November/December 1979

A Cardiff Publication

rf design

Advanced Instrument Does RF Impedance Analysis
Measuring Generator Output Impedance
Microstrip Translator Program

GET YOUR FREE SUBSCRIPTION ... SEE PAGE 9

Fluke Portable Test Instruments

"We built these two new counters for design engineers like us."

You'd expect our engineers to be biased in favor of our new counters. But when we challenged them, they quickly pointed out why they're becoming favorites of design engineers everywhere.

"The 7260A and 7261A represent the best combination of counter performance, pricing and packaging that a design engineer could want. Both incorporate Fluke-designed thick-film hybrid circuits for excellent sensitivity and flat response. Stainless steel RFI shields, switchable attenuators and low-pass filters eliminate unwanted signals. And they can be operated from optional rechargeable batteries."

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"But advanced technology means little unless the instrument does the job for you. So both feature a basic bandwidth of 125 MHz with options to 1300 MHz. Each with manual or autoranging through all measurement modes.

Model	Resolution	Max. Sensitivity	Price
7260A	100 ns	10 mV	*$850
7261A	10 ns	10 mV	*$995

Built for IEEE-488 systems.

"Fluke's exclusive portable test instrument (PTI) packaging design lets us stack and latch multiple instruments on top of our counters. And by using the new Fluke 1120A Translator, we can assemble an inexpensive IEEE-488 system."

Convincing evidence.

Our engineers are sold on our new counters. How about you? For more information call toll free **800-426-0361;** use the coupon below; or contact your Fluke sales office or representative.

*U.S. prices only.

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5004 EB Tilburg,
The Netherlands
(013) 673 973 Tlx: 52237

☐ Please send 7260A/7261A specifications.
☐ Please send information on Fluke's 80-MHz 7250A Counter.
☐ Please send 1120A IEEE-488 Translator info.
☐ Please have a salesman call.

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For technical data circle no. 1

RFD 11/79

Your 800 MHz Microwave Power Transistors begin here. . . at Solid State Microwave

For the last two years Solid State Microwave has proven its leadership with *high volume production* of Microwave Power Transistors for the new 800MHz Land Mobile Industry. We have been involved in this new market from the beginning and have developed a sound, reliable, highly reproducible line of devices which have satisfied many large production contracts. When you are considering Microwave Power Transistors for your next 800MHz Land Mobile design, consider Solid State Microwave, the 800MHz *technology* and *production* leader.

For technical information on our complete line of 800MHz Transistors, call Bob Tyson at (215) 362-8500.

DEVICE TYPE	P OUT POWER OUTPUT WATTS	P IN INPUT POWER WATTS	PG POWER GAIN dB MIN	fo TEST FREQUENCY MHz	PACKAGE
SD1409	2.0	.35	7.6	870	XO72
SD1411	20	4.5	6.5	836	.230 6LFL
SD1414	50	15	5.2	836	.230 6LFL

V_{cc} (supply voltage: 12.5 volt)

SSM

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a division of **Thomson-CSF** Components Corporation

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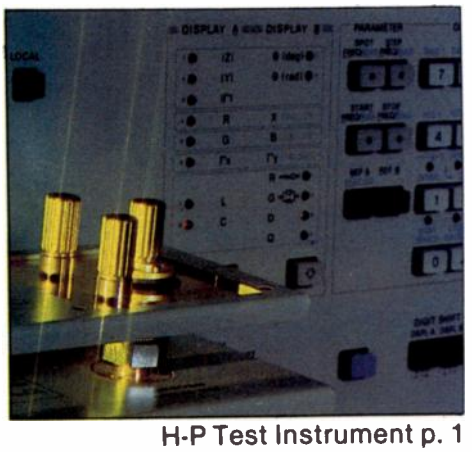
INFO/CARD 2

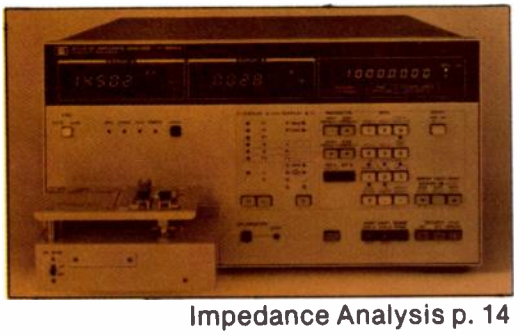
r.f. microwave design

November/December 1979



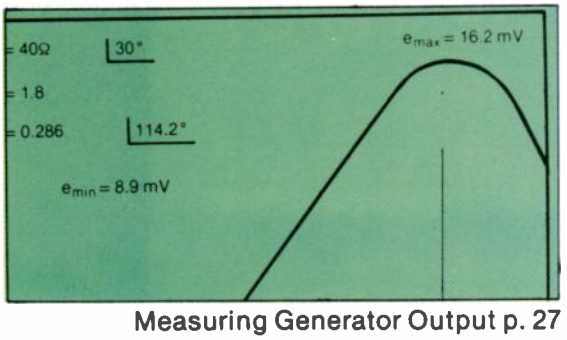
H-P Test Instrument p. 1

Cover. Every now and then a truly new test instrument comes along that offers real advantages to the RF designer. This month's cover story (p. 14) describes such an instrument. **1**



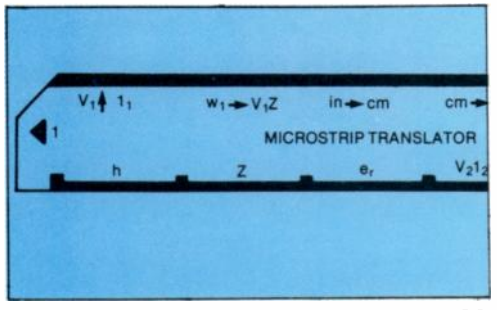
Impedance Analysis p. 14

Advanced Instrument Does RF Impedance Analysis. New H-P instrument measures 14 impedance parameter; |Z|, |Y|, |Γ|, θ, R, X, G, β, Γx, Γy, L, C, D, and Q from 1-1000 MHz. **14**



Measuring Generator Output p. 27

Measuring Generator Output Impedance. With the aid of a line stretcher and a sensitive RF millivoltmeter, a simple measurement can be made of the complex output impedance, $Z_g \angle\Phi$, and the reflection coefficient, $\rho \angle\theta$, of an active source. **27**



Microstrip Translator Program p. 32

Microstrip Translator Program for Your HP-67. Now you can translate an existing microlayout to a different substrate material. **32**

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Don't let the low price mislead you. As the world's number one manufacturer of double-balanced mixers, Mini Circuits' has accumulated extensive experience in high-volume production and testing, a key factor in achieving a successful low cost/high performance line of products.

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Here are some of the steps taken to ensure quality: Every SBL-1 is RF tested two times, every solder connection is 100 per cent inspected under a high power microscope, all transformer leads are double-wrapped, and all components are rated for more than + 85 C operation.
Of course, our one-year guarantee applies to these units.

Model SBL-1
metal case, non hermetic-seal

Frequency Range, MHz
LO 1-500 RF 1-500 IF DC-500

Conversion Loss, dB		Typ.	Max.
One Octave from Band Edge		5.5	7.5
Total Range		6.5	8.5
Isolation, dB		**Typ.**	**Min.**
Lower Band Edge to One Decade Higher	LO-RF	50	35
	LO-IF	45	30
Mid Range	LO-RF	45	30
	LO-IF	40	25
Upper Band Edge to One Octave Lower	LO-RF	35	25
	LO-IF	30	20

Signal, 1dB Compression Level +1dBm
Impedance, All Ports 50 ohms
Electronic Attenuation Min (20mA) 3dB

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INFO/CARD 3

Tektronix 492 Spectrum Analyzer

A spectrum analyzer with convenience and capability. In one compact package.

Easy Operation. Using the 492 couldn't be easier. You set frequency, frequency span, and reference level in a simple 1, 2, 3 knob operation. Automatic turn-on takes care of input protection and normal operational settings, and microprocessor-aided coupled controls take care of the rest. Digital storage and signal processing relieve you of time-consuming display adjustments. Constant tuning rate (CTR) lets you position the signal more quickly and accurately than conventional tuning. And crt readout of parameters lets you read the display at a glance.

Wide frequency range. The 492 covers the widest frequency range of any spectrum analyzer on the market. 50 kHz to 21 GHz with internal mixer capability, to 60 GHz with calibrated external waveguide mixers from Tektronix, and to 220 GHz with commercially available external waveguide mixers.

High performance. The 492 offers you exceptional performance — 80 dB dynamic range on-screen, and measurement capability to 100 dB for applications such as microwave harmonic measurements with the internal preselector. Excellent sensitivity, with an average noise level of −123 dBm at 100 Hz resolution. Low phase noise — 70 dBc at only 3 kHz offset — to give you confidence in your small-signal analysis. High stability for signal source spectral purity analysis, with residual FM no more than 50 Hz peak-to-peak. Amplitude comparison in super-fine 0.25 dB steps, for measuring signal differences with a high degree of accuracy. Plus much more.

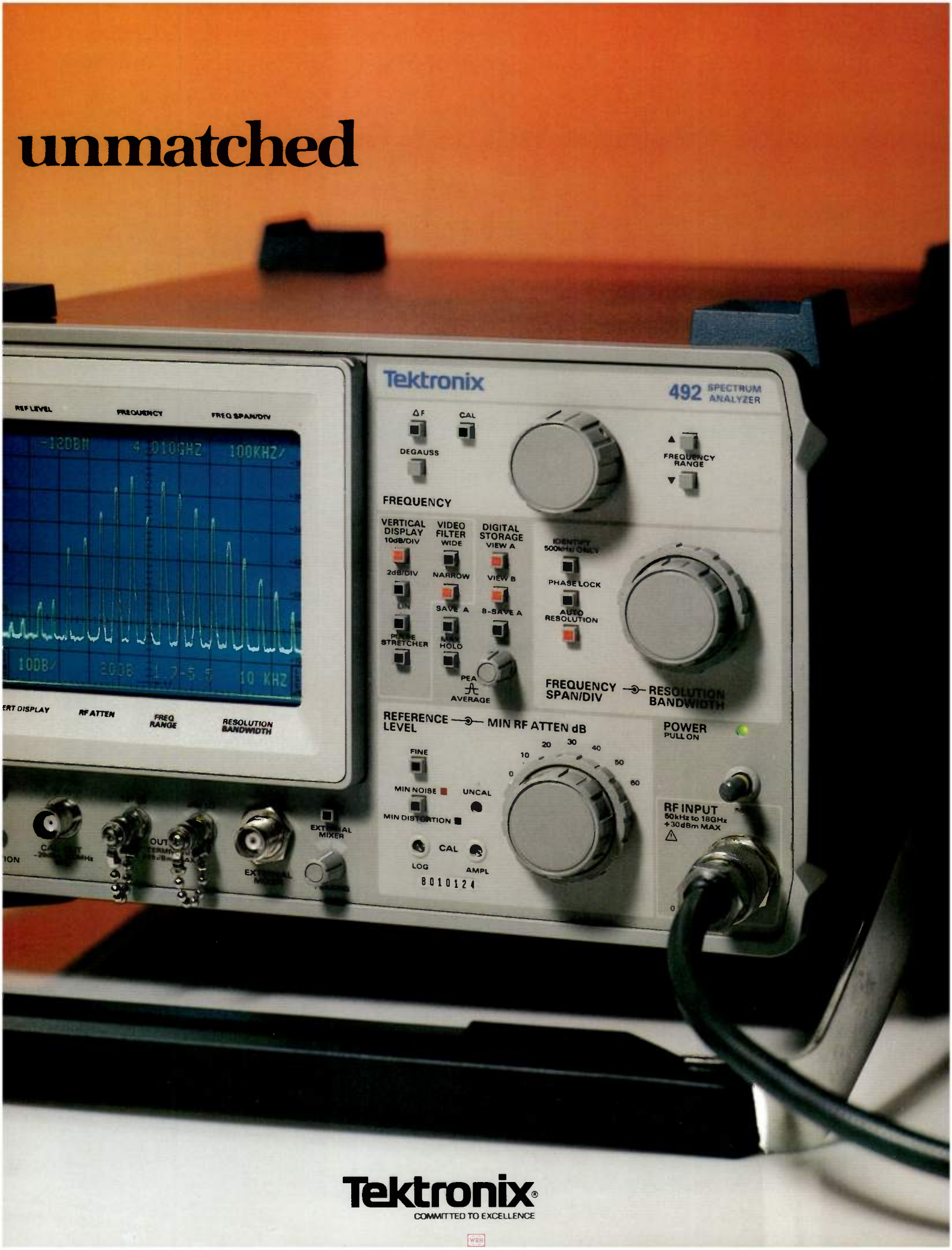
Built to take the tough times. Because the 492 is built to handle a variety of measurements wherever you need it, you can be sure it will perform as well on site as it does in the design lab or systems test area.

Many options. You can order your 492 with phaselock stabilization, digital storage and signal processing, front-end preselection, and external waveguide mixer connection. Or you can choose just the options you need to tailor the 492 for your measurement applications. Specify the 492P for full IEEE 488-1975 programmability via GPIB interface. The 492 is priced from $17,000, and the 492P is priced from $20,000. Consult your Tektronix Sales Engineer for details on options pricing.

Seeing is believing! Call your nearest Tektronix Field Office (listed in major city directories) for complete technical information and a demonstration. For a detailed technical brochure with full specifications, write:
Tektronix, Inc., P.O. Box 1700, Beaverton, OR 97075. In Europe: European Marketing Centre, Postbox 827, 1180 AV Amstelveen, The Netherlands.

We go where you go.

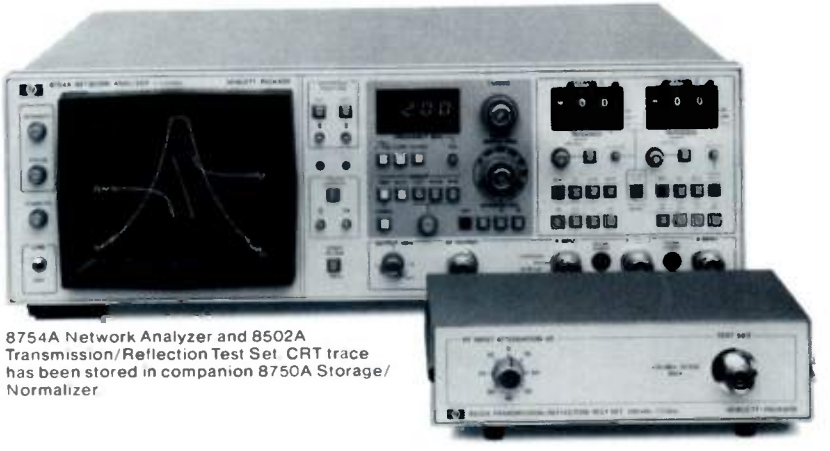
unmatched



Tektronix®

COMMITTED TO EXCELLENCE

When your RF network measurement needs are large, but your budget isn't.



8754A Network Analyzer and 8502A Transmission/Reflection Test Set. CRT trace has been stored in companion 8750A Storage/ Normalizer.

HP's New 1300 MHz Network Analyzer. It brings speed and convenience to RF measurements for only $11,500.

The HP 8754A consists of:

- 4-1300 MHz swept source with +10 dBm leveled output, calibrated sweeps and crystal markers.
- Three channel receiver to measure any two transmission/reflection parameters simultaneously with >80 dB dynamic range.
- CRT display for rectilinear and polar plots with resolution 0.25 dB and 2.5°/major division.

Just add the appropriate test set and you can make thorough and accurate measurements quickly and easily. Such as:

Transmission Magnitude and Phase.

Measure loss, gain and phase shift using the 11850 Power Splitter ($600). Completely identify filter passbands and skirt characteristics without misleading harmonic or spurious responses.

Impedance.

Measure and display impedance in polar form, with crystal markers to give precise frequency data. Test sets are available for both 50 and 75Ω systems.

Simultaneous Transmission and Reflection.

Use the 8502 Test Set ($2000) and see the trade offs between transmission gain/loss and input match in a single setup. For two-port characteristics of networks, including transistors, an S-parameter test set is available.

Storage/Normalizer increases the 8754A's capabilities.

Add the 8750A and you can automatically remove system frequency response variations also make comparison measurements easily. Digital storage permits flicker-free displays even for measurements requiring slow sweep rates.

A call to your nearby HP field sales office is all you have to do to get more information, or write 1507 Page Mill Road, Palo Alto, CA 94304.

Domestic US prices only.

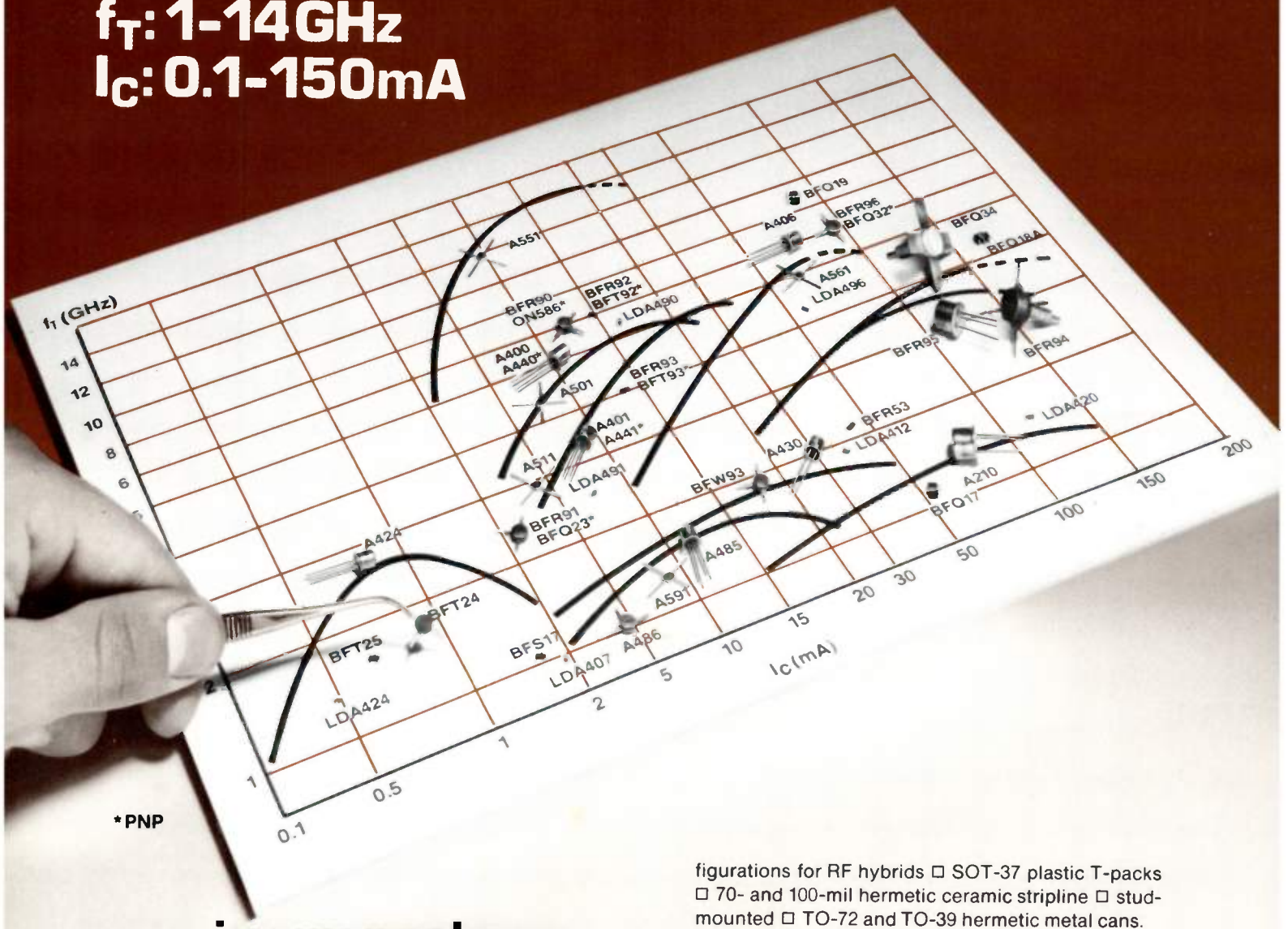
45907A

HEWLETT PACKARD

INFO/CARD 4

How's this for complete coverage in small-signal GHz transistors?

f_T: 1-14 GHz
I_C: 0.1-150 mA



*PNP

...in any package, from Lids to Studs.

World leadership in shallow diffusion technology and unsurpassed packaging skills come together at Amperex to produce the industry's best combinations of GHz transistor performance specifications, packaging and prices:

- Gain-bandwidth products from 1 to 14 GHz at collector currents from 0.1 to 150 mA.
- Noise figures as low as 1.9 dB at 500 MHz.
- Low intermodulation and cross-modulation types for those sophisticated linear applications.
- Full-range package versatility; microminiature ceramic LIDS and plastic SOT-23 and SOT-89 configurations for RF hybrids □ SOT-37 plastic T-packs □ 70- and 100-mil hermetic ceramic stripline □ stud-mounted □ TO-72 and TO-39 hermetic metal cans.

There's a high-performance Amperex GHz transistor for virtually any small-signal RF application up to 4 GHz...including CATV-MATV amplifiers, wideband counters and scopes, communications gear through 900 MHz and beyond, miniature pocket pagers, radars, telemetry, etc.

For further information and applications assistance on the Amperex line of high-performance GHz transistors, contact: Amperex Electronic Corporation, Slatersville Division, Slatersville, Rhode Island 02876. Telephone: 401-762-3800.

Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS

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INFO/CARD 5

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Want More Money?

I recently heard a true story about a young engineer whose actions and attitude about himself are bound to get for him the money and recognition as a professional that all engineers feel they should be getting.

This man was interviewing at one of the big aerospace companies on the West Coast. The meeting had gone along more-or-less according to the book. The interviewer had asked every sort of question and was noticeably impressed with the education, background experience and credentials of the applicant. Then he came to that most predictable place in the questioning where his eyes narrowed almost imperceptibly and he asked, "How much money do you want?"

E. Patrick Wiesner, Publisher

Without hesitation, and as though he were telling the number of years of his experience, he said, "$80,000."

"$80,000 a year?!", the interviewer said incredulously, clearly impressed as he fell back in his chair. "Yes, $80,000," said our hero, matter-of-factly. "I'm worth every cent, and I won't take less."

You can imagine the conversation that followed. The good news is that our man got it!...even though he was paid for only one week.

His manner and confidence soon was brought to the attention of the people who could make such a decision. He was told they were unable to hire him at that salary, but that they would pay him at that rate as a consultant. They had a very elusive design problem to solve and would he join their company in a consulting capacity until the problem was solved.

He worked one week, solved the problem and pocketed $1538.40.

There is a lot of feeling among engineers that we deserve the kind of income and professional standing of, say, a physician. It will begin to come when our attitude, self-worth and real-worth are clearly perceived by the rest of the world to be of the highest caliber. The first requirement for success is that we must truly believe in ourselves to the point that others sense it in a positive way. Those who expect a high level of performance from themselves deserve to expect a high level response from their environment.

This may have been a somewhat temporary victory for the ambitious engineer in this story. But, based on his behavior and competence, I'll bet he will exceed his own expectations and ambitions soon!

When quality counts

Do not be fooled by the low prices, these brand new lab quality frequency counters have important advantages over instruments costing much more. The models 7010 and 8010 are not old counters repackaged but 100% new designs using the latest LSI state-of-the-art circuitry. With only 4 IC's, our new 7010 offers a host of features including 10 Hz to 600 MHz operation, 9 digit display, 3 gate times and more. This outperforms units using 10-15 IC's at several times the size and power consumption. The older designs using many more parts increase the possiblity of failure and complexity of troubleshooting. Look closely at our impressive specifications and note you can buy these lab quality counters for similar or less money than hobby quality units with TV xtal time bases and plastic cases!

Both the new 7010 and 8010 have new amplifier circuits with amazingly flat frequency response and improved dynamic range. Sensitivity is excellent and charted below for all frequencies covered by the instruments.

Both counters use a modern, no warm up, 10 MHz TCXO [temperature compensated xtal oscillator] time base with external clock capability - no economical 3.579545 MHz TV xtal.

Quality metal cases with machine screws and heavy guage black anodized aluminum provide RF shielding, light weight and are rugged and attractive - not economical plastic.

For improved resolution there are 3 gate times on the 7010 and 8 gate times on the 8010 with rapid display update. For example, the 10 second gate time on either model will update the continuous display every 10.2 seconds. Some competitive counters offering a 10 second gate time may require 20 seconds between display updates.

The 7010 and 8010 carry a 100% parts and labor guarantee for a full year. No "limited" guarantee here! Fast service when you need it too, 90% of all serviced instruments are on the way back to the user within two business days.

We have earned a reputation for state-of-the-art designs, quality products, fast service and honest advertising. All of our products are manufactured and shipped from our modern 13,000 square foot facility in Ft. Lauderdale, Florida.

When quality counts...count on Optoelectronics.

MODEL 8010 1 GHz

MODEL 7010 600 MHz

- 100% U.S.A. FACTORY ASSEMBLED
- 100% PARTS & LABOR YEAR GUARANTEE
- CERTIFIED NBS TRACEABLE CALIBRATION
- EXTERNAL CLOCK INPUT
- DISPLAY HOLD FUNCTION
- 9 RED LED DIGITS .4" HIGH
- .1 Hz RESOLUTION
- 0.1 PPM 10 MHz TCXO TIME BASE
- LAB/PORTABLE-AC ADAPTER INCLUDED
- 1 MEGOHM & 50 OHM INPUTS
- STATE-OF-THE-ART LSI DESIGNS
- COMPREHENSIVE USER MANUAL PROVIDED
- COMPACT SIZES—7010- 1-¾" Hx4-¼" Wx5-¼"D 8010- 3" Hx7-½" Wx6-½"D

MODEL	$ PRICE	RANGE 10Hz to	LED DIGITS	SENSITIVITY 50 OHM INPUT 25-250 MHz	50 OHM INPUT 250-450 MHz	50 OHM INPUT 450 MHz-1GHz	HI-Z INPUT 10Hz - 60 MHz	GATE TIMES	RESOLUTION 12 MHz	RESOLUTION 60 MHz	RESOLUTION MAX. FREQ.	TCXO TIME BASE 20°-40°C	TCXO TIME BASE FREQ.	EXT CLOCK INPUT	NI-CAD BATT PACK
7010 *7010.1	145.00 225.00	600 MHz	9	5-20 mV	5-20 mV	20-40 mV * 600 MHz	5 mV	1 SEC	.1Hz	1 Hz	10 Hz 600 MHz	1 PPM 0.1 PPM	10 MHz	YES OPTION $25.	YES OPTION $15.
8010 *8010.1	325.00 405.00	1 GHz	9	1-10 mV	5-20 mV	10-25 mV	1-10 mV	(8).01-20 SEC	.1 Hz	1 Hz	10 Hz 1 GHz	1 PPM 0.1 PPM	10 MHz	YES STD	YES OPTION $39.

* Has precision 0.1 PPM TCXO time base

MODEL 7010

#7010 600 MHz Counter - 1 PPM TCXO $145.00
#7010.1 600 MHz Counter - 0.1 PPM TCXO $225.00

OPTIONS
#Ni-Cad-701 Ni-Cad Battery Pack & charging circuitry Installs inside unit $ 15.00
#EC-70 External Clock Input,10 MHz $ 25.00
#CC-70 Carry Case, Padded Black Vinyl $ 8.95

MODEL 8010

#8010 1 GHz Counter - 1 PPM TCXO $325.00
#8010.1 1 GHz Counter - 0.1 PPM TCXO $405.00
#8010-1-13 1.3 GHz Counter - 0.1 PPM TCXO $495.00

OPTIONS
#Ni-Cad-801 Ni-Cad Battery Pack & charging circuitry Installs inside unit $ 39.00
#CC-80 Carry Case, Padded Black Vinyl $ 9.95

ACCESSORIES

#TA-100 Telescope Ant with Right Angle BNC $ 9.95
#P-100 Probe, 50 ohm, 1x $13.95
#P-101 Probe, Lo-Pass, Audio Usage $16.95
#P-102 Probe, Hi-Z, General Purpose $16.95

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INFO/CARD 6

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Advanced Instrument Does RF Impedance Analysis

This new instrument measures 14 impedance parameter; |Z|, |Y|, |Γ|, θ, R, X, G, β, Γx, Γy, L, C, D, and Q from 1-1000 MHz.

Hewlett-Packard's RF Impedance Analyzer is the most recent addition to their new generation of microprocessor-based impedance measuring instrumentation. It is a "friendly" instrument that is easy to use. HP's 4191A has an internal frequency synthesizer, automatic calibration, automatic error correction and specially designed test fixtures make stable, accurate impedance measurements possible over a measurement range of 1 mΩ to 100 kΩ (1 μS to 50 S). In addition, it features an internal bipolar dc bias source (0 to ±40V), linear and log sweep capability of both frequency and bias, self test and deviation measurement capability (Δ, Δ%) on all 14 parameters. These features make this new RF Impedance Analyzer an excellent design and testing tool for high frequency evaluation of electronic materials, components and circuitry.

Basic Theory

The basic measurement of HP's RF Impedance Analyzer is the reflection coefficient (Γ). It is determined by the vector ratio of the incident wave from the unknown port to the device under test and the reflected wave from the DUT to the measurement port. This technique is the same as the s-parameter (s11 or s22) measurement made by a network analyzer. Once the reflection coefficient is precisely known, all other parameters can be determined mathematically.

Careful design techniques were used to insure accurate measurements over so wide an impedance range. Particular care was taken to minimize the residual noise of the test signal and to insure the accuracy of the RF to IF converter. To further enhance accuracy, the measured data is corrected using data stored during the calibration procedure at turn-on. In this way, any residual error in the system is eliminated and a very accurate determination of the reflection coefficient of the DUT can be obtained.

Basically, the reflection coefficient of a device is determined by the RF directional bridge shown in Figure 1. The test signal from the frequency synthesizer is fed into the RF bridge through a power

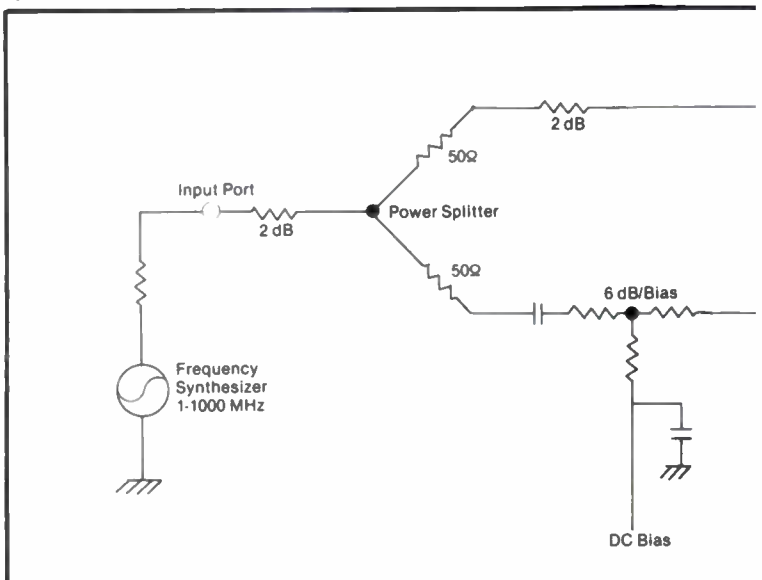
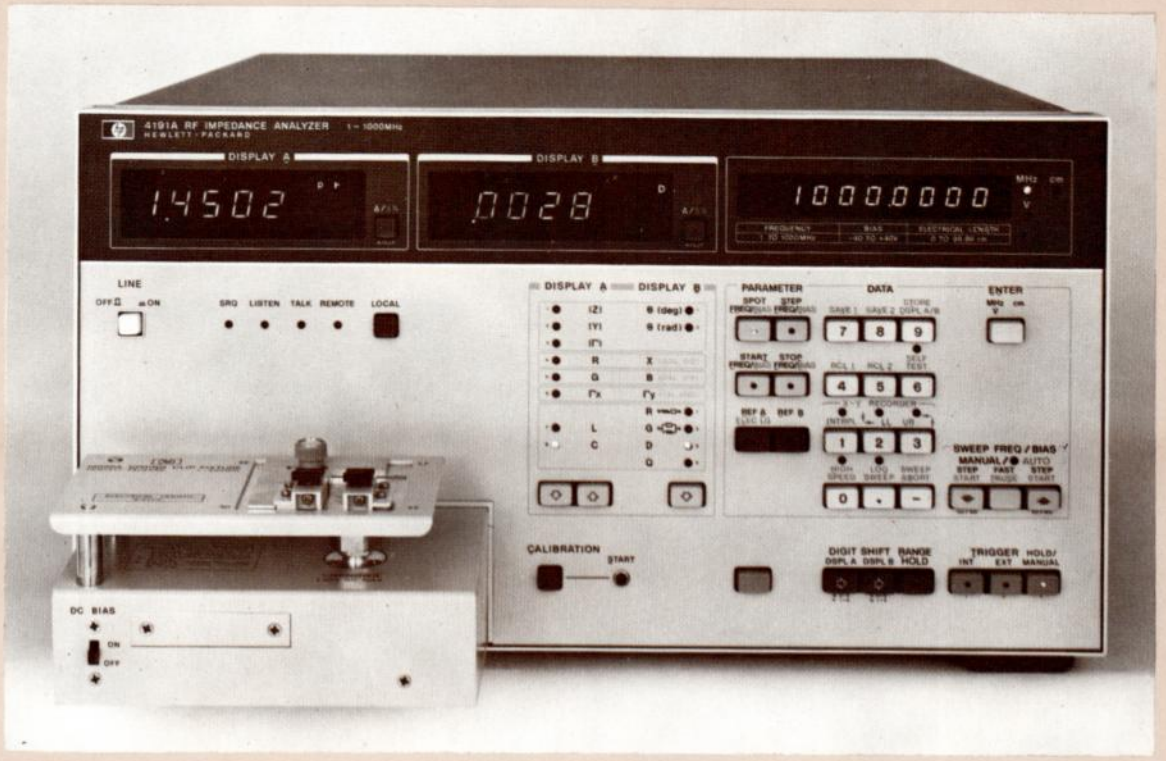


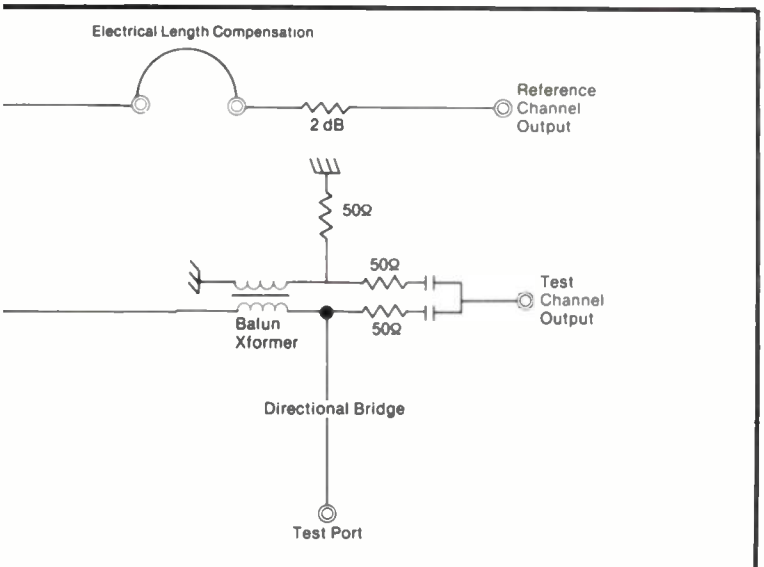
Figure 1. RF directional bridge



splitter. The reference signal then passes through an electrical length compensation network and is applied to the reference channel of the sampler.

The test signal passes through an attenuator/dc bias network and is then applied to the directional bridge. A balanced-unbalanced transformer couples the signal into two channels, one leading to the DUT test port, the other to an internal 50 ohm standard resistor. The voltages across the 50 ohm resistor and the DUT are combined and applied to the test channel of the sampler. If the DUT is exactly 50 ohms, the bridge is balanced and the test channel output is zero.

The entire RF bridge section is enclosed in a temperature controlled oven to maintain measurement accuracy.



determines reflection coefficient.

Operational Features and Benefits

A microprocessor is used to maintain the accuracy and wide measurement range in HP's new RF Impedance Analyzer. The measurement data is digitally corrected from stored calibration data and the corrected data is then converted to the desired parameter.

To provide accurate high resolution measurements over the instruments entire frequency and impedance ranges, an automatic calibration sequence is initiated at turn-on. When the power switch is depressed, a self test procedure is automatically performed, verifying the internal circuitry is operational. At the same time, a ten minute warm-up period is started for temperature stabilization of the oven that encloses the measurement circuitry. During this period, the RF Impedance Analyzer displays its I/O address and also the codes indicating the optional features (high resolution synthesizer and/or analog recorded output) that are installed in the instrument. This warm-up period may be manually negated if desired.

At the completion of the warm-up period, a calibration should be performed with the three standards (50Ω, 0Ω, 0S) provided with the instrument. The standards are connected and a total of 51 calibration frequencies are automatically selected

between the start and stop frequencies. The data is then stored in the units non-volatile memory for later use in the data correction procedure. Once the calibration process is completed, the instrument is ready for use. If a specific measurement frequency is selected that does not coincide with a calibration frequency, a Lagrange interpolation is used in the error correction process. This insures accurate measurements over the entire frequency range selected.

The key feature of the HP 4191A RF Impedance Analyzer is its capability to display impedance in any of fourteen different parameters. These parameters include impedance (|Z|), admittance (|Y|), reflection coefficient (|Γ|), phase angle (θ in degrees and radians), resistance (R), reactance (X), conductance (G), susceptance (B), rectangular coordinates of the reflection coefficient (Γx and Γy), capacitance (C), inductance (L), dissipation factor (D), and quality factor (Q). In addition, the deviation of a measurement from a stored reference value is displayed as a value (Δ) or as a percent (Δ%) for all fourteen parameters.

The wide frequency range of 1 MHz to 1000 MHz is generated by an internal synthesizer phase locked to a quartz reference oscillator. Frequency resolution of the standard model is 100 kHz, with 100 Hz resolution optionally available for evaluation of high Q devices such as crystals and crystal filters. This synthesizer has the stability and repeatability necessary to detect small changes in the resonant frequency of an unknown device. Flexible frequency control capabilities include start, stop and step frequency selection, frequency step up and down controls, and sweep stop and abort. Both linear and log sweep modes may be selected either manually or remotely.

An internal bipolar dc bias source is provided with 10 mV resolution over its entire range of -40 volts to +40 volts. A dc level may be selected, or the bias voltage may be swept over its entire range. Both linear and log sweep modes may be selected.

Two storage registers are provided in the non-volatile memory for storage of two complete front panel settings. Often-used conditions may be stored in memory and recalled at any time with the touch of a key. These settings are retained in memory even when the line switch is off. This feature improves measuring efficiency in applications where repetitive measurements are required.

The standard HP-IB capability allows the 4191A to be easily integrated into an automatic measurement system. By adding a system controller and one or more peripheral devices, the measurement capability is extended to include fully automatic impedance measurements, data manipulation and hard copies of the data in any desired format.

An optional recorder output is available for making a permanent record of measured data if data manipulation is not required. Output voltages proportional to the measured data and the applied frequency or bias are available on the rear panel. This provides an inexpensive method to determine the dc bias or frequency characteristics of a DUT. X-Y recorder scaling (lower left and upper right) and interpolation capability are provided with the option.

Test Fixtures

When making RF impedance measurements, test fixture design is of the utmost importance. If device under test cannot be connected to the measurement port without introducing significant errors, it cannot be accurately measured. Four test fixtures, specially designed for use with HP's RF Impedance Analyzer, provide accurate repeatable measurements on a variety of DUT's (see Figure 2).

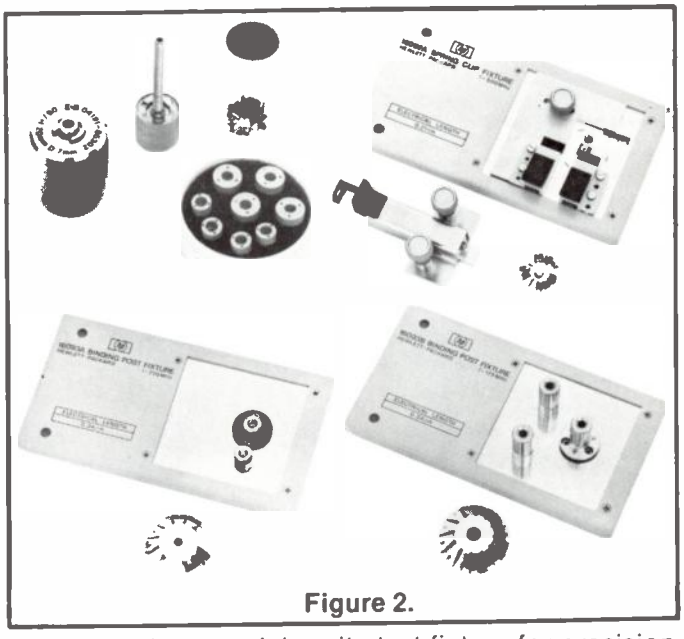


Figure 2.

The first is a coaxial cavity test fixture for precision measurements over a frequency range of 1 MHz to 1000 MHz. It is very useful in evaluating small axial leaded devices such as varactor diodes. Most devices used at high frequencies are either chip, short leaded, or stripline configuration. A spring clip test fixture was designed to accommodate all three types of devices. The recommended frequency range is 1 MHz to 500 MHz.

Two binding post test fixtures are available for connection to radial and axial lead devices. The configuration of these fixtures were patterned after the familiar R-X Meter and Q-Meter. Recommended test frequencies are 250 MHz and 125 MHz respectively.

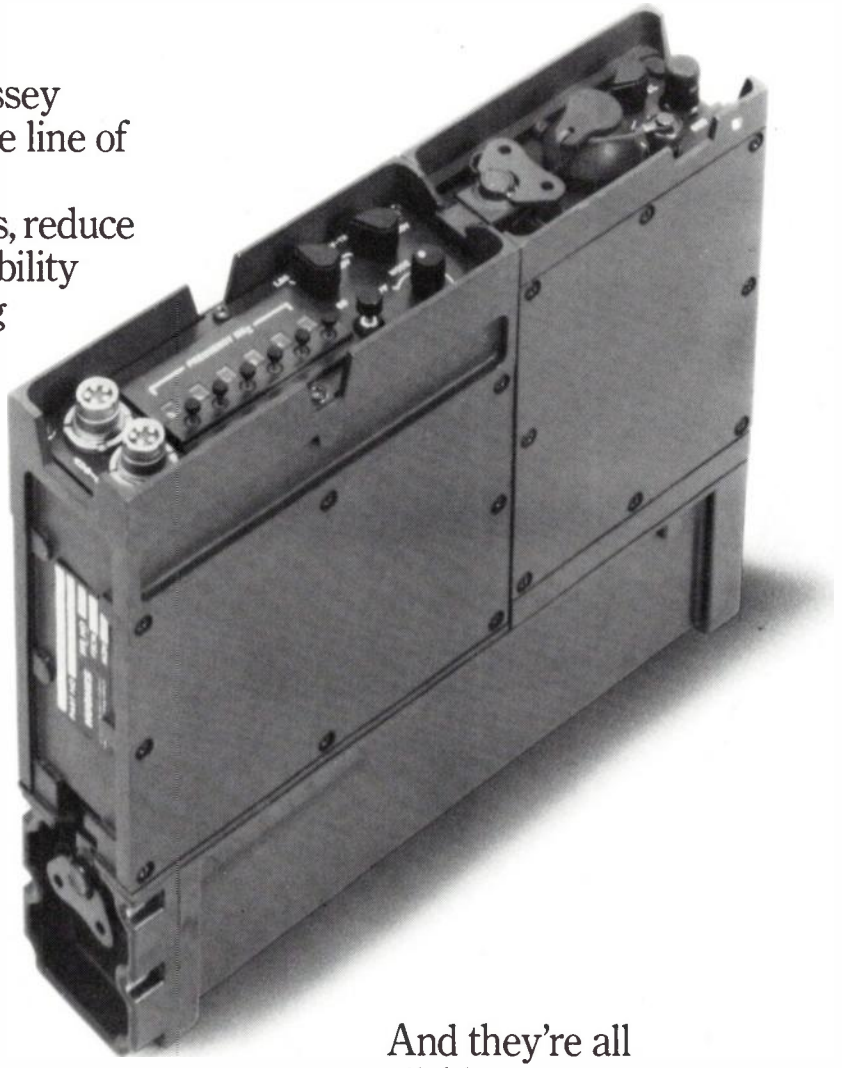
These test fixtures are designed to be coupled directly to the APC-7 unknown test port. However, they all have some electrical associated with them that would cause a measurement error. The 4191A provides a digital electrical length compensation of up to 99.99 cm. to eliminate this error.

Test fixtures are not limited to the four shown here. The unknown test port is the standard APC-7 design and is compatible with many existing test fixtures and air lines used with other high frequency test equipment. If the electrical length is greater than one meter, electrical length compensation is accomplished by adding an external air line of appropriate length.

Accurate, High Resolution Measurements

The 4191A was designed to provide accurate and stable measurement data. In order to obtain high

Radio Active



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accuracy with 4½ digit resolution, several unique features were developed. They include an automatic error correction capability, test fixtures for various DUT sizes and shapes, electrical length compensation by numeric key input, and the measurement circuit enclosed in a temperature controlled oven. Therefore, minor impedance changes of components or materials can be obtained easily by resonant impedance measurements or equivalent circuit calculations. Typical applications of this type include high resolution crystal measurements, low loss measurement of an air capacitor, thin or thick film circuit analysis and PIN diode impedance measurements.

Traditional RF Impedance Measurements

Traditionally, RF impedance measurements have been made with manual balanced impedance bridges. More recently, analog vector impedance meters and network analyzers have been used as well. These methods have shortcomings. Measurements can be time-consuming, and accuracy and dynamic impedance range may be limited for a particular measurement. This new RF Impedance Analyzer gives greater measurement speed, accuracy and impedance measurement range when compared to traditional impedance bridges and network analyzers. It can be used as a bench instrument or integrated into a high speed system with the standard IEEE interface.

Impedance Analyzer vs. Network Analyzer

The 4191A should not be confused with a network analyzer. The network analyzer is a 2-port device that measures both transmission and reflection parameters very rapidly. It is quite helpful in giving the circuit designer an overall picture of how his circuit behaves over the frequency range of interest.

The RF-Impedance Analyzer is a 1-port device measuring only the reflection parameter, but with greater accuracy, wider impedance range and higher resolution. This allows the designer to make evaluations to the component level. Therefore, it is designed for component analysis while the network analyzer is for circuit analysis.

Major Applications

Automatic Evaluation of Semiconductor Devices

This new Impedance Analyzer has the stable automatic measurement capability necessary for the high frequency evaluation of semiconductor devices. The internal dc bias voltage source with 10 mV resolution and the high resolution measurements (0.1fF for capacitance and 1 uS for conductance) meet even the most stringent requirements in both R&D and process control applications. These features can lead to improved yields in the wafer process and aid in the development of new devices such as CCD and compound semiconductor devices. Of major interest is the high frequency C-V, G-V and ac conductance characteristics of the DUT. Figure 1 is the ac

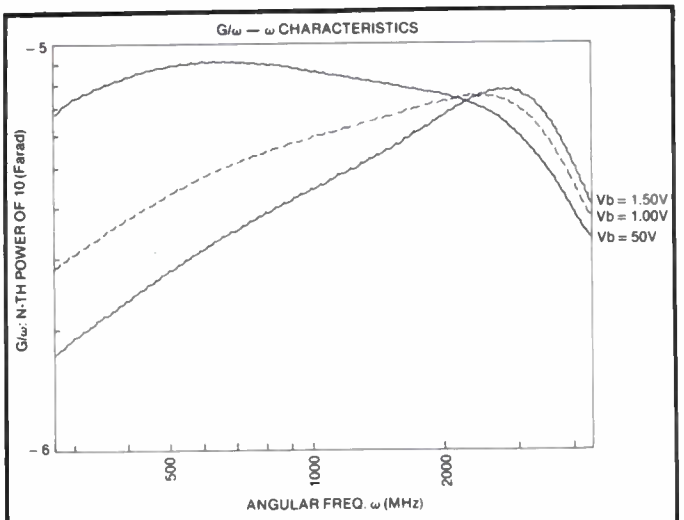

Figure 3. AC Conductance Characteristics of an MOS Device. The Nicollian-Goetzberger analysis requires fast accurate measurements complex calculations and graphic data presentation. The automatic system capability makes this analysis possible.

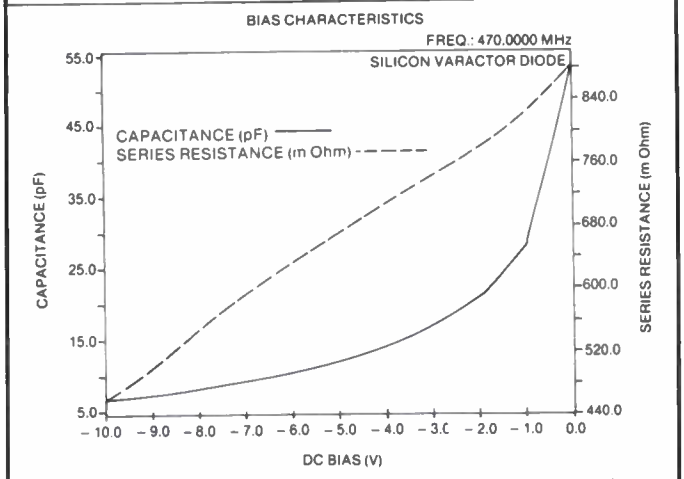

Figure 4. Bias Characteristics of a Silicon Varactor diode measured at 470 MHz. This type of diode is used extensively in tuner design.

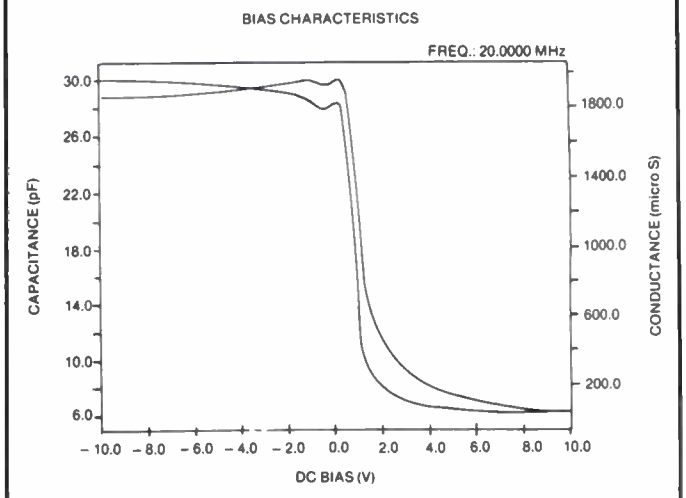

Figure 5. High Frequency C-V and G-V plot of an MOS junction.

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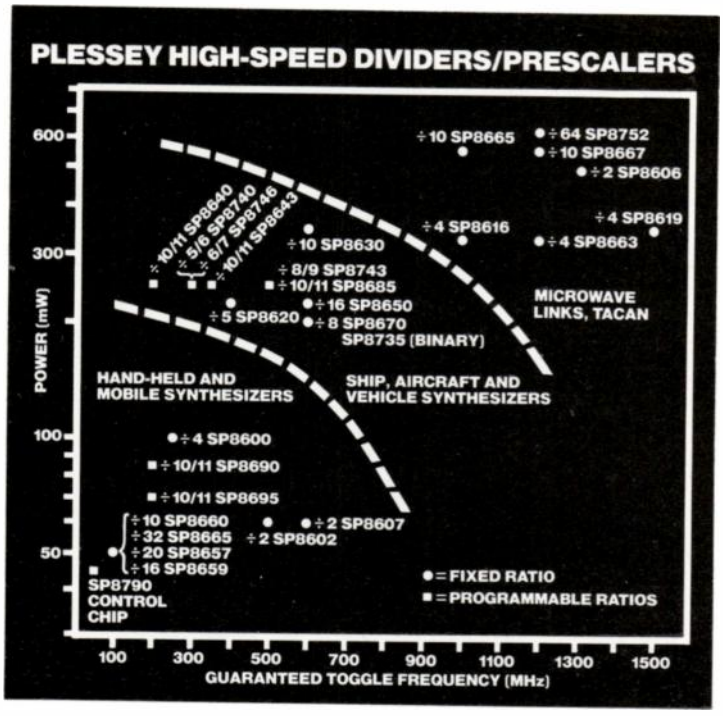

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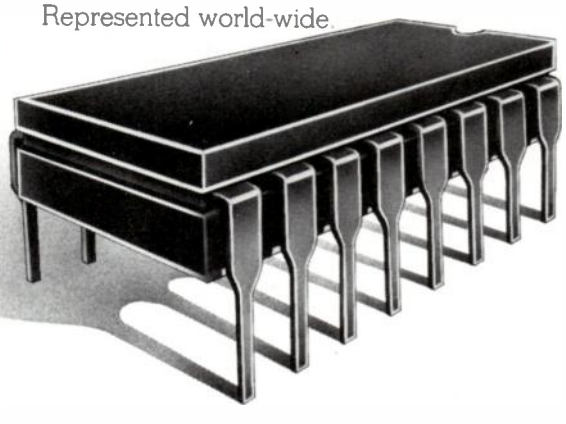


conductance characteristics of an MOS device. Figure 2 is the high frequency capacitance—voltage (C-V) and conductance—voltage (G-V) characteristics of an MOS diode.

Electronic Component Evaluation

Improved reliability and performance can be achieved in high frequency component design with the 4191A. The capability to evaluate capacitors, inductors, and resistors over the wide frequency, DC, bias and impedance ranges gives the design engineer an indication of exactly how these devices will behave in the actual circuit. Figure 3 shows the frequency characteristics of a ceramic chip capacitor.

Complex and Hybrid Component Evaluation

The resonating characteristics of complex devices can be precisely determined at frequencies between 1 MHz and 1000 MHz. The impedance measurement range of 1 mΩ to 100 kΩ gives excellent resolution over the entire frequency range. Figure 4 shows the impedance frequency characteristics and the equivalent circuit calculations of a crystal resonator. Figure 5 is the impedance and phase characteristics of a 10.7 MHz ceramic filter used in FM receivers. Other applications include the evaluation of signal propagation characteristics of communications devices using the reflection coefficient measurement and analysis of complex components through the frequency dependence of the R-X and G-B parameter measurements. For more information circle #134.

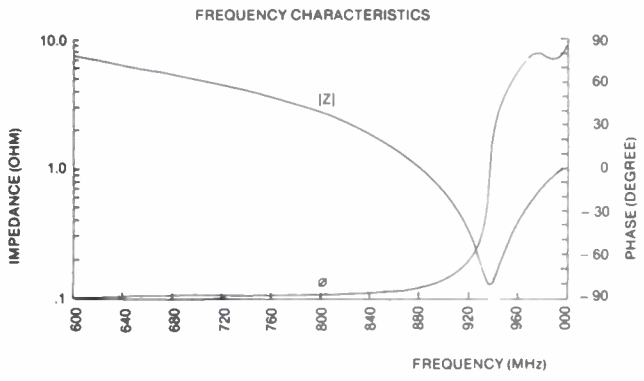


Figure 6. Chip Capacitor Characteristics. The |Z| characteristic curves of this capacitor indicate that, below the resonance point, it is indeed a capacitor. At 938 MHz, it is purely resistive with an ESR of 110Ω and it becomes inductive above that frequency.

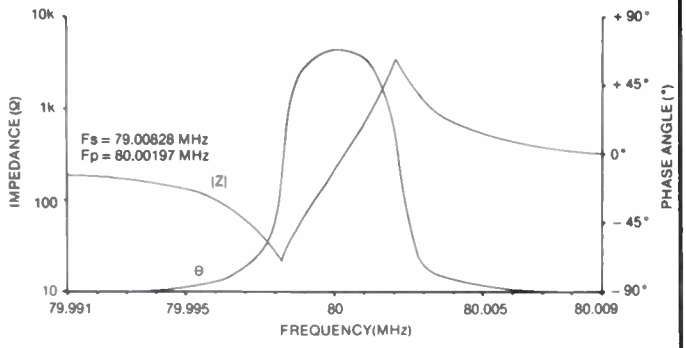


Figure 7. Crystal Resonator Measurement.

The |Z| – θ characteristics of an 80 MHz crystal resonator are measured from 79.991 MHz to 80.009 MHz in 100 frequency steps.

Component values of the equivalent circuit are calculated from the following equations:

$$C = Co\left(\frac{Fp}{Fs}\right)^2 - 1 \; ; \; L = \frac{1}{(2\pi Fs)^2 C} \; ; \; Q = \frac{2\pi FsL}{R}$$

Fs, Fp, Co, R: Measured data of services resonant frequency, parallel resonant frequency, parallel capacitance and series resistance.

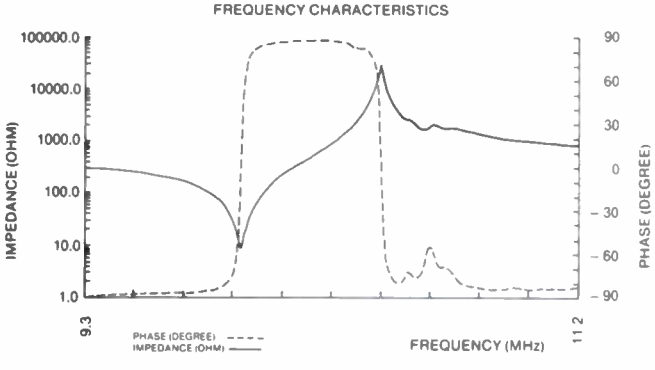


Figure 8. Frequency Characteristics of a 10.7 MHz Ceramic Filter used in an FM receiver.

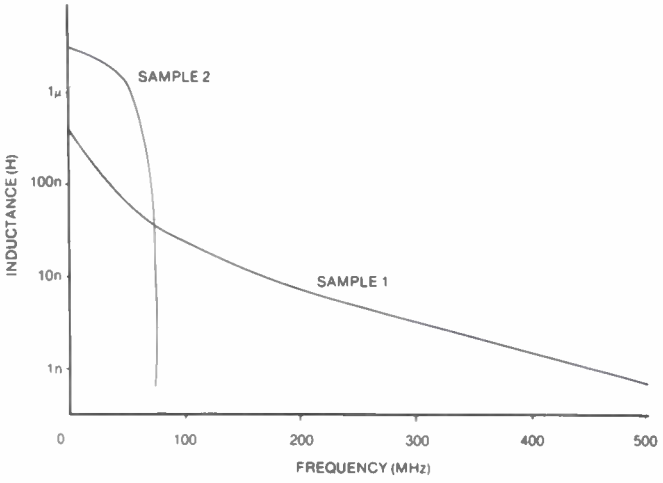
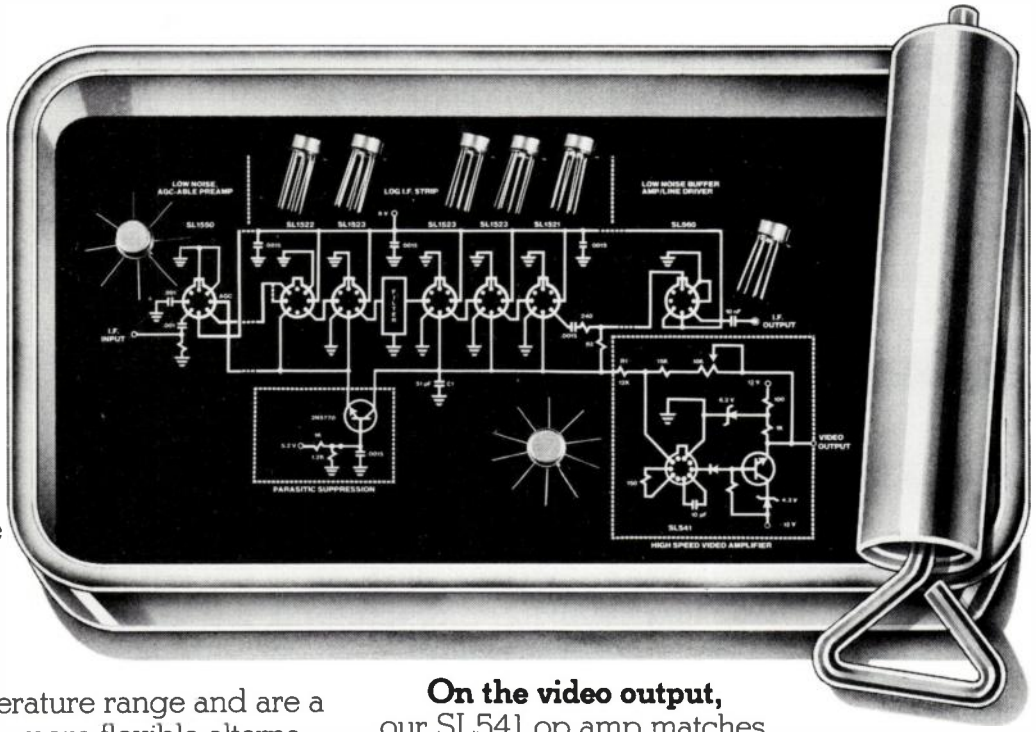


Figure 9. Inductance vs. Frequency of two Ferrite Core Material Samples.

I.F. cram course



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On the video output, our SL541 op amp matches the IF strip to your system, and lets you vary video sensitivity. It has the high slew rate (175 V/μsec), fast settling time (1% in 50 nsec) and high gain stability you need, with on-chip compensation so it's not tricky to use.

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And for the IF output, the Plessey SL560 buffer amp/line driver operates up to 320 MHz with a noise figure less than 2 dB, gain of up to 40 dB, and drives 50 ohm lines with a minimum of external compensation (none in this application).

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Measuring Generator Output-Impedance

R.E. Lafferty
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The measurement of the output impedance of a signal generator, or oscillator, is usually meaningful only if the source is operating. With the aid of a line stretcher and a sensitive RF millivoltmeter, a simple measurement can be made of the complex output impedance, $Z_g \angle\Phi$, and the reflection coefficient, $\rho\angle\theta$, of an active source.

A constant-impedance line stretcher is connected through a capacitive signal sampler to the output port of the source to be measured. The far end of the line is terminated in a near short-circuit ($Z_L << Z_o$). The termination, in its simplest form, consists of an unterminated probe-adapter, modified with a 1-ohm concentric resistor. For measurement frequencies of less than 1 GHz, a low inductance strap may be connected in place of the resistor between the center conductor and outer wall of the adapter. When the probe is coupled to the adapter, the RF millivoltmeter will indicate the voltage across the termination, which is a measure of the current at this point.

The impedance of the line stretcher should equal the nominal impedance of the source, $Z_0 = Z_g$, and for this special case, the power reflected at the termination will be absorbed completely by the source impedance. Extending the line stretcher from its minimum to maximum length should produce little or no change in voltage at the receiving end of the line. $\rho = 0$ for this condition.

When $Z_o \neq Z_g$, and assuming a sufficient range of extension for the line stretcher. i.e., $\Delta\ell > \lambda/2$, adjusting the line through its full length of travel should yield at least one minimum and one maximum millivoltmeter reading. The s.w.r. of the source, relative to the line impedance, Z_o, is equal to e_{max}/e_{min}. From this the magnitude of the reflection coefficient obtains. If the s.w.r. = S,

$$|\rho| = (S - 1)/(S + 1) \qquad (1)$$

Figure 1 depicts the measurement system which consists of an RF power source and its impedance Z_g, a capacitive signal sampler, a line stretcher, and a low impedance termination across which is connected a sensitive RF millivoltmeter.

The phase angle is needed in order to define the reflection coefficient fully, and this obtains from a measurement of the electrical length of the line between the termination and the source impedance for

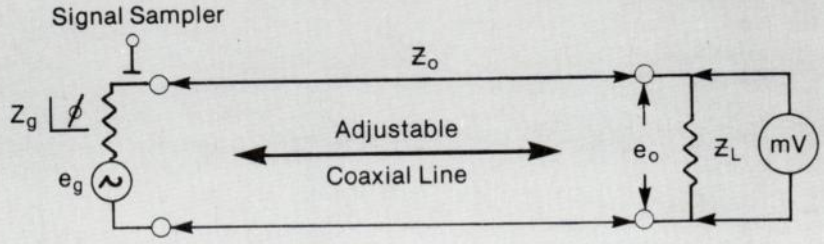


Figure 1.

the condition of maximum received current (e_{max}). The length for the maximum indication, rather than the minimum, is taken because voltage vs. travel is better defined at this point, especially for large values of s.w.r., as shown in Figure 2.

This defines $\beta\ell$ which is used to calculate the phase angle of the output impedance, Φ, as well as θ, the phase component of the reflection coefficient.

Finding the electrical length of the line, however, is not a simple matter. If the impedance of the source is directly behind the output port, or very close to it, a careful measurement of the physical length of the distance between the termination and the location of the source impedance may be adequate, provided the relative velocity of propagation for the system is known. In most instances, however, there are intervening connectors, adapters, and cables with relative velocities less than that of air, particularly when the power source is located within the instrument and remote from the front-panel output port.

A technique for measuring the electrical length of the line with an accuracy suitable for this purpose makes use of the variable output frequency of the signal generator. A sensitive RF millivoltmeter is coupled to the point that defines the location of the source impedance. If this is the output port, or if you wish to determine the impedance referenced to the output port[1], a coaxial signal sampler (capacitive type) connected at this point, as shown in Figure 1,

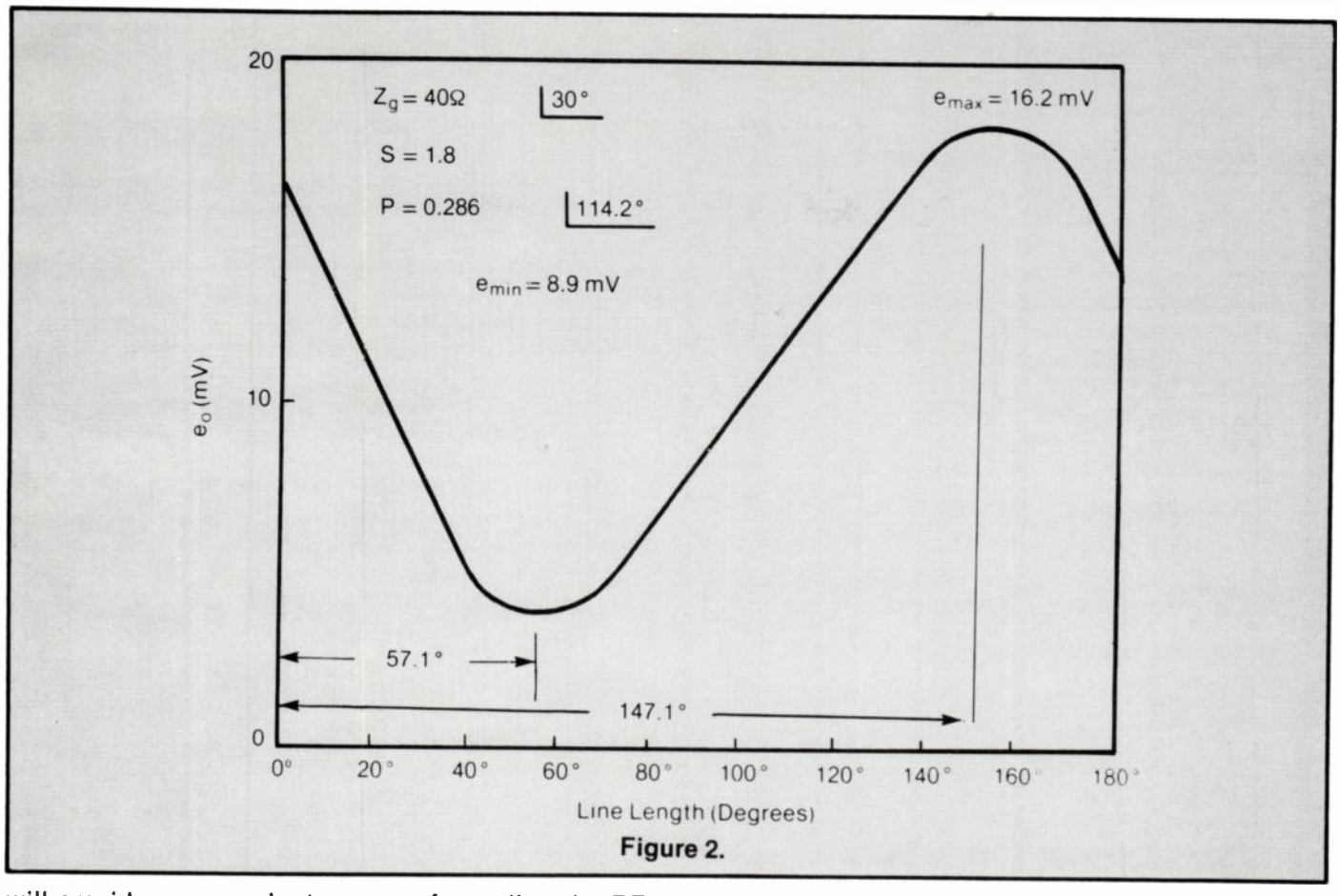


Figure 2.

will provide a convenient means of coupling the RF millivoltmeter to the line.

If the signal source is located within the instrument and it is the impedance of this source that is to be measured, the probe of the RF millivoltmeter should be lightly coupled to the defined point. The connection may be made either with a 100:1 capacitive voltage divider, available with the millivoltmeter, or through a simple capacitive divider consisting of a series element of 1 pF, or less, and shunt element of about 100 pF. If the test level is too low to be measured with a 100:1 divider, the probe may be connected directly if the input impedance is at least an order of magnitude greater than the source impedance, or it may be placed in the proximity of the defined point with the center pin insulated by a short length of thin tubing. In some cases a simple tee adapter installed at the source will permit coupling through its unused port.

With the adjustable line still in the position of maximum received current, gradually lower the output frequency of the generator until the RF millivoltmeter (coupled to the source impedance) detects a pronounced point of minimum voltage and record this frequency as f_n. Continue to lower the frequency until the second point of minimum voltage is reached. This is f_{n-1}.

The difference in the two frequencies is the natural half-wavelength frequency of the line, between the termination and the coupling point of the RF millivoltmeter.

Advertiser Index

Let f = the frequency of measurement. (MHz)
f_n = first frequency below f that yields a sharp voltage minimum at the RF probe. (MHz)
f_{n-1} = second frequency below, etc. (MHz)
n = number of half wavelengths of the line at f_n.
$\Delta f = f_n - f_{n-1}$ (MHz)
and,
$n = f_n/\Delta f$ (truncate n to make it a simple integer)

The electrical length of the line at the measurement frequency is:

$$\beta\ell = (f/\Delta f)\,180° - (n)\,180° \qquad (°) \qquad (2)$$

It can be shown that θ, the phase component of the reflection coefficient, is related to $\beta\ell$ by:

$$\theta = 2(\beta\ell - 90°) \qquad (°) \qquad (3)$$

The output impedance of the signal source is:

$$Z_g = Z_0 \frac{1 - jS\tan\beta\ell}{S - j\tan\beta\ell} \qquad (4)$$

Two measurements of the output impedance of a signal generator were made at 500 MHz using a 50-ohm constant-impedance line stretcher.

Example 1.
Conditions: Source impedance defined at output port of attenuator.
Output level = 0 dBm
Attenuator step = − 10 dB
Measurements: e_{max} = 10 mV, e_{min} = 9.3 mV
f_n = 432.206 MHz, f_{n-1} = 360.764 MHz

From these data, S = 10/9.3 = 1.075, Δf = 432.206 − 360.764 = 71.44 MHz, n = 432.206/71.44 = 6.0499 which we truncate to 6, and

$$\beta\ell = (500/71.44)\,180° - (6)\,180° = 179.798°$$

Solving for the reflection coefficient, ρ = (1.075 − 1)/(1.075 + 1) = 0.0361, and its phase component is, θ = 2(179.798° − 90°) = 179.597°.

$$\rho = 0.0361 \angle 179.6°$$

The tangent of 179.798° is − 0.00353, and the source impedance is:

$$Z_g = 50\frac{1 - j1.075(-0.00353)}{1.075 - j(-0.00353)} = 46.5\,\Omega \angle 0.029°$$

Example 2.
Conditions: Source impedance defined at output end of build-out resistor, which is driven from leveled source.
Output level = + 10 dBm
Attenuator step = 0 dB
Measurements: e_{max} = 30 mV, e_{min} = mV
f_n = 495.080 MHz, f_{n-1} = 433.180 MHz

From these data, S = 30/20 = 1.5, Δf = 495.080 − 433.180 = 61.9 MHz, n = 495.080/61.9 = 7.998 which we truncate to 8, and

$$\beta\ell = (500/61.9)\,180° - (8)\,180° = 13.958°$$

The reflection coefficient for this case, is ρ = (1.5 − 1)/(1.5 + 1) = 0.200, and the phase angle is, θ = 2(13.958° − 90°) = − 152.084°.

$$\rho = 0.2 \angle -152°$$

The tangent of $\beta\ell$ in this instance is 0.2485, therefore,

$$Z_g = 50\frac{1 - j1.5(0.2485)}{1.5 - j0.2485} = 35.1\,\Omega \angle -11.04°$$

Appendix

From the system of Figure 1, and using conventional transmission-line equations, the output voltage, e_o, can be expressed as:

$$e_o = \frac{2e_g Z_c Z_L}{(Z_o+Z_g)(Z_o+Z_L)\varepsilon^{\gamma\ell} - (Z_o-Z_g)(Z_o-Z_L)-\varepsilon\gamma\ell} \quad (1)$$

If $Z_L << Z_o$, then $Z_o + Z_L \simeq Z_o \simeq Z_o - Z_L$, and for low loss lines $\varepsilon\gamma\ell \simeq 1 \angle \beta\ell$, and $\varepsilon^{-\gamma\ell} \simeq 1 \angle -\beta\ell$. Substituting,

$$e_o = \frac{2e_g Z_L}{(Z_o + Z_g)\angle \beta\ell + (Z_g - Z_o)\angle -\beta\ell} \quad (2)$$

The reflection coefficient of the source impedance, relative to Z_o, is defined as $\rho = (Z_g - Z_o)/(Z_g + Z_o)$. Rearranging (2) and substituting for ρ,

$$e_o = \frac{2e_g Z_L}{(Z_o + Z_g)\angle \beta\ell (1 + |\rho| \angle \theta \angle -2\beta\ell)} \quad (3)$$

When the denominator of (2) is differentiated with respect to $\beta\ell$, it is found to be maximum when

$$\beta\ell = \frac{1}{2}\tan^{-1}\left(\frac{2|Z_o|\,|Z_g|}{|Z_g|^2\,|Z_o|^2}\sin\Phi\right) \quad (4)$$

and minimum at $\beta\ell \pm 90°$

When the denominator of (2) is maximum, e_o is minimum, and when it is minimum, e_o is maximum.

We can show that $2\beta\ell$, from (4), for minimum output voltage, is equal to the angle of the reflection coefficient, θ. Writing the expression for ρ, and expanding and dividing, we have

$$\rho = \frac{|r_g|^2 + |X_g|^2 - |Z_o|^2 + j2X_g Z_o}{(r_g + Z_o)^2 + X_g^2} \quad (5)$$

The tangent of the phase angle is the ratio of the imaginary to the real terms, and remembering that $X_g = Z_g \sin\Phi$,

$$\theta = \tan^{-1}\left(\frac{2Z_o Z_g}{|Z_g|^2 - |Z_o|^2}\sin\Phi\right) = 2\beta\ell \quad (6)$$

In (3) under the conditions of minimum and maximum output voltage, it is evident that $(\theta) + (-2\beta\ell) = 0$, and $(\theta) + (-2[\beta\ell - 90°]) = 180°$. Substituting in (3) for each case,

$$e_{min} = 2e_g Z_L/(Z_o + Z_g)\angle \beta\ell (1 + |\rho|) \quad (7)$$

and,

$$e_{max} = 2e_g Z_L/(Z_o + Z_g)\angle \beta\ell (1 + |\rho|\angle 180° = 2e_g Z_L/(Z_o + Z_g)\angle \beta\ell (1 - |\rho|) \quad (8)$$

From which,

$$e_{max}/e_{min} = (1 + |\rho|)/(1 - |\rho|) = s.w.r. = S \quad (9)$$

The equation for the generator impedance is derived as follows. From the equation for the impedance at any point on a line[2],

$$Z_s = Z_o\frac{Z_o \sinh\gamma\ell + Z_L\cosh\gamma\ell}{Z_o\cosh\gamma\ell + Z_L\sinh\gamma\ell} \quad (10)$$

The reciprocity theorem permits us to interchange e_g and the near short-circuit termination of Figure 1, and the same analysis that yields (10) results in a similar expression in which Z_L is replaced by Z_g. With a line stretcher of essentially air dielectric, with little error we can write $\alpha\ell \simeq 0$, thus, $\sinh\alpha\ell \simeq 0$, and $\cosh\alpha\ell \simeq 1$. This then reduces to:

$$Z_s = Z_o\frac{Z_g + jZ_o\tan\beta\ell}{Z_o + jZ_g\tan\beta\ell} \quad (11)$$

Solving for Z_g

$$Z_g = Z_o\frac{Z_s - jZ_o\tan\beta\ell}{Z_o - jZ_s\tan\beta\ell} \quad (12)$$

Dividing the numerator and denominator by Z_s, and defining $\beta\ell$ as that length of line which produces maximum received current (and e_{max}), then the ratio of Z_o/Z_s that results from this division is equal to S because the reflected line impedance $\beta\ell$ degrees from the source impedance (and each additional half-wavelength) is resistive and (1/S)th of Z_o.

$$Z_g = Z_o\frac{1 - jS\tan\beta\ell}{S - j\tan\beta\ell} \quad (13)$$

[1]The impedance reflected from the internal power source to the output port will be frequency sensitive.
[2]Everitt, W.L., and Anner, G.E.: "Communications Engineering," p. 337, 3rd Ed., McGraw-Hill Book Company, Inc., New York. □

Now you can translate an existing microstrip layout to a different substrate material.

Microstrip Translator For Your

Frederick W. Hauer
EDMAC Associates Inc.

This program allows a microstrip layout designed for one particular substrate thickness and dielectric constant to be converted to a different substrate material. It lets the designer explore the effect of layout size and conductor width variations. It can be used, for instance, to convert teflon-fiberglass layouts to Epsilam-10* material to really reduce the size of existing L-band and S-band designs.

It solves for line impedance when line dimensions are given and solves for line width when line impedance is given. Dimensions must be in cm.

The program development was loosely based upon the Microstrip Line program #EE-14A in the HP-67 EE PAC. The formulas[1] used, however, are more accurate and include the effect of conductor thickness. An interactive process has been added to solve for width by converging to a given line impedance.

Basic operations to solve for impedance are:

1. Input e_r, h, and t in any order. Convert dimensions to cm if necessary.
2. Input ω in cm by keying f b, the output is V_{r1} followed by Z.

Note that e_r, h, and t remain in the proper storage registers and Z is stored in register B so that only those parameters that are different have to be entered when converting to a new substrate. If, for any reason, you want a repeat of the output just key f e.

To solve for microstrip width and length for different conditions:

1. Input the new conditions e_r, h, and t in any order. Also input the original phase velocity, V, and the original length, l_1.
2. Key D, the output has the following format:

V_2 — phase velocity
1 — length, cm
ω — width, cm
Z — impedance, ohms

The impedance displayed will be within 1 percent of the original impedance and is the value the calculator converged to. As before, if a repeat of the output is needed, key f e.

It should be apparent that this procedure can be used to solve for conductor width under any condition when the other characteristics are known. Proceed as above and input the desired line impedance by keying B. If line length is unknown or unimportant, input some number (1, for instance) for V_1 and 1 and ignore the length in the output format.

The following relationships are used:

For $\omega/h \leq 1$:

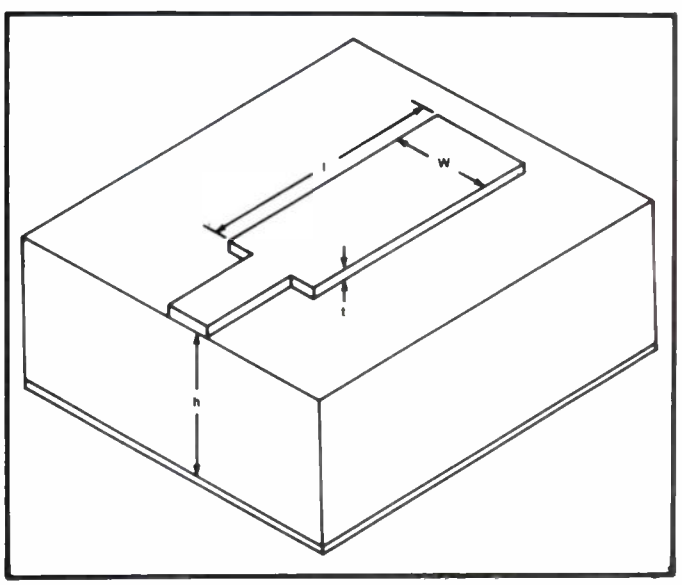
$$Z = \frac{60 \ln (8h/\omega + .25\omega/h)}{\sqrt{e_{eff}}}$$

where

$$e_{eff} = \frac{e_r + 1}{2} + \frac{e_r - 1}{2}\left[(1 + 12h/\omega)^{-1/2} + .04(1 - \omega/h)^2\right]$$

*3M Company microwave substrate.

Program HP-67



For $\omega/h > 1$:

$$Z = \frac{120\pi/\sqrt{e_{eff}}}{\omega/h + 1.39 + .667 \ln(\omega/h + 1.44)}$$

where

$$e_{eff} = \frac{e_r + 1}{2} + \frac{e_r - 1}{2}(1 + 12h/\omega)^{-1/2}$$

Also:

For $\omega/h \geq 1/2\pi$:

$$\frac{\omega_e}{h} = \frac{\omega/h + t(1 + \ln 2h/t)}{\pi h}$$

and for $\omega/h < 1/2\pi$:

$$\frac{\omega_e}{h} = \frac{\omega/h + t(1 + \ln 4\pi\omega/t)}{\pi h}$$

Finally:

$$V_r = \frac{1}{\sqrt{e_{eff}}} \qquad \text{and } I_2 = I_1(V_{r2}/V_{r1})$$

ω = microstrip width
ω_e = effective microstrip width
h = height of dielectric (substrate)
t = thickness of microstrip conductor
e_r = relative dielectric constant of substrate
e_{eff} = effective dielectric constant of substrate
Z = characteristic impedance of microstrip line
V_r = relative phase velocity of microstrip line
l = length of microstrip line

Example: Determine the phase velocity and characteristic impedance of the microstrip line in the figure. Use the following data:

h = 50.8×10^{-3} cm
t = 3.33×10^{-3} cm
ω = 990.6×10^{-3} cm
e_r = 2.55

Step	Key Entry	Key Code	Comments
001	f LBL A	31 25 11	
	STO 7	33 07	Store h
	h RTN	35 22	
	f LBL B	31 25 13	
	STO B	33 12	Store Z
	EEX	43	
	2	2	
	−	81	
	STO D	33 14	Store 1%Z
010	RCL B	34 12	
	h RTN	35 22	
	f LBL C	31 25 12	
	STO C	33 13	Store e_r
	h RTN	35 22	
	f LBL E	31 25 15	
	STO 0	33 00	Store t
	h RTN	35 22	
	f LBL D	31 25 14	
	h CF 1	35 61 01	
020	3	03	
	EEX	43	
	2	02	
	RCL 7	34 07	
	X	71	
	RCL B	34 12	
	÷	81	
	RCL C	34 13	
	h 1/X	35 62	
	f √X	31 54	
030	X	71	
	STO 6	33 06	Store $W_{(est)}$
	f LBL 9	31 25 09	Start Loop
	RCL 7	34 07	
	RCL 6	34 06	
	h SF 0	35 51 00	
	g x > y	32 81	Is ω>h?
	h CF 0	35 61 00	
	÷	81	
	h 1/X	35 62	ω/h
040	h π	35 73	
	2	02	
	X	71	
	h 1/X	35 62	1
	g x ≤ y	32 71	Is ω/h< ?
	GTO 7	22 07	2π
	RCL 6	34 06	
	4	04	
	X	71	
	h π	35 73	
050	X	71	
	RCL 0	34 00	
	−	81	
	f LN	31 52	
	1	01	
	+	61	
	RCL 0	34 00	
	RCL 7	34 07	
	÷	81	
	h π	35 73	
060	GTO 0	22 00	
	f LBL 7	31 25 07	
	RCL 7	34 07	
	2	02	
	X	71	
	RCL 0	34 00	
	÷	81	
	f LN	31 52	
	1	01	
	+	61	
070	RCL 0	34 00	
	h π	35 73	
	÷	81	
	RCL 7	34 07	
	f LBL 0	31 25 00	
	÷	81	
	X	71	
	RCL 6	34 06	
	RCL 7	81	

Step	Key Entry	Key Code	Comments
	÷	81	
080	+	61	
	STO 8	33 08	ωe/h
	h 1/X	35 62	
	f LBL 8	31 25 08	CALC e_{eff}
	1	01	
	2	02	
	X	71	
	1	01	
	+	61	
	f √X	31 54	
090	h 1/X	35 62	
	h F? 0	35 71 00	
	GTO 3	22 03	
	GTO 4	22 04	
	f LBL 3	31 25 03	
	1	01	
	RCL 8	34 08	
	—	51	
	g x^2	32 54	
	2	02	
100	5	05	
	÷	81	2
	+	61	
	f LBL 4	31 25 04	
	RCL C	34 13	
	1	01	
	—	51	
	2	02	
	÷	81	
	X	71	
110	RCL C	34 13	
	1	01	
	+	61	
	2	02	
	÷	81	
	+	61	= e_{eff}
	f √X	31 54	
	h 1/X	35 62	
	STO 2	33 02	Store V_{r2}
	h F? 0	35 71 00	
120	GTO 1	22 01	
	RCL 8	34 08	
	1	01	
	.	83	
	4	04	
	4	04	
	+	61	
	f LN	31 52	
	2	02	
	Enter	41	
130	3	03	
	−	81	
	X	71	
	1	01	
	.	83	
	3	03	
	9	09	
	+	61	
	RCL 8	34 08	
	+	61	
140	2	02	
	h π	35 73	
	X	71	
	h x↔ y	35 52	
	−	81	
	GTO 2	22 02	
	f LBL 1	31 25 01	
	8	08	
	RCL 8	34 08	
	÷	81	
150	h LST X	35 82	
	4	04	
	÷	81	
	+	61	
	f LN	31 52	
	f LBL 2	31 25 02	
	6	06	

Step	Key Entry	Key Code	Comments	Step	Key Entry	Key Code	Comments
	0	00		190	.	83	
	X	71			8	08	
	X	71			9	09	
160	STO 1	33 01			STO X 6	33 71 06	
	h F? 1	35 71 01			GTO 9	22 09	
	GTO fe	22 31 15			f LBL 6	31 25 06	
	RCL B	34 12			.	83	
	—	51			9	09	
	STO E	33 15	= error		1	01	
	h ABS	35 64			STO ÷ 6	33 81 06	
	RCL D	34 14	1%Z	200	GTO 0	22 09	
	g x ≤ y	32 71			g LBL fa	32 25 11	
	1	01			STO 3	33 03	
	+	61			h R↓	35 53	
	GTO 5	22 05			STO 4	33 04	
170	g LBL fe	32 25 15			h RTN	35 22	
	RCL 2	34 02			g LBL fc	32 25 13	
	f -X-	31 84	V_{r2}		2	02	
	h F? 1	35 71 01			.	83	
	GTO 1	22 01			5	05	
	RCL 4	34 04		210	4	04	
	÷	81			X	71	
	RCL 3	34 03			h RTN	35 22	
	X	71			g LBL fd	32 25 14	
	f -X-	31 84	ℓ_2		2	02	
180	RCL 6	34 06			.	83	
	f -X-	31 84	ω_2		5	05	
	f LBL 1	31 25 01			4	04	
	RCL 1	34 01			÷	81	
	f GSB B	31 22 12	Z		h RTN	35 22	
	h RTN	35 22		220	g LBL fb	32 25 12	
	f LBL 5	31 25 05			h SF 1	35 51 01	CALC V_{r1},Z
	RCLE	34 15			STO 6	33 06	
	f x > 0	31 81			GTO 9	22 09	
	GTO 6	22 06			R/S	84	

Input	Key	Output
e_r	C	2.550
h	A	50.80×10^{-3}
t	E	3.330×10^{-3}
ω	fb	$647.5 \times 10^{-3} = V_r$
		10.61 = Z

Now translate this line to a high-K substrate[2] (e_r = 10.2) having a height, h, of .025 inches. The original length is .190 in.

Input	Key	Output	
e_r	C	10.20	
h	fc	63.50×10^{-3} cm	
	A	63.50×10^{-3}	
V_{r1}	Enter	647.5×10^{-3}	
l_1	fc	482.6×10^{-3} cm	
	fa	647.5×10^{-3}	
	D	$340.4 \times 10^{-3} = V_{r2}$	Converging
		253.7×10^{-3} cm $= l_2$	time approx.
		578.1×10^{-3} cm $= \omega_2$	1 minute
		10.57 ohms = Z	

References

1. Bahl and Trivedi, "A Designer's Guide to Microstrip Line," Microwaves, pp. 174-182, May 1977.

2. Woermbke, "Better Your MIC Designs With High-K Substrates," Microwaves, pp. 66-68, March 1979. □

Low-Cost Monolithic 4-Bit A/D Converter

A low-cost, video-speed, monolithic, 4-bit analog-to-digital converter has been introduced by TRW LSI Products. The TDC-1021J, is available off the shelf. The price is $29 in 100s.

The new converter can digitize an analog signal at rates from DC to 30 megasamples per second without an external sample and hold circuit. The single chip is fully parallel, TTL compatible, and utilizes 1,000 closely matched bipolar components.

Contact TRW LSI Products, P.O. Box 1125, Redondo Beach, Calif. 90278. INFO/CARD #93.

Continuous Phase Shifter

A compact, long life transducer that translates physical angle to electrical angle at radio frequencies is being introduced by Timing Systems, Inc. of Salem, Massachusetts.

Timing Systems 30 series continuous phase shifter is an angular transducer that provides a full 360° phase range at radio frequencies. Allowing signal transmission through 50 ohm coaxial cables, it also offers inductive coupling without contacts for infinite resolution, 0 to 5 VRMS input range, and 14 dB insertion loss.

Installed with two coaxial cables and only one panel hole, the Timing Systems continuous phase shifter measures 1½" dia. x 3½"l behind the panel, and has a ¼" dia. shaft.

Contact: Timing Systems, Inc., Shetland Industrial Park, P.O. Box 2074, Salem, MA 01970. INFO/CARD #92.

Precision Voltage Source

Systron-Donner has developed a new precision voltage source that includes programming via the IEEE-488 instrumentation bus as a standard feature, not an option. Designated the model M107, this instrument can be mounted in a 19-inch rack for systems use. It may also be used as a stand alone bench top calibrator or in a variety of test configurations.

Among its outstanding performance features are four DC output ranges up to ±1000 V, an accuracy of ±20 PPM, a 6-digit LED display, one microvolt resolution on the one volt range, output current of 50 mA (1 to 120 V)

and 5 mA (120 to 1000 V), and a current limit control (uncalibrated).

Other design highlights include overload indications, remote voltage sensing, both front and rear panel outputs, plus third generation reliability with emphasis on human engineering.

Contact Systron-Donner Corp., 935 Detroit Ave., Concord, CA 94518. INFO/CARD #95.

Pin Diode Attenuator

Model AGC-1426 is an absorptive PIN diode attenuator operating over the frequency range 1.4-2.6 GHz. It features 0.5 dB, max insertion loss, an attenuation range of 25 dB, min and a VSWR of 2.0:1, max over the range. Attenuation flatness is ±1 dB max at 10 dB attenuation setting. Operating bias

current range is 0-10ma, typical. RF connectors are SMA female and bias connector is SMC.

Contact American Microwave Corp., P.O. Box 41, Damascus, Maryland 20750. INFO/CARD #96.

Signal Generator

Ailtech has announced the addition of a new synthesized signal generator to its product line. Called the 460, the new product represents an advancement in the design of low noise instrumentation. Covering a broad frequency range of 300 kHz to 650 MHz (1300 MHz with doubler), the phase noise is -134 dBc/Hz at 12.5 kHz from the carrier with a noise floor at -145 dBc/Hz.

The low noise performance, coupled with its remote programmability through an IEEE-488 bus interface option, makes the instrument ideally suited for use as a local oscillator in communications systems and for receiver testing.

The design also incorporates a microprocessor which permits not only frequency and output level control, but also the programming of all modulation related functions. To the user, the microprocessor also

means convenience of operation, reliability and confidence through a built-in auto-test system.

Amplitude, frequency and phase modulation can be achieved either from an internal 400 Hz or 1 kHz source or by an external signal. The amplitude modulation meets all the test requirements of VOR-ILS systems.

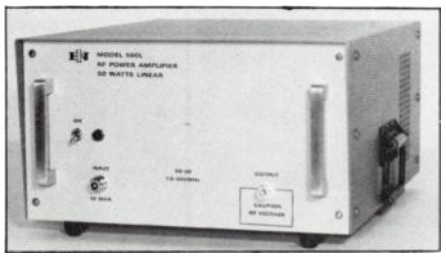
Contact Ailtech, 2070 Fifth Ave., Ronkonkoma, NY 11779. INFO/CARD #97.

Power Amplifier

The model 550L RF power amplifier a linear power level exceeding 50 watts over a frequency range of 1.5 to 400 MHz. This ultra linear Class A unit is compatible with any commercial signal or sweep generator, making it ideal as a source of laboratory power. The wide frequency and linear phase response of this instrument enables it to amplify AM, FM, SSB, TV or pulse signals with minimum distortion. Unconditional stability and instantaneous failsafe provisions in the unit provide absolute protection from damage due to transient and overload conditions. It will operate continuously into any load impedance from an open

to a short circuit without shut-down.

For applications where slightly higher distortion levels can be tolerated the model 550L will provide more than 100 watts of CW and pulse power



from 1.5 to 220 MHz. This rugged, compact unit is complete with integral power supply and cooling system for operation from 115/230 VAC. Priced at $4925.00, delivery is from stock to 60 days.

Contact Electronic Navigation Industries Inc., 3000 Winton Rd. South, Rochester, NY 14623. INFO/CARD #99.

Crystal and Fuse Cartridge Bolometers

Micronetics' crystal and fuse-shaped bolometers are rugged devices specifically designed for accurate square law detection and measurement of absolute power at microwave frequencies. These precision-engineered bolometers, permanently sealed against moisture and ambient conditions, are thoroughly pre-tested and performance guaranteed.

Type CWB crystal bolometers are completely interchangeable with 1N21 and 1N23 crystals. These units offer positive contact and alignment in all makes of standard or special waveguide and coaxial crystal holders, detector mounts, probes and impedance meters. Available in three models.

Type FSB fuse bolometers are completely interchangeable with all standard type 821 barretters. Type FSB bolometer dimensions are held to close tolerances for positive contact and alignment in standard barretter mounts.

Contact Micronetics, Inc., 36 Oak Street, Norwood, New Jersey 07648. INFO/CARD #98.

900 MHz Mobile Radio Band Transistors

Most industrial and commercial communications are carried on in the VHF and UHF frequency bands, which are becoming severely congested. FCC approval of the 900 MHz band, provides more channel capability than all of the other mobile and hand-held communications bands combined. Motorola has introduced a complete line of 8 RF power transistors, with up to 40-watt power capability, to populate new equipment designed to operate in this band.

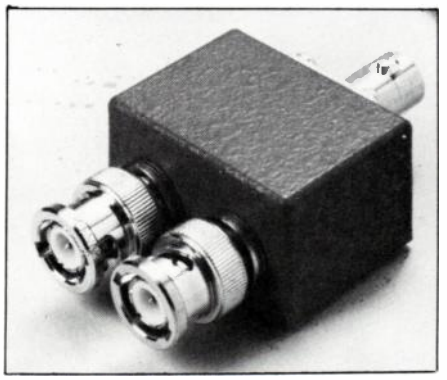
The new NPN RF power transistors, with guaranteed performance at 870 MHz, are designed for 12.5 V UHF large-signal, amplifier applications in industrial and commercial FM equipment operation in the range of 806-947 MHz. These new state-of-the-art products are characterized for Class C amplifier service in FM mobile two-way radio equipment. The MRF838/A and MRF870/A 1 W and 3 W output parts, respectively, are designed for common-emitter operation.

The 10 W, 20 W, 30 W and 40 W output devices—MRF840, 842, 844 and 846—are connected for common-base operations in the internally matched input (CQ) CS-12 package.

Contact Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036. INFO/CARD #102.

BNC Adapter

ITT Pomona Electronics has developed a new BNC adapter that will accept two BNC jacks on 17.0 mm (.68") centers and one BNC plug on the opposite end. Model 4607 has a die



cast aluminum housing with baked enamel finish. It's all metal construction assures proper shielding.

Contact ITT Pomona Electronics, 1500 E. Ninth Street, Pomona, CA 91766. INFO/CARD #100.

Dual IF Microwave Link Analyzer

Both the traditional 70 MHz and the newer broad band 140 MHz IF carrier communication systems are covered with this new Hewlett-Packard microwave link analyzer. Called the model 3711/12A, this new MLA consists of the model 3711A IF/BB transmitter and the model 3712A IF/BB receiver. Along with the dual IF capability, the MLA features enhanced specifications to enable microwave network operators make more precise measurements on both types of systems. For example,

back-to-back residual performance of the MLA has been improved and sensitivity is now quoted at -20 dBm.

Direct readout of the variable marker frequency is displayed on a five-digit LED counter. Resolution is to 10 kHz and accuracy is typically to 20 kHz, making it ideal for narrow-band satellite filter testing. Naturally, the counter is also useful in establishing IF inputs and setting modulator center frequencies.

Although MLA measurements are made and displayed using analog methods, the power of digital techniques may be added by using the HP 8501A storage normalizer. This instrument, when connected via a special interface, simultaneously converts the analog X and Y signals from both traces to digital form, processes them as required, and reconverts them to analog form for display on the MLA screen. Traces may be stored for later display, or may be subtracted from current measurements. This facility may be used in production testing to compare a known good device with the units being tested, allowing them to be adjusted for 'best straight line' rather than to a complex mask.

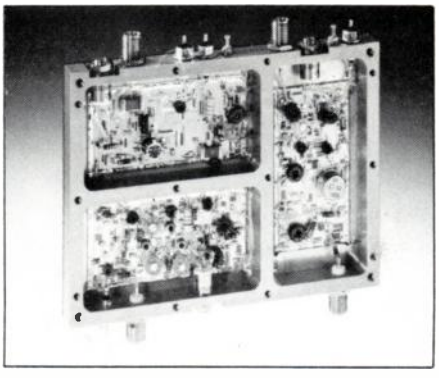
Contact Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, California 94304. INFO/CARD #103.

Multimode IC IF Amplifiers

A new series of multimode linear IF amplifiers with numerous special features and functions normally found only in custom designs is available. Features include instantaneous automatic gain control (IAGC), gating and blanking, fast time constant (FTC), etc. These features are those most often needed for radar simulation systems.

Identified as the ICXT series, six standard frequency/bandwidth combinations are offered. Special hybrid IC technology developed by RHG is utilized. Materials and processes are fully compatible with MIL-E-5400, Class II, and MIL-E-16400.

The price for model ICXT3010 is $1,950 with delivery 90 days ARO typically. For additional information, contact RHG Electronics Laboratory, Inc., 161 East Industry Court, Deer Park, New York 11729. INFO/CARD #104.

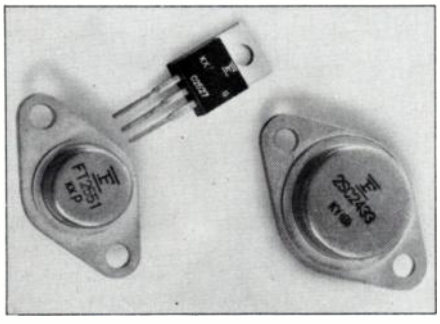


RET Power Transistors

Fujitsu America Inc. has announced a new RET (ring emitter transistor) power transistor that provides combinations of power and speed not available with other types of power transistors.

Typical characteristics include a high gain bandwidth product of more than 80 MHz, which is from 5 to 8 times better than conventional transistors, and a switching speed of 0.3us. RETs also have superior inductive loading characteristics with an I_{SB} of more than 1.0 A. Conventional power transistors by way of comparison, do not begin to approach 0.5 A.

The ring emitter design concept is that of many, small geometry, high frequency devices integrated on one chip to provide a high power capa-



bility. These small, ring-shaped emitters connect to a common emitter electrode through diffused ballast resistors which ensure uniform current density in each emitter ring.

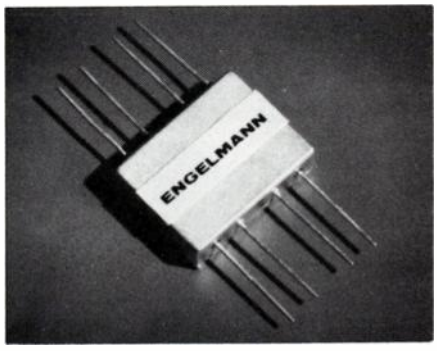
Fujitsu RETS come in standard package configurations: TO-3, TO-66 and TO-220. Power ratings range from 25W up to 150W. RETs are in volume production and are available for immediate delivery.

Contact Fujitsu America, 2945 Kifer Road, Santa Clara, CA 95051. INFO/CARD #105.

0.5-800 MHz Power Divider

Engelmann Microwave has introduced a new flat pack power divider that operates over the frequency range of 0.5-800 MHz with a 20 dB minimum isolation. The maximum insertion loss for the model PSF-210 is only 1.0 dB over the full band. Phase and amplitude variation port to port are maintained at ±0.2dB and ±4 degrees respectively.

The Engelmann flat pack measures 1/2 inches x 3/8 inches x .140 inches. Specials and integrated circuits are also available. The model PSF-210 is



priced at $20.00, in 1-24 piece quantity and is available from stock.

For additional information, contact Engelmann Microwave Company, Skyline Drive, Montville, New Jersey 07045. INFO/CARD #108.

"Lossyline" Flexible Filter Wire

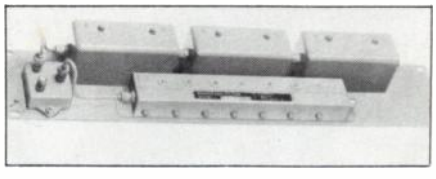
"Lossyline" flexible filter wire and cable for suppression of noise, radio-frequency and electromagnetic interference generated by electronic and electrical equipment, computers, microwave ovens, magnetrons, klystrons, travelling wave tubes, crossed field amplifiers, backward wave oscillators, tunnel diode amplifiers, planar ceramic tubes and microwave heating tubes.

The Capcon "Lossyline" flexible filters are engineered for the suppression of noise and EMI in the various applications caused by radio-frequency interference, harmonics, resonance, intercoupling, unwanted oscillation, thermal noise, uneven cathode emission and spurious energy.

Full technical literature and samples may be obtained free of charge by contacting Capcon, Inc., 147 West 25th Street, New York, N.Y. 10001. INFO/CARD #107.

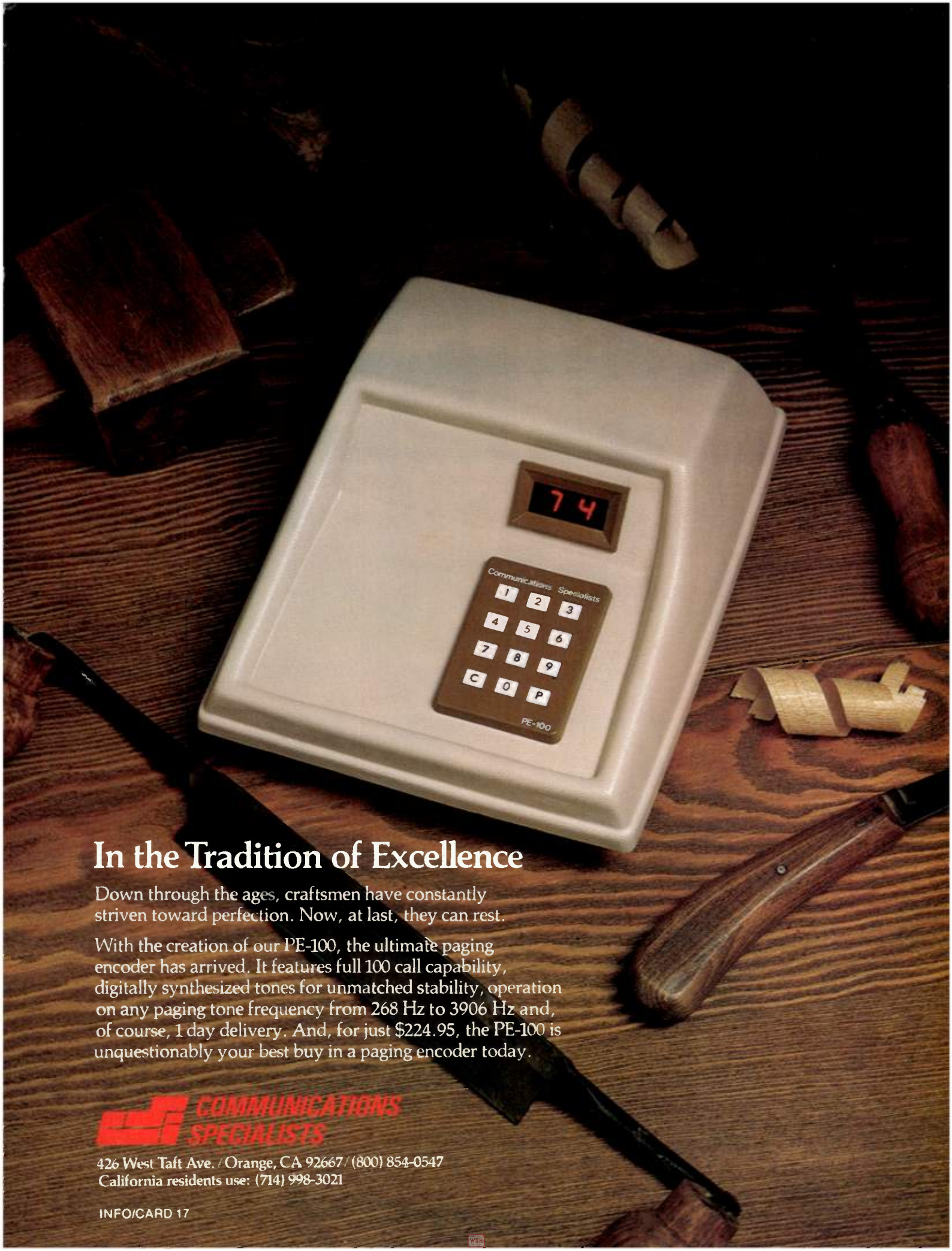
Filter Reroutes a Channel

Model 3618, called "Channel Extractor", removes a selected channel from the line with little impact to adjacent channels. The removed channel is made available at a separate output



with all other channels suppressed 50 dB. Model 3618 is used to transfer a single channel from one system to another. It is made to order for any channel.

Contact Microwave Filter Company, Inc., 6743 Kinne St., E. Syracuse, N.Y. 13057. INFO/CARD #106.



In the Tradition of Excellence

Down through the ages, craftsmen have constantly striven toward perfection. Now, at last, they can rest.

With the creation of our PE-100, the ultimate paging encoder has arrived. It features full 100 call capability, digitally synthesized tones for unmatched stability, operation on any paging tone frequency from 268 Hz to 3906 Hz and, of course, 1 day delivery. And, for just $224.95, the PE-100 is unquestionably your best buy in a paging encoder today.

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INFO/CARD 17

RF Video Adaptor Kit

AVA Electronics Corp., manufacturer of RF connectors, adaptors and cable assemblies for the CATV, MATV, CCTV and CB markets, announces the introduction of their new RF video adaptor kit, according to Don Workman, sales manager.

The RF video adaptor kit, designated model 1801, can be used with video, television, camera, electronic equipment and instruments. The kit is housed in a sturdy, reusable plastic box. It contains one each of the 12 most often needed RF video adaptors. Send for free video adaptor catalog sheet.

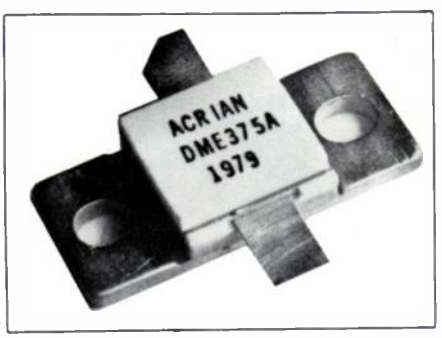
Contact AVA Electronics Corp., 4000 Bridge Street, Drexel Hill, Pa. 19026. Circle INFO/CARD #113.

DME Power Transistors

Acrian, Inc. has available its 1025-1150 MHz NPN power transistors designed specifically for airborne distance measuring equipment (DME). Offered in power outputs of 10, 50, 150, 250 and 375 watts, the DME devices feature exclusive use of gold thin-film metalization for maximum protection from operational degradation and for proven longest lifetime. Additionally, gold controlled-loop wire bonding is used to provide consistant RF performance.

The low thermal-resistance packages and eutectic die attach permit junction temperatures which are the lowest in the industry, contributing to maximum MTTF. Extended operational life also results from passivation of device surfaces to eliminate contamination.

RF performance is 100% tested and guaranteed in a wide-band fixed tuned



text fixture. Operating conditions are: F = 1025-1150 MHz, VCC = 50 volts, pulse width = 10μs, duty factor = 1%.

Acrian specializes in the manufacture of bipolar high-power transistors for avionics, communications and radar applications, and can be contacted for more information at 10131 Bubb Road, Cupertino, California 95014. INFO/CARD #112.

Capacitance Meter

Capacitance meter combines the precision, range and flexibility of heavy-duty, multi-function industrial models with the economy and operating ease of single-function hand-held units has been announced. In addition to high-accuracy measurements, faster readings and in-circuit testing capabilities, the new Model 3001 3½-digit benchtop capacitance meter and its accessories provide such optional functions as tri-mode comparison, interface for automated testing and sorting, and a jig for high-speed production testing applications. Its suggested domestic U.S. resale is $190.00.

The Model 3001 can measure capacitances from 1 pF to .1999 Farad in nine ranges (1000 pF to 100 mF nominal readings), with results displayed on a large 3½-digit LED readout. Rear-panel digital *gated clock* and *clock enable gate* outputs are provided for use with sorting and control acces-

sories or remote displays.

CSC's unique dual-threshold measurement technique eliminates reading errors caused by dielectric absorption—the tendency of capacitors to hold a "memory" or residual charge—by measuring charging time only over a Voltage range above this residual level. Maximum excitation Voltage is 3.5 VDC, and test cycles are 0.3 seconds or less on the lower eight ranges; 0.5 VDC and 3.5 seconds on the 100 mF range.

For additional information or the name of the stocking CSC distributor most convenient to you, call Continental Specialties Corporation toll-free (not available in Connecticut) at 1-800-243-6077, or write Continental Specialties, 70 Fulton Terrace, New Haven, Conn. 06509. INFO/CARD #117.

Microwave Crystal Detector

This new low-cost, general purpose microwave detector can be used in applications such as CW and pulsed detection as well as external leveling of microwave sources. The HP model 420C, the detector replaces the previously available model 420A, covers the same 10 MHz to 12.4 GHz range, but is more compact, with flatter frequency response, higher sensitivity and with lower SWR.

The 420C is available with either negative or positive polarity output, and in matched pairs of either polarity. Its diode is replaceable. Replacement diodes have key matching elements built in, and are individually tested to insure performance to specifications. Connectors are Type N male input, BNC female output.

Contact Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Ca. 94304. INFO/CARD #119.

IC Segment Driver

The Dionics DI-232/242 series high voltage IC segment driver circuit is for alpha-numeric displays; delivering nine outputs in a group of four and a group of five, each output group having a different and independent programmed segment-current level. These momolithic silicon dielectrically isolated circuits are designed to drive gas discharge display devices from signals originating from MOS and TTL circuitry and provide for simple interfaces with displays such as the Beckman, Burroughs, Cherry, Dale or Pantek types. Each output is a switched programmable constant current sink with a voltage compliance or 80 or 125 volts. They offer an exceptionally high input voltage capability of 40 V and an output current of 5 mA max. All output currents in each group of outputs are programmable with a single resistor.

Contact Dionics, Inc., 65 Rushmore St., Westbury, N.Y. 11590. INFO/CARD #118.

Low-Cost Detector Covers 10 MHz to 34 GHz

A new detector from Wiltron covers the full 10 MHz to 34 GHz range in a single unit. Designed specifically for wide-band system applications, these low-cost units offer the OEM designer frequency coverage previously unavailable in coax systems, plus the best performance and lowest price. The detectors use a recently-developed Wiltron WSMA connector that has

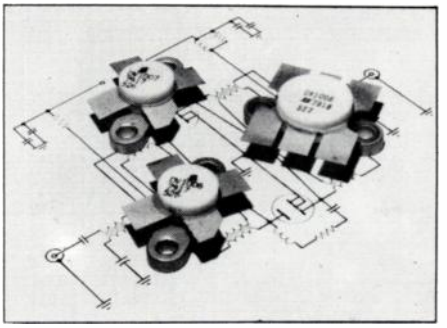
excellent SWR characteristics, improved life expectancy, and compatibility with conventional SMA connectors. They are ideal for applications requiring output voltage tracking over a wide dynamic range.

The zero-bias Schottky diode modules used are field-replaceable. Price of the diode module is $85 for the 70S50A and $100 for the 70S50B. This is much less than the replacement module for competitive models. Replacement diode module sells for approximately $150.

For additional information, contact Wiltron Company, 825 East Middlefield Road, Mountain View, CA 94043. INFO/CARD #122.

High Frequency VMOS Transistors

Three high-power, high frequency VMOS transistors have been introduced by Siliconix Incorporated. The DV1006, DV1007, and DV1008 are rated at 25, 50, and 100 watts power output respectively, at a test frequency of 175 MHz., operating at 28 V. Operation may be Class A, B, or C. The DV1006, DV1007, and DV1008 are packaged in the popular Flange ceramic strip-line. Unique to VMOS technology is the low baseband noise,



immunity to burn-out resulting from an infinite VSWR, and the ease of operating in Class A and B.

Because of higher gain associated with VMOS, designs exceeding octave bandwidths are possible. Contact Siliconix, 2201 Laurelwood Rd., Santa Clara, Calif. 95054. INFO/CARD #121.

Rack Mounted Cesium Beam Frequency and Time Standard

The FTS 4050 rack cesium standard (in a 19" x 5¼" x 21" frame) combines the high performance and reliability of the FTS 4000 modular standard with complete functional controls required for uses such as in the laboratory, marine/submarine platforms and telecommunications terminals.

The FTS 4050 comes complete with 115 VAC power supply; 1, 5, 10 MHz (1 VRMS/50 ohm) and 1 pps (3V peak) outputs. A monitor meter is provided with selectable settings for quartz oven voltage, cesium oven current, cesium beam current, quartz control voltage, AC supply voltage, and battery charge current (with optional 3 hour battery). f fine tuning (C-field adjust) is controlled by a 3 decade digital potentimeter. In addition, controls are provided for modulation ON/OFF, servo-loop OPEN/CLOSED and autolock ON/INHIBIT. Inputs are 1 pps SYNC, SYNC ENABLE, and ZEEMAN INPUT.

FTS' standard 5 year cesium beam tube warranty applies to the FTS 4050. In addition, FTS' unique service policy provides a no-charge loan unit if a standard under warranty fails, and warranty repairs will take longer than 30 days. Contact Frequency and Time Systems, Inc., 182 Conant St., Danvers, Ma. 01923. INFO/CARD #120.

LEDS in T-1 Packages

Super-bright LEDS in T-1, submidget flanged packages are now available from Data Display Products. These MF125 LEDS have comparable brightness, and are a direct replacement for, incandescent lamps of the

same package style.

The MF125 LEDS provide reliability and lifetimes exceeding any of the incandescents they replace . . . eliminated are burned-out filaments and blackened glass envelopes. In addition, the ruggedness of these LEDS allows them to operate in high vibration environments where incandescents could not survive.

Devices exhibit a 2.4-V drop at 20 mA and require an external resistor. Red, amber and green versions are available with clear or translucent lenses.

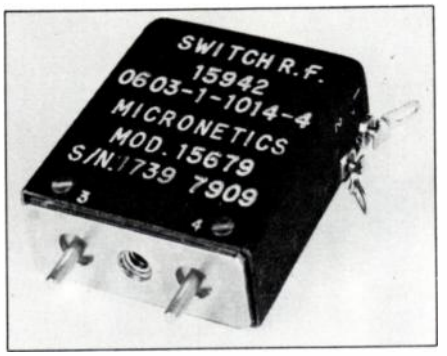
Contact Data Display Products, 303 North Oak St., Inglewood, CA 90302. INFO/CARD #125.

Remote Mini Coaxial Switches

Micronetics RET-1 type SPST all-purpose mini switches are the first of its kind designed for use with printed circuit boards, microstrip and stripline.

The SPST mini coaxial switches are inexpensive, offer very low insertion loss, substantial power capability, high isolation and wide bandwidth. They are available in a normally open (unenergized) configuration.

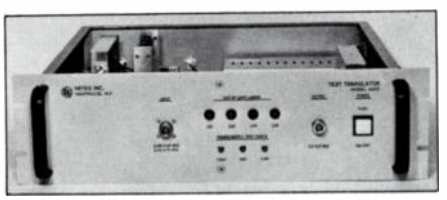
Specifications are as follows—switch type: SPST; frequency range: DC-100 MHz (useful to 2 GHz derated specifications); insertion loss: 0.1 dB max.; VSWR: 1.10 max.; isolation: 80 dB min.; weight: 2 oz.; power rating (RF): 850W CW max.; impedance: 50 ohms; connectors: PCB mounted; input: 45V DC; 100 MA max.; switching time: 25 Msec.; life: 1,000,000 cycles min.; operating temp.: -55° C. to +85° C. Other input voltages and TTL logic can be supplied.



Price $48.00 each in 100 piece quantities. Delivery off-the-shelf. For further details, write or call Micronetics, Inc., 36 Oak Street, Norwood, NJ 07648. INFO/CARD #124.

Loop Test Translator

New generation of loop test translators for satellite communications include Ku-band uplink to X-band downlink, C-band uplink to C-band downlink, Ku-band uplink to C-band



downlink, Ku-band uplink to Ku-band downlink. Features include minimum distortion, input and output filtering, input and output calibrated PIN diode gain control.

For further information contact Miteq Inc., 100 Ricefield Lane, Hauppauge, New York 11787. INFO/CARD #123.

Communications Essentials Brochure

A new 4-page brochure describing communications accessory equipment is now available from the J.W. Miller Division Bell Industries, of Compton, California. Direct reading SWR, forward power and reflected power are provided by models CN-720 and CN-620 over the 1.8-150 MHz range. Model CN-630 covers the 140-450 MHz range. RF clipping that assures low distortion is provided by models RF-440 and RF-660 Speech Processors.

Adjacent channel isolation of better than 50 dB at 300 MHz and 45 dB at 450 MHz is provided by 2-position model CS-201 and 4-position model CS-401 coaxial switches. The broad line of interference filters includes high pass, low pass, audio and AC power line filters.

For additional information, contact Jerry Hall, operations manager, J.W. Miller Division, Bell Industries, 19070 Reyes Avenue, Compton, California 90221. INFO/CARD #126.

Ultra Broadband Termination

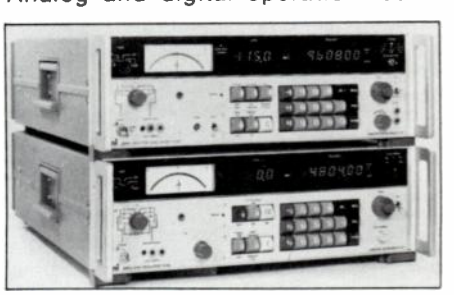
The Micronetics TO-12N is a broadband, DC-12, 4 GHz, N type termination with an average power capability of 5 watts—yet only 0,840 in diameter, 1.330 long, including type N made connector.

Micronetics terminations will also meet the environmental requirements of MIL-E-16400, class 1 and MIL-E-5400, class 3 with higher levels available.

For additional information, contact Micronetics, Inc., 36 Oak Street, Norwood, NJ 07648 (201) 767-1320. INFO/CARD #130.

New Generation S.L.M.S.

A new microprocessor controlled selective level measuring set. Two units, a level oscillator, TF2356 (sender) and a selective level meter, TF2357 (receiver) form a 20 MHz SLMS suitable for any application where the generation and measurement of signals to high accuracy is required. Analog and digital operation tech-



niques are blended to provide speed, versatility and ease of use, made possible by microprocessor control and built-in synthesizers.

In the maintenance of wideband communications systems the selective level meter provides fast, precise frequency setting and immediate in-traffic level measurement including an automatic search for spurious signals above a selected threshold. The unit features a built-in demodulator and loudspeaker for traffic identification and as an aid in fault finding. Digital control of frequency allows incrementing for fast measurement of linearly spaced signals including reference pilots, carrier leaks and channel traffic. Since all functions can be remotely controlled via the IEEE 488 Interface, the receiver forms the basis of a fully automatic in-traffic baseband monitor system.

Level oscillator, TF2356 and selective level meter, TF2357 are available for delivery in 30 days. For full information contact Marconi Instruments, 100 Stonehurst Court, Northvale, N.J. 07647. INFO/CARD #129. □

Toroidal Components Catalog

Engelmann Microwave has just released a new catalog covering its line of toroidal components. This 18-page catalog details the Engelmann line of microcube mixers, 10 kHz to 4200 MHz in 8 pin, 4/8 pin miniature, flat pack, TO-5, TO-8 and connectorized versions; microcube power dividers with 2, 3, 4, 6, 8, 12 and 16 outputs covering the frequency range of 10 kHz to 1500 MHz; microcube directional couplers, 10 kHz to 2000 MHz in flat pack, 8 pin, TO-8 and connectorized types; microcube hybrid couplers and quadrature couplers covering 1 MHz to 500 MHz plus microcube switches/transformers, 1 MHz to 1500 MHz. Each microcube product line is presented with general specifications, environmental specifications, outline drawings, photographs and detailed specifications for each model number. Copies of the Toroidal Components Catalog are available by writing Engelmann Microwave Company, Skyline Drive, Montville, New Jersey 07045. INFO/CARD #140.

Quartz Crystal Guide

"A Specifier's Guide to Quartz Crystals" is just that. In a concise, understandable new booklet, Reeves-Hoffman has provided a long-sought explanation of the properties of crystals, and reduced the task of ordering the right crystal unit for oscillator applications to a very simple procedure.

The new guide opens with a description of the electrical and physical parameters (including holder types) necessary to the proper selection of a quartz crystal unit for a given frequency-control application. Emphasis is given to the advisability of not overspecifying (i.e., avoiding unnecessary specifications which can add to cost without necessarily contributing to performance).

Besides providing its simplified selection procedure, the Specifier's Guide includes a glossary intended to clear up certain aspects of crystal technology that have confused circuit designers for decades.

Contact Reeves-Hoffman, Division of Dynamics Corporation of America, 400 W. North St., Carlisle, PA 17013. INFO/CARD #139.

Magnetic Shielding Brochure

Magnetic Radiation Laboratories has released a new four page brochure which describes their services in the design and production of magnetic shielding. Complete with photos and illustrations, the brochure describes the various requirements, materials and design factors involved in producing the correct magnetic shielding for a given use. Contact Magnetic Radiation Laboratories, Inc., 2475 E. Devon Avenue, Elk Grove Village, IL 60007. INFO/CARD #138.

Lo Cost Computerized Cal System

A new catalogue from Julie Research Laboratories, Inc. describes Lo Cost computerized calibration system that is available at low cost leasing terms to fit into the budgets of even small calibration and testing laboratories. This system includes all of the high performance hardware and software needed for full-quality, fully documented and fully traceable calibrations.

Contact Julie Research Laboratories, Inc., 211 West 61st Street, New York, N.Y. 10023. INFO/CARD #137.

Engineering Power Supply Handbook

A recently published, 36-page, three-color power supply handbook by Datel Systems details the electrical and mechanical parameters on more than 180 power supplies. This comprehensive line of power conversion products includes: modular encapsulated single, dual and triple output, modular encapsulated chassis mount, high voltage modular, high power open frame, DC-DC converter modules 1-10 watts, miniature 4.5 watt DC-DC converters, microcomputer DC-DC converter module.

This handbook is a complete presentation to the design engineer. Detailed specifications on Datel's power supplies are presented in tabular form and includes complete case, pin and socket configurations. Additionally, an outline of modern power supply principles and practices,

and a section on power supply terminology have been incorporated.

Contact Data Systems, Inc., 1020 Turnpike St., Canton, Mass. 02021. INFO/CARD #136.

Instruments Catalog

A number of new oscilloscopes, frequency counters and audio and video instruments, are among the products featured in a newly published, 60-page, full line catalog issued by Leader Instruments Corp. of Plainview, N.Y. Commenting that the new publication is "the most comprehensive presentation we have ever issued", William L. Brydia, corporate vice president, said the new catalog includes complete features, specifications and applications for more than 50 instruments.

Among the latest products are two 10 MHz oscilloscopes offering 1 mV sensitivity and Z axis modulation available in dual trace and single trace versions. In addition, a new production testing oscilloscope system, designed to facilitate rapid and precise production line test by non-technical personnel is being made available. A total of 11 oscilloscopes, ranging in bandwidth from 4 to 30 MHz are now included in the Leader line.

Leader instruments have a broad range of application in industry, education, service, research and government and are covered by a two year parts and labor warranty backed by service centers on the east and west coasts. Contact Leader Instruments Corp., 151 Dupont Street, Plainview, N.Y. 11803. INFO/CARD #135.

Specifications on Polyester & Foil Capacitors

An easy to read six-page fold-out bulletin on Panasonic's "ECQ-M" polyester and foil capacitors is now available from the Electronic Components Division of Panasonic. Design features include non-inductive construction—with tinned copper leads welded to the foils, high peak current capability, solvent-resistant resin coated body and automatic insertion capability.

The fold-out bulletin presents detailed and general specifications on this family of capacitors. This includes voltage range, capacitance values, complete capacitor dimensions, lead configurations, variety of mechanical and electrical specifications and other performance factors. The latter includes dissipation factor (DF), insulation range, moisture resistance, lead tensile strength and lead bending strength.

Information on how to order the ECQ-M series capacitors directly from the bulletin is also included.

For a free copy of the bulletin, write to Panasonic Company, One Panasonic Way, Secaucus, N.J. 07094 and ask for a copy of "ECQ-M Series Polyester & Foil Capacitor Bulletin." INFO/CARD #133.

TACAN Power Transistor Product Line Sheet

Acrian, Inc. has available a product line sheet describing its 960-1215 MHz NPN power transistors designed for Tactical Air Navigation (TACAN) systems. The two-color literature provides details regarding design and process technologies used in production of the devices, lists the benefits of these technologies, gives performance parameters and illustrates typical amplifier lineups.

Also included are package diagrams specifying exact device dimensions and physical characteristics. Available from Acrian, Inc., 10131 Bubb Road, Cupertino, California 95014. INFO/CARD #132.

Pushbutton Switch Catalog

A new comprehensive catalog featuring Centralab's MPS and PBS series lighted and non-lighted pushbutton switches is now available from Centralab.

The 36-page catalog elaborates on the design flexibility and typical applications of Centralab's modular pushbutton switches, also included are detailed electrical and mechanical specifications, assembly options and methods of operation information.

A useful button and lens color chart aids in the selection of switch buttons and keycaps. Colored illustrations depict a cross section of industries where Centralab's MPS and PBS series pushbutton switches are specified.

Copies of the new catalog are readily available by writing to Centralab Electronics Division of Globe-Union Inc., 5757 North Green Bay Avenue, P.O. Box 591, Milwaukee, Wisconsin 53201. INFO/CARD #131.

IEEE-488 Programming Procedures

A new 72-page Application Note from Hewlett-Packard explains the principles of programming instrument systems under the control of HP 1000 Computer Systems, interconnected by means of the HP-IB (Hewlett-Packard Interface Bus, HP's implementation of IEEE Standard 488-1978). There are chapters on Getting Started, System Preparations, Bus Status and Configuration Utility, Performance Measurements, and Assigning Logical Unit Numbers. The publication also lists 21 other HP Application Notes, each giving specific details on programming an HP-IB-interconnected HP 1000 system for use with a particular HP instrument.

Hewlett-Packard Application Note 401-1, "HP 1000/HP-IB Programming Procedures," is available only by writing, on letterhead, to Roger Ueltzen, marketing manager, Hewlett-Packard Data Systems Division, 11000 Wolfe Road, Cupertino CA 94014. No charge. INFO/CARD #91. □

portable spectrum analyzer

.4—1000 MHz Model AL-51A From Texscan

■ .4-1000 MHZ IN ONE SCAN ■ 500 CYCLE RESOLUTION ■ 115 dBM SENSITIVITY ■ AM-FM DEMODULATION & AUDIO SYSTEM ■ PHASELOCK STABILITY ■ CRYSTAL MARKERS STANDARD

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TO-5 RELAY UPDATE

Still the world's smallest RF relay ...and the stingiest

When we first told you about the inherently low inter-contact capacitance and low contact circuit losses of our TO-5 relays, you agreed that they were ideal for RF switching. And you began designing them in immediately. They provided high isolation and low insertion loss up through UHF (typical performance 45 db isolation and 0.1 db insertion loss at 100 MHz).

Then you discovered another benefit – particularly for hand-held transceivers where battery drain is critical. The TO-5 is very stingy on coil power; the sensitive versions draw only 210mW at rated voltage.

So if you're looking for a subminiature RF switch, don't settle for anything less than TO-5 technology. It's available in commercial/industrial as well as MIL qualified types. Write or call us today for full technical information.

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