microwave
JOURNAL

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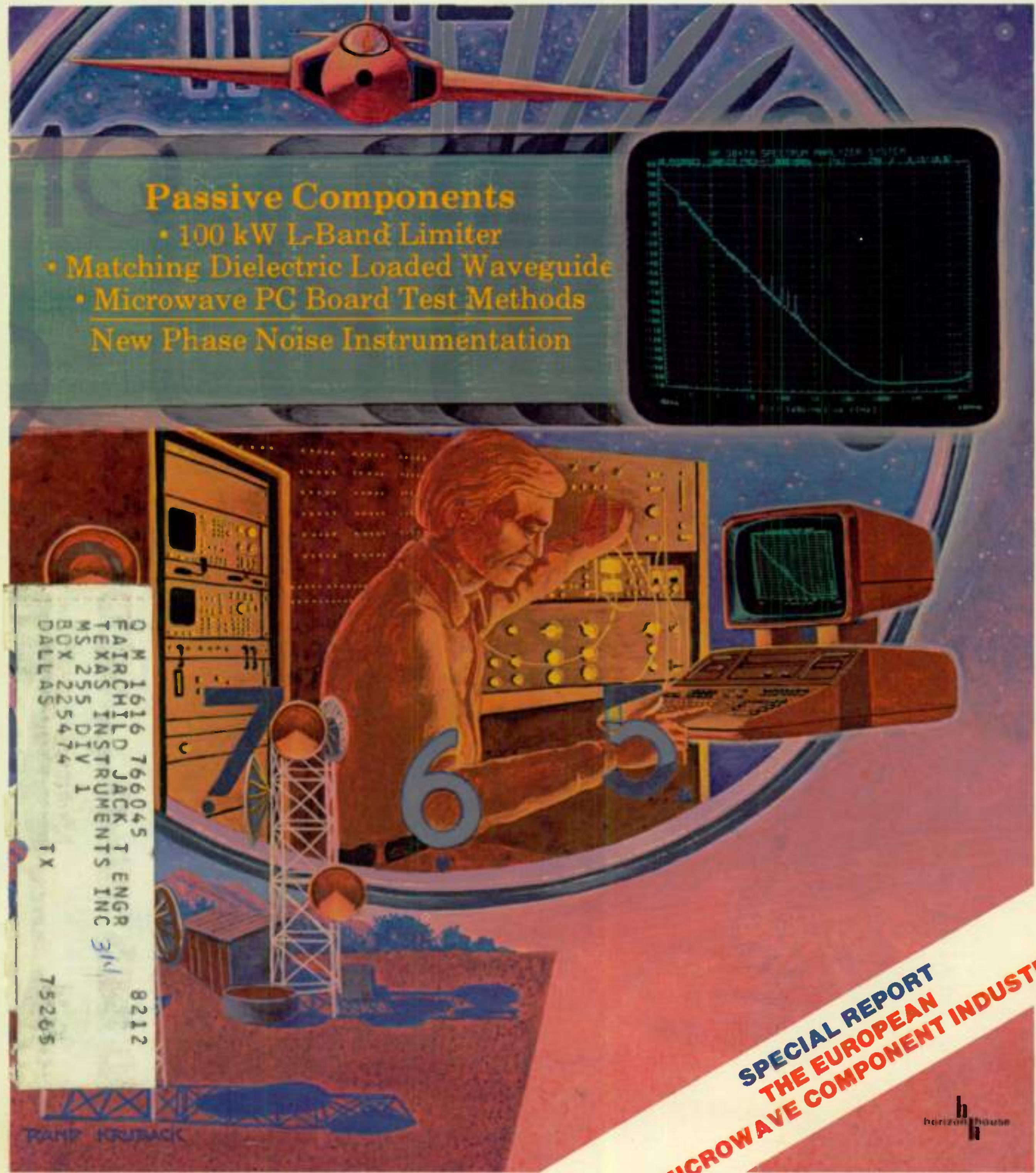
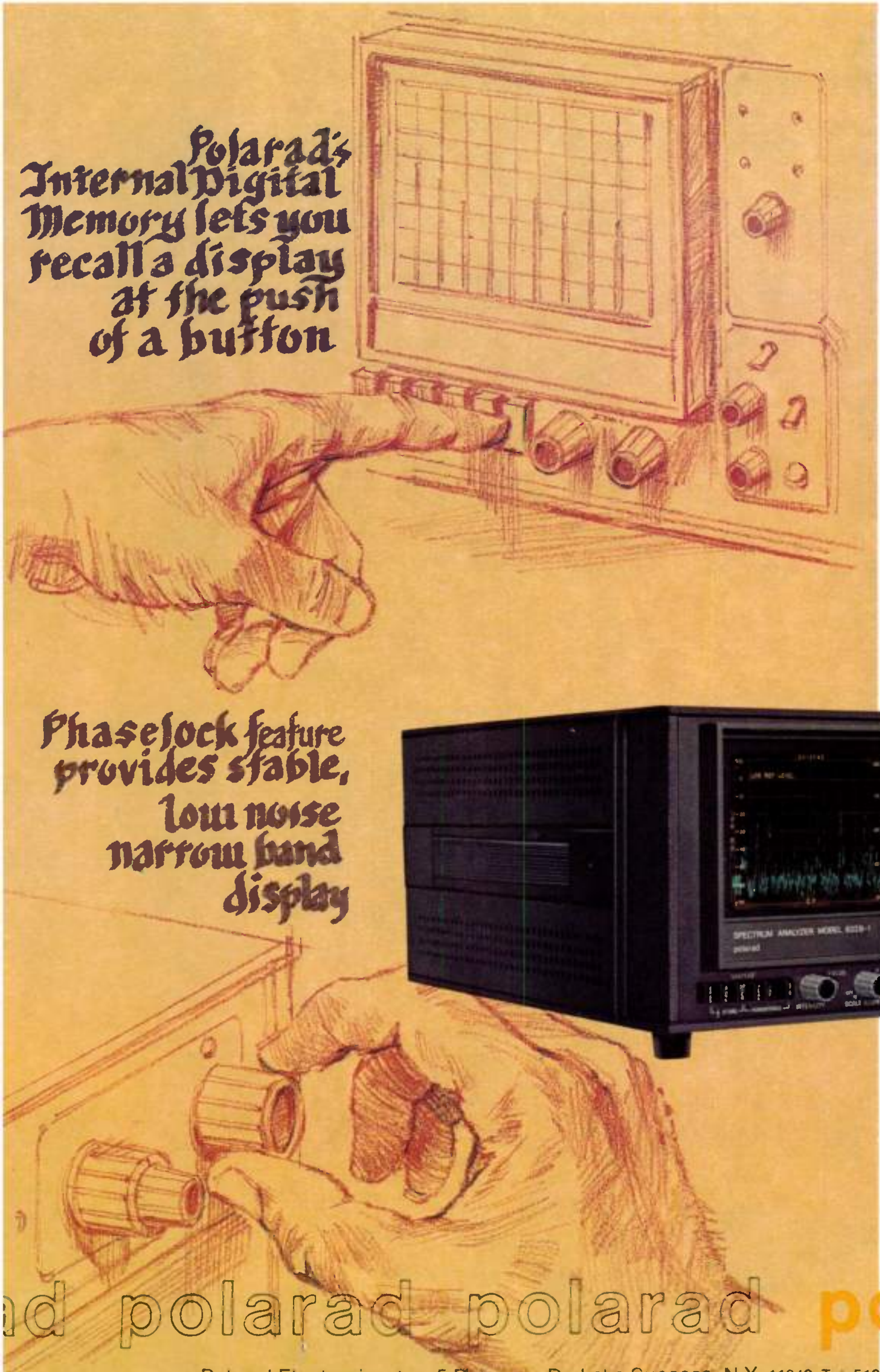


horizon house

OUR SPECTRUM ANALYZERS NEVER FORGET A SIGNAL.



Polarad's Internal Digital Memory allows you to recall a display.

With Polarad's new 600B Series Spectrum Analyzers, a display that ap pears today, can also appear tomorrow. And because our memory is digital (far superior to variable persistence types), you can expect high resolution with continuously update displays—without blooming, fading smearing.

But you'll be saying a lot more than "thanks for the memory," once you put the new 600 Series to work. You' also like our phase lock feature that provides stable, low-noise, narrowba displays and minimizes residual nois sidebands.

The new 600 Series are also light an compact, so they can be moved from bench to bench in the lab or be transported for field measurements.

Polarad's 600B Series of Spectrum Analyzers...the performance, ease of use and versatility you need, at a pric we know you can afford.

Call us for a demonstration and quot tion today or write for further informa tion and specifications.

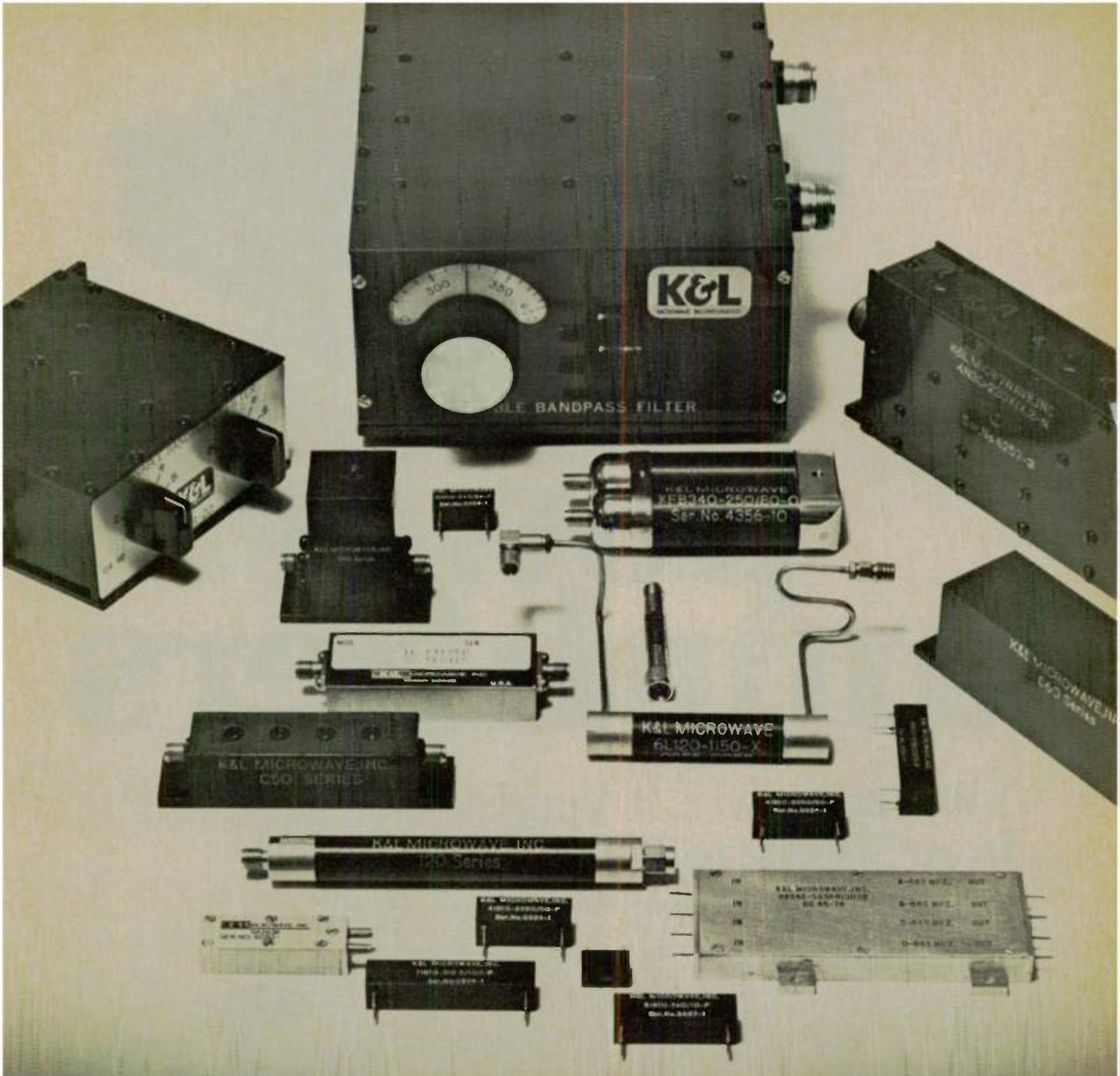
Selection Guide

Model	Frequency
632B-1	100 kHz-2 GHz
630B-1	3 MHz-40 GHz
640B-1	3 MHz-40 GHz

CIRCLE 1 ON READER SERVICE CAR

ad polarad polarad **polarad** p

Polarad Electronics, Inc. 5 Delaware Dr. Lake Success, N.Y. 11042 Tel 516-328-1100 TWX 510-223-0414



The complete filter line ...only from K&L

From Microminiature Receiving Filters to Transmitting Filters . Gaussian Bessel . Butterworth . Chebychev . Monotonic or Elliptic Function . Highpass Lowpass . Bandpass . Band Reject . Coaxial and Waveguide

Whatever your filter needs may be, only K&L can satisfy them all.

Call or write for our descriptive catalog . . . and if you don't find the model that meets your needs, we'll design one for you.

Mini Filter Shown actual size

K&L MICROWAVE INCORPORATED

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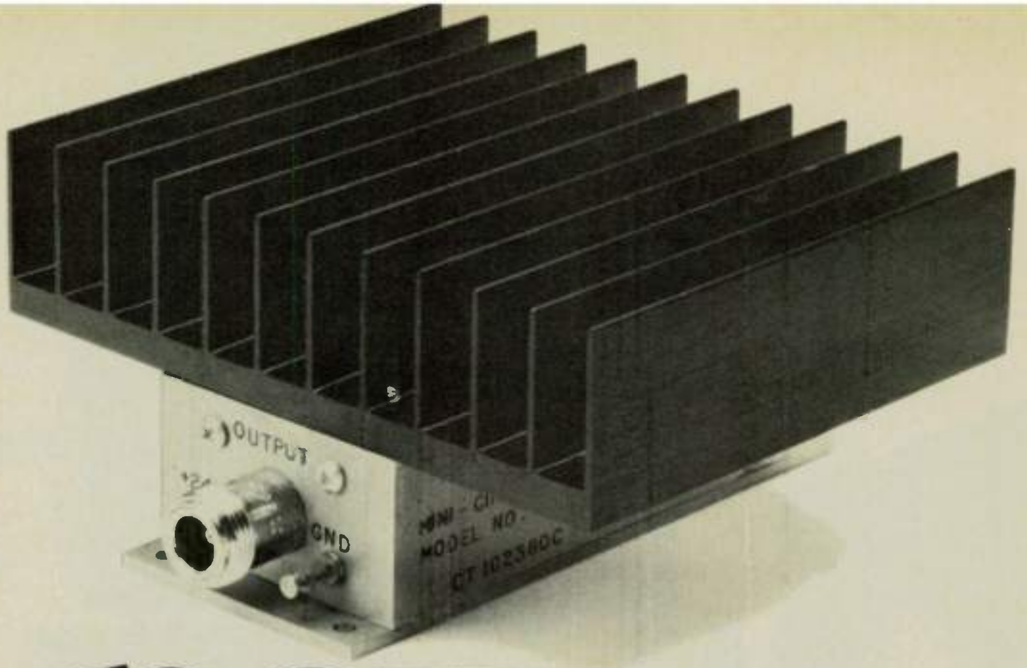


power amplifiers

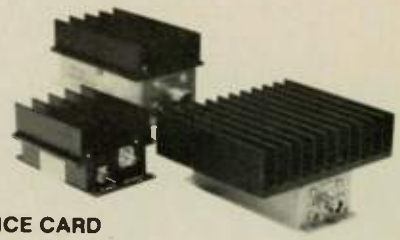
1 Watt and now. . . 2 Watts linear output from 50KHz to 1200 MHz from $199

If your application requires up to 2 watts for intermodulation testing of components... broadband isolation... flat gain over a wide bandwidth... or much higher output from your frequency synthesizer or signal/sweep generator... Mini-Circuits' ZHL power amplifiers will meet your needs, at surprisingly low prices. Seven models are available, offering a selection of bandwidth and gain.

Using an ultra-linear Class A design, the ZHL is unconditionally stable and can be connected to any load impedance without amplifier damage or oscillation. The ZHL is housed in a rugged ⅛ inch thick aluminum case, with a self-contained hefty heat sink.

Of course, our one-year guarantee applies to each amplifier.

So from the table below, select the ZHL model for your particular application ...we'll ship within one week!



CIRCLE 4 ON READER SERVICE CARD

* Model No.	Freq. MHz	Gain dB	Gain Flatness dB	Max. Power Output dBm 1-dB Compression	Noise Figure dB	Intercept Point 3rd Order dBm	DC Power Voltage	DC Power Current	Price $ Ea.	Price Qty.
ZHL-32A	0.05-130	25 Min	±1.0 Max	+29 Min	10 Typ	+38 Typ	+24V	0.6A	199.00	(1-9)
ZHL-3A	0.4-150	24 Min	±1.0 Max	+29.5 Min	11 Typ	+38 Typ	+24V	0.6A	199.00	(1-9)
ZHL-1A	2-500	16 Min	±1.0 Max	+28 Min	11 Typ	+38 Typ	+24V	0.6A	199.00	(1-9)
ZHL-2	10-1000	15 Min	±1.0 Max	+29 Min	18 Typ	+38 Typ	+24V	0.6A	349.00	(1-9)
ZHL-2-8	10-1000	27 Min	±1.0 Max	+29 Min	10 Typ	+38 Typ	+24V	0.65A	449.00	(1-9)
ZHL-2-12	10-1200	24 Min	±1.0 Max	+29 Min*	10 Typ	+38 Typ	+24V	0.75A	524.00	(1-9)
ZHL-1-2W	5-500	29 Min	±1.0 Max	+33 Min	12 Typ	+44 Typ	+24V	0.9A	495.00	(1-9)

Total safe input power +20 dBm, operating temperature 0° C to +60° C, storage temperature −55° C to +100° C, 50 ohm impedance, input and output VSWR 2:1 max.
* +28.5 dBm from 1000-1200 MHZ
For detailed specs and curves, refer to
1980/81 MicroWaves Product Data Directory, Gold Book, or EEM

* BNC connectors are supplied; however,
SMA, TNC and Type N connectors are also available

For Mini Circuits sales and distributors listing see page 46

Mini-Circuits
A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
2625 East 14th Street, Brooklyn, New York 11235 (212)769-0200
Domestic and International Telex 125460   International Telex 620156

70 REV ORIG

Microwave Journal (USPS 396-250) is published monthly per request by Horizon House-Microwave Inc., 610 Washington Street, Dedham, MA 02026. Second Class postage paid at Dedham MA 02026 and additional offices. **POSTMASTER:** Send form 3579 to Microwave Journal, 610 Washington Street, Dedham MA 02026.

90° power splitters

World's largest variety of off-the-shelf models

1.5 to 450 MHz...from $12.95

Choose from more than 20 models of 2-way, 90° power splitters, spanning 1.4-450 MHz, with typically better than 25 dB isolation and insertion loss less than 0.3 dB. Models are available in hermetically sealed pin packages as well as connector versions.

Of course, if you need a "special" for a specific application, contact us for a prompt, informative response. We can supply your needs...at regular catalog prices!

For complete specs, performance curves and application information, refer to 1980-1981 MicroWaves Product Data Directory (pgs. 179-216) or EEM (pgs. 2923-3142).

90° SERIES SPECIFICATIONS

Model No.	Freq. Range MHz	Isolation dB Typ.	Isolation dB Min.	Insertion Loss dB* Typ.	Insertion Loss dB* Max.	Phase Unbalance Degrees Max.	Amplitude Unbalance dB Max.	Price $ Each	Price Qty
PSCQ-2-1.5	1.4-1.7	29	25	0.4	0.7	3.0	1.2	12.95	(5-49)
PSCQ-2-3.4	3.0-3.8	30	25	0.4	0.7	3.0	1.2	16.95	(5-49)
PSCQ-2-6.4	5.8-7.0	30	25	0.4	0.7	3.0	1.2	12.95	(5-49)
PSCQ-2-7.5	7.0-8.0	35	25	0.4	0.7	3.0	1.2	12.95	(5-49)
PSCQ-2-10.5	9.0-11.0	25	20	0.4	0.7	3.0	1.2	12.95	(5-49)
PSCQ-2-13	12-14	29	25	0.4	0.7	3.0	1.2	12.95	(5-49)
PSCQ-2-14	12-16	30	25	0.3	0.6	3.0	1.8	16.95	(5-49)
PSCQ-2-21.4	20-23	30	25	0.4	0.7	3.0	1.2	12.95	(5-49)
PSCQ-2-50	25-50	30	20	0.3	0.7	3.0	1.5	19.95	(5-49)
PSCQ-2-70	40-70	25	20	0.3	0.7	3.0	1.2	19.95	(5-49)
PSCQ-2-90	55-90	30	20	0.3	0.7	3.0	1.2	19.95	(5-49)
PSCQ-2-120	80-120	25	18	0.3	0.7	3.0	1.5	19.95	(5-49)
PSCQ-2-180	120-180	23	15	0.3	0.7	4.0	1.2	19.95	(5-49)
PSCQ-2-250	150-250	23	18	0.4	0.8	4.0	1.5	19.95	(5-49)
PSCQ-2-400	250-400	22	16	0.4	0.9	4.0	1.5	19.95	(5-49)
PSCQ-2-450	350-450	22	16	0.4	0.9	4.0	1.5	19.95	(5-49)
ZSCQ-2-50	25-50	30	20	0.3	0.7	3.0	1.5	39.95	(4-24)
ZSCQ-2-90	55-90	30	20	0.3	0.7	3.0	1.2	39.95	(4-24)
ZSCQ-2-180	120-180	23	15	0.3	0.7	4.0	1.2	39.95	(4-24)
ZMSCQ-2-50	25-50	30	20	0.3	0.7	3.0	1.5	49.95	(4-24)
ZMSCQ-2-90	55-90	30	20	0.3	0.7	3.0	1.2	49.95	(4-24)
ZMSCQ-2-180	120-180	23	15	0.3	0.7	4.0	1.2	49.95	(4-24)

*Average of coupled outputs less 3 dB   Impedance 50 ohms all models

Mini-Circuits

MINI-CIRCUITS LABORATORY A DIVISION OF SCIENTIFIC COMPONENTS CORPORATION
2625 E. 14th St., Brooklyn, NY 11235 (212) 769-0200 Dom. Telex 125460 Int'l. Telex 620156

94 Rev. Orig.

For Mini-Circuits sales and distributors listing see page 46

CIRCLE 5 ON READER SERVICE CARD

HOMECOMING FOR A CHOPPER

FINDING THE RIGHT OIL RIG IN STORM OR DARK OF NIGHT COMES EASIER WHEN YOUR CHOPPER USES A LITTON LOW TC MAGNETRON

From −55°C to 150°C, **Litton's L-4642 temperature compensated magnetron** has the frequency stability and power to get you down fast. With up to 8.5 KW out, a TC of 75 kHz/°C and a fixed frequency of 9375 ± 5 MHz, it keeps your helicopter on target every time. For lightweight airborne weather radar systems, this durable magnetron weighs only 3.5 lbs. It's well suited to the coming generation of weather radar systems.

For other applications requiring extreme frequency stability, take a good hard look at these Litton temperature compensated magnetrons.

For interrogating beacons, the Litton L-4693. Here's a coaxial magnetron with low thermal drift and TC to yield high frequency stability in a wide range of environmental conditions. Minimum peak power is 65 KW. Tunable frequency is 9365 to 9395 MHz.

The coaxial pulse magnetron L-5409 is especially suited for use in all-weather aircraft landing systems. Operates in J-band with a tunable frequency of 15,400 to 15,700 MHz. With a TC of 20 kHz/°C, it's capable of frequency stable operation over a wide range of duty cycles without heater reprogramming. Minimum peak power is 2.5 KW.

The L-4502 RF stable magnetron for radars using coherent receivers. Here's a pulse magnetron featuring 200 KW minimum peak power and closed loop servomechanical tuning over the 8700 to 9400 MHz range. Thoroughly ruggedized, it's designed to meet severe environmental conditions demanding maximum thermal and pulse-pulse stability as well as tuning sensitivity. Servo-equipment can be mounted on the tube.

All of Litton's magnetrons feature proven performance characteristics to lead the way toward satisfying your most demanding design criteria.

Find out more.

Complete data sheets are available from your Litton Field Engineer. Or address Litton Industries, Electron Tube Division, 1035 Westminister Drive, Williamsport, PA 17701. Phone: (717) 326-3561.

LITTON
ELECTRON TUBE DIVISION

CIRCLE 6 ON READER SERVICE CARD

phase detectors

the world's highest output phase detectors

1000 mV (+7 dBm input), less than 1 mV DC offset

The new RPD Series from Mini-Circuits from $15.95

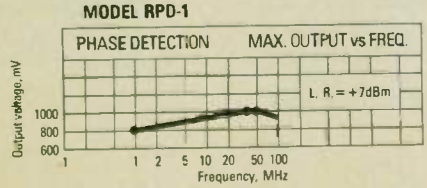
These new high efficiency phase detectors offer state-of-the-art performance while still economically priced. These are the only units in the world offering a figure-of-merit greater than 125 and at only $15.95.

The figure-of-merit M or efficiency of a phase detector can be defined as the ratio of maximum DC output voltage (in mV) divided by the RF power (in dBm). The maximum DC output of the RPD-1 is 1000 mV with +7 dBm applied to the LO and RF ports, and DC offset is typically 400 micro volts. Thus, its figure-of-merit M is 143, which represents a highly efficient phase detector. For comparison a double-balanced mixer used as a phase detector offers 350 mV DC output with the same LO and RF inputs for a figure-of-merit M of 50.

So when your system requires a high output phase detector, specify the new RPD series.

For complete specs, performance curves and application information request Mini-Circuits technical bulletin, Q & A no. 3.

MODEL RPD-1



RPD-1 SPECIFICATIONS

FREQUENCY RANGE	
L and R ports	1-100 MHz
Output ports	DC-50 MHz
SCALE FACTOR	8 mV/Degree
IMPEDANCE	
L and R ports	50 ohms
I port	500 ohms
L and R SIGNAL LEVELS	+7 dBm
ISOLATION, L-R	40 dB min
MAXIMUM DC OUTPUT, mV	1000 mV typ 750 mV min
DC OUTPUT POLARITY (L and R in-phase)	Negative
DC OUTPUT OFFSET VOLTAGE	0.2 mV typ 1 mV max
FIGURE-OF-MERIT, M	143 Typical

Mini-Circuits

A Division of Scientific Components Corporation

World's largest manufacturer of Double Balanced Mixers

2625 East 14th Street, Brooklyn, New York 11235 (212)769-0200
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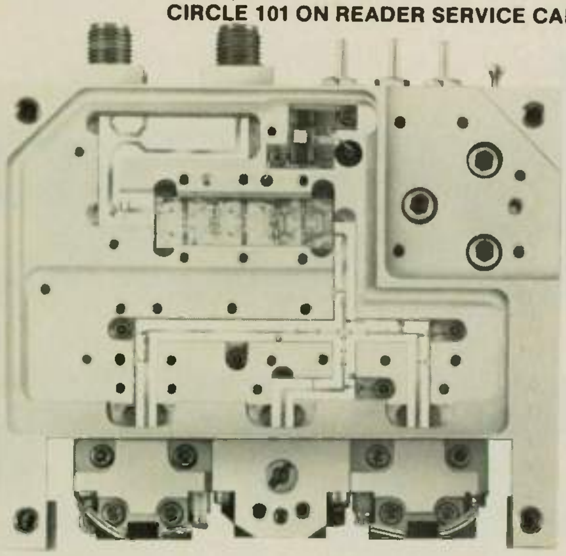
For Mini Circuits sales and distributors listing see page 46

CIRCLE 7 ON READER SERVICE CARD

TECHNOLOGY: EW SYSTEM INTEGRATION

This electronic warfare Supercomponent-N draws upon the many technologies available from Narda. Vertical integration is the key ingredient at Narda, by using the in-house capabilities and facilities to develop this switched oscillator for airborne RF receivers. Noteworthy is the design innovation to build 8 to 18 GHz modules consisting of 3 ultra stable, low power, coaxial Gunn oscillators combined with low noise power GaAs FET amplifiers with hybridized regulators. An industry first.

CIRCLE 101 ON READER SERVICE CARD



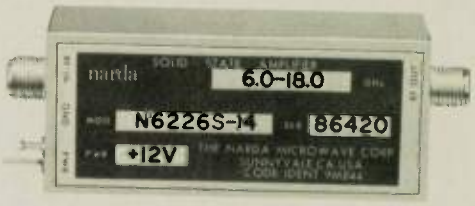
Note:
In a single 2½ inch square high density package are ultra stable Gunn Oscillators, a unique high performance terminated switch, a multi stage low noise GaAs FET amplifier, attenuators, filters, couplers and all electronic circuitry. All designed and manufactured by Narda's East and West coast facilities right down to the diodes and transistors. Narda can do the same for you. (516) 349-9600.

THE NARDA TRADITION.

For 26 years, the people at Narda have been dedicated to making truly reliable components, supercomponents, sub-systems designed for your microwave applications. Every major Military Microwave System contains products engineered by Narda. Designed and built to the same standard of excellence. Write for technical information concerning products for EW, Communications and Radar to Marketing Services Group. **CIRCLE 102 ON READER SERVICE CARD**

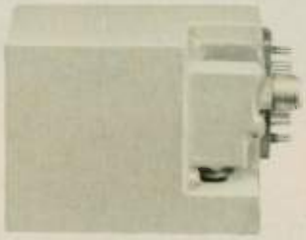
BREAK THROUGH IN POWER GaAs FET AMPLIFIERS.

The designs for EW systems in military aircraft currently in production and other such applications require stability, low noise operation in high density amplifiers.



The smallest, lightest, high density GaAs FET amplifiers are now available for the first time in the 6 to 18 GHz and 8 to 18 GHz range. Engineered to exhibit superior low noise performance and high power output.

Write to our Marketing Services Group for Narda's New Catalog. There are 100 models with the widest dynamic range available. Important note: many models can be shipped within 48 hours. Another industry first. **CIRCLE 103 ON READER SERVICE CARD**



LOCAL OSCILLATORS FOR EW APPLICATION.

Solid-State Gunn Oscillators for receivers and radar systems. Small size, lightweight, offers excellent performance for MIL-Spec applications. Power up to 200mW over the full EW frequency range. Exhibits high frequency stability and low noise. Gunn-effect varactor tuned and mechanically tuned oscillators are available. New technical literature can be secured by writing our Marketing Services Group, or call us directly. **CIRCLE 104 ON READER SERVICE CARD**

MICROWAVE MULTIMETER FOR MICROWAVE MEASUREMENTS BOTH ON TEST BENCH AND FIELD

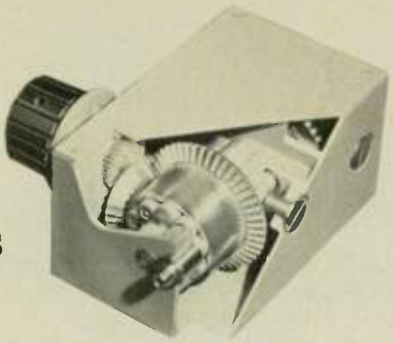
Priced from $5975.

Measure Power, Reflection, Transmission and DC Voltage. Self-contained microwave test station that leads the operator step-by-step through the procedure, automatically calibrates itself, selects the proper range, sets zero references and performs measurements over the .01 to 18 GHz - and it's portable.

CIRCLE 105 ON READER SERVICE CARD

Write For New Technical Bulletin.

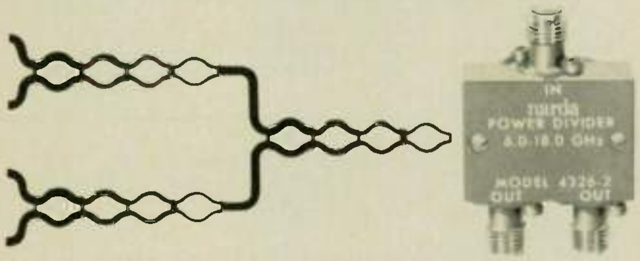
THE NARDA MICROWAVE CORPORATION • PLAINVIEW, L.I., NEW YORK 11803



ATTENUATORS FOR SYSTEM AND LAB USE.

Whatever your requirements for attenuation products, you get the same excellence which, for the last 26 years, has made Narda the standard of the industry. Take Narda's precision miniaturized attenuators for EW systems. The thin film element between the SMA connectors of the 4780 series is the secret to the low VSWR, flat response and high power handling capability over DC to 18 GHz...or the precision pads that meet MIL-A-3933...or one of over 125 models of subminiature, fixed, variable - all designed for optimum performance to meet your specific system or bench requirements.

Usable flexibility is what you get with Narda's revolution in precision step attenuators, (the cutaway photo will give you an idea of the high precision). The Series 700 has successfully completed 3 million steps positioning without degradation. Select from the turret attenuator line - DC to 18 GHz, manual or motorized and programmable, single or dual configuration, 0 to 99 dB, 0 to 9 dB, 0 to 90 dB (or anywhere in between) with a variety of connectors. Every one of the Narda step attenuators features Narda's precision Micro-Pads™ which meet MIL-A-3933B. You also get the unique detent design which assures resettability to better than 0.05 dB...and with extremely uniform group delay on all steps. Write Marketing Services Group for our new literature. **CIRCLE 106 ON READER SERVICE CARD**



MINIATURIZED FOR EW APPLICATIONS.

Narda's track record on miniature 2-way power dividers led to extending the line to 4-way dividers early this year. Both are packaged in the lightest, smallest size possible. The enlarged view illustrates the configuration of the micro-miniature circuitry used in the power dividers. The electrical performance features excellent amplitude and phase tracking at the output ports from 0.5 GHz to 40 GHz. These octave and multi-octave dividers give you equal in-phase divisions of input power, low VSWR (all ports) and unparalleled high isolation. Being reciprocal you can use these dividers to re-combine in-phase signals applied to the output ports to function as a power combiner.

Both the 2-way and 4-way versions are particularly well suited for EW systems, wide band LO networks, phased arrays, multi-octave antenna feeds, or test and instrumentation systems.

Repeatability of performance, which is so important in military applications and to system reliability, is assured through tightly controlled manufacturing processes. This high reliability is synonymous with Narda's standard of excellence established over 26 years in serving the microwave industry. Write to our Marketing Services Group for our new literature.

CIRCLE 107 ON READER SERVICE CARD

PIN DIODE SWITCHES FOR EW.

A complete line to SPST, SP2T, SP3T and SP4T switches have numerous MIL-Spec. application as solid state modulators and attenuators and are particularly useful for ECM applications. Typical operating characteristics of 200 nsec. switching speed and 60 dB minimum isolation over the full 2 - 18 GHz frequency range. A unique microwave integrated circuit design utilizes shunt mounted PIN diodes, providing reflective switching of RF inputs up to 6 watts average or 50 watts peak power. This new line of switches is available with and without drivers in the same small, light weight packages. Write our Marketing Services Group for technical literature.

For special applications requiring switches with matched impedance in both the ON and OFF state, linearized PIN attenuators or leveling attenuator modules, consult the Narda Customer Applications Engineering Group for assistance in optimizing switch performance for YOUR application.

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narda

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microwave JOURNAL

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VOLUME 24 NUMBER 12
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DECEMBER 1981

ON THE COVER: High performance telecom and radar systems will benefit from quieter sources as HP's new 3047A Spectrum Analyzer System makes routine oscillator phase noise measurements practical for both design and production activities. Cover story begins on page 47. Cover art by Rand Kruback, Hewlett Packard.

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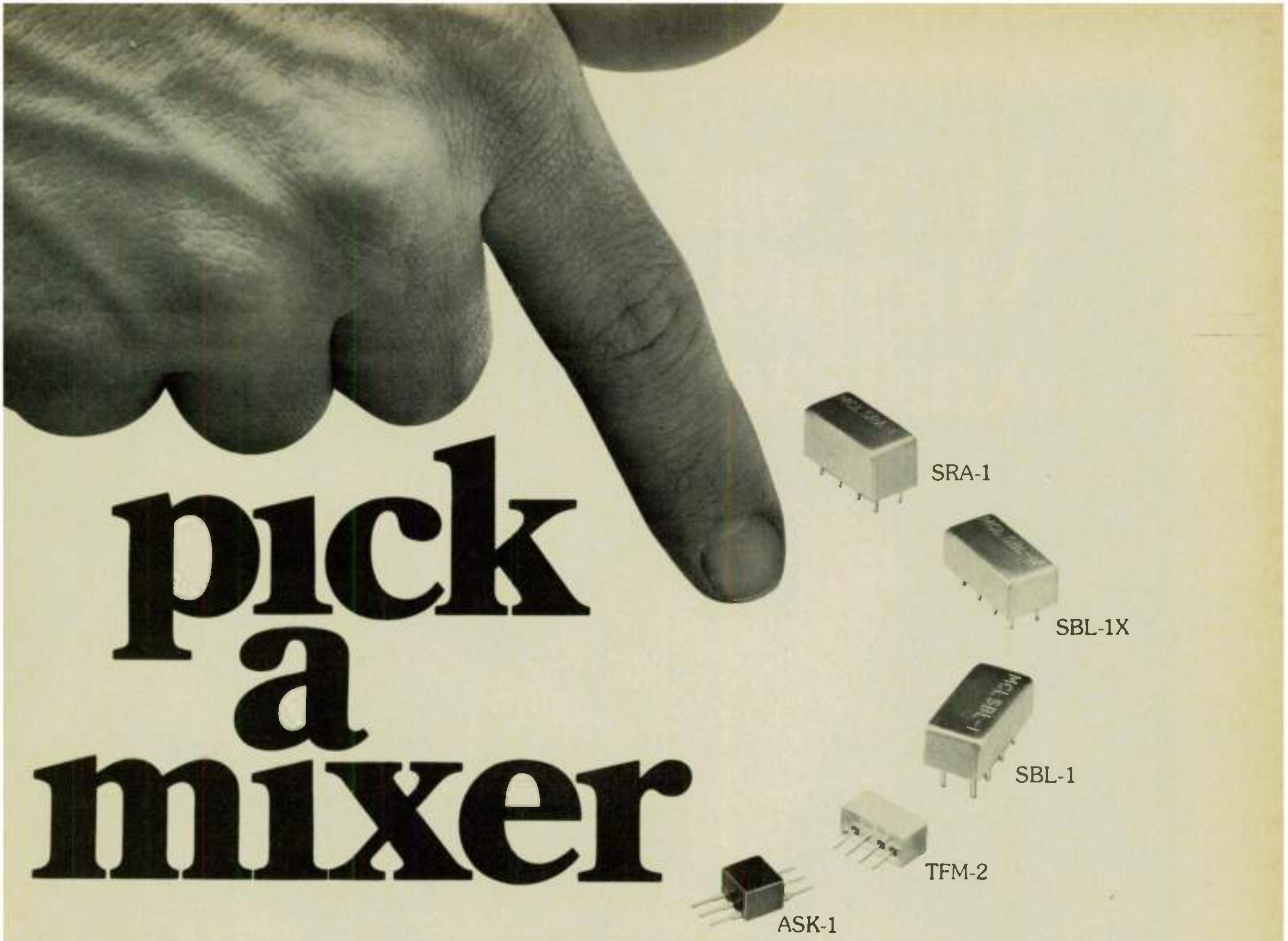

pick a mixer

standard level (+7dBm LO)

from 500 KHz to 1GHz... hi-rel and industrial miniature, flatpack, and low profile from $3^{95}

Choose from the most popular mixers in the world. Rugged construction and tough inspection standards insure MIL-M-28837/1A performance.*

Check these features...

SRA-1 the world standard, covers 500 KHz to 500 MHz, Hi-REL, 3 year guarantee, HTRB tested, MIL-M-28837/1A-03 S performance.* $11.95 (1-49).

TFM-2 world's tiniest Hi-REL units, 1 to 1000 MHz, only 4 pins for plug-in or flatpack mounting. MIL-M-28837/1A performance.* $11.95 (6-49).

SBL-1 world's lowest cost industrial mixers, only $3.95 (100), 1 to 500 MHz, all metal enclosure.

SBL-1X industrial grade, low cost, $4.95 (10-49) 10 to 1000 MHz, rugged all metal enclosure.

ASK-1 world's smallest double-balanced mixers, 1-600 MHz, flat-pack mounting, plastic case, $5.95 (10-49).

*Units are not QPL listed

MODEL	SRA-1	TFM-2	SBL-1	SBL-1X	ASK-1
FREQUENCY, MHz					
LO, RF	.5-500	1-1000	1-500	10-1000	1-600
IF	DC-500	DC-1000	DC-500	5-500	DC-600
CONVERSION LOSS, dB					
one octave bandedge	6.5	6.0	7.5	7.5	7.0
total range	8.5	7.0	8.5	9.0	8.5
ISOLATION, dB, L TO R					
lower bandedge	50	50	45	45	50
mid range	40	40	35	30	35
upper bandedge	30	30	25	20	20

For complete specifications and performance curves refer to the 1980-1981 Microwaves Product Data Directory, the Goldbook or EEM

For Mini Circuits sales and distributors listing see page 46

finding new ways...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
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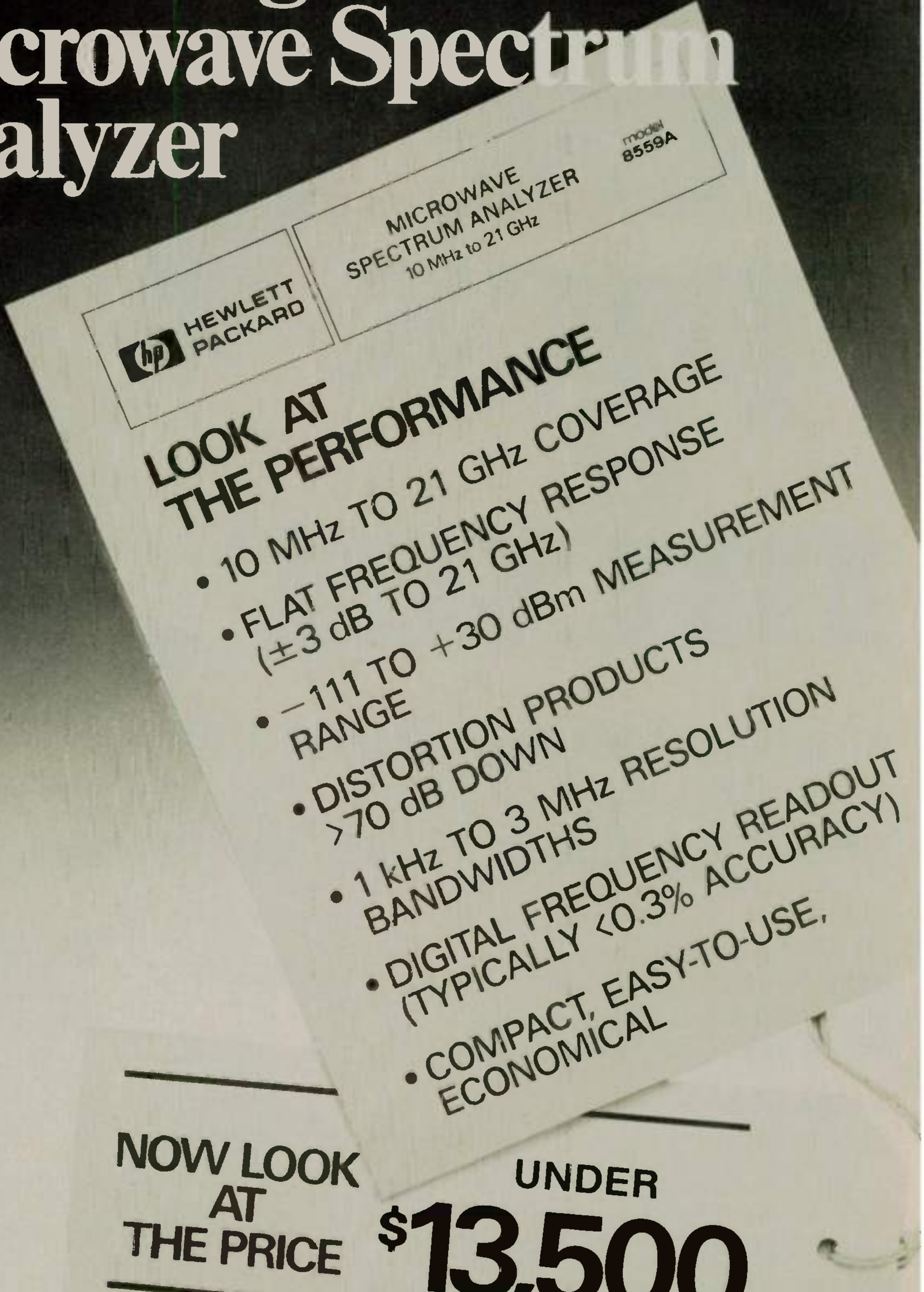
CIRCLE 10 ON READER SERVICE CARD

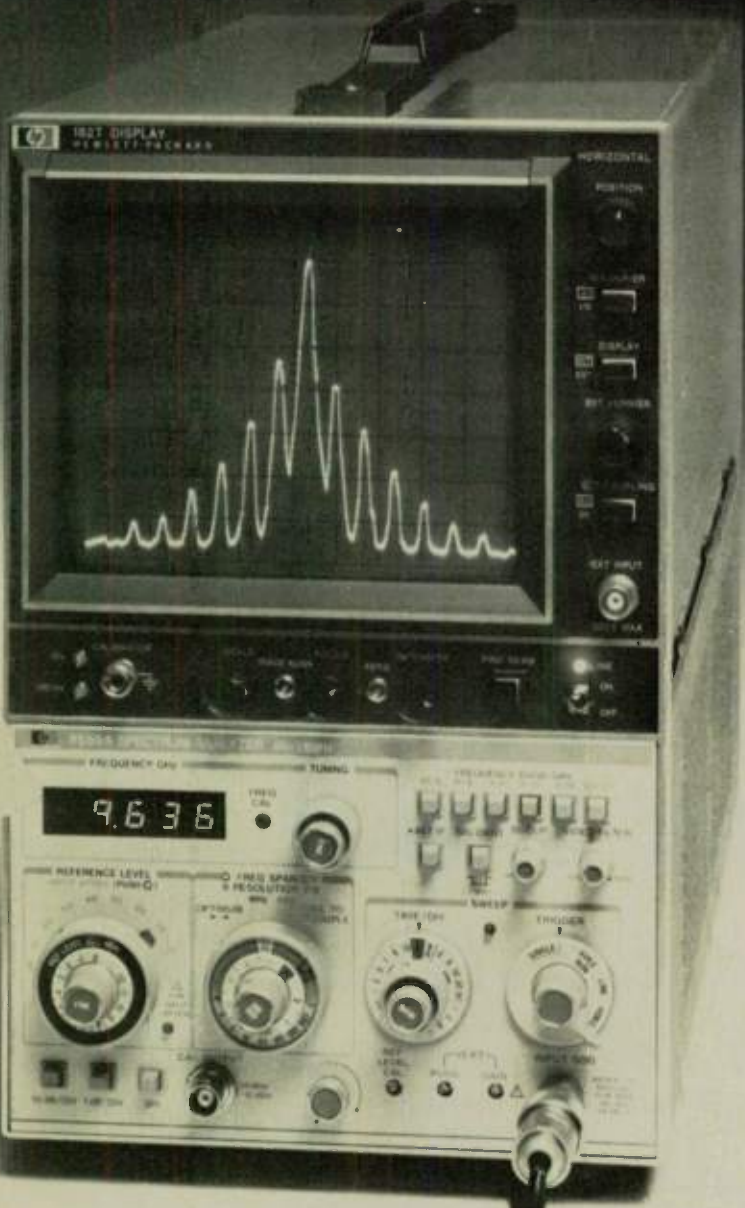
74 REV.B

HP's budget-minded Microwave Spectrum Analyzer



53106A

The HP 8559A delivers precision and convenience for a wide range of applications.



HP's 8559A Spectrum Analyzer plug-in with the HP 182T display is easy-to-use, economical, and portable. The combination weighs less than 40 pounds and its rugged design makes it excellent for field use. Most measurements can be made using only 3 controls. You simply tune to the signal, set frequency span (resolution and sweep time are automatically optimized), and then set the reference level and read signal amplitude.

The 8559A/182T is a high-performance instrument at a truly affordable price, $13,115. For more information on this budget-minded instrument call your nearby HP sales office, or write Hewlett-Packard, 1507 Page Mill Rd., Palo Alto, CA 94304.

Domestic U.S. price only.

HEWLETT PACKARD

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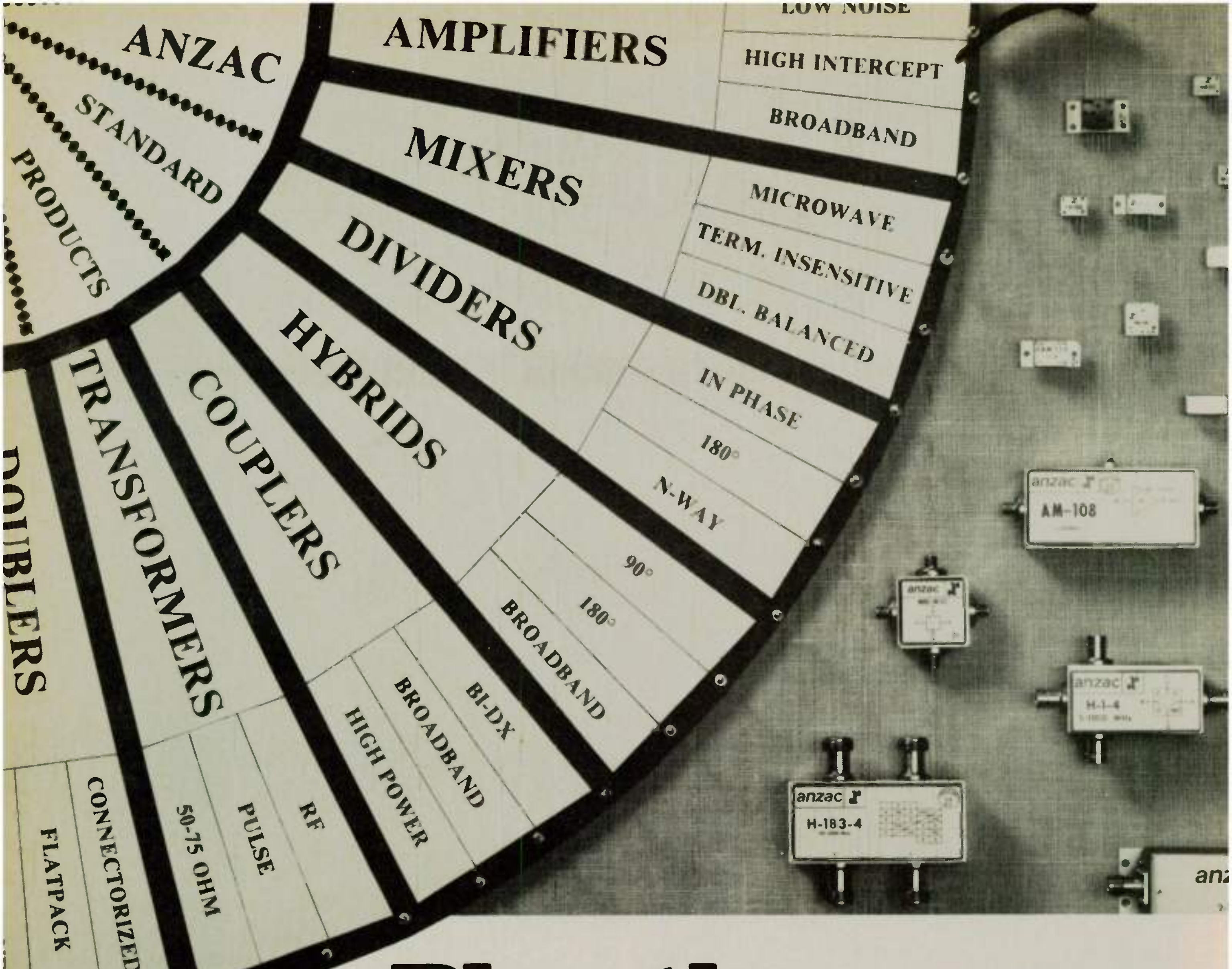

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Coming Events

1982 POWER TUBE CONFERENCE APR. 26-28, 1982
Call for papers Sponsor: Electron Devices Society of the IEEE and the DoD Advisory Group on Electron Devices. Place: Naval Postgraduate School, Monterey, CA. Topics: Microwave power tubes and tube-related system needs and problems. Submit 100 copies of abstracts appropriate for a 20 minute paper (indicating classified content if any) by January 22, 1982 to: Mr. Leonard H. Klein, Secretary, 1982 Microwave Power Tube Conference, Palisades Institute for Research Services, Inc., 201 Varick St., New York, NY 10014. Attendance at the conference will be by invitation only.

1982 IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM JUNE 15-17, 1982
Call for papers Sponsors: IEEE Microwave Theory and Techniques Society. Place: Hyatt Regency Hotel, Dallas, Texas. Topics: Original works in microwaves particularly computer-aided design and measurement techniques, radiometry and remote sensing, GaAs monolithic circuits, phased array and active array techniques, microwave field and network theory and other areas. Submit 5 copies of a 35 word abstract and a 500-1000 word summary (up to 6 illustrations) by Jan 8, 1982 to: Steven L. March, TPC 1982 MTT-S Symposium, COMPACT Engineering Div., CGIS, P.O. Box 401144, Garland, TX 75040.

1982 IEEE MICROWAVE AND MILLIMETER-WAVE MONOLITHIC CIRCUITS SYMPOSIUM JUNE 18, 1982
Call for papers Sponsors: IEEE Microwave Theory and Techniques Society and The IEEE Electron Devices Society Place: Hyatt Regency Hotel, Dallas, TX. Topics: Original works in microwave and millimeter wave technology. Authors are asked to submit 5 copies of one page abstract explaining the contribution, its originality and importance by January 15, 1982 to: M. Yoder, ONR-414, Arlington, VA 22217 Tel: (202) 696-4218.

CONFERENCE ON PRECISION ELECTRO-MAGNETIC MEASUREMENTS JUNE 28-JULY 1, 1982
Call for papers Sponsor: National Bureau of Standards. Place: NBS, Boulder, Colorado. Topics: Design, performance, or application of electromagnetic measurements, techniques, instruments or systems. Submit both a 35-40 word abstract and a 500-1000 word summary in camera ready form by February 15, 1982. David W. Allen, CPEM, '82, National Bureau of Standards, 325 Broadway, Boulder, CO 80303. (303) 497-3981. ■

EUROPEAN MICROWAVE COMPONENT INDUSTRY

UK microwave component suppliers have experienced a sharp decline in demand during the past twelve months as the British MOD buying moratorium remains largely in force. Continental European suppliers appear to be enjoying a continuation of the good growth rates of the past few years. Based on a series of interviews in September of this year, the Special Report in this issue details the views of a sampling of UK and Continental component manufacturers on this and other subjects.

Sum Up

A NEW PHASE NOISE MEASUREMENT SYSTEM

At some point, performance of microwave communications and radar systems is limited by the phase noise characteristics of their sources. Historically, phase noise measurements have been difficult, time consuming and have suffered from inadequate accuracy. HP's new spectrum analyzer system reduces the measurement of phase noise to a practical and reproduceable procedure which can be applied to both system verification and, more importantly, component design.The system is a significant new addition to the microwave engineer's measurement resources.

A 100 kW L-BAND SOLID STATE LIMITER - Part I

The proper relationship between RF rise time and PIN diode charge injection time can enhance the peak power limiting ability of PIN diodes beyond that which might be inferred from their bulk breakdown voltage. This property has been exploited in the design of a 100 kW peak power, self-biasing coaxial limiter for the 1250 to 1350 MHz band. Four PIN diodes supported by four GaAs varactor diodes to provide fast leading edge current biasing pulses are employed in the design. Part I covers design considerations and analysis. Part II will describe its performance.

IMPROVED MILLIMETER WAVE DETECTORS

The advent of DC-coupled scalar network analyzers capable of storing calibration information greatly simplified swept frequency measurements at mm wave frequencies. A new generation of mm wave detectors for use with those analyzers employing zero-bias low barrier Schottky diodes promises to further improve analyzer utility at high frequencies. The fabrication of zero-bias Schottky barrier diodes specifically for mm wave applications is described. A waveguide mount suitable for the diodes is shown and the performance of the diode-mount combination in the 75-110 GHz band is illustrated.

DIELECTRIC LOADED WAVEGUIDE MATCHING PROGRAM

A program for the HP 67/69 computes a quarter wavelength dielectric transformer for matching into dielectric loaded waveguide. The program provides the impedance, length and dielectric width of the matching transformer for any value of transformer dielectric constant. Dimensions of cascaded quarter wave transformers for broadband matching may also be calculated.

Howard Ellowitz

Workshops & Courses

MICROWAVE DEVICES AND CIRCUITS SHORT COURSE

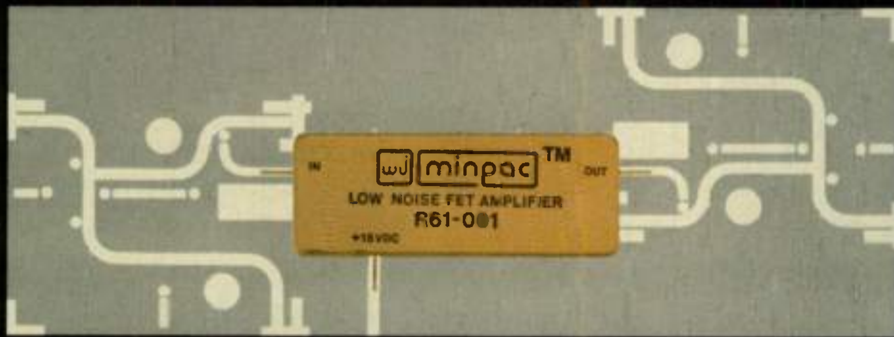
Topic: Operation, design and application of microwave semi-conductor material and devices and their applications.
Sponsor: Continuing Professional Education, UCLA
Site: URC Conference Center, UCLA
Date: February 22-26, 1982
Fee: $795.00
Contact: G. I. Haddad (313) 764-3317 Short Course Program Office, 6266 Boelter Hall, UCLA Extension, Los Angeles, CA 90024

FIBER OPTICS SHORT COURSE

Topic: Fiber Optical Communications
Sponsor: Center for Professional Development
Site: Arizona State University
Date: March 15-17, 1982
Fee: $450.00
Contact: Center for Professional Development, College of Engineering and Applied Sciences, Arizona State University 85287 Tel: (602) 965-1740.

SPREAD SPECTRUM COMMUNICATION SYSTEMS

Topic: Spread spectrum techniques for anti-jam communications, ranging, and synchronization.
Sponsor: Continuing Engineering Education, George Washington University
Site: Sheraton Inn La Guardia, Long Island, NY
Date: March 29 - April 2, 1982.
Fee: $760.00
Contact: Director, Continuing Engineering Education, George Washington University, Washington, DC 20052 (800) 424-9773. ■



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William A. Bourke *was awarded a B.S.E.E. degree from Carnegie-Mellon University and worked as a project engineer at Sperry Gyroscope until co-founding the Narda Microwave Corporation in 1953. He acted as Executive Vice President until 1959, when he became President of the company. In 1971 he was named President and Chairman of the Board. Mr. Bourke holds a commercial pilot's license and has been active in a large number of organizations, among them Catholic Charities [Board of Trustees], Cleary School for the Deaf [President 1977-78], and the Chaminade High School Advisory Board. In addition to professional memberships, Mr. Bourke is affiliated with Tau Beta Pi and Etta Kappa Nu. Under his leadership, Narda has become a world leader in microwave instrumentation and components, pioneering such technical innovations as the first 6-18 GHz GaAs FET amplifier and a general purpose Microwave Multimeter with wide applications. It is also in the forefront of microwave radiation monitoring.*

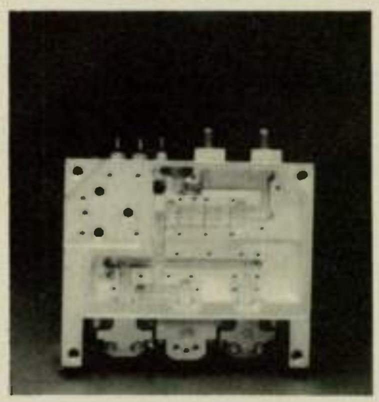
Passive Microwave Components

WILLIAM A. BOURKE
THE NARDA MICROWAVE CORPORATION

Evolution and change, technological advances, fabrication and manufacturing process advances, and the crossing of new frontiers in miniaturization and higher performance have been the bywords of the passive microwave components business for at least as long as we have been involved in it.

The changing world of passive microwave components has always been market driven. The microwave communications applications, such as point-to-point microwave and today's ever expanding satellite communications systems, have contributed their demands, but the most visible and pervasive influence upon passive microwave component evolution has come from the world of military radar and from the amazing counterworld of electronic warfare. Each forward step in radar capability to locate, identify, track and thwart or destroy — as soon as it is matched by the other side — must be met by an EW response for self defense. Any particular major weapon, a specific fighter aircraft, for example, has a lifetime in our arsenal of well over a decade. During that lifetime, however, its missions and the threats against it are constantly changing and increasing while the space aboard, the maximum allowable weight carried and the power available are relatively fixed. The systems design engineer is faced with the problem of addressing these threats and adding increased capability within the system constraints. In other words, to respond successfully to the needs of our customers, we must package many units in areas previously occupied by a single component.

Once upon a time, a broad line of passive microwave components comprised a handful of simple directional couplers, terminations, attenuators and detectors available in a few standard rectangular waveguide sizes plus waveguide to coaxial adapters to interconnect with type "N" connector coaxial cables. Performance was typically specified at a fixed frequency or covering a 10 per cent bandwidth; occasionally we might have seen a 1.5 to 1 bandwidth. As surveillance and countermeasure needs attempted to address all the various radar and beacon bands, the use of miniaturized coaxial components became increasingly necessary because of bandwidth considerations. New connector types were needed to accommodate miniaturization. Coaxial components with octave band performance ultimately became commonplace, as did the SMA connector.



Typical microwave super component.

The pressure for miniaturization brought about the introduction of stripline technologies and many discrete components shrunk by

[Continued on page 20]

THE NEW NS-20... THE COMPLETE INSTRUMENT FOR AUTOMATIC NETWORK TESTING

Our new NS-20 Network Measurement System is an entirely new concept in network analysis. It integrates our powerful scalar network analyzer and our new RF source module into a single microprocessor-driven design. Now you can easily run pre-programmed measurement tests directly from one front panel, expertly, accurately, and automatically... even without a host computer in many applications. Total bus programmability is also available if needed.

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- The analyzer continuously zeros automatically, without any operator input required.
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[From page 18] **COMPONENTS**

as much as 65 per cent. The various discrete stripline passive microwave components, such as hybrids, directional couplers, power dividers, in SMA connector configuration, seemed to be as small as they could get as they were crammed into whatever space was not taken up by TWT's, power supplies and antennas.

The higher density packaging increased the high temperature performance limits required of these components well beyond those imposed by the climatic extremes, from outer space to broiling deserts, imposed on the systems themselves. Components which may have been originally designed for 0°C to 70°C were redesigned for exposure from -50°C to over 100°C and storage temperatures of -60°C to +125°C.

Even while these miniature designs were going into production, they were already being obsoleted and microstrip transmission line technology was a new byword before stripline became commonplace. Microstrip thin-film technology offered even greater potential for miniaturization because of the dielectric property of ceramic substrates and differences in transmission line parameters. For discrete components, however, the benefits of miniaturization were initially realizable only below 4 GHz because, at higher frequencies, the provisions for connectors and the correlary requirements for enough center line distance between connectors to permit fastening limited the possible size reductions.

The marketplace, particularly for the ever widening frequency spectrum of EW systems, continued to require still broader frequency range performance covering several octaves and orders of magnitude in size and weight reductions. The responses to this pressure took the form of integration of passive microwave components and the development of solid state replacements for active components. Today we see the limitations formerly imposed by the connectors and cables between discrete components blown away by integrating blocks of components on to relatively few microwave integrated circuit substrates. At the same time, solid state oscillators and amplifiers, utilizing the same techniques of hybrid integrated circuits in stripline or microstrip form, have replaced their earlier counterparts.

But all of that is already yesterday as still higher forms of circuit integration reduce the package size further. The cables and connectors between oscillators, amplifiers and passive components assemblies are now also disappearing, but so is the passive microwave circuit supplier unless he can also supply the active circuits in a fully integrated assembly: today's super component. Only a few years ago, companies specializing in passive components were best known for their directional couplers, attenuators and other discrete coaxial components. Today in many of those companies those former skills are greatly expanded and directed at creating super components like that shown in the photograph. This single small unit incorporates three ultra-stable, low noise GUNN oscillators, a low noise GaAs FET amplifier, a high isolation PIN switch plus low pass filters, hybridized regulators and drivers, directional couplers, attenuators and electronics all designed and manufactured by such a company even including the GUNN diodes, the GaAs FET's, resistor chips, machined housings, connectors, etched microstrip circuits and stripline segments.

Tomorrow? Before long the sequel to this article will undoubtably embrace the wide utilization of monolithic microwave integrated circuits. And, will the discrete components market disappear? Definitely not. The innovators in microwaves will continue to create new features, new kinds of devices and components, new circuits and new approaches. Prototypes and breadboards, only partly simulated on the computer, will often incorporate discrete components as will production systems not requiring extreme compactness. We do believe that integrated approaches, however, will dominate at an increasing pace. ■

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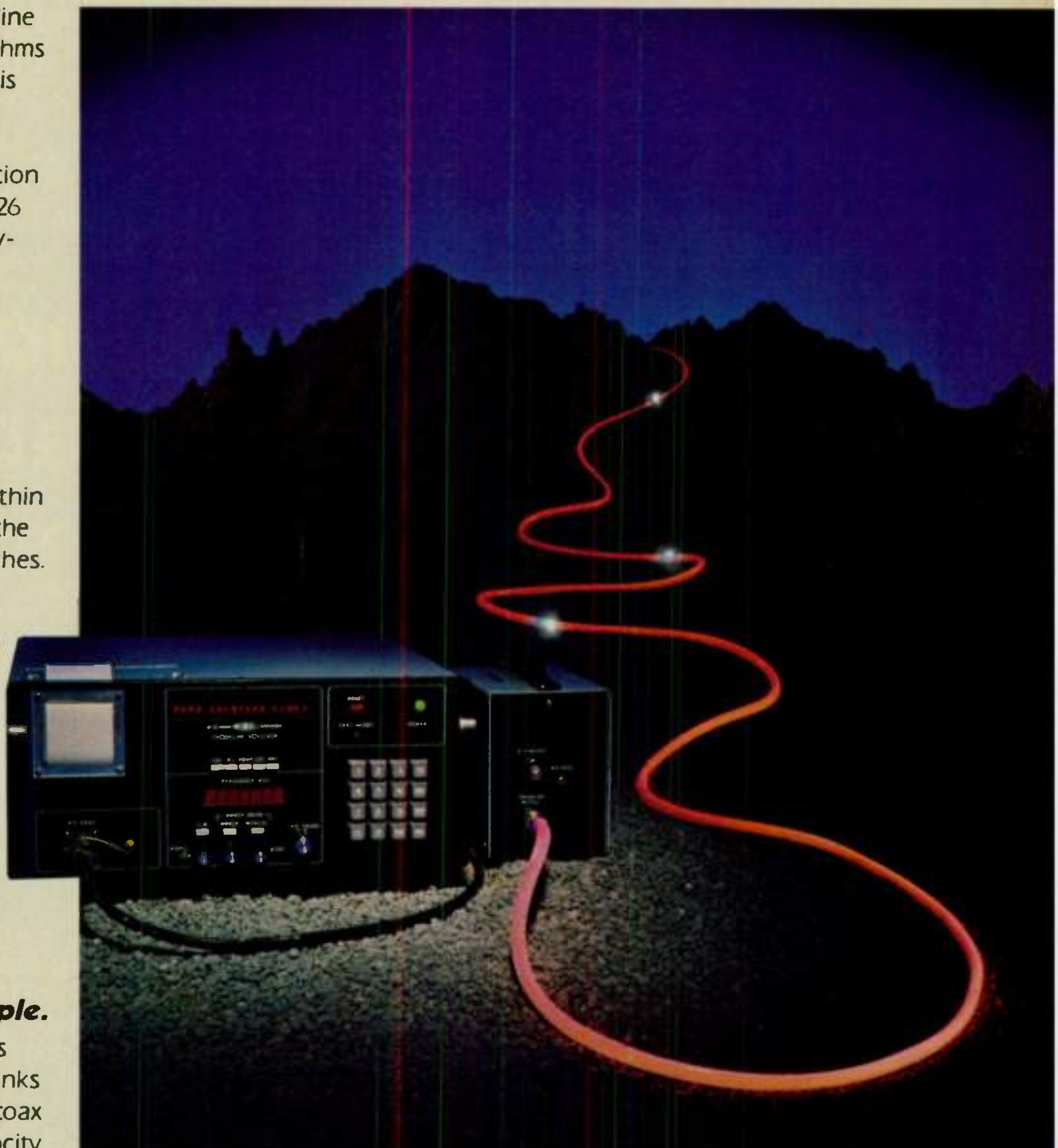

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An alphanumeric display provides step-by-step prompting, so even a non-technician can operate the Transline Analyzer effectively. A hard copy printout provides calibration, data input, parameter selection, actual measurement, and results evaluation for future reference.

Furthermore, custom software will be prepared to handle your special needs.

Digital performance. Analog price.

Systron Donner's new Transline Analyzer provides the performance, speed, and convenience you'd expect from digital technology. Yet the price is well within the range of conventional analog equipment. Call us at (800) 423-2004 for a brochure with complete details. Or write Systron Donner Microwave Division, 14844 Oxnard Street, Van Nuys, CA 91409.

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The European Microwave Component Industry -1981

HOWARD I. ELLOWITZ
Publisher

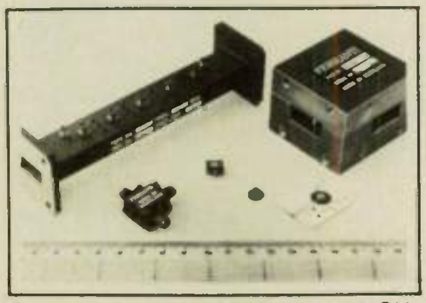
UK REVIEW

In September 1980 there was widespread speculation about the ultimate effect on the British microwave industry of a recently imposed British MOD buying moratorium. Originally scheduled to expire in November 1980 and then extended to April 1981, the minimal MOD buying activity through September 1981 made it clear that its real lifetime is still somewhat indefinite. As a result, the UK microwave industry is struggling through a recession.

Responding to questions about their expectations for 1981, British microwave component and instrument company executives forecast, at best, a flat year for their well established product lines. These forecasts are in sharp contrast with the growths of 20-25% a year enjoyed by those lines in recent years. Without exception, any real growth expected in 1981 by a UK microwave component supplier is a direct result of his expansion into new products or foreign markets.

Malcolm Low, Marketing Manager at Ferranti, Dundee, projected a no-growth performance for his ferrite as well as his other established component lines. Dr. Colin Gaskell, Managing Director of Marconi Instruments at Hertfordshire and Will Foster, Commercial Manager of that activity, similarly saw little opportunity for growth this year. In their case, somewhat more promising prospects are seen for early 1982 when a number of recently introduced instruments will begin to contribute.

Dennis Gill, Manager of Marconi Specialized Components Division attributes the prospects for a flat 1981 for his ferrite line directly to the severe cuts in UK defense

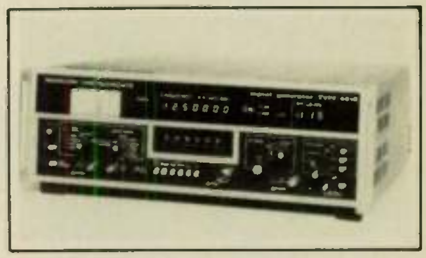


A sampling of Ferranti, Dundee 11 GHz communications components includes a passband filter, 3-port circulator, coaxial circulator and isolator and microstrip Drop-in circulator and isolator.

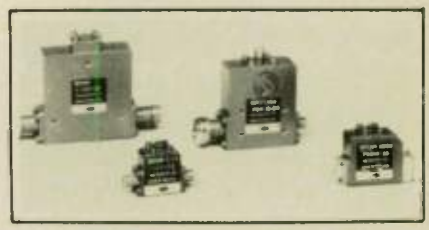
spending. He does not anticipate a sharp increase in MOD business in the near term and is concentrating on expansion of his export business into Europe and other areas.

David McNeil, Managing Director, and Terry Allen, Commercial Director at Gabriel Manufacturing Company, also expect little real growth for their waveguide products in 1981. Both recognize the need for the company to broaden its product base and offer components which can compete with those now available in the UK almost exclusively from US producers. They still consider the military market the sector in which investment will be most productive. In sharp departure from its usual direction, the company is making a significant investment in a new microwave instrument which will require 18-24 months to bring to market and expects it to make a substantial contribution to future growth.

With one of the most optimistic forecasts encountered in the UK, Ken Alstaff, Sales and Marketing Manager at Racal-MESL Microwave, is targeting for a 25% growth for his year ending March 1982. According to Alstaff, performance improvements available in his SAW components will make that line the principle contributor to the expected growth. In addition, he expects some contribution from efforts to improve the price competitiveness of his other product lines.



An 8-12.4 GHz Marconi Instrument signal generator.



Marconi Specialized Component Division circulators and isolators include versions for direct connection to stripline.

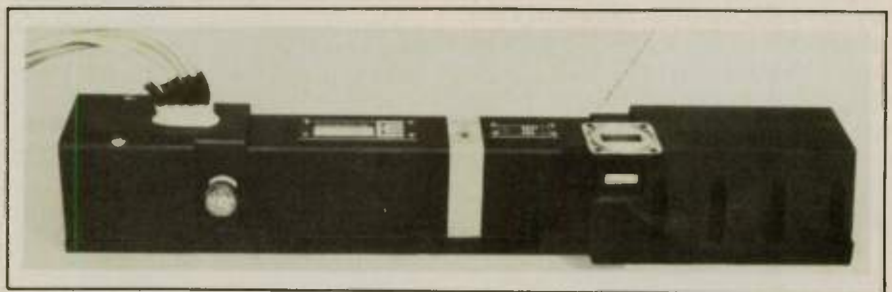
A similarly optimistic outlook was held by Mr. M. Esterson, Divisional Manager of English Electric Valve's TWT Operation in Witham. Mr. Esterson's operation occupied new quarters consolidating all of EEV's TWT activities in September 1980. He anticipates a factor of 2 growth in 1980-81 and a further doubling in 1981-82. Principle ingredient of this performance is the strong demand for EW TWT's developed specifically for equipments designed in the UK and now in production. The new facility represents a considerable investment in expectations for an expanding TWT market. Performance has thus far outstripped forecasts by almost 1 full year and further growth may require substantially more export business than has been done so far.

[Continued on page 24]

Newly introduced double-ridged flexible twistable waveguide by Gabriel Manufacturing.

Flann Microwave has also been able to grow measurably more than the inflation rate according to Alan Frampton, its Managing Director. In his case, the company's ability to respond to the growing demand for millimeter wave instrumentation will be largely responsible for 1981 results. In particular, Flann has been able to fill the needs related to the extensive work underway at 94 GHz.

R. H. Phillips, Marketing Manager of ITT Components Group Tube Unit, credits a variety of changing market conditions for his operation's prospects for a reasonable 1981 performance. The maturing integrated receiving TWTA subsystems incorporating power supplies, gain equalizers and, in some cases, multiple tubes represent a significant shift in the manner in which military systems are assembled and new opportunities for tube suppliers. Communications tube requirements are moving to smaller packaged TWT's and, like the military, to integrated tube-power supply packages. The strong shift to digital operation of commercial communications systems is also creating demands for new tube types.



An English Electric Valve X-band dual mode (200W CW, 800W peak) TWT.

The helix TWT assembly area of EEV's tube facility at Witham.

Finally in the UK, Filtronic Components is in a somewhat special situation since it has been in a pure R&D mode since its founding. While it will find 1981 relatively flat, Marketing Manager Robert Gougth anticipates strong growth next year when a number of the company's suspended substrate stripline components will be made in quantity. Marketing efforts in the US and Europe will

[Continued on page 26]

Spanning the millimeter wave spectrum!

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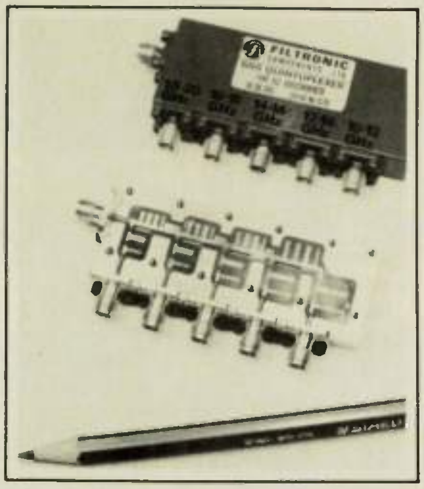


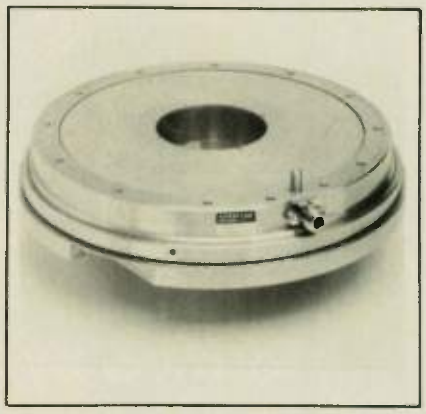
Filtronic Components suspended substrate stripline quintuplexer.

be expanded during 1982 and there are plans for establishing an engineering office in California. According to Gougth, proprietary CAD software which converts designs for high performance filters and multiplexers into mask and machine drawings and machine control tapes will permit the company to compete successfully for such components.

CONTINENTAL REVIEW

In contrast to the interrupted growth of standard microwave component lines in the UK, continental European manufacturers appear to have had little difficulty in realizing growths in those same lines comparable to the excellent rates enjoyed in 1980. G.J.P. Sloots of Philips Electronic Components and Material Division in Eindhoven reported a real growth of 9% for his operation with high production microstrip components the principle contributors. Design tailored for high yield, reproducible results from the manufacturing process are heavily credited for the division's success in that market in 1981.

Taking full advantage of its integrated YIG facility, Sivers Lab in Stockholm closed 1981 with a 30% sales increase (sales have doubled during the last 2½ years). According to Peter Fredholm, Marketing Manager, YIG-based MIC sales have been the major contributor to those results. In addition, the new emphasis on microwave education for entry-level employees of microwave companies in Europe and the US has spurred sales of the company's training equipment and its established rotary joint and switch lines have continued to grow at reasonable rates.



Sivers Lab 8-18 GHz, 5mW YIG-tuned oscillator and its stackable L-band coaxial rotary joint.

Lief Bergstrom, Managing Director, IMA Microwave Products, reviewed the rapid growth of his activity during its short history and projected a continuation of 25-30% per year increases over the next few years. He credits the broad growth of military radar markets in Europe and their demand for tunable LO sources for the company's performance thus far and the bright prospects for the near term. Recent efforts to market into Italy are also expected to contribute to continued growth.

Confining his remarks to the magnetron activity at Philips PEAB in Jarfalla, Anders Lyden, Manager, Sensors and Countermeasures Department, reported that the tube operation, relying primarily on X band types, is presently growing at a rate of 5 to 10% a

[Continued on page 28]

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W40F	1 to 40	1.1	1.3	42	±.5	+15	+27
W110H	5 to 110	1.2	1.4	30	±.5	+5	+17
W250G	5 to 250	1.3	1.5	43	±.5	+25	+37
W500H	5 to 500	1.2	1.4	33	±.5	+5	+17
W1GE	5 to 1000	1.6	1.8	20	±.5	-3	+9
W15GB3	50 to 1500	1.7	2.0	30	±.5	+5	+17
W2G2H	1 to 2 GHz	2.2	2.5	30	±.5	+5	+17
W25GA	0.5 to 2.5 GHz	3.0	3.5	30	±1	+3	+15

MEDIUM POWER

Model Number	Frequency Response (MHz) Minimum	Gain (dB) Minimum	1 dB Gain Compression (dBm) Minimum	Intercept Point for IM Products (dBm) Typical	Noise Figure (dB) Maximum
P150P	0.08 to 150	60	+30	+42	1.5
P700S	700 ± 50	40	+34	+46	6.0
P1GB	0.010 to 1 GHz	30	+30	+41	6.0
P2GS-7	0.5 to 2.0 GHz	30	+30	+41	10.0
P175M	150 to 200 MHz	23	+34	+45	8.0
P20GA	1.5 to 2.0 GHz	20	+30	+40	8.0

The above tables represent a small sampling of our amplifier capabilities. Frequency, gain, bandwidth, noise figure, and power output can be tailored to your specific amplifier specifications. Please call Trontech for a rapid response to your particular requirements.

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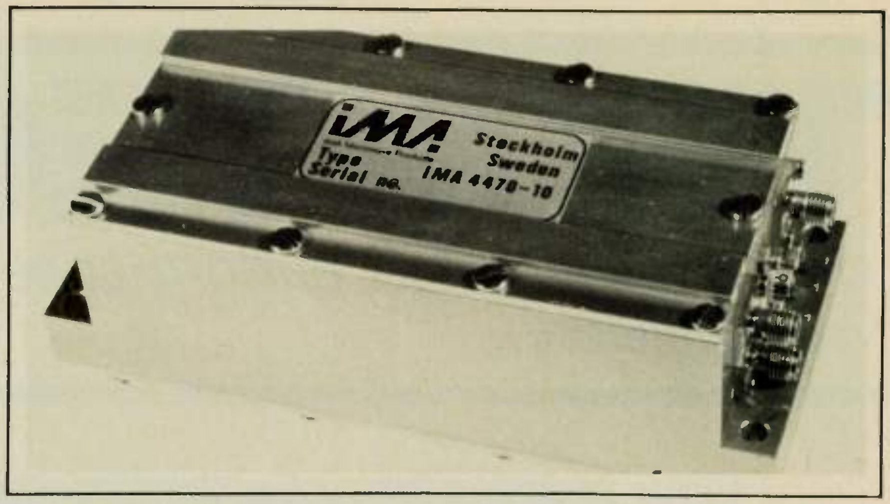
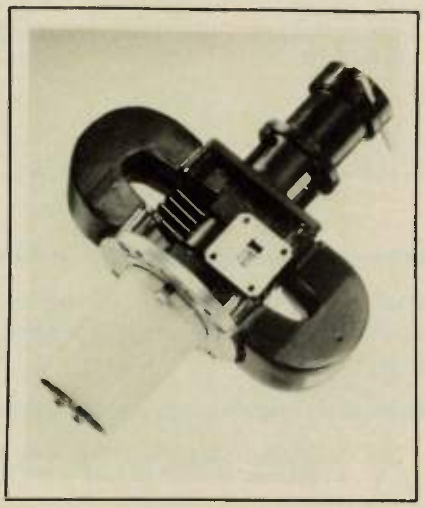


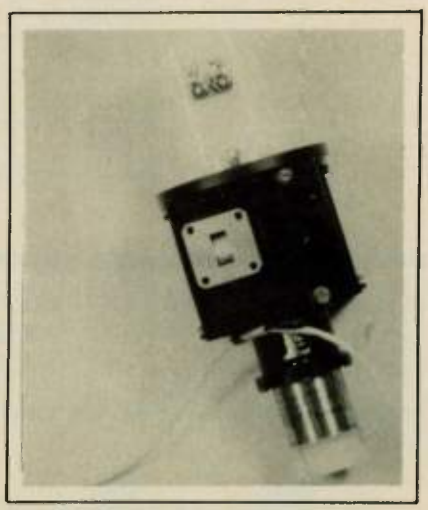
An I.M.A. Microwave Products voltage-tuned Ku band transistor oscillator.

year. Recent sales of Philips fire control systems on the export market and the licensing of the Signal Mark 92 for US production are expected to sustain or improve that rate. A significant increase would be realized if new demands for Ku tubes materialize. In his domestic market, potential applications for the higher frequency types include a Bofors 40 mm gun director and a seeker for the Swedish Navy's RB 50 surface-to-surface guided missile. A SAAB/Bofors consortium is also involved in efforts to market those systems internationally.

The general optimism of continental microwave component suppliers was evident in a number of discussions in France. Radiall's Dominique Pouchard reported 30% gain in that product line during 1981 and expectation of similar growth in the coming year. Principle contributors to 1981 results were increases in isolator and switch sales, increased sales of components for applications above 12 GHz and the relatively new (1½ year old) cable assembly line which is serving a growing demand for phased matched types for military applications.

Dr. Roger Agniel, Thomson CSF DTE's Marketing Manager, was similarly pleased with 1981 and cited a number of program likely to play major roles in the division's future growth. His space communications tubes will be used in the first operational direct broadcast satellite, the Japanese DS-2, positioning the company to play a major role in that market. With some 35 applications on file with the FCC for US direct broadcast satellites, prospects for ad-





Conventional and samarium cobalt magnet versions of Philips PEAB Ku band spin-tuned magnetron.

[*Continued on page 30*]

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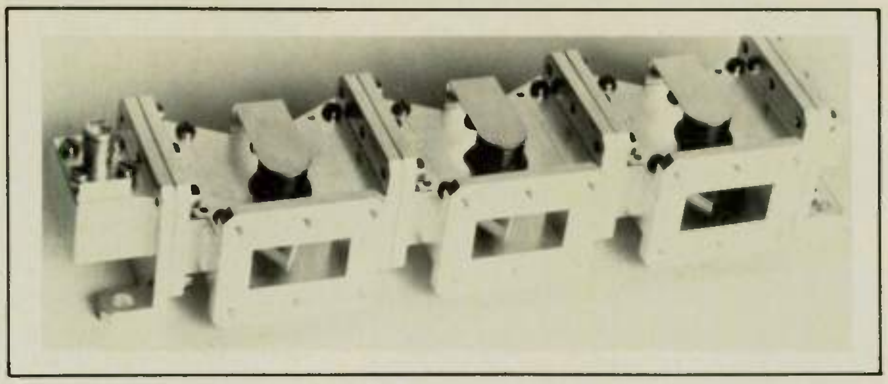

Thomson CSF DCM 80W, 12 GHz circulator for the Telecom I satellite.

ditional business are bright. Ground station tube demand is also expected to expand sharply in Europe as its domestic satellite systems develop.

Broadband tubes for French EW equipment are expected to play a major role in the division's future growth. A development program spanning the past 6-7 years is culminating in requirements for EW systems for the Mirage 2000. Production of tubes for these systems will establish a viable source of broadband tubes on the continent.

Prior to the creation of Thomson CSF's DCM Division about three years ago, Thomson's equipment operations were almost the sole customers of the microwave device and component departments which now comprise the new division. During the past year, DCM, which is responsible for all Thomson device and component activity except electron tubes and subsystems, has expanded its outside sales to 25-30% of its total output.

On an overall basis, the division's silicon diode volume has grown in real terms at 25% per year with the largest number of units going to communications equipment frequency multipliers. Silicon Impatt sales are expected to benefit in the near term from widespread military millimeter system activity. The division's ferrite material facility deals with types for both control and dielectric resonator applications. Over the past three years, its sales have expanded by 50% and, in the past year, 50% of its sales went to exports.

While the diode and ferrite businesses represent roughly 50% military and 50% commercial usage, about 80% of its hybrid activity is for military applications. A broad line of single and multifunction assemblies, amplifiers, oscillators, mixers and bulk acoustic wave (BAW) components is handled by this group with much of its output targeted for French military equipments.

CO-PRODUCTION

With few exceptions neither the British nor the continental European microwave component suppliers indicated significant benefit from US-NATO co-production programs. Those that had bid unsuccessfully cited a number of reasons for which European equipment makers involved in production of US-designed systems would stay with US component suppliers. Foremost among these were cost considerations. The need to recover investments required to duplicate US component designs makes it difficult for European suppliers to be price competitive. Secondly, European equipment makers are reluctant to fund new component qualification programs. There was some feeling that European commodity, e. g., resistor, suppliers may be involved in some co-production programs, however, unless the European system manufacturer elects to make his own, US microwave components selected for the original design are likely to be used.

GOVERNMENT R&D SUPPORT

European microwave companies have long envied the relatively high level of government R&D support enjoyed by their US competitors. Today they see the

[*Continued on page 32*]

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Our high-performance assemblies still give you low insertion loss through 26.5 GHz, phase and loss stability with flexure and temperature, excellent shielding effectiveness, and superior flexibility and flex life.

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GORE-TEX Type P cable assemblies are ruggedized by use of a steel coil spring and an extruded polyurethane jacket. Tapered strain relief boots control bend radius at the connectors. These assemblies have been flexed more than 2,000 times over a two-inch diameter mandrel, with no significant change in insertion loss or VSWR, flexure was performed directly behind the connectors (the most failure-prone area of any assembly). Connector retention force is in excess of 80 pounds, and resistance to plane-compressive force is 300 pounds per linear inch.

For military applications

GORE-TEX Type R cable assemblies have a MIL-I-23053/5 polyolefin jacket applied over the ruggedizing spring. Internal graduated-length springs control bend radius at the connectors. Although slightly stiffer than Type P ruggedization, flex life is excellent. Again, connector retention force is in excess of 80 pounds, resistance to plane-compressive force is 300 pounds per linear inch.

The ultimate

Armored GORE-TEX assemblies (Type A) wear a stainless steel flexible conduit. Connector retention force is well over 100 pounds; resistance to plane-compressive force is 800 pounds per linear inch. Bend radius is intentionally restricted to prevent damage, but excellent flexibility is maintained. Flex life is in excess of 10,000 flexes over a three-inch diameter mandrel.

Many configurations

Many standard connector configurations and variations of these assemblies are manufactured routinely, so inquire about what you need. Special features generally don't take any longer.

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Gore puts the specs in black and white and guarantees that the assembly you get will meet them.

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gap widening as current support in Europe declines and the burden of maintaining competitive positions is shifting further toward private investment. The large companies, having had the major share of government R&D funds in the past, have the biggest adjustment to make. Many of these, however, view the freedom to select markets for investment themselves rather than being directed by available support funds as a positive development.

There were, of course, comments on the manner in which available money is being spent. The difficulty of getting British support for development of second sources for items available from the US was cited. A particular example was the need expressed for local suppliers of double-ridged waveguide components and wide band sources with which it was claimed that US suppliers are having serious delivery problems.

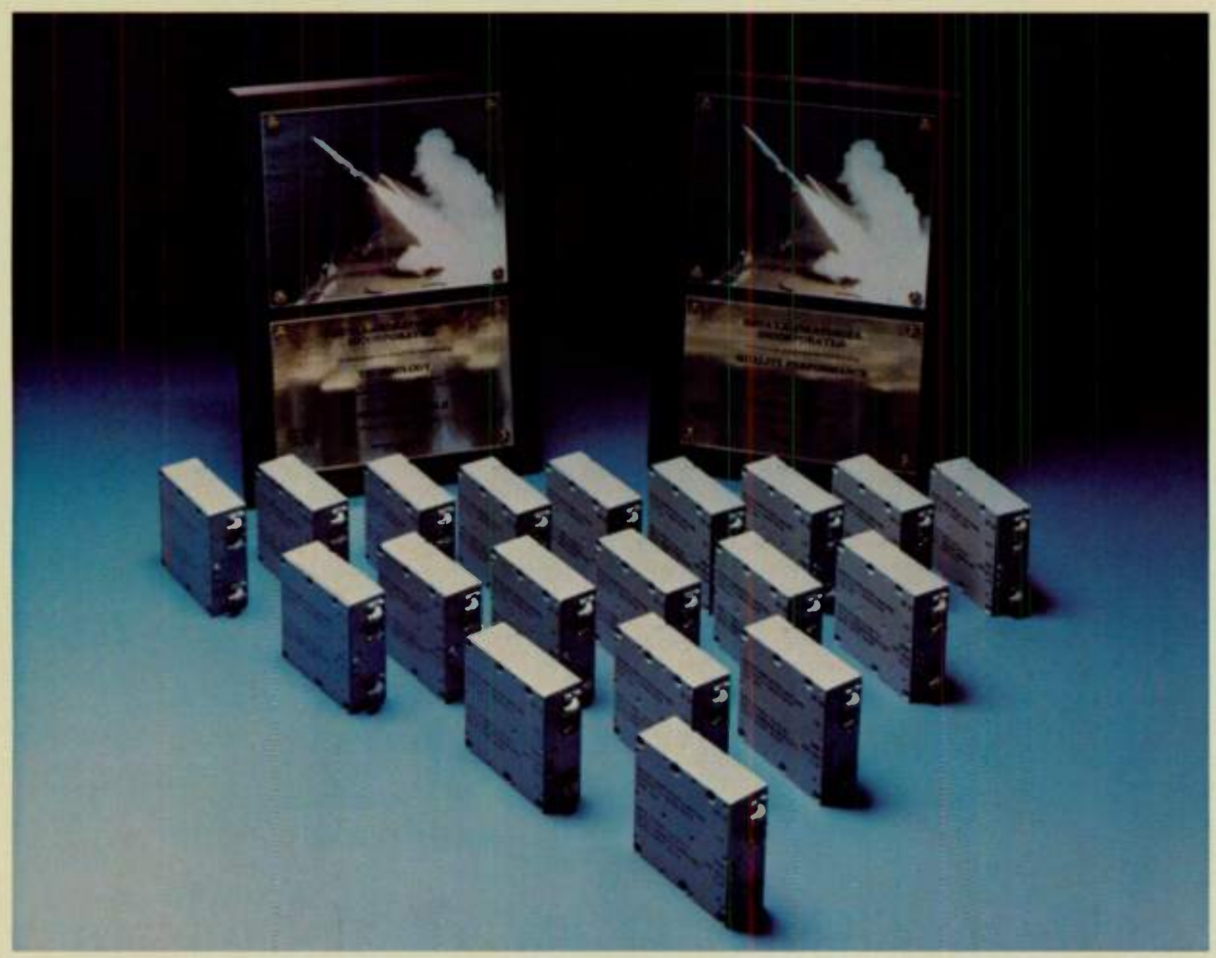
British tube manufacturers take issue with the allocation of money to basic tube research. They feel that much more benefit would be derived from its application to technology and material improvement programs. And, of course, they question the relative size of tube and solid state program allocations.

PRIVATE INVESTMENT

In the face of reduced levels of British MOD business, the major share of private investment by UK microwave component companies continues to favor military applications. There are some prospects for commercial communications business within the UK but most British companies are relying on an eventual upturn in military markets for future growth. Among the UK companies interviewed, only Ferranti, Dundee and Racal-MESL Microwave estimated that military-related programs took as little as 50% of their internal development funds.

The likelihood that TV-SAT, Telesat I, TDF I and other domestic satellite systems will be realities during the 80's has generated high expectations among continental European microwave component manufacturers for a significant

[Continued on page 96]



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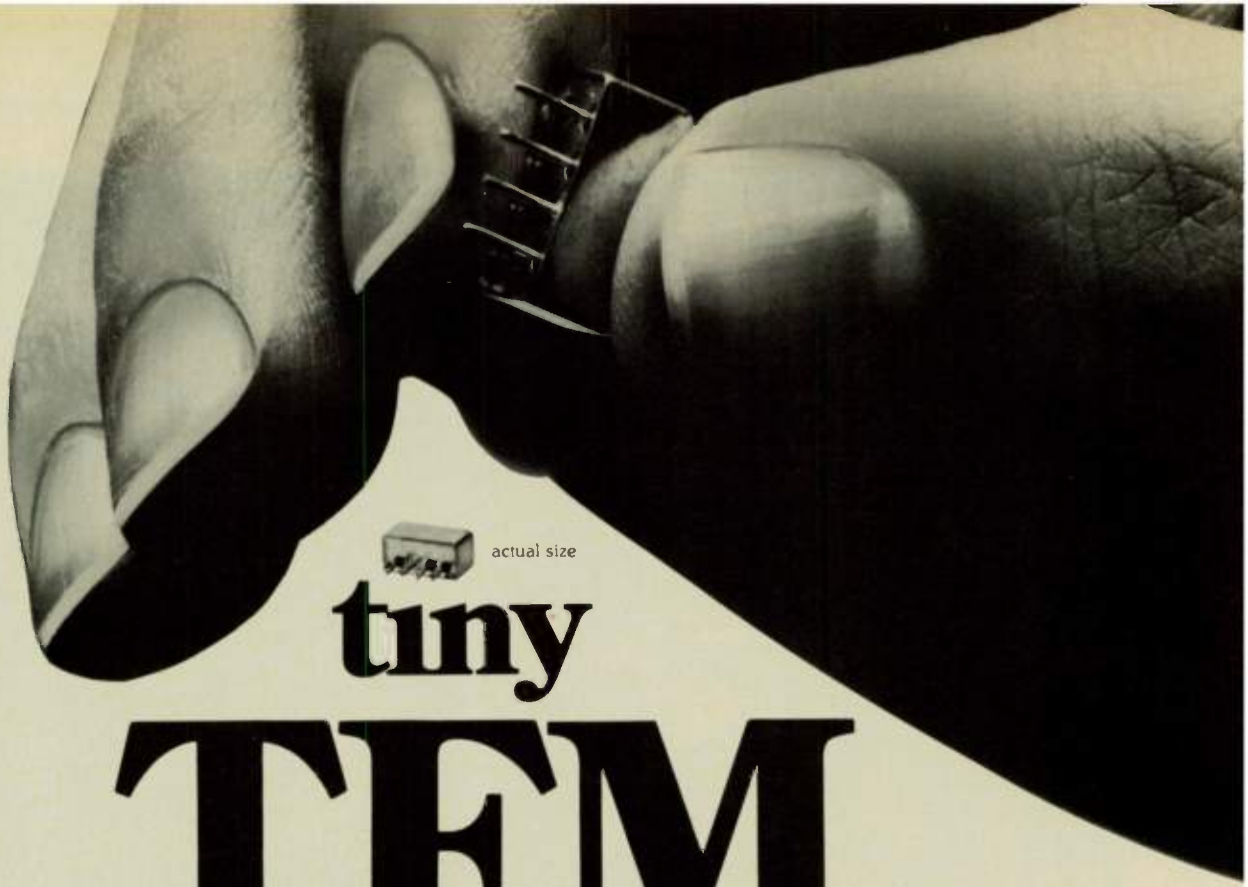

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Increase your packaging density, and lower your costs... specify Mini-Circuits miniature TFM Series. These tiny units 0.5" x 0.21" x 0.25" are the smallest, off-the-shelf Double Balanced Mixers available today.

Requiring less PC board area than a flat-pack or TO-5 case, the TFM Series offer greater than 45 dB isolation, and only 6 dB conversion loss.

Manufactured to meet all the requirements of MIL-M-28837, the tiny but rugged TFM units have become the preferred unit in new designs for military equipment.

Model No.	Frequency Range MHz		Conversion Loss dB. Typical		Isolation dB, Typical						Price	
			One Octave from		Lower Band Edge to One Decade Higher		Mid Range		Upper Band Edge to One Octave Lower		$	
	LO/RF	IF	Band Edge	Total Range	LO-RF	LO-IF	LO-RF	LO-IF	LO-RF	LO-IF	EA.	QTY.
TFM-2	1-1000	DC-1000	6.0	7.0	50	45	40	35	30	25	11.95	(1-49)
TFM-3	.04-400	DC-400	5.3	6.0	60	55	50	45	35	35	19.95	(5-49)
TFM-4	5-1250	DC-1250	6.0	7.5	50	45	40	35	30	25	21.95	(5-49)
•TFM-11	1-2000	5-600	7.0	7.5	50	45	35	27	25	25	39.95	(1-24)
•TFM-12	800-1250	50-90	—	6.0	35	30	35	30	35	30	39.95	(1-24)
••TFM-15	10-3000	10-800	6.3	6.5	35	30	35	30	35	30	49.95	(1-9)
••TFM-150	10-2000	DC-1000	6.0	6.5	32	33	35	30	35	30	39.95	(1-9)

•If Port is not DC coupled
•• +10 dBm LO, +5 dBm RF at 1dB compression

For complete specifications and performance curves refer to the 1980-1981 Microwaves Product Data Directory, the Goldbook or EEM.

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Use the TFM series to solve your tight space problems. Take advantage of the mounting versatility—plug it upright on a PC board or mount it sideways as a flatpack.

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News from ☆ Washington

GERALD GREEN, *Washington Editor*

C^3 GETS TOP PRIORITY

Officials of the Reagan Administration have given command, control, and communications (C^3) top priority in their efforts to rapidly improve the strategic forces of the United States. In rapid fire appearances on Capitol Hill, officials of the Department of Defense, from Secretary of Defense Caspar W. Weinberger to Principal Deputy Under Secretary of Defense James P. Wade, Jr. stressed the importance of C^3.

In testimony before the Subcommittee on Strategic and Theatre Nuclear Forces of the Senate's Armed Services Committee, Wade provided details of the Pentagon's plans to upgrade C^3. According to the testimony, the following elements of C^3 will be improved on a top priority basis:

- DoD will upgrade the survivability of our warning satellites and deploy mobile ground terminals to back up our data processing capability in order to improve strategic warning capability. Both satellite and ground-based radar warning systems will be improved to obtain more definite warning should an attack occur. Surveillance radars, which would help to detect a surface launched ballistic (SLBM) attack, will be added to cover potential submarine operating areas to the Southeast and Southwest.
- A new satellite communications system will be developed employing extremely high-frequency channels so the President's orders can be passed from command centers to commanders and forces. Bombers will receive very low-frequency and low-frequency communications-receivers to enhance their ability to communicate with command centers. Deployed submarines will also receive an upgraded communications package. At the same time, a research and development program will be initiated leading to a command and control system which will endure for an extended period beyond any initial nuclear attack.
- E-4B airborne command posts will be deployed to serve the National Command Authority (NCA) in time of war, and existing EC-135 airborne command posts will be hardened against nuclear effects. The EC-135s will also receive additional enhancements in their ability to communicate with both the NCA and strategic forces.

FIRST AN/TSC-99 COMMUNICATION SYSTEM

The first AN/TSC-99 Communication Central program system has been completed by Rockwell International's Defense Electronics Operations division for the U.S. Army.

The AN/TSC-99, part of the U.S. Army Special Forces' Burst CJommunications System, is built by DEO's Collins Communication Systems Division ground systems in Dallas, TX.

The system relays secure messages between U.S. Army Special Forces tactical operations centers and out-station elements operating in hostile territory. Through the burst communications technique and the system's automated message processing and equipment control system, the TSC-99 is able to minimize the time that an out-station is on the air. This capability significantly reduces the susceptibility of these ground forces to detection and location.

The burst communication system uses single sideband HF as the primary communication mode and satellite communication for special requirements. The system features Rockwell's HF-80 radio equipment and other commercial equipments specially packaged in two shelters: receive and transmit.

A second TSC-99 system is being readied at the CCSD Dallas facility for Army Extension Training Material Validation.

FCC APPROVES EXTENSION OF PRIVATE NETWORK SERVICES TO CANADA

In what appears to be a major policy change by both the FCC and the Executive Branch of the U.S. Government, the FCC has unanimously approved the request of a U.S. firm, Satellite Business Systems (SBS), for authority to extend its private network services to Canada. Since 1972, the U.S. Government had been following a restrictive policy on use of domestic satellites between the U.S. and Canada.

Implementation of SBS service to Canada will require the Canadian Government's concurrence and specific operating arrangements between SBS and the Canadian carriers, which will operate the earth stations in Canada. In addition, coordination with INTELSAT will be required. SBS spokesmen indicated that they hope that these tasks can be accomplished in 1982, permitting initial service availability as early as the end of 1982.

U.S. PLANS INCREASED ACQUISITION OF FOREIGN TECHNICAL INFORMATION

Today one thinks of technology transfer as the transfer of technical information from the United States to foreign governments and industry. The U.S. is now stepping up its efforts to make technology transfer a two-way street.

The acquisition of foreign technology for U.S. industrial development is the foundation upon which the Publication Board, the predecessor of today's National Technical Information Service, was created by Presidential Order in 1945.

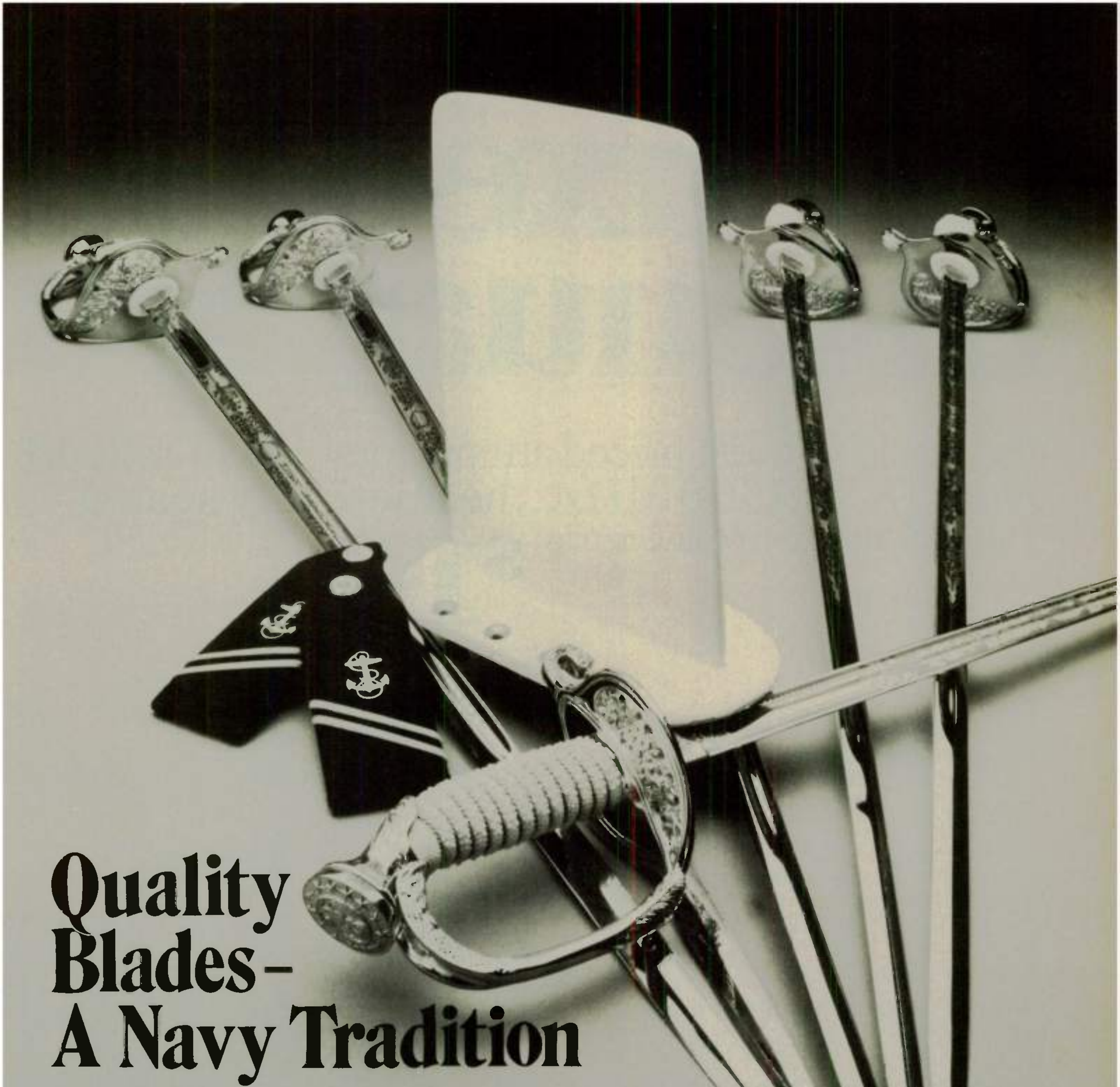
Now, 36 years and several organizational changes later, the availability of timely and generally unpublished foreign technical information has become more important than ever.

Today, about 20 percent of the NTIS collection, some 300,000 titles, could be identified as foreign technology or marketing information and about 1000 new foreign technical reports are becoming available each month.

Currently, the principal effort of the greatly enhanced program is to locate and acquire technical information in the form of technical reports generated as a result of R&D done by foreign government and quasi-government agencies, research associations, academic institutions, and similar organizations. Such reports are relatively unknown and inaccessible even within the countries where they originate.

Surprisingly, it appears that a large number of engineers and scientists in industry are unaware of the wealth of material at NTIS. Officials of NTIS told Microwave Journal's Washington Report that it is a fundamental objective of the NTIS program to respond to the information needs of the U.S. industry. Quality and relevance are sought in acquisitions, not just volume.

NTIS is located near Washington, DC, at 5285 Port Royal Road, Springfield, VA 22161 and can be contacted by telephone (703) 487-4600. ■



Quality Blades – A Navy Tradition

In keeping with this tradition, Adams-Russell has introduced the AN-400 Blade Antenna. There are three of these blades on every F-18. These high performance antennas, designed for use with the AN/ARC-182 Radio Set, each cover three bands - VHF, UHF, and L. That's quite a feat for a blade only 9 inches tall! And the two inputs (SC and TNC) are isolated by an internal filter, effectively eliminating the need for an external diplexer. This vertically polarized antenna has a radiation pattern typical of a quarter-wave stub. Qualified for MIL-E-5400 service conditions, of course. Similar versions under development for the F-15E, F-14, and other aircraft. Another innovation in antennas from Adams-Russell.

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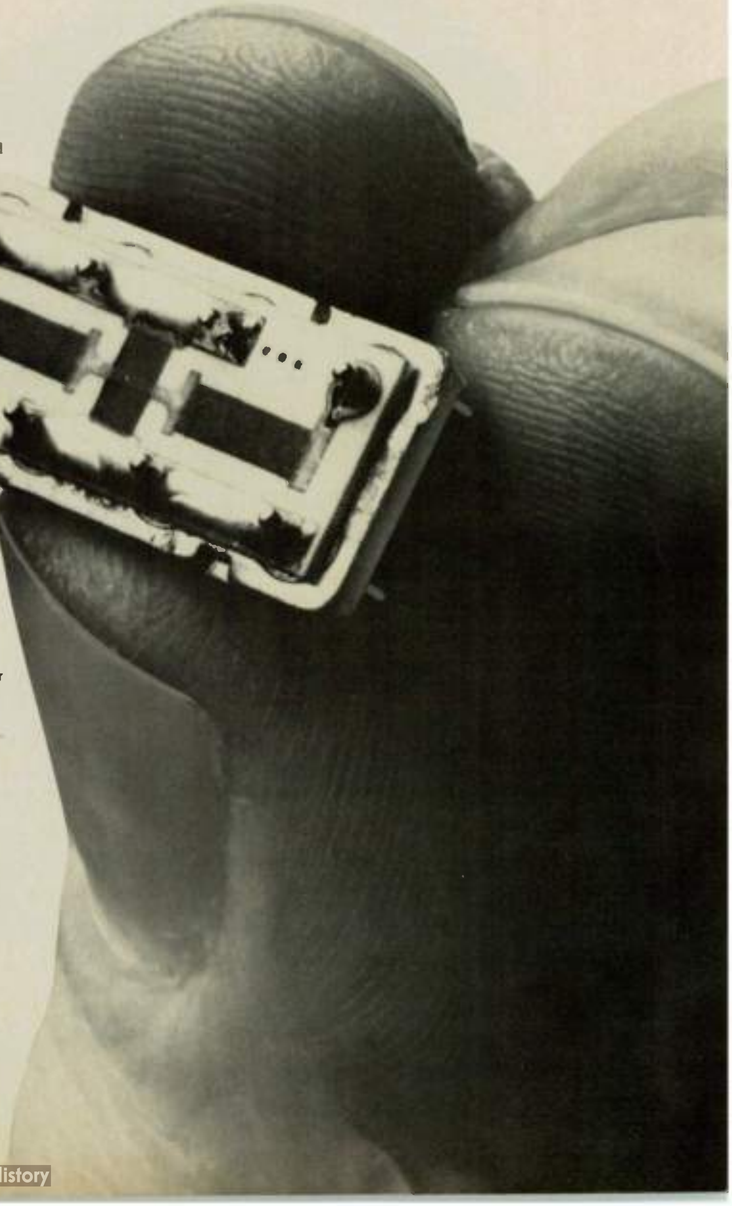

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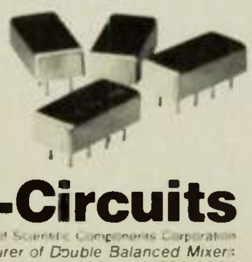
DESIGNERS KIT AVAILABLE, KAT-1
4 attenuators of each type
AT-3, AT-6, AT-10, AT-20 only $39.95

For Mini Circuits sales and distributors listing see page 46

Model	Attenuation, dB Nominal Value	Attenuation Tolerance from Nominal	Frequency Range MHz	Attenuation Change From Nominal Over Frequency Range, MHz DC-1000	1000-1500	VSWR Max. DC-1000	1000-1500	Power Max.
AT-3	3	±0.2dB	DC-1500	0.6dB	1.0dB	1.3:1	1.5:1	1W
AT-6	6	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W
AT-10	10	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W
AT-20	20	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W



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CIRCLE 33 ON READER SERVICE CARD

International Report

GERALD GREEN, *Washington Editor*

U.S. AND JAPAN AGREE TO REDUCE TARIFFS ON SEMICONDUCTORS

The U.S. and Japanese governments have announced an agreement to lower tariffs on semiconductors to 4.2 percent starting in 1982.

The agreement is especially heartening since the tariff reduction was originally planned as an eight year incremental reduction program back in 1980 when the U.S. tariff on semiconductors was 6 percent and the Japanese tariff was 12 percent. The governments decided, however, with considerable assistance from the semiconductor industry of the U.S., to accelerate the reductions.

According to the present plan, the U.S. will reduce its tariff in two stages On January 1, 1982 the U.S. will reduce its tariff to 4.24 percent and will reach the 4.2 percent tariff on January 1, 1983. The Japanese will reduce its tariff to 4.2 percent on April 1, 1982.

Although the tariff reductions were agreed to by high officials of both governments, the Japan Tariff Council must formally agree to the reduction and then the Diet must also approve the plan.

BRAZIL PROCURES ITALIAN RADAR SYSTEMS FOR AIRSPACE SURVEILLANCE AND CONTROL

Brazil, which is in the process of extending and modernizing its airspace surveillance and control system, has contracted with an Italian company for mobile radar systems.

The contract, worth approximately $60 M, was awarded to Selenia for the radars, including Selenia's MRCS-403 and GCA.

The MRCS-403 mobile and control system, is an autonomous system capable of providing the surveillance and control of airspace. The system in its basic configuration is composed of a shelterized RAT-315 three dimensional radar, data processing and display shelter which is already operative in a number of European sites.

The GCA, ground control approach system, is a mobile system designed to control the aircraft during the approach and landing phase of a flight. The system consists of a state-of-the-art Air Field Surveillance Radar, a precision approach radar and an operations shelter fully equipped. The PAR is manufactured by FIAR, Milano, Italy. This GCA configuration has been ordered by a number of Air Forces throughout the world.

ROYAL NAVY LEASES UHF SATELLITE CAPACITY

Her Majesty's Royal Navy, UK, has recently leased UHF satellite communications capacity on a MARISAT Satellite.

The multi-frequency MARISAT satellites also provide service to the U.S. Navy at dedicated UHF frequencies, and to the commercial shipping and offshore industries at separate L-band and C-band maritime frequencies.

The MARISAT System, developed and operated by COMSAT General of the U.S. is the world's first maritime satellite communications system. Services to the international maritime market include telephone, telex, facsimile and data communications.

International Report

ENGLAND EVALUATING NAVSTAR

Ferranti Limited of the UK has completed a British Ministry of Defense contract to study the operational navigation and weapon aiming requirements for a wide variety of military aircraft as the first stage in evaluating the potential contribution of the NAVSTAR Global Positioning System (GPS) now under development in the UK.

NAVSTAR is a satellite-based, universal positioning and navigation system, designed to provide precise 3-dimensional navigation information, and developed to arrest the proliferation of differing navigation systems. It is planned to be operational in 1985 with eventually eighteen NAVSTAR satellites circling the earth, probably in three orbits — six per orbit — giving global coverage under all weather conditions.

With a GPS receiver a user can process the signals transmitted by the satellites and determine his position within tens of feet, his velocity within a fraction of a mile per hour, and the time within a millionth of a second. It is expected that a single NAVSTAR receiver aboard an aircraft could achieve or surpass the capabilities of many of the current navigation aids, and do so at a lower equipment cost.

The applications envisaged for NAVSTAR include: precision weapons delivery; en route navigation for space, air, land, and sea vehicles; aircraft runway approach; photo-mapping, geodetic surveys; aerial rendezvous/refueling; tactical missile navigation system up-dating; air traffic control; range instrumentation and safety, as well as search and rescue operations.

CANADA PLANS COMMUNICATIONS NETWORK

The Canadian government will use Telesat Canada's Anik B satellite to provide communications services between some government offices in Canada.

Field trials are scheduled to start in December 1981 with completion scheduled for September 1982. It will test the application of state-of-the-art satellite technology to government operations. The Canadian Telecommunications Agency will connect an experimental communications network already established within the Department of Communications.

The field trial will evaluate electronic distribution of documents and messages and will test satellite services for voice, computer communications and teleconferencing. The trial will also involve the Atmospheric Environment Service (AES) of Environment Canada and the Canada Employment and Immigration Commission.

AES will evaluate the cost effectiveness of transmitting weather maps between weather centers and of providing access by satellite to data stored in a central computer. The CEIC will evaluate the effectiveness of using satellite systems for improving its own administrative communications and its service to the public.

System earth stations will be erected in Toronto, Montreal, Ottawa, Kitchener (Ontario) and Bathurst (New Brunswick). ■

Around the Circuit

PERSONNEL **Harold W. Harrison** has been appointed V.P. and general manager for Addington Solid State products at Eaton Corporation's Communications Products Division . . . **Louis E.Goetz** is the new executive V.P. and CEO of Systems Research Laboratory, Inc. . . . Systron Donner's Test and Measurement Group has a new director of sales: **George Archuleta** . . . Alpha Industries has announced the promotion of **Nicholas A. Bishop** to national sales manager . . . **Don V. Lee** is V.P. and general manager of Comstron Corporation's new Communication Systems Division . . . **Robert E. Bilby** has been named corporate communications manager at **TECKNIT** . . . **Keith Larson** is the new engineering project manager for satellite video receiver terminal products at Hughes Aircraft Company's Microwave Communications Products . . . **William G. Parzybok, Jr.** has been named general manager of the newly created Electronic Measurement Group at Hewlett-Packard Company . . . North Hills Electronics, Inc., has appointed **John Murz**, product manager for the company's new microwave product line . . . **Dr. Barry S. Perlman** is the new manager for computer aided design and testing at the microwave technology center at RCA Laboratories . . . **Eugene Blum** has been appointed to Chief Applications Engineer at General Microwave Corporation . . .**Richard P. Jansen** has been appointed applications engineer at Rogers Corporation's Microwave Material Division. GTE's Electronic Warfare Organization has named **Robert W. Mark** marketing manager . . . **Lawrence W. Coombs** is the recently appointed chief engineer at Diamond Antenna and Microwave Corporation . . .**John Kominitsky** has been appointed marketing engineer in the western region at Narda Microwave Corporation . . . **John R. Shaw** has been promoted to sales manager of Texscan's Indianapolis Division . . . American Electronics Laboratories, Inc., has promoted **Edgar O. Morgenson** to manager of the countermeasures division . . . Amplifonix Incorporated has named **Edward T. Andrews** to the newly created position of marketing manager.

INDUSTRY NEWS **Satellite Transmission Systems, Inc.**, a subsidiary of **California Microwave, Inc.**, will supply Citibank, N.A. with a system of ten 11-meter earth stations for the corporation's satellite transmission network . . . The **Fil-Shield Division** of **Filtron Company, Inc.** has moved to a new facility located at 410 Surf Ave., Stratford, CT Tel: (203) 372-1775 . . . **Electronic Resources, Inc.** of Cupertino, California is the new distributor for **Amplifonix's** line of standard RF modules, amplifiers and attenuators . . . **Randtron Systems, Inc.** has announced that it plans to combine two of its operations: Aercom and Contours, under the name **Aercom Industries, Inc.** John Middaugh is president of the new company . . . **Zebra Electronics, Inc.** is the **Omni Spectra, Inc.** franchised distributor of coaxial connectors and RF components in the New Jersey, Maryland and Pennsylvania markets.

CONTRACTS **Cincinnati Electronics Corporation** has received an $8.6M contract from the U.S. Army Communications — Electronics Command, Ft. Monmouth, NJ to produce AN/PSC-3 and AN/VSC-7 radio sets and ancillary equipment . . . Warner Robins Air Logistics Command, Robins AFB, GA has awarded a contract in excess of $7M to the **Hazeltine Corporation** for AN/APX-76 Air-by-Air Interrogator equipment . . . **Antekna, Inc.,** a subsidiary of Itek Corporation, has been awarded two contracts totalling $2.5M from the U.S. Air Force for standard emitter simulators with deliveries scheduled for 1982 . . . **RCA Missile and Surface Radar** has received $339M in contracts for the AEGIS Weapons System for three additional U.S. Navy guided missile cruisers . . .**Eaton Corporation's AIL Division** has been awarded a $5.8M contract to supply two additional microwave scanning beam landing systems used to land the NASA space shuttle.

NEW MARKET ENTRY **Microwave Development Company** has entered the double-ridged and rectangular waveguide market with a full line of passive components in all waveguide and double-ridged sizes and custom designed microwave assemblies. Gary F. Watkins, Microwave Development Company, 10 Railroad St., Lawrence, MA 01841 Tel: (617) 681-1949.

FINANCIAL **Loral Corporation** reported a net income for the three months ended September 30, 1981 of $5.5M or 54¢ per share, compared with $4.7M or 47¢ per share in the previous year . . . Sales for the fiscal 1982 first quarter ended September 30, 1981 at **Narda Microwave Corporation** rose ten percent to $6M from the comparable period in 1980 of $5.4M; net income rose to $515K from $311K in the fiscal 1981 first quarter . . . **Sage Laboratories, Inc.** reported net income of $106K, or 24¢ per share on sales and contract revenues of $703K for the first quarter of the 1982 fiscal year ended September 26, 1981; this compares to net income of $75K or 17¢ per share on sales of $623K for the 1980 period . . . For the six months ended September 30, 1981 **Alpha Industries** reported net income of $1.8M up from $1.4M in the comparable period in 1980 with earning per share of 64¢ up from 54¢. ■

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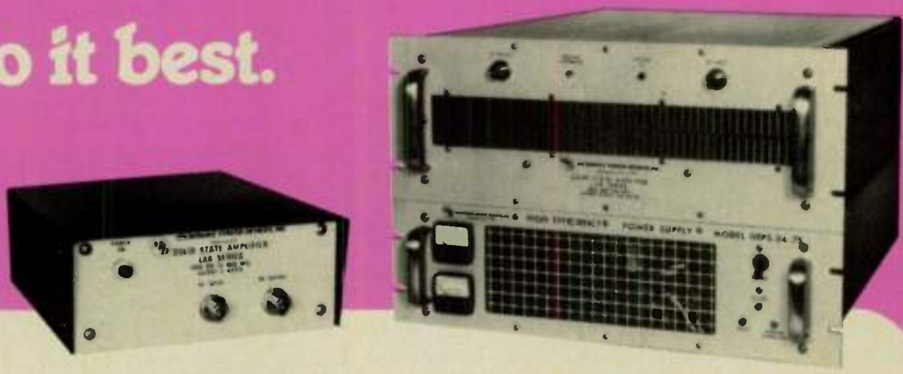

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Microwave And Millimeter-Wave Devices And Circuits

KENNETH J. SLEGER
Naval Research Laboratory
Washington, D.C.

This contract news report will serve to update the more extensive NRL article that appeared in the July 1981 issue and also to give a preliminary rundown of FY-82 contract starts.

CONTRACT NEWS UPDATE

The S-band GaAs FET program at TI, N00014-81-C-2064, is currently focusing on power FETs capable of delivering 25 watts peak power over the 3.1-3.5 GHz frequency band. Recent results from a 38.4 mm gate width device yielded 20 watts CW with 6 dB gain and 33% efficiency at 3 GHz. The epitaxial doping profile was not believed to be optimum, and it is expected that still better performance is possible with an optimum profile and gate recess. Related GaAs FET work at TI is continuing in the development of a 1 watt, 7-18 GHz hybrid amplifier, N00173-79-C-0047. A four stage amplifier with a balanced output stage has achieved 20 dB gain over the 7-18 GHz band. This can serve as the driver for the balanced 1 watt output stage. To date, the best performance from a balanced power output stage is 1 watt from 7 to 17 GHz with 2.5 dB gain. Further device refinement is underway to increase the gain to 5 dB or more and the uppper frequency to 18 GHz. InP IMPATT work at Varian, N00173-80-C-0096, is concentrating on the optimum low-high-medium profile for maximum power in Ka band. A three layer epitaxial growth of n^-, n and n^+ is used for the profile followed by beryllium or magnesium implants to form the p region. In general, the best rf results occurred with the beryllium implants. 7.7 watts peak power with 10% efficiency was obtained from free running IMPATT oscillators at 29.5 GHz. At 33 GHz the peak power was 4.5 watts with 8.27% efficiency. Doping profile optimization is continuing toward the goal of 10 watts peak power at 35 GHz.

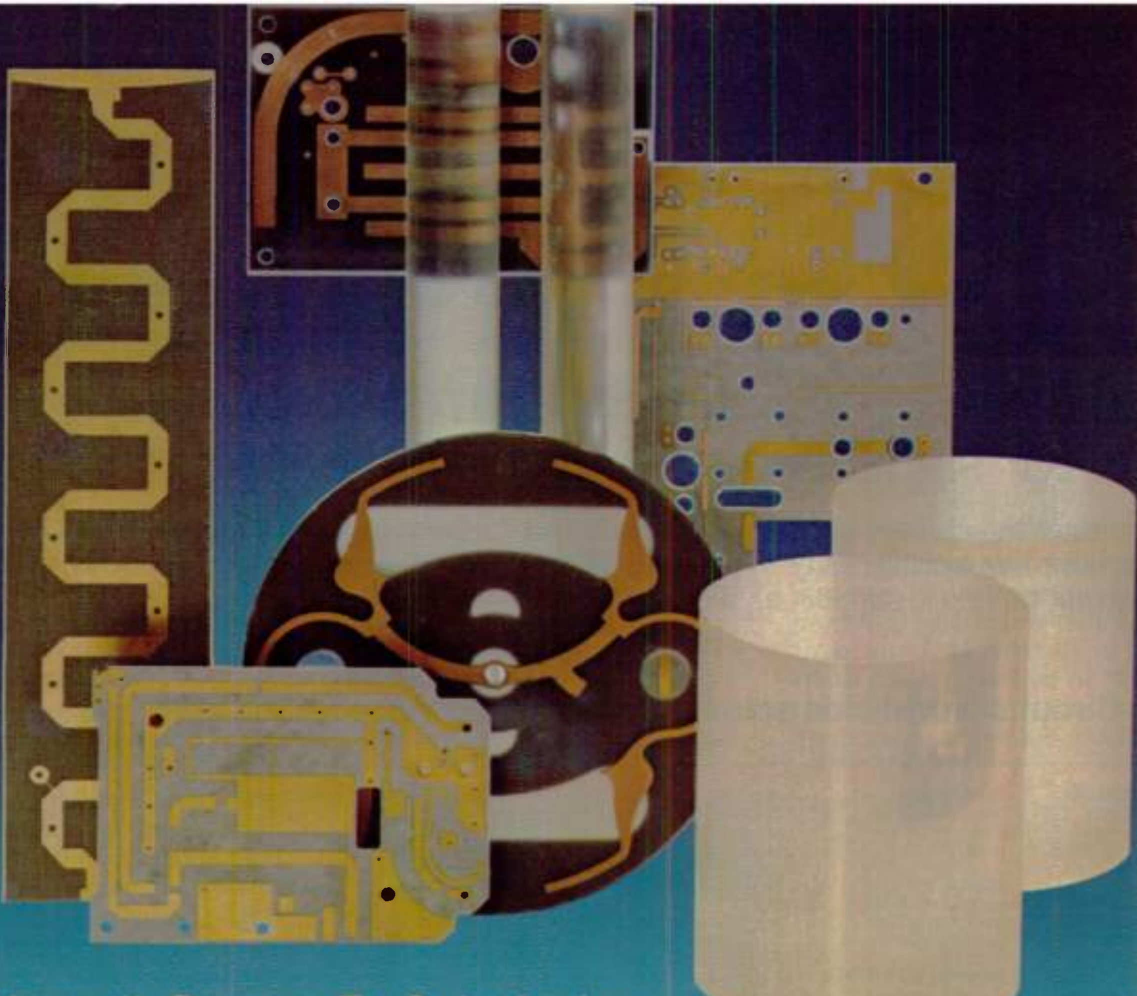
A one year program has been awarded to Westinghouse Defense and Electronic Systems Center, N00014-81-C-2404, to investigate cascode GaAs FET structures for S band power FET amplifiers. The cascode connection combines two GaAs FET structures in a monolithic format and is expected to deliver more power, gain, and power added efficiency than GaAs FETs of conventional design. In addition, the high output impedance of the structure is attractive for broadbanding. Technical goals include 1 watt/mm gate width, 8 dB gain at 1 dB compression and a 40% power added efficiency. Four cell structures will be fabricated with a peak power goal of 12-15 watts. A dual award for a nine month study program to establish a monolithic receiver front-end configuration viable in wideband millimeter-wave receiver systems has been awarded to Hughes Torrance Laboratory, N00014-81-C-2649, and to TRW Systems, N00014-81-C-2650. The front end will cover the full 75 to 110 GHz band using a diplex system to achieve dual band outputs with extension to an instantaneous frequency multiplex system.

FY-82 CONTRACT STARTS

A follow-on to the S band Si bipolar transistor amplifier contract at MSC, N00173-78-C-0019, is planned to begin early in calendar year 1982. Novel device designs and processing will be stressed for power added efficiency and yield improvement. Optimized transistor cell size will be determined for implementation into a final 500 watt amplifier/combiner demonstration circuit. Exploratory development work will follow on the heels of a basic research program on GaAs memories finishing up at Hughes Research Laboratories, N00173-80-C-0549. The follow-on program will focus on assessment of GaAs enhancement mode technology for low power, high speed memory circuits. Follow-ons are open bid.

A variety of wideband, monolithic GaAs FET amplifier programs are in the planning stage. Bandwidths of interest are 2-8 GHz, 7-18 GHz and 18-26 GHz. Power outputs will be 5-10 watts, 1-5 watts and 10 milliwatts, respectively. In addition, a monolithically compatable high power ($>$ 10 watts) X band GaAs FET technology will be pursued which stresses novel device design and broadband amplifier potential. Finally, a procurement will be initiated for a solid state 500 watt X-band power combiner to be used as a driver for a CFA.

These programs and planned program starts are sponsored by the Naval Electronic Systems Command: all S-band transistors and amplifiers, InP IMPATTs, 75-110 GHz receiver front end, 18-26.5 GHz monolithic amplifier, GaAs memory (basic research phase) and X-band power modules. The exploratory GaAs memory follow-on is co-sponsored by the Naval Electronic Systems Command and the Naval Air Systems Command. All other programs and planned program starts are sponsored by the Naval Air Systems Command. NRL personnel serve a contracting officer's technical representatives on these programs. ■



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Division Headquarters: Franklin, NH 03235/Tel. 603—934-5736 • Technical Services and Manufacturing Facilities: Franklin, NH • Hoosick Falls, NY • Hayward, CA • Seoul, Korea • Taipei, Taiwan contain a wealth of information on the factors limiting system operation. For instance, it can be readily determined from these plots if a flicker or white noise process is dominant.

PHASE NOISE DEFINITIONS

With the HP 3047A a very broad definition of phase noise is used; phase noise is any variation from the phase of an ideal sine wave. This definition includes deterministic modulation such as power line sidebands as well as phase or frequency noise modulation. Both noise and deterministic phase modulation appear in all the figures in this article. However, the text deals only with noise effects. The causes of deterministic modulation are usually phenomena like power supply ripple or stray coupling of reference frequencies. Such phenomena are well understood, if at times very difficult to eliminate. The effects of noise processes, however, are less well known. Examining phase noise plots, like those generated by this system can identify the noise process causing performance limitations.

Throughout the article we use a very common measure of phase noise, $L(f)$. This is defined as the power that would be measured in a 1 Hertz bandwidth, f Hertz away from the carrier. It is measured in dB below the carrier and so has units of dBc/Hz.

While there are many possible noise processes, we will consider only the two most common noise generation processes, white and flicker noise. White noise is fairly well understood. It is typically caused by either the random motion of electrons in a resistance (thermal noise) or by the random movement of electrons across a potential barrier such as a diode or transistor junction. It is called white noise because it has a flat frequency power spectrum like white light. Flicker noise may not be as familiar to most engineers. Although flicker noise is a common occurance in amplifiers, multipliers, and oscillators, its sources are not well understood. Unlike white noise, its frequency spectrum is not flat but increases as the frequency is decreased (l/f). It is called flicker noise because if a light bulb has a l/f noise, we would say it was flickering.[2]

Let us now see how these noise processes affect the performance of typical system components, starting with amplifiers.

PHASE NOISE OF AMPLIFIERS

White noise is inherent in all amplifiers and has a flat frequency power spectrum. A sine wave input of any frequency to the amplifier would thus be phase (and amplitude) modulated by the white noise processes. With the typical noise-figures and signal levels found in most systems, this forms a white phase noise floor at approximately -160 dBc.

A more surprising phenomena is that flicker noise is also found in the phase noise of high frequency sine waves. Apparently, the sine wave is modulated by the very low frequency flicker noise because of slight non-linearities in the amplifier. This conclusion is reinforced by adding RF negative feedback to the amplifier, the best known method for reducing flicker noise phase modulation. It has been determined that a wide variety of well designed amplifiers and other components have a flicker noise modulation of about -115 dBc/Hz at a frequency 1 Hz away from the carrier.[3]

The noise response of a typical amplifier is shown in Figure 2. Notice that at frequencies close to the carrier, flicker noise is the dominant process, while at frequencies far from the carrier, white noise is dominant. One can define the frequency at which the dominant process crosses over from flicker noise to white noise as f_c. Because the amplitude of white noise changes with carrier level while the amplitude of the flicker noise remains constant, f_c will be dependent on the carrier level.

PHASE NOISE OF OSCILLATORS

Oscillation occurs at the frequency when the phase shift around the loop, composed of an amplifier and resonator, is zero degrees. However, one can ob-

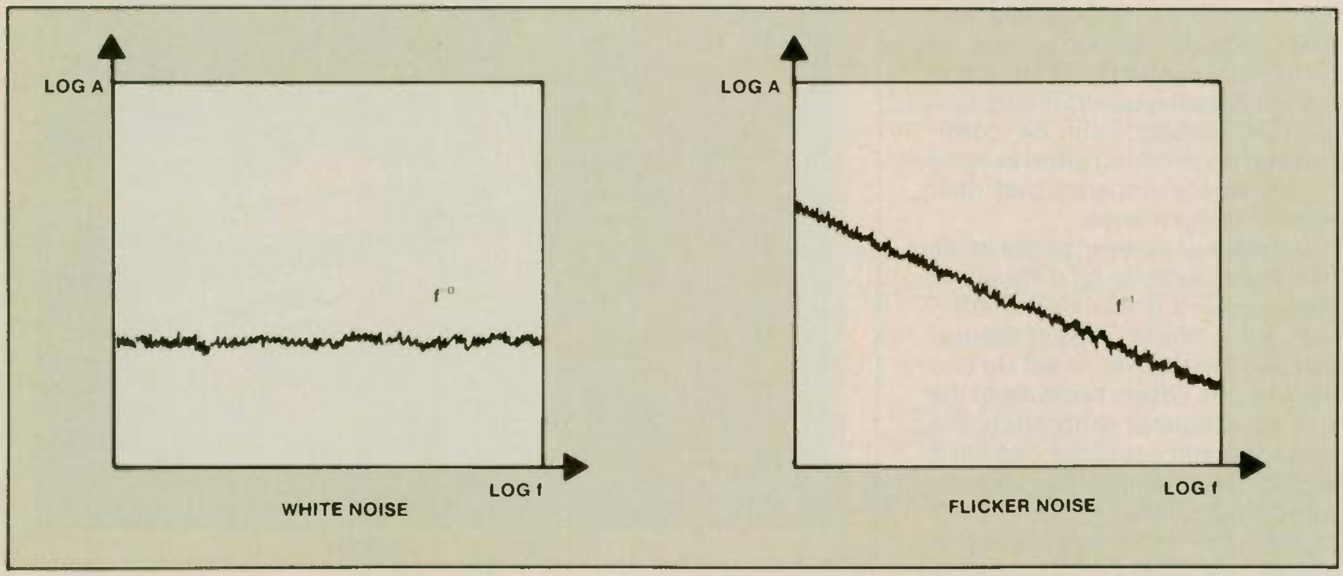
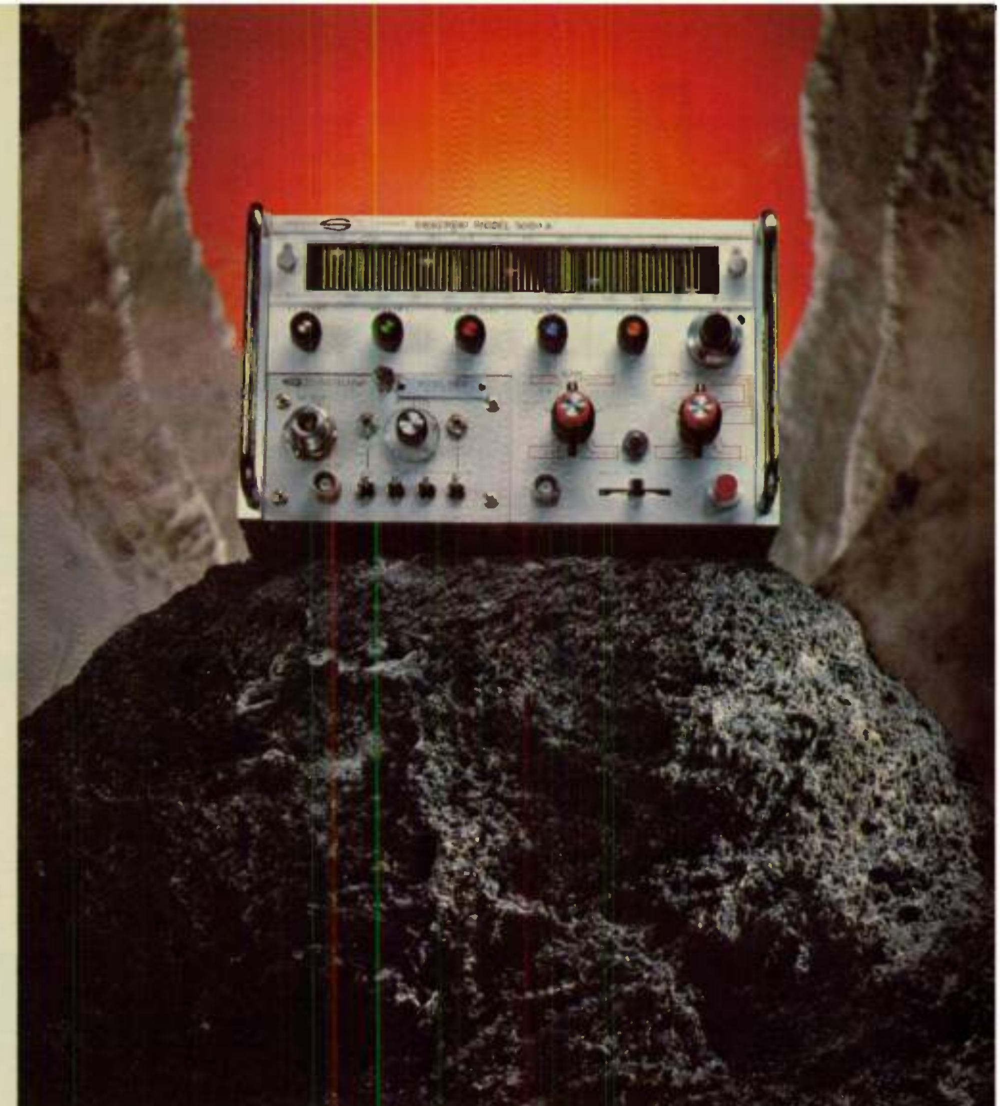


Fig. 1 Two common noise spectrums.

[Continued on page 50]



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[From page 50] **PERFORMANCE**

some actual oscillator measurements. Figure 3 shows the phase noise plot of a high Q crystal oscillator. The noise can be fitted with a series of straight lines with slopes f^0, f^{-1}, and f^{-3}. Notice that far from the carrier, the phase noise is flat (f^0) which is caused by a white noise process such as thermal or shot noise phase modulating the carrier. Closer in, however, the slope breaks to f^{-1}, indicating the noise is caused by a flicker noise source phase modulating the carrier. The most likely source for both of these processes is in the amplifier. Still closer to the carrier, the noise breaks into a f^{-3} slope which indicates that the noise process is flicker noise at frequencies inside the resonator bandwidth. Notice that since the noise plot changes from f^{-1} to f^{-3} at the half bandwidth of the resonator, the Q can be estimated to be about 250,000.[4,5]

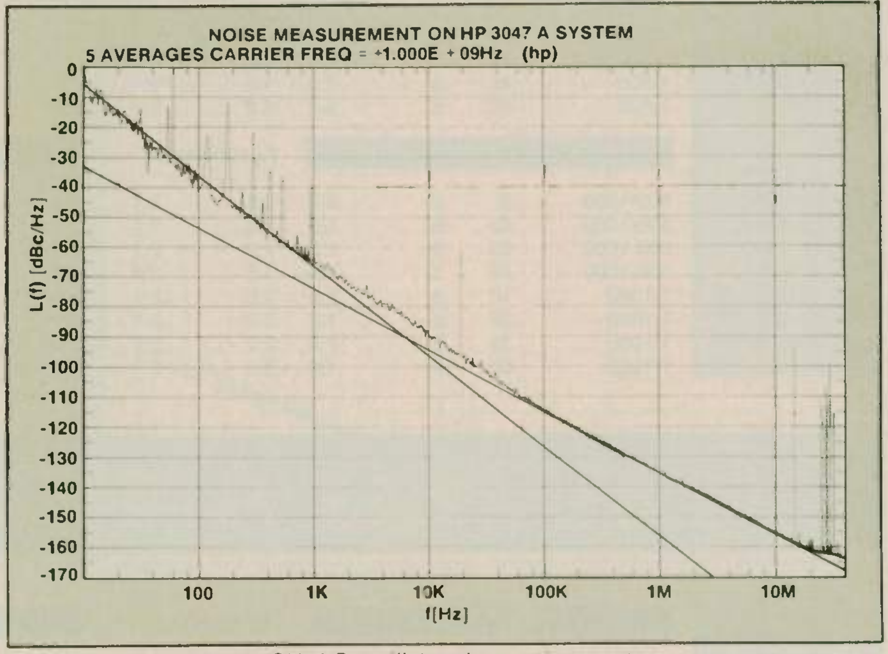

Fig. 4 1 GHz LC oscillator phase noise spectrum.

$$Q < \frac{1\ \text{GHz}}{2 \times 10\ \text{MHz}} = 50$$

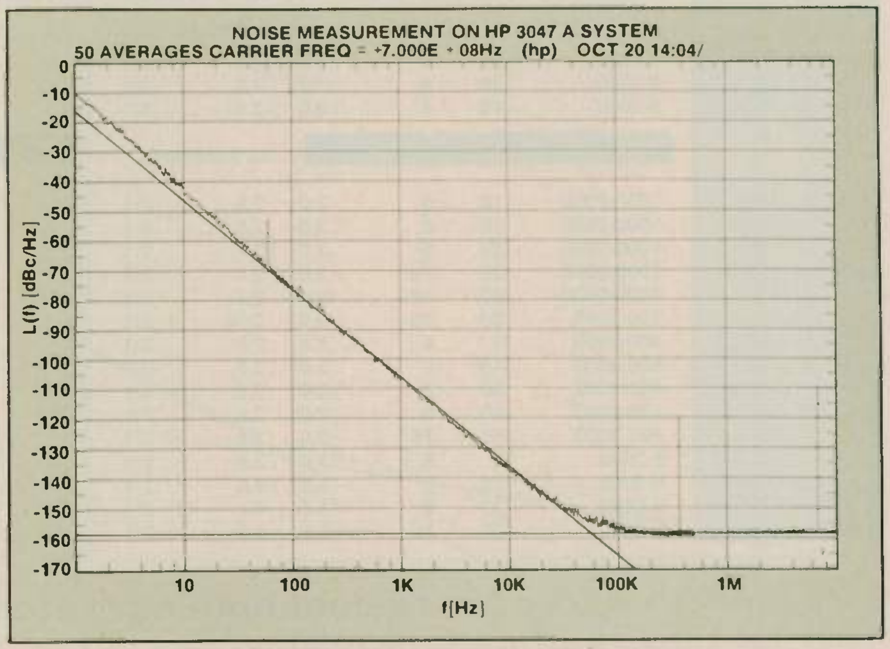

Fig. 5 700 MHz SAW oscillator phase noise spectrum.

$$Q = \frac{700\ \text{MHz}}{2 \times 80\ \text{kHz}} \cong 4500$$

[Continued on page 54]

[From page 52]

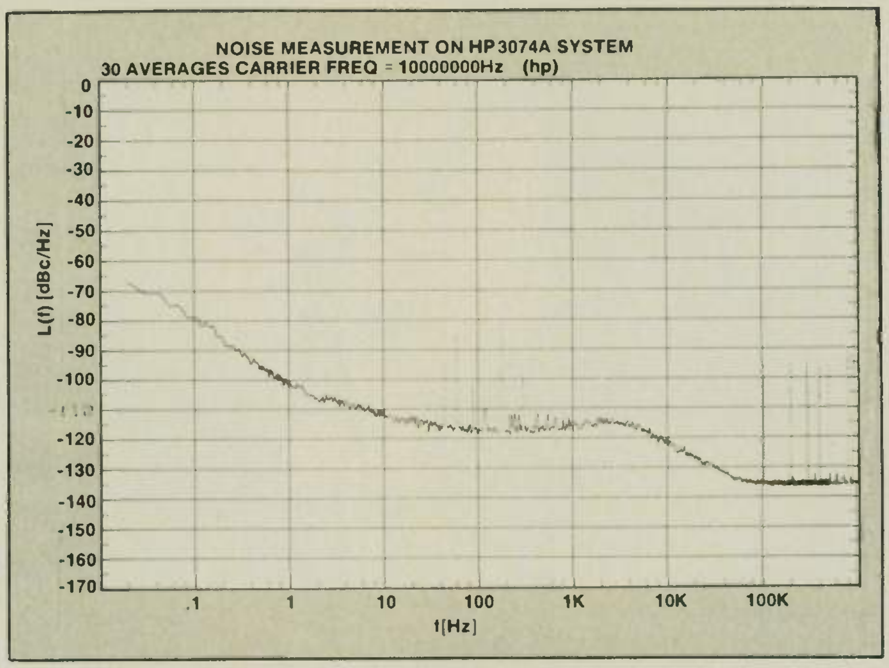

Fig. 6 10 MHz frequency synthesizer phase noise spectrum.

For lower Q oscillators, other noise effects can be seen. For instance, Figure 4 shows the phase noise of a 1 GHz LC oscillator. Even as far as 40 MHz from the carrier, the phase noise has an f^{-2} slope, indicating the half bandwidth of the resonator is greater than 40 MHz. At about 10 kHz the noise breaks into a f^{-3} slope, flicker FM, caused by the flicker noise of the amplifier frequency modulating the oscillator.

As a last example, consider the noise plot of a SAW oscillator shown in Figure 5. The far out phase noise is again white, and it breaks immediately into f^{-3}, FM flicker noise. Apparently the half bandwidth of the resonator and the flicker frequency break, fc, are at approximately the same frequency.

PHASE NOISE OF SYSTEMS

With this basic knowledge of the effects of noise processes on system components, we can determine the components that limit system performance. For instance, Figure 6 shows the residual phase noise of a low frequency synthesizer. Beyond the 6 kHz loop bandwidth of the phase lock loop of the frequency synthesizer, the f^{-2} slope (white FM) of the VCO can be seen until the white phase noise of the oscillator (or possibly the following buffer amplifier) dominates at about 50 kHz. Below 3 kHz, the white and flicker phase noise effects of the loop amplifier can be seen. These have been multiplied up by the loop by the ratio of the output frequency to reference frequency of the loop.[5]

CONCLUSION

With the introduction of the Hewlett-Packard 3047A Spectrum Analyzer System, fast and accurate phase noise measurements can now be routinely made on a wide variety of components. From these measurements, the fundamental processes limiting performance can be identified. Armed with this information on the exact nature of the problem, the designer can optimize his circuit to meet his phase noise design objectives.

REFERENCES

1. Hewlett-Packard Application Notes 207 & 246-2.
2. Voss, R. F., "1/f (flicker) Noise: A Brief Review", *33rd Symposium on Frequency Control*, p. 40, June 1979.
3. Halford, D., A.E. Wainwright, J. A. Barnes, "Flicker Noise of Phase in RF Amplifiers and Frequency Multipliers: Cause, and Cure", *22nd Annual Symposium on Frequency Control*, p. 340 April 1968.
4. Leeson, D. B., "Simple Model of Feedback Oscillator Noise Spectrum", *Proceedings of the IEEE*, p. 329, Feb. 1966.
5. Sauvage, G., "Phase Noise in Oscillators: A Mathematical Analysis of Leeson's Model", *IEEE trans, on Instrumentation and Measurement*, Vol. IM-26, No. 4, p. 408, Dec. 1977.
6. Martin, L., "Noise-Property Analysis Enhances PLL Designs", *EDN*, p. 91, Sept. 1981.

[Continued on page 56]

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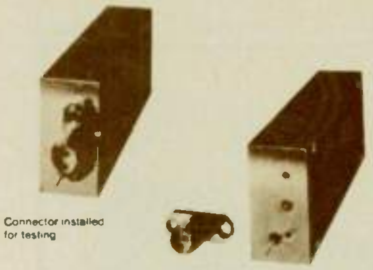
8081-1602	20-80	140	50	+7	201	80
8081-1603	20-80	220	50	+7	201	180
8081-1604	20-80	280	50	+7	201	220
8081-1605	20-80	340	50	+7	201	260
8081-1611	20-60	250	45	+14	201	140
8081-1612	20-60	340	45	+14	201	180
8081-1201	60-180	140	80	+9	201	180
8081-1202	60-180	180	80	+9	201	220
8081-1203	60-180	230	80	+9	201	260



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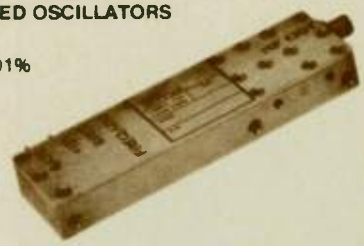
5044-1611	4.0 - 8.0	>10	>40	110
5045-1911	8.0 - 10.0	+10	>40	120



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When making phase noise measurements, the HP 3047A system can measure phase noise using a frequency discriminator or by the quadrature phase detector method from 0.02 Hz to 40 MHz away from carriers in the 5 MHz to 18 GHz range. Phase noise measurements can be made with 2 dB accuracy and the system noise floor is -170 dBc/Hz.

Another operating mode of the HP 3047A system is called direct spectrum. In this mode, the system hardware is used as a down converter to bring 19 kHz to 40 MHz signals into the frequency range of the HP 3582A Real Time Spectrum Analyzer. This allows the very high resolution and measurement speed of the Real Time Spectrum Analyzer to be used up to 40 MHz. In this mode, the system is capable of resolution bandwidths as narrow as 0.02 Hz and is one to two orders of magnitude faster than a Swept Spectrum Analyzer. An additional feature of this mode is that one can observe intermittant signals. In swept analyzer situations one might miss an important phenomena because the swept analyzer is not currently tuned to that frequency. The system provides these measurements over the wide dynamic range of 70 dB, calibrated in both frequency and amplitude.

MEASUREMENT THEORY

All the phase noise plots in this article were generated using the HP 3047A system by the phase quadrature measurement technique. If two signals of the same frequency and 90° out of phase are applied to a double balanced mixer, the output will contain a low frequency signal whose amplitude represents the phase noise of the sources. This signal can be amplified and analyzed by a low frequency spectrum analyzer to give the noise as a function of frequency away from the carrier frequency.

One of the advantages of this quadrature phase detector method is that it uses an inherently wideband mixer as the phase detector. Therefore, only two detectors are needed to cover the 5 MHz to 18 GHz frequency range of HP 3047A and this frequency range can be easily extended either higher or lower in frequency by adding appropriate mixers and filters.

Another advantage of the quadrature phase detector method is that it inherently rejects amplitude modulation (AM) noise, whereas other phase noise detection circuit often do not. In many systems the AM noise is less than the phase noise, but in cases where this is not true, this rejection is an important advantage.

This phase detector system depends on the 90° phase relation between the two sources. Unless the sources are extremely stable, they will not stay 90° out of phase for any length of time. A solution to this problem is to lock one of the sources to the other with a phase lock loop. The loop provides a tuning voltage to one of the sources to maintain the two sources at the same frequency and/or the average, 90° out of phase. For frequencies relatively far from the carrier, the phase-lock loop does not affect the signal to the analyzer. For lower frequencies, the phase-lock loop causes the controlled source to follow the phase variation of the other source. This causes the voltage to the analyzer to represent the frequency noise at low frequencies and phase noise at higher frequencies.

To avoid this difficulty, traditional techniques restricted the loop bandwidth to much less than the lowest frequency to be measured. These techniques work well with very quiet sources like crystal oscillators, but a narrow bandwidth loop can not track the variations in a noisy source. Therefore, these techniques have not been used to measure phase noise close to noisy signals.

The HP 3047A's uniques approach solves this problem by adding the computing power of the HP 9845B Desktop Computer. The computer software measures the transfer function of the phase-lock before the phase noise measurement. This information is then used to correct for the effects of the phase-lock loop on the voltage to the analyzer. Thus the loop bandwidth can now be chosen to be wide enough to keep a noisy source in lock and yet measurements can still be made as close as 0.02 Hz to the carrier.

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Model No.	Frequency Range GHz	Nominal* Coupling dB	Deviation from Nominal Coupling vs. Frequency dB	Minimum Directivity dB	Max. Input/Output VSWR	Max Ins. Loss Above Coupling Loss dB	Max. Peak Power kW	Max. Avg. Power Watts	Outline
CA-516	.5-1.0	6	±0.7	25	1.10	0.1	10	50	1
CA-511	.5-1.0	10	±0.8	25	1.10	0.1	10	50	1
CA-512	.5-1.0	20	±0.8	25	1.10	0.1	10	50	1
CA-513	.5-1.0	30	±1.0	25	1.10	0.1	10	50	1▲
CA-521	.5-2.0	10	±0.75	23	1.20	0.2	10	50	2
CA-522	.5-2.0	20	±1.0	23	1.20	0.2	10	50	2
CA-556	.75-1.5	6	±0.7	24	1.15	0.2	8	50	3
CA-551	.75-1.5	10	±0.8	24	1.15	0.2	8	50	3
CA-552	.75-1.5	20	±0.8	24	1.15	0.2	8	50	3
CA-553	.75-1.5	30	±1.0	24	1.15	0.2	8	50	3▲
CA-596	1.0-2.0	6	±0.7	24	1.15	0.2	8	50	4
CA-591	1.0-2.0	10	±0.8	24	1.15	0.2	8	50	4
CA-592	1.0-2.0	20	±0.8	24	1.15	0.2	8	50	4
CA-593	1.0-2.0	30	±1.0	24	1.15	0.2	8	50	4▲
CA-636	1.5-3.0	6	±0.7	22	1.20	0.2	7	50	5
CA-631	1.5-3.0	10	±0.8	22	1.20	0.2	7	50	5
CA-632	1.5-3.0	20	±0.8	22	1.20	0.2	7	50	5
CA-633	1.5-3.0	30	±1.0	20	1.20	0.2	7	50	5▲
CA-676	2.0-4.0	6	±0.7	22	1.20	0.2	5	40	6
CA-671	2.0-4.0	10	±0.8	22	1.20	0.2	5	40	6
CA-672	2.0-4.0	20	±0.8	22	1.20	0.2	5	40	6
CA-673	2.0-4.0	30	±1.0	20	1.20	0.2	5	40	6▲
CA-691	2.0-8.0	10	±0.75	17	1.30	0.3	2	20	7
CA-692	2.0-8.0	20	±1.0	17	1.30	0.3	2	20	7
CA-716	2.6-5.2	6	±0.7	22	1.25	0.25	4	40	8
CA-711	2.6-5.2	10	±0.8	22	1.25	0.25	4	40	8
CA-712	2.6-5.2	20	±0.8	22	1.25	0.25	4	40	8
CA-713	2.6-5.2	30	±1.0	20	1.25	0.25	4	40	8▲
CA-771	6.0-18.0	10	±.75	14	1.45	0.50	2	20	8
CA-772	6.0-18.0	20	±1.0	14	1.45	0.50	2	20	8
CA-756	4.0-8.0	6	±0.7	18	1.25	0.3	4	40	8
CA-751	4.0-8.0	10	±0.8	18	1.25	0.3	4	40	8
CA-752	4.0-8.0	20	±0.8	18	1.25	0.3	4	40	8
CA-753	4.0-8.0	30	±1.0	17	1.25	0.3	4	40	8▲
CA-796	7.0-12.4	6	±0.7	17	1.30	0.4	2	30	8
CA-791	7.0-12.4	10	±0.8	17	1.30	0.4	2	30	8
CA-792	7.0-12.4	20	±0.8	17	1.30	0.3	2	30	8
CA-793	7.0-12.4	30	±1.0	17	1.30	0.3	2	30	8▲
CA-836	8.0-16.0	6	±0.7	15	1.40	0.5	2	30	8
CA-831	8.0-16.0	10	±0.8	15	1.40	0.5	2	30	8
CA-832	8.0-16.0	20	±0.8	15	1.40	0.4	2	30	8
CA-833	8.0-16.0	30	±1.0	15	1.40	0.4	2	30	8▲
CA-876	8.0-18.0	6	±0.8	14	1.45	0.5	2	20	8
CA-871	8.0-18.0	10	±1.0	14	1.45	0.5	2	20	8
CA-872	8.0-18.0	20	±1.0	14	1.45	0.5	2	20	8
CA-873	8.0-18.0	30	±1.2	14	1.45	0.5	2	20	8▲
CA-916	12.4-18.0	6	±0.7	15	1.40	0.5	2	30	8
CA-911	12.4-18.0	10	±0.8	15	1.40	0.5	2	30	8
CA-912	12.4-18.0	20	±0.8	15	1.40	0.4	2	30	8
CA-913	12.4-18.0	30	±1.0	15	1.40	0.4	2	30	8▲

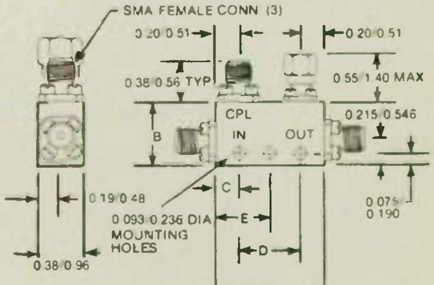
*Nominal Coupling ±0.25 dB

MECHANICAL OUTLINES

Outline	A in/cm	B in/cm	C in/cm	D in/cm	E in/cm
1	3.10/7.87	0.50/1.27	0.80/2.03	1.50/3.81	—
2	3.40/8.64	0.50/1.27	0.95/2.41	1.50/3.81	—
3	2.50/6.35	0.50/1.27	0.60/1.52	1.30/3.30	—
4	1.80/4.57	0.50/1.27	0.43/1.09	0.94/2.39	—
5	1.40/3.56	0.50/1.27	0.50/1.27	0.40/1.02	—
6	1.00/2.54	0.50/1.27	—	—	0.50/1.27
7	1.30/3.30	0.50/1.27	—	—	0.65/1.65
8	0.90/2.29	0.50/1.27	—	—	0.45/1.14

INCHES/CENTIMETERS XX ± .03 XXX ± .010 / XX ± .08 XXX ± .025

▲For all 30dB coupler "B" dimensions 0.55/1.40



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CIRCLE 48 ON READER SERVICE CARD

A 100 kW SOLID-STATE COAXIAL LIMITER FOR L-BAND
Part I

S.D. PATEL AND H. GOLDIE
Westinghouse Defense and Electronic Systems Center
Advanced Technology Laboratory
Microwave Operations
Baltimore, MD

INTRODUCTION

For many years investigators have been seeking and experimenting with solid state RF passive power limiters that will supplant gas TR tubes used for radar duplexing and receiver protecting. Substantial progress has been made over the microwave frequency range for low to moderate peak powers (milliwatt to a few kilowatts) using ferrite and diode technologies. Ferrite limiters have seen wide use in low RF power, inexpensive commercial radars. However, because of their slow turn-on response time leading to high spike leakage, and because of their increasing insertion loss with temperature rise caused by the absorbed incident RF power, ferrites have seen limited use in modern radars of high average power.

PIN diode limiters, on the other hand, can be designed to handle substantial RF power levels,[1,2,3] and such limiters have been designed to handle a few hundred kilowatts of peak power at frequencies below 0.5 GHz. Maddix[4] has recently shown that the RF voltage-handling capabilities of a shunt-mounted PIN limiter is related, not only to V_{BB}, the bulk breakdown voltage, but also to an additional factor, which is the rate of rise of the RF line voltage pulse. Therefore PIN diodes with rapid charge injection times, when combined with relatively slow risetime RF line pulses, can operate as relatively high peak power limiters beyond the normal V_{BB} design limits. Thermal or average power ratings are not affected by this rate of rise parameter except that the use of thin I-regions to obtain rapid charge injection require additional paralleling of diodes for RF current-sharing.

This paper concerns experiments that have investigated the enhanced peak-power capability using the above risetime effects to obtain a 100-kW peak power, self-biasing, coaxial limiter, the output leakage power levels of which can be handled easily by a conventional cascaded varactor limiter to provide adequate receiver protection.

DIODE TECHNOLOGY

High power PIN diodes used as switches and duplexers have been reported in the literature for many years.[5,6,7] However, the use of wide I-region PIN diodes as a microwave high-peak-power passive limiter has seen limited application due to the slow RF-induced turn-on time and the difficulties associated with the manufacture of high voltage PIN diodes with low punchthrough voltage. Low punchthrough voltage yields lowest RF cold losses without the need for a reverse bias voltage to keep the I-region substantially free of charge. It has been shown[1] that a large array of thin PIN diodes are necessary in order to handle several hundred kilowatts of power at UHF. Alternatively, a large reduction in the number of diodes used can be made by increasing the I-region thickness and utilizing fast turn-on self-biasing techniques. Thick PIN diodes with low zero-bias punchthrough voltages now have become available and have made possible relatively low insertion loss in high peak power-limiting at typical radar bandwidths above 1 GHz.

DIODE BIASING CONFIGURATION

The concept of self-switching in which a PIN diode is biased by a fast-acting detector diode has also been known for many years.[3] In these designs the reverse breakdown voltage of the PIN diode is chosen so as to handle the peak RF voltage swing of the micro-

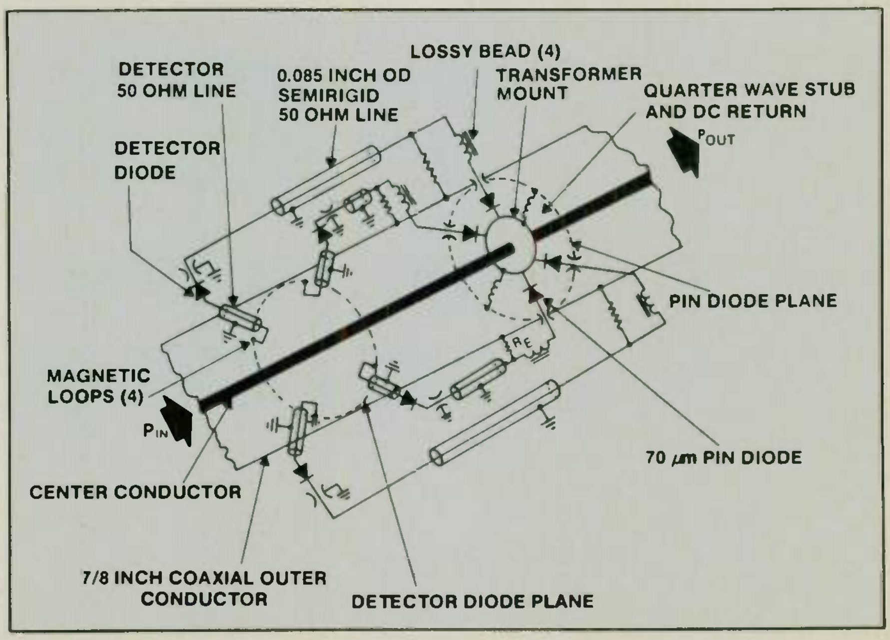


Fig. 1 Schematic of quadrodiode limiter showing four-diode symmetry.

wave incident pulse. In the device described in this paper a decoupled varactor diode biases the PIN into conduction on a time scale considerably shorter than the risetime of the incident power pulse so as to minimize the RF voltage developed across the PIN diode. Both Si and GaAs diodes were experimentally tried as biasing rectifiers. It was found that the GaAs varactor diode provided a relatively large output current response with a leading edge of approximately 10 ns. We chose a recently developed (Microwave Associates) GaAs varactor diode with a V_B = 450 V, 1.3 pF, 0.5 A capability. This diode was found to be reliable and efficient in the 26 dB decoupled self-bias auxiliary line. At the full 100 kW line power, the RF voltage across the decoupled biasing diode in the nonconducting direction was 160 volts peak.

Four biasing diodes were circumferentially mounted in 50 ohm decoupled lines to drive four PIN diodes as shown schematically in Figure 1. In this configuration each biasing diode supplied 10-ns-risetime current pulses of up to 350 mA at 100 kW. The detailed mount, shown in Figure 2, was designed so the coupling factor could be widely varied by rotating or recessing the loop. The ability of the biasing current to reduce the PIN diode impedance more rapidly than the risetime of the leading edge of the incident pulse is critical to the lowering of the limiter design voltage rating. In this mode low voltage PIN diodes can be made to handle RF line voltages much greater than the diodes' V_{BB}.

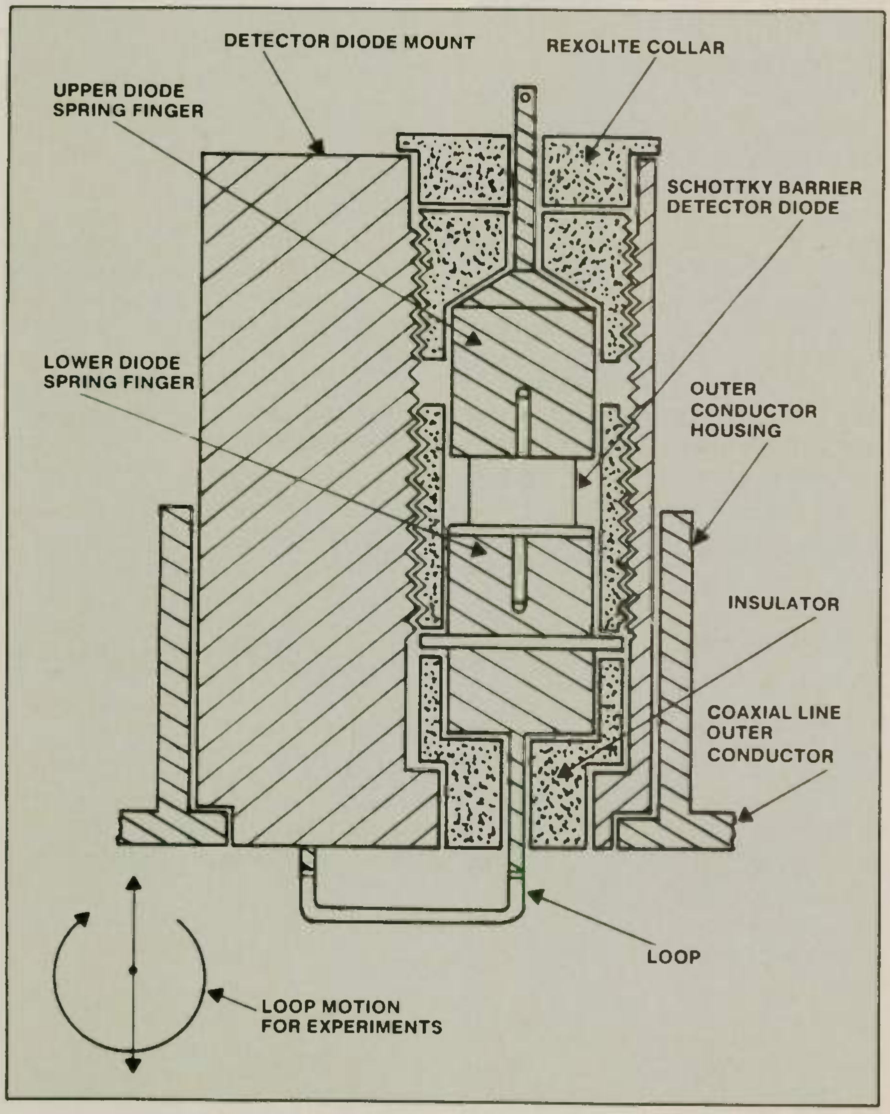


Fig. 2 Detailed sketch of loop-controlled biasing diode circuit.

HIGH POWER CONSIDERATIONS

The high power PIN diode limiter is shunt-mounted because of the ease of RF current sharing and the compatible external rectifying GaAs diode biasing network. The detail for the design is shown in Figure 3. The maximum peak and average power that a shunt-mounted circuit can handle will be determined by using two separate models: thermal and bulk breakdown.

- **Thermal Model**

When a high power pulse is incident on the PIN diode plane, the diode absorbs a fraction of the RF energy during the turn-on time, and the device impedance varies rapidly from a high to a low value of diode forward resistance R_F. The power that can be dissipated by a shunt diode in a line with characteristic impedance Z_o is given by

$$P_D = \frac{4\, R_F \times P_{inc}}{Z_O \times N^2}$$

where

P_D = Power dissipated in shunt diode

R_F = Forward diode resistance

N = Number of diodes

P_{inc} = Peak incident power

The maximum power that can be dissipated by the PIN diode is limited by the junction temperature and is given by the transient equations:

$\Delta T_j \approx P_D t/H$ for $0 \leq t \geq 0.25\, \tau_T$

$\Delta T_j \approx P_D\, \theta\, (1 - e^{-t}\, \tau T)$ for $0.25\, \tau_T < t < 2\, \tau_T$

$\Delta T_j \approx P_D\, \theta$ for $t > 2\tau_T$

where

$\Delta \tau_j$ = Junction temperature rise above ambient in °C
H = Heat capacity W-μs/°C = 11 $C_j w^2$
C_j = Diode capacitance in pF
w = Intrinsic region thickness in milliinches
θ = Steady state thermal resistance, °C/watt
τ_T = Thermal time constant = $H\theta$

With R_F = 1.5 ohms at 100 mA, C_j = 0.6 pF, θ = 12°C/W, and w = 2.8

milliinches (70 μm), and using Equations 1 and 2, we vary N until the ΔT_j is approximately half the allowed junction temperature for silicon PIN diodes. According to White[5] Equation 2a is accurate to within 50 percent. The computed data show that, for N = 4, using an 80 kW/3 μs incident pulse with a diode where R_F = 1.5 ohms, C_j = 0.6 pF, and θ = 12°C/W results in a junction temperature rise of 101°C. The experimental results discussed later showed a 115°C temperature rise at 80 kW line power.

- **Bulk Breakdown Model**

A model has been suggested by Maddix[4] in which the PIN diode is charged in a time period shorter than the risetime of the leading edge of the RF incident line pulse. In this model the injected current I_{RF} into the I-region gives rapid rise to conductivity modulation resulting in the reverse RF cycle seeing the same diode impedance Z_d as the forward RF cycle. The RF wave experiences a dynamically decreasing microwave impedance such that the RF voltage developed across the diode remains considerably smaller than the peak amplitude of the line voltage pulse. By proper selection of incident pulse risetime and diode turn-on-time, the RF voltage developed across the PIN diode will remain well below V_p (the RF peak source voltage).

This mode of operation leads to a limiter where $V_p > V_{BB}$, whereas heretofore it was necessary in zero-bias limiter design to provide $V_p \leq V_{BB}$. The maximum peak power handling capability of the shunt diodes, assuming a linear risetime of the leading edge of the microwave pulse, is given by

$$P_{max} = \frac{V_{BB}^2}{Z_T} \times \frac{t_r}{t_d}$$

where

V_{BB} = reverse breakdown voltage of PIN diode
Z_T = mount impedance
t_r = incident pulse risetime
t_d = diode turn-on time.

A 70 μm diode with V_{BB} = 800 V mounted on a 35 ohm transformer section must turn on 5.5 times faster than the risetime of an incident pulse to handle a 100 kW power level. This suggests that the PIN diode must be externally charged in a time that is brief compared to the risetime of the input microwave pulse so that the line voltage does not exceed the rated reverse bulk breakdown voltage. This is a severe condition for a very wide I-region diode because of the large volume necessary to be filled with charge. Therefore, for a given PIN diode where V_{BB} and t_d are fixed, the transmitter pulse risetime t_r must be adjusted to obtain the required power handling capability. Five different values of t_r were chosen for the experimental evaluation of the device performance.

The parameters are:

I-region width w = 70 μm
Reverse bulk breakdown V_{BB} = 800 V
Mount impedance Z_T = 35 ohms
Measured gated diode turn-on time t_d = 80 ns
Input pulse risetime t_r = 440, 330, 220, 110, and 30 ns

In the limiter mount shown in Figure 4, each diode develops approximately the same RF voltage because of the axially symmetrical arrangement. It is necessary that, in the suggested model, the transmitter pulse leading-edge rate of rise be specified for the limiter design to optimize peak power handling capability.

QUADRODIODE MOUNT

The high power quadrodiode limiter consists of a four PIN diode limiter circuit and a quasiactive biasing diode circuit that supplies the pulsed bias as shown in Figure 3. The PIN diodes are shunted across the 7/8 inch coaxial 50 ohm line in an axial spoke arrangement. The biasing diodes rectify a 26 dB decoupled RF signal received from the high power input pulse through a magnetic loop. The PIN diodes are mounted in the center of an electrically short length transformer section, and the biasing diodes are mounted approximately 45 electrical degrees ahead of the PIN diode plane. Because of dimensional limitations this distance could not be reduced to a more desirable angle of 30 degrees. Under this latter condition, the coupled RF voltage would be identical whether the PIN diodes were biased ($Z_d << Z_o$) or unbiased ($Z_d >> Z_o$).

The quadrodiode assembly was fabricated using a 2.5 inch diameter mount and locating the PIN diodes approximately in the center of a 6 inch length of a 7/8 inch OD coaxial line. The PIN diodes

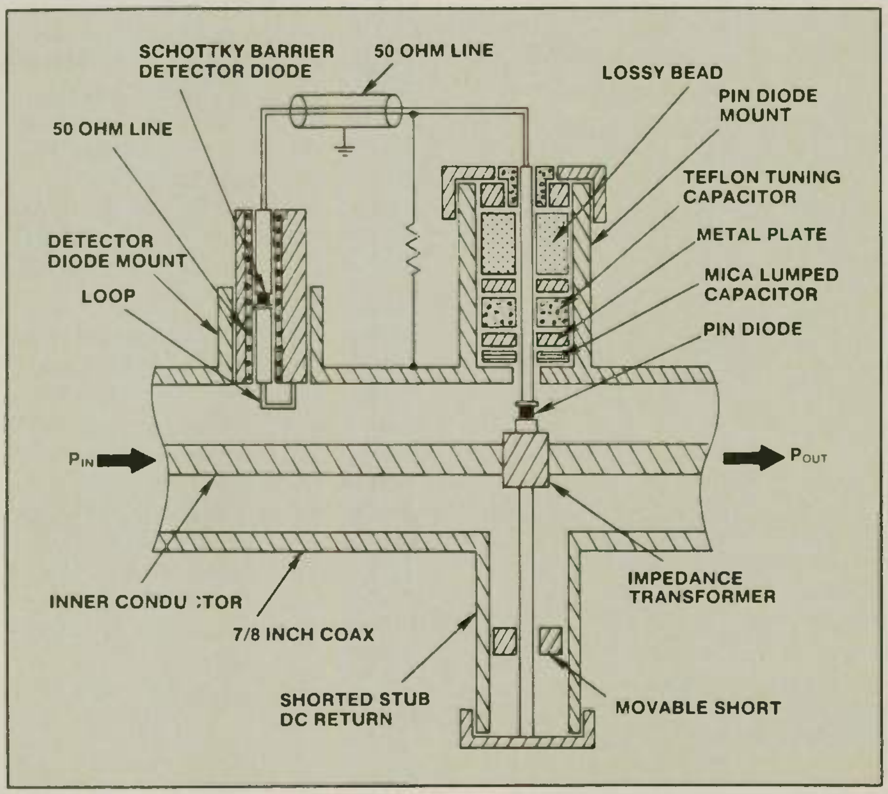


Fig. 3 Detail of limiter circuit.

[Continued on page 64]

and stubs are arranged diametrically opposite to minimize mount parasitics. The diodes are mounted on berylium copper posts and are fixed in position by two spring fingers. The zero-biased insertion loss and input VSWR are tuned by the movable shorts in the stubs, and the forward-biased isolation is optimized by a lumped mica capacitor and a variable teflon-loaded line length. A 1 inch cylinder of lossy iron provides at least 25 dB of attenuation to the RF signal leaking past the tuning capacitor.

Initial tests at high peak power levels were made to determine the temperature rise of the PIN diodes and to determine the accuracy of RF current sharing. The junction temperatures were measured by first calibrating the diode voltage drop at known currents in a heating chamber at controlled temperatures. The mount then was subjected to an 80 kW/3 μs incident pulse where the voltage drop and rectified current were measured. Comparison with calibration charts indicated the highest junction temperature was approximately 135°C.

A test was made to determine the RF current sharing from 0 to 5 kW incident power using 10 μsec pulsewidths at 1.3 GHz. A Hall-effect current probe loop surrounded each PIN diode feedline, which was returned to ground. No external biasing currents were used. The rectified current pulse amplitudes of PIN diodes were all within $\pm$5 percent, indicating excellent RF power sharing.

SMALL SIGNAL ANALYSIS

The appendix describes the computer analysis for four 70 μm PIN diodes shunting a 50 ohm 7/8 inch coaxial line and mounted on a short 35 ohm transformer. The worst-case values of cold insertion loss = 0.36 dB, input VSWR = 1.17, and isolation = 31 dB are predicted in the 1250-1350 MHz bandwidth by using the ABCD matrix method.

By disconnecting the GaAs biasing diodes and driving the four 70 μm PIN diodes in the quadrodiode mount as a switch, a set of small-signal data was experimentally observed. This data is shown

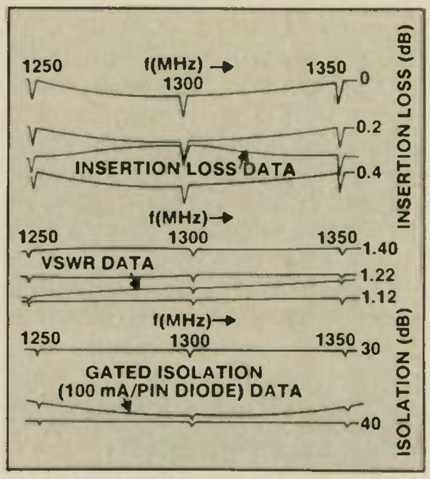


Fig. 4 Measured parameters of zero-bias loss, VSWR, and forward bias loss for quadrodiode limiter.

in Figure 4 over the 1250 to 1350 MHz band. The worst-case measured values of 0.37 dB zero-biased loss, 1.2 VSWR, and 36 dB gated isolation were in good agreement with the computer predictions in the appendix. Gated isolation was performed with 100 mA dc through each PIN diode. The gated recovery period was 17 μs for a 330 ohm shunting resistor. The experiment was run so that the charged PIN's had to discharge through this shunting resistor.

Editor's Note: Part II of this paper will describe the high power experiments conducted on the prototype limiter and report their results.

REFERENCES

1. Brown, N. J., "Design Concepts for High-Power PIN Diode Limiting," *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-15 December 1967.
2. Leenov, D., "The Silicon PIN Diode as a Microwave Power Limiter at Megawatt Levels," *IEEE Transactions on Electron Devices*, Vol. ED-11 February 1964, pp. 53-61.
3. Higgins, V. J., R. H. Brunton, and G. Hall, "Semiconductor Limiters as Microwave Duplexing Devices," *The Microwave Journal*, April 1966.
4. Maddix, H. S., and D. C. Broderick, "Rectified RF for High Power PIN Duplexing," *IEEE MTT 1979 International Microwave Symposium Digest.*
5. White, J. F., *Microwave Semiconductor Engineering* (Van Nostrand-Rinehold New York: 1981) previously published under the title *Semiconductor Control* (Artech House, Inc., Dedham, Massachusetts: 1977), pp. 104-114.
6. Muehe, C. E., "High Power Duplexers" *IRE Transactions on Microwave Theory and Techniques*, Vol. MTT-9 November 1961, pp. 506-512.
7. Mortenson, K. E., and J. F. White, "Non-Refrigerated Bulk Semiconductor Microwave Limiters," *IEEE Journal of Solid State Circuits*, March 1968, pp. 5-11.

APPENDIX

Small-signal insertion loss, VSWR, and isolation analysis for a four PIN diode L-band coaxial limiter.

An ABCD matrix method was used to compute the small-signal insertion loss, input VSWR, and gated isolation of the limiter device using the following expressions:

$$\text{Insertion loss or isolation, } I \text{ (dB)} = 10 \log_{10} \left| \left\{ \frac{CZ_0^2 + (D+A) Z_0 + B}{2Z_0} \right\} \right|^2 \quad (1)$$

$$\text{Input impedance, } Z_{IN} = \frac{AZ_0 + B}{CZ_0 + D} \quad (2)$$

Then the reflection coefficient magnitude (Γ_{IN}) and input VSWR (ρ) are:

$$\Gamma_{IN} = \frac{Z_{IN} - Z_0}{Z_{IN} + Z_0} \quad (3) \qquad \rho = \frac{1 + |\Gamma_{IN}|}{1 - |\Gamma_{IN}|} \quad (4)$$

where A, B, C, and D are the components of an [ABCD] matrix of a limiter device. It is assumed that the source and load impedances are equal to Z_0

The [ABCD] matrix of a device is a matrix multiplication of [ABCD] matrices consisting of the coaxial line, transformer, and PIN diode circuit.

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \text{ABCD of one-half coaxial line length (2.8 inches) from input end} \end{bmatrix} \begin{bmatrix} \text{ABCD of one-half transformer length + step discontinuity capacitance} \end{bmatrix} \quad (5)$$

$$\begin{bmatrix} \text{ABCD of four PIN diodes in zero bias (insertion loss) or forward bias (isolation)} \end{bmatrix} \begin{bmatrix} \text{ABCD of one-half transformer length + step discontinuity capacitance} \end{bmatrix} \begin{bmatrix} \text{ABCD of remaining one-half coaxial line length (2.8 inches)} \end{bmatrix}$$

The insertion loss and isolation of the device can be computed by finding [ABCD] matrices of the PIN diodes in the zero-bias and forward-bias conditions respectively. The computer program for four 70-μm PIN diodes shunted across a 50-ohm, 6 inch long, 7/8-inch coaxial line and mounted on a 0.16 inch long, 35-ohm transformer was generated to evaluate insertion loss, input VSWR, and isolation parameters in a 1250 to 1350 MHz bandwidth. The computer input/output printout is as shown:

PIN DIODE LIMITER: DIODE TRANSFORMER MOUNT

DIODE PARAMETERS

N = 4 No. of Diodes
CT = .5 Total Pin Diode Capacitance (PF)
RP = 3000 REV Biased EQ RES (OHM)
RF = 1 For Biased RES (OHM)
LS = 1 Lead Inductance (NH)
LC = 7.24442 Calculated RES IND (NH)
CC = 3.74707 Calculated RES CAP (PF)

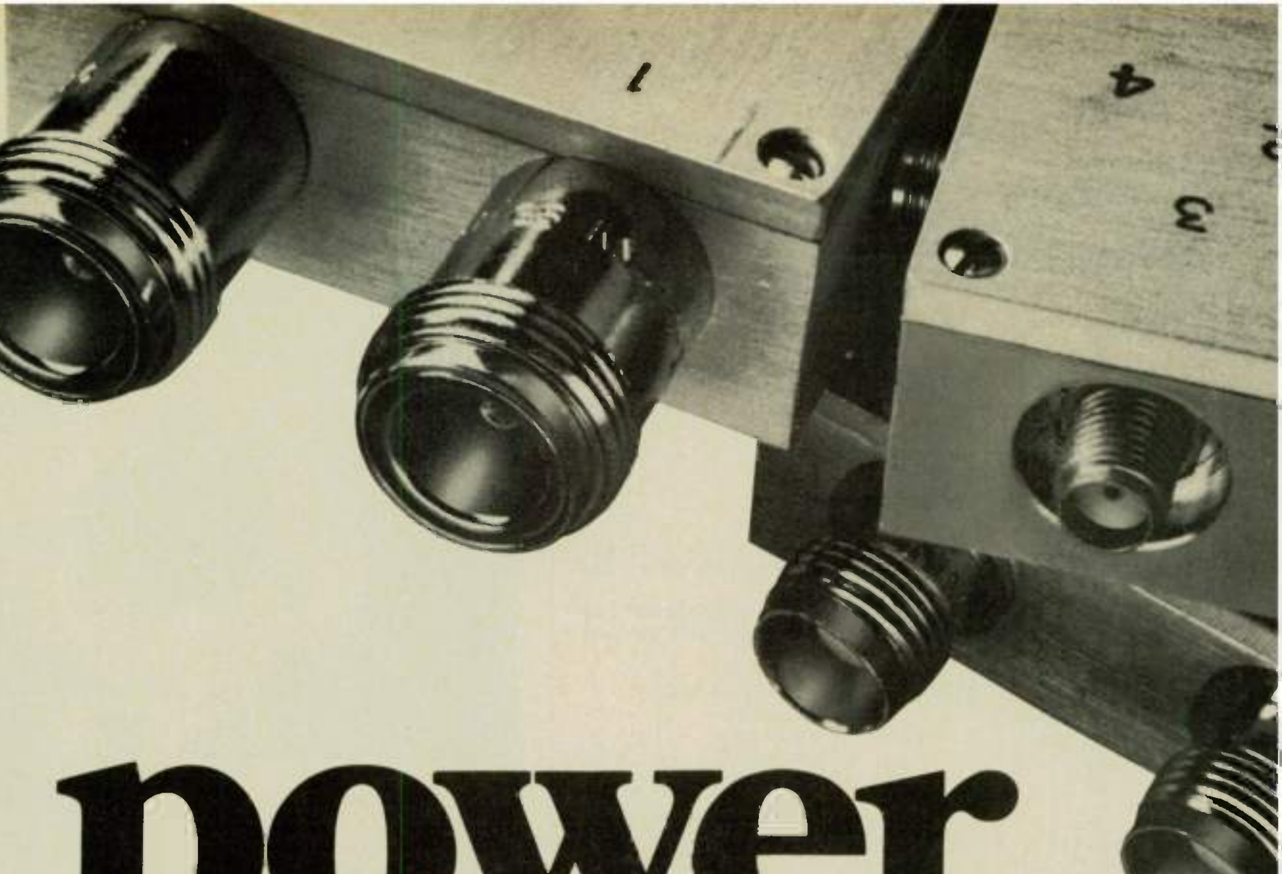
LB = 100 Biased Choke (MICR-H)
LP = 7.24442E-9 PAR Resonance IND (HEN)
LG = 3 Diode Post IND (NH)
CS = 3.74707E-12 SER Resonance CAP (PF)

TRANSFORMER VALUES

ZT = 35 Transformer IMP (OHM)
CD = 3.44700E-14 Step Discont CAP (FARAD)
LT = 16 Transformer Cond Length (IN)
HO = 1.138 Outer Cond DIA (IN)
CN = .05 N-Connector Loss (DB)

SL = 1.44888E-8 Each Stub Induct (HEN)
LS = 1.25572 Stub Length (IN)
ZS = 100 Stub Imped (OHM)

FREQ (MHZ)	INS. LOSS (DB)	VSWR (# :1)	ISOLATION (DB)
1250	.33	1.04	31.3
1270	.33	1.06	34.8
1290	.34	1.08	39.1
1310	.34	1.11	39.1
1330	.35	1.14	35.0
1350	.36	1.17	31.6



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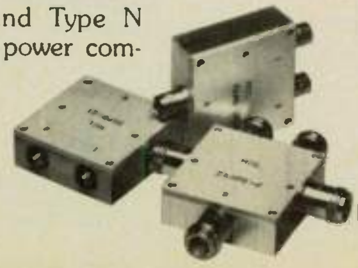
For complete specs, performance curves and application information, refer to 1980-1981 Micro-Waves Product Data Directory (pgs. 179–216) or EEM (pgs. 2923–3142).

POWER DIVIDERS SPECIFICATIONS

Model	No Divider	Frequency Range GHz	Insertion Loss dB		Isolation dB		Max Amplitude Unbalance dB	VSWR (All Ports)	Power Rating		Price (1-9)
			Typ	Max	Typ	Min		Typ	Divider	Combiner	
ZAPD-1	2-WAY	0.5-1.0	0.3	0.6	25	19	0.3	1.2	10W	10mW	39.95
ZAPD-2	2-WAY	1.0-2.0	0.3	0.6	25	19	0.3	1.2	10W	10mW	39.95
ZAPD-21	2-WAY	0.5-2.0	0.4	0.7	25	18	0.4	1.2	10W	10mW	49.95
ZAPD-4	2-WAY	2.0-4.2	0.4	0.8	25	18	0.4	1.2	10W	10mW	39.95
ZA4PD-2	4-WAY	1.0-2.0	0.3	0.8	25	19	0.7	1.2	10W	10mW	79.95
ZA4PD-4	4-WAY	2.0-4.2	0.5	1.0	25	18	0.8	1.2	10W	10mW	79.95

Dimensions 2" x 2" x 0.75"   Connectors Available BNC, TNC $5.00 additional for SMA and Type N
BNC not available for -4 models



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Schottky Diode mm Detectors

With Improved Sensitivity and Dynamic Range

A. R. KERR*
and Y. ANAND
Microwave Associates, Inc.
Burlington, MA

INTRODUCTION

Compared with other millimeter-wave components, direct (video) detectors have undergone little change in recent years. This paper describes a new detector using a low-barrier silicon Schottky diode, which offers superior sensitivity, dynamic range, and TSS (tangential signal sensitivity) in the WR-10 band (75-110 GHz).

To millimeter-wave engineers engaged in swept frequency measurements, the development eight years ago of a new generation of DC-coupled scalar network analyzers[1] sounded like the answer to a prayer. Swept millimeter-wave measurements had been difficult for three reasons: 1) The output power of most sweep oscillators was far from flat, with variations of several dB in the space of a gigahertz being common. 2) The sensitivity of most detectors was frequency dependent. 3) It was hard to obtain a well matched pair of detectors. The new scalar network analyzer offered a solution to all of these problems through their use of an integral digital memory, which could store a reference trace and then display subsequent swept measurement on a dB scale normalized to the stored reference. The same square-law detector could be used to take the reference trace and for subsequent swept measurements. The normalization would correct sweeper and detector variations with frequency, and the use of a single detector would remove the need for matched pairs of detectors.

*NASA Goddard Institute for Space Studies, NY.

In recent years scalar network analyzers used in this way have greatly simplified millimeter-wave measurements. However, their full potential has not been realized because of two shortcomings of existing millimeter-wave detectors: lack of sensitivity and insufficient square-law range. Occasionally point-contact detectors could be found in which these limitations were not severe, but point-contact detectors, usually in Sharpless-wafer packages, were very delicate, mechanically and electrically, and it was not common for them to survive a laboratory environment for long without losing sensitivity.

Schottky-diode detectors produced greatly improved reliability, but had such high video impedance (typically many megohms) that direct connection to a scalar network analyzer was not possible in many cases. The small bias current of the network analyzer's DC amplifier flowing through the Schottky detector diode, caused an offset voltage that could not be removed using the analyzer's input offset (sometimes called "noise level") adjustment. To overcome this problem the detector diode could be shunted by a resistor (typically 100 kilohms) which reduced the offset voltage sufficiently. Unfortunately the shunt resistor also greatly reduced the sensitivity of the detector.

The new detector described in this article uses an un-biased low-barrier silicon Schottky diode. The low video impedance of this diode allows the detector to be operated directly in a scalar network analyzer with no shunt resistor. Excellent sensitivity and square-law range are obtained over the full WR-10 waveguide band (75-110 GHz) without retuning. The TSS is substantially better than for other un-biased millimeter-wave detectors, which makes these low-barrier diodes extremely attractive for ECM applications, as well as in the laboratory.

LIMITATIONS OF THE DETECTOR

In order to understand the behavior of a Schottky-diode detector it is useful to analyze two special cases. First, the detector is operated in a DC load resistance R_L which is very small compared with the video resistance R_V of the detector. In the second case the DC load resistance is made very large compared with the video resistance. The equivalent circuit of the detector is shown in Figure 1.

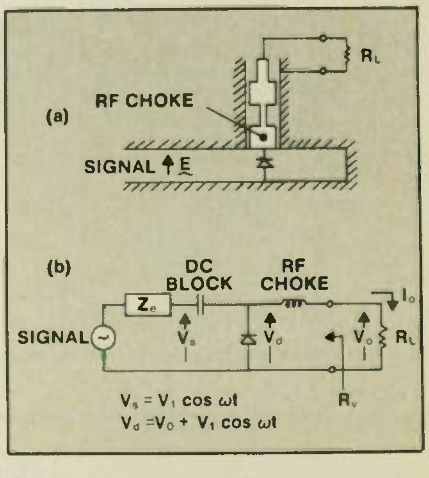


Fig. 1 (a) The waveguide mounted detector, and (b) the equivalent circuit.

The DC I-V curve of a Schottky diode can be approximated well over the range of interest by:

$$i = i_o\,[e^{\alpha v} - 1] \qquad (1)$$

The video impedance is given by:

$$R_V = \left(\frac{di}{dv}\right)^{-1} = \frac{1}{\alpha i_o}. \qquad (2)$$

For the case $R_L << R_V$, the DC output voltage across the load R_L is given by:

$$V_O = R_L \frac{i_O}{T} \int_O^T \{\exp[\alpha\, v_1 \cos \omega t] - 1\} dt \qquad (3)$$

The case of $R_L >> R_V$ requires that the DC detected current I_O approaches O. This occurs when:

$$\int_O^T \{\exp(V_O + \alpha V_1 \cos \omega t) - 1\} dt = 0, \qquad (4)$$

which can be solved iteratively for V_O.

Equations 3 and 4 were solved by computer to enable us to predict the DC output vs RF input characteristics of a commercially available Schottky-diode detector. The diode's DC I-V curve was measured to determine the constants in Equation 1: $i_O = 7 \times 10^{-9}$ A, $\alpha = 35\ V^{-1}$. The resulting rectification characteristics are shown in Figure 2 for the cases R_L = 100 kΩ and $R_L = \infty$. It is clear from these curves that the 100 kΩ load reduces the low-level sensitivity by 16 dB, while the power level at which a 1 dB deviation from square-law occurs is almost the same in the two cases. Because the departure from square-law is in opposite senses for the two values of R_L, one would expect to find an intermediate value of R_L which would result in an extended square-law range at the high-power end. Unfortunately, when operating this detector with a scalar network analyzer, the 100 kΩ value of R_L was necessary to allow the input offset voltage to be nulled, as explained in the introduction.

Experimental measurement of the rectification characteristics of the same detector, at 95.5 GHz, gave the results shown in Figure 3. These results agree well with computed results based on the DC I-V curve shown in Figure 2. For the two cases $R_L >> 4$ megohms and R_L = 100 kilohms, the low-level sensitivities differ by 16 dB, and the curves depart from square-law by 1 dB near 40 mV and 1 mV DC output, respectively. Also shown in Figure 3 is the rectification characteristic of the new low-barrier diode for $R_L >> 30$ kilohms.

THE LOW BARRIER DETECTOR

The use of a low-barrier Schottky diode with video impedance around 120 kilohms overcomes all the difficulties of conventional Schottky-diode detectors. The low video impedance enables the off-

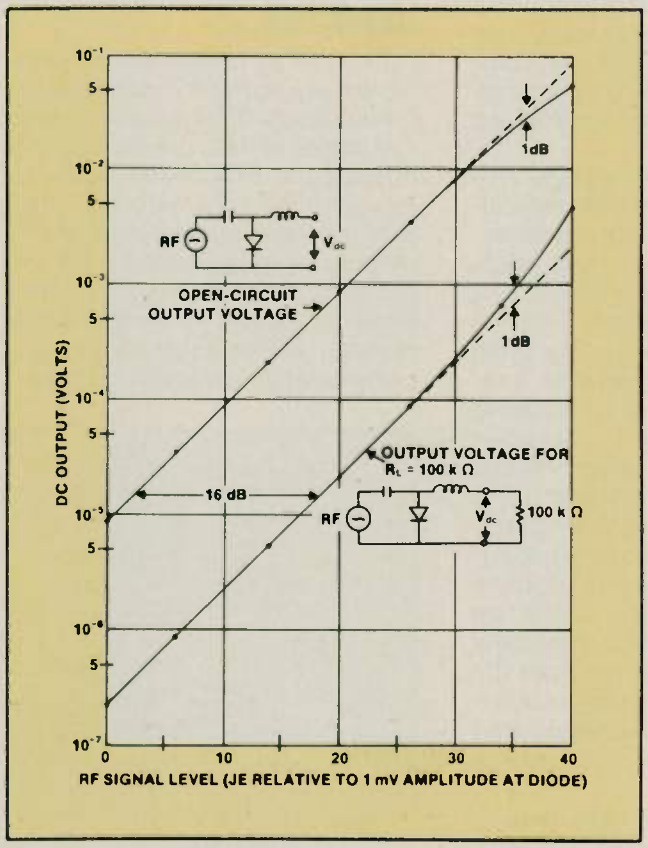


Fig. 2 Computed rectification characteristics for a silicon Schottky diode detector with very high (upper curve) and very low (lower curve) DC load resistances relative to the diodes video resistance R_v=4 megohms.

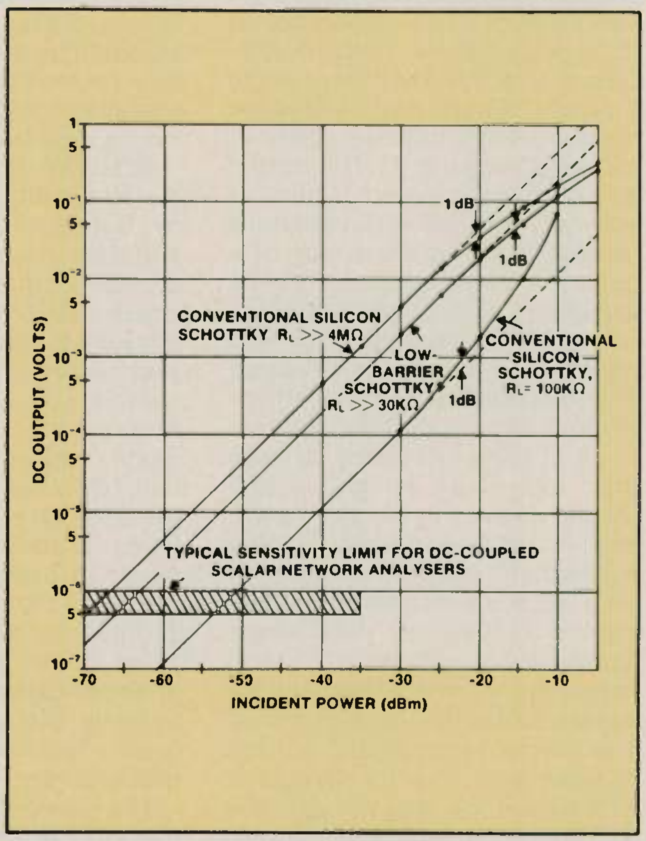


Fig. 3 Measured rectification characteristics at 95.5 GHz for the conventional silicon Schottky-diode detector with load impedance R_L>>4 megohms (upper curve) and with R_L=kilohms (lower curve). The middle curve is for the new low-barrier Schottky detector.

set voltage, produced by the bias current of the scalar network analyser flowing through the diode, to be nulled using the appropriate control. The detector sees the network analyzer as a relatively high-impedance load so the superior performance, demonstrated for the open-circuited detector in Figure 2, can be approached.

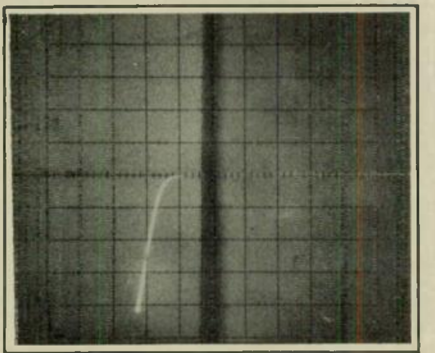
Schottky barrier diodes are usually dc biased in the forward direction for operation as low level detectors at microwave frequencies. External bias is necessary for both silicon and GaA Schottky barrier diodes as they both exhibit barrier height, ≥0.35 volts and this addtional voltage is needed to bias them in the nonlinear region.[2]

In the early 70's extremely low barrier height silicon Schottky barrier diodes (Zero Bias Schottky Detectors) were developed which exhibited a barrier height, ≤0.15 volts*, and do not require external biasing for low level detector applications.[2] Zero bias Schottky barrier diodes are fabricated by using heavily doped p- and n-type silicon material and low barrier height metals such as palladium, platinum for p-type and hafnium for n-type silicon.[3]

Millimeter wave zero bias Schottky barrier diodes were fabricated by depositing a platinum-nickel alloy on heavily doped p-type silicon. Zero bias Schottky barrier diodes were fabricated by planar techniques. A 5000 - A° layer of SiO_2 was grown on epitaxial silicon by reacting silane and oxygen at 450 °C. Multi dot array (honey comb) structure windows (2μm in diameter and 4μm apart) were etched in SiO_2 by photolithographic techniques. Platinum-nickel alloy and gold were deposited by RF sputtering on the entire wafer, and the unwanted excess metal on the oxide were etched off by the photo-lift off technique. Ohmic contact to the p+ layer was obtained by electroplating nickel and gold after etching the wafer to 4 mils. in thickness.

Zero bias Schottky barrier beam lead diodes for mm frequencies are also being developed and will be available in the near future.

The I-V curve of the new diode shown in Figure 4, together with that of the conventional silicon Schottky detector used in this comparison. The difference in video impedances is clear: 28 kilohms vs. 4 megohms.



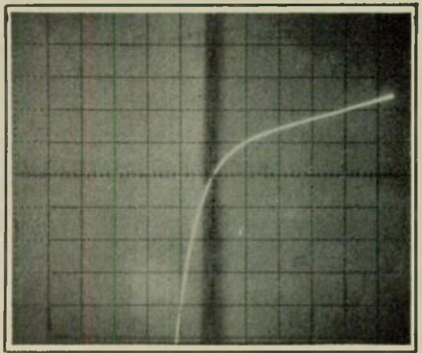


Fig. 4 I-V curves of the low-barrier diode (left) and the conventional silicon Schottky diode (right), showing the radically different video resistances at zero bias: 28 kilohms vs 4 megohms.

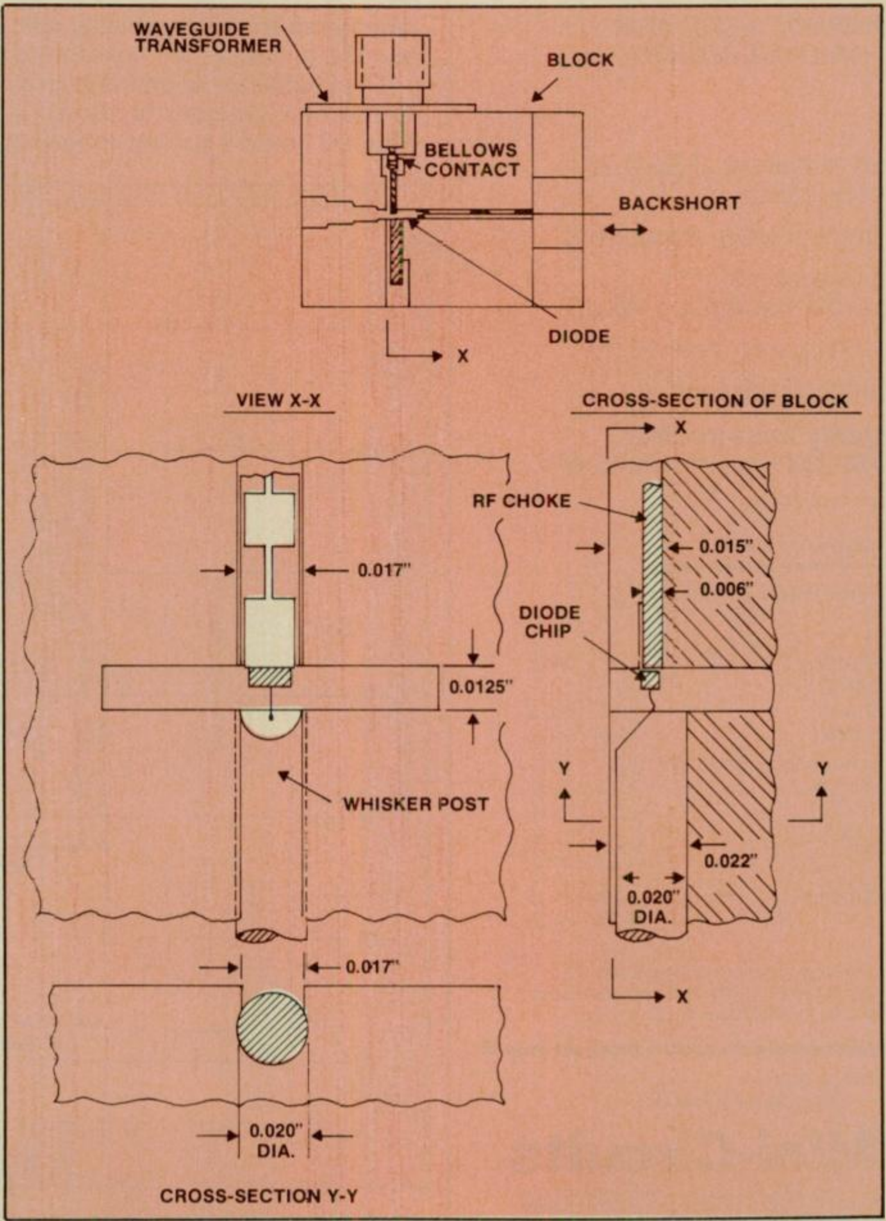


Fig. 5 Details of the mount used for low-barrier Schottky detectors.

*lower than that of Silicon point contact diode.

[Continued on page 70]

[From page 69] **DETECTORS**

The low-barrier diode was installed in a waveguide mount originally designed as a mixer.[4] Figure 5 shows the details of the mount, which uses a stepped transformer to reduce the waveguide height to one quarter of the standard height. A fused-quartz microstrip RF choke presents a low impedance to RF at the plane of the waveguide wall, while coupling the DC output to an SMA connector. The whisker - post hole in the brass block is reamed to 0.0200 in. diameter. The 0.0198 in. alloy-25 beryllium copper whisker post is plated with gold until it is a firm, smooth fit in the hole. A .0005 in. diameter gold plated phosphor-bronze contact whisker[5] is then mounted on the chamfered end of the whisker post, and the diode is then contacted.

The rectification characteristic of the new detector is shown in Figure 3 (middle curve) along with that of the commercially available conventional Schottky-diode detector. When operated with a Pacific Measurements model 1038-V12 scalar network analyzer, the detectors gave the results shown shown in Figure 6. A 100 K ohm shunt was required with the conventional Schottky detector, but the low-barrier diode was able to operate directly into the analyzer. It is clear from Figure 6 that the low-barrier detector is 12 dB more sensitive than the conventional Schottky detector, and has a dynamic range 23 dB greater. At high output levels the square-law compensation built into the network analyzer improves the dynamic range of the low-barrier detector, while degrading that of the conventional detector; this can be seen comparing Figures 3 and 6.

The broadband performance of the low-barrier detector is shown

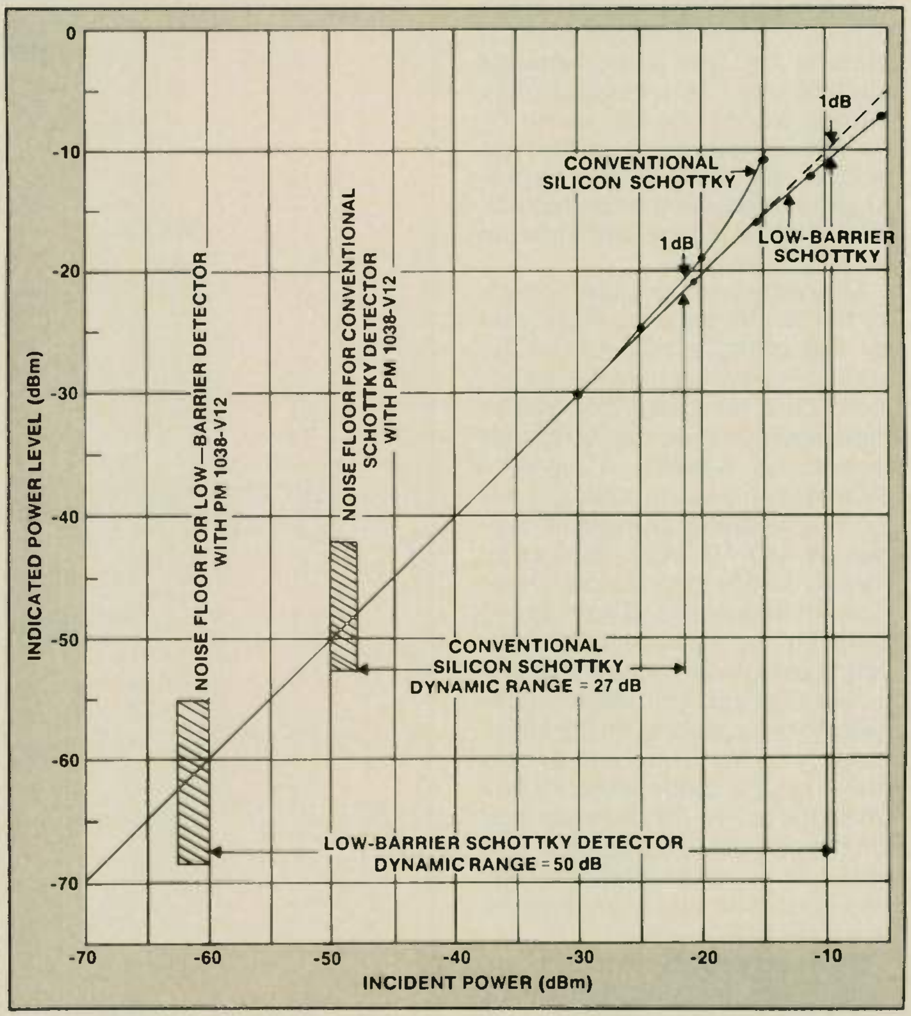


Fig. 6 Performance of the low-barrier and conventional Schottky-diode detectors at 95.5 GHz with a PM 1038-V12 analyzer. The conventional detector has a 100 kilohm shunt.

in Figure 7. For this measurment the backshort was positioned as close to the diode as mechanically possible. It is clear that the sensitivity of the detector varies by less than ±2.5 dB across the full WR-10 band. We believe that with a modified backshort which can be positioned closer to the diode, it should be possible to reduce this variation by a factor of two.

The tangential signal sensitivity was measured at 94 GHz and found to be -46 dBm using a video bandwidth of 1 MHz.

CONCLUSION

It has been shown that the problems of poor sensitivity and limited dynamic range, often encountered with conventional millimeter-wave detectors, are overcome by using zero bias Schottky barrier diodes. The WR-10 low-barrier detector reported here has a sensitivity of -60 dBm and a dynamic range of 50 dB at 95 GHz when operated with a Pacific Measurements 1038-V12 scalar network analyzer. The sensitivity of the detector is within ± 2.5 dB from 75 to 110 GHz, with fixed tuning, and it is believed that a small modification to the design will improve the flatness by a further factor of 2. The TSS is -46 dBm for a video bandwidth of 1 MHz, which makes the detector extremely attractive for radar, communications, and ECM application, as well as in the laboratory.

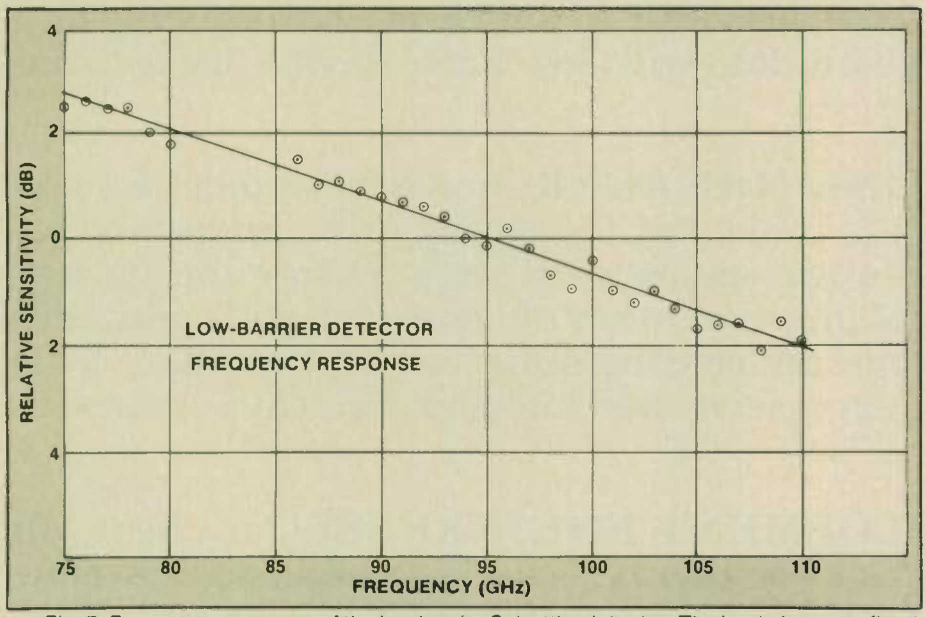


Fig. 7 Frequency response of the low barrier Schottky detector. The backshort was fixed throughout the measurements.

ACKNOWLEDGEMENTS

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REFERENCES

1. Initially by Pacific Measurements, and later by Wiltron.
2. Anand, Y., & W. J. Moroney, "Microwave Mixer and Detector Diodes," *Proc. IEEE*, Vol. 59, pp. 1182-1190, August 1970.
3. Anand, Y., Zero Bias Schottky Barrier Detector Diodes, U.S. Patent 3968, 272 July 1976.
4. Cong, I. H., and R. J. Mattauch, "The Low-Noise 115-GHz Receiver on the Columbia-GISS 4-ft. Radio Telescope," *IEEE Trans. Microwave Theory Tech.*, Vol. MTT-27 No. 3, pp. 245-248, March 1979.
5. Kerr, A. R., J. A. Grange, and J. A. Lichtenberger, "Contact Whistler for Millimeter-Wave Diodes," *NASA Technical Memorandum* No. 79616, Goddard Space Flight Center, August 1978.

Electrical Test Methods For Microwave PCB's

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ABSTRACT

The stripline resonator test method offers advantages over other methods, but variables in running the test need attention. Modifications of the method can be made to study temperature effects, to measure high dielectric constant materials and to compare single specimens of varying thicknesses. Other methods should be considered for their potential advantages.

INTRODUCTION

Resonator test methods for determining the dielectric constant, K', and the dissipation factor, DF, of copper clad laminates for microwave applications currently appear to be the most practical for routine testing. For sensitive measurement of both K'_{app} and dissipation factor the use of a loosely coupled resonator element is most popular. With loose enough capacitive coupling the loaded Q of the resonator is very nearly the same as the unloaded Q and may be used directly for determining the losses due to conductor and dielectric. The method for stripline resonator elements has been made a standard.[1] The method requires minimally a leveled X-band manually adjustable frequency generator, a frequency meter or counter and a means for measuring the microwave power level transmitted through the test fixture.

To determine the electrical properties at X-band frequencies one determines the dimensions of the resonator element, the resonant frequency (at maximum transmitted power) and the half power band width of the response curve. Simple calculations are used to obtain the K' and dissipation factor, DF.

There have been other methods used for determining electrical characteristics. One procedure involves placing the specimen in a waveguide resonant cavity and determining the change in resonant frequency and Q of the cavity.[2] One may place a closely fitting specimen in a shorted transmission line and then determine the properties by observing the shift in the location of the standing wave minimums at a fixed frequency as well as the reduction of the voltage standing wave ratio (VSWR). The problem with such methods has been the time to prepare and measure specimens as well as the rather exacting precision with which one must determine the position or frequency changes.

A time domain reflectometer may be used to measure the propagation velocity of a signal along a transmission line in the material of interest. This method requires that one assume that the K'_{app} is independent of frequency.

The purpose of this paper is to share some thoughts about the stripline resonator test method and to offer some ideas that should be considered for incorporation in the standard procedure. The following topics will be discussed:

- Advantages of stripline over microstrip measurements
- Test variables that should be considered
- Recommended modifications for the ASTM D 3380 fixture
- Modifications of the ASTM D 3380 fixture for high K' materials
- A semi- or non-destructive single specimen stripline method.

WHY PREFER STRIPLINE OVER MICROSTRIP FOR A RESONATOR TEST?

Specimen preparation is faster and simpler. The microstrip method requires well controlled etching of a photomasked pattern for every test made. For stripline the specimen needs to be merely etched free of copper foil. Both methods require proper rinsing and drying of course.

There can be a problem with microstrip patterns varying in dimension (measurable) or in the quality of the etching job, such as undercut or the like. Occasionally specimens can be irretrievably lost due to a mask failure.

The specimens from the stripline resonator test may be retained and selected ones used later for direct comparison with current materials under test to verify that there has not been a drift in test results. In other words one can retain reference standards as a control of the test method. For microstrip the retained specimens are actually a part of the test fixture so that a comparison is not as readily made.

The ability to control the temperature during a test either to remove that as a test variable or to deliberately observe the effect of temperature is an important feature of a test method as will be discussed below. With the stripline method temperature can be readily adjusted by use of various means for controlling the temperature of the aluminum clamping blocks on either side of the specimen. Because of the very high thermal conductivity of the aluminum blocks and the fact that the blocks and pressure plates on either side of the specimen assembly are in very good contact with most of the area of the specimen one can be assured that thermocouple readings in the plates represent the specimen with little lag in time.

To control the temperature of a microstrip specimen it would be necessary to set up the test arrangement in an oven, preferably with forced convection and proportioning control. Such an arrangement would be limited to mild temperature variations. Very high temperatures could damage connectors or other components, and very low temperatures could give moisture condensation problems not encountered in the clamped stripline.

The stripline method is not limited to a given thickness. Thinner specimens may be stacked to the nominal value and thicker ones may be machined to the nominal value. The concern about several layers with air inclusions during test is handled by use of a fluid of similar K′ to the material under test. In the microstrip case one either must limit the test to only a certain thickness panel or provide a series of etched pattern designs that will represent a change in the method to some extent and leave some question about how well the different thicknesses actually correlate.

Losses in the stripline method are confined to the dielectric and the conductor. Since the conductor is part of the fixture the DF of various specimens is readily comparable even though the exact contribution of the conductor to the loss may not be known. The microstrip losses include radiation losses that could be affected by ambient conditions. In addition the conductors in the microstrip specimen are part of the specimen and their contribution to the losses can be ambiguous.

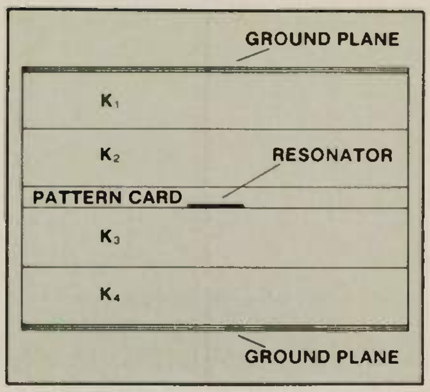


Fig. 1 Cross sectional sketch of the arrangement of RT/Duroid 6010 specimen cards around the resonator pattern card for evaluation of the effect of Kν variance vs proximity to the resonator.

It is quite easy to use the stripline method to explore material for localized uniformity by moving an oversize test card to a series of positions over the resonator pattern. Once a microstrip specimen has been prepared the location of the test area on the specimen is fixed.

ATTENTION TO VARIABLES IN THE STRIPLINE METHOD ARE REQUIRED

As with any test method it is important to take into account the effect of test variables. This is either done by compensating for observed deviations or by controlling the variable within limits that minimize its effect on the results. The following list covers variables found to be important to the success of a testing program.

Material for the Resonator Pattern Card

It is important to use material for the resonator pattern card that is similar to the material being tested. Since the card carrying the resonator is adjacent to the resonator element it will have an appreciable effect on the apparent values for both K′ and DF.

For an example of the importance of proximity to the resonator of a layer of dielectric in the stripline assembly we ran a series of tests with 10.5 K′ material, RT/duroid 6010 laminate, where the resonator card was .008 inch thick and the specimen consisted of two stacks of two .025 inch cards each. By substitution of each of the cards in turn with a series of four other specimens of differing K′ in a range of 10.37 to 11.02 K′ we obtained 16 K'_{app} readings. A regression analysis yielded the following result:

$$K'_{app} = 0.19K_1 + 0.37K_2 + 0.71K_3 + 0.27K_4 + 5.78$$

where the subscripted K's represent the K′ values for each of the card positions in order through the stack except for the pattern card. The card at position 3 is the one that is in direct contact with the resonator as shown in Figure 1.

The standard error of estimate for the constant was 0.039, and for the coefficients was 0.09.

THICKNESS OF THE SPECIMEN

Since the stripline resonator is behaving as a TE mode line in the homogeneous medium of the specimen and the card bearing the pattern, one would not expect the variation in geometry of the cross section due to thickness variation of the specimen to have any important effect. Deliberately varying the width of the resonator element for a given thickness has little effect as long as the dielect-

TABLE I
EXAMPLE DETERMINATION OF ΔL USING RT/DUROID 6010 SPECIMEN E

L in.	f_r GHz	N	f_r/N	L f_rN
.1374	10.2707	1	2.49864	1.4119
.3196	10.11408	2	3.33058	1.62049
.5049	9.9917	3	5.07038	1.68161
.6865	9.9946	4	10.27070	1.71532

A linear plot of L f_r/N vs f_r/N gives a slope of -Δ L
For this example of Δ L=0.0391 in.

ric medium is close to isotropic in dielectric constant.

However the end fringing correction is related to the thickness and has a second order effect on the reading one obtains. One needs to determine this fringing correction, delta L, by empirical means. This is done by measurements of a given series of specimens with a series of resonator pattern cards with resonator elements that are 1, 2, 3, and 4 half wave lengths in the material to be tested. For a given specimen card pair, frequency and resonator length data are obtained with each of the resonator pattern cards. By linear regression one can then determine the delta L value that fits the data.

If a series of specimen pairs are selected to cover the range of thicknesses that are expected to be encountered by the fixture then the delta L values associated with them will be found to be strongly correlated to the thickness. Such a correlation can then be used as a correction for deviation of the thickness of specimens or specimen stacks from the nominal thickness value for which the fixture was designed.

In the case of the high K' materials the 4 half wave length resonator used for day-to-day testing is quite small and variations in the delta L value due to thickness variances can have significant effect on the results. Thus one should correct delta L for measured specimen thickness to avoid erroneous test results.

TABLE II
Δ L VARIATION FOR RT/DUROID 6010 CERAMIC — PTFE SPECIMENS

Specimen	Thickness (in.)	ΔL
A	0.0480	0.0381
B	0.0500	0.0393
C	0.0525	0.0431
D	0.0488	0.0397
E	0.0488	0.0391
F	0.0490	0.0399
G	0.0537	0.0437

Linear regression gave the equation:
Δ L=-.0157+1.126 (thickness, in.) r=.92

Pressure

The dielectric constant appears to be a function of the clamping stress. Particularly with the high dielectric constant material we have noted a pressure dependence of the apparent K'. This is believed to be an elastic response of the soft substrate that actually stretches the resonator element. In fact, excessive pressure on such a soft substrate can cause the foil in the resonator to stretch beyond its elastic limit causing a drift in the readings obtained.

Clamp Time

In the case of high K' materials, the time at which the specimen is clamped has a log relationship to the observed K' presumably due to viscoelastic response of the substrate.

Both pressure level and time of clamping would affect the degree to which air is included in the clamped assembly due to surface roughness of the dielectric material left when the copper foil with its surface texture has been removed with etching. These asperities would gradually collapse under stress reducing the air layer.

Reflection in the Fixtured Due to Electrical Discontinuities

One should be aware of this problem in spite of the fact that the loosely coupled resonator is quite insensitive to reflections elsewhere in the fixture or cable connections. The foil probe lines of the pattern card can become fatigued and fracture microscopically leading to spurious resonances that are often misleading especially when they occur near the resonant frequency of the specimen being tested. The band broadening effect of a spurious resonance near the f_r of a specimen can raise the apparent dissipation factor.

Our experience with copper fatigue led to some modifications of the fixture used in the ASTM D3380 Method. This is to be covered further.

Temperature

Unfortunately the materials that seem most suited for microwave applications are based on a polymer, PTFE, that is inconsiderate enough to undergo a crystalline rearrangement as the temperature is passed through the room temperature region. This transition may be detected by calorimetry or by thermal expansion measurements. The transition involves a two step reordering of the crystal lattice nominally occuring at 19 and 30° C with the 19° C step being the major one. Aside from this, polymeric materials do exhibit a variation of K' and DF with temperature. This may be simply thermal expansion effect on density, the case for PTFE composites. For some polymers the temperature change can affect the response to electric fields due to molecular changes other than density.

The point is that temperature should be considered an important variable to control. For a given material it is worth while to evaluate the thermal coefficient of dielectric constant in the temperature region to be encountered in testing. This would be used to make a correction on readings for observed deviations from a standardized temperature.

It is valuable to develop data on the variation of the permittivity over a wide termperature range for design information. This can be done quite readily by clamping a resonator assembly between aluminum blocks that may be heated or cooled. Fluid from a laboratory constant temperature bath may be circulated through clamp blocks on a fixture for convenient control of temperature during routine tests.

Thermal History

Above we discussed the room temperature crystalline transition for PTFE. There appears to be a thermal lag in this transition that is similar to the difference between the crystalline melt and freeze points of 327°C and 315°C respectively. It is observable as a thermal history effect. Normally one would expect to oven dry specimens after etching and then condition for a day in standard laboratory atmosphere before testing to control this variable.

Recommended Modifications to the ASTM D3380 Fixture

There are several problems with the standard fixture. In order for

[Continued on page 76]

TABLE III
THERMAL HISTORY EFFECT ON A SPECIMEN OF RT/DUROID 5870

Readings are arranged in chronological order.

Condition	Test fixture temperature, °C	Dielectric	Constant	Reading
as rcvd.	35	2.336		
as rcvd.	25		2.340	
as rcvd.	15			2.368
1hr./0°C	15			2.368
1hr./0°C	25		2.352	
1hr./0°C	35	2.343		
1hr./150°C	35	2.330		
1hr./150°C	25		2.335	
1hr./150°C	15			2.356

one to change resonator cards it becomes necessary to completely disassemble the fixture. The stripline launcher pins are particularly susceptable to damage with this sort of repeated handling. It is necessary for changes in the resonator pattern card to be made periodically due to wear and tear of daily use and the likelihood of an operator fumble. In addition changes in the cards become a necessity if one is to use a series of patterns with the resonator length varied in order to determine the delta L end fringing correction.

These problems have been resolved with some modifications so that the ground plane foils and the resonator pattern card may be changed without disturbing the launcher assembly (Figure 2a, 2b). The resonator card makes a lap joint contact with permanent stripline cards that in turn connect to the launcher pins. The permanent cards are clamped between two pairs of clamping plates. The first pair permanently clamps the cards about the pins but the second are loosened for card and foil changes. The permanent cards have edges that extend beyond the clamp plate so that they, being thicker than the pattern card, are able to absorb stresses from mishandling.

In addition the revised design has the added flexibility to be usable in cases where the pattern is etched directly on the specimen card, for comparisons of copper foils, for example. Such a capability can also be used for the measurement of bonded stripline assemblies after environmental exposures.

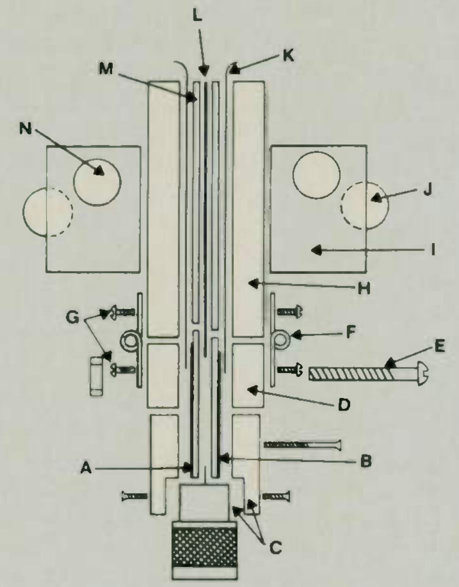
There is a further problem with the 3mm coax-to-stripline fittings. The small size is sensitive to mishandling, especially when it must support either a crystal detector mount and cable or an attenuator and heavy flexible coaxial cable connected in the test setup. We are planning to evaluate the use of type N coaxial/stripline adapters as shown in Figure 2.

MODIFICATIONS FOR 10.5 K′ SPECIMENS

For the reasons given earlier we have used modifications of D3380 for high K′ materials. In addition the confidence built up with experience at the lower K′ values reinforced this preference.

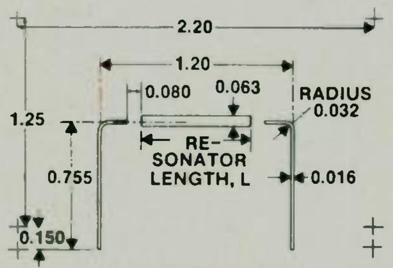
The resonator card was redesigned to preserve what we felt were the important features of the D3380 method as shown in Figure 3. The probe line widths are intended to maintain the 50 ohm Z_0 while the resonator width was planned to maintain a 25 ohm Z_0 value. The resonators are of 1, 2, 3, and 4 half wave-lengths at 10 GHz to make it convenient to determine delta L experimentally. The capacitive gap was determined by trial and error to obtain an insertion loss of the fixture of about 40 dB when the power level of the circuit at resonance is compared to the power level through the fixture when the resonator card is replaced with a straight through line.

It is important to avoid air gaps when testing high K′ material. Voids in the system contribute much more error than they would for low K′ value materials. We accomplished this for our resonator pattern card by using a high



- **A** RT/duroid 5870 stripline card carries two 0.098 wide striplines spaced 2.186 on centers. Upper edge extends 0.100 beyond edge of D. Ground plane foil is etched back 0.200 from the extended edge.
- **B** RT/duroid 5870 cover card. Upper edge is 0.050 beyond edge of D. Ground plane foil is etched off back 0.150 from extended edge.
- **C** Type N-to-stripline launcher body and cover plate. Two required.
- **D** Aluminum clamp bar, 0.50 x 0.25 x 3.00. Two required.
- **E** Brass RDH screw and nut #6-32 UNC. Four required.
- **F** Butt hinge, brass, 1 x 0.75. Two required.
- **G** Brass RDH screws #4-40 UNF 0.14 long. Fit into blind holes tapped into D and H. Eight required.
- **H** Aluminum clamp plate, 0.25 x 2.00 x 2.70. Two required.
- **I** Aluminum clamp block, 0.75 x 1.00 x 2.00. Two required.
- **J** Steel ball, 0.375 diameter, press fits into I. Two required.
- **K** Copper foil ground planes, 2.5 x 7 x 0.0014. Two required.
- **L** Pattern card, 0.010 thick RT/duroid dielectric with ASTM D3380 pattern. If testing materials in the 2.20 to 2.35 range of K' the probe line widths should be 0.106.
- **M** Test specimen, .062 x 2.0 x 2.7. Two required.
- **N** Hole bored and tapped both ends for 1/8 inch NPT for temperature control by fluid circulation.

Fig. 2 Exploded end view of modified fixture for ASTM D3380.



PATTERN	N	L
a.	4	0.689
b.	3	0.507
c.	2	0.324
d.	1	0.124
e.	0	NONE

Fig. 3 Detail of resonator pattern card.

temperature pressing technique to bring the exposed surface of the copper foil pattern flush with the surface of the card.

The fixture is somewhat different from the fixture for lower K' value materials besides being smaller (as shown in Figure 4). We found that one cannot readily purchase coax-to-stripline adapters for K' at 10.5. The line width for 50 ohm Z_0 is too small for the launch pin normally available even in 3mm coax. Our solution was to build our own by using a flange type 3mm coaxial semi-rigid cable-to-pin adapter. The pin is filed to a cone shape. Half of that is filed away to form a half cone that can lay upon the stripline in a notched out area of the cover board. To minimize the reflections we found that additional notches in the circuit board on either side of the strip were needed.

[Continued on page 78]

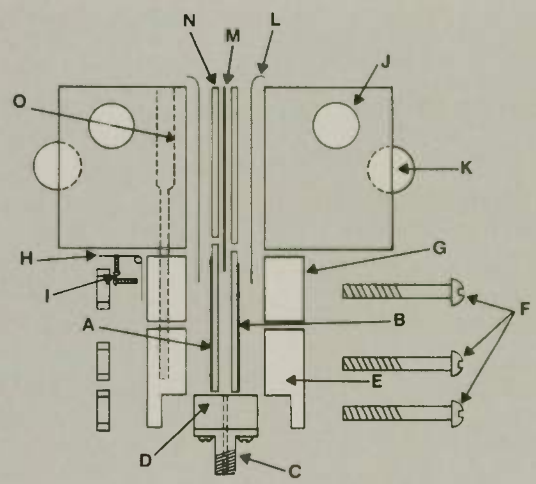
[From page 77]

A SEMI- OR NON-DESTRUCTIVE SINGLE SPECIMEN METHOD

Modifications of the stripline method permit using a single specimen free of copper on one or two sides for what can be a semi-destructive test. The fixture consists of a resonator pattern on a PCB that is solder reflow bonded by its groundplane to a brass block. Semi-rigid 3mm coaxial cables are soldered into the block so that the center conductors are capacitively coupled out of the plane of the resonator. Thus the connections to the fixture need not interfere with clamping the fixture anywhere against a board much larger than the fixture.

The resonant frequency for such a fixture is a function of the thickness and dielectric constant of the specimen against which it is clamped. Calibration is accomplished by accumulating resonant frequency data for a series of laminates of selected different K' values based on another test such as the D3380 method. Specimens of a series of thicknesses for each dielectric constant are measured and a polynomial is determined by regression analysis that fits the data well.

Such a fixture may be set up in a wide frame for scanning panels. This is valuable as a tool for evaluating the uniformity of panels and providing feed back to the laminating process.



A RT/duroid 6010 stripline board, 0.048 dielectric thickness, 1.10 x 2.20 with two .016 wide striplines spaced 1.200 on centers. Ground plane is etched back 0.200 from the upper edge. Four V notches are cut in both sides of the striplines on the opposite edge. The notches start 0.015 from the center line of the strip, are 0.065 wide and are 0.10 deep.

B RT/duroid 6010 cover board, 0.048 dielectric thickness, 1.05 x 2.20. Ground plane is etched back 0.150 from the upper edge. Two V notches, 0.10 wide and 0.075 deep, are cut from the opposite edge centered over the striplines of A.

C 3mm jack/flange terminal (Cable Wave Systems P/N 625-001). Two required.

D Flange mount plate, brass, 0.50 x 0.250 x 2.200.

E First clamp block (permanent), brass, 0.3125 x 0.750 x 2.200, rabbitted edge to fit D. Two required.

F Brass RDH screw & hex nut, 6-32 x 0.9. Nine required.

G Second clamp block (for card change), brass, 0.3125 x 0.500 x 2.200. Two required.

H Brass butt hinge, 1 x .75 (loosely fastened). One required.

I Brass RDH screw, 4-40 x .18, fit blind holes tapped into G and J. Four required.

J Third clamp block 1.00 x 1.25 x 2.00. Bore a hole through the 2.20 dimension and tap both ends for 1/8 inch NPT and fit with tubing connections for circulating fluid from a constant temperature bath. Two required.

K 3/8 inch diameter steel ball, press fit into J. Two required.

L Copper foil ground plane, 0.0014 x 1.50 x 2.20. Two required.

M Resonator pattern card. See Figure 3.

N Test specimen, .050" dielectric thickness. Two required.

O Dowel pin and screw to align clamp blocks on one side.

Fig. 4 Exploded end view of test assembly for high K' materials modified from ASTM D3380.

Measurements may also be made on open areas of PCB's prior to assembly with components as a non-destructive in-process test.

CONCLUSION

Other test methods that are less destructive or non-destructive are desired. One idea that is appealing is to use an entire panel as a parallel plate waveguide resonator. Such a technique has been evaluated for small ceramic specimens with good results [3, 4, 5]. How to handle the edge effects of the panel needs to be understood and the use of higher mode resonances needs to be investigated. In the case of the PTFE based laminates which have dielectric constant quite insensitive to frequency, it should be reasonable to use lower frequencies than microwave to obtain the fundamental and lower harmonics of an entire panel for simple evaluation.

Until other such methods become standardized, however, the stripline resonator method appears to be a reliable and practical method for production control.

REFERENCES

1. "ASTM D3380-75 Standard Test Method for Permittivity (Dielectric Constant) and Dissipation Factor of Plastic-Based Microwave Circuit Substrates," *American Society of Testing and Materials, Annual Book of Standards,* Part 39, (1980).
2. "ASTM D2520-77 Standard Test Methods for Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures to 1650° C," *American Society of Testing and Materials, Annual Book of Standards,* Part 39, (1980).
3. Napoli, L. S., and J. J. Hughes, "A Simple Technique for the Accurate Determination of the Microwave Dielectric Constant for Microwave Integrated Circuit Substrates", IEEE Trans. on Microwave Theory Tech. (Corresp.), *MTT-19,* July 1971, pp. 664-665.
4. Howell, J. Q., "A Quick Accurate Method to Measure the Dielectric Constant of Microwave Integrated Circuit Substrates," IEEE Trans. on Microwave Theory Tech. (Short Paper), *MTT-21,* March 1973, pp. 142-143.
5. Ladbrooke, P. H., M. H. N. Potok and E. H. England, "Coupling Errors in Cavity-Resonance Measurements on MIC Dielectrics", IEEE Trans. on Microwave Theory Tech. (Short Paper), *MTT-21,* Aug. 1973, pp. 560-562. ■

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CIRCLE 61 ON READER SERVICE CARD

An HP 67/97 Program To Match Dielectric Loaded Waveguides

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Methods for dimensioning transformers to match dielectric slab loaded waveguide Figure 1a are rather long or inaccurate. The literature[1] provides many formulas, which are not as yet in an explicit form, and require iterative methods for their calculation or approximate graphic solutions. Remanence ferrite phase shifters Figure 1b[2,3] which have different impedance levels in the two possible operation states present a further concern.

This program computes the $\lambda/4$ matching section impedance, and the length and the width (c) in millimeters of the transformer for any value of transformer dielectric constant. The input data needed are the frequency in MHz, the waveguide width (a) in mm, the parameters P+, P- which are the normalized loaded ferrite dielectric waveguide impedances ($Z_f^{\pm}$ $\eta/P\pm = 377/P\pm$) and the dielectric constant (ε) of the transformer material. The program uses the average of P+ and P-. This assumption does not affect the final result since the difference between the two values is very small. When a ferrite-free dielectric slab is being matched the same number should be stored twice, as P+ = P- = P.

Input data storage locations are presented in Table 1.

TABLE I

INPUT DATA STORAGE LOCATIONS

DATE	MEMORY
Frequency (MHz)	A
a (mm)	B
P+	C
P-	D
ε	E

The calculation is initiated by keying A.

The calculator will then compute and print the transformer parameters in the following sequence:

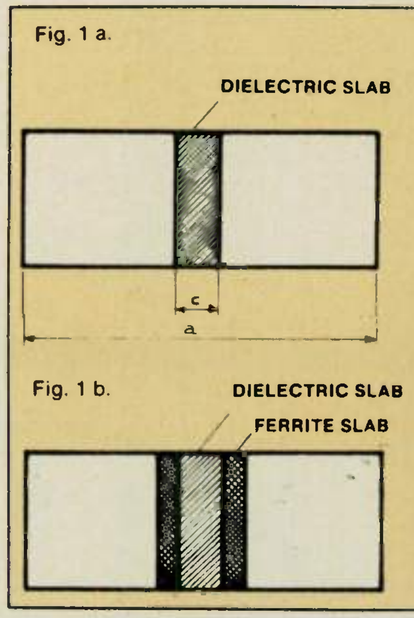
Transformer Impedance, Z_T, in Ohms

Transformer Length, 1, in millimeters

Transformer Width, c, in millimeters

The program can also be usefully utilized to calculate the dimensions of cascaded quarter wave transformers having broadband matching. In this case, the impedance of the transformer steps should be evaluated beforehand as in references[4,5]. The impedance values thus obtained are stored one by one in register 9, and calculation of the dielectric thickness is begun by keying GSB 1. Print out in this case is only the dielectric length, 1, and the width, c, in mm.

This program has been used to dimension transformers for a large number of frequencies in S, C and X band with very good experimental results, so we are sure that, when the approximations of the theory are satisfied, the formula works very well.



APPENDIX I
Calculator Program

```
001  *LBLA   21 11
002   RCLA   36 11
003   ENT↑     -21
004    1/X      52
005      3      03
006      0      00
007      0      00
008      0      00
009      0      00
010      0      00
011      ×     -35
012   STO5   35 05
013    1/X      52
014     Pi   16-24
015      ×     -35
016      2      02
017      ×     -35
018   STO6   35 06
019   RCL5   36 05
020      2      02
```

021	÷	-24	053	RCL7	36 07	085	÷	-24	117	RCL6	36 06	149	RCL7	36 07
022	RCLB	36 12	054	×	-35	086	STO8	35 08	118	×	-35	150	×	-35
023	÷	-24	055	√X	54	087	RCL0	36 00	119	RCLB	36 12	151	STO1	35 01
024	X²	53	056	PRTX	-14	088	1/X	52	120	×	-35	152	RCLI	36 46
025	CHS	-22	057	STO9	35 09	089	RCLB	36 12	121	X²	53	153	eˣ	33
026	1	01	058	*LBL1	21 01	090	×	-35	122	4	04	154	STO5	35 05
027	+	-55	059	RCL9	36 09	091	Pi	16-24	123	÷	-24	155	RCLI	36 46
028	√X	54	060	1/X	52	092	×	-35	124	STO1	35 01	156	CHS	-22
029	1/X	52	061	RCL6	36 06	093	2	02	125	RCLE	36 15	157	eˣ	33
030	RCL5	36 05	062	×	-35	094	÷	-24	126	1	01	158	CHS	-22
031	×	-35	063	RCLB	36 12	095	PRTX	-14	127	-	-45	159	RCL5	36 05
032	RCL6	36 06	064	×	-35	096	.	-62	128	RCL1	36 01	160	+	-55
033	×	-35	065	3	03	097	0	00	129	×	-35	161	STO0	35 00
034	3	03	066	7	07	098	0	00	130	STO1	35 01	162	RCLI	36 46
035	7	07	067	7	07	099	1	01	131	RCL7	36 07	163	CHS	-22
036	7	07	068	×	-35	100	STO7	35 07	132	RCLI	36 46	164	eˣ	33
037	×	-35	069	STO0	35 00	101	0	00	133	×	-35	165	RCL5	36 05
038	2	02	070	RCL6	36 06	102	STO3	35 03	134	X²	53	166	+	-55
039	÷	-24	071	÷	-24	103	*LBLB	21 12	135	CHS	-22	167	1/X	52
040	Pi	16-24	072	RCLB	36 12	104	RCL7	36 07	136	RCL1	36 01	168	RCL0	36 00
041	÷	-24	073	÷	-24	105	1	01	137	+	-55	169	×	-35
042	STO7	35 07	074	X²	53	106	+	-55	138	√X	54	170	RCLI	36 46
043	RCLC	36 13	075	CHS	-22	107	1/X	52	139	STO1	35 01	171	÷	-24
044	RCLD	36 14	076	1	01	108	RCL8	36 08	140	5	05	172	RCL1	36 01
045	+	-55	077	+	-55	109	×	-35	141	7	07	173	-	-45
046	2	02	078	CHS	-22	110	STOI	35 46	142	.	-62	174	STO2	35 02
047	÷	-24	079	√X	54	111	RCL7	36 07	143	3	03	175	X>0?	16-44
048	1/X	52	080	RCL6	36 06	112	1	01	144	×	-35	176	GTOC	22 13
049	3	03	081	×	-35	113	+	-55	145	TAN	43	177	RCL3	36 03
050	7	07	082	RCLB	36 12	114	1/X	52	146	RCL1	36 01	178	X>0?	16-44
051	7	07	083	×	-35	115	RCL7	36 07	147	×	-35	179	GTOD	22 14
052	×	-35	084	2	02	116	×	-35	148	1/X	52	180	RCL7	36 07

```
181      .     -62
182      0      00
183      1      01
184      +     -55
185    STO7   35 07
186    GTOB   22 12
187   *LBLC   21 13
188      1      01
189    STO3   35 03
190    RCL7   36 07
191      .     -62
192      0      00
193      0      00
194      1      01
195      -     -45
196    STO7   35 07
197    GTOB   22 12
198   *LBLD   21 14
199    RCL7   36 07
200      1      01
201      +     -55
202    1/X      52
203    RCL7   36 07
204      ×     -35
205    RCLB   36 12
206      x     -35
207    PRTX    -14
208    RTN      24
209    R/S      51
```

APPENDIX II
Formula

The theory of dispersive lines provides the transformer length:

$$\frac{\lambda T}{4} = \frac{\pi}{2\beta}$$

where:
$\beta = 377k/Z_T \quad K = 2\pi/\lambda_0 \quad Z_T = \sqrt{Z_i Z_g}$

and Zg is the air filled waveguide impedance.

To obtain the transformer width, an iterative method is used increasing the transformer width and solving eq. 13 of (1):

$$9^2 = r^2 p^2 + \frac{(\varepsilon\text{-}1)\ (r\ Ka)^2}{4\ (1 + r)^2}$$

where:
r = (c/a)/(1 - c/a)

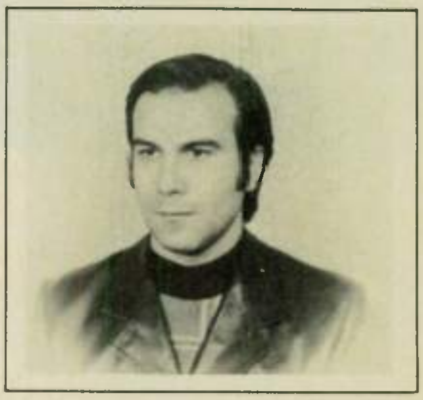
until eq. 11 of (1) is satisfied, that is:

$$\frac{\tan p}{P} = \frac{r \cot 9}{9}$$

r is increased in steps of Δ r = 0.001 starting from r = 0.001.

REFERENCES

1. Vartanian, P. H., et al, "Propagation in Dielectric Loaded Rectangular Waveguide" *IEEE Trans. on MTT*, April. 1958, pg. 215-222.
2. Ince, W. J., and E. Stern, "Nonreciprocal Phase Shifters in Rectangular Waveguide" *IEEE Trans. on MTT*, Vol. MTT 15, No. 2 Feb. 1967, pg. 80-95.
3. Cattarin, G., M. Parodi, "Remanence Waveguide Phase Shifters: Theory Computer Program, Some Applications" *Rivista Tecnica Selenia* Vol. 7, No. 1, 1980.
4. Young, L., "Tables for Cascaded Homogeneous Quarter-Wave Transformers", *IEEE Trans. on MTT*. Apr. 1959, pg. 233-239.
5. Matthaei, G. I., L. Young, E.M.T. Jones, *Microwave Filters, Impedance Networks and Coupling Structures"* McGraw-Hill Book Company.



Giuseppe Cattarin *received the degree of Perito Industriale in Telecomunicazioni from the E. Fermi Institute of Rome, Rome, Italy, in 1964. The following year he joined the Research Division of Selenia S.P.A. where he was engaged in measurements of the microwave properties of ferrite materials at low-and high-peak powers.*

In 1980 he received the degree of Dottore in Fisica from the University of Rome, Italy. He is presently working on the development of several advanced high-power ferrite devices from L to X band. ■

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2-WAY							
42000	0.5-2	22	0.4	1.25/1.15	0.5	2	1.60 x 1.70
42010	1-4	20	0.4	1.30/1.20	0.5	3	1.50 x 1.40
42020	2-8	20	0.4	1.35/1.25	0.5	4	1.50 x 1.00
42030	4-12	19	0.4	1.40/1.30	0.6	8	1.00 x 1.00
42040	6-18	18	0.5	1.50/1.40	0.8	10	0.75 x 1.00
42100	2-18	18	0.6	1.50/1.40	1.2	10	1.58 x 1.00
4-WAY							
44000	0.5-2	22	0.6	1.45/1.25	0.9	4	3.20 x 2.60
44010	1-4	20	0.6	1.45/1.30	0.9	4	3.00 x 2.30
44020	2-8	18	0.6	1.50/1.40	0.9	6	1.75 x 2.00
44030	4-12	18	0.6	1.60/1.40	1.2	10	1.20 x 2.00
44040	6-18	17	0.8	1.70/1.50	1.6	14	1.03 x 2.00
44100	2-18	17	0.8	1.70/1.50	1.8	14	1.75 x 2.00

All Models 0.38 inches in thickness. Allow 0.03 inches in all dimensions for sealant buildup. Please write for complete specifications on our 8-way models.

Anaren

Anaren Microwave Inc.
6635 Kirkville Road
E. Syracuse, NY 13057
Phone: (315) 432-8909 TWX: 710-541-1507

CIRCLE 64 ON READER SERVICE CARD

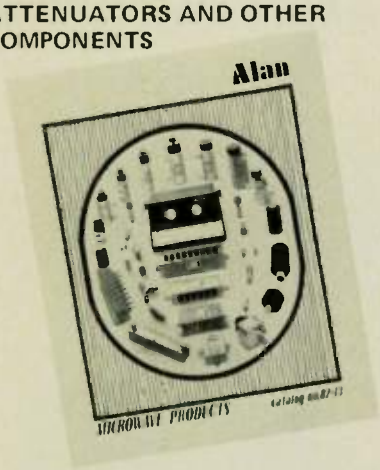
Catalog Update

MICROSTRIP DROP-IN ISOLATORS AND CIRCULATORS

A new line of Microstrip Drop-in Isolators and Circulators is described in a two-page brochure from Aertech Industries. Designated the Aer-Drop™ Series. The units are available in discrete frequency ranges from 2.1 to 14.5 GHz. Insertion loss is typically 0.4 dB, isolation 20 dB and VSWR 1.3:1. Units are available on Kovar carriers to simplify installation and minimize device breakage. The brochure presents a detailed description of the line, as well as electrical specifications and outline drawings. **Aertech Industries, 825 Stewart Drive, Sunnyvale, CA 94086, (408) 732-0880. TWX: 910-339-9207.**

Circle 178.

ATTENUATORS AND OTHER COMPONENTS



A new 40-page attenuator catalog, No. 82-13, has just been released by Alan Industries. This catalog features high performance fixed attenuators and terminations operating from dc to 18 GHz and step attenuators that operate by dial, toggle, push-button or rocker switches, from dc to 2 GHz. Other components are programmable attenuators, broadband detectors for video through UHF, return loss bridges, RF fuses and reactive power dividers/combiners. Alan Industries, Inc., 745 Greenway Drive, P.O. Box 1203, Columbus, IN 47201. Bill Kennedy, Tel: 812-372-8869. **Circle 179**

RF MODULE CATALOG

A 4 page data sheet lists a standard line of plug-in RF amplifier modules for a variety of applications. Models for low cost applications in TO-39 packages feature coverage to 400 MHz. A series of amplifiers in TO-12 packages are intended for general application at frequencies from the kHz range through 400 MHz. A TO-8 series offers somewhat higher output powers and a multi-stage series in 4-pin DIP offers higher gain and output power. **Amplifonix Inc., 220 Route 13, Bristol, PA 19007**

Circle 180.

[Continued on page 86]

MICROWAVE COMPONENT CATALOG

This 40-page catalog covers NEC's complete line of microwave product transistors, GaAs FETs and diodes. Performance curves, specifications and detailed package outline drawings are included. The catalog is divided into small signal, medium power and power categories. **California Eastern Laboratories, Inc., 3005 Democracy Way, Santa Clara, CA 95050. (408) 988-3500**

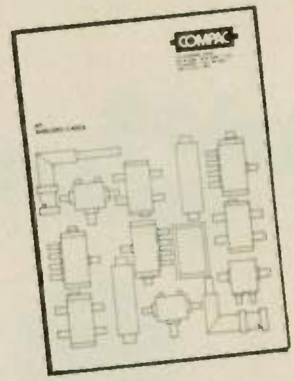
Circle 181.

CRYSTAL OSCILLATOR BROCHURE

Comstron, the technology leader in oscillators for military, commercial and deep-space applications can assist with crystal oscillator requirements. Through proprietary computer-generated design, testing and production techniques, Comstron delivers state-of-the-art low noise performance on VCXOs, TCXOs, oven controlled crystal oscillators and phase locked sources to 1 GHz. Design for Optimum Performance (DOP) programs provide optimization of performance and sensitivity analysis. **Comstron Corp., 200 East Sunrise Highway, Freeport, NY 11520. Len Borow, (516) 546-9700.**

Circle 207

RFI SHIELDED CASES CATALOG



An 8-page catalog describes low cost RFI shielded cases and accessories. Catalog contains photos and drawings describing a variety of blank cases, standard size cases and a custom series plus accessories. It also features the RFT series which offers greater shielding effectiveness. Cases are effective from 60 to > 100 dB at 100 MHz and are available with an optional nickel plate finish. Various configurations are noted in the numerous outline drawings. A series of die cast boxes and a comprehensive group of gaskets are also shown. **COMPAC, 279 Skidmore Road, Deer Park, NY 11729. Tel: (516) 667-3933. Circle 206**

TUNNEL DIODE LINE BROCHURE

A complete line of tunnel diodes for amplifiers, detectors, mixers and switches is described. Each product section includes specifications, performance curves and applications, plus product features and schematic drawing. Package outlines for type 23 package provided. **Custom Components, Inc., Box 334, Lebanon, NJ 08833. Tel: (201) 236-2128; TLX: 132-445.**

Circle 208

PRECISION CERAMIC MACHINING BROCHURE

A 4 page brochure lists the machining services available for aluminum oxide, ferrite, garnet, sapphire, quartz, fused silica, titanates and other ceramic materials. Photographs illustrate sample shapes which can be handled. **Ellis Ceramtek Inc., 215 Annandale Center, Clinton, NJ 08809.**

Circle 182.

COMPLETE OSCILLATOR CATALOG

This brochure covers a broad spectrum of oscillators including fundamental oscillators, oscillator multipliers, and push-push oscillators. Other types detailed in the literature are mechanically tuned, phase-locked, crystal and special purpose oscillators. **EMF Systems, Inc., 121 Science Park, State College, PA 16801 (814) 237-5738.**

Circle 183.

270-PAGE PRODUCT AND APPLICATIONS MANUAL

A new, 270-page product and applications manual is offered free of charge by Frequency Devices, Inc. Twenty-six product families of Analog Signal Filters, Instruments, Telecommunications and Data Communications Components, Low Distortion Sine Wave Signal Generators and Modular Power Supply Products are included. Complete electrical specifications, mechanical specifications and applications support data are provided, for each product described. **Frequency Devices, Inc., 25 Locust Street, Haverhill, MA. John C. McGuire (617) 374-0761.**

Circle 184.

[Continued on page 88]

MODULAR RF DISTRIBUTION SYSTEM BROCHURE

A 6 page brochure describes a line of militarized, high reliability RF distribution system modules for satellite ground station, shipboard, mobile and laboratory applications. Primary and secondary units for low noise distribution of 5 MHz reference signals are described. As many as 56 outputs are available from a single chassis. **Frequency Electronics Inc., 3 Delaware Drive, New Hyde Park, NY 11040.**

Circle 185.

[From page 87] **CATALOG UPDATE**

SOLID STATE MICROWAVE COMPONENT CATALOG

A 40 page catalog describes a line of solid state attenuators, modulators and phase shifters for application at frequencies ranging from 0.2 to 18 GHz. Complete specifications for both digital and analog control versions of the components are provided. Schematic and outline drawings are shown, and a glossary of terms is provided. **General Microwave Corp., 155 Marine Street, Farmingdale, NY 11735.**

Circle 186.

MICROWAVE POWER TRANSISTOR BROCHURE

A 4 page brochure provides complete data for a line of emitter-ballasted silicon bipolar transistors offering output powers up to 5W at 3 GHz. Tables provide maximum rating, static and function electrical characteristics. Typical operation under a variety of conditions is illustrated by a set of 12 graphs. **International Microwave Devices, 51 Chubb Way, Somerville, NJ 08876.**

Circle 187.

ATTENUATOR CATALOG

This attenuator catalog contains specifications and prices on a wide range of units, including fixed attenuators, coaxial switches, rotary attenuators, solid-state programmable attenuators and more. **JFW Industries, Inc., 2719 East Troy Avenue, Indianapolis, IN 46203 (317) 783-9875.**

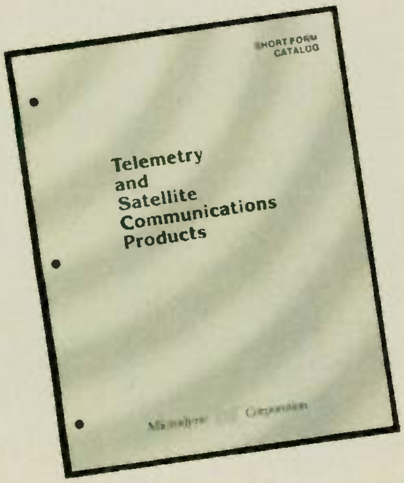
Circle 188.

SIGNAL PROCESSING COMPONENTS CATALOG

This updated catalog details a wide range of double balanced mixers and thin film voltage controlled oscillators. Wideband mixers up to 18 GHz, plus a family of low frequency mixers are described with complete specifications, outline drawings and photographs. Information and specifications for the V72T and V82T series oscillators ranging from 2.7 to 4.5 GHz are also included. **Magnum Microwave Corporation, 1080-C East Duane Ave., Sunnyvale, CA 94086. Contact David Fealkoff (408) 738-0600.**

Circle 189.

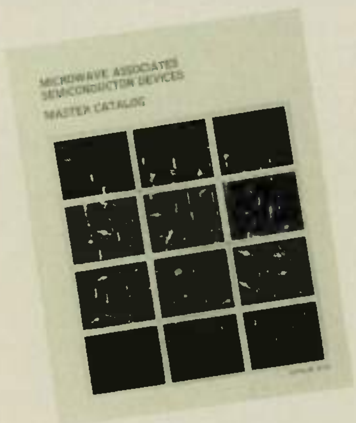
SATCOM SHORT FORM CATALOG



A new 17 page, fully illustrated short form catalog lists all of Microdyne's telemetry, satellite TT&C and meteorological satellite receivers, precision RF signal generators the latest state-of-the-art, high fade rate diversity combiners and many other related products. **Microdyne Corporation, 627 Lofstrand Lane, Rockville, MD 20850. (301) 762-8500.**

Circle 190.

SEMICONDUCTOR CATALOG



M/A's latest semiconductor catalog covers a complete line of devices including packaged mixer diodes, beam lead and chip mixer diodes for MIC applications, detector diodes, packaged control diodes, beam lead and chip PIN diodes for MIC applications, multithrow TR switching modules, tuning varactors, multiplier varactors, parametric amplifier varactors, Si and GaAs IMPATT diodes, Gunn diodes. **Microwave Associates, Inc., Second Avenue, Burlington, MA 01803. Larry Ward (617) 272-3000.**

Circle 192.

PASSIVE MICROWAVE COMPONENTS

This 39 page catalog is representative of Microtech's capabilities in the design and manufacture of flexible and rigid waveguide assemblies and passive microwave components featuring frequencies ranging from DC to 40 GHz. Items manufactured include, but are not limited to, couplers, terminations, windows, attenuators, and tees in both rectangular and double ridged waveguides. **Microtech, Inc., 1425 Milldale Rd., Cheshire, CT 06410. Bill Broer (203) 272-3234, TWX 710-455-3729.**

Circle 191.

GUIDE TO SIGNAL PROCESSING COMPONENTS

Mini-Circuits Laboratory will provide its free 205-page catalog, giving over 1,000 performance curves, technical application notes, reliability data, environmental specifications, frequence selection guides, features of each components, temperature ratings, schematics and dimensions, as well as pricing information. **Mini-Circuits Laboratory, 2625 East 14th St., Brooklyn, NY 11235. Harvey Kayile. (212) 769-0200.**

Circle 209

[Continued on page 90]

[*From page 89*] **CATALOG UPDATE**

STRUCTURAL COMPONENTS CATALOG

Newton Instruments pocket size catalog lists the manufacturer's complete line of structural components for the communications industry. Distribution frames, cable racks, equipment racks, frames and hardware in all sizes are schematically detailed. **Newton Instrument Company, Inc., Box 2915, Durham, NC 27705. (919) 596-8251.**
Circle 193.

"LAMI-NETS" BROCHURE

A six-page brochure describing the North Hills "Lami-Nets" technology is available. The literature describes an approach to combining thermal lamination packaging techniques with integrated microwave stripline assemblies resulting in lightweight, rugged, low-cost 'super-components'. Both active and passive elements can be used in basic microwave assemblies. Active elements include mixers, detectors, amplifiers and diode switches and attenuators. Passive elements include filters, isolators, couplers, attenuators and dividers. North Hills will combine these elements into complete, laminated stripline microwave circuits to customer specifications. **North Hills Electronics, Inc., Glen Cove, NY 11542. John Mruz (516) 617-5700.**
Circle 195.

DC COUPLED DETECTOR/LOG VIDEO AMPLIFIERS

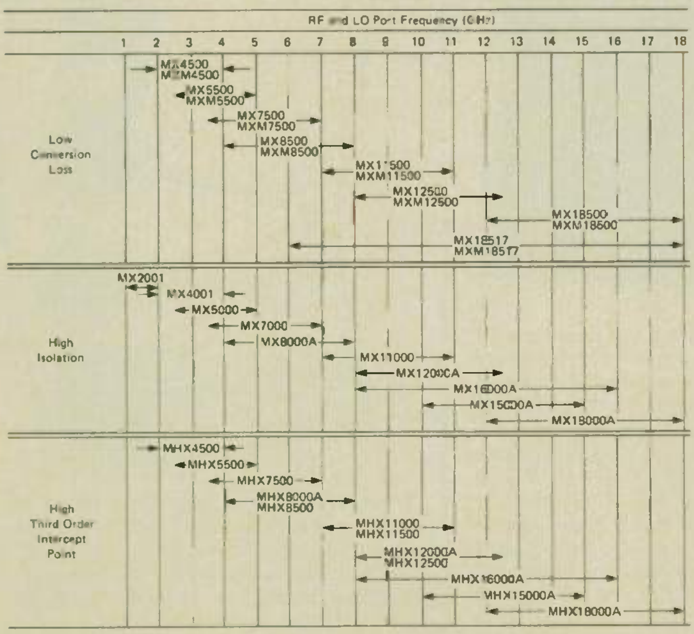
This literature provides a profile of DLVA products available in the 1 to 18 GHz frequency range. Catalog includes technical data, tracking graphs, and stability over temperature graphs. All models are available for immediate delivery in standard configurations. **Norlin Communications Microwave Systems, 9125 Gaither Road, Gaithersburg, MD 20760. Bruce Duerson (301) 948-5210.** **Circle 194.**

[*Continued on page 92*]

When Timing Is Important You Can Count On AERTECH For Mixers

- RF Frequencies from 2 to 18 GHz
- IF Frequencies to 5.2 GHz
- Guaranteed Isolation Greater Than 23 dB
- Guaranteed Conversion Loss Less Than 6 dB
- Delivery, Stock to 90 Days

Double Balanced Mixer Selection Guide



Whether your application is communications, EW, or radar, Aertech can deliver mixers when you need them . . . in fact many of the standard production units shown here are available from stock. In addition, mixers can be integrated with other Aertech components such as amplifiers, isolators, and PIN diode modules to provide complete subsystems.

Contact us today for fast service on all your mixer requirements . . . or send for our detailed brochure.

Aertech INDUSTRIES

a subsidiary of TRW

825 Stewart Drive, Sunnyvale, CA 94086, (408) 732-0880, TWX: 910-339-9207

CIRCLE 73 ON READER SERVICE CARD

[From page 90] **CATALOG UPDATE**

MEASUREMENT SYSTEM DATA SHEET

A data sheet on the new NS20 network measurement system is offered. The instrument described is an RF source and network analyzer in a single system design. The stand-alone system offers high accuracy and the highest degree of automation available with today's technology. Delineated in the data sheet is the complete system including the D14 mainframe, MS20 plug-in, NS201 RF module with a 2-18.5 GHz and two detectors. **Pacific Measurements Inc., 488 Tasman Drive, Sunnyvale, CA 94086. Ed Mendel (408) 734-5780.**

Circle 196.

RECEIVE AND TEST EQUIPMENT BROCHURE

This brochure features a complete line of ancillary RF receiving and test equipment. Described in the brochure are HF and VHF/UHF multicouplers, video distribution amplifiers, IF to tape and tape to IF predection converters, programmable preselectors tunable notch filters, FDM exciter and group delay set. This equipment has excellent performance specifications and can be modified to suit specific user requirements. **Reaction Instruments, Inc., 1916 Issac Newton Square, Reston, VA 22090. (703) 471-6060.**

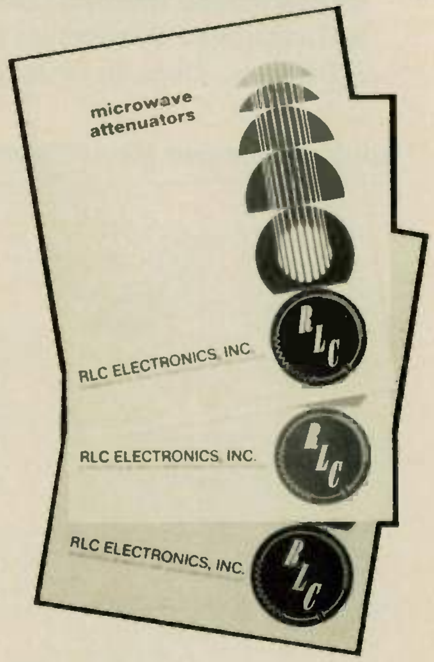
Circle 197

SPECTRUM ANALYZERS

New 16-page brochure describes their 600B Series spectrum analyzers with new enhanced performance capabilities and versatile accessories. Design refinements and new accessories provide significantly upgraded performance capabilities. "B" Models replace the popular "A" Models with the same compact size, easy to use controls, and internal digital memory and data processing interface. The third generation includes many circuit improvements, RF module integration and a new IF design to provide enhanced performance. **Polarad Electronics, 5 Delaware Drive, Lake Success, NY 11042. Joe Schindler, (516) 328-1100.**

Circle 210

FILTER, SWITCH AND ATTENUATOR LITERATURE



Three six page, four color microwave data sheets detailing coaxial switches, filters and attenuators cover specifications, applications price and ordering information. **RLC Electronics, Inc., 83 Radio Circle, Mt. Kisco, NY 10549. (914) 241-1334.**

Circle 198.

[Continued on page 94]

PEAK PERFORMANCE FROM YOUR SATELLITE EARTH STATION

. . . with Avantek low-noise and medium-power amps.

You can count on high performance and long-term reliability with Avantek low-noise and medium-power satellite communication amplifiers.

Avantek has a wide variety of amps for you to choose from. Our 6 GHz uplink drivers put out 5 watts of RF power with exceptional linearity. Our 4 GHz downlink amps are already offering superior performance in numerous systems worldwide, with noise figures as low as 80°K. And our advances in GaAs FET technology now let us offer lower noise figures at 12 GHz.

Fully integrated front ends simplify your downlink system architecture and reduce overall cost. Avantek is the leading supplier of integrated uplink and downlink assemblies for Inmarsat, including the transmitting power amplifier.

Choose the *quality* manufacturer.

Whether you're designing a satellite system for CATV, data or other commercial or military communications, Avantek has a high performance amp to fit your need.

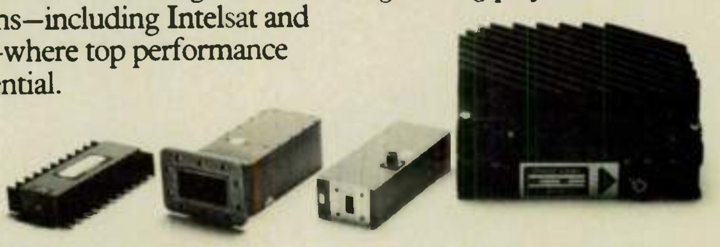
Avantek components have been proven in leading satellite systems—including Intelsat and SBS—where top performance is essential.

All Avantek amps are backed by the manufacturing innovation, rigid quality controls and full technological integration that have made us the leader in low-noise and medium-power amps. These amplifiers use many of the same space-qualifiable transistors that are on the satellites themselves.

We'd like to help *you* build an exceptional earth station. For more information or a free copy of our 1981-1982 catalog, contact your nearest Avantek representative. Or write, telex or call us today.

Avantek, Inc., 3175 Bowers Avenue, Santa Clara, CA 95051. Telex 34-6337. TWX 910-339-9274. Phone (408) 496-6710.

Contact Avantek regarding current openings for Microwave and Telecommunications Engineering professionals.



Avantek

Avantek is a vertically integrated company.

10 MHz - 4 GHz AMPLIFIER BROCHURE

This 8 page Trontech amplifier brochure provides technical information, application data, and specifications for the low noise and medium power amplifier product line. Over 150 models are listed from the frequency band of 10 MHz through 4 GHz. **Trontech, Inc., 63 Shark River Road, Neptune, NJ 07753. Charles Brand (201) 922-8585.**

Circle 199.

FERRITE DEVICES AND FILTERS BROCHURE

A brochure detailing a complete product line of ferrite devices and filters is offered — including complete table specifications and updated information on applications for isolators, circulators, filters and special designs. This 10-page catalog includes product photographs, performance curves and schematic diagrams. UTE Microwave Inc., 3500 Sunset Ave., Asbury Park, NJ 07712. Tel: (201) 922-1009; TLX: 132-461 UTE APK. **Circle 211**

10 MHz - 40 GHz MICROPROCESSOR-BASED SWEEP GENERATOR BROCHURE

A new family of microprocessor-based sweep generators covering the 10 MHz to 40 GHz range is described in this 24-page 6600 Series brochure. Also included is the 560 Scalar Network Analyzer which when used with the 6600 Sweep Generator forms a network analyzer system with 40 dB directivity over the 10 MHz to 18 GHz continuous-sweep range. Graphics illustrate controls, test setups, applications, accuracy characteristics, specifications, and test results. This informative brochure documents recently developed techniques for making the most accurate transmission loss/gain and return loss measurements. **Wiltron Company, 805 East Middlefield Road, P.O. Box 7290, Mountain View, CA 94042-7290. Walt Baxter (415) 969-6500 Twx: 910-379-6578.**

Circle 200

MICROWAVE CABLE ADVANCE!

IW microwave cable embodies a new concept in **flexible** cable construction. When under tests from 2 to 18 GHz it finally **duplicates the attenuation loss performance of solid PTFE dielectric semi-rigid microwave cable with solid outer conductors.**

This flexible microwave cable also provides unprecedented reductions in weight, bulk, RF leakage and noise generation.

For more information please write or call Carl Anderson

Insulated Wire Inc., MacArthur Airport
Post Office Box 37
Ronkonkoma, New York 11779
(516) 981–7424

CIRCLE 77 ON READER SERVICE CARD

growth of commercial business. As a result, their investment plans are much more heavily weighted toward commercial applications than those of their British counterparts.

Peter Weissglass, Managing Director of Sweden's Institute of Microwave Technology, forecasts an explosive growth of a commercial/consumer market for microwave devices for use with satellite services in Europe. He views the satellite TV projects now underway as the basis of a rapid expansion of European domestic systems into other communications services. The 200W channels of the systems in development eliminate the need for earth terminal low noise amplifiers, reducing terminal costs significantly and expanding potential markets.

Weissglass is a firm believer in the proposition that monolithic technology is essential to products truly suitable for mass marketing. However, he questions the ability of classical microwave houses to handle such markets and forecasts the entry of experienced mass marketeers who will simply buy the required technology.

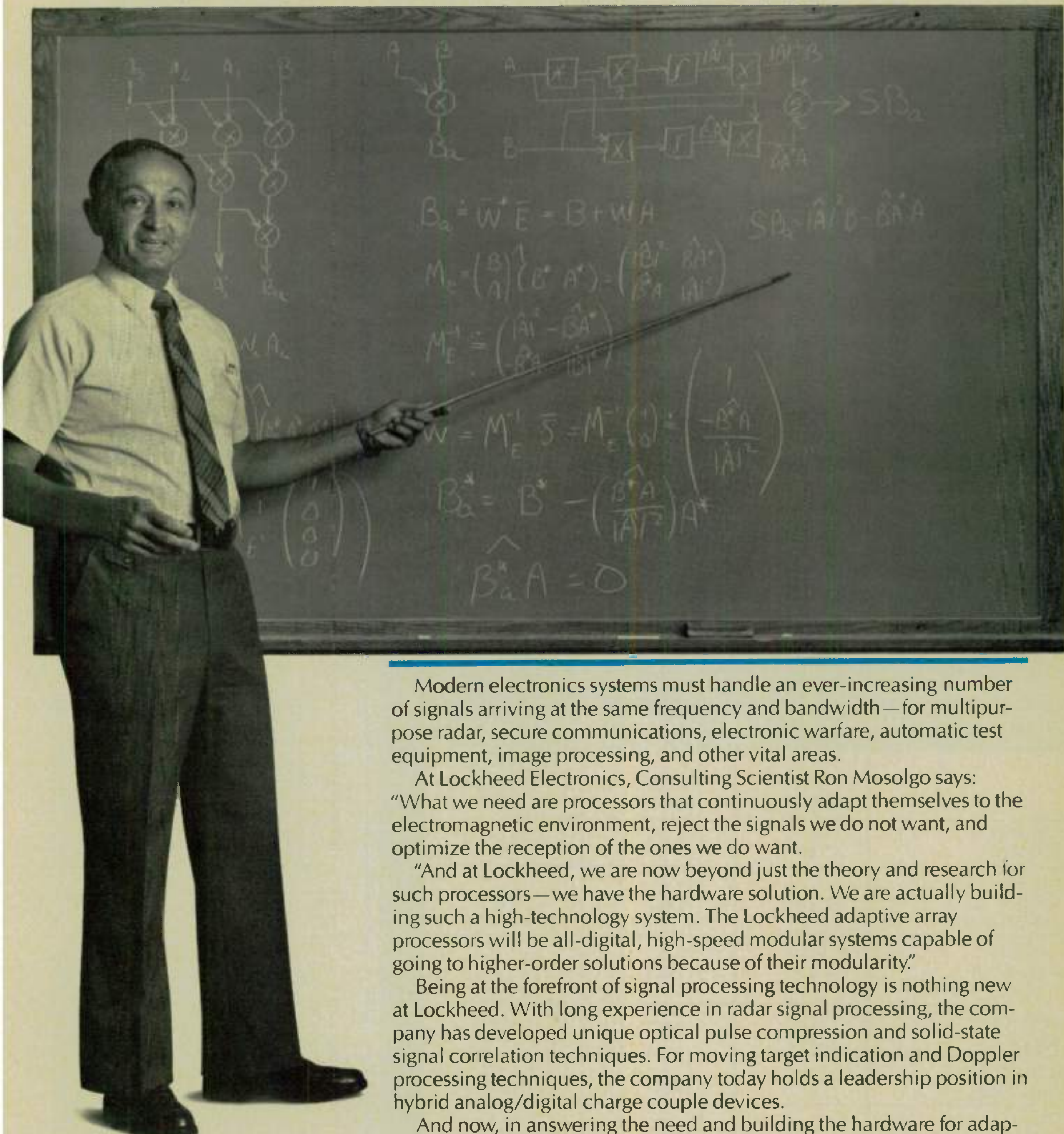
CONCLUSIONS

The heavily military-dependant UK microwave component companies are weathering a rather sudden decline in demand. At this time, there is no indication that the military markets will improve during the next 6-12 months. There is also little activity which promises to improve commercial demand in the UK in the near term. British companies are faced with prospects of little or no growth, at best, unless they can expand product lines or compete more successfully for export business. Many are more busily engaged in those efforts than they have been for many years.

Continental European manufacturers continue to enjoy the growths to which they have become accustomed during the past few years, rates comparable to those of US suppliers. The imminent growth of commercial demand on the Continent together with continuing military requirements there represent opportunities to maintain those rates. ■

Signal processing technology on the move.

Ron Mosolgo on turning adaptive processing theory into the reality of hardware.



Modern electronics systems must handle an ever-increasing number of signals arriving at the same frequency and bandwidth—for multipurpose radar, secure communications, electronic warfare, automatic test equipment, image processing, and other vital areas.

At Lockheed Electronics, Consulting Scientist Ron Mosolgo says: "What we need are processors that continuously adapt themselves to the electromagnetic environment, reject the signals we do not want, and optimize the reception of the ones we do want.

"And at Lockheed, we are now beyond just the theory and research for such processors—we have the hardware solution. We are actually building such a high-technology system. The Lockheed adaptive array processors will be all-digital, high-speed modular systems capable of going to higher-order solutions because of their modularity."

Being at the forefront of signal processing technology is nothing new at Lockheed. With long experience in radar signal processing, the company has developed unique optical pulse compression and solid-state signal correlation techniques. For moving target indication and Doppler processing techniques, the company today holds a leadership position in hybrid analog/digital charge couple devices.

And now, in answering the need and building the hardware for adaptive array processors, Lockheed is once more leading the way.

Lockheed Electronics

CIRCLE 79 ON READER SERVICE CARD

PRODUCT FEATURE

Low Noise For Less

MICROWAVE ASSOCIATES
Burlington, MA

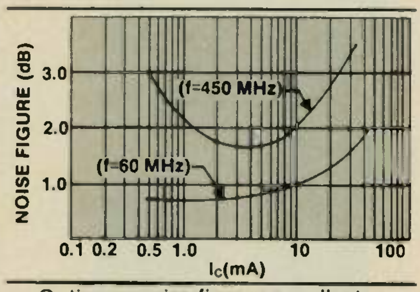
A new low cost, low noise NPN transistor, the MA 42197, is available for commercial applications including TV, CATV, radio links and IF amplifiers.

The MA 42197 is priced at less than $1.00 in quantities of 1,000 ($3.90 each in 1-99 quantities) and is encased in a TO-92 package.

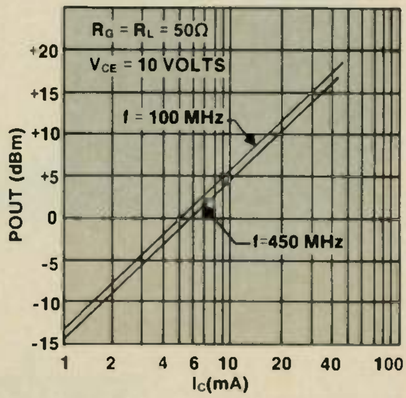
The MA 42197 is a silicon planar transistor with interdigitated geometry. At Ic = 5 mA, 60 MHz noise figure is 1 dB maximum and gain at 1 dB compression is 28 dB. Performance at 450 MHz at Ic = 5 mA includes a noise figure of 1.7 dB and gain of 14 dB.

Typical noise figure and power output curves are shown below.

Detailed data sheets and sample transistors are available from Microwave Associates Semiconductor Department at (617) 272-3000. ■ **Circle 213.**



Optimum noise figure vs. collector current @ 60 and 450 MHz.



Typical power output @ 1 dB compression point vs. collector current.

Microwave Products

Subsystem

Ku TO C BAND TRANSLATOR

Model DC12/4 Ku to C-band frequency translator provides block down conversion of the 11.7 to 12.2 GHz satellite frequency assignment to 3.7 to 4.2 GHz converting C-band receiving equipment to Ku-band use. The unit can also be used to downconvert a Ku-band video signal into an unused channel in a 24 channel C-band TV receiver at a cable TV head end. The DC12/4 interfaces directly with a 12 GHz LNA and 4 GHz receivers or converters and is suitable for video, message or data carriers. The self-contained unit is designed for unattended operation and has a remote summary alarm, and front panel monitors for key operating parameters. Designed for rack mounting the unit measures 1 3/4" in height. **LNR Communications, Inc., Hauppauge, NY. Nancy Wagner (516) 273-7111.**

Circle 170.

Device

0.5 μm GaAs FET

Series ALF 3000 is a 0.5 μm gate GaAs FET for oscillator and low noise amplifier application up to and above X-band frequencies. The device features a recessed gate structure and is available in chip and packaged form. Typical performance of the chip is 0.9 dB noise figure, 13.5 dB associated gain at 4.0 GHz, and 1.5 dB noise figure, 11.0 dB associated gain at 8.0 GHz. Price: $62.50 in 100 quantity. Availability: stock. **Alpha Industries, Inc., Woburn, MA. Nancy Knowlton (617) 935-5150.**

Circle 145.

HYPER ABRUPT TUNING DIODES

Diode types KV 3201, 3901 and 3902 offer capacitance swings as high as 8 to 1 from 3 to 25 V and 3 V capacitance values of 11, 25 or 29 pF. The low inductance devices have Q values up to 400 at 50 MHz and can be used up to 1 GHz in voltage controlled oscillators and filters. All types are available taped and reeled for automatic insertion and are sealed in hermetic glass DO-34 packages. Price: from 64¢ to 70¢ each (100-999). Delivery: 60 days in production quantities. **Frequency Sources, Semiconductor Division, Chelmsford, MA. (617) 256-8101.**

Circle 151.

Instrument

POWER METER THERMISTOR MOUNT

Model TM400 thermistor mount features installation of replacement thermistors; high sensitivity thermal compensation and is calibrated for effective efficiency. The assembly consists of four thermistor elements selected for matched thermal and resistive characteristics. Detector and thermal compensation elements are isolated thermally from the aluminum case and the tightening nut for the connector has a plastic jacket for maximum thermal isolation. Model TM400 is interchangeable with and equivalent to the HP478A thermistor mount and is normally used with the HP4318 power meter. **Micronetics, Inc., Norwood, NJ. Gary Simonyan (201) 767-1320.**

Circle 168.

DIGITAL STORAGE OSCILLOSCOPE

Model PR8101 digital storage oscillator oscilloscope features a 20 MHz sample rate, a 10MHz bandwidth, 8 bit resolution, 4K memory (expandable to 8K), dual channel, pre and post trigger data capture, cursor control and IEEE-488 interface. The model also features dual mode capability functioning as an analog oscilloscope in 'real-time' mode and providing for single sweep storage in the 'stored' mode. Price: $5400. **Micro-Pro, Inc., Colmar, PA. John Grimes (215) 822-8971.**

Circle 169.

World Conference — ITU Plenipotentiary

Delegates from 155 Countries
Nairobi, Kenya — October 1982

PLENICOM 82

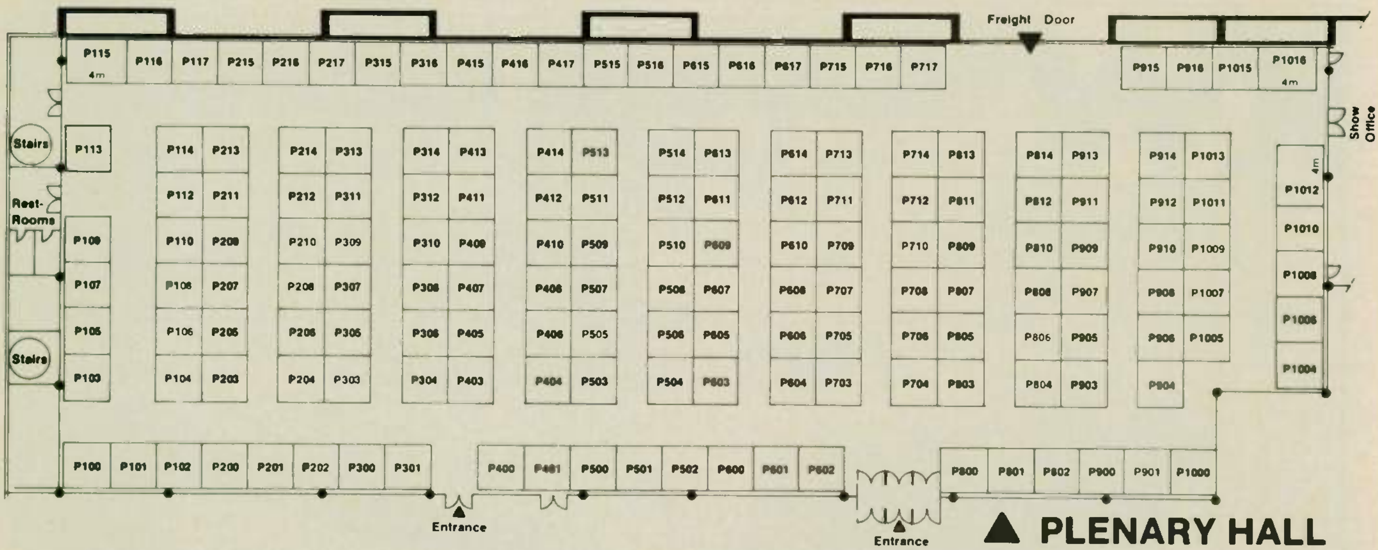
AN INTERNATIONAL TELECOMMUNICATIONS EXHIBITION

Horizon House Expositions, Inc. announces PLENICOM, an international telecommunications exhibition to be held concurrent with the World Conference of the ITU Plenipotentiary in Nairobi, Kenya, October 1982. The merging of the developed and developing worlds for telecommunications becomes possible at the time of PLENICOM. The market for products is best identified with the needs and programs of all 155 member countries attending the Plenipotentiary Conference. There is no other occasion in the decade of the 80's that represents the prestigious assemblage meeting in Nairobi, Kenya, in October of 1982 for the Plenipotentiary Conference. It is inconceivable that any company providing a product or service can afford to miss this priceless opportunity. The Government of Kenya has recognized the great value of this meeting by establishing the agreement and authorizing the establishment of an exhibition for this occasion.

The ITU Plenipotentiary Conference is an assembly of senior officials - Ministers, Vice Ministers, Directors General, Chief Planners and Systems Engineers - those individuals directly responsible for purchases of equipment used in the national networks.

As the UN agency that coordinates the planning and operation of the world's national and international networks, the ITU convenes its Plenipotentiary Conferences at irregular intervals - the last being in 1973. Thus, it is almost a decade since there has been a comparable gathering of top telecommunications officials. Their stature and competence emphasize the importance of decisions made at a Plenipotentiary - major economic and political policy issues as well as a range of technical, operating and equipment considerations affecting radio, telephone, telex, satellite, digital switching and transmission, and data.

At present, the plans are to open the Plenipotentiary Conference on September 28, 1982. The exhibition, while presently scheduled for October 11, reserves the right to move the schedule forward by one week to open on October 4 if the plans and programs of the Conference change. The exhibition is to start at the time nearest the conclusion of the opening ceremonies, at which time the key political figures involved with this exhibition are able to schedule themselves to participate in this program. Adequate notification will be provided to all exhibitors and potential attendees to the exhibition of any changes should they occur.



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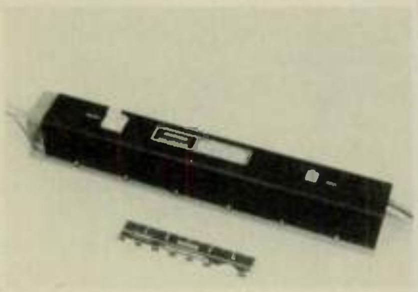
Model 4101 modulation meter is capable of automatically measuring either AM or FM modulation of RF signals in the 1.5 MHz to 2.0 GHz frequency range at levels as low as 3 mV. Standard-de-emphasis networks of 50, 57 and 750 μsecs are selectable making Model 4101 useful for checking FM transmitters and two-way transceivers. De-emphasis networks may be turned off when checking signal generators or other linearly modulated signals. A variety of ranges are selectable to assure maximum meter deflection for any modulation level. Price: $1095 (domestic U.S.) Delivery: 30 days. **Wavetek Indiana, Inc., Beech Grove, IN Jerry Bush (317) 787-3332.**

Circle 175.

TUBE



TWT FOR SATELLITE TERMINALS

Model 677H traveling-wave tube provides 125 watts of CW output power over the frequency range of 5.925 to 6.425. The tube is metal-ceramic construction with PPM focusing and conduction cooling. A modulating anode is utilized for switching beam current during normal operating sequencing and under fault conditions. A standard "Pierce" design is used for the electron gun, and the collector is single-staged depressed type with conduction cooling to the baseplate. Alnico VIII magnets provide the focusing field, and the coaxial input and output connectors provide a low-profile package. **Hughes Electron Dynamics Division, Torrance CA (213) 517-6000.**

Circle 177.

14 GHz EARTH STATION TWT

Model TH3639 traveling wave tube is a 160 watt, 14 GHz brazed-helix traveling wave tube for both national and international satellite communications systems. The tube is designed primarily for small, unattended stations. Tube cooling is by conduction only, beam confinement is by permanent magnets and the overall efficiency is about 28%. **Thomson — CSF Electron Tubes, Clifton, NJ. (201) 779-1004.**

Circle 159.

Material

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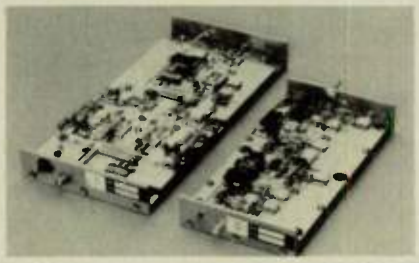
Amplifier

900 MHz RF AMPLIFIER

Model LNA1100 amplifier provides typical gain of 13 dB in the 20 to 900 MHz range and a noise figure of 3.0 dB at 900 MHz. The unit features typical gain flatness of ± 0.5 dB, maximum input and output SWR of 2.0 in a 50 system and typical output power at 1 dB of compression of 6 dBm. The unit is a self-contained hybrid general purpose amplifier with all bias, matching and de-coupling components in a TO-8 package. Price: $65.00 each in 100 quantity. Availability: from stock. **TRW Semiconductors, Lawndale, CA. (213) 679-4561. Circle 157.**

100 W VHF AND UHF OEM AMPLIFIERS



Models V100 and U100 wideband amplifiers allow operation at 100 to 160 MHz and 225-400 MHz in 100 watt increments. The units require 28VDC, 10 A maximum and 2-4 W drive for Class AB operation, and harmonics are -20 dB. The V100 and U100 may be combined in pairs or quads to achieve a high power wideband system. Price: $695 each (1-3) for V100; and $1295 each (1-3) for U100. Availability: from stock to 30 days. **RF Power Labs, Inc., Woodinville, WA. Larry Kezner (206) 481-8833. Circle 154.**

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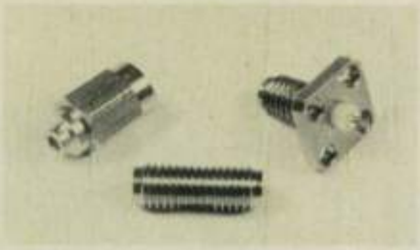
TVRO REMOTE ANTENNA POST AMPLIFIER

Model IFLA 463 TVRO post amplifier covers the frequency range from 950 to 1450 MHz with 40 dB gain and a noise figure of 5 dB. The amplifier is available as a single unit or as part of a dual redundant panel with single or redundant power supply. The Model IFLA 463 is designed for use in satellite video receiving terminals where the TVRO antenna must be located at a signicant distance (up to ½ mile) from the receiver electronics. The unit is compatible with block down conversion receivers using the industry standard 1 GHz interface. Price: $600.00. Delivery: stock. **Hughes Microwave Communications Products, Torrance, CA. (213) 517-6100.**

Circle 166.

40 GHz SSMA CONNECTORS



SSMA type coaxial connectors operate over the DC to 40 GHz range with a SWR of 1.05 +.010 f(GHz), insertion loss of .05 dB. Cable connectors are available in plug and jack configurations with flange types for .085, .047, and .034 diameter semi-rigid and RG-315 cable. Price: from $3.90 each in 100-249 quantity. Delivery: 12 weeks ARO. **Solitron/Microwave Connector Division, Port Salerno, FL. (305) 287-5000**

Circle 212

THE ELECTRIFICATION OF EGYPT — PART II

Co-sponsored by the Ministry of Electricity of Egypt In cooperation with the Egyptian Insitute of Electrical Engineers (EIEE).

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Microwave Products

MARISAT L-BAND AMPLIFIER

Model LA6046 solid state power amplifier delivers 45 watts CW from 1636.5 to 1645.0 MHz with an input drive level of 100 mW. The amplifier may be internally leveled to provide power flatness of ±0.5 dB over an operating temperature range of -41° C to +65° C, operating voltage is +28 VDC at 6.0 amps maximum. Harmonics are specified at -10 dB for the second and third and -50 dB for all others from 5 to 40 GHz. Non-harmonic spurious is specified at -75 dB between 200 and 5000 MHz and -85 dB from 5 to 40 GHz. Incorporated in the amplifier is a forward and reflected power monitor and a detected RF power output monitor. Overall size of the unit is 1.25 x 2.5 x 7.5 inches excluding projections and weight is 1.75 lbs. Amplifiers are available with output powers to 70 watts. **RFD, Inc., Tampa, FL. (813) 872-1502.**

Circle 155.

Microwave Products

Component

SUB-NANOSECOND ECL CLOCK TO 500 MHz

Model CO-533KE clock oscillator provides a stable ECL 100K sub-nanosecond logic compatible output at any specified frequency in the 150-500 MHz frequency range. The oscillator operates from -4.5 VDC, with -5.2 VDC operation optional. The unit is factory set to within ±.001% of the specified frequency and a frequency adjustment for setting to within ±.0001% is an available option. The standard model provides stability better than ±.0025% over 0° to 70° C; with higher stability and wider temperature range models available. Price: from $275 for 1-4 quantity. Delivery: 5-10 weeks. **Vectron Laboratories, Inc., Norwalk, CT (203) 853-4433.**

Circle 176.

DOUBLE-RIDGE WAVEGUIDE

The frequency range from 3.5 to 18 GHz is covered by three double-ridged waveguide sizes; WRD350, WRD475, WRD750. Components available for each size include 90° E and H plane bends, 90° twists, straight sections, bulkhead feed-thrus and matched terminations. Special variations of the standard units are available upon request. **ARRA, Inc., Bay Shore, NY. Mike Geraci (516) 231-8400.**

Circle 141.

0.5 TO 18 GHz MIXER

Model MD-170 mixer covers the 0.5 to 18 GHz range and features a +12 dBm 1 dB compression point and an 8 dB typical conversion loss. The mixer has an IF bandwidth of 2 to 5000 MHz and a port-to-port isolation of better than 20 dB. The MD-170 is designed for military application and comes in a hermetic drop in module or a connectorized housing. Price: $565, in small quantity. Delivery: from stock. **Anzac Division, Adams Russell, Burlington, MA. (617) 273-3333.**

Circle 142.

3 GHz ATTENUATORS

Model AT-53 coaxial fixed attenuators for use from DC to 3 GHz are available in 1 dB steps from 1 thru 10 dB and 2 dB steps from 10 thru 20 dB. The units exhibit a SWR of 1.2 nominal and 1.35 maximum, and are supplied in 50 ohm nominal impedance in BNC, TNC, and SMA connectors. Price: from $15.00 to $20.50 depending upon connector type. Availability: stock to 30 days ARO. **Elcom Systems, Inc., Boca Raton, FL L. Pollachek (305) 994-1774.**

Circle 147.

1.0 - 18.0 GHz MICROWAVE QUADRUPLEXER

A miniature microwave quadruplexer divides the frequency range from 1 to 18 GHz into four channels: 1 to 4 GHz, 4 to 7 GHz, 7 to 11 GHz and 11 to 18 GHz. Cross-over loss is 5 dB maximum with a maximum band insertion loss of 1.2 dB to within 3% of crossover. SWR is 2.0. The unit measurers 2.8 x 2.6 x .81 inches. **Contours Div. Frequency Sources, Inc., Sunnyvale, CA. Leon Becker (408) 727-8500.**

Circle 152.

TV BASE-BAND SPLITTER

Model 3329 VB separates or combines base band audio and video signals. Audio output loss is 4.0 dB maximum while video output has a maximum roll-up (at 4.2 MHz) of 4 dB. Mutual isolation is 25 dB and return loss is greater than 15 dB. The unit has 75 ohm impedance and type F connectors. Price: $58.00. Delivery: 10 days. **Microwave Filter Company, Inc., East Syracuse, NY Emily Bostick (800) 448-1666.**

Circle 163.

Microwave Products

Ku-BAND DUAL CHANNEL ROTARY JOINT

Model FRJ2660 Ku-band dual channel rotary joint offers an SWR of less than 1.3 and a power handling capability of 20 W CW. The unit has a sum channel insertion loss of 0.20 dB maximum and a difference channel loss of 0.35 dB maximum. **Sage Laboratories, Inc., Natick, MA. Ken Paradiso (617) 653-0844.**

Circle 161.

OCTAVE BAND DIGITAL ATTENUATORS

Eight models of series 345 programmable PIN diode attenuators cover the frequency range from 0.5 to 18 GHz in octave or greater bandwidths and provide 60 dB of attenuation in steps as low as 0.25 dB with binary or BCD logic. Each unit is an integrated assembly of a PIN diode attenuator, and a driver consisting of a hybridized V/I converter and 8-bit TTL compatible D/A converter. A connection is available to monitor the D/A converter output, or apply an over-riding analog control signal. Accuracy of attenuation at 60 dB is within ± 1.5 dB at +25° C. The operating range is -65° C to +110° C with a temperature coefficient of ± 0.03 dB/° C. The 8 - 18 GHz model measures 2 x 3 x 0.8 inches, the largest unit for 0.5 - 1 GHz is 2.56 x 3 x 0.85 inches. **General Microwave Corporation, Farmingdale, NY. Moe Wind (516) 694-3600.**

Circle 153.

.141 CABLE SMA PLUG

Part No. 55-624-2003-31 is an SMA cable plug for .141 semi-rigid cable featuring an internal thick wall design which provides a stainless steel mating face over the soft copper cable jacket. The thick wall design prevents flaking and smearing of the copper across the teflon butt mating surfaces , serves as a built-in stop for the cable jacket eliminating the usual fixturing and the cable dielectric remains in place after soldering and trimming. **RF Components Division, Sealectro Corporation, Mamaroneck, NY (914) 698-5600.**

Circle 156.

10 μS FREQUENCY SYNTHESIZER

Model 6802 direct frequency synthesizer covers 750 to 1000 MHz in 1.0 MHz steps with +15 dBm output. Switching time is 10 μs, spurious outputs are less than -50 dBc and harmonics less than -25 dBc. Phase noise measured in a 1 Hz bandwidth is -75 dBc at 100 Hz, -85 dBc at 1 kHz and -100 dBc at 100 kHz. Inputs are a 10 MHz reference which establishes the long term stability, +28 and +5 volts and TTL compatible, BCD commands on 10 lines. The unit measures 40 cubic inches. **Zeta Laboratories, Inc., Santa Clara, CA. (408) 727-6001.**

Circle 158

2.5 TO 18 GHz ATTENUATORS ARE FLAT THROUGH X AND Ku BANDS

Series 960 lossy-line attenuators are designed for signal level control in the 2.5 to 18 GHz frequency range. The 12 models in the series are for level setting and channel balancing where flatness of attenuation and minimal phase shift vs. attenuation are of prime consideration. The uncalibrated 960 and calibrated 961 are thumb wheel controlled and are suited for bread board application; Model 929 is designed for system applications requiring low RF leakage and are varied with a screw adjustment. Model 963 is suited for measurement system level setting with rapid movement slider control. Each model is available in 3, 6, or 10 dB values. Linear phase shift is 1°/dB x f(GHz); insertion loss is less than 1.0 dB and frequency sensitivity is less than 1.0 dB. **Weinschel Engineering, Gaithersburg, MD. (301) 948-3434.**

Circle 160.

Microwave Products

SMALL EARTH STATION VTO AND MIXER

Model TVO-8370 varactor tuned oscillator covers the 3.6 to 4.2 GHz frequency band (optional coverage of 3.5 to 4.1 GHz and 3.7 to 4.3 GHz is available) with a minimum of 10 mW output power and typical output power variation of ±0.5 dB over the full tuning range. It features -90 dBc/Hz at 50 kHz offset from the carrier. Typically the TVO-8370 will operate with all specified performance characteristics into a 2.0 VSWR. It requires 15 VDC at 50 mA maximum bias, and maximum tuning voltage of 14 VDC. Model UMX-4220 double balanced mixer is optimized for 3.7 to 4.2 GHz RF-port operation and will accept an LO frequency range of 2.4 to 5.5 GHz. IF-port response is DC to 1.3 GHz and the mixer features 6.0 dB maximum, SSB conversion loss and 0.2 dB maximum peak-to-peak conversion loss and 0.2 dB maximum peak-to-peak conversion flatness over any 40 MHz segment of the 3.7 to 4.2 GHz RF range. Price: TVO-8370, $64.00; UMX-4220, $38.00 both in 100 quantity. Delivery: 15-30 days ARO. **Avantek, Inc., Santa Clara, CA. Mark Sellnger (408) 496-6710.**

Circle 162.

CONNECTOR FLANGE GASKET

Model 4780 connector RFI-EMC shielding flange gasket fits standard BN/BNC flanges and Model 4795 fits standard type N and UHF flanges. Both gaskets feature monel fibers for positive electro-magnetic shielding. Price: Model 4780: $3.50, Model 4795: $3.20. Delivery: 3-4 weeks. **ITT Pomona Electronics, Pomona CA. Carl W. Musarra (714) 623-3463.**

Circle 173.

MICROMINIATURE BANDPASS FILTER

A typical microminiature bandpass filter from a new series has a center frequency of 180 MHz, a 1 dB bandwidth of 60 MHz, 3 dB bandwidth of 75 MHz and 40 dB isolation from DC to 120 MHz and above 240 MHz. Insertion loss at center frequency is 2 dB. The unit measures .4 x .4 x 1.8 inches. Filters are available with spurious free response to 12.4 GHz. Price: from $250.00 in unit quantity. Availability: 6 weeks for small quantity. **RLC Electronics, Inc., Mt. Kisco, NY. Alan Borck (914) 241-1334.**

Circle 174.

40 GHz PLUG/JACK ADAPTOR

Model 9128 SM connector plug/jack adaptor operates over the frequency range from DC to 40 GHz. The unit features 1.3 maximum SWR, a maximum insertion loss of .05 db x f (GHz) and is designed for use as a connector saver or as a referenced two port device in network analysis. The body is stainless-steel and the center contact and complete transmission path is beryllium copper. The unit is 0.54 inches long. The connector is designed to interface with and directly replace subminiature connectors having a 10-36 UNS-2A thread size. **Kevlin Microwave Corporation, Woburn, MA. (617) 935-4800.**

Circle 164.

OCTAVE MIXERS COVER 1 TO 6.4 GHz

A series of octave band double balanced mixers operate down to 0 dBm LO power without external bias. Conversion loss is 6 dB maximum at frequencies above 2 GHz, 7dB, typical, from 1-2 GHz. IF frequencies up to 500 MHz are standard for models operating down to 1 GHz; others offer IF's to 1 GHz. (1-2 GHz) Units measure 1 x 1 x 3/8". Price: Model 1250: $275.00. Availability: stock to 8 weeks for straddle and octave bands. **Norsal Industries, Inc., Central Islip, NY. (516) 234-1200.**

Circle 165.

Microwave Products

DIODE HOLDER

Diode holders for securing and tuning microwave diodes into precise attitudes for optimum circuit performance are offered. The self-locking constant torque drive mechanism of the rotor screw maintains low dynamic tuning noise and high Q throughout the full excursion of the diode holder travel. The unit facilitates one-hand tuning and lessens mechanical tolerances in circuit fabrication and provides precise adjustment resolution. Applications include impatt diode transmitters, high-power waveguide limiters and switches, Gunn oscillators, detectors and mixers. Price: less than $5.00 each in 1,000 quantity. Availability: 8-12 weeks. **Johansan Mfg. Co., Boontan, NJ. Bob Kapner (201) 334-2676.**

Circle 171.

COAXIAL LOWPASS FILTERS

Series HPL/KW coaxial lowpass filters for cutoff frequencies from 30 MHz to 450 GHz can handle up to 10 kW average input power and feature a 13 pole Zolotarev design. SWR is less than or equal to 1.2 to 1.35 up to fc. Typical response for Model A versions with a signal passband of 0.6 to 1.0 maximum free signal passband is 5:1; Model B with a signal passband of 0.2 to 1 fsp maximum is 5:1. Passband insertion loss is less than 0.3 dB (fps) and spurious levels are typically greater than 60 to 80 dB greater than 2.4 GHz. Average input power rating is up to 10 kW (continuous) into a matched load; up to 2.5 kW (short term) into an open or shorted load; and up to 5 kW (continuous) with a 3:1 SWR load. Filters are supplied with type SC, HN or N right-angle connectors. **CIR-Q-TEL, Inc., Kensington, MD. Paul Leo (301) 946-1800.**

Circle 140.

DIODE SWITCH COVERS 2-3000 MHz

Model SW-2000-1 SPST PIN diode switch covers the frequency range from 2 to 3000 MHz. The unit features 50 ohm impedance and SWR of 1.25 maximum. Insertion loss is typically 0.8 dB to 400 MHz, 1.2 dB to 1000 MHz, 2.1 dB to 2000 MHz, and 3.3 to 3000 MHz. Switching speed is typically 5 μs; power handling is 2 watts CW and harmonics are -60 dBc at 0 dBm. On-to-off isolation is 70 dB, minimum to 2000 MHz and 60 dB, minimum to 3000 MHz. Price: (1-9) $230.00. Delivery: from stock. **American Microwave Corporation, Damascus, MD. (301) 948-6800.**

Circle 143.

VOLTAGE CONTROLLED OSCILLATORS

Series C8000 voltage controlled oscillators provide center frequencies between 8 and 13 GHz with a 6% electronic tuning range. Output power is +10 dBm minimum over a temperature range of -20° C to 65° C., D.C. input voltage is between -5 and -18 V depending on frequency, with tuning voltage typically 0 to -25 VDC. Spurious outputs are -60 dBc maximum and phase noise is -85 dBc/Hz maximum 100 kHz from the carrier. Price: From $1,400 for small quantities. **Ad-Tech Microwave, Inc., Scottsdale, AZ. R.C. Havens (602) 998-1584.**

Circle 144.

20 - 500 MHz 20 W SWITCH

Part No. 100C1592 is a SP2T solid state 20 watt CW switch which covers the 20 to 500 MHz frequency range. Insertion loss is .5 dB maximum (20-300 MHz) and .75 dB maximum (300-500 MHz), isolation is 65 dB minimum (20-300 MHz) and 55 dB mini-mum (300-500 MHz) and SWR is 1.2 maximum at 20 - 300 MHz and 1.25 at 300 - 500 MHz. The switch contains an internal single line TTL driver and switching speed including driver delay in 10 μs maximum. DC power required is +5 V at 220 mA, -15 to -30 V at -20 mA. **Dalco Industries, Inc., Compton, CA. (213) 631-1143.**

Circle 146.

Microwave Products

3.7 - 4.2 GHz POWER DIVIDER

Model D1634M is 16 way isolated stripline power divider covering the frequency range from 3.7 to 4.2 GHz. It provides a minimum output isolation of 20 dB between adjacent boards with typical isolation figures as high as 25 to 30 dB. The unit can be utilized as either a power divider or combiner with a maximum SWR of 1.25 in either case. Total passive insertion loss is 1.2 dB maximum with a typical amplitude balance over any 40 MHz bandwidth is less than .01 dB, full frequency band amplitude balance is ± 0.3 dB and phase symmetry of balance is maintained over the full frequency within ± 4° maximum. The unit operates over the -55 to + 125 C temperature range with power handling capabilities up to 50 watts CW, 3 kW peak. Price: $275 per unit in small quantities. Delivery: from stock. **Engelmann Microwave Company, Boonton, NJ Carl Schraufnagl (201) 334-5700.**

Circle 149.

ZERO BIAS SCHOTTKY DETECTORS

Model DZN19 zero bias Schottky detector offers a frequency range of 100 kHz to 21 GHz with a K factor of 1000 minimum open circuit and 600 minimum with a 3K ohm load. Flatness is ±1.5 dB, (±.76 dB 10 MHz to 14.5 GHz), TSS is -53 dBm minimum and the square law region covers -10 dBm to -35 dBm. Model DZN20 operates over the 100 MHz to 18 GHz frequency range with a TSS of -51 dBm minimum; all other specifications are the same as those for DZN19. Units are supplied with SMA male inputs and SMA female output in a 1.17" long package. Price: DZN19, $210 and DZN20, $195.00. Delivery: 6-8 weeks ARO. **Omniyig, Inc., Santa Clara, CA (408) 988-0843.**

Circle 172.

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New Literature

LOSSLESS FEEDBACK AMPLIFIER BROCHURE

A brochure describing the application of lossless feedback technology to RF amplifiers for improved noise figure and output performance power is available. The publication details design approach, expected performance improvements and includes a list of the manufacturer's lossless feedback products. **Anzac Division, Adams Russell, Burlington, MA (617) 273-3333.**
Circle 131.

LOW LOSS DIELECTRICS BROCHURE

A six-page full color brochure describes the line of Di-Clad low-loss microwave PC substrates with dielectric constants ranging from 2.1 to 10. Detailed in the publication are Di-Clad 522 and 527, standards for military program designers; 810 and 806 which produce high yields on small circuits and 870 and 880 which assure reproduction of circuit designs for systems operating above C-band. **Keene Corporation, Chase-Foster Division, Bear, DE. Larry Girouard (302) 834-2100.**
Circle 132.

PIN DIODE SWITCH CATALOG

A brochure detailing a complete line of standard microwave PIN diode switches operating over the 100 MHz to 18 GHz frequency range is available. The line features a variety of switches including octave or multi-octave, current or TTL-controlled, and reflective or non-reflective units. Recent additions to the line are high-speed multi-octave multithrow switches. **General Microwave Corporation, Farmingdale, NY. Moe Wind (516) 694-3600.**
Circle 137.

STRIPLINE CIRCUIT BOARD MANUFACTURING

Literature describing the manufacturing capabilities for precision microwave stripline circuit boards is available. The 4-page illustrated brochure highlights production methods and manufacturing techniques to successfully plate-thru-holes and edges and describes bonded assemblies and the close front-to-back circuit registration available. **Soladyne, Inc., San Diego, CA. Lloyd Wigman (714) 279-7872.**
Circle 134.

SOLID STATE MICROWAVE BROCHURE

A 4-color, 16-page brochure describes a line of solid state microwave products. Amplifiers for radar applications, broadband amplifiers for electronic warfare, amplifiers for communication systems and limiting amplifiers are detailed. Included in the publication are technical discussions, warranty provisions and product descriptions. **Varian Solid State Microwave Division, Santa Clara, CA. (415) 493-4000.**
Circle 138.

ATTENUATOR DATA SHEET

Series 769 High Power Attenuator is described in this data sheet. Specifications, outline drawing and Derating Curve for the bidirectional attenuator available in 3, 6, 10, 20 and 30 dB versions are included in the literature. Coverage from DC to 6 GHz, low VSWR and flat frequency response are features of the attenuator. The unit is suited for testing in the small-signal range where high power is used for the signal source. **Narda Microwave Corporation, Plainview, NY. (516) 349-9600.**
Circle 139.

TEM CELL LITERATURE

A brochure describing a line of TEM cells for electromagnetic testing is available. Included are details for the CC-series of TEM cells with features, specifications and applications for each deliniated. **Instruments for Industry, Inc., Farmingdale, NY. Ronald Richards (516) 694-1414.**
Circle 133.

RF ROTARY JOINT MANUAL

A 400-page technical manual for RF rotary joints contains twenty pages of technical information on the design aspects of rotary joints and three hundred and fifty pages of consumated designs are pictured and described. **Kelvin Microwave Corporation, Woburn, MA. (617) 935-4800.**
Circle 135.

GaAs MESFETS NOTE

A six page technical note, "Reliability Study of High-Power Microwave GaAs MESFETS" (Technical Note TN80901) includes data on failure modes, area of safety operation, and screening by gate leakage under RF operation. The note also explains how to eliminate gradual degradation and catastrophic failure. **California Eastern Laboratories, Inc., Santa Clara, CA. Jerry A. Arden (408) 988-3500.**
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Model Number	Test Frequency (MHz)	P_{out} Min. (W)	P_{in} (W)	Eff Min. (%)	V_{CC} (V)	θ_{JC} Max. (°C/W)
MSC 1600M	1090	600	150	35	50	0.09
MSC 1550M	1025–1150	550	150	33	50	0.09
MSC 1450M	1090	450	90	38	50	0.12
MSC 1400M	1025–1150	400	90	35	50	0.12
MSC 1350M	1090	350	70	35	50	0.20
MSC 1325M	1025–1150	325	70	35	50	0.20
MSC 1300M	1090	300	70	35	50	0.20
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MSC 1175M	1025–1150	175	30	35	50	0.30
MSC 1150M	1025–1150	150	25	35	50	0.30
MSC 1090M	1025–1150	90	13	35	50	0.60
MSC 1075M	1025–1150	75	13	35	50	0.60
MSC 1035M	1025–1150	30	3	35	50	1.00
MSC 1015M	1025–1150	15	1.5	35	50	2.00
MSC 1004M	1025–1150	4	0.5	35	28	5.00
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