PC for instrument control, Tektronix sells the GURU II package. In addition to the National PC2A card and a GPIB cable, GURU II includes device drivers, diagnostic, applications software, and a detailed tutorial manual with many examples. In recent months, several manufacturers have introduced interface cards that simplify GPIB programming. IOtech's Personal 488 interface card includes a handler that passes both literals and variable data, unlike some drivers that pass only variables. This simplifies programming calls considerably.

Another example is Hewlett Packard's HP82300A which is a 488 controller/coprocessor card for the HP Vectra (IBM compatible). This card includes a MC68000 processor with 512K of RAM, and can run programs written in Rocky Mountain Basic, the language of HP9800 series controllers.

Scientific Software for the PC

Several powerful integrated software packages have been introduced which combine the functions of data acquisition, analysis, and graphics. These packages simplify the system programmer's task by including a library of routines that perform such complex functions as integration, differentiation, convolving, correlation, and FFT. A number of powerful statistical functions are also available.

One popular package is ASYST from Macmillan Software Company. This package is a fully integrated software tool that provides the user with the most commonly used data acquisition, statistical and graphical functions required in engineering and scientific applications. ASYST is available from leading instrument manufacturers who have written instrument drivers to work with the software. This package also has GPIB drivers for a number of IEEE 488 interfaces.

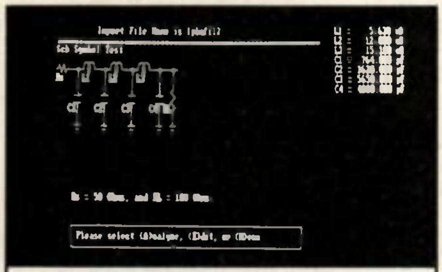
The Signal Processing and Display (SPD) package from Tektronix also runs on the PC with power similar to ASYST. This package contains routines for signal processing, analysis and graphical display of data. Unlike ASYST, which is a stack-oriented programming environment, SPD routines can be called from compiled IBM BASIC or Microsoft QUICK BASIC, and from Lattice C or Microsoft C.

The Trend Toward Smarter Instruments

In the not-too-distant past, most programmable instruments had very little built-in intelligence. This meant that the system programmer had to acquire a complete array of data from the instrument, then do all of the waveform processing within the controlling computer. This not only placed a heavier workload on the programmer and instrument controller, but it also consumed considerable bus time in transferring data to and from the instrument(s).

Manufacturers are now including powerful decision-making routines within the test instrument's firmware. This innate intelligence usually involves either signal processing routines or macro programming capability. A spectrum analyzer is a good example of an instrument that benefits from signal processing. A typical application is a signal search routine which catalogs all spectral lines above a user-defined threshold. Previously, it was necessary to acquire the complete spectrum from the analyzer then do the peak find routine in an external computer.

Another significant trend in instrument firmware is the ability to create small programs called macro-functions, that can be downloaded from a controller to an instruments's non-volatile memory. These macros can perform a complete measurement sequence independent of the controller, such as THD, S/N ratio, or spectrum surveillance. Measurement results can then be displayed on screen (Fig. 1).



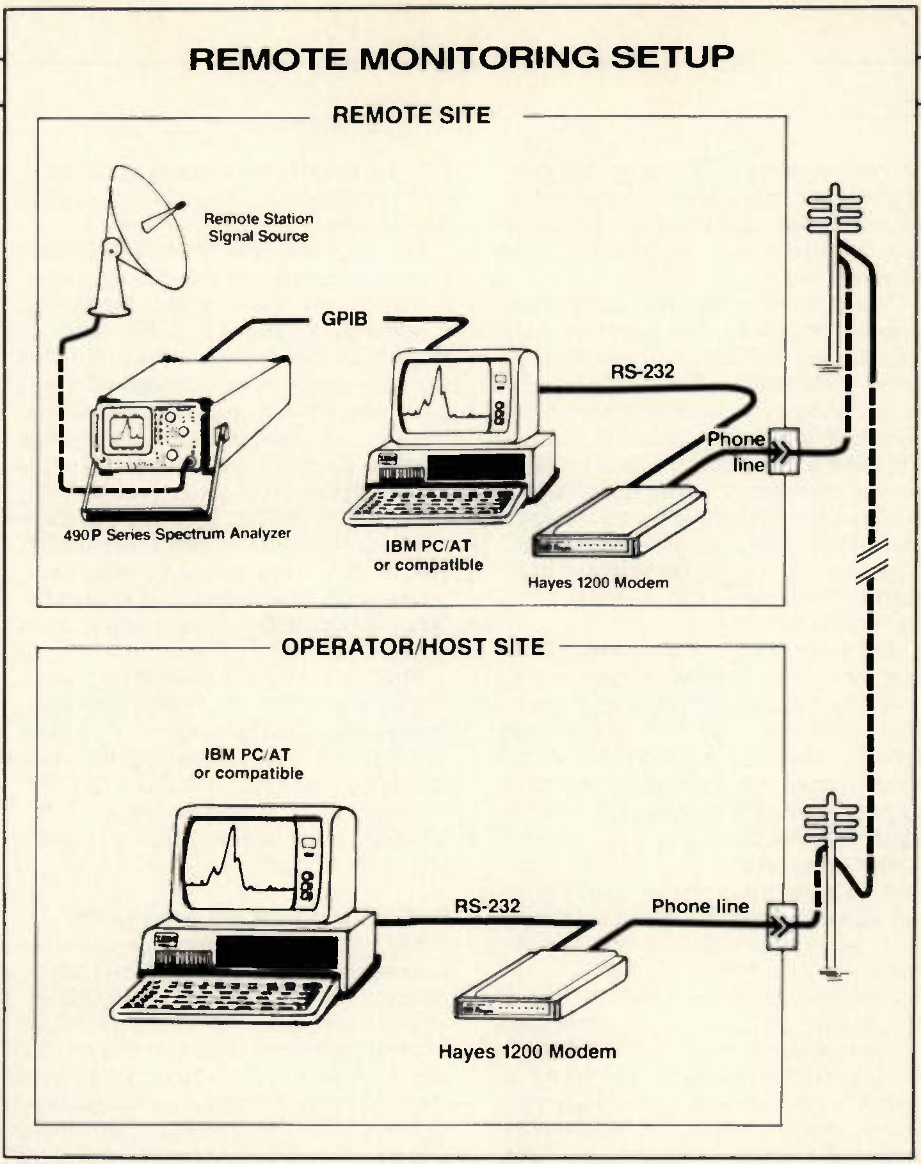


Figure 3. Equipment setup for remote-site signal monitoring.

Macros are particularly useful in portable instruments (such as spectrum analyzers) where it may not be convenient to haul around an external computer/controller. In this case, the macro is stored for field execution, selected from a menu displayed on the instrument CRT. Macros can also be used with external controller, to execute a particular sequence while the controller goes on to another task. Later, the controller can query the macro readout buffer to get the results.

Turnkey Systems

Another trend among test equipment manufacturers is to offer turnkey systems configured for a particular application. Such systems contain the instruments, controller, and applications software designed for the hardware supplied. One advantage of a turnkey system is reduced programming time for the user because the software has already been designed for the system. Also, since components are supplied by a single vendor, system incompatibilities are minimized.

One application where turnkey systems are becoming quite popular is EMC (electromagnetic compatibility) compliance testing. A typical system includes a spectrum analyzer, instrument controller/computer, antennas, probes or other interference sensors, and other supporting equipment such as a preamplifier and printer/plotter (Fig. 2).

The software for EMC radiated and conducted emissions testing sets the correct frequency range, acquires raw spectral data, converts the data into proper form, and provides analysis of the data for the appropriate FCC, VDE or MIL STD specifications. Where manual EMC compliance testing can take hours, automated testing can decrease the testing time to a few minutes, with greatly reduced operator error.

Another novel application for programmable instruments is remote-site monitoring of a signal source, such as a radar station. Tektronix' new Remote Site Monitoring (RSM) software package allows control of virtually any Tek programmable instrument using PC's and phone lines (Fig. 3). The PC is located at the remote installation, and is connected to a spectrum analyzer and perhaps other programmable instruments via the GPIB. The host-site PC is located at some convenient spot, perhaps an office or lab, where the user also has complete control over the instruments. The Tek RSM package also provides a mode for automated signal monitoring. In this mode, the remote site spectrum analyzer can continuously determine whether the signal falls within a user-defined amplitude and frequency window, and provide a warning when the signal falls out of tolerance.

Summary

These are only a few applications of programmable instruments. Nearly every manual test procedure for components and systems can now be performed faster and more accurately using the programmability of instruments now on the market. While these instruments are more expensive than their non-programmable counterparts, the cost is easily justified when the same test must be performed repeatedly. The factors that are most significant to automated test system development are:

1) A variety of interface options now exist (IEEE 488, RS-232, HP- IL, etc.).

2) Emergence of common programming protocol or bus languages for instruments (IEEE 488.2 and MATE/CIIL).

3) Availability of programming tools for those who are using the PC as a system controller (GURU II, ASYST, etc.).

4) Instruments are increasingly including intelligent signal processing routines, easing the burden on the programmer and instrument controller.

5) Decision-making capability, in the form of downloadable macros, allows more efficient use of the instrument controller and IEEE 488 bus.

6) Applications assistance, in the form of factory applications engineers and users groups, is available.

As with any evolving engineering technique, there are still obstacles to be overcome when configuring and programming test equipment for a particular application. With recent industry trends, however, the task is becoming much easier and the benefits much greater. rf

About the Author

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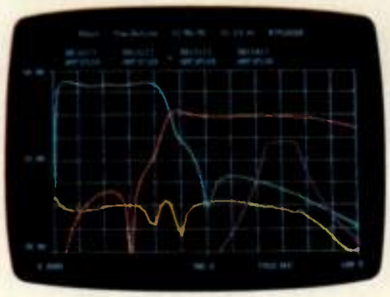

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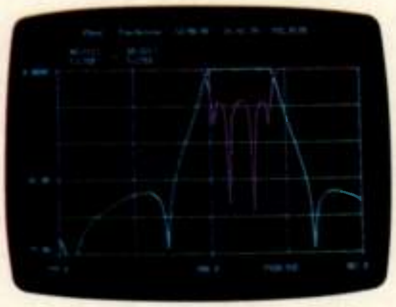

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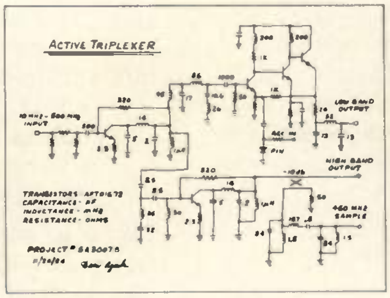

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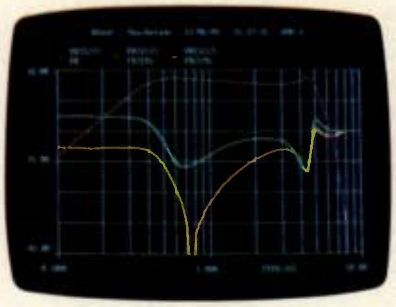

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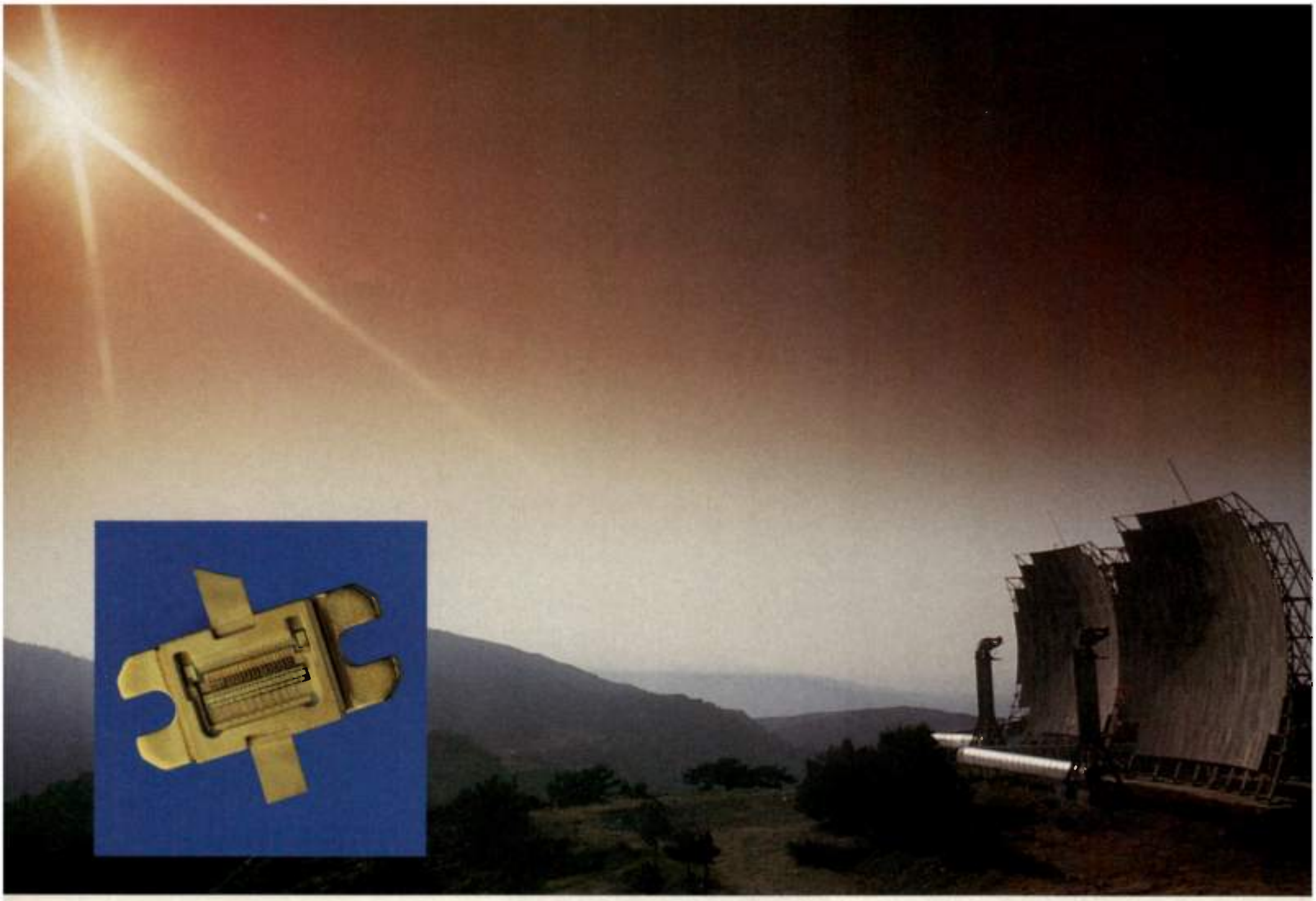

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AM 2931-110	2.9-3.1	120	7.2	38	42	65

Pulse = 50 μ/4% T_F = 30°C

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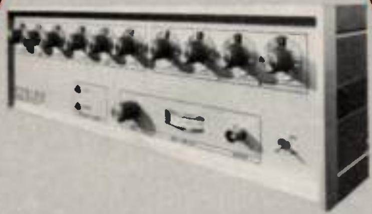

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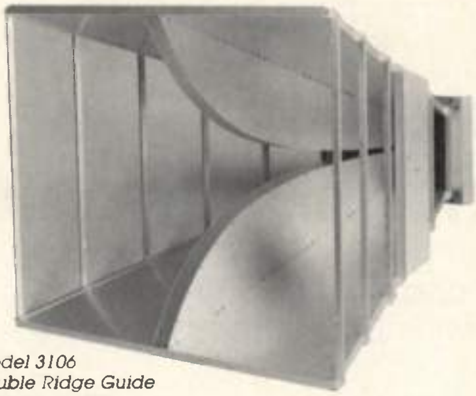

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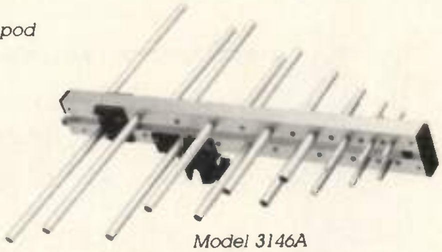

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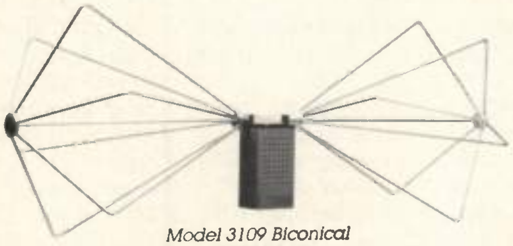

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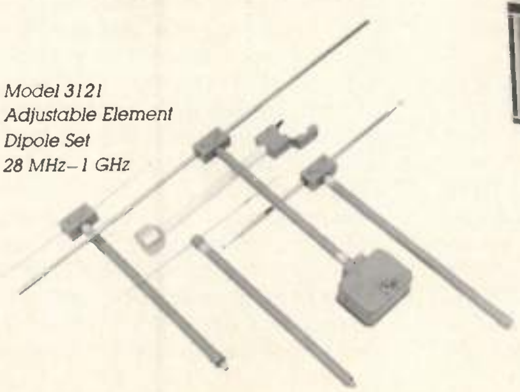

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EMC Test Labs: Standards and Requirements

A Qualified EMC Test Laboratory and Personnel are Valuable Assets to Today's Electronics Industry.

By Mike Howard
Norand Corporation EMC Test Lab

EMI/EMC test labs are becoming an indispensable service to the electronics community. This necessity has been generated by voluntary and regulatory EMI test requirements for a broad range of electronic products in the commercial and military market place. The scope of an EMI/EMC lab and its organization is as varied as the range of test standards and requirements that exist. The type of EMC lab required for a selected product may range from a materials or component evaluation EMC lab to a full scale EMC system lab for evaluation of the electromagnetic compatibility of large racks of equipment to large scale vehicles.

This article will detail items an individual or organization contemplating their first EMC test and/or improvements and enhancements needed for an existing EMC lab. Measurements for EMI/EMC range from the simplistic to the very complex in form and requirements. This article will demonstrate the need for laboratory accreditation such as the EMC NVLAP (National Voluntary Accreditation Program) sponsored by the NBS (National Bureau of Standards). Personnel certification is a needed requirement as well, but to date, no programs exist for EMC personnel certification.

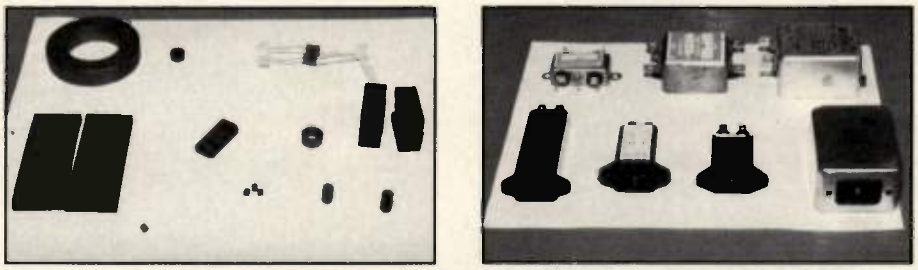

Figure 1. A variety of components can be evaluated at bench level.

At certain points in the developmental phase of a product for compliance to an EMC standard(s), four basic EMC test facilities services are required. They are as follows:

I. Materials and Component Level Analysis

At the start of any design the selection of materials and components must be finalized. These items must be selected with care to maintain the maximum performance versus cost. The EMC test lab can provide such test services as shielding effectiveness tests of conductive paints and plastics used as RF barriers. Insertion loss measurements of line filters, ferrite beads, etc., can also be performed to aid the design engineer in selecting the optimum materials and components for his design. Figure 1 illustrates components that can be tested at bench level.

II. Prototype and Sub-system Tests

These tests should be performed as early as possible in the product design build schedule to ensure that it is on track for compliance with the requested EMI/EMC standard. If major changes in EMI hardening is required, it is much easier to implement these changes at this point in the design and testing phase. Again, bench level tests may be used for evaluation of the product at this stage, or, testing within a shielded anechoic chamber or an open-field test site may be required. Such items as raw PCB's, power supplies, and sub-assemblies can be evaluated individually to characterize and harden their EMI/EMC performance before they are integrated into the final design.

III. Production and Full System Level Tests

In essence, these should be the final verification of compliance of the product to the requested EMI/EMC test standard. If non-compliance is detected in these tests, then only minor design changes should be needed if proper testing has occurred during the materials, components, and prototype stage. Major EMI/EMC design issues must be shaken out in these early stages to minimize major EMI design changes at the tail end of the product development cycle. EMI/EMC design considerations must be considered, tested, and proven up front. A wide range of EMC test facilities may be required for this final production or system EMC evaluation.

IV. Audit Testing

This is a must if even only on a voluntary basis versus mandatory audit test requirements. Minor or insignificant changes in the design may compromise the product's compliance with a requested EMI/EMC standard. Such changes as PCB layout, parts selection, process changes and many others can alter compliance. All design changes should be reviewed, with the EMC test lab staff being included, to determine if and what testing will be required. As a minimum, a product should be audited on a yearly basis. Some degree of statistical testing may also be required. For example, in VDE 0871 testing for West Germany, if a production product is found to be over the limit by no more than 2dB, the production run is still acceptable if it can be proven that a minimum of 80% of the equipment in the production run does not exceed the limit. A minimum sample of five units, up to a maximum of twelve units, may be required to demonstrate this requirement.

Experience needs to be, and is, developed with these four levels of test evalua-

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SAS-200 530	150 - 550 MHz	Broadband Dipole
SAS-200 540	20 - 300 MHz	Biconical
SAS-200 541	20 - 300 MHz	Bicon'l Collapsible

MODEL #	FREQ. RESP.	DESCRIPTION
SAS-200 542	20 - 300 MHz	Biconical Folding
SAS-200 550	001 - 60 MHz	Active Monopole
SAS-200 560	per MIL-STD-461	Loop - Emission
SAS-200 561	per MIL-STD-461	Loop - Radiating
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tion by the EMC lab and the design engineers of the submitted product. This is to ensure compliance of the product and to develop a resource and data base for future designs to draw upon. The percentage of first time designs found non-compliant as submitted by design personnel with a minimum of first time hardening experience is quite high.

Several key items must be in place to ensure having a competent EMC test lab and personnel to perform measurements in the four areas addressed earlier. They are as follows:

Support Facilities

Consideration must be given to adequate facilities to house and operate test mediums from bench level to large anechoic chambers and open-field test sites. Planning for future expansion is critical here. Many EMC test labs are experiencing a doubling or tripling effect in their operations in a few short years. This is due in part to the increased awareness of EMI/EMC standards by Industry today and recent regulatory enforcement of requlations such as the FCC rulings on computing devices (i.e., FCC Part 15 Subpart J). The support facilities must give considerations to such items as:

- areas for bench level tests
- pre-stage area for demonstration, repair, and set up of products to be tested
- storage areas for controlled samples, compliance EUT samples, and support equipment
- office space for test personnel and product engineers in attendance at the lab.
- specialized test mediums such as large anechoic chambers and open-field sites. These test mediums require large floor space and land requirements as well as specialized support in electrical, heating, cooling, and fire protection. Compliance with facility standards specified in such documents as the FCC's MP-4 and OST-55 and the NBS NVLAP standards must be met.

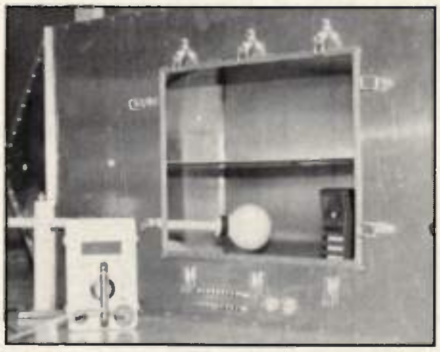

Figure 2. A TEM cell is a versatile evaluation test.

Test Facility

As discussed earlier, the actual test facility can range in size and complexity depending on the scale of the testing required. Some of the test facilities commonly utilized by EMC laboratories today are described below.

Shielded Chambers: A shielded chamber is typically constructed of single or dual walled metal plates bonded mechanically or their seams welded contінously to provide an RF tight seal. These shielded rooms are well suited for both emissions and susceptibility tests. The shielded enclosures do have a deficiency in that they can introduce serious measurement errors as large as +40 dB. The high conductivity and reflectivity of the enclosure walls set up standing waves that may interfere with the signal being

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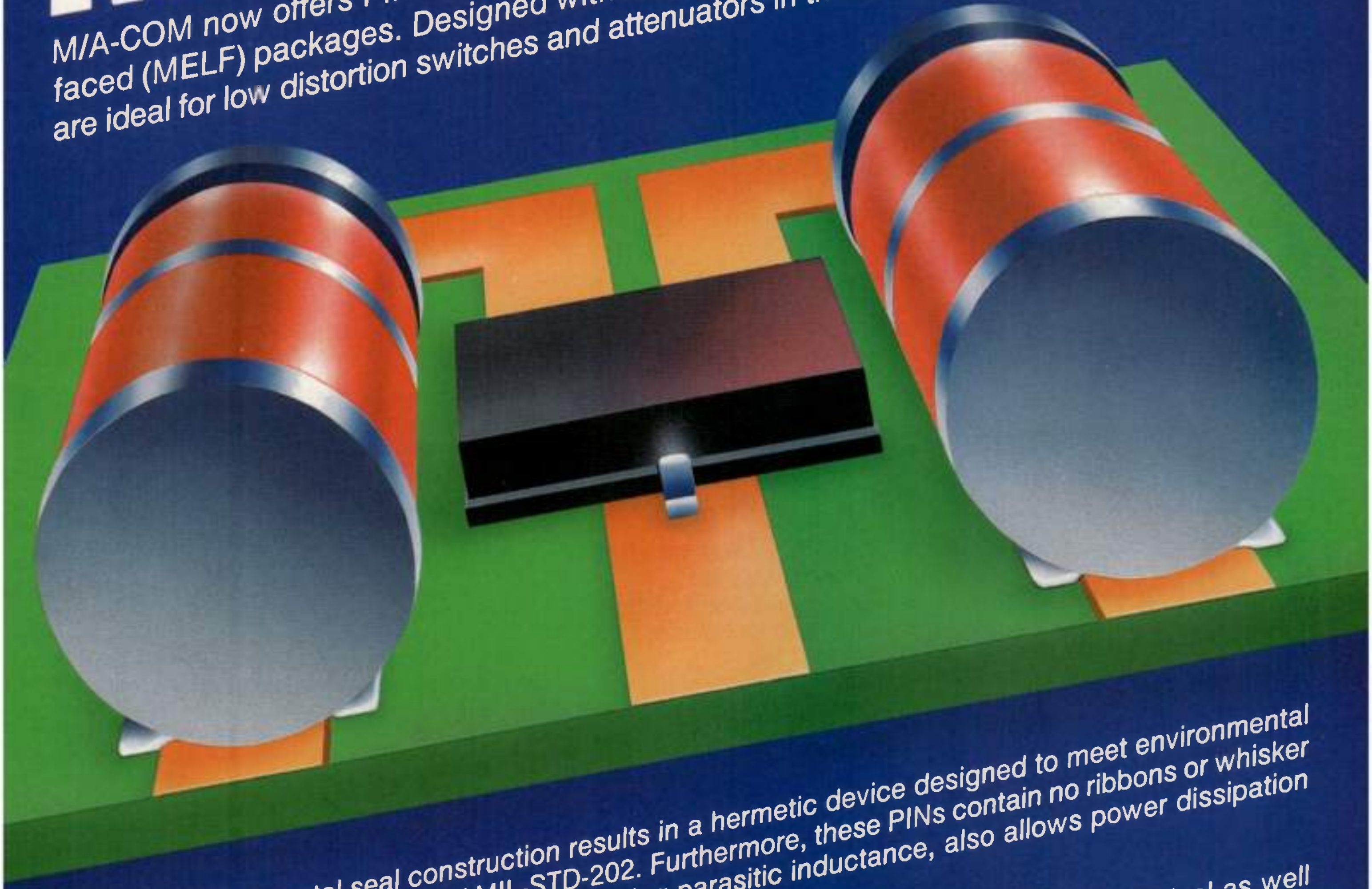

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measured and cause large gradients in the susceptibility test field. Absorbing material can be used to suppress these reflections but this may only be effective above 200 MHz. Below 200 MHz, alternate techniques being explored today are the reverberation chamber using mode-stirred or mode-tuned methods of reverberation to suppress the unwanted TEM modes within a shielded enclosure.

TEM Cell: The TEM Cell is a 50 ohm triplate transmission line with its sides closed. This design prevents radiation of RF energy into the environment and provides electrical isolation. It can be used for both emission and susceptibility measurements. The TEM Cells have seen a growth in usage due to its versatility, measurement accuracy and ease of operation. The TEM Cell is limited in the physical size of product that can be evaluated and has an upper useful frequency range determined by the cell's physical size and geometry. The TEM cell can be used for both radiated emissions and susceptibility testing. Some shielding effectiveness tests can be performed with a dual TEM cell arrangement. See Figure 2.

Open Field Sites: An open field site is just the opposite of the shielded enclosure type of facility. An open field site provides both a reference and a perturbation free environment in which actual operational conditions of the equipment can be simulated. Open field sites must cope with the environment of the RF ambient that is present. Facility personnel must take extra care to discearn the radiated emissions from a product from those of ambient RF signals present. The open-field site is predominently used for radiated emission measurements as specified by FCC Part 15-J and West Germany's VDE 0871. Radiated susceptibility tests can also be performed on an open-field site but is severly limited by frequencies and RF power that are licensed for testing purposes. A properly designed and run open-field site can provide very accurate measurement results. Figure 3 represents an open field test facility.

There are other types of facilities or slight variations of the ones mentioned above. But by using these three basic types of facilities in combination, the overall capability of the EMC test lab and its ability to meet future test requirements of product submitted to the test facility will be greatly enhanced.

Instrumentation

As with test facilities, a wide range of instrumentation is required to complement an EMC lab's capabilities. With

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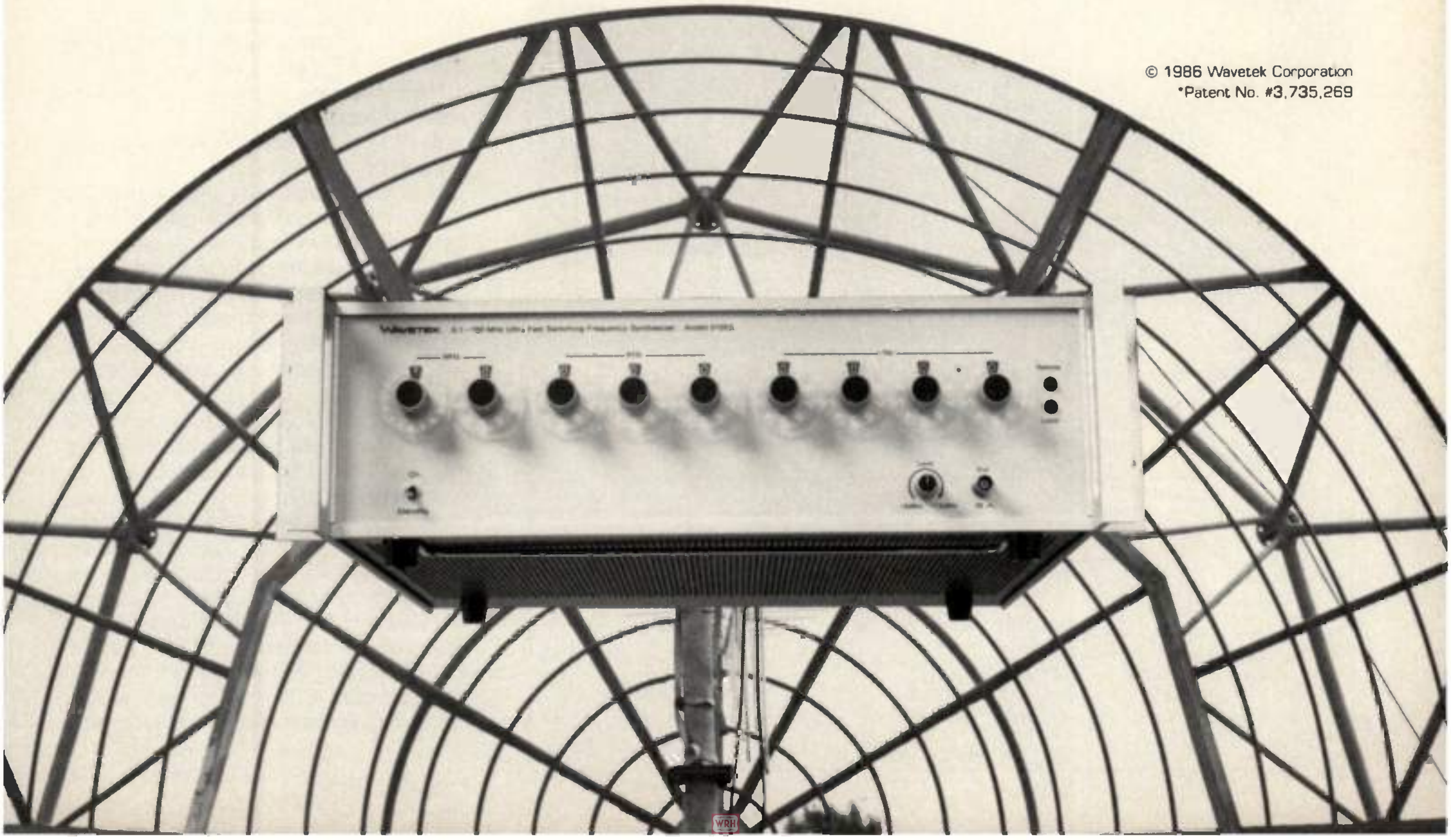
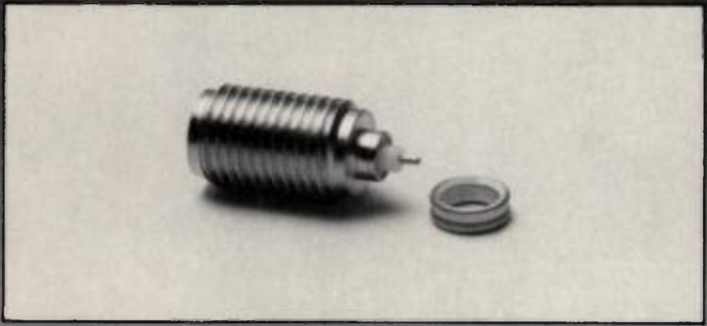
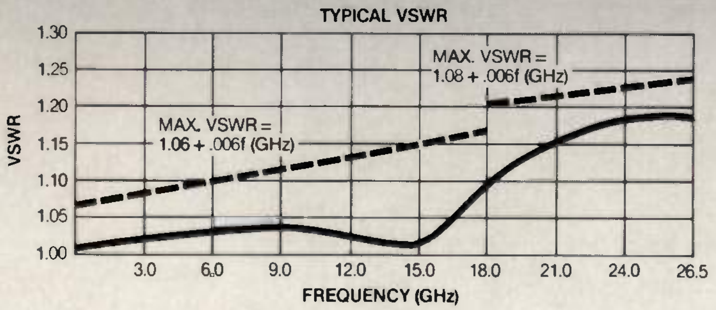


*Patent No. #3,735,269

these different types of test facilities, each type of instrumentation will have a certain degree of measurement deficiency or a more suitable measurement capability than the other. For both emissions and susceptibility testing, more than one type of instrumentation and test method is required to be utilized. As with test facilities, the EMC Lab has it in it's best interest to select the best from both worlds. For example in emission testing, it is highly beneficial for the EMC lab to have at it's disposal the use of both tuned recievers and spectrum analysers to perform its emission measurements. For susceptibility testing both discrete and swept frequency measurements need to be utilized to fully characterize the EUT's performance accurately and efficiently by the test lab.





Automation

To maintain a high degree of accuracy and throughput in the EMC lab some degree of automation is required. Due to the large number of operations required for various EMI/EMC tests, automation has shown to be a very cost effective approach in EMC testing. An overall reduction of 50 to 70 percent in test execution times can be achieved with automation of EMC tests versus manual methods. Reliable and meaningful automated EMC tests can be achieved only when a thorough knowledge of the test facilities, intrumentation, and test standards is known. Only then will the automated EMC test lab system or facility be an effective tool and aid for the EMC lab. No matter how much automation is placed within an EMC test lab, a degree of manual methods will still be needed and required particularly in the case of I/O cabling placement and movement by lab personnel to maximize emissions for test performed according to FCC Part 15 Subpart J for computing devices.

Personnel

Even with the increased awareness of EMI/EMC in the Electronics industry today, there is a critical shortage of qualified EMC engineers and technicians.

NBS NVLAP Laboratory Accrediation Program

The NBS NVLAP is a voluntary system for accrediting laboratories found competent to perform specific testing operations. NVLAP's goals are to:

1. Provide national recognition for competent laboratories
2. Provide a laboratory with a quality assurance check
3. Identify competent laboratories for regulatory agencies purchasing authorities, and product certification systems.
4. Provide guidance from technical experts to aid laboratories in reaching a higher level of performance to improve engineering and product information.
5. Foster international acceptance of test data produced by U.S. Laboratories.

The NBS NVLAP program for EMC Labs currently offers accrediation for test methods under FCC Part 15 Subpart J for computing devices and Part 68 for telecommunications terminal equipment. Additional test methods for accrediation have just recently been announced by the NBS. They include FCC Part 15 Subparts C, D, E, & H for low power communications devices and receivers, FCC Part 18 for industrial, scientific, and medical equipment, FCC Part 90 for type acceptance of radio transmitters and receivers.

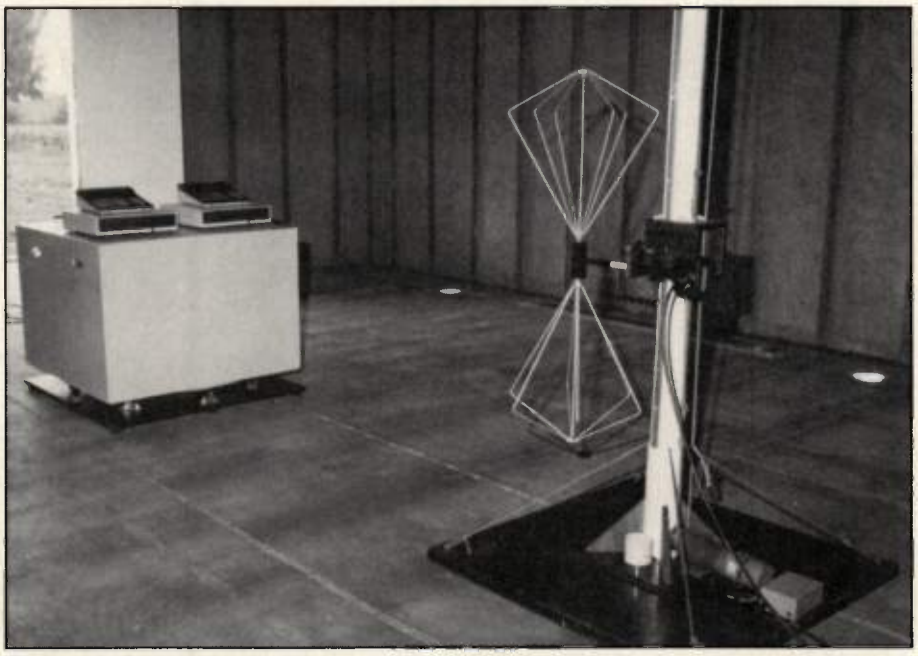


Figure 3. An all-weather enclosed open-field test site is suitable for testing for FCC Part 15-J and VDE 0871.

Selected methods under MIL-STD 462 will also be offered. In essense, the NVLAP program provides the needed qualification, standards, and quality assurance programs required for EMC Labs in an industry with a wealth of standards for product qualification and but with limited standards for facilities and personnel.

Summary

If you are considering setting up an EMC Test Lab for the first time or considering expanding or improving a present facility, careful planning and thought must be pursued to ensure that the lab will meet its intended goals today and into the future. EMC Labs will continue to see increased growth and opportunities in a wide range of areas from measurement methodology to types of facilities available to perform EMI/EMC measurements within. There will be more and improved standards established for the EMC test lab and it's personnel in the near future. It will be imperative for the EMC test lab to meet these standards established for their facility and personnel before attempting to test EMI/EMC standards of product submitted to their lab. The undertaking and operation of an EMC test lab is in no way a light task. Commitments in facilites, capital equipment and qualified personnel must be set in a firm foundation to provide the quality and quantity that is expected from an EMC Test Lab. A basic EMC test lab will typically cost from $100,000, with a staff of one, to as large as $10,000,000 in investment, with staffs as large as 30 personnel. A new and exciting future lays ahead for todays EMC Test Labs. rf

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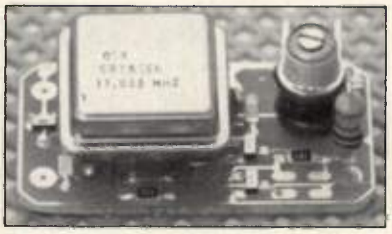
About the Author

Mike Howard is the supervisor at the Norand Corporation EMC Test Lab. He has over 15 years experience in various types of commercial/military EMI/EMC test and design. He can be reached at Norand Corporation, EMC Test Lab, 550 2nd St. S.E., Cedar Rapids, IA 52401. Tel: (319) 846-2415.



PIN Diode Switches — Part III

Transmit/Receive Switch Applications

By Andrzej B. Przedpelski
A.R.F. Products, Inc.

*The PIN diode T/R switch is described in this article. Shunt and series SPST switches were described in Parts I (*RF Design, *Nov. 1986) and II (* RF Design, *Feb. 1987). Combining several switch sections can provide other serviceable switch configurations.*

A T/R switch is a SPDT switch used to switch a single antenna between a transmitter and a receiver. This can be done with two or more PIN diode switches, depending on system requirements. As an illustration, the following requirements are specified:

- minimum transmitter path insertion loss
- high attenuation in receiver path
- low overall power consumption
- receiver ON period is 10 percent of total time
- simple diode switching drive

To provide a simple switching drive circuit, it is desirable to use the same drive for the receiver and the transmitter switch. For minimum power consumption, the diodes should be back biased during the transmitting period since the transmit period occurs 90 percent of the time. A simple SPDT switch using two series diodes (one in each leg) will not satisfy these requirements. However, using one shunt switch and one series switch configuration satisfies both.

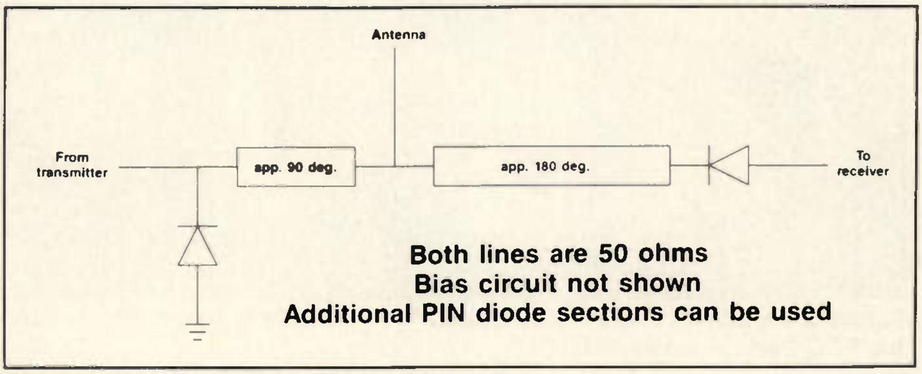
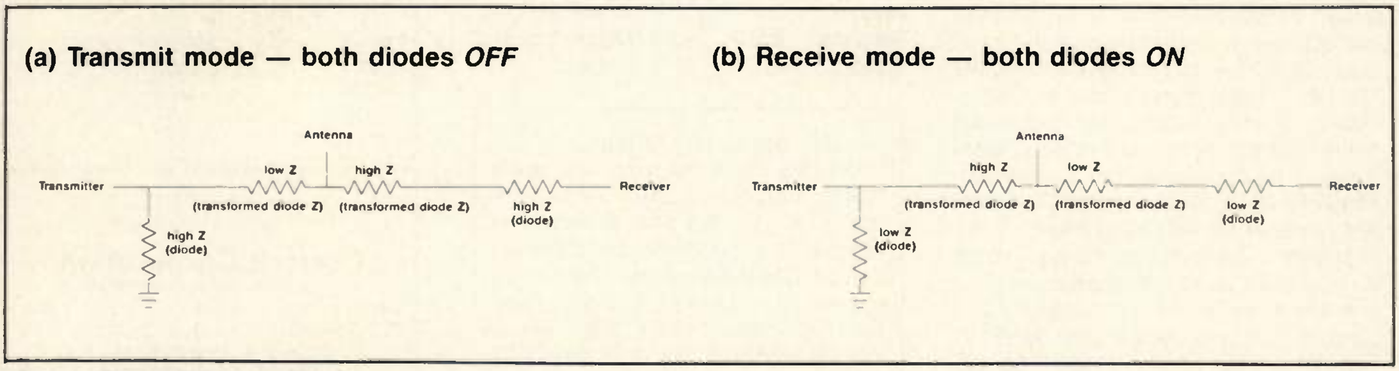


Figure 1. Simple T/R switch configuration.

It is more desirable to use the shunt configuration in the transmitter path and the series configuration in the receiver path, as shown in Figure 1. In this configuration, the transmitter diode is out of the circuit (back biased) during the transmit period. Hence, it is not required in order to pass the large RF current. Its only requirement is to withstand the combined DC-bias and peak RF voltage and a low power diode can still be used. Insertion loss of this configuration is low, as described in Part I.

In the receiver path, the isolation can be increased by using several diodes in series, as described in Part II. Figure 2 shows the equivalent circuits in the transmit and receive modes. In the transmit mode, the transmitter diode is in its high impedance state, and its effect on the transmitted signal is usually negligible (its reactance can be compensated by transmitter tuning). The receiver diode appears directly at the antenna terminal (a 180 degree line does not change the impedance) as a high series impedance. In the receiver mode, the receiver diode places a small resistance in the receive path, introducing some loss. The transmitter diode has also a low impedance, which is transformed by the 90 degree line into a high impedance at the junction. Switching the antenna between the transmitter and the receiver is then accomplished.

The transmitter 90 degree line is obviously needed to provide the impedance transformation shown in Figure 2. There is no need for the receiver 180 degree line. It is used for convenience to adjust


(a) Transmit mode — both diodes *OFF*

(b) Receive mode — both diodes *ON*

Figure 2. Equivalent circuit.

Angle	R	X
80	62.943	268.97
81	76.642	295.95
82	95.265	328.18
83	121.38	367.07
84	159.35	414.27
85	216.94	471.23
86	308.34	537.1
87	459.16	601.3
88	706.69	618.78
89	1046.5	461.07
90	1250	6.2832
91	1054.2	−453.89
92	713.77	−617.81
93	463.64	−602.52
94	311.03	−538.68
95	218.6	−472.66
96	160.42	−415.47
97	122.1	−368.05
98	95.771	−328.99
99	77.009	−296.63
100	63.216	−269.54

Table 2. Receiver *OFF* transferred impedance.

Angle	R	X
170	266.25	892.33
171	551.8	1222.8
172	1510	1627.7
173	3253.2	− 199.84
174	1336.9	−1605.3
175	504.12	−1179
176	249.21	− 865.67
177	146.35	− 673.88
178	95.781	− 548.79
179	67.425	− 461.62
180	50	− 397.89
181	38.55	− 349.18
182	300.633	− 310.83
183	24.934	− 279.86
184	20.698	− 254.32
185	17.465	− 232.9
186	14.941	− 214.66
187	12.934	− 198.95
188	11.312	− 185.26
189	9.9825	− 173.22
190	8.8791	− 162.55

Table 1. Transmitter *OFF* transferred impedance.

the impedance at the junction to any desired impedance at the switch junction. It also compensates for the diode impedance in the OFF position. It is apparent that the two transmission lines perform useful functions in the respective diode OFF conditions. This can be demonstrated by using typical PIN diodes with an OFF capacity of 0.2 pF. The operating frequency is 2000 MHz.

Table 1 shows the transmitter diode OFF impedance, transferred to the function point. It appears that a 90 degree line would be most suitable. Table 2 shows the receiver diode OFF impedance transferred to the junction point. In this case, a shorter line (173 degrees) seems preferable to the nominal 180 degrees. rf

References

1. SDI, N. Billerica, MA; Bulletin D-1008.
2. Hewlett-Packard; Application Notes 922, 929, 957, 971, 985.
3. Alpha Industries, Inc., Semiconductor Div.; App. Note 80200.
4. Gerald Hiller, "Designing with PIN Diodes," *RF Design*, March/April 1979 and May/June 1979.

About the Author

Andrzej B. Przedpelski is vice president, development of A.R.F. Products, Inc., 2559 75th St., Boulder, Colo. 80301. he serves as consulting editor to *RF Design*.

A Low Cost 100 MHz to 2.5 GHZ Amplifier

Contest entry is an excellent example of a practical engineering problem.

By David L. Tharp
Colorado Data Systems

Using low cost MMIC amplifiers in a feedback network that achieves a flat frequency response up to 2.5 GHz earned the author a copy of Superstar 3.0 in the RF Design Awards Contest. The amplifier was developed and incorporated in a smart frequency counter board.

An amplifier with a 24 dB gain from 100 MHz to 2.5 GHz is the basic requirement of the frequency counter board. A simple approach was to utilize a drop-in 50 ohm modular amplifier. This approach, though convenient can prove to be costly. Another method is to design a system with monolithic RF amplifiers. The second technique was used and the finished product proved to be very cost effective.

The amplifiers incorporated in the design were Avantek's MSA-0204. S-parameter files for use by Touchstone™ were generated by extrapolating data from the MSA series spec sheets (taking antilogs where necessary). A hypothetical single-stage amplifier was then constructed in a circuit file for experimentation. This is shown in Figure 1. Various devices were tried and it was observed that the amplifier required several low gain stages since the high gain MSA devices rolled off too quickly. Also, some kind of additional gain equalization was required.

Figures 2 and 3 illustrate that capacitive feedback can be used to achieve the needed equalization. Rather than calculate the values for the feedback network, a resistor and capacitor node was added to the circuit file. Variable values with constraints placed on practical sizes were specified before allowing Touchstone to optimize the circuit. Figure 4 illustrates that Touchstone came up with values that equalized the gain to about 6.8 dB ±0.25 dB across the required bandwidth.

A circuit file simulating four of the single stage amplifiers was implemented using the S-parameter output of the single stage simulation (Figure 5). The frequency response and the return loss of the circuit met the design goals. This is illustrated in Figures 6 and 7.

A prototype was constructed on a sample of 0.015" Rogers 5870 material. This resulted in a 50 ohm microstrip width of 0.044". This closely matched the width of the interstage coupling capacitors and the lead width of the MSA devices. The recommended bias for the MSA-0204 is 5 V at 25 mA. Since the supply voltage is 7.5 V, a bias resistance of 100 ohms was required for each stage.

In spite of less than ideal construction methods, particularly in the feedback networks, the performance of the prototype circuit had a high degree of correlation between the theoretical and measured results. Figure 8 is a plot of data as measured on a spectrum analyzer and a plot of the theoretical result as outlined by Touchstone.

This circuit is an example of what can be done in a short period of time with modern RF components and design tools. Exclusive of the PC board and artwork, the entire circuit was constructed for under $15 in parts. rf

About the Author

David L. Tharp is an RF design engineer at Colorado Data Systems, 3301 West Hampden Avenue, Englewood, CO 80110. He can be reached by telephone at (303) 762-1640.

```
! CIRCUIT FILE  "AVANT204.CKT" SINGLE STAGE AMPLIFIER USING
!               AVANTEK MSA-0204 MMIC RF AMP
! DATE/AUTHOR:  1/8/87 -- DAVE THARP
!
VAR
   FEEDR # 1000 272.43880 10
   CCAP # 1000 649.35680 10
   LWID = .044
   ICAP = .100
DIM
   FREQ  GHZ
   RES   OH
   COND  /OH
   IND   NH
   CAP   PF
   LNG   IN
   TIME  SEC
   ANG   DEG

EQN

CKT
   MSUB ER=2.33 H=0.015 T=0.0014 RHO=.686 RGH=0
   TAND TAND=0.00012
!*************************************************************
! SUBSTRATE ENTRY FOR ROGERS 5870 1 OZ COPPER -- RHG IS TO BE
! DETERMINED (RMS SURFACE ROUGHNESS)
! TAND IS THE DIELECTRIC LOSS TANGENT FOR 5870 (10 GHZ)
!*************************************************************
   MLIN 3 4 W^LWID   L= 0.375     ! MICROSTRIP GOING TO THE MODAMP
   MTAPER 4 5 W1^LWID W2 = .020 L=.05 ! TAPER TO 0404 LEAD WIDTH OF .03
   S2PA 5 6 0 MSA0204            ! MSA-0204 MODAMP 2-PORT DEVICE
   MTAPER 6 7 W1 = .020 W2^LWID L=.05 ! TAPER BACK OUT TO 50 OHM
   MLIN 7 8 W^LWID   L = .5     ! MICROSTRIP TO DC BLOCK CAP
   CAP 8 9 C^ICAP
   RES 5 10 R^FEEDR
   CAP 6 10 C^CCAP

   DEF2P 3 9 AVANT204             DEFINE THE ABOVE AS A 2-PORT

TERM

PROC

OUT
   AVANT204 MAG[S11]   ! THESE ENTRIES USED TO
   AVANT204 ANG[S11]   ! PRODUCE A ".S2P" FILE
   AVANT204 MAG[S21]   ! FOR USE BY OTHER
   AVANT204 ANG[S21]   ! TOUCHSTONE CIRCUIT
   AVANT204 MAG[S12]   ! FILES.
   AVANT204 ANG[S12]   ! UNFORTUNATELY THE "SPAR" MACRO PRODUCES DB MAG[S21]
   AVANT204 MAG[S22]   ! SO WE HAVE TO DO IT THIS WAY.
   AVANT204 ANG[S22]   !

   AVANT204 DB[S21] GR1
   AVANT204 DB[S11] GR2
   AVANT204 DB[S22] GR2
   AVANT204 ANG[S11] GR3
   AVANT204 ANG[S21] GR3
   AVANT204 S11 SC1
FREQ
   SWEEP 0.100 3 .05      ! SWEEP FROM 100 - 3000, 100 MHZ INCREMENTS

GRID
   RANGE 0 3 .5         ! HORIZONTAL AXIS 0-3000 MHZ, 500 MHZ/DIVISION
   GR1   6 12  1        ! VERTICAL AXIS FOR S21 6-8 DB,.5 DB/DIVISION
   GR2   -30 0 5        ! VERTICAL AXIS FOR S11,S22 -30 TO 0, 5 DB/DIVISION
   GR3   -180 180 30    ! VERTICAL AXIS FOR PHASE

OPT
   RANGE .1   2.5        ! OPTIMIZE OVER FULL BANDWIDTH
   AVANT204 DB[S21] = 7   10
   AVANT204 DB[S11]< 10
TOL
```

Figure 1. Circuit file for the amplifier.

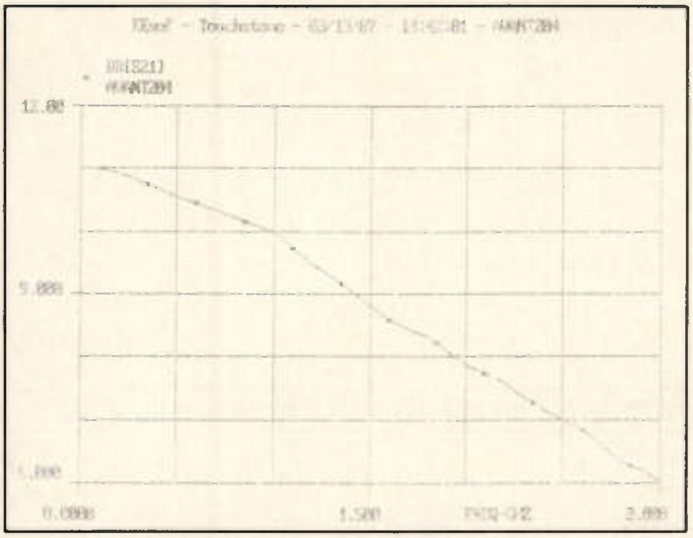


Figure 2. Plot of gain versus frequency.

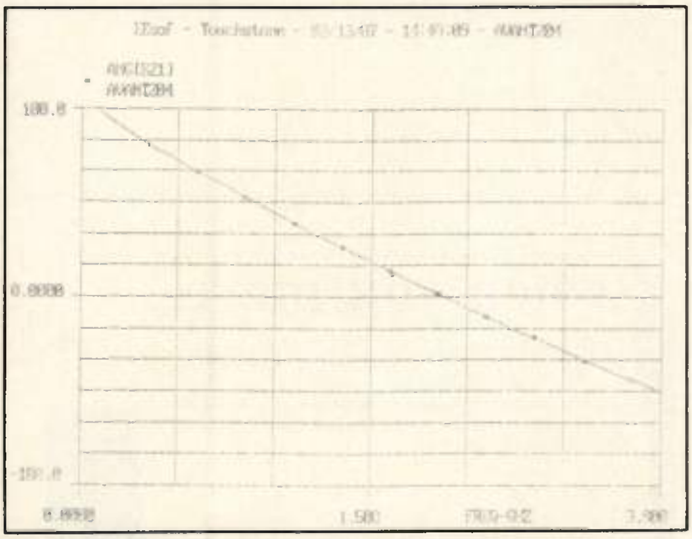


Figure 3. Plot of phase versus frequency.

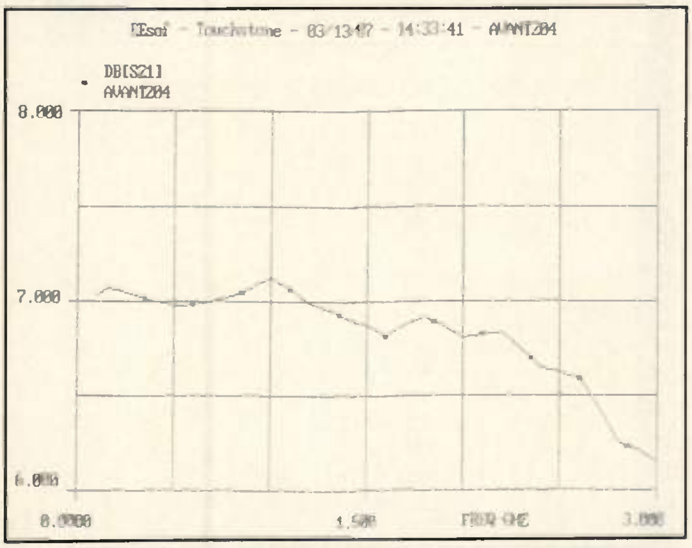
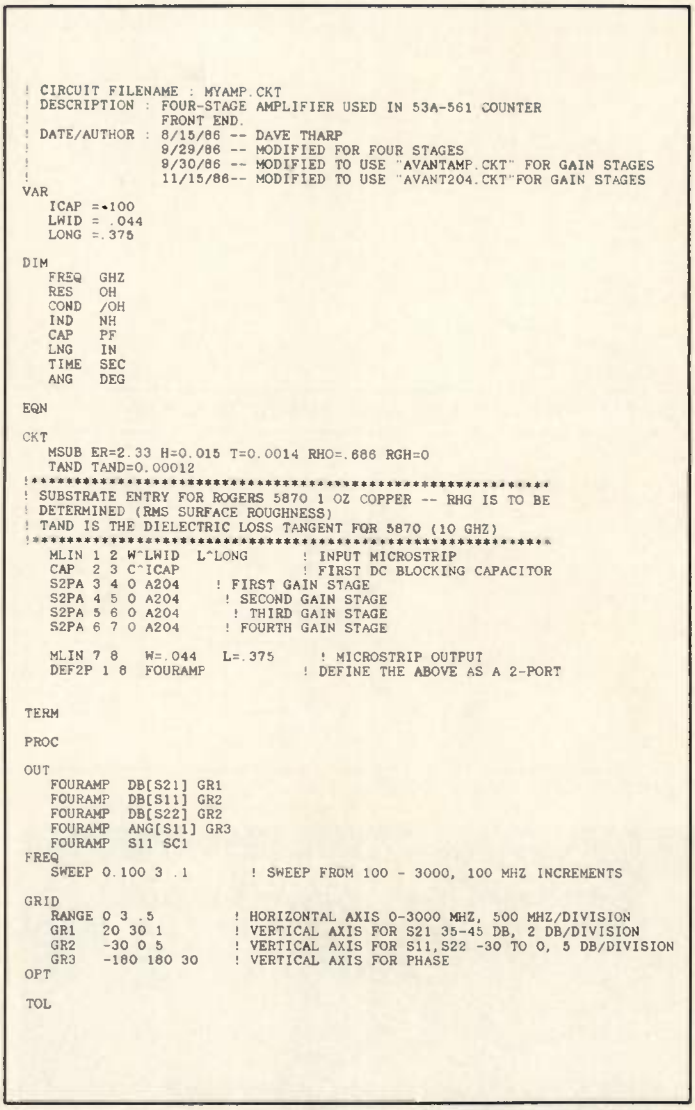


Figure 4. This plot illustrates that the equalized gain is 6.8 dB ±0.25 dB.



```
! CIRCUIT FILENAME : MYAMP.CKT
! DESCRIPTION : FOUR-STAGE AMPLIFIER USED IN 53A-561 COUNTER
!               FRONT END.
! DATE/AUTHOR : 8/15/86 -- DAVE THARP
!               9/29/86 -- MODIFIED FOR FOUR STAGES
!               9/30/86 -- MODIFIED TO USE "AVANTAMP.CKT" FOR GAIN STAGES
!               11/15/86-- MODIFIED TO USE "AVANT204.CKT"FOR GAIN STAGES
VAR
   ICAP =•100
   LWID = .044
   LONG =.375

DIM
   FREQ  GHZ
   RES   OH
   COND  /OH
   IND   NH
   CAP   PF
   LNG   IN
   TIME  SEC
   ANG   DEG

EQN

CKT
   MSUB ER=2.33 H=0.015 T=0.0014 RHO=.686 RGH=0
   TAND TAND=0.00012
!**************************************************************
! SUBSTRATE ENTRY FOR ROGERS 5870 1 OZ COPPER -- RHG IS TO BE
! DETERMINED (RMS SURFACE ROUGHNESS)
! TAND IS THE DIELECTRIC LOSS TANGENT FQR 5870 (10 GHZ)
!**************************************************************
   MLIN 1 2 W^LWID  L^LONG        ! INPUT MICROSTRIP
   CAP  2 3 C^ICAP                ! FIRST DC BLOCKING CAPACITOR
   S2PA 3 4 0 A204    ! FIRST GAIN STAGE
   S2PA 4 5 0 A204     ! SECOND GAIN STAGE
   S2PA 5 6 0 A204      ! THIRD GAIN STAGE
   S2PA 6 7 0 A204     ! FOURTH GAIN STAGE

   MLIN 7 8   W=.044   L=.375      ! MICROSTRIP OUTPUT
   DEF2P 1 8  FOURAMP             ! DEFINE THE ABOVE AS A 2-PORT


TERM

PROC

OUT
   FOURAMP  DB[S21] GR1
   FOURAMP  DB[S11] GR2
   FOURAMP  DB[S22] GR2
   FOURAMP  ANG[S11] GR3
   FOURAMP  S11 SC1
FREQ
   SWEEP 0.100 3 .1         ! SWEEP FROM 100 - 3000, 100 MHZ INCREMENTS

GRID
   RANGE 0 3 .5           ! HORIZONTAL AXIS 0-3000 MHZ, 500 MHZ/DIVISION
   GR1   20 30 1          ! VERTICAL AXIS FOR S21 35-45 DB, 2 DB/DIVISION
   GR2   -30 0 5          ! VERTICAL AXIS FOR S11,S22 -30 TO 0, 5 DB/DIVISION
   GR3   -180 180 30      ! VERTICAL AXIS FOR PHASE
OPT

TOL
```

Figure 5. Simulation of four single-stage amplifiers.

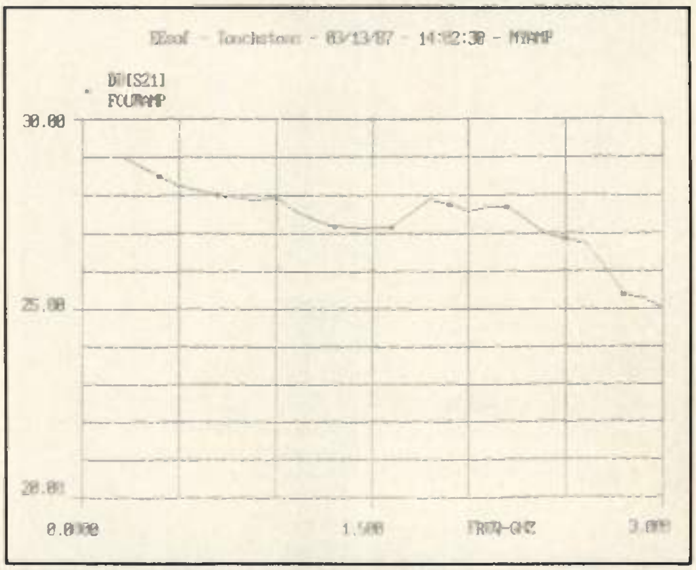


Figure 6. Plot of frequency response versus frequency

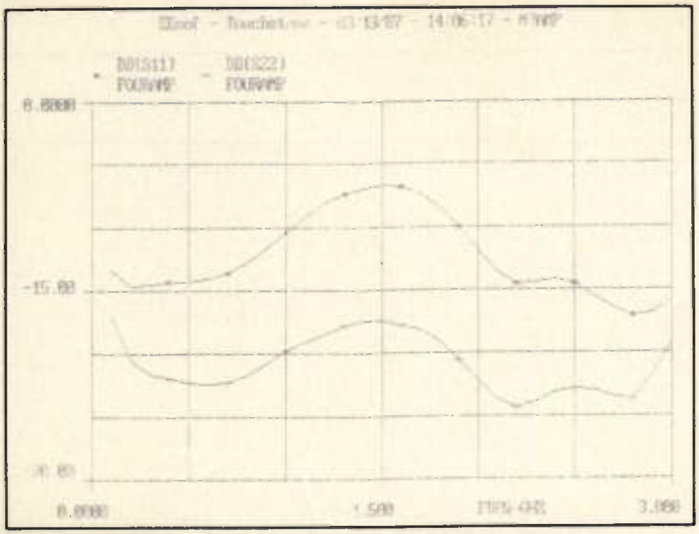


Figure 7. Plot of return loss versus frequency.

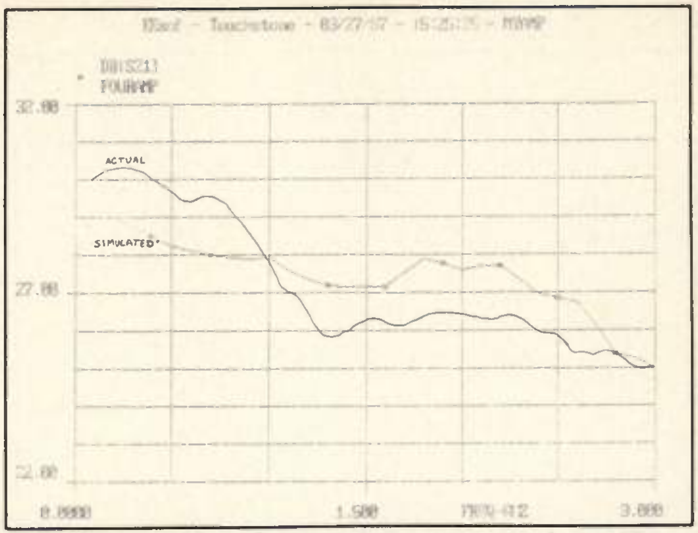


Figure 8. Actual and simulated plots of gain in dB.

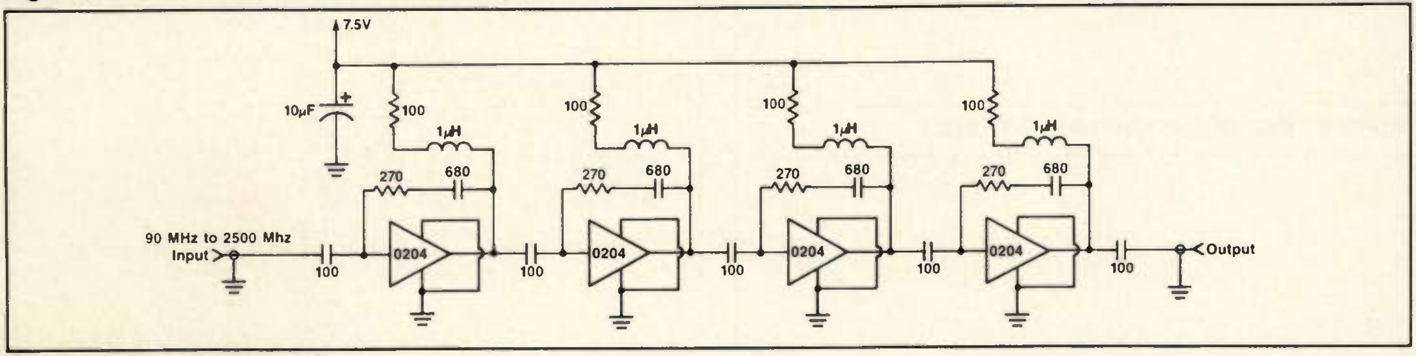


Figure 9. The final circuit.

A Noise Specification Program

BASIC Program Converts Expressions for Noise Power

By James Mikeworth
Boeing Company

The program presented here is based on "A Noise Nomograph" by Seymour Schneider (June 1985, RF Design, *p. 48). The graphical representation of that article has been replaced with a short BASIC program. To explain the principles behind the program, the following text is adapted from the 1985 article:*

The output from a noise source can be expressed in many different ways, depending on the frequency range and the system with which the noise source is used. For example, at microwave frequencies the output of a noise source is typically expressed as ENR (Excess Noise Ratio), which is defined as the noise ratio minus unity, where the *noise ratio* is the ratio of the equivalent noise temperature of the noise source to room temperature.

At audio frequencies the output of a noise source is usually expressed as $uV/\sqrt{Hz}$, where the RMS voltage measured in a given bandwidth is divided by the square root of the measurement bandwidth.

$$ENR = 10 \log \left(\frac{T_E}{T_o} - 1\right)$$

$$P_n = K\ T_E\ B$$

$$V_{rms} = (P_n R_L)^{1/2}$$

$$dBm = 10 \log \left(\frac{P_n}{10^{-3}}\right)$$

$$V/\sqrt{Hz} = V_{rms}/\sqrt{BW}$$

Where
T_o = Room temperature, 290°K
T_E = Equivalent temperature of noise source in °K
K = 1.38 × 10^{-23} joules/°K
B = Bandwidth in Hz
P_n = Available power from noise source in watts

Figure 1. Noise relationships.

Other expressions are dBm (per bandwidth), V_{rms} (per bandwidth), and equivalent noise temperature. The noise program relates these commonly used terms associated with noise power calculations. In addition, it can be used to determine what effect a change in a given parameter has on noise power.

The relationships used in the program refer to a noise generator that provides power output over a specified noise bandwidth into a load (Figure 1).

This program is menu driven and will prompt the user when data needs to be entered. Figure 2 shows examples of the menu and calculations. The program covers all areas of the original Noise Nomograph, with conversions in both "forward" and "reverse" directions. As written, the program runs in IBM BASICA.

About the Author

James Mikeworth is a Circuit Design Engineer at Boeing Company in Seattle, WA. He can be reached at 11020 Kent-Kangley, D110, Kent, WA 98031.

```
  1   ENR TO DBM
  2   ENR TO VRMS ACROSS LOAD RESISTOR
  3   ENR TO NOISE SPECTRAL DENSITY
  4   DBM TO ENR
  5   VRMS ACROSS LOAD RESISTOR TO ENR
  6   NOISE SPECTRAL DENSITY TO ENR
  7   EXIT TO BASIC


ENTER NUMBER OF CHOICE? 5
 VRMS ACROSS LOAD RESISTOR TO ENR


VRMS ACROSS LOAD (uV)=? 1000
RLOAD=? 50
NOISE BANDWIDTH IN MHZ=? 10
ENR=  56.98751  DB
```

```
 1   ENR TO DBM
 2   ENR TO VRMS ACROSS LOAD RESISTOR
 3   ENR TO NOISE SPECTRAL DENSITY
 4   DBM TO ENR
 5   VRMS ACROSS LOAD RESISTOR TO ENR
 6   NOISE SPECTRAL DENSITY TO ENR
 7   EXIT TO BASIC


ENTER NUMBER OF CHOICE? 2
 ENR TO VRMS ACROSS LOAD RESISTOR

ENR=? 57  dB
NOISE BANDWIDTH IN MHZ=? 10
RLOAD=? 50
VRMS ACROSS LOAD RESISTOR=  1001.438  uV
```

Figure 2. Sample calculations, showing menu format.

```
100 REM NOISE ANALYSIS PROGRAM
110 DIM A$(7)
120 TO=290:K=1.38E-23
130 A$(1)=" ENR TO DBM"
140 A$(2)=" ENR TO VRMS ACROSS LOAD RESISTOR"
150 A$(3)=" ENR TO NOISE SPECTRAL DENSITY"
160 A$(4)=" DBM TO ENR"
170 A$(5)=" VRMS ACROSS LOAD RESISTOR TO ENR"
180 A$(6)=" NOISE SPECTRAL DENSITY TO ENR"
190 A$(7)=" EXIT TO BASIC"
200 CLS:REM CLEAR SCREEN
210 FOR I=1 TO 7
220 PRINT I;A$(I):NEXT I:PRINT:PRINT
230 INPUT"ENTER NUMBER OF CHOICE ";CN
240 IF CN(1 OR CN)7 THEN 230
250 CLS:PRINT A$(CN):PRINT:PRINT
260 ON CN GOTO 290,360,440,520,620,730,850
270 REM
280 REM ENR TO DBM
290 GOSUB 920
300 DBM=10*LOG(PN/.001)/LOG(10)
310 PRINT"DBM= ";DBM
320 GOSUB 870
330 GOTO 200
340 REM
350 REM ENR TO VRMS ACROSS LOAD
360 GOSUB 920
370 INPUT"RLOAD= ";RL
380 VRMS=SQR(PN*RL)*1000000!
390 PRINT"VRMS ACROSS LOAD RESISTOR= ";VRMS;" uV"
400 GOSUB 870
410 GOTO 200
420 REM
430 REM ENR TO NOISE SPECTRAL DENSITY
440 GOSUB 920
450 INPUT"RLOAD= ";RL
460 V1=SQR(PN*RL)/SQR(BW)*1000000!
470 PRINT"VRMS PER ROOT HZ ACROSS ";RL;" OHMS= ";V1;" uV"
480 GOSUB 870
490 GOTO 200
500 REM
510 REM DBM TO ENR
520 INPUT"NOISE BANDWIDTH IN MHZ= ";BW:BW=BW*1000000!
530 INPUT"DBM= ";DBM
540 PN=.001*10^(DBM/10)
550 TE=PN/K/BW
560 NR=10*LOG(TE/TO-1)/LOG(10)
570 PRINT"ENR= ";NR;" DB"
580 GOSUB 870
590 GOTO 200
600 REM
610 REM VRMS ACROSS LOAD TO ENR
620 INPUT"VRMS ACROSS LOAD (uV)= ";VRMS:VRMS=VRMS*.000001
630 INPUT"RLOAD= ";RL
640 INPUT"NOISE BANDWIDTH IN MHZ= ";BW:BW=BW*1000000!
650 PN=VRMS^2/RL
660 TE=PN/K/BW
670 NR=10*LOG(TE/TO-1)/LOG(10)
680 PRINT"ENR= ";NR;" DB"
690 GOSUB 870
700 GOTO 200
710 REM
720 REM NOISE SPECTRAL DENSITY TO ENR
730 INPUT"VRMS PER ROOT HZ ACROSS LOAD (uV)= ";V1
740 INPUT"RLOAD= ";RL
750 INPUT"NOISE BANDWIDTH IN MHZ= ";BW:BW=BW*1000000!
760 VRMS=V1*SQR(BW)*.000001
770 PN=VRMS^2/RL
780 TE=PN/K/BW
790 NR=10*LOG(TE/TO-1)/LOG(10)
800 PRINT"ENR= ";NR;" DB"
810 GOSUB 870
820 GOTO 200
830 REM
840 REM EXIT TO BASIC
850 PRINT" END OF NOISE ANALYSIS PROGRAM--GOOD BYE"
860 END
870 REM WAITING SUBROUTINE
880 PRINT:PRINT"PRESS ANY KEY TO CONTINUE"
890 C$=INKEY$:IF C$="" THEN 890
900 RETURN
910 REM
920 REM STANDARD 1-3 INPUT SUBROUTINE
930 INPUT"ENR= ";NR:NR=NR/10
940 TE=TO*(10^NR+1)
950 INPUT"NOISE BANDWIDTH IN MHZ= ";BW:BW=BW*1000000!
960 PN=K*TE*BW
970 RETURN
```

The noise specification conversion program.

LOWEST PRICED, HIGHEST QUALITY ATTENUATORS – BNC $11.00 1-9 EA, SMA $14.40 10 EA AND TERMINATIONS – BNC $5.60 10 EA., SMA $5.60 10 EA., MIL. HI-REL. NETWORKS

Model Number (2)	Impedance Ohms (Power W)	Frequency Range	UNIT PRICE (4) EFFECTIVE 9-15-86					
			BNC	TNC	N	SMA	UHF	PC
Fixed Attenuators 1 to 20 dB								
AT 50(3)	50 (5W)	DC 1 5GHz	14 00	20 00	20 00	18.00	—	—
AT 51	50 (5W)	DC 1 5GHz	11 00	15 00	15 00	14.00	—	12.00
AT 52	50 (1W)	DC 1 5GHz	14 50	20 50	20 50	19.50	—	—
AT 53	50 (25W)	DC 3 0GHz	14 00	17 00	—	15.00	—	—
AT 54	50 (25W)	DC 4 2GHz	—	—	—	18.00	—	—
AT 55	50 (25W	DC 4 2GHz	—	—	—	14 40 (10 Pc)	—	—
AT 75 or AT 90	75 or 93 (5W)	DC 1 5GHz (750MHz)	11 50	20 00	20 00	18 00	—	—
Detector Mixer Zero Bias Schottky								
CD-51 75	50 75	01-4 2GHz	54 00	—	—	54 00	—	—
DM 51	50	01-4 2GHz	—	—	—	64 00	—	—
Resistive Impedance Transformers Minimum Loss Pads								
RT 50 75	50 to 75	DC 1 5GHz	10 50	19 50	19 50	17 50	—	—
RT 50/93	50 to 93	DC 1 0GHz	13 00	19 50	19 50	17 50	—	—
Terminations								
CT 50 (3)	50 (5W)	DC 4 2GHz	11 50	15 00	15.00	17.80	—	—
CT 51	50 (5W)	DC 4 2GHz	9 50	12 00	10.50	8 50	—	—
CT 52	50 (1W)	DC 2 5GHz	10 50	15 00	15.00	13.00	15.50	—
CT 53/M	50 (5W)	DC-4 2GHz	5 60 (10 Pc)	—	—	5.60 (10 Pc)	—	—
CT 54	50 (2W)	DC 2 0GHz	14 00	15 00	15.00	17.50	—	—
CT 75	75 (25W)	DC 2 5GHz	10 50	15 00	15.00	13 00	18.50	—
CT 93	93 (25W)	DC 2 5GHz	13 00	18 00	—	15 00	18.50	—
Mismatched Terminations 1 05 1 to 3 1 Open Circuit, Short Circuit								
MT 51	50	DC 3 0GHz	45 50	45 50	45 50	45 50	—	—
MT 75	75	DC 1 0GHz	—	—	45 50	—	—	—
Feed thru Terminations shunt resistor								
FT 50	50	DC 1 0GHz	10 50	19 50	19 50	17 50	—	—
FT 75	75	DC 500MHz	10 50	19 50	19 50	17.50	—	—
FT 90	93	DC 150MHz	13 00	19 50	19 50	17 50	—	—
Directional Coupler 30 dB								
DC 500	50	250-500MHz	60 00	—	84 00	—	—	—
Resistive Decoupler series resistor or Capactive Coupler series capacitor								
RD or CC 1000	1000 (1000PF)	DC 1 5GHz	12 00	18 00	18 00	17.00	—	—
Adapters								
CA 50 (N to SMA)	50	DC-4 2GHz	13 00	13 00	13 00	13 00	—	—
Inductive Decouplers series inductor								
LD R15	0 17uH	DC 500MHz	12 00	18 00	18 00	17 00	—	—
LD 6R8	6 8uH	DC 55MHz	12 00	18 00	18 00	17 00	—	—
Fixed Attenuator Sets 3 6 10 and 20 dB in plastic case								
AT 50-SET (3)	50	DC 1 5GHz	60 00	84 00	84 00	78.00	—	—
AT 51 SET	50	DC 1 5GHz	48 00	64 00	64 00	60 00	—	—
Reactive Multicouplers 2 and 4 output ports								
TC 125-2	50	1 5-125MHz	64 00	—	67 00	67 00	—	—
TC 125-4	50	1 5-125MHz	67 00	—	81 50	81 50	—	—
Resistive Power Dividers 3 4 and 9 ports								
RC 3 50	50	DC 2 0GHz	64 00	64 00	—	64 00	—	—
RC 4 50	50	DC-500MHz	64 00	64 00	—	64 00	—	—
RC 8 50	50	DC 500MHz	—	—	—	84 50	—	—
RC 3-75 4 75	75	DC 500MHz	64 00	84.00	—	64 00	—	—
Double Balanced Mixers								
DBM 1000	50	5-1000MHz	61 00	—	71 00	61 00	—	34 00
DBM 500PC	50	2 500MHz	—	—	—	—	—	34 00
RF Fuse 1 8 Amp and 1 16 Amp								
FL 50	50	DC 1 5GHz	12 00	18 00	45 50	17 00	—	—
FL 75	75	DC 1 5GHz	12 00	18 00	—	17 00	—	—

NOTE 1) Critical parameters fully tested and guaranteed Fabricated from Mil Spec High-Rel resistors Schottky diodes Mil Spec plated ports and connectors in nickel, silver, and gold 2) See catalog for complete Model Number Specify connector sexes Specials available 3) Calibration marked on label of unit 4) Price subject to change without notice Shipping $5 00 Domestic or $25 00 Foreign on Prepaid Orders

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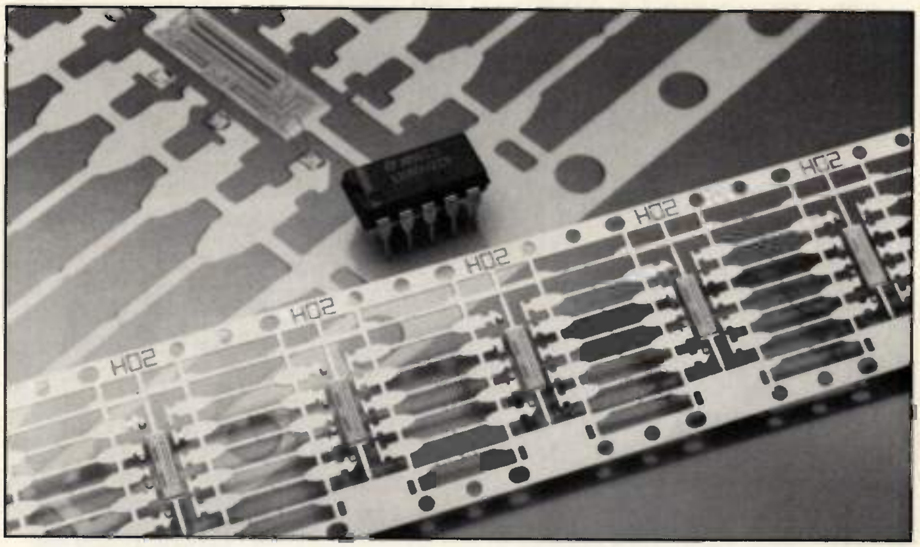
Video Buffer For High Speed Applications



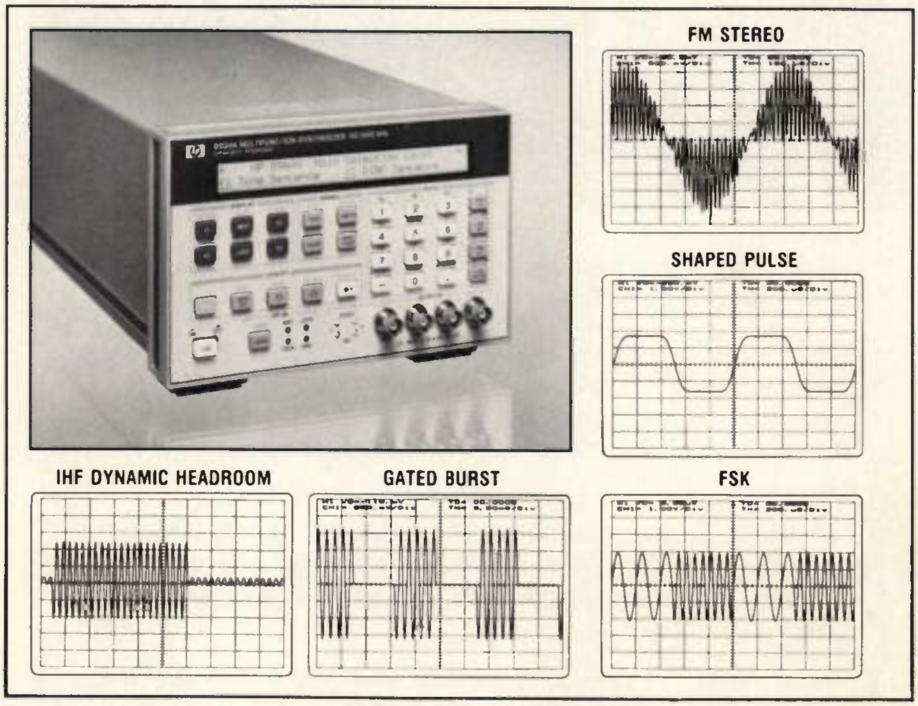
The LH4002 is a high speed unity gain buffer designed to provide high current drive capability at frequencies from DC to over 200 MHz with a bandwidth of at least 100 MHz. It operates on a ±5 V supply and features a minimum slew rate of 1000 V/us with the ability to drive 50 and 75 ohms directly. Additional AC specifications include a phase linearity of 2 degrees (at a bandwidth from 1 to 20 MHz) and distortion of less than 0.1 percent.

The LH4002CN is available in a 10-pin plastic DIP while the LH4002CH, LH4002H and the LH4002H-MIL are encased in 8-pin metal TO-5 packages. The 10-pin plastic DIP uses lead frame construction which provides good power dissipation to ambient.

This buffer is intended for a range of high speed applications such as video distribution, impedance transformation, and load isolation. In current booster applications within an op-amp loop, the device can increase the output current capability of existing op-amps.

In quantities of 100, the LH4002CN and LH4002H cost $9.50, the LH4002H (Military Temp) is $19.25 and the LH4002H-MIL (Military Processed) is priced at $46.40. **National Semiconductor Corporation, Santa Clara, CA. Please circle INFO/CARD #220.**

HP Introduces A Multifunction Synthesizer


FM STEREO

SHAPED PULSE

IHF DYNAMIC HEADROOM

GATED BURST

FSK

The HP8904A multifunction synthesizer is an instrument that digitally creates complex signals from six basic waveforms. It can be used as a function generator, modulation source, or a stimulus for audio circuits. Signals for VOR, ILS, FM stereo or communications signalling can also be created. The instrument starts as a synthesizer that digitally generates sinewaves to 600 kHz, square, ramp, and triangle signals to 50 kHz, and white noise and DC signals. The standard 8904A offers the precision of a digital synthesizer with 0.1 Hz resolution, an electronic 50 ohm output and standard HP-IB.

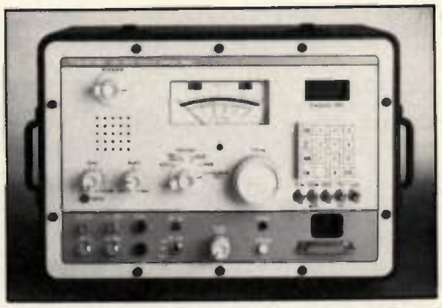
Three option packages are available for this device. Option 001 adds three synthesizers or channels which can either modulate the first synthesizer or be summed to the output. Option 002 adds a second output to the instrument. For digital modulation and fast hop applications, Option 003 adds external timing control.

Complex signals can be created with Option 001 by adding synthesizers which can either AM, FM, PM, DSBSC or pulse modulate the first synthesizer. Or, any can be summed with the first channel at the output. All four channels can be set to generate different waveforms, frequencies, amplitudes, and phase offsets simultaneously. Option 002 adds a second identical synthesizer and floating output section. With phase accuracy between the two outputs specified to be better than ±0.10 degrees, the instrument can test phase detectors, servo systems, shaft encoders, sonar, and other two port devices.

The HP8904A is priced at $2600 while Option 001 costs $1500, Option 002 costs $1200 and Option 003 is approximately $500. **Hewlett-Packard Company, Palo Alto, CA. INFO/CARD #219.**

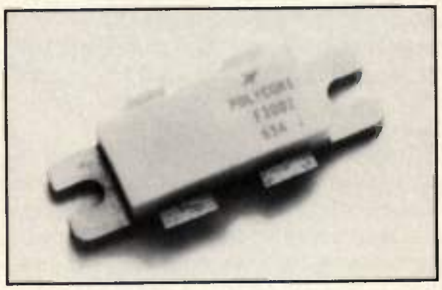
4W Operational Amplifier

The WA01 features a power bandwidth of 150 MHz and a slew rate of 4000V/us. It has a maximum voltage offset of 10 mV, drift of 50 uV/C and non inverting bias current of 20 uA. The internal 1.5 k ohm feedback resistor provides a transimpedance function of 1.5 V/mA in respect to the inverting input. The WA01 is $160.85 in single quantities. **Apex Microtechnology Corp., Tucson, AZ. INFO/CARD #216.**



LAN Analysis Meter

The LAN 450D Network Analysis Meter incorporates signal level measurements and signal generation in one test instrument. It measures RF data carrier levels as well as carrier-to-noise ratio and percent hum modulation. It incorporates a built-in signal generator for measuring round trip signal attenuation or loop loss. The signal generator will generate at a data channel translator input frequency of up to 450 MHz and the LAN measures the signal at the translator output frequency. **Wavetek Indiana, Inc., Beech Grove, IN. INFO/CARD #218.**



Gold Metalized FET

Polycore RF Devices introduces a series of gold metalized FETs at 300 W. The F3000 Series uses layered titanium-tungsten- gold. It offers push-pull linear or single ended high power configurations. The devices operate from 1 MHz to 300 MHz. **Polycore RF Devices, Newbury Park, CA. INFO/CARD #217.**

Scalar Network Analyzer

The Wiltron 561 makes measurements of transmission, return loss, and power over the 10 MHz to 40 GHz range without using external controllers. The instrument displays at one time any two of four input channels over a specified 71 dB dynamic range. Noise floor is less than −62 dBm providing a greater than 76 dB range. Data interpretation at low signal levels is enhanced with smoothing and averaging. **Wiltron Company, Morgan Hill, CA. INFO/CARD #215.**

Flexible Cables

Four types of cables namely FE 10, FE 12, FE 19 and FE 25 are being introduced by Adams Russell's Antenna and Microwave Division. The FE 10 is rated from 30 MHz to 74 GHz with an insertion loss of 1.3 dB and VSWR of 1.25:1. FE 12 goes from 30 MHz to 55 MHz and has an insertion loss of 0.9 dB. The frequency range for FE 19 is 30 MHz to 30 GHz with an insertion loss of 0.48 dB. 30 MHz to 23.5 GHz is the range for Model FE 25. Its insertion loss is 0.42 dB. Note that the frequency ranges are dependent on connector style. **Adams Russell, Antenna and Microwave Division, Amesbury, MA. INFO/CARD #214.**

Miniature Linearized Attenuator

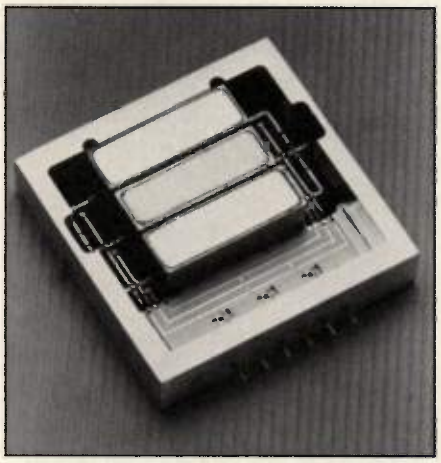
The MA2694 miniature voltage variable attenuator incorporates a hybridized linearizer which reduces the package size. They are offered with 40 dB or 60 dB dynamic range in standard or sub-octave bands from 2 to 18 GHz. **M/A-COM Solid State Division, Hudson, NH. INFO/CARD #213.**

Fiber Optic Chip Set

The chip set provides solutions for encode and decode in high speed digital fiber optic communications systems. The SP9960 encoder /LED driver accepts either TTL or ECL level signals and encodes the clock and data signals for transmission. The SL9901 transimpedance amplifier converts the output from a PIN diode detector into a voltage suitable for driving the amplifier input stage of the decoder circuit. SP9921 is a decoder which operates from 20 MB/sec to 50 MB/sec. It recovers the clock and data from the amplified input signal and provides ECL-level outputs. The quantity prices are $21.04 each for the SP9960, $7.78 each for the SL9901 and $38.69 for the SP9921. **Plessey Semiconductors, Irvine, CA. INFO/CARD #211.**

Switched Filter Banks

Comstron has developed switched filter banks for use in systems where contiguous, overlapping, variable bandwidth or linear phase (constant delay) designs are required. The frequency range is 1 MHz to 12 GHz. **Comstron Corporation, Melville, NY. INFO/CARD #212.**



Linear Power Amplifier

Model A2001 class A linear power amplifier operates from 10 to 2000 MHz. It provides a minimum of 1 W output with a gain flatness of ±1.5 dB. **Amplitech, Paramus, NJ. INFO/CARD #209.**

RF Tuning Network

Mercator Control Systems introduces a line of digital 13.56 MHz RF tuning networks. Five models are available for power levels at 500, 1000, 2500, and 5000 W. Features include display of forward and reflected power, phase and load capacitor position and DC bias value. Three preset positions are included with

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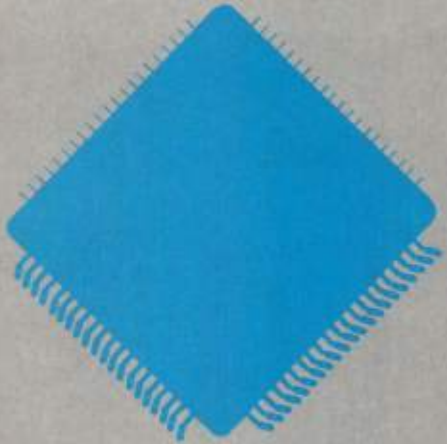

NCMO™ Numerically Controlled Modulated Oscillator
DRFS-2250

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

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

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

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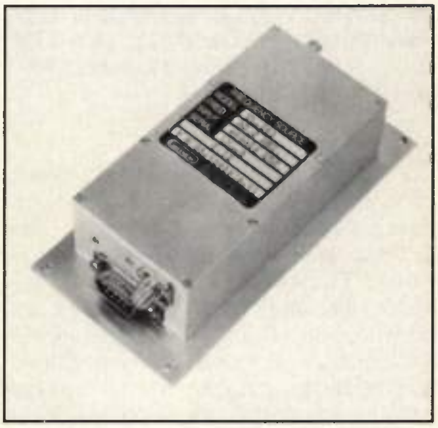
INFO/CARD 47

analog and TTL computer interface, RF generator control, and DC bias controllability. The digital system is fully automatic with manual overrides. **Mercator Control Systems, Inc., Santa Ana, CA. INFO/CARD #208.**

PLL Crystal Oscillator

Greenray Industries introduces a phase locked loop crystal oscillator for frequencies from 10 to 100 MHz. The spurious specification is –70 dBc at F_C ±5 MHz. **Greenray Industries, Inc., Mechanicsburg, PA. INFO/CARD #210.**

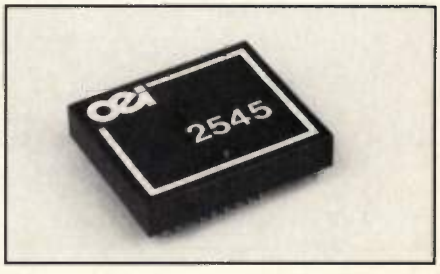


Octave Band VCOs

Model V1 voltage controlled oscillators provide full octave tuning in bands to 200 MHz. These low voltage units feature output buffering with output power at 13 dBm or ECL levels. **Luff Research, Jackson Heights, NY. INFO/CARD #207.**

Video Enhancement Module

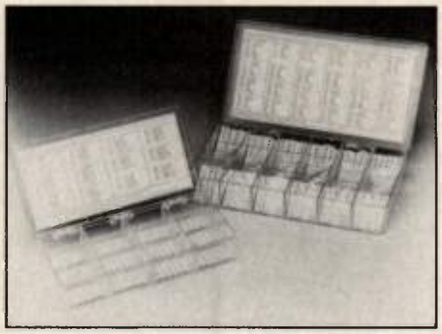
The 2545 enhancement module is a



video signal processing block that contains a high speed logarithmic amplifier and support circuitry for interfacing a logarithmic expansion or compression function into a video system. For 1 to 9 pieces the 2545 is priced at $637. **Optical Electronics, Inc., Tucson, AZ. Please circle INFO/CARD #206.**

Chip Resistor and Capacitor Kits

Communications Specialists introduces a chip resistor (CR-1) and chip capacitor (CC-1) kit. The CR-1 contains 1540 pieces composed of 10 chip resistors for every 5 percent value from 10 ohms to 10 M ohms plus 8 values of 0, 10, 100, 1 k, 10 k, 1 M, and 10 M ohms. CC-1 contains 365 pieces composed of 5 chip capacitors for every 10 percent value from 1 pF to . 33 uF plus 5 additional capacitors for 1 pF, 10 pF, 100 pF, 1000 pF, .01 uF and .1 uF. Each kit sells for $49.95. **Communications Specialists, Inc., Orange, CA. INFO/CARD #205.**



High Voltage Crosspoint Switches

SD1500BD is a high speed 600 V enhancement-mode vertical D- MOS FET in a TO-92 package for low current high voltage switching applications. It is also available in a die form. For 100 pieces and up, individual units cost $0.95. **Topaz Semiconductor, San Jose, CA. Please circle INFO/CARD #204.**

Miniature Voice Scrambler

The VPU-7 features a wide input dynamic range, an antialiasing input filter, and a 6 pole output filter. It has a crystal controlled single inversion, low distortion audio recovery and an optional flip-flop with board extension for momentary push button control. The dimensions are 1.1"× .69"× .18". **Midian Electronics, Inc., Tucson, AZ. INFO/CARD #203.**

Tempest Power Line Filter

The Standex TA and TB Series of power line filters features extended insertion loss to 40 dB/.05 MHz, 60 dB/.1 MHz, 70 dB/.15 MHz, and 80 dB/.3 MHz. Power entry module provides two pole On and OFF switch, fusing, power cord connector, (shielded or unshielded) and flush mounting with optional R.F. gasket. **Standex Electronics, Riviera Beach, FL. Please circle INFO/CARD #202.**

RF Power Amplifier

The Model 4200 delivers over 1000 W of CW power and is protected against excessive VSWR. The gain is 60 dB minimum with a gain flatness of ±1 dB. This Class AB unit has a frequency range of 400 to 450 MHz. **American Microwave Technology, Inc., Fullerton, CA. Please circle INFO/CARD #201.**

ECL VCXO

Piezo Technology introduces a hybrid ECL voltage controlled crystal oscillator. The CHX1004 operates at a frequency of 44.736 MHz. It features a 10 K ECL output signal with a linearity better than ±10 percent, maximum rise and fall time of 2 ns, and a frequency stability of +/-25 ppm over the −40C to +70C. The dimensions for the device are 0.803"× 0.502"× 0.225". **Piezo Technology, Inc., Orlando, FL. INFO/CARD #200.**

Amplifiers With Blindmate Connectors

Aydin Vector introduces the AMX Series of custom modular amplifiers with blindmate connectors. The frequency range is from 5 to 1500 MHz, noise figure range is 2.5 to 10 dB, gain range is from 10 to 55 dB and the power output range is −2 to +22 dBm. The device is available in TO-8, TO-12, and 4 pin dip with miniature

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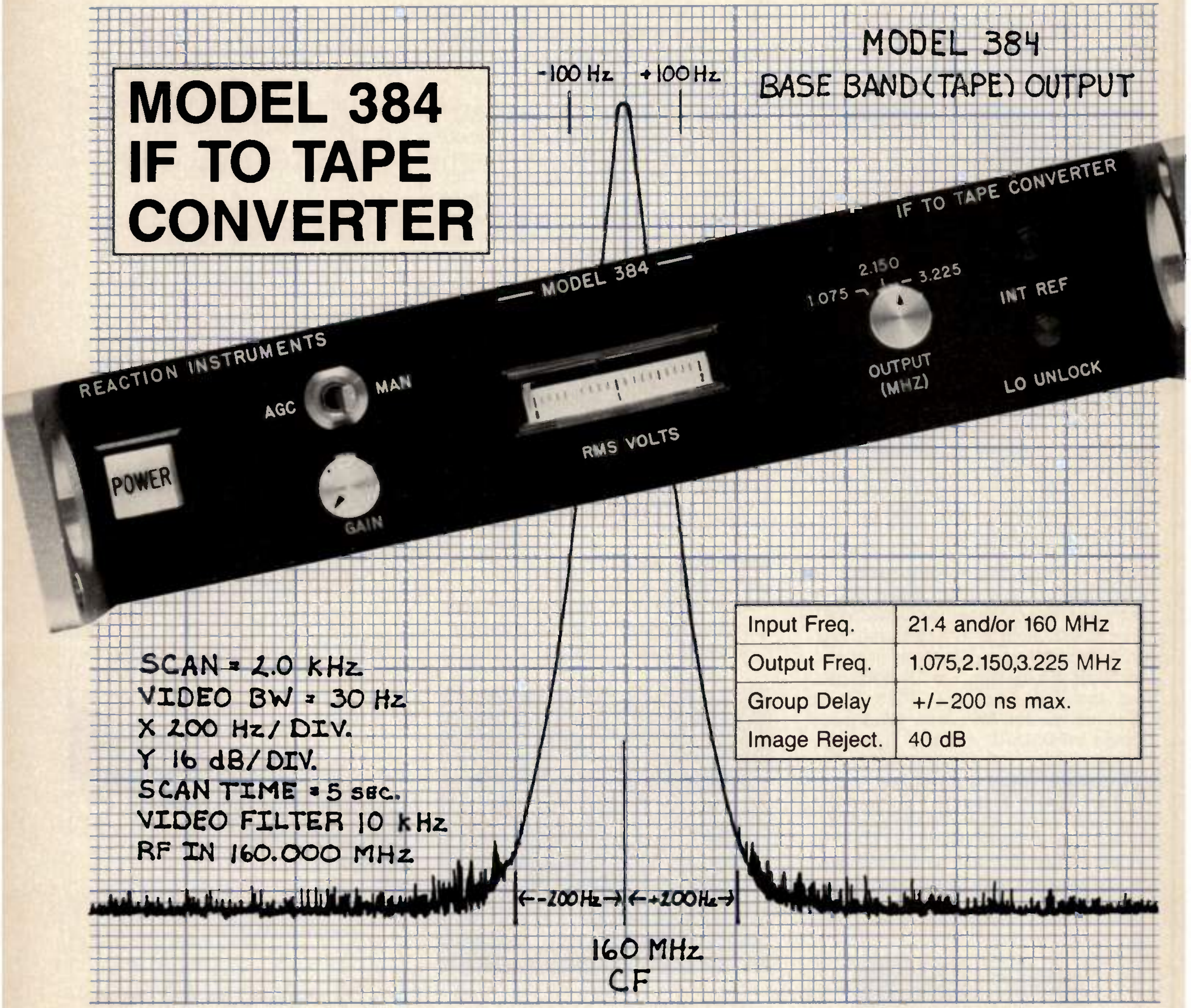

MODEL 384 IF TO TAPE CONVERTER

Input Freq.	21.4 and/or 160 MHz
Output Freq.	1.075,2.150,3.225 MHz
Group Delay	+/−200 ns max.
Image Reject.	40 dB

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SMA and blindmate connectored housing. **Aydin Vector Division, Newton, PA. INFO/CARD #199.**

Digital Storage Oscilloscope

Rapid Systems introduces the R2000 2-channel 20 MHz digital storage oscilloscope that uses the PC for display and storage. The features include 2 channel simultaneous acquisition, 20 MHz sampling rate per channel, switch selectable 1 M ohm or 50 ohm BNC input, programmable gain and sample rate, menu driven operation, and screen dumps to the printer. The system costs $3495 and is tailored for IBM and compatible computers. **Rapid Systems, Inc., Seattle, WA. INFO/CARD #198.**

Low Noise GaAs Amplifier

Tachonics Corporation introduces the TCWL-0100 low noise GaAs monolithic IC that operates over the .05 to 5 GHz frequency range. Within the 0.05 to 4 GHz range, it offers a 12 dB gain and a typical N.F. of 3.5 dB. The output power at 1 dB compression power is 14 dBm. It is available in chip, stripline or surface mount packages. The packaged units also come in single or dual supply configurations. Prices in 100-piece quantities begin at $17.80. **Tachonics Corporation, Plainsboro, NJ. INFO/CARD #197.**

Digital Quadrature Detector

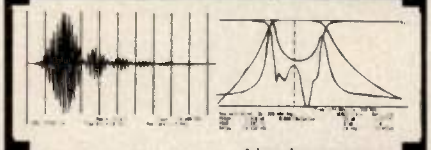
Mirage Systems introduces the Model 850A digital quadrature detector. It operates from 50 to 200 MHz with a dynamic range of greater than 80 dB. The resolution is 16 bits for amplitude and phase. **Mirage Systems, Sunnyvale, CA. INFO/CARD #196.**

Transimpedance Operational Amplifier

Analog Devices introduces a transimpedance operational amplifier that uses current rather than voltage feedback so that the bandwidth is relatively independent of gain. The hybrid AD9610 offers a 100 MHz (−3dB) unity gain bandwidth, 95 MHz bandwidth at a gain of −10, and 75 MHz at a gain of −20. The slew rate is 3500 V/us. Over a frequency range of 5 MHz to 150 MHz noise is measured at 0.7 nV$\sqrt{}$Hz for voltage and 23 pA$\sqrt{}$Hz for current. **Analog Devices, Norwood, MA. INFO/CARD #195.**

Bias Tee

Alford Manufacturing introduces a bias tee, Model 9460-1.0- xxxx, which covers from 500 MHz to 1.5 GHz. The RF loss is measured at 0.2 dB. **Alford Manufacturing Company, Woburn, MA. Please circle INFO/CARD #194.** ☐



Clean sweep to 1 GHz.

50 watts minimum is a lot of rf power throughout a bandwidth of 1 to 1000 MHz. But that's what our new Model 50W1000 delivers for all your broadband test needs.

As your hunger for power plus bandwidth grows, this year and next, our all-solid-state "W" series of 100-kHz-to-1000-MHz linear amplifiers should become more and more important in your plans. Today you may need only 1 watt (the little portable on the top of the pile), or 5, or 10—all with that fantastic bandwidth instantly available without tuning or bandswitching—the kind of bandwidth that lets you sweep clean through with no pausing for adjustment.

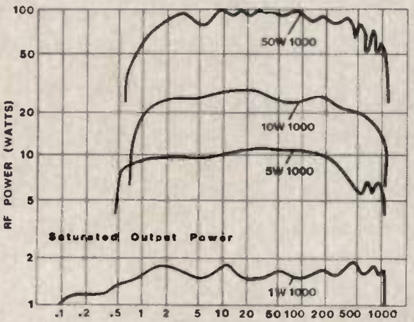
And next year?

But chances are good that next year you'll be moving up into higher-power work in the same bandwidth. Then you'll be glad you have a 50W, the *only* rf power amplifier in its power-to-bandwidth class. At that point, your smaller "W" series amplifiers can be freed for lower-power work around your lab.

What you can't see in the performance curves shown below is the unconditional *stability* of all Amplifier Research amplifiers—immunity to even the worst-case load mismatch or shorted or open cable with no fear of damage or system shutdown.

The "W" series is part of a complete line of amplifiers offering rf power up to 10,000 watts cw, for such diverse applications as plasma/fusion research, NMR, RFI susceptibility testing, and a host of other test situations that demand the very finest in broadband rf power.

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



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INFO/CARD 61

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rf literature

Amplifiers and Signal Processing Components

Cougar Components has published its 1987 catalog entitled *RF and Microwave Cascadable Amplifiers and Signal Processing Components 0.3 to 2400 MHz*. Included are complete specifications and graphs for their line of amplifiers and voltage controlled attenuators. All assembly techniques, parts, and materials are designed to meet the screening and manufacturing requirements of MIL-STD-883. **Cougar Components, Sunnyvale, CA. INFO/CARD #179.**

Solving Coil Design Problems

Magnecraft has developed a graphical method for solving coil design problems. New formulae compare wire gauge to coil resistance, coil turns, power dissipation and ampere turns. **Magnecraft Electric Company, Northbrook, IL. Please circle INFO/CARD #178.**

Signal Processor Information

A set of technical information on the TS68930 Digital Signal Processor is available from Thomson-Mostek. The literature set comprises of a data sheet, a DSP comparison of the TMS 32020 vs TS68930, a TS68930 DSP module library providing a list of software modules and macros, and a real time algorithms application note. **Thomson-Mostek, Carrollton, TX. INFO/CARD #177.**

Pulse Generators and Accessories

Avtech Electrosystems introduces its 1987 general catalog of nanosecond waveform generators and accessories. It describes over 150 models of ultra high speed pulse generators, impulse generators, monocycle generators, power splitters, and scope probes covering the PRF range of 0 to 250 MHz, rise times from 40 ps to 10 ns, pulse widths from 130 ps to 100 us and amplitudes from 2 to 500 V. **Avtech Electrosystems Ltd., Ottawa, Ontario, Canada. INFO/CARD #176.**

MIC Microwave and IF/RF Catalog

RHG Electronics Laboratory has released a catalog (No.400) containing product and technical information on their complete line of MIC Microwave and IF/RF products. It incorporates advancements in component, circuit and packaging technology for IF/RF products, MIC mixers and mixer preamps, microwave components, and microwave links and monopulse receivers. A technical information and article section is also included with information on log amps, phase and gain matching, signal-to-noise ratio, fine gain linearity measurements and monopulse receivers. Test methods for measurement of standard specifications are included. **RHG Electronics Laboratory, Inc., Deer Park, NY. Please circle INFO/CARD #174.**

RF Filters Catalog

This catalog contains information on powerline shielded room filters, RFI/EMC filters for various current levels and ranges, filter discharge units, line impedance networks, and secure communications and signal line filters. RF filtered and shielded circuit breaker panel boards and power factor correction coils are included. **Filtron Company, Inc., Old Bethpage, NY. INFO/CARD #173.**

DPAK Literature Package

Motorola introduces the DPAK literature package which includes literature on all discrete devices currently available in surface mount packaging (DPAK). Bipolar power transistors, TMOS power MOSFETs, and Schottky and ultra-fast rectifiers are featured. The package includes a DPAK update, a surface mount selector guide, and article entitled *DPAK, The Power Package For Surface Mount*, a tape and reel data sheet for surface mount devices, and DPAK product data sheets including 26 bipolar power transistors, 8 power MOSFETs and 16 rectifiers. **Motorola, Inc., Phoenix, AZ. Please circle INFO/CARD #172.**

Test and Measurement Instrumentation Catalog

This 16 page catalog outlines performance features, applications, and specifications for 22 instruments. Products include digital multimeters, and communications test sets. **Solartron Instruments, Elmsford, NY. INFO/CARD #171.**

Short Form Catalog on Instruments

A short catalog covering its line of Test and Measuring instruments has been issued by Iwatsu Instruments. It presents features and specifications on oscilloscopes, function generators, scope wagons, trace recording camera systems, a selection chart of oscilloscope accessories, and a passive and active probes chart. **Iwatsu Instruments, Inc., Carlstadt, NJ. INFO/CARD #170.**

Filter Catalog

A line of active and passive signal-conditioning filters is presented in this catalog from TTE. Filter designs offered are Butterworth, Chebyshev, Gaussian, Bessel, anti-aliasing, programmable and notch types, plus TTE's own designs. The frequency range covered is from 0.1 Hz

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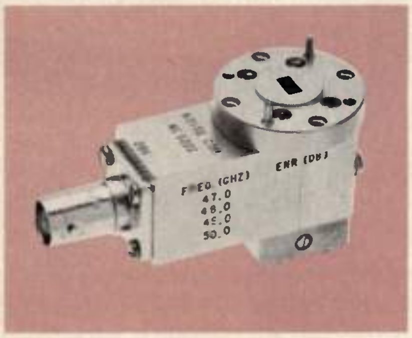

TYPICAL STANDARD MODELS	
NC 5100 Series	up to 50 GHz 15.5 dB ENR, noise figure meter compatible
NC 5200 Series	up to 50 GHz 21-25 dB ENR, high noise output
NC 5300 Series	up to 50 GHz 21-25 dB ENR, high noise output

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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
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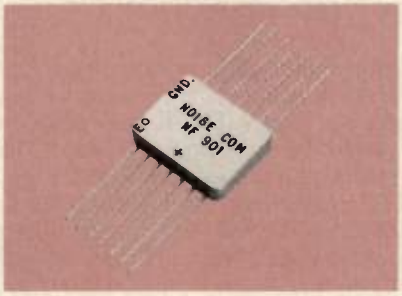

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INFO/CARD 63

rf literature *Continued*

to 500 MHz. Documentation provided includes specifications, attenuation curves, response curves, response comparisons, case drawings and mounting dimensions. **TTE, Inc., Los Angeles, CA. Please circle INFO/CARD #169.**

Scalar Network Analyzer Brochure

The brochure describes a scalar network analyzer that measures transmission, return loss, and power over the 10 MHz to 40 GHz range. Also contained are typical measurement displays, a test setup diagram, front panel functions, applications, accuracy tables, and a list of available models. **Wiltron Company, Morgan Hill, CA. INFO/CARD #168.**

Conductive Silicon Rubber Brochure

Performance data of MOX-C/S conductive silicon rubber for EMI/RFI shielding applications is described in a series of brochures available from Moxness Products. These shielding products are made from electrically conductive rubber. **Moxness Products, Inc., Racine, WI. Please circle INFO/CARD #167.**

Coils and Inductive Components Catalog

The catalog lists primary operational and physical parameters of Delevan's molded, shielded, and variable RF coils with inductance values from 0.022 uH to 150 mH. It also lists toroidal inductors, power chokes, and micro-i chip inductors. **Delevan Division, American Precision Industries, East Aurora, NY. Please circle INFO/CARD #166.**

IEEE 488 Catalog

IOtech has published its 1987 catalog of IEEE 488 interfaces. The products included are IOtech's Personal 488/2 interface, the expanded 488 bus expander, the Extender 488/F fiber optic bus extender, the Chrono 488 bus clock, and the COM488, an IEEE printer/plotter interface. **IOtech, Inc., Cleveland, OH. Please circle INFO/CARD #165.**

Chip Capacitor Data Sheet

A MIL-C-55681 and MIL-C-11272 multilayer chip capacitor brochure #62-08 is available from Murata Erie North America. Included is information on CDR01-06, CRD11-14, CY81-84 and the CDR21 Series with M failure rate level approval. Also listed are performance specifications with respect to capacitance, insulation resistance, voltage temperature limits, life test and resistance to soldering heat. **Murata Erie North America, Inc., State College, PA. INFO/CARD #175.**

rf opportunities

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

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

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

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

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Advertiser Index

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- **Gunn Diodes**
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INFO/CARD 64

SAW Questions and Andersens.

Oscillators:

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

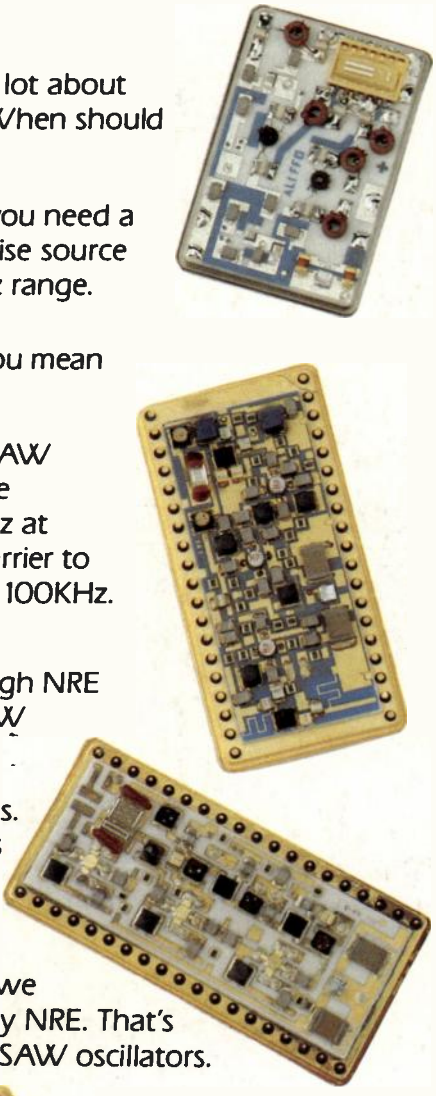
ANDERSEN: Any time you need a compact, rugged low noise source in the 100 MHz to 1 GHz range.

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.

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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

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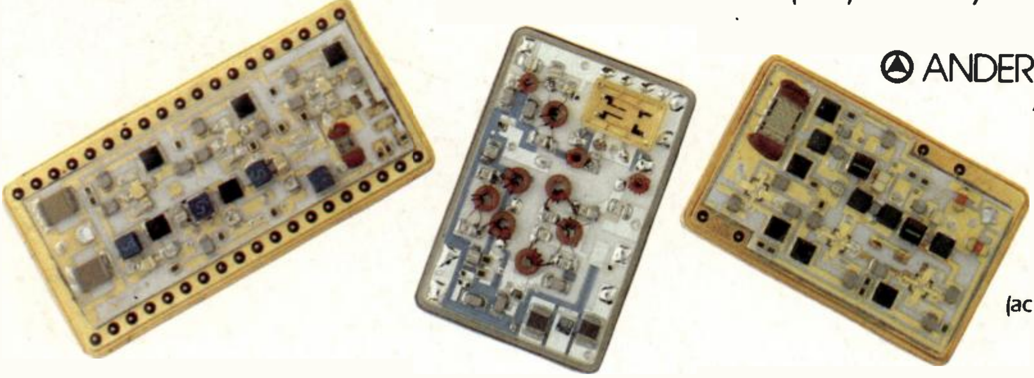

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INFO/CARD 65

rf design
engineering principles and practices
1988 Directory Issue

1988 directory

RF Products and Services
Design Guide References
10-Year Article Index
Company Index

SMA, SMB, and SMC CONNECTORS from AEP

MIL qualification doesn't guarantee that the connectors you need will arrive on time, or work when you get them. And the MIL specs change so much, sometimes it's hard to know *what* you're going to get.

What you see is what you get.

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Wintronics
Arvada, CO
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C.H.P.S.
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Lowell, MA
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Washington
Beltsville, MD
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Pyttronic Industries
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New Haven, CT 06525
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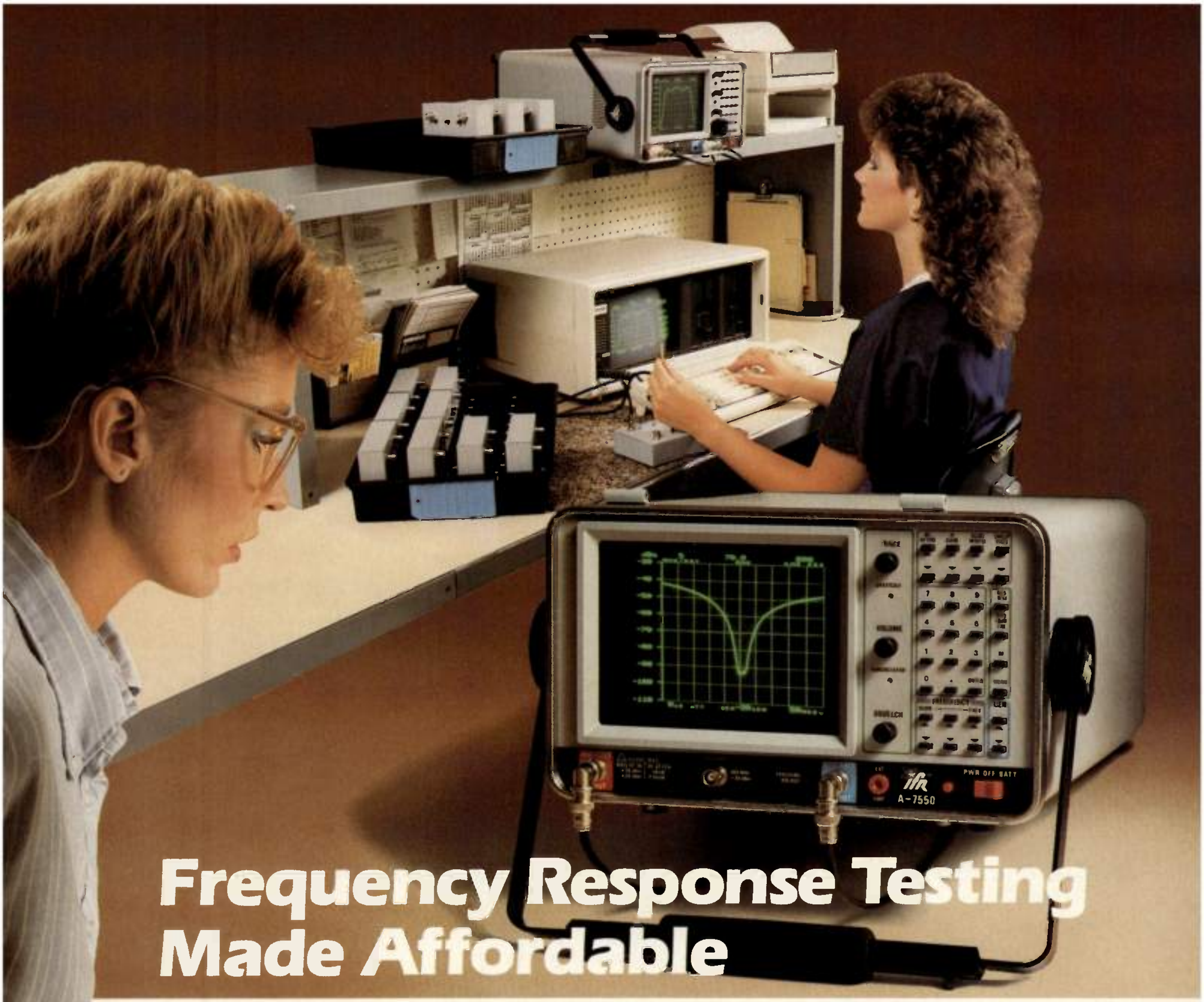
INFO/CARD 1



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For more information or a demonstration, contact your local IFR distributor or representative, or contact IFR directly at 316/522-4981.

*U.S.A. Trade Net Price

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INFO/CARD 2

rf design

1988 Directory Issue

R.F. DESIGN (ISSN: 0163-321X USPS: 453-490) is published monthly plus one extra issue in August. 1988 Directory, Vol. 11, No. 13. March 1987, Vol. 10, No. 3. Second-Class Postage paid at Englewood, CO and at additional mailing offices. Subscription office: 1 East First Street, Duluth, MN 55802, (218-723-9355). Domestic subscriptions are sent free to qualified individuals responsible for the design and development of communications equipment. Other subscriptions are: $30 per year in the United States; $37 per year in Canada and Mexico; $41 (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.
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Phase Noise: –75dBc, (0-15KHz)
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Price: $4,800.00*

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Resolution: 0.1Hz-100KHz (opt.)
Switching: 5-20μs
Output: +3 to +10dBm: 50 ohm
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Phase Noise: –75dBc, (0.5Hz-15KHz)
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Interface: BCD par. or GPIB
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Price: $4,800.00*

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(or 0-99dB with GPIB)
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or any 10 MHz line (20-140)

PTS 160

Range: 0.1-160MHz
Resolution: 0.1Hz-100KHz (opt.)
Switching: 5-20μs
Output: +3 to +13dBm: 50 ohm
Spurious Outputs: –75dB

Phase Noise: –63dBc, (0-15KHz)
Freq. St'd: Oven, TCXO, Ext.
Interface: BCD par. or GPIB
Size: 19"W, 5¼"H, 18"D
Price: $5,850.00*

Other Options:
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(or 0-99dB with GPIB)
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or any 10 MHz line (20-140)

PTS 250

Range: 1-250MHz
Resolution: 0.1Hz-100KHz (opt.)
Switching: 5-20μs
Output: +3 to +13dBm: 50 ohm
Spurious Outputs: –70dB

Phase Noise: –63dBc, (0-15KHz)
Freq. St'd: Oven, TCXO, Ext.
Interface: BCD par. or GPIB
Size: 19"W, 5¼"H, 18"D
Price: $6,700.00*

Other Options:
Progr. Attenuator, 0-90dB
(or 0-99dB with GPIB)
nx10MHz output 20-140MHz
or any 10 MHz line (20-140)

PTS 500

Range: 1-500MHz
Resolution: 0.1Hz-100KHz (opt.)
Switching: 5-20μs
Output: +3 to +13dBm: 50 ohm
Spurious Outputs: –70dB

Phase Noise: –63dBc, (0-15KHz)
Freq. St'd. Oven, TCXO, Ext.
Interface: BCD par. or GPIB
Size: 19"W, 5¼"H, 18"D
Price: $7,850.00*

Other Options:
Progr. Attenuator, 0-90dB
(or 0-99dB with GPIB)
nx10MHz output 20-140MHz
or any 10 MHz line (20-140)

PTS 300 NEW

Range: 0.1-300 MHz
Resolution: 1 Hz
Switching:
20μs (10MHz, 100MHz steps)
5μs (1 MHz steps)
1 + 2μs (transient + delay) for all steps
1 Hz-100 KHz; (phase-continuous)

Output: +3 to +13dBm: 50 ohm

	Type 1	Type 2
Spurious Outputs:	–70/65dB (typ/spec)	–60/55dB
Phase Noise:	–68dBc, (0.5Hz-15KHz)	–63dBc

Freq. St'd: Oven, TCXO, Ext.
Interface: BCD par.

Size: 19 × 3½ × 17"
(relay rack or bench cabinet)

	Type 1	Type 2
Price:	$5,800.00*	$5,300.00*

*Prices are US only, manual & remote, (BCD), 1 Hz res. with oven std.

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INFO/CARD 3

Editorial

This is the *Quick and Easy* Directory

By Gary A. Breed
Editor

The 1988 *RF Design* Directory issue is ready to serve you. In this magazine are product listings for everything in RF from amplifiers to Z-bridges. The simple arrangement of product categories and companies should make it easy to put together a list of firms to contact when you need a particular item.

The products are listed by major categories (components, subassemblies, test equipment, etc.), which are then divided into logical subgroups (small-signal FETs, spectrum analyzers, shielding materials, etc.). These breakdowns have been carefully designed to provide necessary information without forcing you to dig through the dozens of nearly-identical categories found in other product directories.

Companies are listed alphabetically in a single, uninterrupted section. This section is marked with a black band on the outside edge, making it impossible to miss. Finding the address, telephone and contact information on the companies you want is a cinch.

A special feature in this year's Directory is a complete listing of every article published in *RF Design's* ten-year history! *Keep this issue, since the complete listing may not be repeated.* Starting in 1989, our December issue will contain a bibliography of articles for the previous two years.

We continue the Design Guide section introduced last year with some concise notes on coupled-resonator bandpass filters, plus a useful method to keep correct units in propagation path loss formulae.

Finally, there is a Comment Card in the back — this is for you to tell us how you use the Directory, and to offer suggestions for making it more valuable to you and your fellow RF engineers. We hope to hear from you!

Gary A Breed

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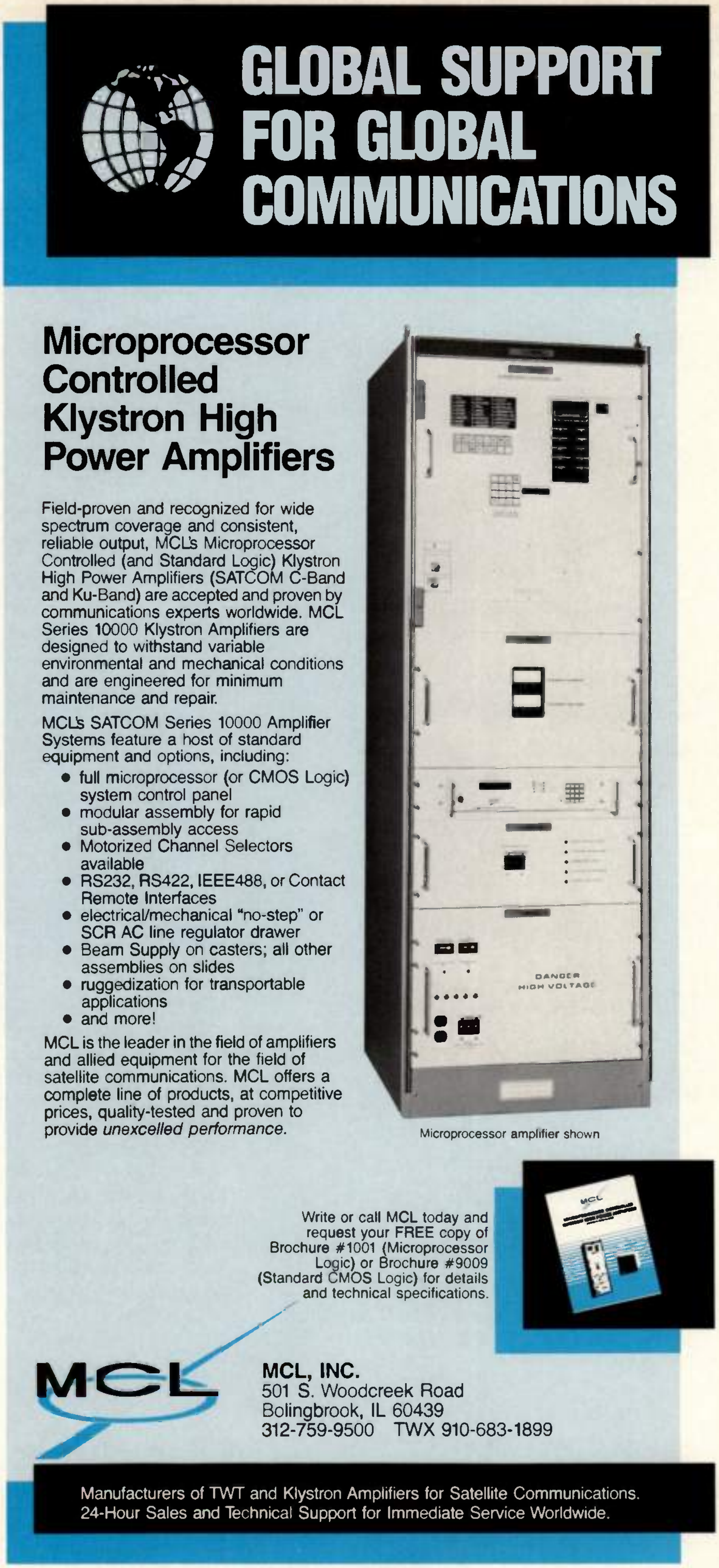

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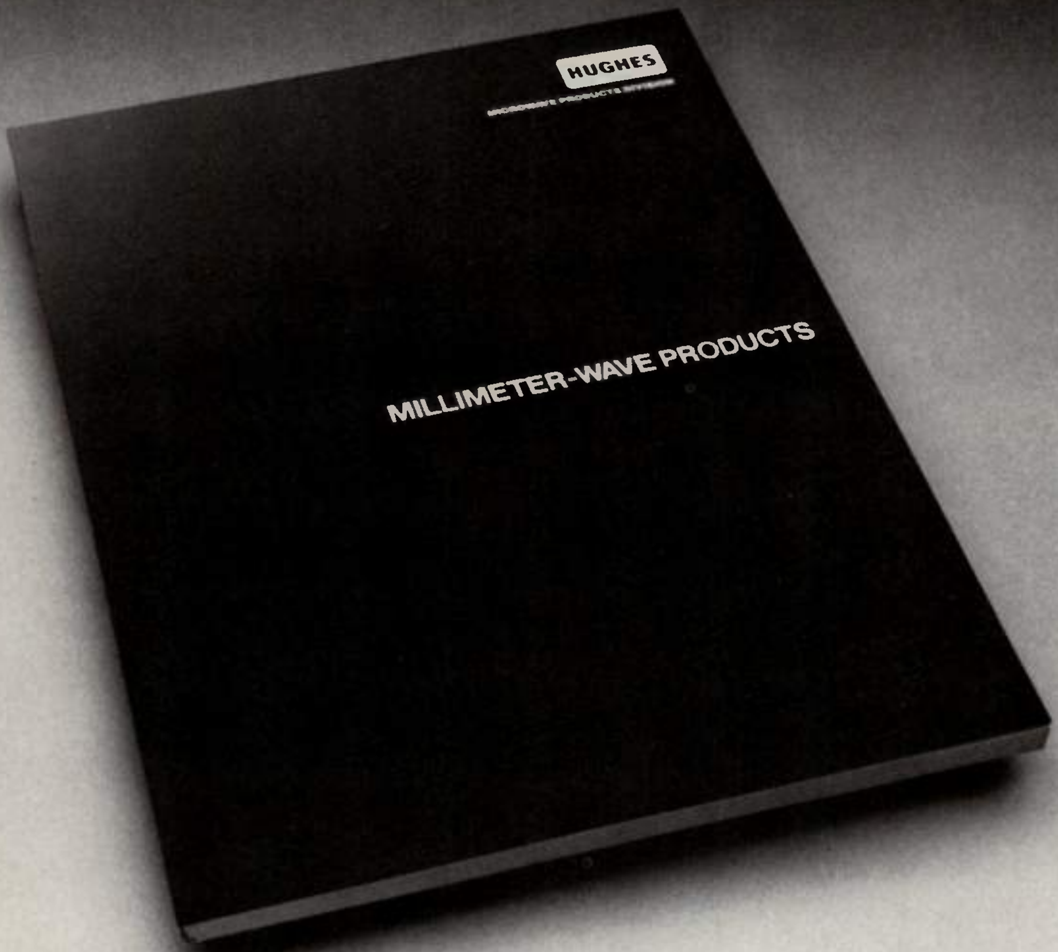
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- Compact, easy to assemble

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- Pill™ design mounts internally
- Small size, simple installation

Surface Mount
- Up to 150 watts
- DC-4GHz
- For microminiature packages
- Ideal for high frequency systems

ATTENUATORS

SMA Coax
- 0-30dB
- DC-18GHz
- 2-10 watts

Flange Mount
- 0-20dB
- DC-18GHz
- Interchangeable transition pins

Stripline
- 0-20dB
- Up to 3 watts
- Ideal for limited space

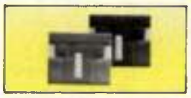
Surface Mount Chips
- 1-20dB
- DC-18GHz
- Many terminals lead choices

Hi Power
- 125 watts
- DC-2GHz
- Up to 60dB

ATTENUATORS

Switchable
- 1-15 dB
- Pre-tinned pads on Al_2O_3
- Surface mounting configurations
- Ideal for fast accurate circuit adjustment

Programmable
- 750MHz-8GHz
- Automatic compensation for signal strength
- Various configurations available



Thin Film Chip
- 5dB to 20dB in 5dB steps
- DC-12GHz
- Unprecedented accuracy
- Low cost, small size

Hi Rel Chip
- 1-20 dB
- Full test documentation
- Low cost, small size

Miniature Chip
- 1-20dB
- DC-18GHz
- Many sizes, shapes, power ratings
- Stable, predictable performance

DC BLOCKS, SHORTS AND CAPACITORS

Stripline
- Pill™ and chip configurations for small packages
- Direct mounting onto stripline circuits
- Fast, simple assembly

Coax
- SMA connector configuration for flexibility
- Replace standard connectors for cost, space savings
- Small size, light weight

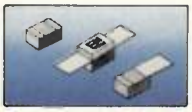
DC BLOCKS, SHORTS, CAPACITORS AND RESISTORS

Flange Mount
- 1-18GHz
- 100V peak
- Ideal for systems where coax blocks can't be used

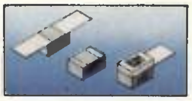
SMA
- 1-18GHz
- 100V peak
- Low VSWR

HIGH POWER RESISTORS
- 25-250 ohms
- DC-2GHz
- Up to 150 watts

ROD RESISTORS
- 10-500 ohms
- 125°C watts
- AL_2O_3 or BeO substrates



THICK OR THIN FILM RESISTORS
- 10-500 ohms
- 0.1-100 watts
- 100-300V
- Many different designs



CHIP RESISTORS
- 10-10K ohms
- 1/20-1 watt
- Chips or tabs
- Many standard sizes, custom configurations

PILL RESISTORS
- DC-12GHz
- 1/4-3 watts
- 10-250 ohms

EMC's interchangeable transition pin concept

The key to better electrical performance, lower costs and improved design flexibility

Interchangeable transition pins for MIC packages permit transitioning circuits to coax with attenuators, terminations, DC blocks or SMA connectors—even after the package has been sealed. Typical advantages of this system include:

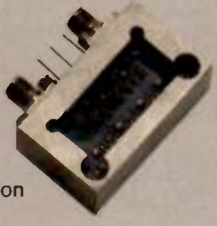
- Increase package design options
- Replace/substitute components without disturbing package
- Assure mechanical integrity for improved electrical performance
- Simplify testing procedures
- Reduce inventory costs

High frequency hybrid circuits

Tested, documented and guaranteed to meet performance specifications

Our capabilities/services include:

- Circuit, package, and tooling design
- Precision patented printing registration
- Infrared firing
- Automatic device adjustment
- Wire or ribbon bonding
- Network analysis/performance documentation
- Thin and thick film processing



EMC technology offers you unprecedented choices for your passive and active microwave components and high frequency hybrid circuits. Our full line catalog is complete and easy to use; it also contains many helpful applications tips. Ask us for a free copy today.

EMC TECHNOLOGY INC

EMC TECHNOLOGY, INC.
1971 OLD CUTHBERT ROAD
CHERRY HILL, NEW JERSEY 08034
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Authorized distributors and technical sales representatives in all major metropolitan areas.

EMC TECHNOLOGY is a full line MIC product manufacturer. Our products include SMA connectors, terminations, attenuators, resistors and DC blocks for stripline, microstrip and SMA coax, and custom hybrid circuits for hi rel applications.

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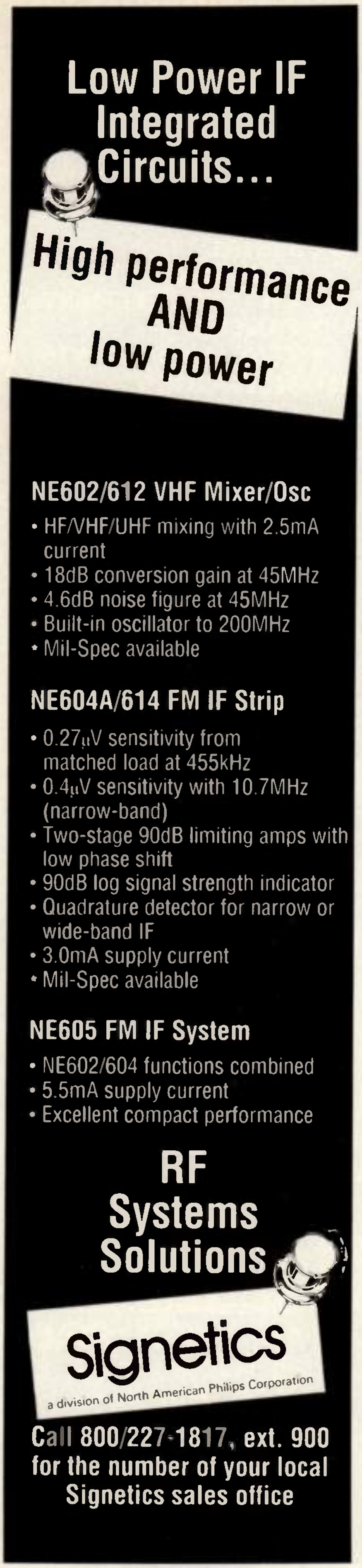

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GOULD INC., MICROWAVE DIV.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
LITTON ELECTRON DEVICES
M/A-COM ADVANCED SEMICONDUCTOR
M/A-COM COMPONENTS MARKETING,INC
MARCH MICROWAVE LTD.
MATCOM, INC.
MICROWAVE SEMICONDUCTOR CORP.
MOTOROLA SEMICONDUCTORS
NEC ELECTRONICS, INC.
OAKBURY COMPONENTS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
RAYTHEON CO., MPTD
RAYTHEON SEMICONDUCTOR
RF GAIN, LTD./RICHARDSON ELECTRONICS, LTD.
RICHARDSON ELECTRONICS, LTD.
SHOKAI FAR EAST LTD.
SIEMENS COMPONENTS INC., SPECIAL PRODUCTS DIV.

VACUUM TUBES

TRANSMITTING

ARCO ELECTRIC CORP.
EEV INC.
GILTRON INC.
LITTON SYSTEMS, INC. ELECTRON DEVICES
RAYTHEON CO., MPTD
RF GAIN, LTD./RICHARDSON ELECTRONICS, LTD.
RICHARDSON ELECTRONICS, LTD.
SHOKAI FAR EAST LTD.
SIEMENS COMPONENTS INC., SPECIAL PRODUCTS DIV.
STANTEL COMPONENTS
SURPLUS SALES OF NEBRASKA
TEMTRON ELECTRONICS LTD.
THOR ELECTRONICS CORP.
VARIAN ASSOC., EIMAC DIV.
VARIAN EIMAC
WATKINS-JOHNSON CO.

RECEIVING

EEV INC.
JOSEPH ELECTRONICS INC.
RF GAIN, LTD./RICHARDSON ELECTRONICS, LTD.
RICHARDSON ELECTRONICS, LTD.
SHOKAI FAR EAST LTD.
SIEMENS COMPONENTS INC., SPECIAL PRODUCTS DIV.
STANTEL COMPONENTS
SURPLUS SALES OF NEBRASKA
TEMTRON ELECTRONICS LTD.
THOR ELECTRONICS CORP.
WATKINS-JOHNSON CO.

MODULES AND HYBRIDS

AMPLIFIERS

HYBRID

A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL, LTD.
ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
AEL DEFENSE CORP.
AIRTRON CORP.
AMPEREX ELECTRONIC CORP.
AMPEREX/PHILLIPS DISCRETE SEMICONDUCTORS
AMPLICA INC.
AMPLIFONIX, INC.
ANALOG DEVICES
ANALOG DEVICES INC., COMPUTER LABS DIVISION
AVANTEK, INC.
AYDIN VECTOR DIV.
AYDIN WEST - MICROWAVE DIV.
CALIFORNIA AMPLIFIER, INC.
CALIFORNIA EASTERN LABORATORIES
CASTLE MICROWAVE
CELERITEK, INC.
COMLINEAR CORP.
COUGAR COMPONENTS
DATEL, INC.
ELECTRONIC RESOURCES INC.
GENNUM CORPORATION
HEWLETT PACKARD, MICROWAVE SEMICONDUCTOR DIV.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
HYBRIDS INTERNATIONAL, LTD.
INTERNATIONAL SENSOR SYSTEMS, INC.
INTERSIL INC.
JCA TECHNOLOGY INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
M-TRON INDUSTRIES INC.
M.S. KENNEDY CORP.
M/A-COM , ACTIVE ASSEMBLIES DIV.

M/A-COM Semiconductor Products

Silicon Products

SCHOTTKY BARRIER DIODES
(Packaged, Chips, Beam Leads)
Detectors
Mixers
Bridge Quads
Ring Quads
Dual Barrier Quads
Anti-Parallel
Tees
Single Beam Leads

PIN DIODES
Packaged
Axial Lead Package
Chips
Hermetic Chips
Beam Lead
Surface Mount (MELF, SOT)
TR Switches
MNS Capacitors
Limiter Diodes

MULTIPLIER VARACTORS
C Swing
Snap
Bimode/Dualmode
Pulse

TUNING VARACTORS
Abrupt
Hyperabrupt

POINT CONTACT DIODES
Detectors
Mixers

BIPOLAR TRANSISTORS
Low Noise Microwave Transistors
Oscillator Transistors

MMIC

EPITAXIAL WAFERS

BULK WINDOWS
Switches (X Band — 94 GHz)

GaAs Products

SCHOTTKY BARRIER DIODES
(Packaged, Chips, Beam Leads)
Mixers
Anti-Parallel Beam Leads
Single Beam Leads
MM Mixer Diodes
Ring Quads
Bridge Quads
Tees

GaAs PIN DIODES
Packaged
Chips
Beam Lead

MULTIPLIER VARACTORS
MM Multipliers
ISIS Multipliers
Parametric Amplifier Varactors

TUNING VARACTORS
Abrupt
Hyperabrupt
Constant Gamma
Beam Lead Constant Gamma

GUNN DIODES
CW Gunn Diodes
Pulse Gunn Diodes

IMPATT DIODES
CW IMPATT Diodes
Pulse IMPATT Diodes
Single Drift/Double Drift

MMIC

For more information, call or write:

M/A-COM Semiconductor Products
South Avenue
Burlington, MA 01803
(617) 272-3000, X-3808
TWX 710-332-6789
Telex 94-9464

Modules & Hybrids

M/A-COM MPD, INC.
M/A-COM PHI
MARCH MICROWAVE LTD.
MERET INC.
MICRO HYBRIDS INC.
MICROPHASE CORP.
MICROWAVE MODULES & DEVICES
MICROWAVE SEMICONDUCTOR CORP.
MICROWAVE SOLUTIONS INC.
MITEQ, INC.
MOTOROLA SEMICONDUCTORS
NATEL ENGINEERING CO., INC.
NEC ELECTRONICS, INC.
OAKBURY COMPONENTS
OLEKTRON SYSTEMS, INC.
OMEGA MICROWAVE, INC.
OPAMP LABS INC.
OPTICAL ELECTRONICS INC.
OPTIMAX, INC
PACIFIC MONOLITHICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PHOENIX MICROWAVE CORP.
PICO PRODUCTS, INC.
PLESSEY SEMICONDUCTORS
Q-BIT CORPORATION
RADAR TECH. INC.
RAMAR COMMUNICATIONS, INC.
RDL, INC.
REL LABS, INC.
REMEC
RHG ELECTRONICS LABORATORY
RICHARDSON ELECTRONICS, LTD.
SANDERS, MICROWAVE DIV. ECB
SCIENTIFIC COMMUNICATIONS
SIEMENS COMPONENTS INC.,
  SPECIAL PRODUCTS DIV.
SILICON DETECTOR CORP.
SOLITRON DEVICES, INC.
TACHONICS CORP.
TE SYSTEMS
TEKTRON MICRO ELECTRONICS INC.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TEMTRON ELECTRONICS LTD.
TRW MICROWAVE
TRW RF DEVICES
WATKINS-JOHNSON COMPANY

LOG

ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
AEL DEFENSE CORP.
AIRTRON CORP.
ALPHA INDUSTRIES, INC.
ANALOG DEVICES
ANALOG DEVICES INC., COMPUTER LABS DIVISION
APCOM, INC.
AVANTEK, INC.
CASTLE MICROWAVE
INTERNATIONAL MICROWAVE CORP.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LOG TECH, INC.
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MERRIMAC INDUSTRIES, INC.
MICROPHASE CORP.
MITEQ, INC.
OAKBURY COMPONENTS
OMEGA MICROWAVE, INC.
OPTICAL ELECTRONICS INC.
PACIFIC MONOLITHICS
PASCALL ELECTRONICS LTD.
PLANAR MICROWAVE, A RAYTHEON CO.
PLESSEY SEMICONDUCTORS
RADAR TECH. INC.
REMEC
RHG ELECTRONICS LABORATORY
SOLITRON DEVICES, INC.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TRW MICROWAVE
VARIAN RF SUBSYSTEMS DIV.
WESTERN MICROWAVE INC.

LIMITING

ADAMS-RUSSELL ELECTRONICS
AEL DEFENSE CORP.
ALPHA INDUSTRIES, INC.

Modules & Hybrids

AMPLIFONIX, INC.
AVANTEK, INC.
AYDIN WEST - MICROWAVE DIV.
CALIFORNIA AMPLIFIER, INC.
CASTLE MICROWAVE
CELERITEK, INC.
COUGAR COMPONENTS
ELECTRONIC RESOURCES INC.
INTERNATIONAL MICROWAVE CORP.
LECTRONIC RESEARCH LABS
LOG TECH, INC.
M/A-COM , ACTIVE ASSEMBLIES DIV.
MARLOW ELECTRONICS LTD.
MICROWAVE SOLUTIONS INC.
MITEQ, INC.
OLEKTRON CORP.
OMEGA MICROWAVE, INC.
OPAMP LABS INC.
OPTIMAX, INC
PACIFIC MONOLITHICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PHOENIX MICROWAVE CORP.
PLESSEY SEMICONDUCTORS
RADAR TECH. INC.
REMEC
RHG ELECTRONICS LABORATORY
TEKTRON MICRO ELECTRONICS INC.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TRW MICROWAVE
VARIAN RF SUBSYSTEMS DIV.
WATKINS-JOHNSON COMPANY
WESTERN MICROWAVE INC.
ZETA LABS

WIDEBAND OP AMP

A.R.F. PRODUCTS, INC.
ALPHA INDUSTRIES, INC.
AMPEREX ELECTRONIC CORP.
AMPEREX/PHILLIPS DISCRETE SEMICONDUCTORS
ANALOG DEVICES
ANALOG DEVICES INC., COMPUTER LABS DIVISION
APEX MICROWAVE
BURR-BROWN, INC.
CASTLE MICROWAVE
DATEL, INC.
FAIRCHILD SEMICONDUCTOR CORP.
HUGHES AIRCRAFT CO.
  MICROELECTRONIC CIRCUITS DIV.
INSTRUMENTS FOR INDUSTRY, INC.
INTERNATIONAL MICROWAVE CORP.
INTERSIL INC.
JENSEN TRANSFORMERS, INC.
LECTRONIC RESEARCH LABS
LORCH ELECTRONICS DIV. OF VERNITRON CORP.
M.S. KENNEDY CORP.
MARCH MICROWAVE LTD.
MATRIX SYSTEMS CORP.
NEC ELECTRONICS, INC.
OLEKTRON SYSTEMS, INC.
OPAMP LABS INC.
OPTICAL ELECTRONICS INC.
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PENTEK, INC.
PLANAR MICROWAVE, A RAYTHEON CO.
PLESSEY SEMICONDUCTORS
REL LABS, INC.
RICHARDSON ELECTRONICS, LTD.
SIEMENS COMPONENTS INC.,
  SPECIAL PRODUCTS DIV.
TEKTRON MICRO ELECTRONICS INC.
TELEDYNE MICROELECTRONICS
TRIQUINT SEMICONDUCTOR INC.
UHF ASSOCIATES
VIEWSONICS

VIDEO

ALLEN AVIONICS, INC.
ALPHA INDUSTRIES, INC.
ANALOG DEVICES
ANALOG DEVICES INC., COMPUTER LABS DIVISION
APCOM, INC.
BURR-BROWN, INC.
CASTLE MICROWAVE
COMLINEAR CORP.
EON INSTRUMENTATION, INC.
FAIRCHILD SEMICONDUCTOR CORP.
GENNUM CORPORATION
HDS, INC.
M.S. KENNEDY CORP.
MATRIX SYSTEMS CORP.
MERET INC.
MICROPHASE CORP.
MITEQ, INC.
OLEKTRON SYSTEMS, INC.
OPAMP LABS INC.
OPTICAL ELECTRONICS INC.
PENSTOCK INC.
PICO PRODUCTS, INC.
PLANAR MICROWAVE, A RAYTHEON CO.
PLESSEY SEMICONDUCTORS
REL LABS, INC.
RHG ELECTRONICS LABORATORY
RICHARDSON ELECTRONICS, LTD.
TEKTRON MICRO ELECTRONICS INC.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TRW RF DEVICES
UHF ASSOCIATES
VIEWSONICS
WESTERN MICROWAVE INC.

DETECTORS

ADVANCED CONTROL COMPONENTS
ALAN INDUSTRIES, INC.
APCOM, INC.
AVANTEK, INC.
CASTLE MICROWAVE
ELCOM SYSTEMS, INC.
ELECTROWAVE PRODUCTS, INC.
FREQUENCY SOURCES, INC.
GENNUM CORPORATION
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INNOWAVE (AND VIRTECH)
IRT CORP.
JCA TECHNOLOGY INC.
JFW INDUSTRIES, INC.
KW MICROWAVE INC.
L & M ENGINEERING SOUTH
M/A-COM OMNI SPECTRA, INC.
MARLOW ELECTRONICS LTD.
MERET INC.
MERRIMAC INDUSTRIES, INC.
MICRONETICS INC.
MICROPHASE CORP.
MIDISCO
MINI CIRCUITS
NARDA MICROWAVE CORP.
NORTH HILLS ELECTRONICS, INC.
OLEKTRON CORP.
OPTICAL COATING LABORATORY, INC.
PENSTOCK INC.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RADIALL, INC.
REMEC
RHG ELECTRONICS LABORATORY
RLC ELECTRONICS, INC.
ROBINSON LABS
SAGE LABORATORIES, INC.
SHOKAI FAR EAST LTD.
SURPLUS SALES OF NEBRASKA
TELEDYNE MICROELECTRONICS
TELONIC BERKELEY, INC.
TEST EQUIPMENT CORP.
TOKO AMERICA, INC.
TONY CHAPMAN ELECTRONICS LTD.
TRIANGLE MICROWAVE INC.
TRW MICROWAVE
UHF ASSOCIATES
VIRTECH
WATKINS-JOHNSON COMPANY

FILTERS

CRYSTALS

A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL, LTD.
ALAUN ENG.
ALPHA COMPONENTS, INC.
B-D CRYSTAL

INFO/CARD 21

CAL CRYSTAL LAB, INC./COMCLOK, INC.
CALREP
CASTLE MICROWAVE
COMSTRON CORP.
CTS CORP.
DAJEM TECHNOLOGY CO.
DAMON CORP./ELECTRONICS DIV.
FOX ELECTRONICS
FREQUENCY ELECTRONICS
HI-Q CRYSTALS DIV.
HUGHES AIRCRAFT CO.
  MICROELECTRONIC CIRCUITS DIV.
HYBRIDS INTERNATIONAL, LTD.
JACK HUSNEY & ASSOCIATES
K & L MICROWAVE, INC.
KVG
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
MCCOY ELECTRONICS CO.
MICROSONICS INC.
MOTOROLA, COMPONENTS PRODUCTS DIV.
MURATA ERIE
OAKBURY COMPONENTS
PIEZO TECHNOLOGY, INC.
REEVES - HOFFMAN
SHOKAI FAR EAST LTD.
SIEMENS COMPONENTS INC.,
  SPECIAL PRODUCTS DIV.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.
STANTEL COMPONENTS
TAUBER-DREYER CORP.
TELEDYNE MICROELECTRONICS
TEMEX ELECTRONICS INC.
TEST EQUIPMENT CORP.
TIME AND FREQUENCY LTD.
UNITED TRANSFORMER CORP.,
  SUB. OF OPT INDUSTRIES
VERNITRON CORP., PIEZO ELECTRIC DIV.

SAW

A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL, LTD.
ALAUN ENG.
ANDERSEN LABORATORIES
COM DEV
CRYSTAL TECHNOLOGY INC.
DAJEM TECHNOLOGY CO.
FREQUENCY ELECTRONICS
HI-Q CRYSTALS DIV.
HUGHES AIRCRAFT CO.
  MICROELECTRONIC CIRCUITS DIV.
KYOCERA NORTHWEST
LECTRONIC RESEARCH LABS
MARCH MICROWAVE LTD.
MURATA ERIE
OAKBURY COMPONENTS
OSCILLATEK, A DIV. OF K&L MICROWAVE
PASCALL ELECTRONICS LTD.
PHONON CORP.
PICO PRODUCTS, INC.
RF MONOLITHICS INC.
SAWTEK INC.
SHOKAI FAR EAST LTD.
SIEMENS COMPONENTS INC.,
  SPECIAL PRODUCTS DIV.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.

STANTEL COMPONENTS
TEKTRONIX, INC.
TELEDYNE MICROELECTRONICS
TEST EQUIPMENT CORP.

LC

ALDA ELECTRONICS, INC.
ALLEN AVIONICS, INC.
ALPHA COMPONENTS, INC.
ANDERSEN LABORATORIES
APOLLO MICROWAVES LTD.
BIRD ELECTRONIC CORP.
CAPTOR CORP.
CERAMIC DEVICES, INC.
CHESTERFIELD PRODUCTS INC.
COMSTRON CORP.
CQT ELECTRONICS
DADEN ASSOCIATES, INC.
DAMON CORP./ELECTRONICS DIV.
DIELECTRIC COMMUNICATIONS
EAGLE
EMINETICS
ESC ELECTRONICS CORP.
HI-Q CRYSTALS DIV.
HUGHES AIRCRAFT CO. MICROELECTRONIC CIRCUITS DIV.
HYBRIDS INTERNATIONAL, LTD.
INTEGRATED MICROWAVE CORPORATION
JACK HUSNEY & ASSOCIATES
K & L MICROWAVE, INC.
KVG
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
MCCOY ELECTRONICS CO.
MICROPHASE CORP.
MICROSONICS INC.
MICROWAVE FILTER CO., INC.
MICROWAVE SOLUTIONS INC.
NORTH HILLS ELECTRONICS, INC.
OAKBURY COMPONENTS
PENTEK, INC.
PICO PRODUCTS, INC.
PICONICS, INC.
PIEZO TECHNOLOGY, INC.
REACTEL, INC.
REEVES - HOFFMAN
RLC ELECTRONICS, INC.
SHOKAI FAR EAST LTD.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.
STANTEL COMPONENTS
TALBOT TECHNOLOGY (T-TECH) CORP.
TAUBER-DREYER CORP.
TDK CORP. OF AMERICA
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TELONIC BERKELEY, INC.
TEMEX ELECTRONICS INC.
TEST EQUIPMENT CORP.
TIL-TEK LTD.
TIME AND FREQUENCY LTD.
TIME MICROWAVE
TOKO AMERICA, INC.
TRI-MAG INC.
TTE, INC.
UHF ASSOCIATES
UNITED TRANSFORMER CORP., SUB. OF OPT INDUSTRIES
VANGUARD ELECTRONICS CO.
VIEWSONICS
WAVETEK RF PRODUCTS, INC.

ACTIVE

ALAUN ENG.
CONTROL CONCEPTS CORP.
DAJEM TECHNOLOGY CO.
DATEL, INC.
FREQUENCY SOURCES, INC.
LECTRONIC RESEARCH LABS
MICRO HYBRIDS INC.
MURATA ERIE
OPAMP LABS INC.
PECA INC.
PENTEK, INC.
PICO PRODUCTS, INC.
REL LABS, INC.
SELECTONE CORP.
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
TALBOT TECHNOLOGY (T-TECH) CORP.
TDK CORP. OF AMERICA
TELEDYNE MICROELECTRONICS
TEST EQUIPMENT CORP.
TIL-TEK LTD.
TOKO AMERICA, INC.
TONY CHAPMAN ELECTRONICS LTD.
TTE, INC.
VIEWSONICS
XETRON CORP.

FREQUENCY MULTIPLIERS

A & A ENGINEERING
A.R.F. PRODUCTS, INC.
ADVANCED COMMUNICATIONS SYSTEMS, INC.
ANGHEL LABORATORIES, INC.
APCOM, INC.
AUSTRON INC.
AVANTEK, INC.
BRIMROSE CORP.
CALIFORNIA EASTERN LABORATORIES
CASTLE MICROWAVE
COMMUNICATION TECHNIQUES, INC.
COMSTRON CORP.
DAJEM TECHNOLOGY CO.
DIGITAL RF SOLUTIONS
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
FG ENGINEERING CO.
FREQUENCY ELECTRONICS
FREQUENCY SOURCES, INC.
GENERAL SERVICES ENGINEERING, INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INTERNATIONAL MICROCIRCUITS, INC.
JOHN FLUKE MFG. CO. INC.
JOSLYN DEFENSE SYSTEMS, INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LNR COMMUNICATIONS, INC.
M/A-COM , ACTIVE ASSEMBLIES DIV.
M/A-COM COMPONENTS MARKETING,INC
MICROWAVE RESEARCH AND MANUFACTURING (MRM)
MICROWAVE SYSTEMS INC.
MIRAGE SYSTEMS
MITEQ, INC.
MM - WAVE TECHNOLOGY INC.
MU-DEL ELECTRONICS, INC.
NARDA
PACIFIC RESEARCH AND DEVELOPMENT
PENTEK, INC.
PHILIPS TEST & MEASURING INSTRUMENTS
PIEZO CRYSTAL CO., INC.
PLESSEY SEMICONDUCTORS
PROGRAMMED TEST SOURCES, INC.
RACAL-DANA INSTRUMENTS, INC.
RDL, INC.
REMTRON, INC.
RF MONOLITHICS INC.
RF PROTOTYPE SYSTEMS
SCITEQ ELECTRONICS, INC.
SIGMOTEK INTL CORP.
SIGNAL ONE
SPECTRACOM CORP.
SPREAD SPECTRUM SCIENCES
STANFORD TELECOMMUNICATIONS, INC.
STEINBRECHER CORP.
SYNTEST CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
SYSTRON DONNER INSTRUMENT DIV.
TALBOT TECHNOLOGY (T-TECH) CORP.
TECHTROL CYCLONETICS, INC.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TELEMUS ELECTRONIC SYSTEMS INC.
TEST EQUIPMENT CORP.

TRAK MICROWAVE CORP.
VARIAN RF SUBSYSTEMS DIV.
WATKINS-JOHNSON CO.
WAVETEK SAN DIEGO, INC.
WILTRON CO.
ZETA LABS

LIMITERS

ADVANCED CONTROL COMPONENTS
ALPHA INDUSTRIES, INC.
AMPLIFONIX, INC.
AVANTEK, INC.
CASTLE MICROWAVE
DAJEM TECHNOLOGY CO.
ELECTROWAVE PRODUCTS, INC.
FREQUENCY SOURCES, INC.
GENERAL MICROWAVE CORP.
HEWLETT PACKARD, MICROWAVE SEMICONDUCTOR DIV.
INNOWAVE (AND VIRTECH)
INTERNATIONAL MICROWAVE CORP.
JCA TECHNOLOGY INC.
KDI ELECTRONICS
KW MICROWAVE INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
MARLOW ELECTRONICS LTD.
MERRIMAC INDUSTRIES, INC.
MICROPHASE CORP.
MIDISCO
MINI CIRCUITS
NORTH HILLS ELECTRONICS, INC.
OAKBURY COMPONENTS
OPTIMAX, INC
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PENTEK, INC.
PHOENIX MICROWAVE CORP.
REMEC
RHG ELECTRONICS LABORATORY
ROBINSON LABS
SDI MICROWAVE INC.
SHOKAI FAR EAST LTD.
TEKTRON MICRO ELECTRONICS INC.
TELEDYNE MICROELECTRONICS
TONY CHAPMAN ELECTRONICS LTD.
TRW MICROWAVE
VIRTECH
WATKINS-JOHNSON COMPANY
WESTERN MICROWAVE INC.
WI-COMM ELECTRONICS INC.

MIXERS

DIODE DOUBLE BALANCED

ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
ALPHA INDUSTRIES, INC.
ANAREN MICROWAVE INC.
AVANTEK, INC.
BURR-BROWN, INC.
CASTLE MICROWAVE

DAJEM TECHNOLOGY CO.
EATON CORP. MICROWAVE PRODUCTS DIV.
EATON CORP., COMPONENT & SEMICONDUCTOR
ELCOM SYSTEMS, INC.
ELECTROWAVE PRODUCTS, INC.
HEWLETT PACKARD,
 MICROWAVE SEMICONDUCTOR DIV.
HEWLETT-PACKARD CO.
JCA TECHNOLOGY INC.
KDI ELECTRONICS
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
MAGNUM MICROWAVE CORP.
MARCH MICROWAVE LTD.
MATCOM, INC.
MERRIMAC INDUSTRIES, INC.
MICROWAVE SYSTEMS INC.
MIDISCO
MINI CIRCUITS
MITEQ, INC.
NORSAL INDUSTRIES INC.
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PREMIER MICROWAVE CORP.
PULSAR MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RHG ELECTRONICS LABORATORY
ROBINSON LABS
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
SYNERGY MICROWAVE CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TACHONICS CORP.
TDK CORP. OF AMERICA
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TIME MICROWAVE
TRW MICROWAVE
WATKINS-JOHNSON COMPANY
WEINSCHEL ENGINEERING
WENZEL ASSOCIATES, INC.
WESTERN MICROWAVE INC.

IMAGE REJECT

ADAMS-RUSSELL ELECTRONICS
ANAREN MICROWAVE INC.
DAJEM TECHNOLOGY CO.
ELECTROWAVE PRODUCTS, INC.
KDI ELECTRONICS
LOCUS INC.
M/A-COM COMPONENTS MARKETING,INC
MAGNUM MICROWAVE CORP.
MERRIMAC INDUSTRIES, INC.
MICROWAVE SYSTEMS INC.
MITEQ, INC.
NORSAL INDUSTRIES INC.
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PREMIER MICROWAVE CORP.
PULSAR MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RHG ELECTRONICS LABORATORY
ROBINSON LABS
SHOKAI FAR EAST LTD.
SYNERGY MICROWAVE CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TACHONICS CORP.
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TIME MICROWAVE
TRM INC.
WATKINS-JOHNSON COMPANY
WESTERN MICROWAVE INC.

MODULATORS

AM

ADAMS-RUSSELL ELECTRONICS
AMERICAN MICROWAVE CORP.
APCOM, INC.
CRYSTAL TECHNOLOGY INC.
EDCO ENGINEERING CORP.
ELECTROWAVE PRODUCTS, INC.
GENERAL MICROWAVE CORP.
JCA TECHNOLOGY INC.
KDI ELECTRONICS
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
MERRIMAC INDUSTRIES, INC.
MICROWAVE SYSTEMS INC.
MINI CIRCUITS
OLEKTRON CORP.
PULSAR MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
SPRAGUE ELECTRIC CO.
SYSTRON DONNER CORP., MICROWAVE DIV.
TALBOT TECHNOLOGY (T-TECH) CORP.
TELEDYNE MICROELECTRONICS
TEST EQUIPMENT CORP.
UHF ASSOCIATES

FM/PM

ADAMS-RUSSELL ELECTRONICS
APCOM, INC.
CRYSTAL TECHNOLOGY INC.
EDCO ENGINEERING CORP.
ELECTROWAVE PRODUCTS, INC.
EON INSTRUMENTATION, INC.
LECTRONIC RESEARCH LABS
MERRIMAC INDUSTRIES, INC.
MICROWAVE SYSTEMS INC.
MINI CIRCUITS
MITEQ, INC.
OLEKTRON CORP.
PACIFIC RESEARCH AND DEVELOPMENT
PULSAR MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RF PLASMA PRODUCTS
RHG ELECTRONICS LABORATORY
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
SPRAGUE ELECTRIC CO.
TEKTRON MICRO ELECTRONICS INC.
TELEDYNE MICROELECTRONICS
TEST EQUIPMENT CORP.
UHF ASSOCIATES
WILMANCO

FSK

ADAMS-RUSSELL ELECTRONICS
APCOM, INC.
ELECTROWAVE PRODUCTS, INC.
LECTRONIC RESEARCH LABS
LNR COMMUNICATIONS, INC.
MERRIMAC INDUSTRIES, INC.
MICROWAVE SYSTEMS INC.
OLEKTRON CORP.
PULSAR MICROWAVE CORP.
RHG ELECTRONICS LABORATORY
SHOKAI FAR EAST LTD.
TEKTRON MICRO ELECTRONICS INC.
TELEDYNE MICROELECTRONICS

QPSK

ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
ANAREN MICROWAVE INC.
ELECTROWAVE PRODUCTS, INC.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
LNR COMMUNICATIONS, INC.
MAGNUM MICROWAVE CORP.
MERRIMAC INDUSTRIES, INC.
MICROWAVE SYSTEMS INC.
MITEQ, INC.
NEC ELECTRONICS, INC.
OLEKTRON CORP.
PULSAR MICROWAVE CORP.
RHG ELECTRONICS LABORATORY
SHOKAI FAR EAST LTD.
SYNERGY MICROWAVE CORP.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS

PULSE

ACRIAN, INC.
ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
AMERICAN MICROWAVE CORP.
ANDERSEN LABORATORIES
CATEL
EPSCO, INC.
GENERAL MICROWAVE CORP.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
MERRIMAC INDUSTRIES, INC.
OLEKTRON CORP.
RHG ELECTRONICS LABORATORY
SHOKAI FAR EAST LTD.
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TEST EQUIPMENT CORP.
VITRO SERVICES CORP.
WILMANCO

NOISE SOURCES

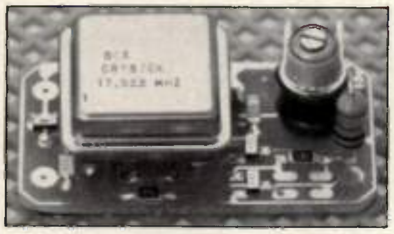
EATON CORP., COMPONENT & SEMICONDUCTOR
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO RENT CORPORATION
HEWLETT-PACKARD CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INTERNATIONAL MICROWAVE CORP.
JCA TECHNOLOGY INC.
LECTRONIC RESEARCH LABS
MDF PRODUCTS INC.
MICRONETICS INC.
MICROWAVE DIODE CORP.
MICROWAVE SEMICONDUCTOR CORP.
NOISE COM INC.
OPTICAL ELECTRONICS INC.
PACIFIC RESEARCH AND DEVELOPMENT
PASCALL ELECTRONICS LTD.
SIEMENS COMPONENTS INC.,
 SPECIAL PRODUCTS DIV.
TEKTRON MICRO ELECTRONICS INC.
TEST EQUIPMENT CORP.
TONY CHAPMAN ELECTRONICS LTD.

OSCILLATORS

CRYSTAL

A.R.F. PRODUCTS, INC.
AD-TECH MICROWAVE INC.
AUSTRON INC.
B AND J MARKETING
B-D CRYSTAL

BERKELEY NUCLEONICS CORP.
BLILEY ELECTRIC CO.
BRIGHTLINE CORP.
CAL CRYSTAL LAB, INC./COMCLOK, INC.
CALREP
CINOX CORP.
COMMUNICATION TECHNIQUES, INC.
COMSTRON CORP.
CONNOR-WINFIELD
CRYSTEK CRYSTAL CORP.
CTS CORP.
CTS CORP./KNIGHTS DIV.
DALE ELECTRONICS, INC.
DAMON CORP./ELECTRONICS DIV.
EG & G CINOX
ELECTRONIC RESEARCH CO.
EMF SYSTEMS INC.
ERBTEC ENGINEERING INC.
ETA INDUSTRIES, INC.
FOX ELECTRONICS
FREQUENCY AND TIME SYSTEMS, INC.



Modules & Hybrids

FREQUENCY CONTROL PRODUCTS, INC.
FREQUENCY ELECTRONICS
FREQUENCY SOURCES, INC.
GREENRAY INDUSTRIES
HUGHES AIRCRAFT CO.
MICROELECTRONIC CIRCUITS DIV.
HYBRIDS INTERNATIONAL, LTD.
JACK HUSNEY & ASSOCIATES
K & L MICROWAVE, INC.
KVG
KYOCERA NORTHWEST
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
M-TRON INDUSTRIES INC.
MATEC CORP./VALPEY - FISHER CORP.
MCCOY ELECTRONICS CO.
MICROSONICS INC.
MITEQ, INC.
MOTOROLA, COMPONENTS PRODUCTS DIV.
MURATA ERIE
NEL FREQUENCY CONTROLS, INC.
OAKBURY COMPONENTS
OSCILLATEK, A DIV. OF K&L MICROWAVE
OVENAIRE
PACIFIC WEST ELECTRONICS
PIEZO CRYSTAL CO., INC.
PIEZO TECHNOLOGY, INC.
Q-TECH CORP.
RDL, INC.
REEVES - HOFFMAN
REMEC
SARONIX
SAVOY ELECTRONICS, INC.
SHOKAI FAR EAST LTD.
SIGMOTEK INTL CORP.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.
SPECTRUM CONTROL, INC.
SPECTRUM TECHNOLOGY INC.
STANDARD CRYSTAL CORPORATION
STANTEL COMPONENTS
STATEK CORP.
TAUBER-DREYER CORP.
TECHTROL CYCLONETICS, INC.
TELEDYNE MICROELECTRONICS
TEST EQUIPMENT CORP.
TIME AND FREQUENCY LTD.
TRAK MICROWAVE CORP.
UNITED STATES CRYSTAL
VALPEY FISHER CORP.
VECTRON LABORATORIES INC.
VIEWSONICS
WENZEL ASSOCIATES, INC.
WILMANCO
ZETA LABS

CLOCK

ANDERSEN LABORATORIES
B-D CRYSTAL
BALL, EFRATOM DIVISION
BERKELEY NUCLEONICS CORP.
BLILEY ELECTRIC CO.
CAL CRYSTAL LAB, INC./COMCLOK, INC.
CALREP
CONNOR-WINFIELD
CRYSTEK CRYSTAL CORP.
CTS CORP.
CTS CORP./KNIGHTS DIV.
DALE ELECTRONICS, INC.
FOX ELECTRONICS
FREQUENCY CONTROL PRODUCTS, INC.
FREQUENCY ELECTRONICS
GREENRAY INDUSTRIES
KYOCERA NORTHWEST
LECTRONIC RESEARCH LABS
M-TRON INDUSTRIES INC.
MATEC CORP./VALPEY - FISHER CORP.
MCCOY ELECTRONICS CO.
MOTOROLA, COMPONENTS PRODUCTS DIV.
MURATA ERIE
NEL FREQUENCY CONTROLS, INC.
OSCILLATEK, A DIV. OF K&L MICROWAVE
PIEZO TECHNOLOGY, INC.
Q-TECH CORP.
REEVES - HOFFMAN
REL LABS, INC.
SARONIX

SAVOY ELECTRONICS, INC.
SEIKO INSTRUMENTS INC.
SHOKAI FAR EAST LTD.
SIGMOTEK INTL CORP.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.
SPECTRUM TECHNOLOGY INC.
STANDARD CRYSTAL CORPORATION
STANTEL COMPONENTS
STATEK CORP.
TAUBER-DREYER CORP.
TELEDYNE MICROELECTRONICS
TEMEX ELECTRONICS INC.
TIME AND FREQUENCY LTD.
VALPEY FISHER CORP.
VECTRON LABORATORIES INC.

HIGH STABILITY

AD-TECH MICROWAVE INC.
ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ALPHA INDUSTRIES, INC.
ANGHEL LABORATORIES, INC.
AUSTRON INC.
AVANTEK, INC.
B AND J MARKETING
B-D CRYSTAL
BALL, EFRATOM DIVISION
BLILEY ELECTRIC CO.
BRIGHTLINE CORP.

CALREP
CINOX CORP.
COMMUNICATION TECHNIQUES, INC.
CONNOR-WINFIELD
CRYSTEK CRYSTAL CORP.
CTS CORP./KNIGHTS DIV.
DALE ELECTRONICS, INC.
DAMON CORP./ELECTRONICS DIV.
EG & G CINOX
ELECTRO RENT CORPORATION
EMCO HIGH VOLTAGE
EMF SYSTEMS INC.
ERBTEC ENGINEERING INC.
FOX ELECTRONICS
FREQUENCY AND TIME SYSTEMS, INC.
FREQUENCY CONTROL PRODUCTS, INC.
FREQUENCY ELECTRONICS
FREQUENCY SOURCES, INC.
GREENRAY INDUSTRIES
HUGHES AIRCRAFT CO.
  MICROELECTRONIC CIRCUITS DIV.
INTERNATIONAL MICROWAVE CORP.
JACK HUSNEY & ASSOCIATES
KDI ELECTRONICS
KVG
KYOCERA NORTHWEST
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
M-TRON INDUSTRIES INC.
M/A-COM , ACTIVE ASSEMBLIES DIV.
MAGNUM MICROWAVE CORP.
MATEC CORP./VALPEY - FISHER CORP.
MCCOY ELECTRONICS CO.
MICROSONICS INC.
MICROWAVE RESEARCH AND MANUFACTURING (MRM)
MITEQ, INC.
MOTOROLA, COMPONENTS PRODUCTS DIV.
NARDA
NEL FREQUENCY CONTROLS, INC.
OSCILLATEK, A DIV. OF K&L MICROWAVE
OVENAIRE
PENSTOCK INC.
PIEZO CRYSTAL CO., INC.
PIEZO TECHNOLOGY, INC.
PROGRAMMED TEST SOURCES, INC.
RDL, INC.
REEVES - HOFFMAN
RFD, INC.
SARONIX
SAVOY ELECTRONICS, INC.
SCITEQ ELECTRONICS, INC.
SHOKAI FAR EAST LTD.
SIGMOTEK INTL CORP.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.
SPECTRUM TECHNOLOGY INC.
STANTEL COMPONENTS
STATEK CORP.
TAUBER-DREYER CORP.
TECHTROL CYCLONETICS, INC.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TEST EQUIPMENT CORP.
TIME AND FREQUENCY LTD.
VALPEY FISHER CORP.
VARIAN RF SUBSYSTEMS DIV.
VECTRON LABORATORIES INC.
WENZEL ASSOCIATES, INC.
WILMANCO
ZETA LABS

VCO

ALPHA INDUSTRIES, INC.
ANDERSEN LABORATORIES
ANGHEL LABORATORIES, INC.
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
AVANTEK, INC.
AYDIN VECTOR DIV.
BRIGHTLINE CORP.
CALIFORNIA AMPLIFIER, INC.
CALREP
CASTLE MICROWAVE
COMMUNICATION TECHNIQUES, INC.
COMSTRON CORP.
CONNOR-WINFIELD
CRYSTAL TECHNOLOGY INC.
CRYSTEK CRYSTAL CORP.
CTS CORP.
DAMON CORP./ELECTRONICS DIV.
ELEC. SURVEILLANCE COMP. INC.
EMF SYSTEMS INC.
ERBTEC ENGINEERING INC.
FOX ELECTRONICS
FREQUENCY CONTROL PRODUCTS, INC.
FREQUENCY ELECTRONICS
FREQUENCY SOURCES, INC.
GENERAL SERVICES ENGINEERING, INC.
GREENRAY INDUSTRIES
HUGHES AIRCRAFT CO.
  MICROELECTRONIC CIRCUITS DIV.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JACK HUSNEY & ASSOCIATES
KDI ELECTRONICS
KVG
LECTRONIC RESEARCH LABS
LITTON ELECTRON DEVICES
M-TRON INDUSTRIES INC.
M/A-COM , ACTIVE ASSEMBLIES DIV.
M/A-COM COMPONENTS MARKETING,INC
MAGNUM MICROWAVE CORP.
MARCH MICROWAVE LTD.
MATEC CORP./VALPEY - FISHER CORP.
MCCOY ELECTRONICS CO.
MICROWAVE RESEARCH AND MANUFACTURING (MRM)
MITEQ, INC.
MOTOROLA, COMPONENTS PRODUCTS DIV.
MURATA ERIE
NARDA
NEL FREQUENCY CONTROLS, INC.
OSCILLATEK, A DIV. OF K&L MICROWAVE
PACIFIC MONOLITHICS
PACIFIC WEST ELECTRONICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PIEZO CRYSTAL CO., INC.
PIEZO TECHNOLOGY, INC.
PLANAR MICROWAVE, A RAYTHEON CO.
RAYTHEON CO., MPTD
RDL, INC.
SANDERS, MICROWAVE DIV. ECB
SCITEQ ELECTRONICS, INC.
SHOKAI FAR EAST LTD.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.
SPECTRUM TECHNOLOGY INC.
SPREAD SPECTRUM SCIENCES
STANDARD CRYSTAL CORPORATION
STANTEL COMPONENTS
TECHTROL CYCLONETICS, INC.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TEXSCAN INSTRUMENTS
UHF ASSOCIATES
VALPEY FISHER CORP.
VARI-L
VECTRON LABORATORIES INC.
WATKINS-JOHNSON CO.
WENZEL ASSOCIATES, INC.
WESTEC COMMUNICATIONS INC.
WILMANCO
ZETA LABS

SAW

ANDERSEN LABORATORIES
CRYSTAL TECHNOLOGY INC.
FREQUENCY ELECTRONICS
HUGHES AIRCRAFT CO.
  MICROELECTRONIC CIRCUITS DIV.
LECTRONIC RESEARCH LABS
MATEC CORP./VALPEY - FISHER CORP.
MURATA ERIE
OAKBURY COMPONENTS
OSCILLATEK, A DIV. OF K&L MICROWAVE
PASCALL ELECTRONICS LTD.
RAYTHEON CO., MPTD
RF MONOLITHICS INC.
SAWTEK INC.
SHOKAI FAR EAST LTD.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.
SPREAD SPECTRUM SCIENCES
STANTEL COMPONENTS
TEKTRONIX, INC.
TELEDYNE MICROELECTRONICS

LC

BRIGHTLINE CORP.
COILCRAFT
CONNOR-WINFIELD
DAMON CORP./ELECTRONICS DIV.
FREQUENCY ELECTRONICS
FREQUENCY SOURCES, INC.
GREENRAY INDUSTRIES
HUGHES AIRCRAFT CO.
  MICROELECTRONIC CIRCUITS DIV.
LECTRONIC RESEARCH LABS
MATEC CORP./VALPEY - FISHER CORP.
MITEQ, INC.
SHOKAI FAR EAST LTD.
SOKOL CRYSTAL PRODUCTS INC.
TELEDYNE MICROELECTRONICS
UHF ASSOCIATES
VECTRON LABORATORIES INC.
ZETA LABS

PHASE LOCKED

A.R.F. PRODUCTS, INC.
ALPHA INDUSTRIES, INC.
ANDERSEN LABORATORIES
ANGHEL LABORATORIES, INC.
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
AUSTRON INC.
AVANTEK, INC.
B AND J MARKETING
BALL, EFRATOM DIVISION
BERKELEY NUCLEONICS CORP.
BLILEY ELECTRIC CO.
BRIGHTLINE CORP.
COMMUNICATION TECHNIQUES, INC.
CONNOR-WINFIELD
CTS CORP./KNIGHTS DIV.
DALE ELECTRONICS, INC.
DAMON CORP./ELECTRONICS DIV.

Modules & Hybrids

ELECTRO RENT CORPORATION
EMF SYSTEMS INC.
ERBTEC ENGINEERING INC.
FREQUENCY AND TIME SYSTEMS, INC.
FREQUENCY ELECTRONICS
FREQUENCY SOURCES, INC.
GREENRAY INDUSTRIES
HUGHES AIRCRAFT CO.
 MICROELECTRONIC CIRCUITS DIV.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INTERNATIONAL MICROWAVE CORP.
JCA TECHNOLOGY INC.
KDI ELECTRONICS
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
M/A-COM , ACTIVE ASSEMBLIES DIV.
M/A-COM COMPONENTS MARKETING,INC
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MATEC CORP./VALPEY - FISHER CORP.
MICROWAVE RESEARCH AND MANUFACTURING (MRM)
MITEQ, INC.
MM - WAVE TECHNOLOGY INC.
NARDA
PACIFIC RESEARCH AND DEVELOPMENT
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PIEZO CRYSTAL CO., INC.
RDL, INC.
RFD, INC.
SCITEQ ELECTRONICS, INC.
SHOKAI FAR EAST LTD.
SOKOL CRYSTAL PRODUCTS INC.
SPECTRUM TECHNOLOGY INC.
SPREAD SPECTRUM SCIENCES
TALBOT TECHNOLOGY (T-TECH) CORP.
TECHTROL CYCLONETICS, INC.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TEST EQUIPMENT CORP.
TIME AND FREQUENCY LTD.
WATKINS-JOHNSON CO.
VALPEY FISHER CORP.
VARIAN RF SUBSYSTEMS DIV.
VECTRON LABORATORIES INC.
WENZEL ASSOCIATES, INC.
ZETA LABS

RESONATORS

SAW

A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL. LTD.
COM DEV
CRYSTAL TECHNOLOGY INC.
HUGHES AIRCRAFT CO.
 MICROELECTRONIC CIRCUITS DIV.
HYBRIDS INTERNATIONAL, LTD.
KYOCERA NORTHWEST
OAKBURY COMPONENTS
PASCALL ELECTRONICS LTD.
RAYTHEON CO., MPTD
RF MONOLITHICS INC.
SAWTEK INC.
SHOKAI FAR EAST LTD.
SOKOL CRYSTAL PRODUCTS INC.
SOLITRON DEVICES, INC.
STANTEL COMPONENTS
TEKTRONIX, INC.
TELEDYNE MICROELECTRONICS

CERAMIC

A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL. LTD.
ALPHA INDUSTRIES, INC.
HYBRIDS INTERNATIONAL, LTD.
KYOCERA NORTHWEST
MURATA ERIE
OAKBURY COMPONENTS
SHOKAI FAR EAST LTD.
SIEMENS COMPONENTS INC.,
 SPECIAL PRODUCTS DIV.
SOLITRON DEVICES, INC.
TDK CORP. OF AMERICA
TELEDYNE MICROELECTRONICS
TOKO AMERICA, INC.
ZETA LABS

LC

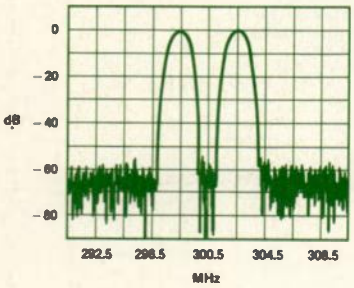
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
TELEDYNE MICROELECTRONICS
TEXSCAN INSTRUMENTS

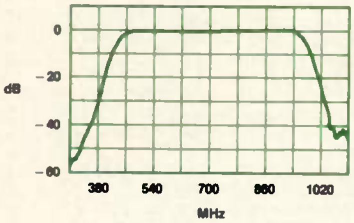
SYSTEM BLOCKS AND SUBASSEMBLIES

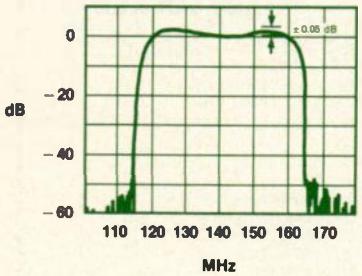
AMPLIFIERS

IF

ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
AEL DEFENSE CORP.
AMPLICA INC.
AMPLIFONIX, INC.
APCOM, INC.
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
APPLIED SPECIALTIES, INC.







System Blocks and Subassemblies

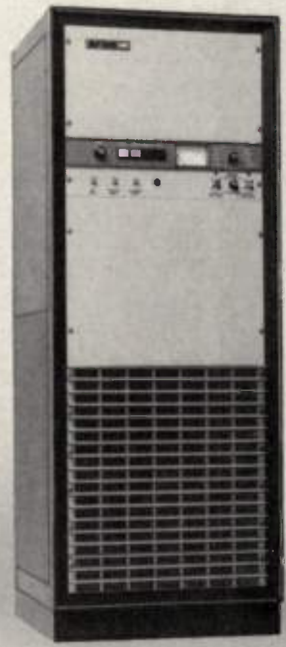
APTRON LABORATORIES, INC.
AVANTEK, INC.
AYDIN VECTOR DIV.
AYDIN WEST - MICROWAVE DIV.
CALIFORNIA AMPLIFIER, INC.
CASTLE MICROWAVE
ELECTRONIC RESOURCES INC.
EON INSTRUMENTATION, INC.
FG ENGINEERING CO.
INTERNATIONAL MICROWAVE CORP.
JANEL LABORATORIES, INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LOCUS INC.
LOG TECH, INC.
M/A-COM , ACTIVE ASSEMBLIES DIV.
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MICROWAVE RESEARCH AND MANUFACTURING (MRM)
MICROWAVE SOLUTIONS INC.
MITEQ, INC.
MU-DEL ELECTRONICS, INC.
OAKBURY COMPONENTS
OLEKTRON SYSTEMS, INC.
P.G. ELECTRONICS LTD.
PACIFIC MONOLITHICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PHOENIX MICROWAVE CORP.
PICO PRODUCTS, INC.
PIEZO TECHNOLOGY, INC.
PLESSEY SEMICONDUCTORS
Q-BIT CORPORATION
RADAR TECH. INC.
RDL, INC.
REMEC
RHG ELECTRONICS LABORATORY
SOLITRON DEVICES, INC.
TACHONICS CORP.
TE SYSTEMS
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TEST EQUIPMENT CORP.
TIW SYSTEMS, INC.
TRAK MICROWAVE CORP.
TRIQUINT SEMICONDUCTOR INC.
TRONTECH, INC.
VARIAN RF SUBSYSTEMS DIV.
WATKINS-JOHNSON COMPANY
WESTERN MICROWAVE INC.
WI-COMM ELECTRONICS INC.

LOG

ACCUTEST INSTRUMENTS INC.
ALPHA INDUSTRIES, INC.
AMERICAN MICROWAVE TECHNOLOGY
AMPLIFIER RESEARCH
APPLIED SPECIALTIES, INC.
AVTECH ELECTROSYSTEMS LTD.
BEHLMAN ENGINEERING
BURLE INDUSTRIES, INC.
CONTINENTAL RESOURCES, INC.
DAMON CORP./ELECTRONICS DIV.
DIGIMAX INSTRUMENTS CORP.
DOTY SCIENTIFIC
EAGLE MAGNETIC CO INC.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
EG&G PRINCETON/ELECTROCHEMICAL INSTR.
ELECTRO RENT CORPORATION
ENI POWER SYSTEMS
EPSCO, INC.
EPSCO, INC.-RF DIV.
EQUITABLE/RENTELCO CORP.
HENRY RADIO INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INSTRUMENTS FOR INDUSTRY, INC.
INTECH INC.
IRT CORP.
JCA TECHNOLOGY INC.
JOSEPH ELECTRONICS INC.
KALMUS ENGINEERING INTL. LTD.
KELTEC FLORIDA, INC.
KROHN-HITE CORP.
L & M ENGINEERING SOUTH
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
M/A-COM MPD, INC.
MARCH MICROWAVE LTD.
MCL INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICROWAVE SOLUTIONS INC.
MILCOM INTL
MILLIVAC INSTRUMENTS, INC.
OMEGA MICROWAVE, INC.
P.G. ELECTRONICS LTD.
PICOSECOND PULSE LABS, INC.
RAG ELECTRONICS INC.
RF POWER LABS INC.
SIGNAL ONE
STANFORD RESEARCH
SYSTRON DONNER CORP., MICROWAVE DIV.
TE SYSTEMS
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
UHF ASSOCIATES
VIEWSONICS
WI-COMM ELECTRONICS INC.
WIDE BAND ENGINEERING CO. INC.

LNA

ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
AEL DEFENSE CORP.
ALPHA INDUSTRIES, INC.
AMPLICA INC.
AMPLIFONIX, INC.
ANALOP ENGINEERING
APCOM, INC.
APPLIED SPECIALTIES, INC.
AVANTEK, INC.
AYDIN WEST - MICROWAVE DIV.
CALIFORNIA AMPLIFIER, INC.
CASTLE MICROWAVE
CELERITEK, INC.
DENSITRON MICROWAVE LTD.
DOTY SCIENTIFIC
FG ENGINEERING CO.
HARRIS CORP. FARINON COMPONENTS OPERATION
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INTERAD LTD.
INTERNATIONAL MICROWAVE CORP.
JCA TECHNOLOGY INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LNR COMMUNICATIONS, INC.
LOCUS INC.
LUNAR INDUSTRIES, INC.
M/A-COM , ACTIVE ASSEMBLIES DIV.
MARLOW ELECTRONICS LTD.
MICROWAVE SOLUTIONS INC.
MINI CIRCUITS
MITEQ, INC.
NARDA
NORTH HILLS ELECTRONICS, INC.
OAKBURY COMPONENTS
OMEGA MICROWAVE, INC.
PACIFIC MONOLITHICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PENTEK, INC.
PHOENIX MICROWAVE CORP.
PICO PRODUCTS, INC.
PLESSEY SEMICONDUCTORS
Q-BIT CORPORATION
RAMAR COMMUNICATIONS, INC.
RAYTHEON CO., MPTD
RAYTHEON CO., SPEC. MICROWAVE OP. DIV.
REMEC
RHG ELECTRONICS LABORATORY
SOLITRON DEVICES, INC.
SYSTRON DONNER CORP., MICROWAVE DIV.
TACHONICS CORP.
TE SYSTEMS
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TELSAT
TEST EQUIPMENT CORP.
TRIQUINT SEMICONDUCTOR INC.
TRONTECH, INC.
TRW MICROWAVE
VIEWSONICS
WATKINS-JOHNSON CO.
WESTERN MICROWAVE INC.
WI-COMM ELECTRONICS INC.
WILMANCO
ZETA LABS



System Blocks and Subassemblies

RF POWER

A.R.F. PRODUCTS, INC.
ACRIAN, INC.
ADVANCED ANALOG SYSTEMS
AEL DEFENSE CORP.
AIRTRON CORP.
AMERICAN MICROWAVE TECHNOLOGY

AMPEREX ELECTRONIC COMPANY
AMPLICA INC.
AMPLIFIER RESEARCH
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
APTRON LABORATORIES, INC.
AVANTEK, INC.
AYDIN VECTOR DIV.
AYDIN WEST - MICROWAVE DIV.
CALIFORNIA AMPLIFIER, INC.
CASTLE MICROWAVE
CELERITEK, INC.
COMARK COMMUNICATIONS, INC.
COMMUNITRONICS
CUBIC COMMUNICATIONS, INC.
DECIBEL PRODUCTS, INC.
DENSITRON MICROWAVE LTD.
DOTY SCIENTIFIC
EATON AIL DIV.
EDAL INDUSTRIES
EHRHORN TECHNOLOGICAL OPERATIONS, INC.
ELECTRO RENT CORPORATION
ELECTRONIC RESOURCES INC.
ENI POWER SYSTEMS
EPSCO, INC.
EPSCO, INC.-RF DIV.
FG ENGINEERING CO.
GENERAL SERVICES ENGINEERING, INC.
GREEN MOUNTAIN RADIO RESEARCH CO.
HARRIS CORP. FARINON COMPONENTS OPERATION
HENRY RADIO INC.
INSTRUMENTS FOR INDUSTRY, INC.
INTECH INC.
INTERAD LTD.
KALMUS ENGINEERING INTL, LTD.
KELTEC FLORIDA, INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LITTON SYSTEMS, INC. ELECTRON DEVICES
LOCUS INC.
LORCH ELECTRONICS DIV. OF VERNITRON CORP.
LUNAR INDUSTRIES, INC.
M/A-COM MPD, INC.
MARCH MICROWAVE LTD.
MCL INC.
MICROWAVE MODULES & DEVICES
MICROWAVE SEMICONDUCTOR CORP.
MICROWAVE SOLUTIONS INC.
MILCOM INTL
MINI CIRCUITS
MITEQ, INC.
MSE
MU-DEL ELECTRONICS, INC.
NARDA
NORTH HILLS ELECTRONICS, INC.
NURAD, INC.
OLEKTRON SYSTEMS, INC.
P.G. ELECTRONICS LTD.
PACIFIC MONOLITHICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PICO PRODUCTS, INC.
POLYCORE RF DEVICES
Q-BIT CORPORATION
RAMAR COMMUNICATIONS, INC.
RAYTHEON CO., MPTD
REMTRON, INC.
RF GAIN, LTD./RICHARDSON ELECTRONICS, LTD.
RF PLASMA PRODUCTS
RF POWER LABS INC.
RFD, INC.
SIGNAL ONE
SOLITRON DEVICES, INC.
TE SYSTEMS
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TELSAT
TEST EQUIPMENT CORP.
TRAK MICROWAVE CORP.
TRANS WORLD COMMUNICATIONS INC.
TRILECTRIC
TRONTECH, INC.
TRW RF DEVICES
UHF ASSOCIATES
VARIAN ASSOC., EIMAC DIV.
WATKINS-JOHNSON CO.
WI-COMM ELECTRONICS INC.
ZETA LABS

HIGH DYNAMIC RANGE

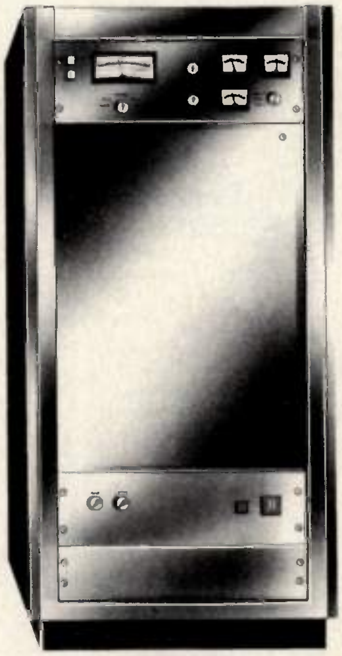
ADAMS-RUSSELL ELECTRONICS
AMPLICA INC.
APPLIED SPECIALTIES, INC.
AVANTEK, INC.
AYDIN WEST - MICROWAVE DIV.
BRIGHTLINE CORP.
CALIFORNIA AMPLIFIER, INC.
CELERITEK, INC.
EATON AIL DIV.
ELECTRONIC RESOURCES INC.
EPSCO, INC.
FG ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JANEL LABORATORIES, INC.
JOSLYN DEFENSE SYSTEMS, INC.
LOCUS INC.
LOG TECH, INC.
LUNAR INDUSTRIES, INC.
MARLOW ELECTRONICS LTD.
MICROWAVE SEMICONDUCTOR CORP.
MICROWAVE SOLUTIONS INC.
MINI CIRCUITS
MITEQ, INC.
NARDA
OLEKTRON SYSTEMS, INC.
OMEGA MICROWAVE, INC.
P.G. ELECTRONICS LTD.
PACIFIC MONOLITHICS
PENSTOCK INC.
PHOENIX MICROWAVE CORP.
Q-BIT CORPORATION
RADAR TECH. INC.
REACTION INSTRUMENTS, INC.
RHG ELECTRONICS LABORATORY
SIGNAL ONE
SINCLAIR RADIO LABS INC.
SOLITRON DEVICES, INC.
SPREAD SPECTRUM SCIENCES
STEINBRECHER CORP.
TACHONICS CORP.
TE SYSTEMS
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TELSAT
TEST EQUIPMENT CORP.
TIW SYSTEMS, INC.
TRM INC.
TRONTECH, INC.
TRW RF DEVICES
VARIAN RF SUBSYSTEMS DIV.
VIEWSONICS
WATKINS-JOHNSON CO.
WI-COMM ELECTRONICS INC.

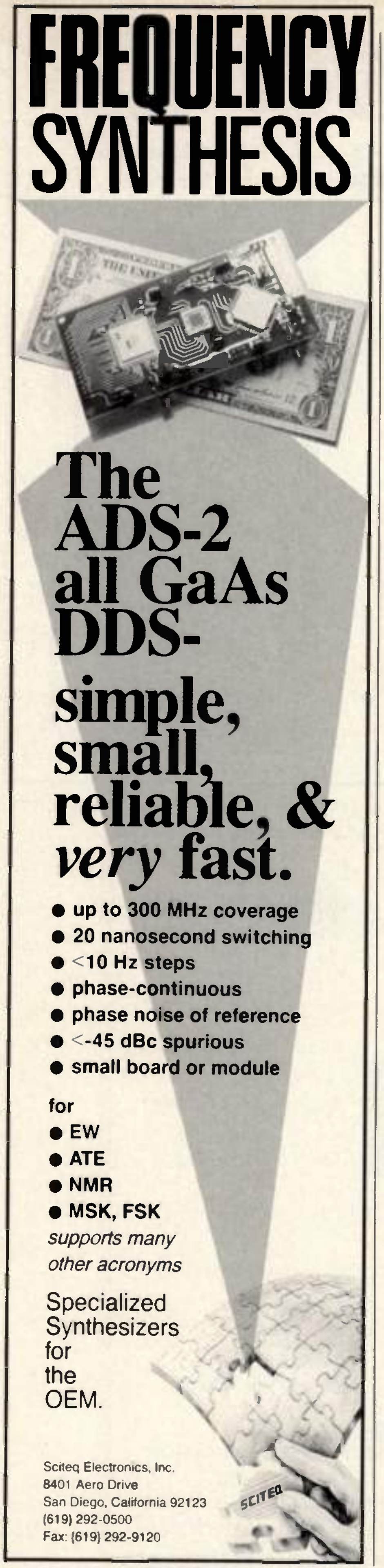
FREQUENCY CONVERTERS

ADAMS-RUSSELL ELECTRONICS
AEL DEFENSE CORP.
ALPHA INDUSTRIES, INC.
ANGHEL LABORATORIES, INC.
APCOM, INC.
APTRON LABORATORIES, INC.
AVANTEK, INC.
AVCOM OF VIRGINIA
AYDIN VECTOR DIV.
CALIFORNIA AMPLIFIER, INC.
CONDOR SYSTEMS
DAJEM TECHNOLOGY CO.
DATEL, INC.
DENSITRON MICROWAVE LTD.
ELECTRO RENT CORPORATION
ERA TRANSPAC DIV., ELECTRONIC RESEARCH
FG ENGINEERING CO.
FREQUENCY SOURCES, INC.
JANEL LABORATORIES, INC.
JCA TECHNOLOGY INC.
JOSLYN DEFENSE SYSTEMS, INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LNR COMMUNICATIONS, INC.
LOCUS INC.
LORCH ELECTRONICS DIV. OF VERNITRON CORP.
LUNAR INDUSTRIES, INC.
M/A-COM , ACTIVE ASSEMBLIES DIV.
MAGNUM MICROWAVE CORP.
MICROWAVE SYSTEMS INC.
MINI CIRCUITS
MITEQ, INC.
MU-DEL ELECTRONICS, INC.
NARDA
NORSAL INDUSTRIES INC.
PACIFIC MONOLITHICS
PACIFIC RESEARCH AND DEVELOPMENT
PENTEK, INC.
PICO PRODUCTS, INC.
PULSAR MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RADAR TECH. INC.
RAMAR COMMUNICATIONS, INC.
RAYTHEON CO., MPTD
REACTION INSTRUMENTS, INC.
REMEC
RHG ELECTRONICS LABORATORY
SPREAD SPECTRUM SCIENCES
STEINBRECHER CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TELEDYNE MICROWAVE
TELSAT
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
TIME MICROWAVE
TRAK MICROWAVE CORP.
TRW MICROWAVE
WATKINS-JOHNSON COMPANY
WESTERN MICROWAVE INC.

FREQUENCY SYNTHESIZERS

A & A ENGINEERING
A.R.F. PRODUCTS, INC.
ADVANCED COMMUNICATIONS SYSTEMS, INC.
ANGHEL LABORATORIES, INC.
APCOM, INC.
AUSTRON INC.
AVANTEK, INC.
BRIMROSE CORP.
CALIFORNIA EASTERN LABORATORIES
CASTLE MICROWAVE
COMMUNICATION TECHNIQUES, INC.
COMSTRON CORP.
DAJEM TECHNOLOGY CO.
DIGITAL RF SOLUTIONS
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
FG ENGINEERING CO.
FREQUENCY ELECTRONICS





FREQUENCY SOURCES, INC.
GENERAL SERVICES ENGINEERING, INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INTERNATIONAL MICROCIRCUITS, INC.
JOHN FLUKE MFG. CO. INC.
JOSLYN DEFENSE SYSTEMS, INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LNR COMMUNICATIONS, INC.
M/A-COM , ACTIVE ASSEMBLIES DIV.
M/A-COM COMPONENTS MARKETING,INC
MICROWAVE RESEARCH AND MANUFACTURING (MRM)
MICROWAVE SYSTEMS INC.
MIRAGE SYSTEMS
MITEQ, INC.
MM - WAVE TECHNOLOGY INC.
MU-DEL ELECTRONICS, INC.
NARDA
PACIFIC RESEARCH AND DEVELOPMENT
PENTEK, INC.
PHILIPS TEST & MEASURING INSTRUMENTS
PIEZO CRYSTAL CO., INC.
PLESSEY SEMICONDUCTORS
PROGRAMMED TEST SOURCES, INC.
RACAL-DANA INSTRUMENTS, INC.
RDL, INC.
REMTRON, INC.
RF MONOLITHICS INC.
RF PROTOTYPE SYSTEMS
SCITEQ ELECTRONICS, INC.
SIGMOTEK INTL CORP.
SIGNAL ONE
SPECTRACOM CORP.
SPREAD SPECTRUM SCIENCES
STANFORD TELECOMMUNICATIONS, INC.
STEINBRECHER CORP.
SYNTEST CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
SYSTRON DONNER INSTRUMENT DIV.
TALBOT TECHNOLOGY (T-TECH) CORP.
TECHTROL CYCLONETICS, INC.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TELEMUS ELECTRONIC SYSTEMS INC.
TEST EQUIPMENT CORP.
VARIAN RF SUBSYSTEMS DIV.
WATKINS-JOHNSON CO.
WAVETEK SAN DIEGO, INC.
WILTRON CO.
ZETA LABS

MOTION/PROXIMITY SENSORS

A.R.F. PRODUCTS, INC.
ALPHA INDUSTRIES, INC.
DAJEM TECHNOLOGY CO.
GILTRON INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JOSLYN DEFENSE SYSTEMS, INC.
MAGNAVOX ADVANCED PRODUCTS
MM - WAVE TECHNOLOGY INC.
NAMCO CONTROLS
SIGNATURE DESIGNS
TELSOR CORP.

RECEIVERS

A.R.F. PRODUCTS, INC.
AACOM DIVISION OF DATUM, INC.
AEL DEFENSE CORP.
AMERICAN LASER SYSTEMS, INC.
ANAREN MICROWAVE INC.
ANDERSEN LABORATORIES
ANGHEL LABORATORIES, INC.
APCOM, INC.
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
APTRON LABORATORIES, INC.
AVCOM OF VIRGINIA
AYDIN VECTOR DIV.
AYDIN WEST - MICROWAVE DIV.
CALIFORNIA AMPLIFIER, INC.
CARDION ELECTRONICS
CASTLE MICROWAVE
COMMUNITRONICS
COMSTRON CORP.
CUBIC COMMUNICATIONS, INC.
DAJEM TECHNOLOGY CO.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
EF JOHNSON
ELECTRO RENT CORPORATION
EPSILON LAMBDA ELECTRONICS CORP.
ERBTEC ENGINEERING INC.
FG ENGINEERING CO.
FREQUENCY SOURCES, INC.
GENERAL SERVICES ENGINEERING, INC.
HDS, INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INTECH INC.
INTERAD LTD.
INTERNATIONAL MICROWAVE CORP.
JCA TECHNOLOGY INC.
JOSLYN DEFENSE SYSTEMS, INC.
L & M ENGINEERING SOUTH
LASER DIODE INC.
LECTRONIC RESEARCH LABS
LNR COMMUNICATIONS, INC.
LUNAR INDUSTRIES, INC.
M/A-COM COMPONENTS MARKETING,INC
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MERET INC.
MICROWAVE MODULES & DEVICES
MICROWAVE SYSTEMS INC.
MITEQ, INC.
MM - WAVE TECHNOLOGY INC.
NEULINK
NURAD, INC.
PACIFIC MONOLITHICS
PACIFIC RESEARCH AND DEVELOPMENT
PASCALL ELECTRONICS LTD.
PICO PRODUCTS, INC.
PLESSEY SEMICONDUCTORS
PRECISION STANDARD TIME, INC.
REACTION INSTRUMENTS, INC.
REMTRON, INC.
RF MONOLITHICS INC.
RFD, INC.
RHG ELECTRONICS LABORATORY
ROSS ENGINEERING CORP.
SIGNAL ONE
SIGNATURE DESIGNS
SILTRONICS LTD.
SPREAD SPECTRUM SCIENCES
STEINBRECHER CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TAUBER-DREYER CORP.
TECH COMM. INC.
TELE-TECH CORP.
TELEDYNE MICROELECTRONICS
TELEDYNE MICROWAVE
TELEMUS ELECTRONIC SYSTEMS INC.
TEST EQUIPMENT CORP.
TONY CHAPMAN ELECTRONICS LTD.
TRAK MICROWAVE CORP.
TRANS WORLD COMMUNICATIONS INC.
UHF ASSOCIATES
VARIAN RF SUBSYSTEMS DIV.
VITRO SERVICES CORP.
WATKINS-JOHNSON CO.
WEINSCHEL ENGINEERING
WILMANCO
XETRON CORP.
ZETA LABS

RF MODEMS

APTRON LABORATORIES, INC.
CODEX
COMMUNITRONICS
DAJEM TECHNOLOGY CO.
EF JOHNSON
ELECTRO RENT CORPORATION
FG ENGINEERING CO.
JOSLYN DEFENSE SYSTEMS, INC.
LUNAR INDUSTRIES, INC.
MIDIAN ELECTRONICS
MITEQ, INC.
MOTOROLA SEMICONDUCTORS
REPCO INC.
RHG ELECTRONICS LABORATORY
SIGNATURE DESIGNS
SPREAD SPECTRUM SCIENCES
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TELEMETRY TECHNOLOGIES, INC.
TEST EQUIPMENT CORP.
TRANS WORLD COMMUNICATIONS INC.
ZETA LABS

TONE ENCODERS/ DECODERS

A & A ENGINEERING
A.R.F. PRODUCTS, INC.
ADVANCED COMMUNICATIONS SYSTEMS, INC.
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
AYDIN VECTOR DIV.
DAJEM TECHNOLOGY CO.
ELECTRO RENT CORPORATION
EON INSTRUMENTATION, INC.
FG ENGINEERING CO.
HDS, INC.
JOSLYN DEFENSE SYSTEMS, INC.
NORCOMM CORP.
PALOMAR ENGINEERS
PICO PRODUCTS, INC.
PLESSEY SEMICONDUCTORS
REMTRON, INC.
SELECTONE CORP.
SIGNATURE DESIGNS
TEXAS SPECTRUM ELECTRONICS INC.

TRANSMITTERS

A & A ENGINEERING
A.R.F. PRODUCTS, INC.
AACOM DIVISION OF DATUM, INC.
ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
AMERICAN LASER SYSTEMS, INC.
ANGHEL LABORATORIES, INC.
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
APTRON LABORATORIES, INC.
AYDIN VECTOR DIV.
BRIMROSE CORP.
CARDION ELECTRONICS
COMARK COMMUNICATIONS, INC.
COMMUNITRONICS
DAJEM TECHNOLOGY CO.
EF JOHNSON
EHRHORN TECHNOLOGICAL OPERATIONS, INC.
ELECTRO RENT CORPORATION
EPSILON LAMBDA ELECTRONICS CORP.
ERBTEC ENGINEERING INC.
FG ENGINEERING CO.
FREQUENCY SOURCES, INC.
GENERAL SERVICES ENGINEERING, INC.
GILTRON INC.
HDS, INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INSTRUMENTS FOR INDUSTRY, INC.
INTECH INC.
INTERAD LTD.
INTERNATIONAL MICROWAVE CORP.
JOSLYN DEFENSE SYSTEMS, INC.
KAPTRON INC.
L & M ENGINEERING SOUTH
LASER DIODE INC.
LUNAR INDUSTRIES, INC.
M/A-COM COMPONENTS MARKETING, INC
M/A-COM MPD, INC.
MCL INC.
MERET INC.
MICROWAVE MODULES & DEVICES
MICROWAVE SEMICONDUCTOR CORP.
MICROWAVE SYSTEMS INC.
MM - WAVE TECHNOLOGY INC.
NEULINK
NURAD, INC.
ORIEL CORP.
ORTEL CORP.
REMTRON, INC.
REPCO INC.
RF MONOLITHICS INC.
RF PLASMA PRODUCTS
RFD, INC.
ROSS ENGINEERING CORP.
SIGNAL ONE
SIGNATURE DESIGNS
SPREAD SPECTRUM SCIENCES
STEINBRECHER CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TEST EQUIPMENT CORP.
TRANS WORLD COMMUNICATIONS INC.
UHF ASSOCIATES
VENTRONICS
VITRO SERVICES CORP.
XETRON CORP.

TRANSMISSION COMPONENTS

ANTENNAS

HF

AEL DEFENSE CORP.
AMPLIFIER RESEARCH
ANDREW CORP.
BARKER & WILLIAMSON
CENTURION INTL INC.
CHILDS CORP.
CUSHCRAFT CORP.
DAJEM TECHNOLOGY CO.
DAYTON-GRANGER, INC.
DYMA ENGINEERING
FLAM & RUSSELL, INC.
JAMES MILLEN ELECTRONICS
JASCO INTL, INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LOGIMETRICS, INC.
PRECISION STANDARD TIME, INC.
RF PRODUCTS, INC.
SHOKAI FAR EAST LTD.
SIGNATURE ANTENNA
SINCLAIR RADIO LABS INC.
SNYDER COMMUNICATIONS CORP.
TECH COMM. INC.
TEST EQUIPMENT CORP.
TRANS WORLD COMMUNICATIONS INC.
WATKINS-JOHNSON CO.

VHF

A.H. SYSTEMS, INC.
ADAMS-RUSSELL ELECTRONICS CO., INC.
AEL DEFENSE CORP.
ALPHA INDUSTRIES, INC.
AMPLIFIER RESEARCH
ANDREW CORP.
ANTENNA SPECIALISTS CO., THE
CENTURION INTL INC.
CHILDS CORP.
COMAD COMMUNICATIONS LTD.
CUSHCRAFT CORP.
DAJEM TECHNOLOGY CO.
DAYTON-GRANGER, INC.
DECIBEL PRODUCTS, INC.
DIELECTRIC COMMUNICATIONS
DYMA ENGINEERING
FG ENGINEERING CO.
FLAM & RUSSELL, INC.
INTERAD LTD.
JAMES MILLEN ELECTRONICS
JOSEPH ELECTRONICS INC.
L & M ENGINEERING SOUTH
LARSEN ELECTRONICS, INC.
LECTRONIC RESEARCH LABS
LOGIMETRICS, INC.
LUNAR INDUSTRIES, INC.
MARK ANTENNA PRODUCTS, INC.
MICRO COMMUNICATIONS, INC.
MICROWAVE SPECIALTY CORP.
MICROWAVE TECHNIQUES
RADIATION SYSTEMS, INC MARK ANTENNAS DIVISION
SCALA ELECTRONIC CORP.
SENSOR SYSTEMS, INC.
SHOKAI FAR EAST LTD.
SIMPLICITY TOOL CO.
SINCLAIR RADIO LABS INC.
SNYDER COMMUNICATIONS CORP.
TECH COMM. INC.
TECOM
TELEWAVE INC.
TELSAT
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
TIL-TEK LTD.
TRANSCO PRODUCTS, INC.
WATKINS-JOHNSON CO.

UHF

A.H. SYSTEMS, INC.
ADAMS-RUSSELL ELECTRONICS CO., INC.
AEL DEFENSE CORP.
ALPHA INDUSTRIES, INC.
AMPLIFIER RESEARCH
ANDREW CORP.
ANTENNA SPECIALISTS CO., THE
CENTURION INTL INC.
CHILDS CORP.
COMAD COMMUNICATIONS LTD.
CUSHCRAFT CORP.
DAJEM TECHNOLOGY CO.
DATRON SYSTEMS
DAYTON-GRANGER, INC.
DECIBEL PRODUCTS, INC.
DIELECTRIC COMMUNICATIONS
DYMA ENGINEERING
FG ENGINEERING CO.
FLAM & RUSSELL, INC.
INTERAD LTD.
JOSEPH ELECTRONICS INC.
L & M ENGINEERING SOUTH
LARSEN ELECTRONICS, INC.
LECTRONIC RESEARCH LABS
LOGIMETRICS, INC.
LUNAR INDUSTRIES, INC.
MARK ANTENNA PRODUCTS, INC.
MICRO COMMUNICATIONS, INC.
MICROWAVE TECHNIQUES
ONEIDA ELECTRONIC MFG CO. INC.
RADIATION SYSTEMS, INC MARK ANTENNAS DIVISION
SCALA ELECTRONIC CORP.
SCIENTIFIC ATLANTA
SENSOR SYSTEMS, INC.
SHOKAI FAR EAST LTD.
SIMPLICITY TOOL CO.
SINCLAIR RADIO LABS INC.
SNYDER COMMUNICATIONS CORP.
TECH COMM. INC.
TECOM
TELEWAVE INC.
TELSAT
TEST EQUIPMENT CORP.
TIL-TEK LTD.
TRANSCO PRODUCTS, INC.
WATKINS-JOHNSON CO.

EMC/EMI

A.H. SYSTEMS, INC.
ALPHA INDUSTRIES, INC.
AMPLIFIER RESEARCH
ANDREW CORP.
C.K. CONSULTANTS, INC.
DOW INDUSTRIES
EATON AIL DIV.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO-MECHANICS CO.,THE (EMCO)
EQUITABLE/RENTELCO CORP.
HEWLETT-PACKARD CO.
INSTRUMENTS FOR INDUSTRY, INC.
LECTRONIC RESEARCH LABS
MAGNETIC RADIATION LABORATORIES, INC.
RADIOMETRICS CORP.

RADIOMETRICS MIDWEST CORP.
SHOKAI FAR EAST LTD.
TEST EQUIPMENT CORP.
TEXAS SPECTRUM ELECTRONICS INC.
TIL-TEK LTD.
WATKINS-JOHNSON CO.

BROADBAND

ADAMS-RUSSELL ELECTRONICS CO., INC.
ALPHA INDUSTRIES, INC.
AMPLIFIER RESEARCH
ANDREW CORP.
CENTURION INTL INC.
CHILDS CORP.
COMAD COMMUNICATIONS LTD.
CUBIC COMMUNICATIONS, INC.
CUSHCRAFT CORP.
DAJEM TECHNOLOGY CO.
DAYTON-GRANGER, INC.
DECIBEL PRODUCTS, INC.
DYMA ENGINEERING
HY GAIN
JOSEPH ELECTRONICS INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LOGIMETRICS, INC.
MARK ANTENNA PRODUCTS, INC.
MICRO COMMUNICATIONS, INC.
MICROFLECT CO., INC.
MICROWAVE SPECIALTY CORP.
NURAD, INC.
O.K. INDUSTRIES INC.
OLEKTRON CORP.
RADIATION SYSTEMS, INC MARK ANTENNAS DIVISION
RADIOMETRICS MIDWEST CORP.
SCALA ELECTRONIC CORP.
SENSOR SYSTEMS, INC.
SHOKAI FAR EAST LTD.
SINCLAIR RADIO LABS INC.
SNYDER COMMUNICATIONS CORP.
SUNAIR ELECTRONICS
TECOM
TELEDYNE RYAN
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
TIL-TEK LTD.
TRANSCO PRODUCTS, INC.
WATKINS-JOHNSON CO.

ANTENNA POSITIONERS

A.H. SYSTEMS, INC.
ANDREW CORP.
C.K. CONSULTANTS, INC.
DATRON SYSTEMS
DYMA ENGINEERING
DYNETIC SYSTEMS CO.
ELECTRO-MECHANICS CO.,THE (EMCO)
FG ENGINEERING CO.
FLAM & RUSSELL, INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.

NURAD, INC.
RADIO RESEARCH INST. CO., INC.
ROTATING PRECISION MECHANISMS, INC.
TIW SYSTEMS, INC.

VITRO SERVICES CORP.
WATKINS-JOHNSON CO.

ATTENUATORS

COAXIAL

ACCUTEST INSTRUMENTS INC.
ADAMS-RUSSELL ELECTRONICS
AIRTRON CORP.
ALAN INDUSTRIES, INC.
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
APPLIED SPECIALTIES, INC.
BARTH ELECTRONICS, INC.
BIRD ELECTRONIC CORP.
CALREP
CASTLE MICROWAVE
COAXIAL COMPONENTS CORP. (COAXICOM)
DAICO INDUSTRIES
DAJEM TECHNOLOGY CO.
DENSITRON MICROWAVE LTD.
ELCOM SYSTEMS, INC.
ELECTRO IMPULSE LABORATORY, INC.
ELECTRO RENT CORPORATION
ELECTRONIC RESOURCES INC.
EMC TECHNOLOGY, INC.
EQUITABLE/RENTELCO CORP.
ESCO ASSOC.
GENERAL MICROWAVE CORP.
GILBERT ENGINEERING
HARRIS CORP./GSSD/PRD INSTRUMENTS
HEWLETT PACKARD CO., COMPONENTS
HEWLETT-PACKARD CO.
HUBER & SUHNER INC.
INMET CORP.
JFW INDUSTRIES, INC.
KAY ELEMETRICS CORP.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
M/A-COM OMNI SPECTRA, INC.
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MARSHALL ELECTRONICS
MATRIX SYSTEMS CORP.
MERRIMAC INDUSTRIES, INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICRO COAX COMPONENTS, INC.
MICROLAB/FXR
MICROWAVE TECHNIQUES
MIDISCO
MIDWEST MICROWAVE INC.
MINI CIRCUITS
MU-DEL ELECTRONICS, INC.
NORTH HILLS ELECTRONICS, INC.
PASCALL ELECTRONICS LTD.
PASTERNACK ENTERPRISES
PENSTOCK INC.
PICO PRODUCTS, INC.
PICOSECOND PULSE LABS, INC.
PREMIER MICROWAVE CORP.
RADIALL, INC.
RFDC INC.
RLC ELECTRONICS, INC.
SAGE LABORATORIES, INC.
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
SOLITRON/MICROWAVE
SYSTRON DONNER CORP., MICROWAVE DIV.
TELONIC BERKELEY, INC.
TEST EQUIPMENT CORP.
TEST PROBES, INC.
TEXSCAN INSTRUMENTS
TONY CHAPMAN ELECTRONICS LTD.
TROMPETER ELECTRONICS
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
VIEWSONICS
WAVELINE INC.
WAVETEK RF PRODUCTS, INC.
WEINSCHEL ENGINEERING
WIDE BAND ENGINEERING CO. INC.
WILTRON CO.

PC MOUNT

ALAN INDUSTRIES, INC.
APPLIED SPECIALTIES, INC.
DAICO INDUSTRIES
ELCOM SYSTEMS, INC.
ELECTRONIC RESOURCES INC.
ION BEAM MILLING, INC.
JFW INDUSTRIES, INC.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
MERRIMAC INDUSTRIES, INC.
MINI CIRCUITS
PENSTOCK INC.
PREMIER MICROWAVE CORP.
RCD COMPONENTS INC.
REMEC
RLC ELECTRONICS, INC.
SALISBURY ENGINEERING INC.
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
SYNERGY MICROWAVE CORP.
TELE-TECH CORP.
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
WAVETEK RF PRODUCTS, INC.

PIN

ADAMS-RUSSELL ELECTRONICS
ALPHA INDUSTRIES, INC.
AMERICAN MICROWAVE CORP.
AMPLIFONIX, INC.
ANAREN MICROWAVE INC.
APPLIED SPECIALTIES, INC.
AYDIN VECTOR DIV.
CASTLE MICROWAVE
DAICO INDUSTRIES
DAJEM TECHNOLOGY CO.
EATON CORP. MICROWAVE PRODUCTS DIV.
ELECTRONIC RESOURCES INC.
ELECTROWAVE PRODUCTS, INC.
EMC TECHNOLOGY, INC.
GENERAL MICROWAVE CORP.
HEWLETT-PACKARD CO.
JCA TECHNOLOGY INC.
JFW INDUSTRIES, INC.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
MERRIMAC INDUSTRIES, INC.
MINI CIRCUITS
NORSAL INDUSTRIES INC.
OAKBURY COMPONENTS
OLEKTRON SYSTEMS, INC.
OPTIMAX, INC
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PHOENIX MICROWAVE CORP.
PLANAR MICROWAVE, A RAYTHEON CO.
PREMIER MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
REMEC
RLC ELECTRONICS, INC.
SDI MICROWAVE INC.
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
UNITRODE
VENTRONICS MICROWAVE CORP.
WATKINS-JOHNSON CO.

VARIABLE

ACCUTEST INSTRUMENTS INC.
ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
AEROWAVE INC.
AIRTRON CORP.
ALAN INDUSTRIES, INC.
ALPHA INDUSTRIES, INC.
AMPLIFONIX, INC.
ANAREN MICROWAVE INC.
APOLLO MICROWAVES LTD.
APPLIED SPECIALTIES, INC.
BIRD ELECTRONIC CORP.
CASTLE MICROWAVE
DAICO INDUSTRIES
DAJEM TECHNOLOGY CO.
DENSITRON MICROWAVE LTD.
ELECTRONIC RESOURCES INC.
ELECTROWAVE PRODUCTS, INC.
GENERAL MICROWAVE CORP.
HARRIS CORP./GSSD/PRD INSTRUMENTS
HEWLETT-PACKARD CO.

JFW INDUSTRIES, INC.
KAY ELEMETRICS CORP.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
LORCH ELECTRONICS DIV. OF VERNITRON CORP.
M/A-COM COMPONENTS MARKETING,INC
MARCH MICROWAVE LTD.
MERRIMAC INDUSTRIES, INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICROLAB/FXR
MICROWAVE TECHNIQUES
MITEC ELECTRONICS LTD.
NARDA MICROWAVE CORP.
NORSAL INDUSTRIES INC.
OLEKTRON SYSTEMS, INC.
OPTIMAX, INC
PACIFIC MONOLITHICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PREMIER MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RADIALL, INC.
RAYTHEON CO., MPTD
REMEC
RHG ELECTRONICS LABORATORY
RLC ELECTRONICS, INC.
ROBINSON LABS
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
SYSTRON DONNER CORP., MICROWAVE DIV.
TACHONICS CORP.
TELE-TECH CORP.
TELONIC BERKELEY, INC.
TEST EQUIPMENT CORP.
TEXSCAN
TEXSCAN INSTRUMENTS
TONY CHAPMAN ELECTRONICS LTD.
TUCKER ELECTRONICS
WATKINS-JOHNSON CO.
WAVELINE INC.
WEINSCHEL ENGINEERING

PROGRAMMABLE

ACCUTEST INSTRUMENTS INC.
AEROWAVE INC.
AIRTRON CORP.
ALAN INDUSTRIES, INC.
ALPHA INDUSTRIES, INC.
ANGHEL LABORATORIES, INC.
APPLIED SPECIALTIES, INC.
DAICO INDUSTRIES
DAJEM TECHNOLOGY CO.
DENSITRON MICROWAVE LTD.
ELECTRONIC RESOURCES INC.
EMC TECHNOLOGY, INC.
EQUITABLE/RENTELCO CORP.
GENERAL MICROWAVE CORP.
HARRIS CORP./GSSD/PRD INSTRUMENTS
HEWLETT PACKARD CO., COMPONENTS
HEWLETT-PACKARD CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JFW INDUSTRIES, INC.
KAY ELEMETRICS CORP.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
MARCH MICROWAVE LTD.
MATRIX SYSTEMS CORP.
MERRIMAC INDUSTRIES, INC.
NARDA MICROWAVE CORP.
NORSAL INDUSTRIES INC.
OPTIMAX, INC
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RADIALL, INC.
REMEC
RLC ELECTRONICS, INC.
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
SOLITRON/MICROWAVE
TACHONICS CORP.
TEKTRON MICRO ELECTRONICS INC.
TEKTRONIX, INC.
TELONIC BERKELEY, INC.
TEXSCAN INSTRUMENTS
TONY CHAPMAN ELECTRONICS LTD.
TUCKER ELECTRONICS
VENTRONICS MICROWAVE CORP.
WAVETEK RF PRODUCTS, INC.
WEINSCHEL ENGINEERING
WILTRON CO.

STEP

ACCUTEST INSTRUMENTS INC.
ADAMS-RUSSELL ELECTRONICS
AIRTRON CORP.
ALAN INDUSTRIES, INC.
ALPHA INDUSTRIES, INC.
AMPLIFONIX, INC.
APPLIED SPECIALTIES, INC.
DAICO INDUSTRIES
DENSITRON MICROWAVE LTD.
EATON CORP. MICROWAVE PRODUCTS DIV.
ELECTRO RENT CORPORATION
ELECTRONIC RESOURCES INC.
EMC TECHNOLOGY, INC.
EQUITABLE/RENTELCO CORP.
GENERAL MICROWAVE CORP.
HEWLETT-PACKARD CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JFW INDUSTRIES, INC.
KAY ELEMETRICS CORP.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
MARCH MICROWAVE LTD.
MICROLAB/FXR
MIDWEST MICROWAVE INC.
NARDA MICROWAVE CORP.
NORSAL INDUSTRIES INC.
OPTIMAX, INC
PENSTOCK INC.
PHOENIX MICROWAVE CORP.
RADIALL, INC.
RHG ELECTRONICS LABORATORY
RLC ELECTRONICS, INC.
SHOKAI FAR EAST LTD.
TEKTRON MICRO ELECTRONICS INC.
TELONIC BERKELEY, INC.
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
TONY CHAPMAN ELECTRONICS LTD.
TUCKER ELECTRONICS
WAVELINE INC.
WAVETEK RF PRODUCTS, INC.
WEINSCHEL ENGINEERING
WILTRON CO.

HIGH POWER

ACCUTEST INSTRUMENTS INC.
ACRIAN, INC.
AEROWAVE INC.
AIRTRON CORP.
ALAN INDUSTRIES, INC.
ALPHA INDUSTRIES, INC.
APOLLO MICROWAVES LTD.
BIRD ELECTRONIC CORP.
EMC TECHNOLOGY, INC.
EQUITABLE/RENTELCO CORP.
INMET CORP.
JFW INDUSTRIES, INC.
KAY ELEMETRICS CORP.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICROLAB/FXR
MICROWAVE TECHNIQUES
NARDA MICROWAVE CORP.
PASTERNACK ENTERPRISES
PENSTOCK INC.
POLYMER DESIGN
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RAYTHEON CO., MPTD
RLC ELECTRONICS, INC.
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
WAVETEK RF PRODUCTS, INC.
WEINSCHEL ENGINEERING

COAXIAL CABLE

ADAMS-RUSSELL ELECTRONICS
ADAMS-RUSSELL ELECTRONICS CO., INC.
AMPHENOL NORTH AMERICA
AMPHENOL RF/MICROWAVE OPERATIONS
ANDREW CORP.
ANTENNA SPECIALISTS CO., THE
APPLIED SPECIALTIES, INC.
BELDEN WIRE AND CABLE
BI-TRONICS, INC.
BRAND REX CABLE SYSTEMS
BREEZE ILLINOIS
BRIM ELECTRONICS, INC.
C & M CORP.
CALREP
CAPCON, INC.
CASTLE MICROWAVE
CERAMSEAL
COAXIAL COMPONENTS CORP. (COAXICOM)
COAXITUBE CORP.
COMARK COMMUNICATIONS, INC.
CONNECTING DEVICES, INC.
CUSHCRAFT CORP.
DABURN ELECTRONICS & CABLE CORP.
DECIBEL PRODUCTS, INC.
DIELECTRIC COMMUNICATIONS
DIELECTRIC SCIENCES
DYMA ENGINEERING
ELECTRONIC RESOURCES INC.
ESCO ASSOC.
FLEXCO MICROWAVE, INC.
FM&T INDUSTRIES, INC.
FREDERICK COMPONENTS
GILBERT ENGINEERING
GILTRON INC.
GLENAIR CORP.
HABIA CABLE
HARBOUR INDUSTRIES, INC.
HAVERHILL CABLE & MFG CORP.
HUBER & SUHNER INC.
INSULATED WIRE INC.
ITT POMONA ELECTRONICS
ITT SCHADOW INC.
JOSEPH ELECTRONICS INC.
JOSLYN DEFENSE SYSTEMS, INC.
KAMAN INSTRUMENTATION CORP.
KINGS ELECTRONICS CO. INC.
L & M ENGINEERING SOUTH
LANCE WIRE AND CABLE, INC.
LARSEN ELECTRONICS, INC.
LECTRONIC RESEARCH LABS
MADISON CABLE CORP.
MALCO, MICRODOT INC., CONNECTOR, INTERCONNECT SYSTEMS DIV.
MANHATTAN ELEC. CABLE CORP.
MARCH MICROWAVE LTD.
MARSHALL ELECTRONICS
MICRO COAX COMPONENTS, INC.
MIDISCO
MINELCO INC.
MOLEX INC.
NEK CABLE, INC.
PASCALL ELECTRONICS LTD.
PASTERNACK ENTERPRISES
PENSTOCK INC.
PICO PRODUCTS, INC.
PRECISION TUBE CO. INC.
RAYCHEM
RF POWER SYSTEMS
SCALA ELECTRONIC CORP.
SEALECTRO
SHOGYO INTL CORP.
SHOKAI FAR EAST LTD.
SINCLAIR RADIO LABS INC.
SOLITRON DEVICES, INC.
TELEWAVE INC.
TEMTRON ELECTRONICS LTD.
TIMES MICROWAVE SYSTEMS, INC.
TONY CHAPMAN ELECTRONICS LTD.

TROMPETER ELECTRONICS
UNITED MICROWAVE PRODUCTS, INC.
VIEWSONICS
W.L. GORE & ASSOCIATES, INC.
WALLINGFORD WIRE & CABLE
WEINSCHEL ENGINEERING
WHITTAKER ELECTRONIC RESOURCES
WORLD BUSINESS CORP. INC.

DIRECTIONAL COUPLERS

ACCUTEST INSTRUMENTS INC.
ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
ADAMS-RUSSELL ELECTRONICS CO., INC.
AEL DEFENSE CORP.
AEROWAVE INC.
AIRTRON CORP.
ALAN INDUSTRIES, INC.
ALPHA INDUSTRIES, INC.
AMERICAN MICROWAVE CORP.
AMPLIFIER RESEARCH
ANAREN MICROWAVE INC.
ANTENNA SPECIALISTS CO., THE
APOLLO MICROWAVES LTD.
APPLIED SPECIALTIES, INC.
BIRD ELECTRONIC CORP.
CASTLE MICROWAVE
COAXIAL COMPONENTS CORP. (COAXICOM)
COAXIAL DYNAMICS, INC.
COMAD COMMUNICATIONS LTD.
COMARK COMMUNICATIONS, INC.
DAJEM TECHNOLOGY CO.
DECIBEL PRODUCTS, INC.
DENSITRON MICROWAVE LTD.
DIELECTRIC COMMUNICATIONS
DOTY SCIENTIFIC
DYMA ENGINEERING
EASTERN MICROWAVE CORP.
ELCOM SYSTEMS INC.
ELECTROWAVE PRODUCTS, INC.
EQUITABLE/RENTELCO CORP.
GAMMA-F CORP.
GILBERT ENGINEERING
HARRIS CORP./GSSD/PRD INSTRUMENTS
HEWLETT-PACKARD CO.
HUBER & SUHNER INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
KAPTRON INC.
KDI ELECTRONICS
L & M ENGINEERING SOUTH
LARSEN ELECTRONICS, INC.
LECTRONIC RESEARCH LABS
LORCH ELECTRONICS DIV. OF VERNITRON CORP.
M/A-COM COMPONENTS MARKETING,INC
M/A-COM OMNI SPECTRA, INC.
MAC TECHNOLOGIES
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MAURY MICROWAVE CORP.
MERRIMAC INDUSTRIES, INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICRO COMMUNICATIONS, INC.
MICROLAB/FXR
MICROWAVE DEVICES, INC.
MICROWAVE FILTER CO., INC.
MICROWAVE SYSTEMS INC.
MICROWAVE TECHNIQUES
MIDISCO
MIDWEST MICROWAVE INC.
MINI CIRCUITS
MITEC ELECTRONICS LTD.
NARDA MICROWAVE CORP.
NORSAL INDUSTRIES INC.
NORTH HILLS ELECTRONICS, INC.
OAKBURY COMPONENTS
OLEKTRON SYSTEMS, INC.
PASTERNACK ENTERPRISES
PENSTOCK INC.
PICO PRODUCTS, INC.
PREMIER MICROWAVE CORP.
PULSAR MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RADIALL, INC.
REMEC
RF COMPONENTS
RLC ELECTRONICS, INC.
SAGE LABORATORIES, INC.
SHOKAI FAR EAST LTD.
SIGNALCRAFTERS, INC.
SOLITRON DEVICES, INC.
SYNERGY MICROWAVE CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TECHNICAL RESEARCH & MFG. (TRM)
TELE-TECH CORP.
TEST EQUIPMENT CORP.
TONY CHAPMAN ELECTRONICS LTD.
TRANSCO PRODUCTS, INC.
TRM INC.
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
VENTRONICS MICROWAVE CORP.
VIEWSONICS
WAVECOM
WAVELINE INC.
WERLATONE, INC.
WI-COMM ELECTRONICS INC.
WIDE BAND ENGINEERING CO. INC.

EQUALIZERS

ALLEN AVIONICS, INC.
ALPHA COMPONENTS, INC.
APPLIED SPECIALTIES, INC.
COMAD COMMUNICATIONS LTD.
DAJEM TECHNOLOGY CO.
DELTA MICROWAVE INC.
EATON CORP., COMPONENT & SEMICONDUCTOR
INMET CORP.
INNOWAVE (AND VIRTECH)
LECTRONIC RESEARCH LABS
M/A-COM OMNI SPECTRA, INC.
MATRIX SYSTEMS CORP.
MIDWEST MICROWAVE INC.
MITEC ELECTRONICS LTD.
NARDA
OPAMP LABS INC.
PENSTOCK INC.
PLANAR MICROWAVE, A RAYTHEON CO.
REMEC
SAGE LABORATORIES, INC.
SALISBURY ENGINEERING INC.
SHOKAI FAR EAST LTD.
SIERRA MICROWAVE TECHNOLOGY
SOLITRON DEVICES, INC.
TELEDYNE MICROWAVE
VIEWSONICS

FILTERS

CAVITY

ANTENNA SPECIALISTS CO., THE
APOLLO MICROWAVES LTD.

APPLIED SPECIALTIES, INC.
COAXIAL DYNAMICS, INC.
COM DEV
COMAD COMMUNICATIONS LTD.
CQT ELECTRONICS
DADEN ASSOCIATES, INC.
DAJEM TECHNOLOGY CO.
DECIBEL PRODUCTS, INC.
DELTA MICROWAVE INC.
DIELECTRIC COMMUNICATIONS
DYMA ENGINEERING
EASTERN MICROWAVE CORP.
GAMMA-F CORP.
GENERAL SERVICES ENGINEERING, INC.
HUBER & SUHNER INC.
INTEGRATED MICROWAVE CORPORATION
K & L MICROWAVE, INC.
KW MICROWAVE INC.
L & M ENGINEERING SOUTH
LARK ENGINEERING CO.,
 DIV. OF BAIER & BAIER INC.
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
M/A-COM LAND MOBILE COMMUNICATIONS
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MICRO COMMUNICATIONS, INC.
MICROLAB/FXR
MICROPHASE CORP.
MICROWAVE FILTER CO., INC.
MICROWAVE TECHNIQUES
MU-DEL ELECTRONICS, INC.
OAKBURY COMPONENTS
PREMIER MICROWAVE CORP.
REACTEL, INC.
REMEC
RLC ELECTRONICS, INC.
SALISBURY ENGINEERING INC.
SHOKAI FAR EAST LTD.
SINCLAIR RADIO LABS INC.
SOLITRON DEVICES, INC.
TELEDYNE MICROWAVE
TELEWAVE INC.
TELONIC BERKELEY, INC.

INFO/CARD 39

TEXSCAN INSTRUMENTS
TIL-TEK LTD.
TIME MICROWAVE
TRANSCO PRODUCTS, INC.
WATKINS-JOHNSON CO.
WAVECOM

COAXIAL

ACCUTEST INSTRUMENTS INC.
AIRTRON CORP.
ALPHA INDUSTRIES, INC.
ANTENNA SPECIALISTS CO., THE
APPLIED SPECIALTIES, INC.
BIRD ELECTRONIC CORP.
CAPCON, INC.
CASTLE MICROWAVE
COM DEV
COMAD COMMUNICATIONS LTD.
COMARK COMMUNICATIONS, INC.
CQT ELECTRONICS
DADEN ASSOCIATES, INC.
DAJEM TECHNOLOGY CO.
DECIBEL PRODUCTS, INC.

INFO/CARD 40

DELTA MICROWAVE, INC.
DENSITRON MICROWAVE LTD.
DIELECTRIC COMMUNICATIONS
DYMA ENGINEERING
GAMMA-F CORP.
GENERAL SERVICES ENGINEERING, INC.
HEWLETT-PACKARD CO.
HUBER & SUHNER INC.
INTEGRATED MICROWAVE CORPORATION
JOSEPH ELECTRONICS INC.
K & L MICROWAVE, INC.
KDI ELECTRONICS
KW MICROWAVE INC.
L & M ENGINEERING SOUTH
LARK ENGINEERING CO.,
 DIV. OF BAIER & BAIER INC.
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MICON, INC./MICROWAVE CONTROL CO. DIV.

INFO/CARD 41

Transmission Components

MICROLAB/FXR
MICROPHASE CORP.
MICROWAVE FILTER CO., INC.
MICROWAVE TECHNIQUES
MINI CIRCUITS
MITEC ELECTRONICS LTD.
MU-DEL ELECTRONICS, INC.
NORTH HILLS ELECTRONICS, INC.
OAKBURY COMPONENTS
OXLEY INC.
PASTERNACK ENTERPRISES
PENSTOCK INC.
PREMIER MICROWAVE CORP.
REACTEL, INC.
RLC ELECTRONICS, INC.
SAGE LABORATORIES, INC.
SALISBURY ENGINEERING INC.
SEALECTRO
SHOKAI FAR EAST LTD.
SOLITRON DEVICES, INC.
SPECTRUM CONTROL, INC.
TELEDYNE MICROWAVE
TELEWAVE INC.
TELONIC BERKELEY, INC.
TEXSCAN INSTRUMENTS
TIME MICROWAVE
TONY CHAPMAN ELECTRONICS LTD.
TRANSCO PRODUCTS, INC.
TUCKER ELECTRONICS
WAVECOM
WESTERN MICROWAVE INC.

HELICAL

APOLLO MICROWAVES LTD.
APPLIED SPECIALTIES, INC.
CAPCON, INC.
CQT ELECTRONICS
DADEN ASSOCIATES, INC.
DAJEM TECHNOLOGY CO.
DECIBEL PRODUCTS, INC.
DELTA MICROWAVE INC.
DENSITRON MICROWAVE LTD.
INTEGRATED MICROWAVE CORPORATION
K & L MICROWAVE, INC.
KW MICROWAVE INC.
L & M ENGINEERING SOUTH
LARK ENGINEERING CO.,
 DIV. OF BAIER & BAIER INC.
LECTRONIC RESEARCH LABS
MARCH MICROWAVE LTD.
MICROPHASE CORP.
MICROWAVE FILTER CO., INC.
REACTEL, INC.
RLC ELECTRONICS, INC.
SALISBURY ENGINEERING INC.
SHOKAI FAR EAST LTD.
TELEDYNE MICROWAVE
TELEWAVE INC.
TELONIC BERKELEY, INC.
TEXSCAN INSTRUMENTS
TIL-TEK LTD.
TOKO AMERICA, INC.
UHF ASSOCIATES

TUNABLE

ACCUTEST INSTRUMENTS INC.
ANTENNA SPECIALISTS CO., THE
APPLIED SPECIALTIES, INC.
AYDIN VECTOR DIV.
COAXIAL DYNAMICS, INC.
COMAD COMMUNICATIONS LTD.
COMARK COMMUNICATIONS, INC.
CQT ELECTRONICS
DADEN ASSOCIATES, INC.
DAJEM TECHNOLOGY CO.
DECIBEL PRODUCTS, INC.
DELTA MICROWAVE INC.
DENSITRON MICROWAVE LTD.
DIELECTRIC COMMUNICATIONS
DYMA ENGINEERING
EAGLE
EQUITABLE/RENTELCO CORP.
FERRETEC, INC.
GAMMA-F CORP.
GENERAL SERVICES ENGINEERING, INC.
HUGHES AIRCRAFT CO.
 MICROELECTRONIC CIRCUITS DIV.
INTEGRATED MICROWAVE CORPORATION
K & L MICROWAVE, INC.
KW MICROWAVE INC.
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MICROLAB/FXR
MICROWAVE FILTER CO., INC.
MITEC ELECTRONICS LTD.
OXLEY INC.
PENSTOCK INC.
PICONICS, INC.
PREMIER MICROWAVE CORP.
REMEC
RF PRODUCTS, INC.
RLC ELECTRONICS, INC.
SALISBURY ENGINEERING INC.
SHOKAI FAR EAST LTD.
TELEDYNE MICROWAVE
TELEWAVE INC.
TELONIC BERKELEY, INC.
TEMEX ELECTRONICS INC.
TEXSCAN
TEXSCAN INSTRUMENTS
TIL-TEK LTD.
TOKO AMERICA, INC.
TRANSCO PRODUCTS, INC.
U.S. INSTRUMENT RENTALS
WATKINS-JOHNSON CO.
WAVECOM
WAVETEK RF PRODUCTS, INC.
WAVETEK SAN DIEGO, INC.

HIGHPASS

ACCUTEST INSTRUMENTS INC.
AEL DEFENSE CORP.
AIRTRON CORP.
ALDA ELECTRONICS, INC.
ALLEN AVIONICS, INC.
ALPHA COMPONENTS, INC.
APOLLO MICROWAVES LTD.
APPLIED RESEARCH PRODUCTS OF
 SERVO CORP OF AMERICA
APPLIED SPECIALTIES, INC.
BIRD ELECTRONIC CORP.
CAPAR COMPONENTS
CAPCON, INC.
CAPTOR CORP.
COAXIAL DYNAMICS, INC.
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COMAD COMMUNICATIONS LTD.
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CQT ELECTRONICS
CTS CORP.
DADEN ASSOCIATES, INC.
DAJEM TECHNOLOGY CO.
DATEL, INC.
DAYTON-GRANGER, INC.
DECIBEL PRODUCTS, INC.
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DENSITRON MICROWAVE LTD.
DIELECTRIC COMMUNICATIONS
EAGLE
EASTERN MICROWAVE CORP.
EATON CORP. MICROWAVE PRODUCTS DIV.
EATON CORP., COMPONENT & SEMICONDUCTOR
EG & G CIRTECH

ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
ESC ELECTRONICS CORP.
FILTRON CO. INC.
GAMMA-F CORP.
GENERAL SERVICES ENGINEERING, INC.
GENISCO TECHNOLOGY CORP.
HUBER & SUHNER INC.
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  MICROELECTRONIC CIRCUITS DIV.
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K & L MICROWAVE, INC.
KDI ELECTRONICS
KW MICROWAVE INC.
L & M ENGINEERING SOUTH
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MICROSONICS INC.
MICROWAVE FILTER CO., INC.
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MINI CIRCUITS
MITEC ELECTRONICS LTD.
MM - WAVE TECHNOLOGY INC.
MU-DEL ELECTRONICS, INC.
NARDA
NORTH HILLS ELECTRONICS, INC.
OLEKTRON SYSTEMS, INC.
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PICONICS, INC.
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REACTEL, INC.
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RF PRODUCTS, INC.
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SHOKAI FAR EAST LTD.
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SOLITRON DEVICES, INC.
TDK CORP. OF AMERICA
TELEDYNE MICROWAVE
TELEWAVE INC.
TELONIC BERKELEY, INC.
TEMEX ELECTRONICS INC.
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EATON CORP., COMPONENT & SEMICONDUCTOR
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KW MICROWAVE INC.
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WAVETEK SAN DIEGO, INC.
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AIRTRON CORP.
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1/2-inch Diameter	3/4-inch Diameter	1-1/4-inch Diameter
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	Bandpass	
Series TBP 100-2,400MHz	Series TBA 50-1,000MHz	Series TBC 30-900MHz

BANDPASS FILTERS

Cavity

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Series TCF 400-3,000MHz, Coaxial 1/4-Wavelength Resonators, Slotted Aluminum Box
Series TCC 500-2,500MHz, Coaxial 1/4-Wavelength Resonators, Bored Aluminum Block
Series TCA 1.0-3.0GHz, Coaxial 1/4-Wavelength Resonators, Bored Aluminum Block
Series TCG 2.0-6.0GHz, Coaxial 1/4-Wavelength Resonators, Bored Aluminum Block
Series TCH 6.0-12.0GHz TM010 Resonant Cavity, Bored Aluminum Block
Series TCB 1.0-2.4GHz, Coaxial 1/4-Wavelength Resonators, Adjustable Center Frequency, Bored Aluminum Block

Interdigital

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Miniature Combline

Series TSJ 1.4-10GHz, Miniature Size, Lightweight, Minimum Insertion Loss, High Rejection, Wide Stopband

Miniature LC or Thick Film

Series TSA 40-1,000MHz, PCB Applications
Series TSC 40-600MHz, Five Sections

WAVEGUIDE FILTERS

Bandpass

TWGBP 2-26GHz, Copper Brass Invar Construction

Band Reject

TWGBR 2-26GHz, Copper Brass Invar Construction

MANUAL BANDPASS & BAND REJECT FILTERS

Iris-coupled, 0.05dB Chebyschev design, Frequency-Reading Dials, Full Octave Coverage 48MHz-4GHz Range, Individually Calibrated, Vernier Tuning, 3 or 5 sections.

TTA Series 3% & 5%, 20W Max. Input Power

TTF Series 5%, 50W Max. Input Power

TUNABLE BANDPASS FILTER SYSTEMS

TCD Series, Iris-coupled, 0.05dB Chebyschev design, 3 or 5 sections. Self-contained μP-Based Control for Interface with Digital System, RS-232, IEEE-488 and BCD Addressing, 32MHz-3GHz.

TCK Series μP-Controlled Multi-Octave Systems for continuous tuning over as many as 6 octaves. Power Supplies and Band-switching included.

SUBMINIATURE & MINIATURE ROTARY STEP ATTENUATORS

Available in 9 models with ranges from 1-100dB, 500MHz-2GHz. Tandem-mounted versions (combinations of step units) available.

BENCH-TYPE ROTARY STEP ATTENUATORS

Discrete instruments for electronics lab, production, testing or QA. 0.1, 1 and 10dB steps, 500MHz-2GHz, 3% accuracy.

COMPUTER-CONTROLLED ATTENUATORS

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- Terminations & Mismatches
- Coaxial Switches
- RF Detectors

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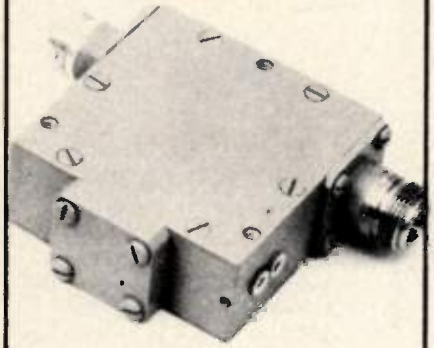
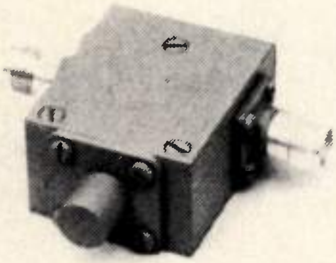
INFO/CARD 47





RLC ELECTRONICS, INC.
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TELEDYNE MICROWAVE
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TELONIC BERKELEY, INC.
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TEXSCAN INSTRUMENTS
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UHF ASSOCIATES
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VIEWSONICS
WATKINS-JOHNSON CO.
WAVECOM
WAVETEK RF PRODUCTS, INC.
WAVETEK SAN DIEGO, INC.
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COMARK COMMUNICATIONS, INC.
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DAJEM TECHNOLOGY CO.
DAYTON-GRANGER, INC.
DECIBEL PRODUCTS, INC.
DELTA MICROWAVE INC.
DIELECTRIC COMMUNICATIONS
DYMA ENGINEERING
EAGLE
EG & G CIRTECH
ESC ELECTRONICS CORP.
FERRETEC, INC.
FOX ELECTRONICS
GAMMA-F CORP.
GENERAL SERVICES ENGINEERING, INC.
GENISCO TECHNOLOGY CORP.
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REACTEL, INC.
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UHF ASSOCIATES
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WAVETEK RF PRODUCTS, INC.
WAVETEK SAN DIEGO, INC.
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COM DEV
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MICA MICROWAVE CORP.
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- FAST SWITCHING DIODES
- SCHOTTKY DIODES/MULTIBARRIER HEIGHT
- PIN/NIP LIMITER DIODES
- MIS CHIP CAPACITORS

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- DROP-INS
- MICROSTRIP CHIP
- MULTI-OCTAVE
- OPTIMIZED STANDARD BANDS TO 21 GHz

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- FREQUENCY AND AMPLITUDE TUNABLE
- SYSTEM OR TWT APPLICATIONS
- HARMONIC PHASE ENHANCERS

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SOLITRON DEVICES, INC.
TELE-TECH CORP.
TELEWAVE INC.
TIL-TEK LTD.
TRANSCO PRODUCTS, INC.
WAVECOM
WERLATONE, INC.
WI-COMM ELECTRONICS INC.
WIDE BAND ENGINEERING CO. INC.
XETRON CORP.

MULTIPLEXERS/ DIPLEXERS

AEL DEFENSE CORP.
AIRTRON CORP.
AMP INC.
ANGHEL LABORATORIES, INC.
ANTENNA SPECIALISTS CO., THE
APCOM, INC.
APOLLO MICROWAVES LTD.
APPLIED RESEARCH PRODUCTS OF
SERVO CORP OF AMERICA
APPLIED SPECIALTIES, INC.
AVNET/CHANNEL MASTER DIV.
AYDIN VECTOR DIV.
CALIFORNIA EASTERN LABORATORIES
CARDION ELECTRONICS
CASTLE MICROWAVE
COM DEV
COMAD COMMUNICATIONS LTD.
COMMUNITRONICS
DADEN ASSOCIATES, INC.
DAJEM TECHNOLOGY CO.
DATEL, INC.
DELTA MICROWAVE INC.
DIELECTRIC COMMUNICATIONS
DYMA ENGINEERING
EASTERN MICROWAVE CORP.
EATON CORP. MICROWAVE PRODUCTS DIV.
EATON CORP., COMPONENT & SEMICONDUCTOR
EON INSTRUMENTATION, INC.
EQUITABLE/RENTELCO CORP.
GAMMA-F CORP.
HUBER & SUHNER INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INTEGRATED MICROWAVE CORPORATION
JOSLYN DEFENSE SYSTEMS, INC.
K & L MICROWAVE, INC.
KAPTRON INC.
KW MICROWAVE INC.
L & M ENGINEERING SOUTH
LARK ENGINEERING CO.,
DIV. OF BAIER & BAIER INC.
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
MARCH MICROWAVE LTD.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICRO COMMUNICATIONS, INC.
MICROLAB/FXR
MICROPHASE CORP.
MICROWAVE FILTER CO., INC.
MICROWAVE SYSTEMS INC.
MICROWAVE TECHNIQUES
MITEC ELECTRONICS LTD.
MU-DEL ELECTRONICS, INC.
NARDA
NARDA MICROWAVE CORP.
NORSAL INDUSTRIES INC.
NORTH HILLS ELECTRONICS, INC.
OAKBURY COMPONENTS
OLEKTRON SYSTEMS, INC.
P&H LABORATORIES
PREMIER MICROWAVE CORP.
RACOM CORP.
REMEC
RF PRODUCTS, INC.
SALISBURY ENGINEERING INC.
SIERRA MICROWAVE TECHNOLOGY
SILICONIX, INC.
SOLITRON DEVICES, INC.
SYSTRON DONNER CORP., MICROWAVE DIV.
TELEDYNE MICROWAVE
TELONIC BERKELEY, INC.
TIME MICROWAVE
TOKO AMERICA, INC.
TRANSCO PRODUCTS, INC.
U.S. INSTRUMENT RENTALS
VIEWSONICS
WAVECOM
WAVELINE INC.
WESTERN MICROWAVE INC.
WIDE BAND ENGINEERING CO. INC.
XETRON CORP.

PHASE SHIFTERS

ACCUTEST INSTRUMENTS INC.
ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
AEL DEFENSE CORP.
AEROWAVE INC.
AIRTRON CORP.
ALPHA INDUSTRIES, INC.
AMERICAN MICROWAVE CORP.
ANGHEL LABORATORIES, INC.
APCOM, INC.
APOLLO MICROWAVES LTD.
APPLIED SPECIALTIES, INC.
CALIFORNIA AMPLIFIER, INC.
CASTLE MICROWAVE
COM DEV
COMAD COMMUNICATIONS LTD.
DAICO INDUSTRIES
DAJEM TECHNOLOGY CO.
DIELECTRIC COMMUNICATIONS
EASTERN MICROWAVE CORP.
EATON CORP. MICROWAVE PRODUCTS DIV.
ELECTROWAVE PRODUCTS, INC.
EQUITABLE/RENTELCO CORP.
GENERAL MICROWAVE CORP.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JCA TECHNOLOGY INC.
KDI ELECTRONICS
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LOCUS INC.
LORCH ELECTRONICS DIV. OF VERNITRON CORP.
M/A-COM COMPONENTS MARKETING,INC
M/A-COM OMNI SPECTRA, INC.
MARLOW ELECTRONICS LTD.
MERRIMAC INDUSTRIES, INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICROLAB/FXR
MICROWAVE SYSTEMS INC.
MICROWAVE TECHNIQUES
MIDWEST MICROWAVE INC.
MITEC ELECTRONICS LTD.
NARDA
NORSAL INDUSTRIES INC.
NORTH HILLS ELECTRONICS, INC.
OLEKTRON SYSTEMS, INC.
PACIFIC MONOLITHICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
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Microwave Frequency Dividers

DIVIDE RATIO	TYPE	F_{max} GHz	I_s MA	OUTPUT	PACKAGES
2	U 6602 B	5.0	50	70 mv	T050
	U 862 BS	2.4	40	250 mv	T050
	U 822 BS	2.1	31	250 mv	T050
	U 2620 BS	2.1	30	250 mv	T050 Ceramic
4	U 864 BS	2.4	45	250 mv	T050
	U 824 BS	2.1	37	250 mv	T050
	U 4620 BS	2.1	35	250 mv	T050 Ceramic
8	U 6608 B	6.0			T050
64	U 664 BS	1.0	50	ECL	DIP8
	U 684 BS	1.0	32	ECL	DIP8, SIP6, SO8
64,128, 256	U 833 BS	1.3	45	ECL	DIP8, SIP6, SO8
	U 833 BSE	1.3	45	EF	DIP8, SIP6, SO8
	U 813 BS	1.1	35	ECL	DIP8, SIP6, SO8
	U 813 BSE	1.1	35	EF	DIP8, SIP6, SO8
256	U 656 BS	1.5	30	ECL	DIP8
	U 847 BST	1.3	TBE	TTL	DIP8
	U 666 B	1.0	53	ECL	DIP8, SIP6
	U 666 BS	1.0	65	TTL	DIP8, SIP6
	U 686 BS	1.0	32	ECL	DIP8, SIP6, SO8
4096	U 496 BS	1.0	60	TTL	DIP8

Dual Modulus

64/65 128/129	U 689 BS	1.0	12	800 mv	DIP8, S08

ICs for Tuners and Tuning

1.0 GHz	PLL	U 6316 B
500 MHz	Front End	U 4062 B
470 MHz	Front End	U 4777 B
200 MHz	Saw Driver	U 4744 B
1.3 GHz	PLL	U 6202 B

Broadband Amplifiers

1.8 GHz	U 4518 B
2.0GHz	U 4521 B

For detailed information and/or design assistance contact:
AEG Corporation
TELEFUNKEN electronic
Rte. 22-Orr Drive, P.O. Box 3800
Somerville, NJ 08876-1269
(201) 231-8493.

TELEFUNKEN electronic
Creative Technologies

INFO/CARD 50

Transmission Components

QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RAYTHEON CO., MPTD
REMEC
RHG ELECTRONICS LABORATORY
ROBINSON LABS
SAGE LABORATORIES, INC.
SANDERS, MICROWAVE DIV. ECB
SEALECTRO
SOLITRON DEVICES, INC.
SYNERGY MICROWAVE CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TELE-TECH CORP.
TEST EQUIPMENT CORP.
TRANSCO PRODUCTS, INC.
VENTRONICS MICROWAVE CORP.
WAVELINE INC.
WERLATONE, INC.

POWER DIVIDERS/ COMBINERS

ACCUTEST INSTRUMENTS INC.
ACRIAN, INC.
ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
ADAMS-RUSSELL ELECTRONICS CO., INC.
AEL DEFENSE CORP.
AEROWAVE INC.
AIRTRON CORP.
ALAN INDUSTRIES, INC.
ALPHA INDUSTRIES, INC.
AMERICAN MICROWAVE CORP.
AMPLIFIER RESEARCH
ANAREN MICROWAVE INC.
ANDREW CORP.
ANTENNA SPECIALISTS CO., THE
APOLLO MICROWAVES LTD.
APPLIED SPECIALTIES, INC.
AVCOM OF VIRGINIA
AVTECH ELECTROSYSTEMS LTD.
BARTH ELECTRONICS, INC.
CASTLE MICROWAVE
COAXIAL COMPONENTS CORP. (COAXICOM)
COM DEV
COMAD COMMUNICATIONS LTD.
COMMUNITRONICS
CUSHCRAFT CORP.
DAJEM TECHNOLOGY CO.
DALE ELECTRONICS, INC.
DAYTON-GRANGER, INC.
DECIBEL PRODUCTS, INC.
DENSITRON MICROWAVE LTD.
DIELECTRIC COMMUNICATIONS
DOTY SCIENTIFIC
DYMA ENGINEERING
EASTERN MICROWAVE CORP.
ELCOM SYSTEMS, INC.
ELECTROWAVE PRODUCTS, INC.
EQUITABLE/RENTELCO CORP.
FLAM & RUSSELL, INC.
GAMMA-F CORP.
HARRIS CORP./GSSD/PRD INSTRUMENTS
HEWLETT-PACKARD CO.
HUBER & SUHNER INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JANEL LABORATORIES, INC.
KDI ELECTRONICS
L & M ENGINEERING SOUTH
LECTRONIC RESEARCH LABS
LOCUS INC.
LORCH ELECTRONICS DIV. OF VERNITRON CORP.
M/A-COM COMPONENTS MARKETING,INC
M/A-COM OMNI SPECTRA, INC.
MAC TECHNOLOGIES
MARCH MICROWAVE LTD.
MARLOW ELECTRONICS LTD.
MERRIMAC INDUSTRIES, INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICRO COMMUNICATIONS, INC.
MICROWAVE FILTER CO., INC.
MICROWAVE SYSTEMS INC.
MICROWAVE TECHNIQUES
MIDISCO
MIDWEST MICROWAVE INC.
MINI CIRCUITS
MITEC ELECTRONICS LTD.
MM - WAVE TECHNOLOGY INC.
NARDA MICROWAVE CORP.
NORSAL INDUSTRIES INC.
NORTH HILLS ELECTRONICS, INC.
OLEKTRON SYSTEMS, INC.
PASTERNACK ENTERPRISES
PENSTOCK INC.
PICO PRODUCTS, INC.
PICOSECOND PULSE LABS, INC.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
RAYTHEON CO., MPTD
RDL, INC.
REMEC
RF POWER SYSTEMS
RHG ELECTRONICS LABORATORY
RLC ELECTRONICS, INC.
SAGE LABORATORIES, INC.
SALISBURY ENGINEERING INC.
SCALA ELECTRONIC CORP.
SINCLAIR RADIO LABS INC.
SOLITRON/MICROWAVE
SYNERGY MICROWAVE CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TELE-TECH CORP.
TELEDYNE MICROWAVE
TELEWAVE INC.
TEST EQUIPMENT CORP.
TIL-TEK LTD.
TONY CHAPMAN ELECTRONICS LTD.
TRANSCO PRODUCTS, INC.
TRIQUINT SEMICONDUCTOR INC.
TRM INC.
VENTRONICS MICROWAVE CORP.
VIEWSONICS
WAVECOM
WAVELINE INC.
WEINSCHEL ENGINEERING
WERLATONE, INC.
WI-COMM ELECTRONICS INC.
WIDE BAND ENGINEERING CO. INC.

RELAYS

VACUUM

GILTRON INC.
JENNINGS, DIV. OF FL INDUSTRIES
KILOVAC CORP.
LSI JENNINGS
RICHARDSON ELECTRONICS, LTD.
ROSS ENGINEERING CORP.
SHOKAI FAR EAST LTD.
SURPLUS SALES OF NEBRASKA

MECHANICAL

ALAUN ENG.
APPLIED SPECIALTIES, INC.
AROMAT CORP.
CARDINAL CONTROL CO. INC.
COMMUNICATIONS INSTRUMENTS INC. (CII)
COTO COIL CORP.
GILTRON INC.
HAMLIN INC.
ITT COMPONENTS
JOSEPH ELECTRONICS INC.
JOSLYN DEFENSE SYSTEMS, INC.
K & L MICROWAVE, INC.
KILOVAC CORP.
LSI JENNINGS
MAGNECRAFT ELECTRIC CO.
MIDISCO
OMRON ELECTRONICS, INC.
RF COMPONENTS
RICHARDSON ELECTRONICS, LTD.
ROSS ENGINEERING CORP.
SAGE LABORATORIES, INC.
SHOKAI FAR EAST LTD.
SIEMENS COMPONENTS INC.,
 SPECIAL PRODUCTS DIV.
SURPLUS SALES OF NEBRASKA
TELEDYNE MICROWAVE
TELEDYNE RELAYS
UHF ASSOCIATES

MULTI-POLE

AROMAT CORP.
CARDINAL CONTROL CO. INC.
COMMUNICATIONS INSTRUMENTS INC. (CII)
DAICO INDUSTRIES
GILTRON INC.
ITT COMPONENTS
JOSLYN DEFENSE SYSTEMS, INC.
K & L MICROWAVE, INC.

MAGNECRAFT ELECTRIC CO.
MATRIX SYSTEMS CORP.

OLEKTRON SYSTEMS, INC.
OMRON ELECTRONICS, INC.
RF COMPONENTS
RICHARDSON ELECTRONICS, LTD.
ROSS ENGINEERING CORP.
SAGE LABORATORIES, INC.
SHOKAI FAR EAST LTD.
SURPLUS SALES OF NEBRASKA
TELEDYNE MICROWAVE
TELEDYNE RELAYS

SOLID STATE

A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL, LTD.
ALAUN ENG.
APPLIED SPECIALTIES, INC.
AROMAT CORP.
CARDINAL CONTROL CO. INC.
DAICO INDUSTRIES
GILTRON INC.
GRAYHILL INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
HYBRIDS INTERNATIONAL, LTD.
ITT COMPONENTS
JOSEPH ELECTRONICS INC.
JOSLYN DEFENSE SYSTEMS, INC.
KIDDE INC.
MAGNECRAFT ELECTRIC CO.
MATRIX SYSTEMS CORP.

OLEKTRON SYSTEMS, INC.
OMRON ELECTRONICS, INC.
REL LABS, INC.
RICHARDSON ELECTRONICS, LTD.
SHOKAI FAR EAST LTD.
SIEMENS COMPONENTS INC.,
SPECIAL PRODUCTS DIV.
SOLITRON DEVICES, INC.
SURPLUS SALES OF NEBRASKA
TELEDYNE RELAYS
UHF ASSOCIATES

RF CONNECTORS

ACCUTEST INSTRUMENTS INC.
ADAMS-RUSSELL ELECTRONICS CO., INC.
ADAMS-RUSSELL ELECTRONICS, MODPAK
AIRBORN CONNECTORS
ALPHA PRODUCTS
AMP INC.

AMPHENOL NORTH AMERICA
AMPHENOL RF/MICROWAVE OPERATIONS
ANDREW CORP.
APPLIED ENGINEERING PRODUCTS
APPLIED SPECIALTIES, INC.
AUTOMATIC CONNECTOR INC.
AVA ELECTRONICS CORP.
AVIEL ELECTRONICS
BI-TRONICS, INC.
BICC TECHNOLOGY VENTURES
BIRD ELECTRONIC CORP.
BREEZE ILLINOIS
CALREP
CAMBRIDGE PRODUCTS CORP.
CASTLE MICROWAVE
CELLTRONICS
CERAMSEAL
CHILDS CORP.
COAXIAL COMPONENTS CORP. (COAXICOM)
COAXIAL CONNECTORS INC.
COAXITUBE CORP.
COMAD COMMUNICATIONS LTD.
COMPAC DEVELOPMENT CORP.
CONCORD ELECTRONICS CORP.
CONNECTING DEVICES, INC.
CONTEC INC.
CORCOM, INC.
CUSHCRAFT CORP.
DALE ELECTRONICS, INC.
DECIBEL PRODUCTS, INC.
DETORONICS CORP.
DIELECTRIC COMMUNICATIONS
DUPONT CONNECTOR SYSTEMS
DYMA ENGINEERING
DYNAWAVE
EF JOHNSON
ELECTRONIC RESOURCES INC.
EMC TECHNOLOGY, INC.
ESCO ASSOC.
FISCHER AMERICA, INC.
FREDERICK COMPONENTS
G & H TECHNOLOGY INC.
GILBERT ENGINEERING
GLASSEAL PRODUCTS, INC.
GLENAIR CORP.
GTE CONNECTOR PRODUCTS
HUBER & SUHNER INC.
ITT CANNON
ITT POMONA ELECTRONICS
ITT SCHADOW INC.
JOSEPH ELECTRONICS INC.
KEVLIN MICROWAVE CORP.
KINGS ELECTRONICS CO. INC.
M/A-COM COMPONENTS MARKETING,INC
M/A-COM OMNI SPECTRA, INC.
MALCO, MICRODOT INC., CONNECTOR, INTERCONNECT SYSTEMS DIV.
MANHATTAN ELEC. CABLE CORP.
MARCH MICROWAVE LTD.
MARSHALL ELECTRONICS

Transmission Components

MAURY MICROWAVE CORP.
MCMURDO CONNECTORS
METHODE ELECTRONICS, INC.
MICRO COAX COMPONENTS, INC.
MICRO COMMUNICATIONS, INC.
MICRODOT
MICROTECH,INC.
MICROWAVE TECHNIQUES
MIDISCO
MOLEX INC.
MOUSER ELECTRONICS
NATIONAL TEL-TRONICS
PALCO CONNECTOR INC.
PASCALL ELECTRONICS LTD.
PASTERNACK ENTERPRISES
PENSTOCK INC.
PICO PRODUCTS, INC.
R.F. INDUSTRIES
RADIALL, INC.
RETCONN INC.
RF INDUSTRIES
SCALA ELECTRONIC CORP.
SEALECTRO
SEMICOA
SINCLAIR RADIO LABS INC.
SOLITRON DEVICES, INC.
SOLITRON/MICROWAVE
SOURIAY
SPECIALTY CONNECTOR CO. INC.
SPECTRUM CONTROL, INC.
SUNBANK ELECTRONICS
SURPLUS SALES OF NEBRASKA
TELEWAVE INC.
TEMTRON ELECTRONICS LTD.
TEST EQUIPMENT CORP.
TONY CHAPMAN ELECTRONICS LTD.
TROMPETER ELECTRONICS
UNITED MICROWAVE PRODUCTS, INC.
VIEWSONICS
W.L. GORE & ASSOCIATES, INC.
WEINSCHEL ENGINEERING
WHITTAKER ELECTRONIC RESOURCES
WILTRON CO.
WORLD BUSINESS CORP. INC.

SWITCHES

ELECTROMECHANICAL

ACCUTEST INSTRUMENTS INC.
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AIRTRON CORP.
AMP INC.
APPLIED SPECIALTIES, INC.
AROMAT CORP.
AUTOMATIC CONNECTOR INC.
BIRD ELECTRONIC CORP.
CHERRY ELECTRICAL PRODUCTS
COM DEV
COMAD COMMUNICATIONS LTD.
COMPAC DEVELOPMENT CORP.
CTS CORP.
DAICO INDUSTRIES
DB PRODUCTS INC.
DIELECTRIC COMMUNICATIONS
DOWKEY MICROWAVE CORP.
DYMA ENGINEERING
DYNATECH
DYNATECH MICROWAVE TECHNOLOGY, INC.
E/M CORP.
ELECTRO MECH. COMPONENTS, INC.
ELECTROSPACE SYSTEMS, INC.
ELECTROSWITCH CORP.
ELMA SWITCH CORP.
GRAYHILL INC.
HEWLETT-PACKARD CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
ITW SWITCHES
JFW INDUSTRIES, INC.
JOSLYN DEFENSE SYSTEMS, INC.
K & L MICROWAVE, INC.
KAY ELEMETRICS CORP.
KILOVAC CORP.
LSI JENNINGS
LUCAS LEDEX, INC.
M/A-COM COMPONENTS MARKETING,INC
M/A-COM OMNI SPECTRA, INC.
MARCH MICROWAVE LTD.
MARLEE SWITCH CO.
MARSHALL ELECTRONICS
MEPCO/CENTRALAB, INC.
MICROLAB/FXR
MICRONETICS INC.
MIDISCO
NAMCO CONTROLS
OMRON ELECTRONICS, INC.
PACIFIC WEST ELECTRONICS
PENSTOCK INC.
PICO PRODUCTS, INC.
POWER DYNAMICS INC.
RADIALL, INC.
RF COMPONENTS
RLC ELECTRONICS, INC.
ROBINSON LABS
ROSS ENGINEERING CORP.
SAGE LABORATORIES, INC.
SEACOR, INC.
SECMA, INC.
SECTOR MICROWAVE IND. INC.
SHOGYO INTL CORP.
SHOKAI FAR EAST LTD.
STANDARD GRIGSBY
STETCO, INC.
SYSTRON DONNER CORP., MICROWAVE DIV.
TEKTRONIX, INC.
TELEDYNE MICROWAVE
TOKO AMERICA, INC.
TONY CHAPMAN ELECTRONICS LTD.
TRANSCO PRODUCTS, INC.
VARI-L
VIEWSONICS
WAVECOM
WAVELINE INC.
WILBRECHT ELECTRONICS

SOLID STATE

ADAMS RUSSELL ELECTRONICS - ANZAC DIV.
ADAMS-RUSSELL ELECTRONICS
ADAMS-RUSSELL SEMICONDUCTOR CENTER
AEL DEFENSE CORP.
AIRTRON CORP.
ALAUN ENG.
ALPHA INDUSTRIES, INC.
ALPHA PRODUCTS
AMERICAN MICROWAVE CORP.
AMPLIFONIX, INC.
ANALOG DEVICES
ANGHEL LABORATORIES, INC.
APPLIED SPECIALTIES, INC.
BRIMROSE CORP.
CASTLE MICROWAVE
DAICO INDUSTRIES
DAJEM TECHNOLOGY CO.
DOTY SCIENTIFIC
DYNATECH
EATON CORP. MICROWAVE PRODUCTS DIV.
EATON CORP., COMPONENT & SEMICONDUCTOR
ELECTROWAVE PRODUCTS, INC.
ELMA SWITCH CORP.
GENNUM CORPORATION
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INNOWAVE (AND VIRTECH)
ITW SWITCHES
JCA TECHNOLOGY INC.
JFW INDUSTRIES, INC.
KDI ELECTRONICS
LORCH ELECTRONICS DIV. OF VERNITRON CORP.
M/A-COM COMPONENTS MARKETING,INC
MARCH MICROWAVE LTD.
MARLEE SWITCH CO.
MAXIM INTEGRATED PRODUCTS
MERRIMAC INDUSTRIES, INC.
MINI CIRCUITS
NAMCO CONTROLS
NARDA MICROWAVE CORP.
NORSAL INDUSTRIES INC.
NORTH HILLS ELECTRONICS, INC.
OAKBURY COMPONENTS
OLEKTRON CORP.
OLEKTRON SYSTEMS, INC.
OPTIMAX, INC
P&H LABORATORIES
PACIFIC MONOLITHICS
PACIFIC WEST ELECTRONICS
PASCALL ELECTRONICS LTD.
PENSTOCK INC.
PHOENIX MICROWAVE CORP.
PICO PRODUCTS, INC.
PLANAR MICROWAVE, A RAYTHEON CO.
PREMIER MICROWAVE CORP.
PULSAR MICROWAVE CORP.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.

RACOM CORP.
RAYTHEON CO., MPTD
RDL, INC.
REL LABS, INC.
REMEC
RLC ELECTRONICS, INC.
ROBINSON LABS
SALISBURY ENGINEERING INC.
SDI MICROWAVE INC.
SHOKAI FAR EAST LTD.
SIERRA MICROWAVE TECHNOLOGY
SOLITRON DEVICES, INC.
TACHONICS CORP.
TEKTRON MICRO ELECTRONICS INC.
TELE-TECH CORP.
TIL-TEK LTD.
TONY CHAPMAN ELECTRONICS LTD.
TRIQUINT SEMICONDUCTOR INC.
VARI-L
VENTRONICS MICROWAVE CORP.
VIEWSONICS
VIRTECH
WATKINS-JOHNSON CO.
WESTERN MICROWAVE INC.
WIDE BAND ENGINEERING CO. INC.

TERMINATIONS

ACCUTEST INSTRUMENTS INC.
ACRIAN, INC.
ADAMS-RUSSELL ELECTRONICS CO., INC.
AEROWAVE INC.
AIRTRON CORP.
ALAN INDUSTRIES, INC.
AMPHENOL RF/MICROWAVE OPERATIONS
ANTENNA SPECIALISTS CO., THE
APOLLO MICROWAVES LTD.
APPLIED RESEARCH PRODUCTS OF SERVO CORP OF AMERICA
APPLIED SPECIALTIES, INC.
AUTOMATIC CONNECTOR INC.
AVA ELECTRONICS CORP.
AVIEL ELECTRONICS
BARRY INDUSTRIES (TRX DIV.)
BARTH ELECTRONICS, INC.
BI-TRONICS, INC.
BIRD ELECTRONIC CORP.
CALREP
COAXIAL COMPONENTS CORP. (COAXICOM)
COAXIAL DYNAMICS, INC.
COM DEV
CONCORD ELECTRONICS CORP.
CORE-TRONICS DIV. KRYSTINEL CORP.
DAJEM TECHNOLOGY CO.
DECIBEL PRODUCTS, INC.
DIELECTRIC COMMUNICATIONS
DIELECTRIC SCIENCES
DYMA ENGINEERING
EASTERN MICROWAVE CORP.
ELCOM SYSTEMS, INC.
ELECTRONIC RESOURCES INC.
EMC TECHNOLOGY, INC.
EQUITABLE/RENTELCO CORP.
ESCO ASSOC.
FLORIDA RF LABS, INC.
GAMMA-F CORP.
GILBERT ENGINEERING
HEWLETT-PACKARD CO.
HUBER & SUHNER INC.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INMET CORP.
ITT POMONA ELECTRONICS
JFW INDUSTRIES, INC.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
M/A-COM LAND MOBILE COMMUNICATIONS
M/A-COM OMNI SPECTRA, INC.
MARLOW ELECTRONICS LTD.
MERRIMAC INDUSTRIES, INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICROLAB/FXR
MICRONETICS INC.
MICROWAVE DEVICES, INC.
MIDISCO
MIDWEST MICROWAVE INC.
MINI CIRCUITS
MITEC ELECTRONICS LTD.
NARDA MICROWAVE CORP.
NORTH HILLS ELECTRONICS, INC.
O.K. INDUSTRIES INC.
P&H LABORATORIES
PASTERNACK ENTERPRISES
PENSTOCK INC.
PICO PRODUCTS, INC.
POLYMER DESIGN
RADIALL, INC.
RAYTHEON CO., MPTD
RESIN SYSTEMS CORP.
RFDC INC.
RLC ELECTRONICS, INC.
SAGE LABORATORIES, INC.
SHOGYO INTL CORP.
SINCLAIR RADIO LABS INC.
SOLITRON DEVICES, INC.
SOLITRON/MICROWAVE
SPECIALTY CONNECTOR CO. INC.
SYSTRON DONNER CORP., MICROWAVE DIV.
TELONIC BERKELEY, INC.
TEST EQUIPMENT CORP.
TEST PROBES, INC.
TEXSCAN INSTRUMENTS
TONY CHAPMAN ELECTRONICS LTD.
TROMPETER ELECTRONICS
UNITED MICROWAVE PRODUCTS, INC.
VIEWSONICS
WAGO CORP.
WAVELINE INC.
WEINSCHEL ENGINEERING
WIDE BAND ENGINEERING CO. INC.
WILTRON CO.
WORLD BUSINESS CORP. INC.

TUNERS

AACOM DIVISION OF DATUM, INC.
ACCUTEST INSTRUMENTS INC.
AEROWAVE INC.
AIRTRON CORP.
COAXIAL COMPONENTS CORP. (COAXICOM)
DAJEM TECHNOLOGY CO.
DIELECTRIC COMMUNICATIONS
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
LECTRONIC RESEARCH LABS
M/A-COM COMPONENTS MARKETING,INC
M/A-COM OMNI SPECTRA, INC.
MAURY MICROWAVE CORP.
MICROLAB/FXR
MICROWAVE TECHNIQUES
PREMIER MICROWAVE CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TEST EQUIPMENT CORP.
TOKO AMERICA, INC.
TONY CHAPMAN ELECTRONICS LTD.
UHF ASSOCIATES
WATKINS-JOHNSON CO.
WAVELINE INC.

CAD/CAE SOFTWARE & SYSTEMS

SOFTWARE

CIRCUIT ANALYSIS/DESIGN

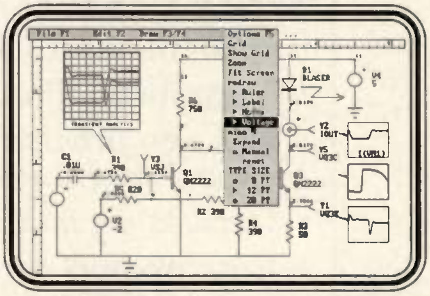
ANALOP ENGINEERING
APPLIED I
CALREP
CIRCUIT BUSTERS, INC.
COMPACT SOFTWARE, INC.
DAJEM TECHNOLOGY CO.
DESIGN AUTOMATION, INC.
E.E. PUBLIC DOMAIN LIBRARY
EESOF, INC.
EI INTL, INC.
G & H TECHNOLOGY INC.
HAYWARD ELECTRONIC SYSTEMS, INC.
HEWLETT-PACKARD CO.
INTERLEAVE, INC.
INTUSOFT
JENSEN TRANSFORMERS, INC.
MADE IT ASSOCIATES, INC.
MICROWAVE SOFTWARE
RF ENGINEERING
SOFCAD ELECTRONICS, INC.
SPEFCO SOFTWARE
SUNCREST SOFTWARE
WEBB LABORATORIES
XETRON CORP.

SYSTEMS ANALYSIS/DESIGN

488 TEST SYSTEMS
ANALOG DESIGN TOOLS
APPLIED I
APPLIED SPECIALTIES, INC.
AUTODESK, INC.
CALIFORNIA SCIENTIFIC SOFTWARE
COMPACT SOFTWARE, INC.
DAJEM TECHNOLOGY CO.
DGS ASSOCIATES
E.E. PUBLIC DOMAIN LIBRARY
EESOF, INC.
EI INTL, INC.
G & H TECHNOLOGY INC.
INTERFERENCE CONTROL TECHNOLOGIES, INC.
INTERLEAVE, INC.
INTERSIL INC.
INTUSOFT
IRT CORP.
JOHN MURRAY ASSOCIATES
L & M ENGINEERING SOUTH
SIGNATURE DESIGNS
SIMON SOFTWARE, INC.
SOFTWARE DEVELOPMENT SYS.
STRAIGHT FORWARD
TELEMUS ELECTRONIC SYSTEMS INC.
TUTSIM PRODUCTS
WEBB LABORATORIES
XETRON CORP.

TRANSMISSION LINE

ANALOP ENGINEERING
COMPACT SOFTWARE, INC.
CONSULTEK SOFTWARE SYSTEMS, INC.



CAD/CAE Software and Systems

DAJEM TECHNOLOGY CO.
E.E. PUBLIC DOMAIN LIBRARY
EESOF, INC.
G & H TECHNOLOGY INC.
HAYWARD ELECTRONIC SYSTEMS, INC.
HEWLETT-PACKARD CO.
INTERLEAVE, INC.
INTUSOFT
L & M ENGINEERING SOUTH
MADE IT ASSOCIATES, INC.
MICROWAVE SOFTWARE
MICROWAVE SOFTWARE APPLICATIONS, INC.
RF ENGINEERING
SIGNAL ONE
SUNCREST SOFTWARE
TEST EQUIPMENT CORP.
WEBB LABORATORIES
WEINSCHEL ENGINEERING

EMC/TEMPEST

A.H. SYSTEMS, INC.
ALPHA INDUSTRIES, INC.
AMPLIFIER RESEARCH
ANDREW CORP.
C.K. CONSULTANTS, INC.
DOW INDUSTRIES
EATON AIL DIV.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO-MECHANICS CO.,THE (EMCO)
EQUITABLE/RENTELCO CORP.
HEWLETT-PACKARD CO.
INSTRUMENTS FOR INDUSTRY, INC.
LECTRONIC RESEARCH LABS
MAGNETIC RADIATION LABORATORIES, INC.
RADIOMETRICS CORP.
RADIOMETRICS MIDWEST CORP.
SHOKAI FAR EAST LTD.
TEST EQUIPMENT CORP.
TEXAS SPECTRUM ELECTRONICS INC.
TIL-TEK LTD.
WATKINS-JOHNSON CO.

TIME DOMAIN ANALYSIS

CALIFORNIA SCIENTIFIC SOFTWARE
COMPACT SOFTWARE, INC.
DAJEM TECHNOLOGY CO.
DESIGN AUTOMATION, INC.
E.E. PUBLIC DOMAIN LIBRARY
EESOF, INC.
EI INTL, INC.
G & H TECHNOLOGY INC.
INTERLEAVE, INC.
INTUSOFT
JENSEN TRANSFORMERS, INC.
MADE IT ASSOCIATES, INC.
RF ENGINEERING
SOFCAD ELECTRONICS, INC.
STAR MICROWAVE
TEST EQUIPMENT CORP.
TUTSIM PRODUCTS
WEBB LABORATORIES
XETRON CORP.

PC BOARD DESIGN

BISHOP GRAPHICS, INC.
COMPACT SOFTWARE, INC.
CONSULTEK SOFTWARE SYSTEMS, INC.
EESOF, INC.
INSTANT BOARD CIRCUITS,CORP.
INTERFERENCE CONTROL TECHNOLOGIES, INC.
INTERLEAVE, INC.
INTUSOFT
SIGNATURE DESIGNS
STEP ELECTRONICS
XETRON CORP.

CIRCUIT OPTIMIZATION

ANALOP ENGINEERING
APPLIED I
CALREP
CIRCUIT BUSTERS, INC.
COMPACT SOFTWARE, INC.
DAJEM TECHNOLOGY CO.
DESIGN AUTOMATION, INC.
E.E. PUBLIC DOMAIN LIBRARY
EESOF, INC.
EI INTL, INC.
G & H TECHNOLOGY INC.
HAYWARD ELECTRONIC SYSTEMS, INC.
HEWLETT-PACKARD CO.
INTERLEAVE, INC.
INTUSOFT
JENSEN TRANSFORMERS, INC.
MADE IT ASSOCIATES, INC.
MICROWAVE SOFTWARE
RF ENGINEERING
SOFCAD ELECTRONICS, INC.
SPEFCO SOFTWARE
SUNCREST SOFTWARE
WEBB LABORATORIES
XETRON CORP.

SYSTEMS - HARDWARE

ANALOP ENGINEERING
AP MICROWAVE
APPLIED SPECIALTIES, INC.
EESOF, INC.
HEWLETT-PACKARD CO.
INTERLEAVE, INC.
INTUSOFT
NORTH HILLS ELECTRONICS, INC.
OLEKTRON SYSTEMS, INC.
SIGNATURE DESIGNS
WEINSCHEL ENGINEERING

ATC Multilayer UHF/Microwave Porcelain & Ceramic Chip Capacitors

ATC 100 UHF/MICROWAVE PORCELAIN **SUPERCHIP**™ CAPACITORS

- QPL Approved, MIL-C-55681, BG Characteristic (+90 ±20 PPM/°C), to Failure Rate Level S, and MIL-C-11272. Meets applicable requirements of MIL-C-123.
- High Q: greater than 10,000 at 1MHz
- Case A: 0.1 pF to 100 pF to 150 WVDC
- Case B: 0.1 pF to 1000 pF to 500 WVDC
- Std. values per RETMA 5% table
- Available in Case A and B chips, pellets, and Case B leaded styles

ATC 100E HF/VHF/UHF LOW LOSS TRANSMITTER PORCELAIN CAPACITORS

- The Industry's Smallest RF High Power Capacitors
- High Q: greater than 10,000 at 1MHz
- 1.0 pF to 2200 pF to 3600 WVDC
- Available in Chips and Pellets, body dimensions 0.395 in. (10.03mm) x 0.390 in. (9.91mm) x 0.170 in. (4.32mm) max.
- Available in leaded styles, body dimensions 0.415 in. (10.54mm) x 0.390 in. (9.91mm) x 0.170 in. (4.32mm) max.

ATC 175 ULTRA HIGH Q PORCELAIN CAPACITORS

- Q is typically 4 × higher than best industry standard (ATC100)
- Case B: 1.0 pF to 100 pF to 500 WVDC
- Std. values per RETMA 5% table
- Available in Case B chips, pellets, and microstrip (MS) leaded style

ATC 700 NPO TEMPERATURE STABLE CERAMIC CAPACITORS

- QPL Approved, MIL-C-55681, BP Characteristic (0 ± 30PPM/°C), to Failure Rate Level S. Meets applicable requirements of MIL-C-123.
- Case A: 0.1 pF to 1000 pF to 150 WVDC
- Case B: 0.1 pF to 5100 pF to 500 WVDC
- Std. values per RETMA 5% table
- Available in Case A and B chips, pellets, and Case B leaded styles

ATC 200 SERIES HIGH PACKAGING DENSITY CERAMIC CAPACITORS

- Ideal for coupling and bypass applications
- Hi Pot: 300% of working voltage
- Case A: 510 pF to 0.01 MF, 50 WVDC
- Case B: 0.005 MF to 0.1 MF, 50 WVDC
- Std. values per RETMA 10% table
- Available in Case A and B chips, pellets, and Case B leaded styles

100 CASE A Chip: Length = .055 ± .015, Width = .055 ± .015
100 CASE A Pellet: Length = .055 ± .025, Width = .055 ± .015
100 CASE B Chip: Length = .110 ± .020, Width = .110 ± .020
100 CASE B Pellet: Length = .110 + .035 − .020, Width = .110 ± .020
NOTE: All dimensions are in inches.

Dielectric Withstanding Voltage (DWV) on 100 A Case units is 400% of working voltage. All other devices are 250% of working voltage.

48 Hour Shipment for 250 Capacitors or Less.

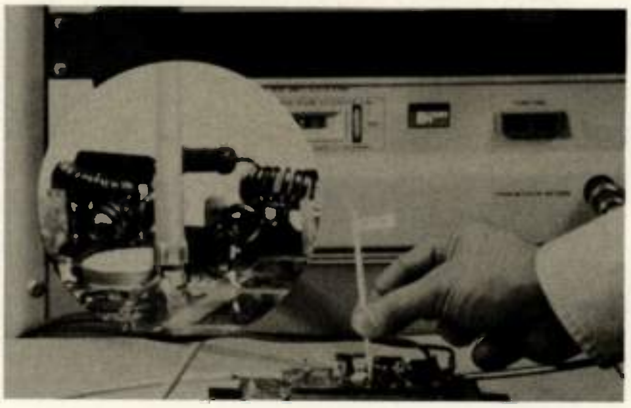
ATC is the industry leader for quality, rugged, reliable **UHF/Microwave Capacitors.** Our new **QUIK-PICK**™ System launches our commitment to be the leader in service and customer satisfaction. At American Technical Ceramics, we know the importance of your deadline.

MIL-C-55681
CDR11 THROUGH
CDR25
NOW AVAILABLE

At ATC, Deadlines Are No Joke.

american technical ceramics CORP.
one norden lane, huntington station, n.y. 11746-2102
516-271-9600 • telexes 221201 • 825707 • fax 516-271-9615

INFO/CARD 60



$49^{95}

New From ATC: Tuning Sticks

Select the capacity value your circuit needs with ease.

Now during bench test or design, value selection can be achieved without soldering capacitors in.

A Tuning Stick consists of an ATC 100 Series Superchip® permanently attached to a non-conductive holder. The Stick material is selected so that its effect on the capacitance value and Q is minimal.

Tuning Stick Kits are available off the shelf. Request **ATC TS1001.** 48 Hour **QUIK-PICK**™ Shipment.

Tuning Stick Kits contain 20 values:

CAPACITY VALUE (pf)	TOL.
0.1	B
0.5	
1.0	C
1.2	
1.5	
1.8	
2.2	

CAPACITY VALUE (pf)	TOL.
2.7	C
3.3	
3.9	
4.7	
5.6	
6.8	J
8.2	

CAPACITY VALUE (pf)	TOL.
10	J
47	
68	
100	
470	K
1000	

TOLERANCE CODE: B = ±0.1 pf; C = ±0.25 pf; J = ±5%; K = ±10%

INFO/CARD 61

MATERIALS AND HARDWARE

CABINETS AND ENCLOSURES

ADVANCED MACHINING TECHNIQUES, INC.
AEG CORPORATION
AIMSCO INC.
AMCO ENGINEERING CO.
BUD INDUSTRIES
CALREP
COMMUNICATIONS EQUIPMENT CO., INC.
COMPAC DEVELOPMENT CORP.
CONTACT EAST
CTS CORP.
DAVLE TECH, INC.
DORLEC CORP.
DYMA ENGINEERING
EAGLE MAGNETIC CO INC.
ELECTRONIC RESOURCES INC.
ENCLOSURE CORP.
EQUIFTO ELECTRONICS CORP.
ESCO ASSOC.
FILCOIL CO., INC.
FOX ELECTRONICS
HEEGER, INC.
HOFFMAN ENGINEERING CO.
JOE QUIN MFG. CORP.
JOSEPH ELECTRONICS INC.
KEYSTONE METAL PRODUCTS, INC.
LECTROMAGNETICS, INC.
LECTRONIC RESEARCH LABS
MAGNETIC RADIATION LABORATORIES, INC.
MARSHALL ELECTRONICS
MOUSER ELECTRONICS
OPTIMA ENCLOSURES
PACIFIC WEST ELECTRONICS
PARTFOLIO, INC.
PLASTRONIC ENGINEERING CO. INC.
PNEUMAFIL CORP.
PREMIER METAL PRODUCTS CO.
SKYDYNE
STRONGBOX
TELEMETRY TECHNOLOGIES, INC.
VECTOR ELECTRONIC CO.
ZERO CORP.

CERAMICS

A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL, LTD.
ACCURATE SCREW MACHINE CO. INC.
ALPHA INDUSTRIES, INC.
AREMCO PRODUCTS, INC.
BRIM ELECTRONICS, INC.
CENTRE ENGINEERING, INC.
CERAMIC DEVICES, INC.
COORS CERAMICS CO.
CORNING GLASSWORKS
DABURN ELECTRONICS & CABLE CORP.
DIELECTRIC LABORATORIES, INC.
GE CERAMICS
HYBRIDS INTERNATIONAL, LTD.
KYOCERA NORTHWEST
MIC TECHNOLOGY CORP.
MORGAN MATROC - UNILATOR DIVISION
MORGAN MATROC LTD., UNILATOR DIV.
MYKROY/MYCALEX CERAMICS
NTK TECHNICAL CERAMICS
OAKBURY COMPONENTS
PIEZO ELECTRIC PRODUCTS INC.
STETCO, INC.
TDK CORP. OF AMERICA
TECHNICAL COMPONENTS INC.
VERNITRON CORP., PIEZO ELECTRIC DIV.

COATINGS - ENVIRONMENTAL

ALPHA INDUSTRIES, INC.
AREMCO PRODUCTS, INC.
ATOCHEM
BEE CHEMICAL, DIV. OF MORTON THIOKOL
CARFOLL COATINGS CO., INC.
CHEMFAB CHEMICAL FABRICS
E/M CORP.
EPOXY TECHNOLOGY INC.
GE SILICONES
MICRO CIRCUITS CO., INC.
PRECISION METAL FINISHING
TAFA INC.

COMPONENT/HYBRID PACKAGES

BALO PRECISION PARTS
BARRY INDUSTRIES (TRX DIV., VALBAR DIV.)
COMTEC ECONOMATION
COORS CERAMICS CO.
ELECTRONIC RESOURCES INC.
INTERNATIONAL SENSOR SYSTEMS, INC.
MICROLAB/FXR
NORCOMM CORP.
PICONICS
PLASTONIC ENGINEERING CO., INC.
POWEREX, INC.
REEVES-HOFFMAN
REL LABS, INC.
SOLITRON DEVICES, INC.
SPECTRUM CONTROL, INC.
TECHNICAL COMPONENTS INC.
TOKO-AMERICA, INC.

CRYSTAL BLANKS

A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL, LTD.
CAL CRYSTAL LAB, INC./COMCLOK, INC.
CRYSTAL TECHNOLOGY INC.
DELTRONIC CRYSTAL INDUSTRIES, INC.
FOX ELECTRONICS
HI-Q CRYSTALS DIV.
HYBRIDS INTERNATIONAL, LTD.
MATEC CORP./VALPEY - FISHER CORP.
PIEZO TECHNOLOGY, INC.
REEVES - HOFFMAN
SOLITRON DEVICES, INC.

ELECTRONIC HARDWARE

ACCURATE SCREW MACHINE CO. INC.
AEG CORPORATION
AIMSCO INC.
BEAD ELECTRONICS DIV., BEAD CHAIN MFG. CO.
BRIM ELECTRONICS, INC.
BUD INDUSTRIES
BUDWIG MFG. CO.
CONCORD ELECTRONICS CORP.
CTS CORP./KNIGHTS DIV.
DABURN ELECTRONICS & CABLE CORP.
DETORONICS CORP.
DORLEC CORP.
DYMA ENGINEERING
EF JOHNSON
FERROXCUBE
JETTRON PRODUCTS, INC.
JOHN FLUKE MFG. CO. INC.
JOSEPH ELECTRONICS INC.
L.E.A. DYNATECH, INC.
MARSHALL ELECTRONICS
MICROTECH,INC.
MITEC ELECTRONICS LTD.
O.K. INDUSTRIES INC.
POWER DYNAMICS INC.
RF PROTOTYPE SYSTEMS
SHOGYO INTL CORP.
SURPLUS SALES OF NEBRASKA
TELEMUS ELECTRONIC SYSTEMS INC.
TEST EQUIPMENT CORP.
VIEWSONICS
VITRO SERVICES CORP.
WAGO CORP.

EQUIPMENT RACKS

ACCUTEST INSTRUMENTS INC.
AEG CORPORATION
AMCO ENGINEERING CO.
BUD INDUSTRIES
CALREP

COMAD COMMUNICATIONS LTD.
COMMUNICATIONS EQUIPMENT CO., INC.
COMPAC DEVELOPMENT CORP.
CTS CORP.
DECIBEL PRODUCTS, INC.
DORLEC CORP.
DYMA ENGINEERING
ENCLOSURE CORP.
EQUIPTO ELECTRONICS CORP.
JOE QUIN MFG. CORP.
JOSEPH ELECTRONICS INC.
LECROY CORP.
LECTRONIC RESEARCH LABS
MARSHALL ELECTRONICS
OPTIMA ENCLOSURES
PNEUMAFIL CORP.
PREMIER METAL PRODUCTS CO.
VIEWSONICS

FERRITES AND OTHER MAGNETICS

ALPHA INDUSTRIES, INC.
ATOCHEM
CAPCON, INC.
CASTLE MICROWAVE
CORE-TRONICS DIV. KRYSTINEL CORP.
CORTEC, INC
DELTRONIC CRYSTAL INDUSTRIES, INC.
ELGIN ELECTRONICS
EMINETICS
FAIR-RITE PRODUCTS CORP.
FERRITE COMPONENTS, INC.
FERRONICS INC.
FERROXCUBE
GILTRON INC.
ISKRA ELECTRONICS
KRYSTINEL CORP.
LODESTONE
MAGNETICS, DIV. OF SPANG & CO.
MICROMETALS
MITEC ELECTRONICS LTD.
NATIONAL MAGNETICS GROUP INC.
NOVAMET SPECIALTY PRODUCTS CORP.
PALOMAR ENGINEERS
POLYMER CORP.
POLYMER DESIGN
RF POWER SYSTEMS
SIEMENS COMPONENTS INC.,
 SPECIAL PRODUCTS DIV.
STACKPOLE CORP.
SURPLUS SALES OF NEBRASKA
TDK CORP. OF AMERICA
TEXAS SPECTRUM ELECTRONICS INC.
TOL-TEC INDUSTRIES INC.

HEAT SINKS

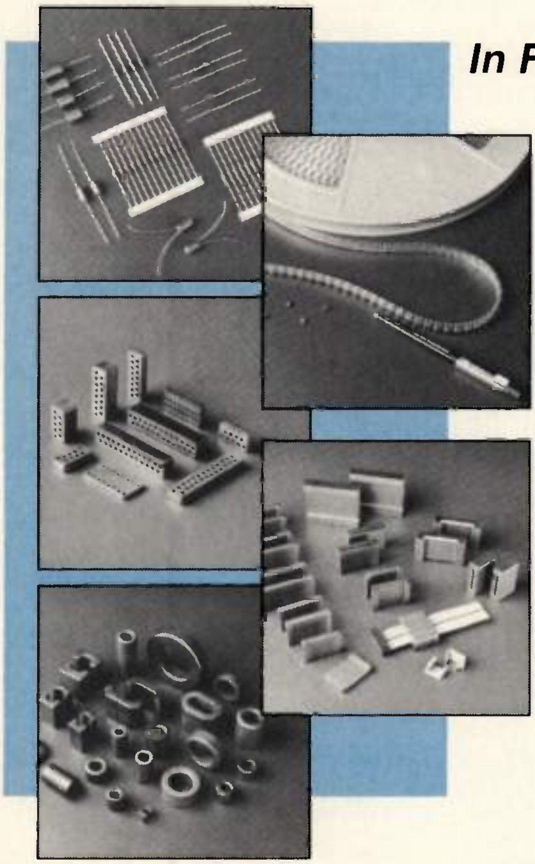
AAVID ENGINEERING
ADVANCED MACHINING TECHNIQUES, INC.
AIMSCO INC.
AREMCO PRODUCTS, INC.
GIGABIT LOGIC INC.
HENRY MANN INC.
JOSEPH ELECTRONICS INC.
MOUSER ELECTRONICS
PNEUMAFIL CORP.
POLYMER CORP.
POWEREX, INC.
REL LABS, INC.
SUMITOMO ELEC.
SURPLUS SALES OF NEBRASKA
TECH ETCH, INC.
TECHNICAL COMPONENTS INC.
TRAN-TEC CORP.

INSULATING MATERIALS

AREMCO PRODUCTS, INC.
ATOCHEM
BRIM ELECTRONICS, INC.
CHOMERICS, INC.
CONAP INC.
COORS CERAMICS CO.
DABURN ELECTRONICS & CABLE CORP.
EMERSON & CUMING INC., A GRACE CO.
EPOXY TECHNOLOGY INC.
GE CERAMICS
INJECTORALL ELECTRONICS
M.M. NEWMAN CORP.
POLYMER CORP.
TACONIC PLASTICS, LTD.

PC BOARDS

3M CO./EPD
A & A ENGINEERING
APPLIED DIELECTRICS, INC.
BARRY INDUSTRIES (TRX DIV.)
BISHOP GRAPHICS, INC.
BUCKBEE - MEARS/ST. PAUL
BUD INDUSTRIES
CALREP
CHERRY ELECTRICAL PRODUCTS
CINCINNATI MILACRON
E/M CORP.
EAGLE MAGNETIC CO INC.
ELGIN ELECTRONICS
ENGLEHARD PREC. MICROWAVE CIRC.
GIGABIT LOGIC INC.
HARMON ELECTRONICS, INC.
INJECTORALL ELECTRONICS



JOSEPH ELECTRONICS INC.
KEMTRON CIRCUITS & ELECTRONICS CORP.
KEPRO CIRCUIT SYSTEMS, INC.
MOUSER ELECTRONICS
O.K. INDUSTRIES INC.
PICO PRODUCTS, INC.
QUAL-TECH, DIV. OF FLEXCO MICROWAVE INC.
REL LABS, INC.
RF PROTOTYPE SYSTEMS
SOLADYNE DIV. OF ROGERS CORP.
TEMEX ELECTRONICS INC.
WORLD BUSINESS CORP. INC.

SOCKETS

BEAD ELECTRONICS DIV., BEAD CHAIN MFG. CO.
CONCORD ELECTRONICS CORP.
EF JOHNSON
GIGABIT LOGIC INC.
GILTRON INC.
INJECTORALL ELECTRONICS
JETTRON PRODUCTS, INC.
JOSEPH ELECTRONICS INC.
MOUSER ELECTRONICS
ONEIDA ELECTRONIC MFG CO. INC.
RF PROTOTYPE SYSTEMS
SHOGYO INTL CORP.

SUBSTRATES

3M CO./EPD
A.G. ELECTRONICS, A DIV. OF HYBRIDS INTL, LTD.
ALPHA INDUSTRIES, INC.
APPLIED SPECIALTIES, INC.
AREMCO PRODUCTS, INC.
BALZERS OPTICAL GROUP
BARRY INDUSTRIES (TRX DIV.)
COORS CERAMICS CO.
CRYSTAL TECHNOLOGY INC.
ELECTRO SCIENCE LABS
FERRO ECA ELECTRONICS
GE CERAMICS
GLASTEEL INDUSTRIAL LAMINATES
HYBRIDS INTERNATIONAL, LTD.
ICI AMERICAS INC.
JOHANSON DIELECTRICS INC.
KEENE CORP.,LAMINATES DIV.
KYOCERA NORTHWEST
M/A-COM OMNI SPECTRA, INC.
MATEC CORP./VALPEY - FISHER CORP.
MIC TECHNOLOGY CORP.
MICROWAVE SEMICONDUCTOR CORP.
MURATA ERIE
MYKROY/MYCALEX CERAMICS
NORPLEX/OAK INC.
OAKBURY COMPONENTS
PENSTOCK INC.
PHOTO TRANSFER INDUSTRIES
POLYFLON CO.
REL LABS, INC.
RF PROTOTYPE SYSTEMS
ROGERS CORP.
ROGERS CORPORATION
SOLITRON DEVICES, INC.
TACONIC PLASTICS, LTD.
TDK CORP. OF AMERICA
TECHNICAL COMPONENTS INC.

TOOLS

APPLIED SPECIALTIES, INC.
CONTACT EAST
DANIELS MFG CORP.
DAVLE TECH, INC.
ESCO ASSOC.
GILTRON INC.
HENRY MANN INC.
HEXACON ELECTRIC CO.
JOSEPH ELECTRONICS INC.
M.M. NEWMAN CORP.
M/A-COM OMNI SPECTRA, INC.
MANHATTAN ELEC. CABLE CORP.
O.K. INDUSTRIES INC.
PASTERNACK ENTERPRISES
PENSTOCK INC.
SOLDER ABSORBING TECHNOLOGY INC.
TRIANGLE TOOL GROUP, INC., THE
UTICA TOOL CO.

TEST EQUIPMENT

AMPLIFIER (LAB)

ACCUTEST INSTRUMENTS INC.
ALPHA INDUSTRIES, INC.
AMERICAN MICROWAVE TECHNOLOGY
AMPLIFIER RESEARCH
APPLIED SPECIALTIES, INC.
AVTECH ELECTROSYSTEMS LTD.
BEHLMAN ENGINEERING
BURLE INDUSTRIES, INC.
CONTINENTAL RESOURCES, INC.
DAMON CORP./ELECTRONICS DIV.
DIGIMAX INSTRUMENTS CORP.
DOTY SCIENTIFIC
EAGLE MAGNETIC CO INC.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
EG&G PRINCETON/
ELECTROCHEMICAL INSTR.
ELECTRO RENT CORPORATION
ENI POWER SYSTEMS
EPSCO, INC.
EPSCO, INC.-RF DIV.
EQUITABLE/RENTELCO CORP.
HENRY RADIO INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INSTRUMENTS FOR INDUSTRY, INC.
INTECH INC.
IRT CORP.
JCA TECHNOLOGY INC.
JOSEPH ELECTRONICS INC.
KALMUS ENGINEERING INTL, LTD.
KELTEC FLORIDA, INC.
KROHN-HITE CORP.
L & M ENGINEERING SOUTH
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
M/A-COM MPD, INC.
MARCH MICROWAVE LTD.
MCL INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICROWAVE SOLUTIONS INC.
MILCOM INTL
MILLIVAC INSTRUMENTS, INC.
OMEGA MICROWAVE, INC.
P.G. ELECTRONICS LTD.
PICOSECOND PULSE LABS, INC.
RAG ELECTRONICS INC.
RF POWER LABS INC.
SIGNAL ONE
STANFORD RESEARCH
SYSTRON DONNER CORP., MICROWAVE DIV.
TE SYSTEMS

INFO/CARD 64

TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
UHF ASSOCIATES
VIEWSONICS
WI-COMM ELECTRONICS INC.
WIDE BAND ENGINEERING CO. INC.

ANTENNA MEASUREMENT SYSTEMS

A.H. SYSTEMS, INC.
ALPHA INDUSTRIES, INC.
ANRITSU
COMAD COMMUNICATIONS LTD.
ELECTRO RENT CORPORATION
FLAM & RUSSELL, INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JOSEPH ELECTRONICS INC.
LECTRONIC RESEARCH LABS
LOGIMETRICS, INC.
MICROWAVE SPECIALTY CORP.
MICROWAVE SYSTEMS INC.
NARDA MICROWAVE CORP.
PACIFIC WEST ELECTRONICS
ROHDE & SCHWARZ INC.
SCIENTIFIC ATLANTA
SYSTRON DONNER CORP., MICROWAVE DIV.
TEST EQUIPMENT CORP.
U.S. INSTRUMENT RENTALS
WEINSCHEL ENGINEERING
WILTRON CO.

CALIBRATORS/ STANDARDS

A.R. BLANCK
ACCUTEST INSTRUMENTS INC.
ALPHA INDUSTRIES, INC.
AUSTRON INC.
B AND J MARKETING
BALLANTINE LABORATORIES
BIRD ELECTRONIC CORP.
BOONTON ELECTRONICS CORP.
DAMON CORP./ELECTRONICS DIV.
DATEL, INC.
DATUM INC.
DOWTY RFL INDUSTRIES INC.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
ERBTEC ENGINEERING INC.
FREQUENCY ELECTRONICS
GENSTAR RENTAL ELECTRONICS, INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JOHN FLUKE MFG. CO. INC.
JOSEPH ELECTRONICS INC.
LECTRONIC RESEARCH LABS
MAURY MICROWAVE CORP.
MICROWAVE SYSTEMS INC.
MICROWAVE TECHNIQUES
NORTH HILLS ELECTRONICS, INC.
PICOSECOND PULSE LABS, INC.
RACAL-DANA INSTRUMENTS, INC.
RAG ELECTRONICS INC.
ROSS ENGINEERING CORP.
RUTHERFORD RESEARCH
SPECTRACOM CORP.
TEST EQUIPMENT CORP.
TRIANGLE TOOL GROUP, INC., THE
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WEINSCHEL ENGINEERING
WENZEL ASSOCIATES, INC.
WIDE BAND ENGINEERING CO. INC.

DUMMY LOADS

ACCUTEST INSTRUMENTS INC.
ADAMS-RUSSELL ELECTRONICS CO., INC.
AEROWAVE INC.
AIRTRON CORP.
ALAN INDUSTRIES, INC.
ALPHA INDUSTRIES, INC.
AMERICAN MICROWAVE TECHNOLOGY
APPLIED SPECIALTIES, INC.
BIRD ELECTRONIC CORP.
COAXIAL DYNAMICS, INC.
COMAD COMMUNICATIONS LTD.
DAMON CORP./ELECTRONICS DIV.

DENSITRON MICROWAVE LTD.
DYMA ENGINEERING
ELECTRO IMPULSE LABORATORY, INC.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INSTRUMENTS FOR INDUSTRY, INC.
IRT CORP.
JOSEPH ELECTRONICS INC.
KDI ELECTRONICS
LECTRONIC RESEARCH LABS
M/A-COM LAND MOBILE COMMUNICATIONS
M/A-COM OMNI SPECTRA, INC.
MICON, INC./MICROWAVE CONTROL CO. DIV.
MICROLAB/FXR
MICRONETICS INC.
MICROWAVE DEVICES, INC.
MICROWAVE FILTER CO., INC.
NARDA MICROWAVE CORP.
OHMWEVE CO. INC., THE
PENSTOCK INC.
RAG ELECTRONICS INC.
RAYTHEON CO., MPTD
RESIN SYSTEMS CORP.
SYSTRON DONNER CORP., MICROWAVE DIV.
TEST EQUIPMENT CORP.
TEXSCAN
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WAVELINE INC.
WILTRON CO.

FIELD INTENSITY METERS

ACCUTEST INSTRUMENTS INC.
ALPHA INDUSTRIES, INC.
AMPLIFIER RESEARCH
ANRITSU
B & K PRECISION, MAXTEC INTERNATIONAL CORP.
BIRD ELECTRONIC CORP.
COAXIAL DYNAMICS, INC.
COMAD COMMUNICATIONS LTD.
CONTINENTAL RESOURCES, INC.
DRANETZ TECHNOLOGIES, INC.
DYMA ENGINEERING
EATON AIL DIV.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO RENT CORPORATION
ELECTRO-METRICS
EQUITABLE/RENTELCO CORP.
HOLADAY INDUSTRIES, INC.
HOPKINS ENGINEERING CO.
INSTRUMENTS FOR INDUSTRY, INC.
JOSEPH ELECTRONICS INC.
LEADER INSTRUMENTS CORP.
LECTRONIC RESEARCH LABS
PICO PRODUCTS, INC.
RAG ELECTRONICS INC.
ROHDE & SCHWARZ INC.
SENCORE INC.
SOUTHWEST RESEARCH INSTITUTE
TEST EQUIPMENT CORP.
TEST PROBES, INC.
TEXSCAN INSTRUMENTS
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
VIEWSONICS

FREQUENCY COUNTERS

A.R.F. PRODUCTS, INC.
ACCUTEST INSTRUMENTS INC.
ADVANTEST AMERICA, INC.
ALPHA INDUSTRIES, INC.
ANRITSU
B & K PRECISION, MAXTEC INTERNATIONAL CORP.
BALLANTINE LABORATORIES
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
CONTACT EAST
CONTINENTAL RESOURCES, INC.
CYBERRESEARCH, INC.
DAMON CORP./ELECTRONICS DIV.
DATEL, INC.
DAVLE TECH, INC.
DIGIMAX INSTRUMENTS CORP.
EIP MICROWAVE
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
ESTERLINE ANGUS
GENSTAR RENTAL ELECTRONICS, INC.
GLOBAL SPECIALTIES
HAMEG INC.
HELPER INSTRUMENTS CO.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
JOHN FLUKE MFG. CO. INC.
JOSEPH ELECTRONICS INC.
KIKUSUI INTL CORP.
LEADER INSTRUMENTS CORP.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
MARCONI INSTRUMENTS INC.
MM - WAVE TECHNOLOGY INC.
MOUSER ELECTRONICS
OPTOELECTRONICS, INC.
PANASONIC INDUSTRIAL CO.
RACAL-DANA INSTRUMENTS, INC.
RAG ELECTRONICS INC.
RAMSEY ELECTRONICS
RUBYTRON INSTRUMENTS
SENCORE INC.
SIGMOTEK INTL CORP.
SIMPSON ELECTRIC CO.
STANFORD RESEARCH
SYSTRON DONNER INSTRUMENT DIV.
TELEMUS ELECTRONIC SYSTEMS INC.
TEST EQUIPMENT CORP.
TEXSCAN
TEXSCAN INSTRUMENTS
TRIPLETT CORP.
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
XL MICROWAVE

INFO/CARD 65

MODULATION METERS

ACCUTEST INSTRUMENTS INC.
ALPHA INDUSTRIES, INC.
BOONTON ELECTRONICS CORP.
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
COMAD COMMUNICATIONS LTD.
CONTINENTAL RESOURCES, INC.
DAMON CORP./ELECTRONICS DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GENSTAR RENTAL ELECTRONICS, INC.
HELPER INSTRUMENTS CO.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
IFR SYSTEMS, INC.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
MARCONI INSTRUMENTS INC.
RACAL-DANA INSTRUMENTS, INC.
TEST EQUIPMENT CORP.
TEXSCAN INSTRUMENTS
U.S. INSTRUMENT RENTALS
WEINSCHEL ENGINEERING

NETWORK ANALYZERS

ACCUTEST INSTRUMENTS INC.
ADVANTEST AMERICA, INC.
ALPHA INDUSTRIES, INC.
ANRITSU
CONTINENTAL RESOURCES, INC.
DAMON CORP./ELECTRONICS DIV.
DRANETZ TECHNOLOGIES, INC.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GENSTAR RENTAL ELECTRONICS, INC.
HARRIS CORP./GSSD/PRD INSTRUMENTS
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JENSEN TRANSFORMERS, INC.
JOSEPH ELECTRONICS INC.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
MICRO VIDEO INC.
RAG ELECTRONICS INC.
RUBYTRON INSTRUMENTS
TEKTRONIX, INC.
TEST EQUIPMENT CORP.
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WAVETEK MICROWAVE, INC.
WAVETEK RF PRODUCTS, INC.
WILTRON CO.

INFO/CARD 66

NOISE FIGURE METERS

ACCUTEST INSTRUMENTS INC.
ALPHA INDUSTRIES, INC.
ANRITSU
CONTINENTAL RESOURCES, INC.
DAMON CORP./ELECTRONICS DIV.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GENSTAR RENTAL ELECTRONICS, INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JOSEPH ELECTRONICS INC.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
MARCH MICROWAVE LTD.
MICRONETICS INC.
RAG ELECTRONICS INC.
RUBYTRON INSTRUMENTS
TEST EQUIPMENT CORP.
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS

NOISE GENERATORS

ACCUTEST INSTRUMENTS INC.
CONTINENTAL RESOURCES, INC.
DAMON CORP./ELECTRONICS DIV.
DENSITRON MICROWAVE LTD.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GENSTAR RENTAL ELECTRONICS, INC.

HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JOSEPH ELECTRONICS INC.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
MARCONI INSTRUMENTS INC.
MAURY MICROWAVE CORP.
MDF PRODUCTS INC.
MICRONETICS INC.
MICROWAVE SEMICONDUCTOR CORP.
NEW WAVE INSTRUMENTS
NOISE COM INC.
RAG ELECTRONICS INC.
RUBYTRON INSTRUMENTS
SYSTRON DONNER CORP., MICROWAVE DIV.
TEST EQUIPMENT CORP.
TOKIN AMERICA INC,
TONY CHAPMAN ELECTRONICS LTD.
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WAVELINE INC.
WAVETEK SAN DIEGO, INC.

OSCILLOSCOPES

A.W. SPERRY INSTRUMENTS, INC.
ACCUTEST INSTRUMENTS INC.
B & K PRECISION, MAXTEC INTERNATIONAL CORP.
BALLANTINE LABORATORIES
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
COMAD COMMUNICATIONS LTD.
CONTACT EAST
CONTINENTAL RESOURCES, INC.
CYBERRESEARCH, INC.
DAMON CORP./ELECTRONICS DIV.
DAVLE TECH, INC.
DYMA ENGINEERING
EAGLE MAGNETIC CO INC.
ELECTRO RENT
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GENSTAR RENTAL ELECTRONICS, INC.
HAMEG INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HYPRES INC.
IFR SYSTEMS, INC.
IWATSU INST. INC.
JAMES MILLEN ELECTRONICS
JOHN FLUKE MFG. CO. INC.
JOSEPH ELECTRONICS INC.
KIKUSUI INTL CORP.
LEADER INSTRUMENTS CORP.
LEASEAMETRIC, INC.
LECROY CORP.
LECTRONIC RESEARCH LABS
PANASONIC INDUSTRIAL CO.
RAG ELECTRONICS INC.
RAMSEY ELECTRONICS
RUBYTRON INSTRUMENTS
SENCORE INC.
SIMPSON ELECTRIC CO.
SIMPSON ELECTRIC COMPANY
TEKTRONIX CORP.
TEST EQIUIPMENT CORP.
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WAVETEK RF PRODUCTS, INC.

POWER METERS

A.W. SPERRY INSTRUMENTS, INC.
ACCUTEST INSTRUMENTS INC.
ADVANTEST AMERICA, INC.
ANRITSU
BERKELEY NUCLEONICS CORP.
BIRD ELECTRONIC CORP.
BOONTON ELECTRONICS CORP.
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
COAXIAL DYNAMICS, INC.
COMAD COMMUNICATIONS LTD.
CONTACT EAST
CONTINENTAL RESOURCES, INC.
CYBERRESEARCH, INC.
DAMON CORP./ELECTRONICS DIV.
DATEL, INC.
DOTY SCIENTIFIC
DOWTY RFL INDUSTRIES INC.
DRANETZ TECHNOLOGIES, INC.
DYMA ENGINEERING
EIP MICROWAVE
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
ESTERLINE ANGUS
FOTEC, INC.
GENERAL MICROWAVE CORP.
GENSTAR RENTAL ELECTRONICS, INC.
GILTRON INC.
HARRIS CORP./GSSD/PRD INSTRUMENTS
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
INSTRUMENTS FOR INDUSTRY, INC.
ITM SYSTEMS INC.
JOHN FLUKE MFG. CO. INC.
JOSEPH ELECTRONICS INC.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
MARCONI INSTRUMENTS INC.
MICROWAVE DEVICES, INC.
MILLITECH CORP.
MM - WAVE TECHNOLOGY INC.
NARDA MICROWAVE CORP.
RACAL-DANA INSTRUMENTS, INC.
RAG ELECTRONICS INC.
RAYTHEON CO., MPTD
RUBYTRON INSTRUMENTS
SIGNALCRAFTERS, INC.
TEST EQUIPMENT CORP.
TEST PROBES, INC.
TEXSCAN INSTRUMENTS
TONY CHAPMAN ELECTRONICS LTD.
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WAVETEK MICROWAVE, INC.
WEINSCHEL ENGINEERING
WILTRON CO.

PROBES

A.W. SPERRY INSTRUMENTS, INC.
ACCUTEST INSTRUMENTS INC.
AMERICAN HV TEST SYSTEMS INC.
AMERICAN LASER SYSTEMS, INC.
AVTECH ELECTROSYSTEMS LTD.
B & K PRECISION, MAXTEC INTERNATIONAL CORP.
BALLANTINE LABORATORIES
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
CERPROBE CORP.
CONTACT EAST
CONTINENTAL RESOURCES, INC.
CYBERRESEARCH, INC.
DAMON CORP./ELECTRONICS DIV.
DAVLE TECH, INC.
DESIGN TECHNIQUE
DOWTY RFL INDUSTRIES INC.
DRANETZ TECHNOLOGIES, INC.
EATON CORP., ELECTRONICS INSTRUMENTATION DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GILTRON INC.
HAMEG INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
JENNINGS, DIV. OF FL INDUSTRIES
JOSEPH ELECTRONICS INC.
KIKUSUI INTL CORP.
LEADER INSTRUMENTS CORP.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
LOGIMETRICS, INC.
LSI JENNINGS
LUXTRON
MICROWAVE DEVICES, INC.
O.K. INDUSTRIES INC.
PANASONIC INDUSTRIAL CO.
PHOTO TRANSFER INDUSTRIES

PICOSECOND PULSE LABS, INC.
R & B ENTERPRISES
RADIOMETRICS MIDWEST CORP.
RAG ELECTRONICS INC.
ROSS ENGINEERING CORP.
RUBYTRON INSTRUMENTS
SAGE ENTERPRISES INC.
SIMPSON ELECTRIC CO.
SOLDER ABSORBING TECHNOLOGY INC.
SOUTHWEST RESEARCH INSTITUTE
TEST EQUIPMENT CORP.
TEST PROBES, INC.
TEXSCAN INSTRUMENTS
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
VIEWSONICS
WEINSCHEL ENGINEERING

PULSE GENERATORS

ACCUTEST INSTRUMENTS INC.
ADVANTEST AMERICA, INC.
ANRITSU
AVTECH ELECTROSYSTEMS LTD.

B & K PRECISION, MAXTEC INTERNATIONAL CORP.
BALLANTINE LABORATORIES
BERKELEY NUCLEONICS CORP.
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
COLBY INSTRUMENTS, INC.
CONTACT EAST
CONTINENTAL RESOURCES, INC.
CYBERRESEARCH, INC.
DAMON CORP./ELECTRONICS DIV.
DAVLE TECH, INC.
ELECTRO RENT CORPORATION
EPSCO, INC.
EPSCO, INC.-RF DIV.
EQUITABLE/RENTELCO CORP.
EXPERIMENTAL PHYSICS CORP.
GENSTAR RENTAL ELECTRONICS, INC.
HAMEG INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
JOHN FLUKE MFG. CO. INC.
JOSEPH ELECTRONICS INC.
KELTEC FLORIDA, INC.
KROHN-HITE CORP.
LEASEAMETRIC, INC.
LECROY CORP.
LECTRONIC RESEARCH LABS
MARLOW ELECTRONICS LTD.
MATEC CORP./VALPEY - FISHER CORP.
MCL INC.
MOUSER ELECTRONICS
PICOSECOND PULSE LABS, INC.
R & B ENTERPRISES
RACAL-DANA INSTRUMENTS, INC.
RAG ELECTRONICS INC.
RUBYTRON INSTRUMENTS
SIGMOTEK INTL CORP.
SIMPSON ELECTRIC CO.
STANFORD RESEARCH
SYSTRON DONNER INSTRUMENT DIV.
TEST EQUIPMENT CORP.
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WAVETEK SAN DIEGO, INC.

RLC/IMPEDANCE BRIDGES

ACCUTEST INSTRUMENTS INC.
BOONTON ELECTRONICS CORP.
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
CAMBRIDGE TECHNOLOGY, INC.
CONTINENTAL RESOURCES, INC.
DAMON CORP./ELECTRONICS DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GENSTAR RENTAL ELECTRONICS, INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
JAMES MILLEN ELECTRONICS
JOSEPH ELECTRONICS INC.
LEADER INSTRUMENTS CORP.
LEASEAMETRIC, INC
LECTRONIC RESEARCH LABS
PALOMAR ENGINEERS
RAG ELECTRONICS INC.
RE INSTRUMENTS CORP.
RUBYTRON INSTRUMENTS
SENCORE INC.
TEST EQUIPMENT CORP.
TEXSCAN
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WIDE BAND ENGINEERING CO. INC.
WILTRON CO.

SIGNAL LEVEL METERS

ACCUTEST INSTRUMENTS INC.
B & K PRECISION, MAXTEC INTERNATIONAL CORP.
BALLANTINE LABORATORIES
BIRD ELECTRONIC CORP.
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
CONTINENTAL RESOURCES, INC.
CYBERRESEARCH, INC.
DAMON CORP./ELECTRONICS DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GENSTAR RENTAL ELECTRONICS, INC.
HAMEG INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
IFR SYSTEMS, INC.
JOSEPH ELECTRONICS INC.
LEASEAMETRIC, INC.

LECTRONIC RESEARCH LABS
RACAL-DANA INSTRUMENTS, INC.
RAG ELECTRONICS INC.
ROHDE & SCHWARZ INC.
RUBYTRON INSTRUMENTS
SENCORE INC.
SIMPSON ELECTRIC CO.
TEST EQUIPMENT CORP.
TEXSCAN
TEXSCAN INSTRUMENTS
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
VIEWSONICS
WAVETEK RF PRODUCTS, INC.
WEINSCHEL ENGINEERING

SIGNAL/SWEEP GENERATORS

ACCUTEST INSTRUMENTS INC.
B & K PRECISION, MAXTEC INTERNATIONAL CORP.
BALLANTINE LABORATORIES
BIRD ELECTRONIC CORP.
CALIBRON INSTRUMENTS DIV.-BURTON-ROGERS CO., INC.
CONTINENTAL RESOURCES, INC.
CYBERRESEARCH, INC.
DAMON CORP./ELECTRONICS DIV.
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
GENSTAR RENTAL ELECTRONICS, INC.
HAMEG INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
IFR SYSTEMS, INC.
JOSEPH ELECTRONICS INC.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
RACAL-DANA INSTRUMENTS, INC.
RAG ELECTRONICS INC.
ROHDE & SCHWARZ INC.
RUBYTRON INSTRUMENTS
SENCORE INC.
SIMPSON ELECTRIC CO.
TEST EQUIPMENT CORP.
TEXSCAN
TEXSCAN INSTRUMENTS
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
VIEWSONICS
WAVETEK RF PRODUCTS, INC.
WEINSCHEL ENGINEERING

SPECTRUM ANALYZERS

A & A ENGINEERING
ACCUTEST INSTRUMENTS INC.
ADVANTEST AMERICA, INC.
ANRITSU
APCOM, INC.
AVCOM OF VIRGINIA
CONTINENTAL RESOURCES, INC.
CYBERRESEARCH, INC.
DAMON CORP./ELECTRONICS DIV.
DYMA ENGINEERING
EAGLE MAGNETIC CO INC.
EATON AIL DIV.
ELECTRO RENT CORPORATION
ELECTRO-METRICS
EQUITABLE/RENTELCO CORP.
FOTEC, INC.
GENSTAR RENTAL ELECTRONICS, INC.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
HUGHES AIRCRAFT CO. MICROWAVE PRODUCTS DIV.
IFR SYSTEMS, INC.

Manufacturers of
▶ SPECTRUM ANALYZERS
▶ COMMUNICATIONS SERVICE MONITORS
▶ AVIONICS TEST EQUIPMENT
IFR SYSTEMS, INC.
10200 West York St., Wichita, Kansas 67215
Phone 316/522-4981 / FAX 316/524-2623
INFO/CARD 70

JENSEN TRANSFORMERS, INC.
JOSEPH ELECTRONICS INC.
LEASEAMETRIC, INC.
LECTRONIC RESEARCH LABS
MARCONI INSTRUMENTS INC.
PACIFIC WEST ELECTRONICS
PANASONIC INDUSTRIAL CO.
RAG ELECTRONICS INC.
ROHDE & SCHWARZ INC.
RUBYTRON INSTRUMENTS
SOLARTRON INSTRUMENTS
TEKTRONIX, INC.
TEST EQUIPMENT CORP.
TEXSCAN
TEXSCAN INSTRUMENTS

WBE

DIRECTIONAL COUPLERS

A73 Series Directional Couplers are of reciprocal hybrid ferrite circuitry, featuring broad bandwidth with outstanding directivity and flatness.

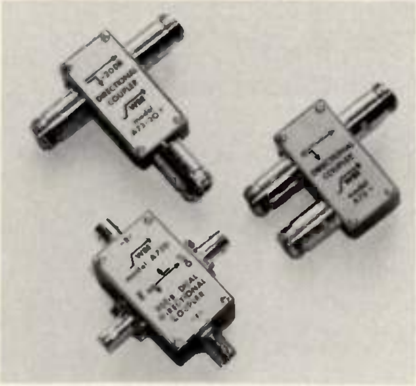
APPLICATIONS

Some general applications for the a73 Series are:

Line Monitoring: Power split from the line is -20 dB down for sampling without altering line characteristics, for level measuring, VSWR alarms, etc..

Power Measurements: Insertion in the line allows level measurements with simple lower level detectors or field strength meters and power measuring equipment. By reversing the coupler in the line or using the A73D types, an indication of impedance match and/or reflected power can be measured by comparing the forward to reflected power levels.

Load Source Isolator: Using a directional coupler in the line, a signal can be taken from the source to the tap with high attenuation (directivity) between the tap and the load.



Model	Freq. Range MHz	Coupling Level dB	Coupler Type	In Line Power	Minimum Directivity (dB) 1-500 MHz	Minimum Directivity (dB) 5-300 MHz	In Line Loss (dB)	Flatness of Coupled Port (dB)	VSWR	Price 50 ohm with BNC conns.
A73-20	1-500	20	single	5W cw (10W cw 5-300 MHz)	20	30	.4 max. .2 typical	±.1 5-300 MHz ±.25 1-500 MHz	1.05:1 5-500 MHz 1.5:1 1-500 MHz	$ 68.00
A73-20GA					30	40				131.00
A73-20GB					40	45				242.00
A73-20P	1-100		single	50W cw (75 ohm limited to 10 W cw)	35 dB min. 40 dB min. typical		.15	±.1	1.1:1 max	91.00
A73D-20P			dual				.3			163.00
A73-20PAX	10-200		single		45 dB min.		.15		1.04:1 typical	150.00
A73D-20PAX			dual				.3			310.00
A73-30P2	1-100	30	single	200 W cw 50 ohm	30 dB		.05	±.15	1.05:1 max	312.00

This chart is just a sampling of couplers available. Connector options are available. Consult factory for specials and OEM applications.

WIDE BAND ENGINEERING COMPANY, INC.

P.O. Box 21652, Phoenix, AZ 85036
Phone 602-254-1570
1838 E. University Dr., Phoenix, AZ 85034

INFO/CARD 71

TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
UHF ASSOCIATES
VEGAS VALLEY GROUP
VIBRATION INSTRUMENTS
WAVETEK RF PRODUCTS, INC.
ZONIC CORP.

SWR METERS

ACCUTEST INSTRUMENTS INC.
BIRD ELECTRONIC CORP.
COMAD COMMUNICATIONS LTD.
CONTACT EAST
CONTINENTAL RESOURCES, INC.
DAMON CORP./ELECTRONICS DIV.
EAGLE
ELECTRO RENT CORPORATION
EQUITABLE/RENTELCO CORP.
HELPER INSTRUMENTS CO.
HEWLETT-PACKARD CO.
HOPKINS ENGINEERING CO.
JOSEPH ELECTRONICS INC.
LECTRONIC RESEARCH LABS
MICROWAVE DEVICES, INC.
PALOMAR ENGINEERS
ROHDE & SCHWARZ INC.
RUBYTRON INSTRUMENTS
SIGNALCRAFTERS, INC.
TELONIC BERKELEY, INC.
TEST EQUIPMENT CORP.
TEST PROBES, INC.
TEXSCAN INSTRUMENTS
TUCKER ELECTRONICS
U.S. INSTRUMENT RENTALS
WEINSCHEL ENGINEERING
WILTRON CO.

TEST FIXTURES

ACCUTEST INSTRUMENTS INC.
AMERICAN HV TEST SYSTEMS INC.
AUGAT MICROTEC
CERPROBE CORP.
COILCRAFT
DAMON CORP./ELECTRONICS DIV.
DESIGN TECHNIQUE
DIGITAL EQUIPMENT CORP.
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MICROWAVE SPECIALTY CORP.
MM - WAVE TECHNOLOGY INC.
NORAND EMC TEST LAB
RADIOMETRICS CORP.
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SOUTHWEST RESEARCH INSTITUTE
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RADIOMETRICS CORP.
RADIOMETRICS MIDWEST CORP.
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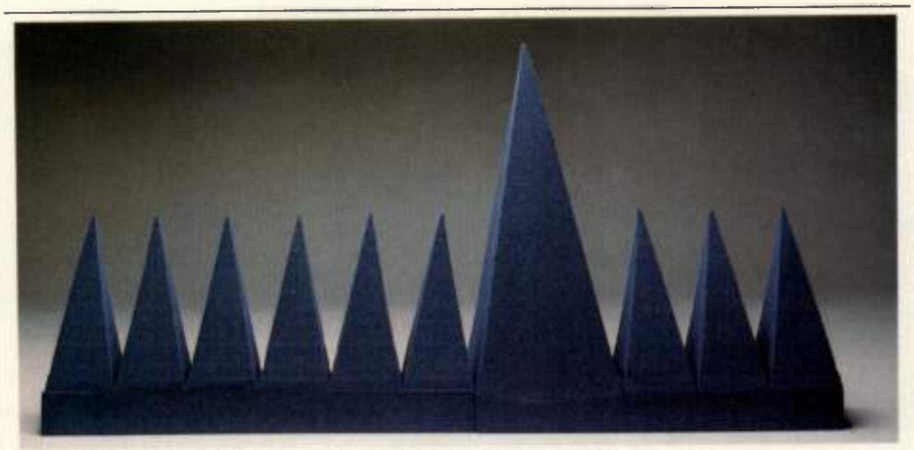

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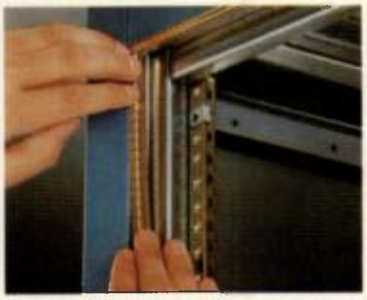

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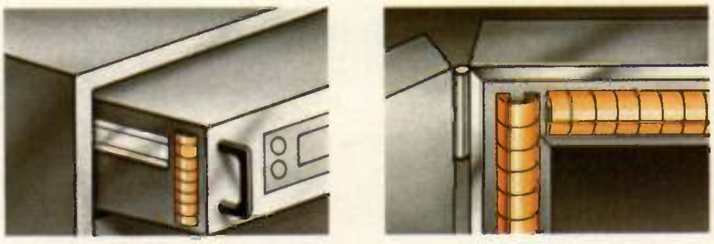

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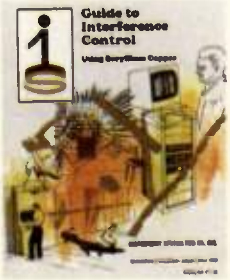

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Low Impedance Double-Tuned Matching Circuit

By Andrzej B. Przedpelski
A.R.F. Products, Inc.

Filters at 50-300 ohm impedance levels are usually hard to design because of component value limitations. A circuit which overcomes this problem is the double-tuned circuit with taps on the input and output. Real input and output impedances are assumed. Any stray capacitance can be subtracted from C_1 and C_2 values.

The required inputs are (steps 80-130):

F_0 = center frequency, MHz
BW = approximate bandwidth, MHz
Q_L = inductor Q
R_s = source resistance, ohms
R_o = load resistance, ohms
L = inductance, uH

Using the values shown in the program, the circuit values are:

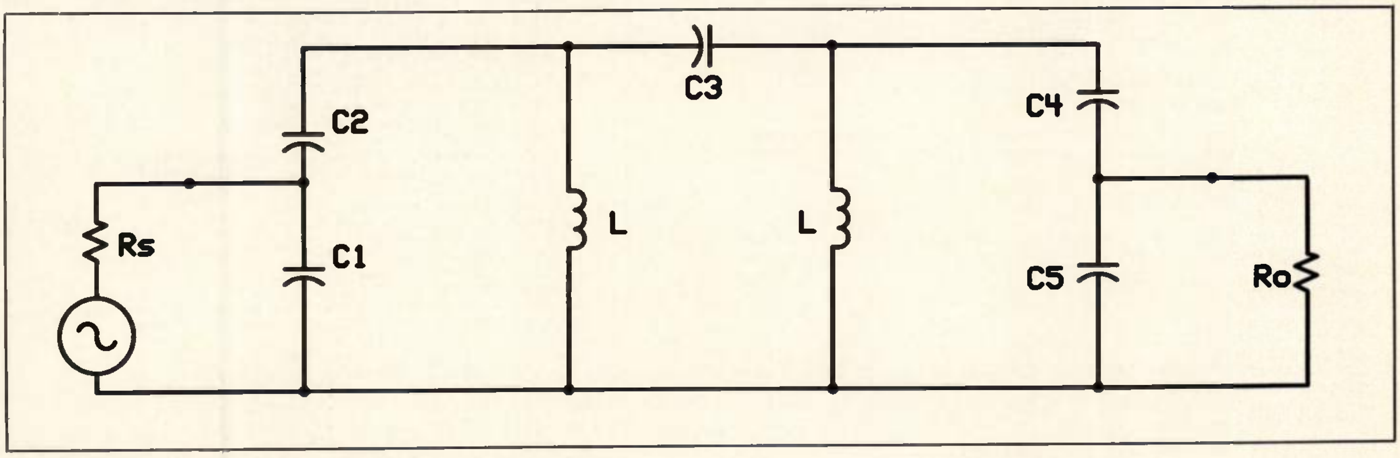
X_L = 188.47
X_1 = −31.604
X_2 = −161.66
X_3 = −8076.2
X_4 = −180.52
X_5 = −13.276

C_1 = 167.89 pF
C_2 = 32.821 pF
C_3 = 0.65698 pF
C_4 = 29.392 pF
C_5 = 399.66 pF

```
10 ! LOW IMPDANCE DOUBLE TUNED MATCHING CIRCUIT - #595
20 !         A. PRZEDPELSKI    -  18 APRIL 1988
30 !         A.R.F. PRODUCTS, INC.LI DTUNE"
40 !         BOULDER, CO
50 !            REF:  "Low Impedance Double Tuned Circuits"
60 !                   RF DESIGN - MAY/JUN 1982
70 ! ******** ENTER KNOWNS ******************************************
80 F0=30 !                  Center frequency, MHz
90 BW=1 !                   Approximate desired bandwidth, MHz
100 QL=150 !                Inductor Q
110 RS=300 !                Source (series) resistance, ohm
120 RO=50 !                 Load (series) resistance, ohm
130 L=1 !                   Inductor, uH
140 ! ************* CALCULATION **************************************
150 SHORT C1,C2,C3,C4,C5,XL,X1,X2,X3,X4,X5
160 F=SQR ((F0-.5*BW)*(F0+.5*BW))*1000000 ! Geometric center frequency
170 W=2*PI *F
180 Q0=F/(.7*BW*1000000)
190 XL=W*L*.000001
200 RL=QL*XL
210 X3=-(XL*Q0)
220 C3=-(1/(W*X3)*1.E12) ! IN pF
230 A1=((-X3)*RL)/(RL+X3)
240 A2=X3/(Q0-1)
250 A3=(A1/A2)^2
260 A4=A1/(1+A3)
270 X1=-SQR (RS^2*A4/(RS-A4))
280 C1=-(1/(W*X1)*1.E12) ! IN pF
290 X5=-SQR (RO^2*A4/(RO-A4))
300 C5=-(1/(W*X5)*1.E12) ! IN pF
310 A5=A2*A3/(1+A3)
320 A6=(A5/X1)^2
330 X2=A5-X1*((RS/X1)^2/(1+(RS/X1)^2))
340 C2=-(1/(W*X2)*1.E12) ! IN pF
350 X4=A5-X5*((RO/X5)^2/(1+(RO/X5)^2))
360 C4=-(1/(W*X4)*1.E12) ! IN pF
370 CLEAR @ DISP "CENTER FREQUENCY = ";F0;"MHz"
380 DISP "BANDWIDTH = ";BW;"MHz"
390 DISP "COIL Q = ";QL
400 DISP "XL = ";XL,"L = ";L;"uH"
410 DISP "X1 = ";X1,"C1 = ";C1;"pF"
420 DISP "X2 = ";X2,"C2 = ";C2;"pF"
430 DISP "X3 = ";X3,"C3 = ";C3;"pF"
440 DISP "X4 = ";X4,"C4 = ";C4;"pF"
450 DISP "X5 = ";X5,"C5 = ";C5;"pF"
460 END
```

About the Author

Andrzej B. Pzredpelski is vice president, development of A.R.F. Products, Inc. 2559 75th St., Boulder, CO 80301. He serves as consulting editor to *RF Design*.



Double-tuned circuit with taps on input and output.

Tapped Double-Tuned Matching Circuit (Bandpass)

By Andrzej B. Przedpelski
A.R.F. Products, Inc.

When more selectivity is desired than a simple matching circuit can provide, and a considerable impedance step-up/step-down is needed, the double-tuned tapped circuit can be useful. A simple double-tuned circuit relies on the mutual coupling between two tuned circuits. For optimum performance, critical coupling is normally used. In conventional IF transformers, the coupling is usually inductive, but for most applications, especially R&D work, the capacitively coupled circuit is easier to design and adjust. Providing a capacitive tap on one side permits a large input/output impedance ratio.

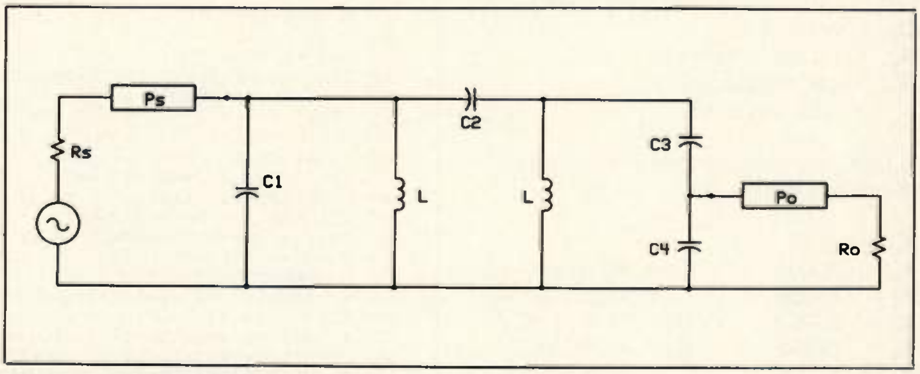
The needed inputs are:

R_s = source resistance, ohms
P_s = source capacitance or inductance (− for capacitance), pF or uH
R_o = load resistance (must be less than R_s), ohms
P_o = load capacitance or inductance (− for capacitance), pF or uH
Q_0 = circuit Q (can be selected to obtain the desired bandwidth, must be less than Q_L)
Q_L = inductor Q (it is assumed that capacitor Qs are high)
F_0 = center frequency, Hz

These values are overwritten over the values shown in the program in steps 80-140. If desired, these can be changed to an *Input* statement. The program provides all the necessary circuit values. It also provides an approximate value of loss caused by the finite inductor Q.

Using the values shown in the program, the following circuit elements were obtained:

L = 0.53649 uH
C_1 = 124.04 pF
C_2 = 6.5576 pF
C_3 = 181.4 pF
C_4 = 417.67 pF



The double-tuned tapped circuit.

```
10 ! TAPPED DOUBLE-TUNED MATCHING CIRCUIT (BANDPASS)
20 !       PROGRAM NO. 592  -  "DTUNE"
30 !       A. PRZIEDPELSKI  -  15 APRIL 1988
40 !
50 !              REF.:  "Double Tuned Circuits"
60 !                      RF DESIGN - JAN/FEB 1982
70 ! ******** ENTER KNOWNS *********************************************
80 F0=60000000 !    Frequency, Hz
90 Q0=20 !          Desired circuit Q
100 QL=100 !        Inductor Q
110 Rs=500 !        Source (series) resistance, ohm
120 Ps=-50 !        Source capacity or inductance (- for capacity), pF or uH
130 Ro=50 '         Load (series) resistance, ohm
140 Po=.05 !        Load capacity or inductance (- for capacity), pF or uH
150 ' ************* CALCULATION *******************************************
160 SHORT L,C1,C2,LOSS,C3,C4
170 W=2*PI *F0
180 IF Ps<0 THEN Xs=1/(W*Ps*.000000000001) ELSE Xs=W*Ps*.000001
190 IF Po<0 THEN Xo=1/(W*Po*.000000000001) ELSE Xo=W*Po*.000001
200 RS=Rs @ XS=Xs @ GOSUB STOR
210 R1=RP @ X5=XP
220 RS=Ro @ XS=Xo @ GOSUB STOR
230 R5=RS @ X10=XP
240 IF R1<R5 THEN DISP "REVERSE COUPLING CIRCUIT" @ LIST 70,140
250 XL=R1*(QL-Q0)/(QL*Q0)
260 L=XL/W
270 RL=QL/XL
280 Rp=Q0/XL
290 R2=RL*Rp/(RL-Rp)
300 X2=-(Q0*XL)
310 C2=-(1/(W*X2))
320 X1=X2*X5/(X5*(Q0-1)-X2)
330 C1=-(1/(W*X1))
340 X6=1/(1/X1+1/X5)
350 X7=1/(1/X6+1/XL)
360 K=1/Q0
370 X6=X2/(1/K-1)
380 X7=1/(1/X6+1/XL)
390 RP=R1 @ XP=X6 @ GOSUB PTOS
400 R6=RS @ X13=XS
410 X3=X13+R6*SQR (R5/R6-1)
420 C3=-(1/(W*X3))
430 R6=RS @ X11=X13-X3
440 X4=X11*X10/(X10-X11)
450 C4=-(1/(W*X4))
460 DISP "L = ";L*1000000;"uH"
470 DISP "C1 = ";C1*1.E12;"pF"
480 DISP "C2 = ";C2*1.E12;"pF"
490 DISP "C3 = ";C3*1.E12;"pF"
500 DISP "C4 = ";C4*1.E12;"pF"
510 LOSS=2*(-(10*LGT (1-Q0/QL)))
520 DISP "APPROX. LOSS (due to QL) = ";LOSS;"dB"
530 END
540 ! **************** STANDARD SUBROUTINES *******
550 STOR: ! SERIES TO PARALLEL CONVERSION
560 ! INPUT RS, XS
570 IF RS=0 THEN RS=1.E-30
580 IF XS=0 THEN XS=1.E-30
590 RP=XS^2/RS+RS
600 XP=RS^2/XS+XS
610 ! OUTPUT RP, XP
620 RETURN
630 ! *******************************************
640 PTOS: ! PARALLEL TO SERIES CONVERSION
650 ! INPUT RP, XP
660 IF XP=0 THEN XP=1.E-30
670 RS=RP/(1+(RP/XP)^2)
680 XS=XP*RP^2/(XP^2+RP^2)
690 ! OUTPUT RS, XS
700 RETURN
```

Response of Low Impedance Double-Tuned Matching Circuit

By Andrzej B. Przedpelski
A.R.F. Products, Inc.

The frequency response of the low impedance double-tuned matching circuit can be calculated using this program. The circuit values are entered in steps 90 to 170. The program will then ask for start frequency, end frequency and frequency steps in MHz. It then prints out a frequency response table in dB. In step 1170, if the ATN2 function is unavailable (which places it in the quadrant), the equivalent subroutine may have to be substituted. The remarks refer to the equations and variables in the referenced article. Using the given circuit values, the table shown was obtained using 0.5 MHz steps.

Note: The response (insertion loss) includes loss due to the finite inductor Q and the voltage step-down due to impedance step-down.

References

1. Andrzej B. Przedpelski, "Low Impedance Double Tuned Circuit," *RF Design*, May/June 1982.

```
FREQUENCY,   RESPONSE,   PHASE,    GAMMA      FREQUENCY,   RESPONSE,   PHASE,
MHz          dB          DEG                  MHz          dB          DEG
 25          -60.215     -89.036    .99799     30.5        -19.604     -58.482     .57714
 25.5        -58.011     -88.627    .99751     31          -28.568     -82.794     .92019
 26          -55.601     -87.882    .99682     31.5        -35.11      -86.641     .97106
 26.5        -52.927     -86.251    .99581     32          -39.792     -87.953     .9852
 27          -49.904     -80.853    .99421     32.5        -43.387     -88.583     .99099
 27.5        -46.402      12.521    .99146     33          -46.285     -88.946     .99393
 28          -42.204      76.359    .9861      33.5        -48.7       -89.177     .99562
 28.5        -36.917      79.719    .97313     34          -50.763     -89.336     .99669
 29          -29.748      77.214    .92657     34.5        -52.557     -89.45      .99741
 29.5        -19.996      54.548    .59552     35          -54.141     -89.535     .99792
 30          -16.724     -6.2611    .28574
```

Frequency response calculated from 25 to 35 MHz.

```
10 ! RESPONSE OF LOW IMPEDANCE DOUBLE TUNED MATCHING CIRCUIT - #596
20 !       A. PRZEDPELSKI   -  19 APRIL 1988
30 !       A.R.F. PRODUCTS, INC.
40 !       BOULDER, CO
50 !            REF.:   "Low Impedance Double Tuned Circuits"
60 !                     RF DESIGN - MAY/JUN 1982
70 ! Program No. 595 calculates circuit values
80 ! ******** ENTER KNOWNS ****************************************
90 Rs=300 !               Source (series) resistance, ohm
100 Ro=50 !               Load (series) resistance, ohm
110 L=1 !                 Inductor. uH
120 QL=150 !              Inductor Q
130 C1=167.89 !           Parallel input capacitor, pF
140 C2=32.821 !           Series input capacitor, pF
150 C3=.65698 !           Coupling capacitor, pF
160 C4=29.392 !           Series output capacitor, pF
170 C5=399.66 !           Series output capacitor. pF
180 ! ************** CALCULATION *************************************
190 CLEAR @ DEG @ SHORT LM,LP,GAINA.GAINM,GAMMA
200 DISP "START FREQUENCY, MHz = " @ INPUT F1
210 DISP "STOP FREQUENCY, MHz = " @ INPUT F2
220 DISP "FREQUENCY STEPS, MHz = " @ INPUT FS
230 CLEAR
240 DISP "FREQUENCY. MHz"."RESPONSE. dB"."PHASE, DEG"."GAMMA" @ DISP
250 FOR F=F1 TO F2 STEP FS
260 W=2*PI *F*1000000
270 XL=W*L*.000001 ! Reactance of L
280 X1=-(1/(W*C1*.000000000001)) ! Reactance of C1
290 X2=-(1/(W*C2*.000000000001)) ! Reactance of C2
300 X3=-(1/(W*C3*.000000000001)) ! Reactance of C3
310 X4=-(1/(W*C4*.000000000001)) ! Reactance of C4
320 X5=-(1/(W*C5*.000000000001)) ! Reactance of C5
330 RL=QL*XL ! Close approximation
340 RP=Ro @ XP=X5
350 GOSUB PTOS
360 R1=RS @ X6=XS !             (b)
370 X7=X6+X4 !                  (c)
380 RS=R1 @ XS=X7
390 GOSUB STOR
400 R2=RP @ X8=XP !             (d)
410 X9=1/(1/X8+1/XL) @ R3=1/(1/R2+1/RL) !      (e)
420 RP=R3 @ XP=X9
430 GOSUB PTOS
440 R4=RS @ X10=XS !            (f)
450 X11=X10+X3 !                (g)
460 RS=R4 @ XS=X11
470 GOSUB STOR
480 R5=RP @ X12=XP !            (h)
490 X13=1/(1/X12+1/XL) @ R6=1/(1/R5+1/RL) !     (i)
500 RP=R6 @ XP=X13
510 GOSUB PTOS
520 R7=RS @ X14=XS !            (j)
530 X15=X14+X2 !                (k)
540 RS=R7 @ XS=X15
550 GOSUB STOR
560 R8=RP @ X16=XP !            (l)
570 X17=1/(1/X16+1/X1) !        (m)
580 RP=R8 @ XP=X17
590 GOSUB PTOS
600 R9=RS @ X18=XS !            (n)
610 ! ************** GAMMA CALCULATION ****************************
620 R=R9-Rs @ X=X18 @ GOSUB RTOP
630 G1=MAG
640 R=R9+Rs @ X=X18 @ GOSUB RTOP
650 G2=MAG
660 GAMMA=G1/G2 ! Reflection coefficient
670 ! *************** RESPONSE CALCULATION ************************
680 R=1 @ X=0 @ GOSUB RTOP
690 E1M=MAG @ E1A=ANG !  Input voltage in polar form (e1=1)
700 R=Rs+R9 @ X=X18 @ GOSUB RTOP
710 ZiM=MAG @ ZiA=ANG !  Total input impedance (including source)
720 I1M=E1M/ZiM @ I1A=E1A-ZiA ! Input current in polar form
730 R=R9 @ X=X18 @ GOSUB RTOP
740 NM=MAG @ NA=ANG ! Numerator of (26) in polar form
750 R=R7 @ X=X15 @ GOSUB RTOP
760 DM=MAG @ DA=ANG ! Denominator of (26) in polar form
770 I3M=I1M*NM/DM @ I3A=I1A+NA-DA ! I3 in polar form
780 R=R7 @ X=X14 @ GOSUB RTOP
790 NM=MAG @ NA=ANG
800 R=R4 @ X=X11 @ GOSUB RTOP
810 DM=MAG @ DA=ANG
820 I5M=I3M*NM/DM @ I5A=I3A+NA-DA ! I5 in polar form
830 R=R4 @ X=X10 @ GOSUB RTOP
840 NM=MAG @ NA=ANG
850 R=R1 @ X=X7 @ GOSUB RTOP
860 DM=MAG @ DA=ANG
870 I7M=I5M*NM/DM @ I7A=I5A+NA-DA ! I7 in polar form
880 R=R1 @ X=X6 @ GOSUB RTOP
890 NM=MAG @ NA=ANG
900 DM=Ro @ DA=0
910 I9M=I7M*NM/DM @ I9A=I7A+NA-DA ! I9 in polar form
920 EoM=I9M*Ro @ EoA=I9A ! Output voltage in polar form
930 EIM=1 @ EIA=0 ! Input voltage in polar form
940 GAINM=20*LGT (EoM/EIM) @ GAINA=EoA-EIA ! Gain in polar form
950 ! ************** DATA DISPLAY **********************************
960 DISP F,GAINM,GAINA,GAMMA
970 NEXT F
980 END
990 ! ************** STANDARD SUBROUTINES **************************
1000 STOR: ! Series to parallel conversion
1010 ! INPUT RS. XS
1020 IF RS=0 THEN RS=1.E-30
1030 IF XS=0 THEN XS=1.E-30
1040 RP=XS^2/RS+RS
1050 XP=RS^2/XS+XS
1060 ! OUTPUT RP, XP
1070 RETURN
1080 PTOS: ! Parallel to series conversion
1090 ! INPUT RP, XP
1100 IF XP=0 THEN XP=1.E-30
1110 RS=RP/(1+(RP/XP)^2)
1120 XS=XP*RP^2/(XP^2+RP^2)
1130 ! OUTPUT RS, XS
1140 RETURN
1150 RTOP: ! Rectangular to polar conversion
1160 ! INPUT R, X - series resistance and reactance
1170 MAG=SQR (R^2+X^2) @ ANG=ATN2 (XS,RS)
1180 ! OUPUT MAG. ANG - magnitude and angle
1190 RETURN
```

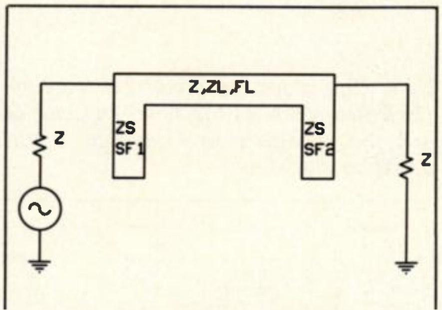
Dual Trap Frequency Response

By Andrzej B. Przedpelski
A.R.F. Products, Inc.

The dual trap circuit is useful when a single frequency or a small frequency band has to be eliminated. The circuit shown can be designed to provide a large variety of frequency responses. For instance, the two traps can be tuned to the same frequency to provide maximum single frequency rejection or the traps can be stagger tuned to provide a rejection band. The line between the open circuited traps adjusts the overall response characteristic. For instance, if both traps are tuned to the same frequency, and the connecting line is 90 or 180 degrees long (at the trap frequency), the response will be symmetrical.

On the other hand a very short line will give an overall skewed response, while the maximum frequency of attenuation will remain the same. The two traps are 90 degrees long at the desired maximum attenuation frequencies and are open circuited stubs. The stubs do not have to be the same characteristic impedance as the system impedance, but can be adjusted for the desired frequency response or space and line impedance available.

An example is given for a narrow band trap with the first trap tuned to 99 MHz and the second to 101 MHz, the connecting line being 90 degrees at 100 MHz. All lines are 50 ohms.



Dual trap circuit.

```
FREQUENCY, HZ          GAIN, DB
  90000000             -25.538
  91000000             -27.52
  92000000             -29.713
  93000000             -32.178
  94000000             -35.01
  95000000             -38.362
  96000000             -42.506
  97000000             -48.014
  98000000             -56.567
  99000000             -1.E80
  100000000            -66.137
  101000000            -1.E80
  102000000            -56.567
  103000000            -48.014
  104000000            -42.506
  105000000            -38.362
  106000000            -35.01
  107000000            -32.177
  108000000            -29.712
  109000000            -27.52
  110000000            -25.538
```

Frequency versus gain.

```
10 REM DUAL TRAP [OPEN STUB] RESPONSE - #545
20 '     A. PRZEDPELSKI    -  24 FEB 1986 / 22 AUG 1988
30 '     A.R.F. PRODUCTS, INC.
40 '     BOULDER, CO
50 !         REF.: "CALCULATOR DESIGN OF MICROSTRIP TRAPS"
60 !                 R.F. DESIGN, JULY/AUGUST 1979
70 CLEAR @ DEG @ SHORT L.F
80 DISP "SECOND TRAP FREQUENCY [HZ]":@ INPUT SF2
90 DISP "FIRST TRAP FREQUENCY [HZ]":@ INPUT SF1
100 DISP "STUB IMPEDANCES":@ INPUT ZS
110 DISP "ANGLE AND FREQUENCY [HZ] OF LINE BETWEEN STUBS":@ INPUT ZL,FL
120 DISP "START, STOP AND STEP FREQUECIES [HZ]":@ INPUT S1.S2,S3
130 DISP "SYSTEM CHARACTERISTIC IMPEDANCE":@ INPUT Z
140 DISP @ DISP "FREQUENCY, HZ","GAIN, DB"
150 ! ******************************************************************
160 FOR F=S1 TO S2 STEP S3 ' FREQUENCY SWEEP
170 ! ******************** CALCULATE SECOND STUB ***************************
180 W2=F/SF2 ! SECOND STUB ANGLE CORRECTION
190 Zo=ZS ' SECOND STUB LINE IMPEDANCE
200 SANG=90 ' LENGTH OF OPEN STUB
210 ANG=SANG*W2 ! CORRECTED SECOND STUB LENGTH FOR FREQUENCY
220 Ro=1.E30 ' OPEN  CIRCUITED STUB
230 Xo=1.E30 '    "        "        "
240 ! ******************************************************************
250 GOSUB ZTRANS  ! CALCULATE SECOND STUB REACTANCE
260 XSTUB2=Xi ! SECOND STUB REACTANCE
270 ' ************************ CALCULATE FIRST STUB ***********************
280 W1=F/SF1 ! ANGLE CORRECTION
290 Zo=ZS ' STUB LINE IMPEDANCE
300 ANG=SANG*W1 ! CORRECTED SECOND STUB LENGTH FOR FREQUENCY
310 GOSUB ZTRANS  ! CALCULATE FIRST STUB REACTANCE
320 XSTUB1=Xi ! SECOND STUB REACTANCE
330 ! ************** CALCULATE IMPEDANCE AT SECOND STUB *****************
340 RP=Z ! PARALLEL OUTPUT RESISTANCE
350 XP=XSTUB2 ! PARALLEL STUB REACTANCE
360 GOSUB PTOS  ' CONVERT TO SERIES IMPEDANCE
370 R2=RS @ X2=XS ! IMPEDANCE AT SECOND STUB
380 ! **************** CALCULATE IMPEDANCE AT FIRST 3TUB ****************
390 Ro=R2 @ Xo=X2 ! IMPEDANCE AT SECOND STUB
400 W3=F/FL ! CONNECTING LINE CORRECTION
410 ANG=W3*ZL ! CONNECTING LINE LENGTH CORRECTED
420 Zo=Z ! CONNECTING LINE IMPEDANCE
430 GOSUB ZTRANS  ! TRANSFORM TO FIRST STUB
440 RS=Ri @ XS=Xi ! CONVERTED SECOND STUB IMPEDANCE AT FIRST STUB
450 GOSUB STOR  ! CONVERT TO PARALLEL
460 XP=1/(1/XSTUB1+1/XP) ! TOTAL PARALLEL REACTANCE
470 GOSUB PTOS  ! CONVERT TO SERIES
480 R=RS @ X=XS ! SERIES IMPEDANCE AT FIRST STUB
490 ' ******************** CALCULATE INSERTION LOSS *********************
500 GOSUB GAM  ! CALCULATE GAMMA AT FIRST STUB
510 GOSUB LOSS  ! CALCULATE LOSS
520 ! ************************ OUTPUT DATA *************
530 DISP F.L
540 NEXT F
550 END
560 REM **************** STANDARD ROUTINES ***********
570 PTOS: ' PARALLEL TO SERIES CONVERSION
580 ! INPUT RP,XP
590 RS=RP/(1+(RP/XP)^2)
600 XS=XP*RP^2/(XP^2+RP^2)
610 ! OUTPUT RS,XS
620 RETURN
630 ZTRANS: ' TRANSFORMATION USING TRANSMISSION LINE
640 ! INPUT Zo,ANG,Ro,Xo
650 IF ANG=90 THEN T=1.E100 ELSE T=TAN (ANG)
660 A=Zo*Ro @ B=Zo*Xo+Zo^2*T
670 C=Zo-Xo*T @ D=Ro*T
680 Ri=(A*C+B*D)/(C^2+D^2)
690 Xi=(B*C-A*D)/(C^2+D^2)
700 ! OUTPUT Ri,Xi
710 RETURN
720 STOR: ! SERIES TO PARALLEL CONVERSION
730 ! INPUT RS,XS
740 RP=XS^2/RS+RS
750 XP=RS^2/XS+XS
760 ! OUTPUT RP,XP
770 RETURN
780 ZTRANS: ! TRANSFORMATION USING TRANSMISSION LINE
790 ' INPUT Zo,ANG,Ro,Xo
800 IF ANG=90 THEN T=1.E100 ELSE T=TAN (ANG)
810 A=Zo*Ro @ B=Zo*Xo+Zo^2*T
820 C=Zo-Xo*T @ D=Ro*T
830 Ri=(A*C+B*D)/(C^2+D^2)
840 Xi=(B*C-A*D)/(C^2+D^2)
850 ! OUTPUT Ri,Xi
860 RETURN
870 GAM: ! CONVERTS Z TO GAMMA
880 ! INPUT R,X
890 GAM=SQR (((R-Z)^2+X*X)/((R+Z)^2+X*X))
900 ! OUTPUT GAM
910 RETURN
920 LOSS: ! POWER LOSS DUE TO GAMMA
930 ! INPUT GAM
940 ON ERROR GOTO 960
950 L=10*LGT (1-GAM^2) @ GOTO 970
960 OFF ERROR @ L=-1.E80
970 ! OUTPUT LOSS (IN DB)
980 RETURN
990 END
```

Simplifying Propagation Loss Calculations

By Mel Bebee
Rockwell International

Engineers working with communication systems performance need to calculate propagation loss. A major component of this calculation is the free space loss between two isotropic antennas. Most engineers derive the formula each time it is needed by taking 10 log of the ratio between a spherical surface at a distance "D" ($4\pi D^2$) and the effective area of an isotropic radiator ($\lambda^2/4\pi$). Another formula for the above ratio is:

$$\text{Loss (dB)} = 20\log(F)+20\log(D)+K \qquad (1)$$

The problem arises in remembering the value of K. For F in MHz and D in meters, the value of K is −27.56 dB. Note that this value changes with various values of D. Table 1 shows the different values of K for the various distance units. Unless the engineer has this table handy or has memorized it, the equation above is useless.

A unit of distance can be defined for which K will equal 0. This distance is $300/(4\pi)$ or $75/\pi$ meters. The author has named this constant a "Perry," inspired by Beth Perry, a Rockwell engineer who conducted a propagation analysis. It is not uncommon to define a unit of distance for convenience in a particular field. Examples include fathoms, mils and fermis. The resulting equation is:

$$\text{Loss (dB)} = 20\log(F)+20\log(D) \qquad (2)$$

where F is in MHz and D is in Perrys.

Distance Unit (D)	K (in dB)
meters	−27.56
yards	−28.34
feet	−37.88
kilometers	+32.44
miles, statute	+36.57
miles, nautical	+37.79

Table 1. K values for various distance units.

Example 1

Find the free space loss (dB) at 10 MHz for a distance of 150 km between isotropic antennas.

Distance = 150 km
= $150{,}000(\pi/75)$Perrys = 2000π
Loss(dB) =
$20\log(10) + 20\log(2000\pi) = 95.96$ dB

Conclusion

Using this formula, the engineer only has to remember the conversion for Perrys ($75/\pi$) and equation 2. This eliminates the problem of memorizing Table 1.

About the Author

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Issue	Shows & Special Coverage	Featured Technology	Industry Insight
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FEBRUARY	• RF Technology Expo 1989 • Aerospace Conference	Small-Signal Amplifiers	GaAs Technology
MARCH		Filter Design	Power Transistors
APRIL	• National Association of Broadcasters (NAB)	The RF Spectrum: I. Low and Medium Frequencies	Packaging Update
MAY	• Frequency Control Symposium • IEEE EMC Conference • Recruitment Issue/College Distribution	The RF Spectrum: II. HF Technologies	Frequency Synthesis
JUNE	• MTT-S • European Microwave Show	The RF Spectrum: III. VHF and UHF	Subsystems
JULY	• EMC Expo	Electromagnetic Compatibility • 1989 Design Contest Results	Filters
AUGUST	• Quartz Devices Conference • Antenna Measurement Techniques Association (AMTA)	Crystal Oscillators and Filters	Attenuators and Switches
SEPTEMBER	• Coil Winding Show	Test and Measurement Techniques	Inductors, magnetic materials (ferrite, iron powder)
DIRECTORY (SEPT.)	All Shows	**DIRECTORY ISSUE** Vendor Listings, Design Notes	
OCTOBER	• Old Crows • Ultrasonics Symposium • Electronica (Europe)	System Design: Build-or-Buy Decision	SAW Update
NOVEMBER	• RF Expo East 1989	Using Passive Components	RF Software
DECEMBER	Article Index	Mixers, Modulators and Demodulators	Cables & Connectors

PUBLISHER'S STATEMENT

FOR 6 MONTH PERIOD ENDING DECEMBER 1988

R. F. DESIGN

Cardiff Publishing Company
6300 South Syracuse Way
Suite 650
Englewood, CO 80111
(303) 220-0600

Official Publication of: None
Established: 1978
Issues Per Year: 12

No attempt has been made to rank the information contained in this report in order of importance, since BPA believes this is a judgement which must be made by the user of the report.

BUSINESS PUBLICATIONS AUDIT
OF CIRCULATION, INC.
360 Park Avenue South
New York, NY 10010
(212) 532-6880

BPA BUSINESS PUBLICATION

FIELD SERVED

R.F. DESIGN serves engineers, managers, and other personnel responsible for the design and development of electronic systems and equipment using radio frequencies (RF), in the following industries: military, aerospace, ECM, EW, radar, land mobile, marine, navigation, CATV, broadcast, video and other communications; test and instrumentation; consumer components; electronics; and user industries. It is also distributed to labs, consultants.

DEFINITION OF RECIPIENT QUALIFICATION

Qualified recipients of R.F. DESIGN are engineering managers, engineers, members of technical staff, and other titled and non-titled personnel in the field served.

AVERAGE NON-QUALIFIED CIRCULATION

	Copies
Advertiser and Agency	1,142
Non-Qualified Paid	280
Rotated or Occasional	-
Samples	103
All Other	1,563
TOTAL	3,088

1. AVERAGE QUALIFIED CIRCULATION BREAKDOWN FOR PERIOD

	Qualified Non-Paid		Qualified Paid		Total Qualified	
	Copies	Percent	Copies	Percent	Copies	Percent
Single	35,474	13.2	102	0.3	35,606	100.0
Group	-	-	-	-	-	-
Association	-	-	-	-	-	-
Bulk	-	0.3	3	-	3	-
TOTALS	35,474	13.5	105	0.3	35,609	100.0

2. QUALIFIED CIRCULATION BY ISSUES WITH REMOVALS AND ADDITIONS FOR PERIOD

1988 Issue	Qualified Non-Paid	Qualified Paid	Total Qualified	Number Removed	Number Added
July			35,080	122	1,060
August			35,081	647	648
September			35,113	59	91
October			36,115	776	1,778
November			36,174	485	544
December			36,090	860	776
			TOTALS	2,949	4,897

3a. BUSINESS/OCCUPATIONAL BREAKDOWN OF QUALIFIED CIRCULATION FOR ISSUE OF NOVEMBER 1988

This issue is 1.9% or 678 copies above the average of the other 5 issues reported in Paragraph 2.

			CLASSIFICATION BY TITLE				
BUSINESS AND INDUSTRY	TOTAL QUALIFIED COPIES	PERCENT OF TOTAL	ENGINEERING MANAGER	ENGINEER, MEMBER TECHNICAL STAFF	Engineering Service Titles (Standards, Reliability, QC, Test Engineers	President, Owner/Operator, Vice President, General Manager, Plant Manager	OTHER TITLED & NON-TITLED PERSONNEL & COMPANY COPIES
Government, Military, Aerospace, ECM, EW, Radar Manufacturers	1,134	3.1	193	722	193	15	11
a. EW, ECM and Radar Systems	5,185	14.3	1,103	3,362	581	103	36
b. Government Agencies other than Military	1,327	3.7	344	718	232	20	13
c. Military Communications Systems ...	4,573	12.6	937	2,915	576	122	23
d. Satellite and Space Systems	2,217	6.1	448	1,450	244	58	17
CATV & Broadcast Equipment	1,580	4.4	508	618	228	217	9
Land Mobile Equipment	2,120	5.9	529	994	241	338	18
Ground Communication Equipment Manufacturers	274	0.8	65	154	39	12	4
Video, Audio Equipment	648	1.8	168	322	79	74	5
Data Transmission/Computer Systems	2,167	6.0	505	1,167	313	173	9
Instruments & Test Equipment	3,466	9.6	732	1,844	537	309	44
Medical Electronics Equipment	632	1.7	143	365	61	59	4
Industrial Controls & Power Supplies ...	689	1.9	168	329	84	103	5
Consumer Electronics Equipment	1,168	3.2	267	545	182	171	3
Components & Subsystems	3,673	10.2	878	1,804	393	535	63
Aviation, Marine, Navigation Systems ..	2,438	6.7	497	1,497	353	77	14
Lab or Consultant	2,299	6.4	479	968	241	577	34
Users of Electronic Equipment	406	1.1	108	158	99	32	9
Others Allied to the Field	178	0.5	41	88	19	16	14
TOTAL	36,174	100.0	8,113	20,020	4,695	3,011	335
PERCENT	100.0	-	22.4	55.4	13.0	8.3	0.9

3b. QUALIFICATION SOURCE BREAKDOWN FOR ISSUE OF NOVEMBER 1988

QUALIFICATION SOURCE	Qualified Within			Qualified Non-Paid	Qualified Paid	Total Qualified	Percent
	1 year	2 years	3 years				
I. Personal direct request from the recipient:							
a. Written	33,323	2,851	-			36,174	100.0
b. Telecommunication	-	-	-			-	-
II. Request from recipient's company:							
a. Written	-	-	-			-	-
b. Telecommunication	-	-	-			-	-
III. Association or society membership:							
a. Individual	-	-	-			-	-
b. Organizational	-	-	-			-	-
IV. Communication from recipient or recipient's company (other than request):							
a. Written	-	-	-			-	-
b. Telecommunication	-	-	-			-	-
V. Sources other than above (listed alphabetically):							
Association rosters and directories	-	-	-			-	-
Business directories	-	-	-			-	-
Independent field reports	-	-	-			-	-
Licensees-Federal, State or Local Government	-	-	-			-	-
Manufacturer's, distributor's and wholesaler's lists	-	-	-			-	-
Other sources	-	-	-			-	-
TOTALS	33,323	2,851	-			36,174	100.0
Percents	92.1	7.9	-			100.0	

3c. MAILING ADDRESS BREAKDOWN OF QUALIFIED CIRCULATION FOR ISSUE OF NOVEMBER 1988

	Qualified Non-Paid	Qualified Paid	Total Qualified	Percent
Individuals by name and title and/or function			36,137	99.9
Individuals by name only			18	0.1
Titles or functions only			3	-
Company names only			13	-
Bulk copies			3	-
TOTALS			36,174	100.0

4. GEOGRAPHICAL BREAKDOWN OF QUALIFIED CIRCULATION FOR ISSUE OF NOVEMBER 1988

State & Zip Code	Qualified Non-Paid	Qualified Paid	Total Qualified	Percent
039-049 ME			36	
030-038 NH			396	
050-059 VT			28	
010-027 MA			2,231	
028-029 RI			84	
060-069 CT			494	
NEW ENGLAND			3,269	9.0
100-149 NY			2,539	
070-089 NJ			1,574	
150-196 PA			1,124	
MIDDLE ATLANTIC			5,237	14.5
430-458 OH			661	
460-479 IN			728	
600-629 IL			1,461	
480-499 MI			379	
530-549 WI			222	
EAST NO. CENTRAL			3,451	9.5
550-567 MN			410	
500-528 IA			337	
630-658 MO			334	
580-588 ND			16	
570-577 SD			26	
680-693 NE			64	
660-679 KS			219	
WEST NO. CENTRAL			1,406	3.9
197-199 DE			23	
206-219 MD			1,476	
200-205 DC			189	
220-246 VA			967	
247-268 WV			22	
270-289 NC			270	
290-299 SC			59	
300-319 GA			435	
320-349 FL			1,496	
SOUTH ATLANTIC			4,937	13.7
400-427 KY			45	
370-385 TN			172	
350-369 AL			264	
386-397 MS			37	
EAST SO. CENTRAL			518	1.4
716-729 AR			35	
700-714 LA			44	
730-749 OK			106	
750-799, 885 TX			1,707	
WEST SO. CENTRAL			1,892	5.2
590-599 MT			24	
832-838 ID			38	
820-831 WY			15	
800-816 CO			690	
870-884 NM			310	
850-865 AZ			1,038	
840-847 UT			237	
889, 890-898 NV			121	
MOUNTAIN			2,473	6.8
995-999 AK			14	
980-994 WA			599	
970-979 OR			300	
900-961 CA			8,754	
967-968 HI			42	
PACIFIC			9,709	26.9
UNITED STATES			32,892	90.9
969 & 006-009 U.S. Territories			41	
Canada			886	
Foreign			2,276	
APO/FPO			79	
TOTALS			36,174	100.0

QUALIFIED PAID CIRCULATION

5. PRICES

6. LENGTH OF SUBSCRIPTIONS

7. SOURCES

PARAGRAPHS 5 THROUGH 10 ARE NOT APPLICABLE

8. PREMIUMS

9. STATUS OF QUALIFIED PAID SUBSCRIPTION PAYMENTS

10. RENEWAL PERCENTAGE OF QUALIFIED PAID CIRCULATION

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11. ADDITIONAL DATA

PUBLISHER'S AFFIDAVIT

We hereby make oath and say that all data set forth in this statement are true.

Robert Searle President

Patricia Shapiro Circulation Director

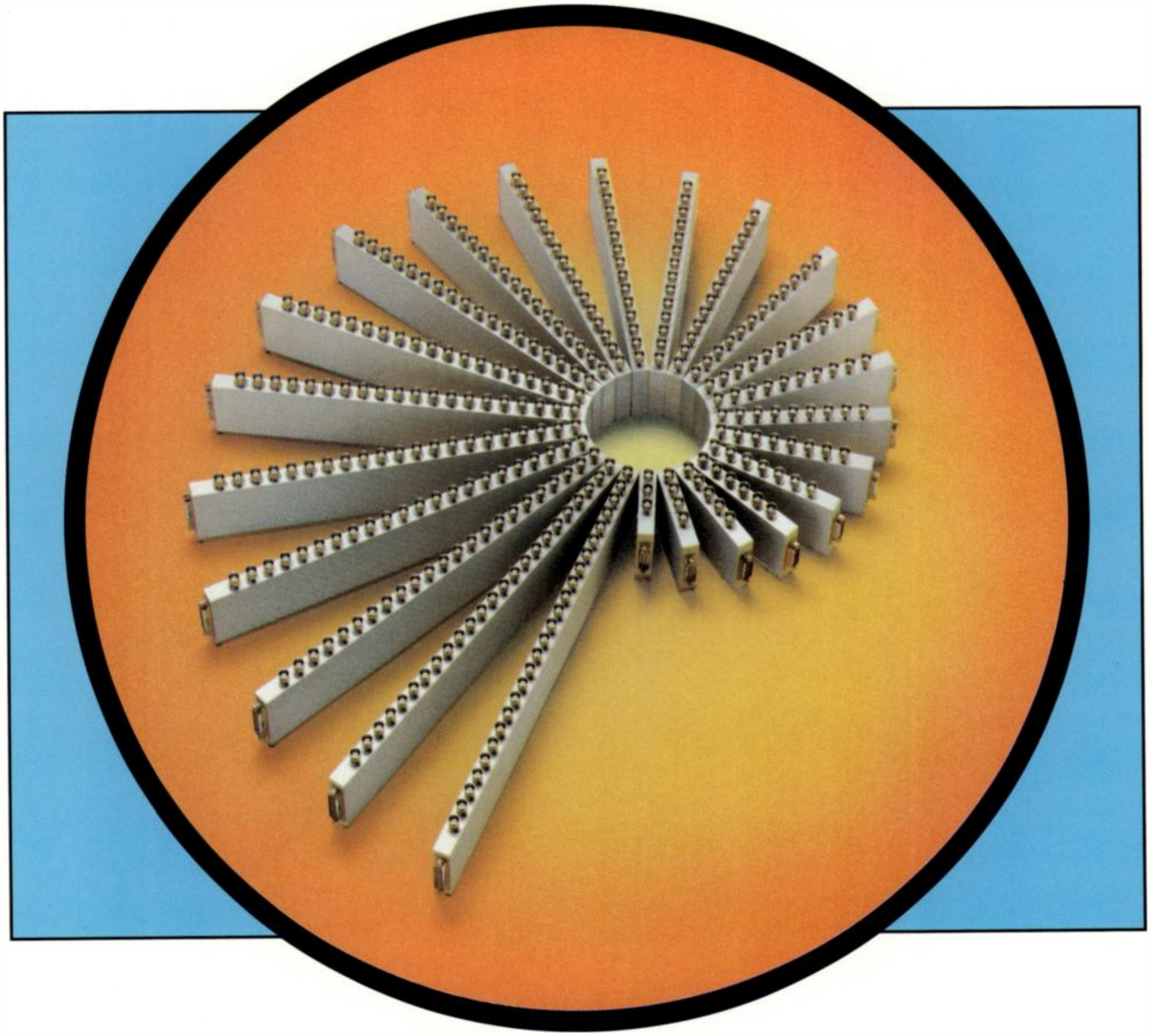
(At least one of the above signatures must be that of an officer of the publishing company or its authorized representative.)

Date signed	December 13, 1988
State	Colorado
County	Arapahoe
Received by BPA	December 15, 1988
Number	10752PJ

IMPORTANT NOTE:

This unaudited publisher's statement has been checked against the previous audit report. It will be included in the annual audit made by Business Publications Audit of Circulation, Inc.

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



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

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

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

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

Non-blocking Matrix configuration may be easily assembled using our self-terminating relays and 5100A series power dividers. Built-in Video/RF amplifiers allow zero insertion loss designs.

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

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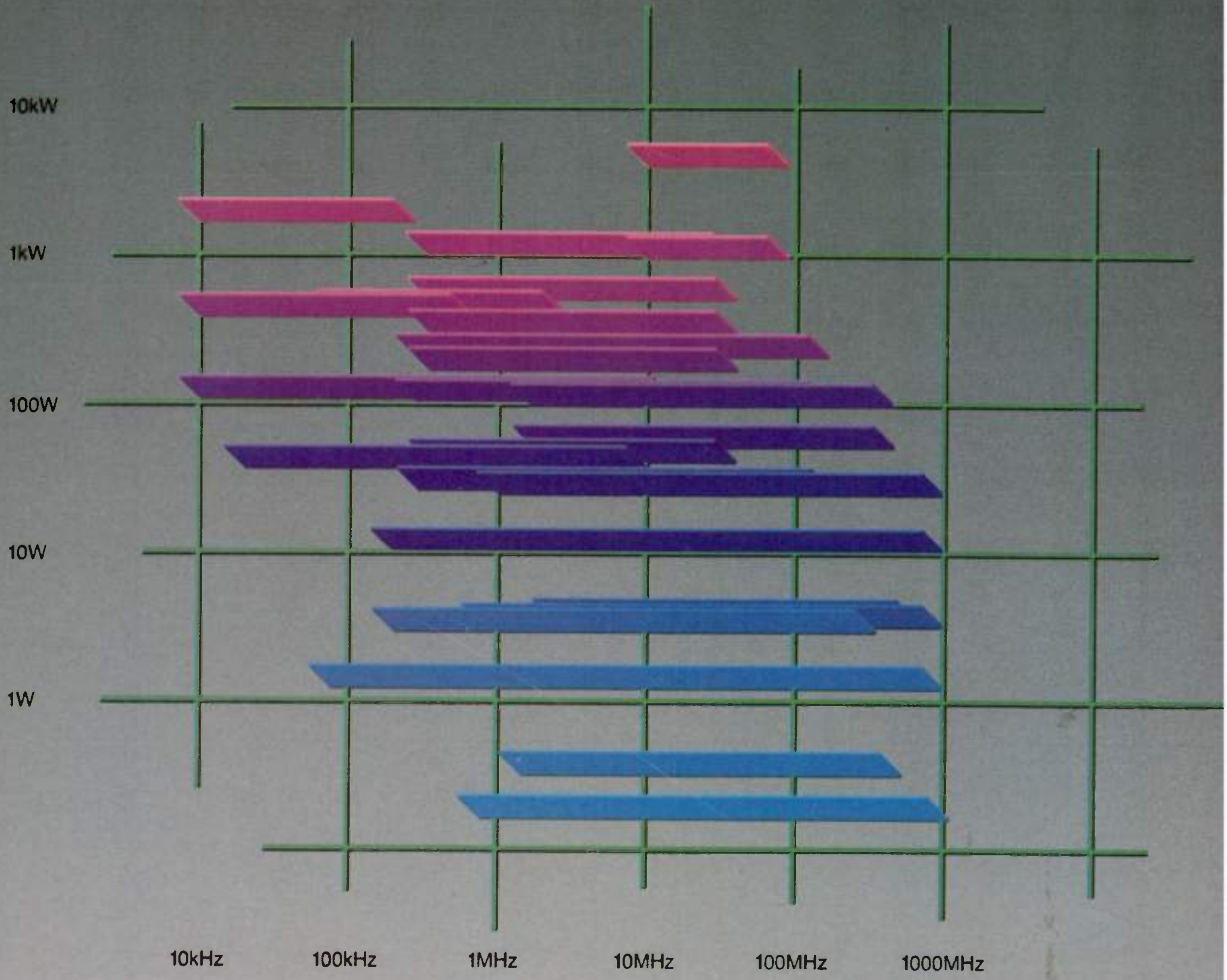
INFO/CARD 80

RF POWER

As You Like It.



All solid state. Unconditionally stable. Compact. Tremendously versatile. Whatever your need for RF Power, ENI offers you a choice of Class A power amplifiers unsurpassed in quality. Our wide line spans a frequency spectrum from 10kHz to 1GHz with power outputs that range from 300 milliwatts to over 4000 watts.

These units can be driven by virtually any signal source. They're completely broadband and untuned, amplifying inputs of AM, FM, TV, SSB, and pulse modulations with minimum distortion. Their unconditional stability and fail-safe design make them impervious to severe mismatch conditions, and capable of delivering rated power to any load impedance from an open to a closed circuit.

The design excellence of ENI amplifiers is symbolized by the perfect geometry of the design elements we use with our logo. For our latest catalog, please contact us at any of the offices listed below.

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