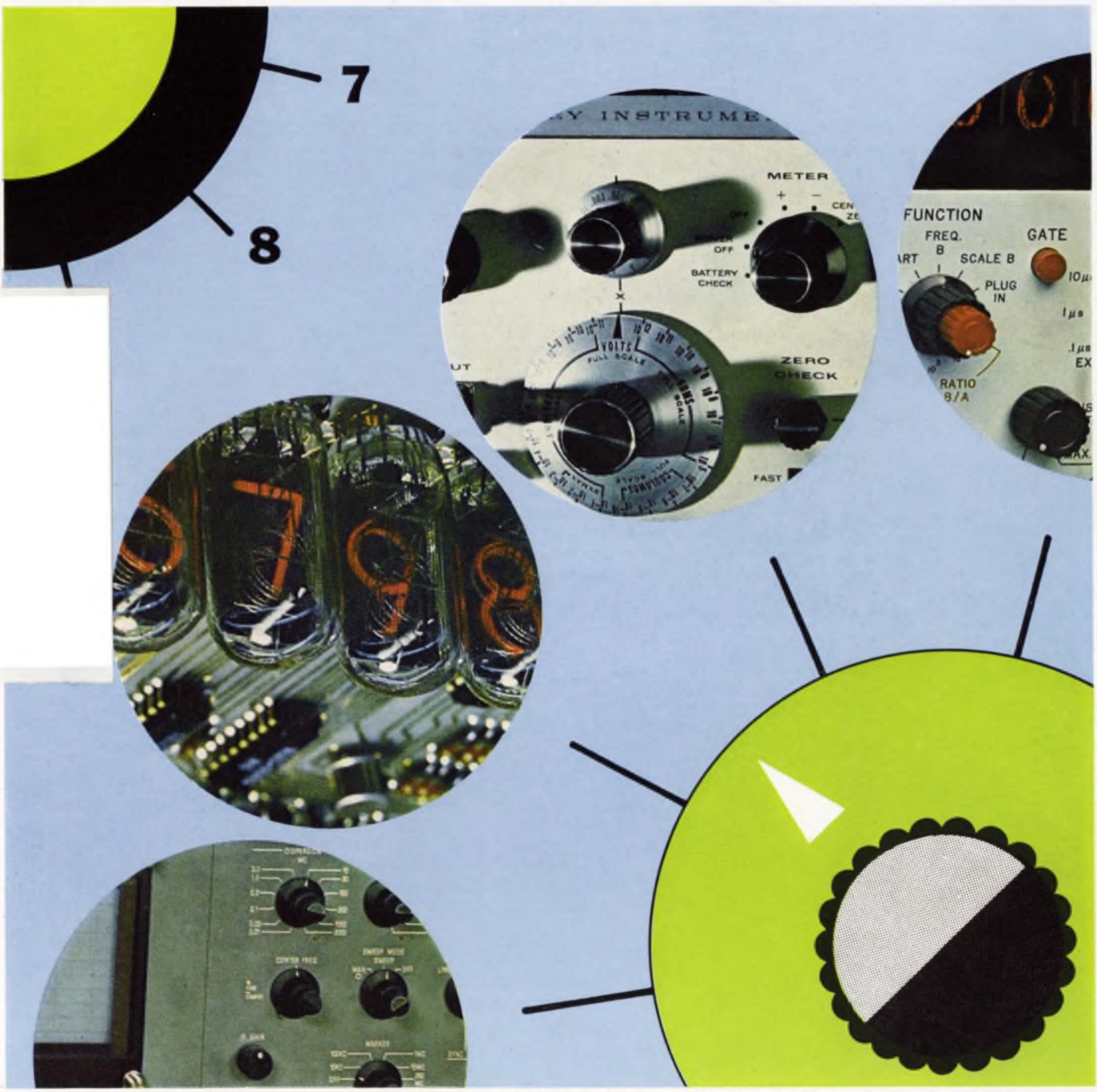
VOL. 15 NO.

Electronic Design 20

FOR ENGINEERS AND ENGINEERING MANAGERS

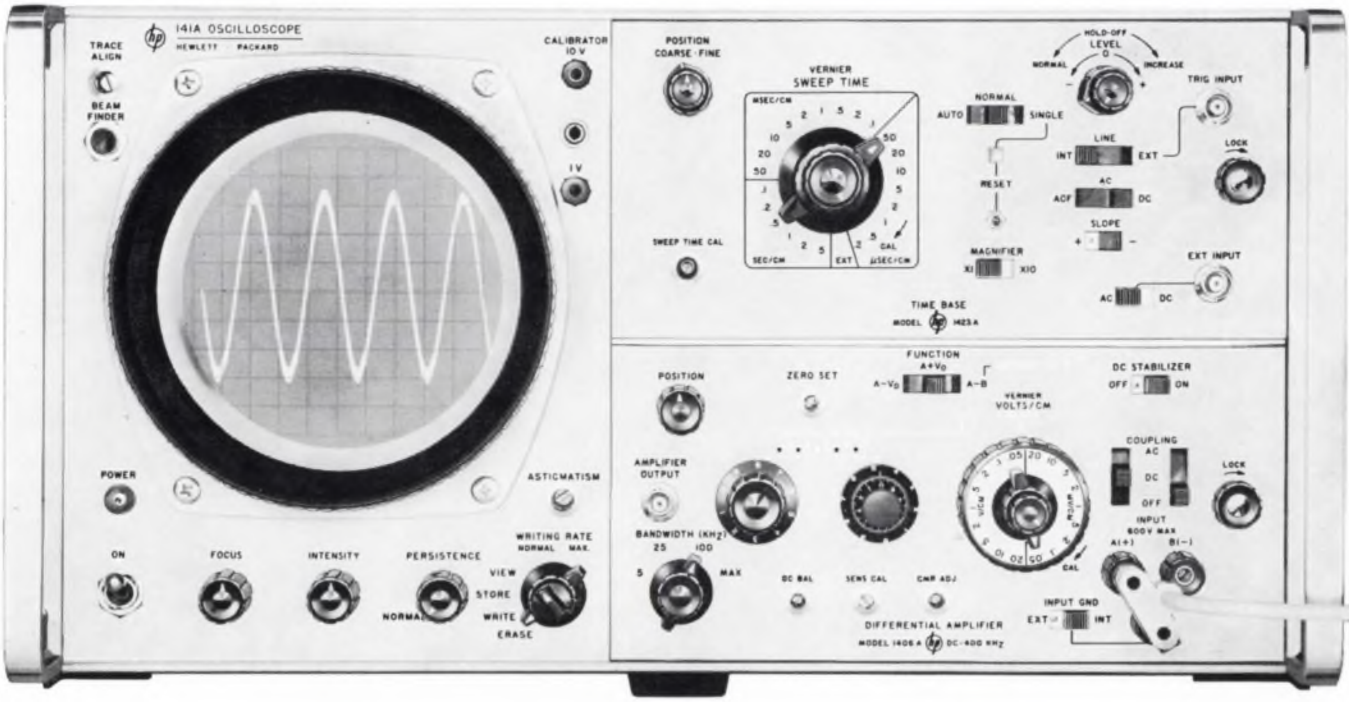
SEPT. 27, 1967

Buy smart. Check prices and specs of test instruments in the easy way. From voltmeters to counters, the charts in this issue list more than 2500 instruments. But there is more than just a list. The impact of digital and linear ICs and of automated testing on new test methods and instruments are also explored. For the full story, turn to p. T1.



hp 140A—The Scope System that gives you

PRECISION DC & AC MEASUREMENTS



Zero drift, calibrated offset, DC coupled, 50 μV/cm The versatile hp 140A Scope System gives you a choice of 17 plug-ins—five of them especially designed for high sensitivity measurements. For example, the 1406A vertical plug-in offers high 50 μv/cm sensitivity with no dc drift—plus precision calibrated dc offset for extreme magnification.

With the hp calibrated offset feature, the 1406A gives you all the advantages of a dc and ac voltmeter—four-digit readout, auto decimal placement, better than 0.5% accuracy. As a dc voltmeter, the 1406A offers you the additional advantages of no drift in the measurement instrument, and the ability to observe and measure any ac riding on the dc voltage. With these capabilities, you can make measurements never before possible. For example, you can simultaneously display a 10 V dc output at 50 μv/cm (giving a magnification of 200,000), measure signal levels accurately to four digits, see short term dc drift in microvolts, and view all ac ripple—an impossible measurement with a meter. (CRT display above is at 50 μv/cm at 8.500 dc offset.)

The hp 1406A plug-in operates in two modes: as a dc coupled, no drift differential amplifier with 80 dB common mode rejection, or as a single ended amplifier with no dc drift and large offset capability. Maximum sensitivity is 50 μv/cm. The 400 kHz bandwidth may be reduced with a bandpass filter to 5, 25 or 100 kHz, eliminating high-frequency noise in the unused bandwidth. There are five offset voltage ranges from $\pm$0.1 V to $\pm$1000 V.

Price of the 1406A is $850. Time bases start at $225. The 140A mainframe is $595. The Variable Persistence and Storage 141A mainframe, $1395.

Ask your hp Sales Engineer for brochure (Data Sheet 140A) with specs on the 140A high-sensitivity dc & ac measurement systems. Hewlett-Packard, Palo Alto, California, 94304. Phone 415 326-7000. In Europe: 54 Route des Acacias, Geneva.

087/15

hp 140A: **PERFORMANCE IN ANY DIRECTION**
20 MHz Wideband • High-Sensitivity, no drift • 150 ps TDR • 12.4 GHz Sampling • Variable Persistence and Storage

HEWLETT hp PACKARD
An extra measure of performance

ON READER-SERVICE CARD CIRCLE 242

Metal Glaze resistors offer .02% reliability and low cost

IRC Metal Glaze resistors now offer you a combination of proved reliability and economy that just can't be matched. You can upgrade your circuit designs and still keep the lid on costs.

- RELIABILITY PROVEN DESIGN. A design so conservatively rated that even at *twice rated load*, performance still far exceeds applicable MIL requirements.
- RELIABILITY PROVEN BY TESTS. After more than 4 million unit hours of testing, estimated maximum failure rate is .02%/1000 hours, full load @ 70°C, at 60% confidence. Failure is defined as Δ R > ± 4%.
- RELIABILITY PROVEN IN USE. Millions used in a wide range of applications. No in-circuit failure—*catastrophic or otherwise*—has ever been reported.

Metal Glaze resistors offer other benefits, too: indestructible thick-film resistance element, plated-on copper end cap, high-temperature soldered termination and a smooth, tough molded body that resists solvents, corrosion, and mechanical abuse.

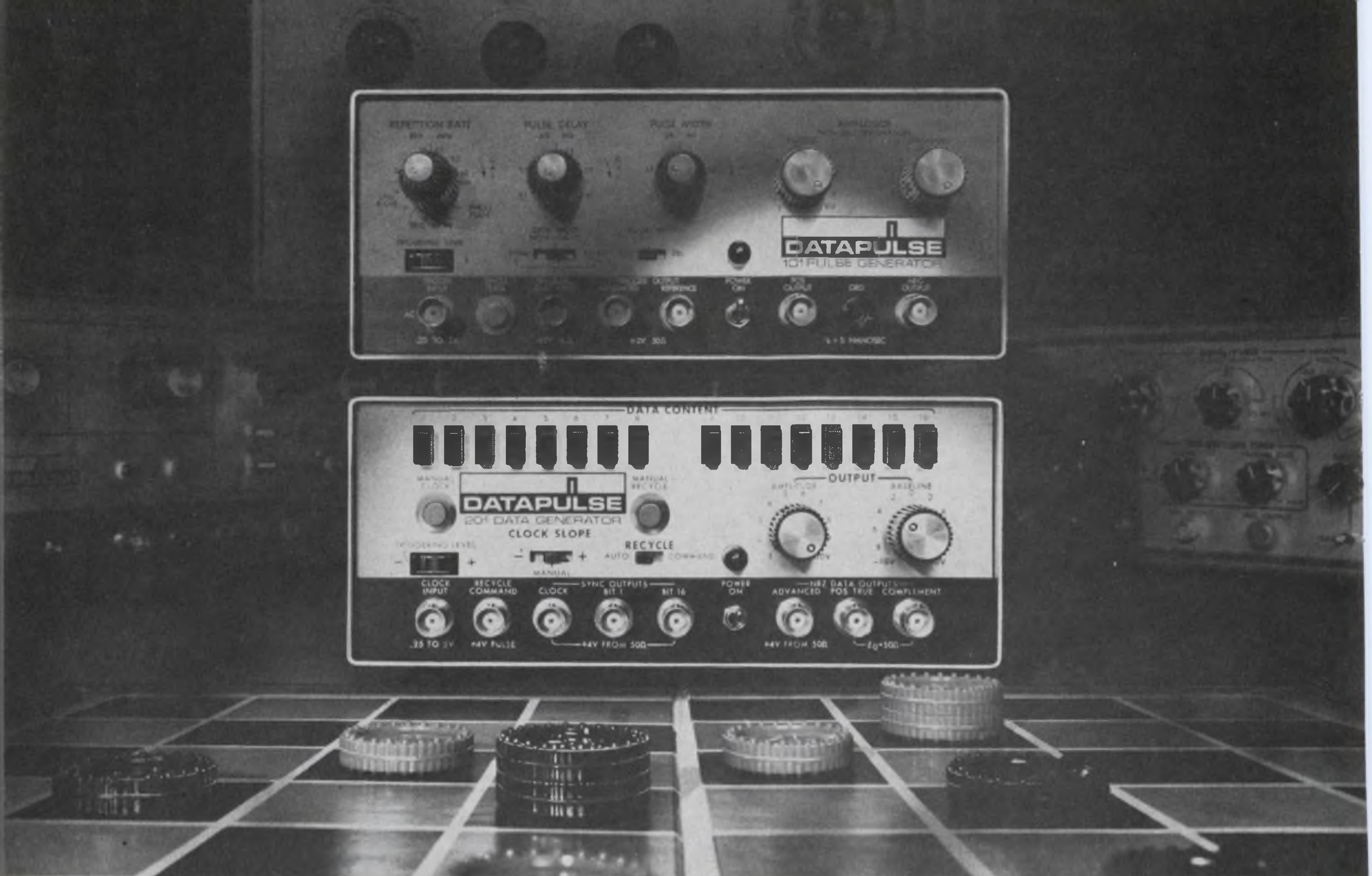
For top resistor performance without any cost penalty, specify IRC Type RG. Write for data, prices, and sample. IRC, Inc., 401 N. Broad St., Phila., Pa. 19108.

CAPSULE SPECIFICATION

WATTAGE:	¼ W @ 70°C	½ W @ 70°C
RESISTANCE:	51Ω thru 150K	10Ω thru 470K
TOLERANCES:	± 2%, ± 5%	± 2%, ± 5%
TEMP. COEF.	± 200ppm/°C	± 200ppm/°C
IRC TYPE:	RG07	RG20

IRC

ON READER-SERVICE CARD CIRCLE 3



KING ME!

Outwit Your Data Simulation Problems

Crown the Datapulse Model 201 16-Bit Data Generator with a pulse generator and solve your data simulation problems economically.

For only $680.00, the 201 provides these superior features: 16-bit cycle lengths, bit rates to 10 MHz (from an external clock), NRZ outputs to 10V, variable baseline offset to ±10V, and continuous or command recycle.

To king the 201 simply add a Datapulse 101 Pulse Generator — $395.00 — or any other async-gated pulse generator with the output characteristics you need.* The result: a system capable of producing variable parameter RZ formats — ideal for a host of simulation tests on components, circuitry, memory elements, or data transmission links — the perfect programmer for developing time related sequential signals to command systems operations.

Interconnect several 201's for longer serial words or additional parallel channels. Then set up programs for core testing, drive any gate array from zero to +10V, produce true complimentary outputs to drive adders, etc.

There's one more thing about the 201. It's small. Two units can be mounted in just 3½ inches of rack panel height.

If the 201 doesn't solve all your data simulation problems, pick up a copy of our catalog! We offer more off-the-shelf digital test instrumentation than any other manufacturer in the world, so if you don't have our catalog, do something about it!

Your move!

*Datapulse Model 111 for ultra-fast linear rise times; Datapulse Model 108 for 50V outputs; Datapulse Model 110A for fully controllable fast pulses, etc.

DATAPULSE®

Datapulse Incorporated — A Subsidiary of Systron Donner Corporation, 10150 West Jefferson Blvd., Culver City, California 90230. Telephone: (213) 836-6100, 871-0410. TWX: 910-340-6766. CABLE: Datapulse • Microwave Division: DeMornay-Bonardi.

VOL. 15 NO.
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FOR ENGINEERS AND ENGINEERING MANAGERS
SEPT. 27, 1967

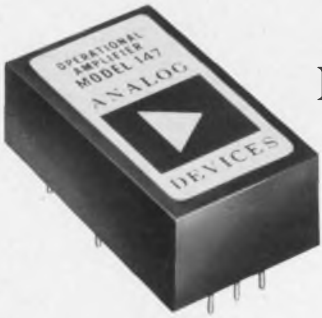
NEWS

TECHNOLOGY

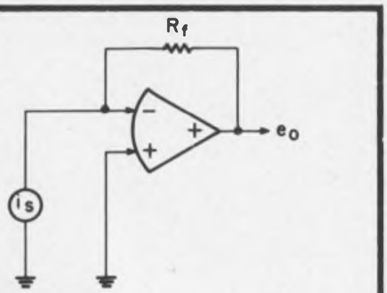
PRODUCTS

Departments

ELECTRONIC DESIGN is published biweekly by Hayden P blishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Controlled-circulation postage paid at Chicago, Ill., and New York, N. Y. Application to mail at controlled postage rates pending at St. Louis, Mo. 63,304 copies this issue.



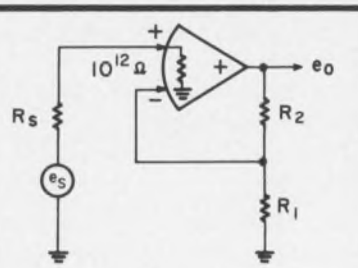
NEW! A FET operational amplifier that solves tough application problems



$$e_o = -R_f(i_s \pm e_{os}/R_f \pm i_b)$$

Measure Picoamp Current Signals

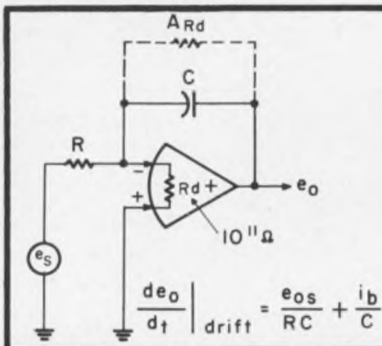
With bias current drift of only 1.5pA/°C (i_b) and noise of only 0.1pA the 147 can resolve signal currents as low as one picoamp. Voltage drift errors (e_{os}/R_f) are negligible for R_f greater than 10^7 ohms. Flame detectors, phototubes, ion gauges, and semiconductor tests are typical applications.



$$e_o = \frac{R_2+R_1}{R_1}(e_s \pm e_{os} \pm i_b R_s)$$

Measure Microvolts from Megohm Sources

Low bias current drift (i_b) gives only microvolt errors when measuring signals from megohm sources (R_s). FET circuit gives $10^{12}\Omega$ and 3 pf input impedance and with 300,000 CMR generates only .003% error. Response is fast too — 10MHz and 10V/µsec.



$$\left.\frac{de_o}{d_t}\right|_{drift} = \frac{e_{os}}{RC} + \frac{i_b}{C}$$

Integrate Accurately over Long Periods

Drift of 2µV/°C (e_{os}) and 1pA/°C (i_b) approaches chopper stabilized amplifier performance for integrator circuits. Gain is high too ($A=10^6$) giving 10^{17} ohm equivalent leakage resistance (AR_d). Low bias current allows small capacitors to be used for a given accuracy.

The Model 147 is aimed at solving more difficult application problems where moderate performance, lower cost operational amplifiers are just not adequate. With common mode rejection of 300,000 and voltage drift of 2uV/°C, the 147 solves the limitations of present day FET amplifier designs and sets new performance standards for FETs. Bias current has also been improved — 5pA typical and 15pA maximum at 25°C — reducing current drift to 1pA/°C.

The Model 147 approaches the performance of chopper stabilized amplifiers and yet has lower price, smaller size, lower noise and can achieve input impedance of 10^{12} ohms when connected non-inverting.

Write for 4-page brochure giving complete specs and application notes on the Model 147 — We'll also send information on other models for use where dollars count more than performance.

SPECIFICATIONS

Open Loop Gain, min.	10^6
Rated Output, min.	±10V @ 10mA
Unity Bandwidth	10MHz
Full Power Response, min.	150kHz
Slewing Rate, min.	10V/µsec
Common Mode Rejection	300,000
Input Impedance, C.M.	$10^{12}\Omega$, 3pF
Voltage Noise	3µV, p-p, DC to 1Hz
Current Noise	0.1 pA, p-p, DC to 1Hz

	Model A	Model B	Model C
Bias Current, max.*	30pA	15pA	15pA
Current Drift, max.*	3pA/°C	1.5pA/°C	1.5pA/°C
Voltage Drift, max.			
(+10 to +60°C)	15µV/°C	5µV/°C	2µV/°C
(−25°C to +85°C)	15µV/°C	10µV/°C	5µV/°C
Price (1-9)	$110.	$120.	$135.

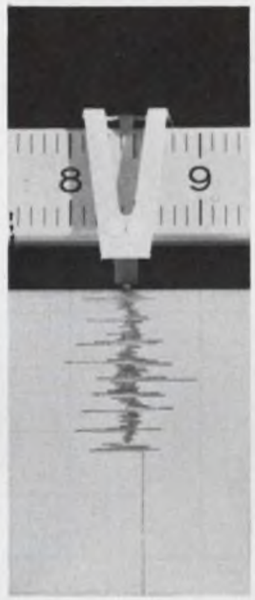
*At 25°C, doubles each 10°C

ANALOG DEVICES, 221 FIFTH STREET, CAMBRIDGE, MASS. 02142
617/492-6000 — TWX 710/320-0326

ON READER-SERVICE CARD CIRCLE 5

Inkless recording isn't a "record-breaking" technique.

It's designed not to be.



The exclusive new inkless writing option for the Hewlett-Packard 10″ 7100 series or the 5″ 680 series strip-chart recorders won't "break" your records by tearing, smearing or running out of ink when you're not around to notice it.

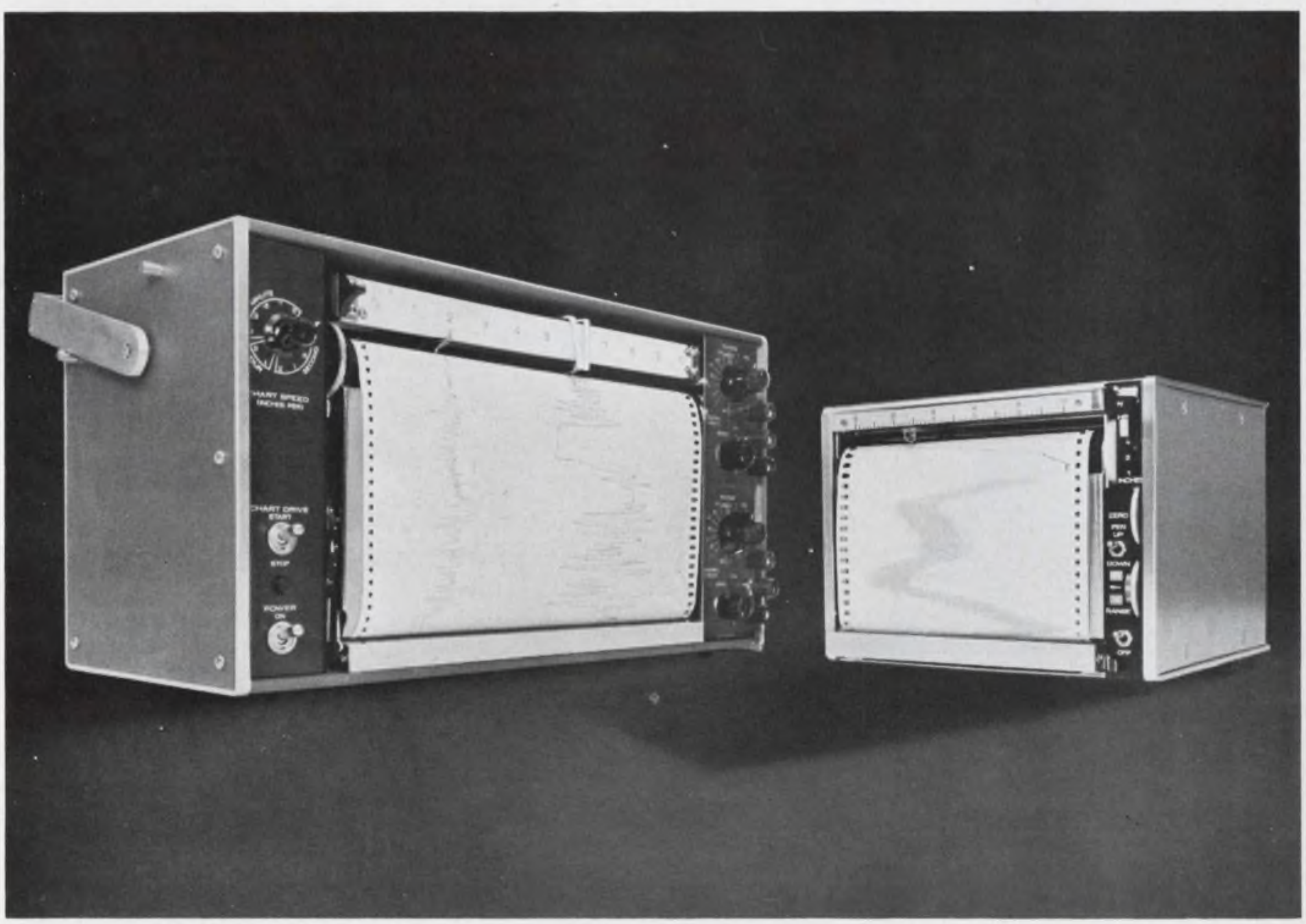
Instead, it takes the uncertainty out of strip-chart use by offering reliable, long-term recording—without interruption or constant attention—with economical and maintenance-free operation. This new low-voltage electric writing method gives you sharp and clear printing on unique electro-sensitive paper—and with instant start-up.

Call your local HP field engineer or write Hewlett-Packard, Palo Alto, Calif. 94304. Europe: 54 Route des Acacias, Geneva.

11702

HEWLETT hp PACKARD

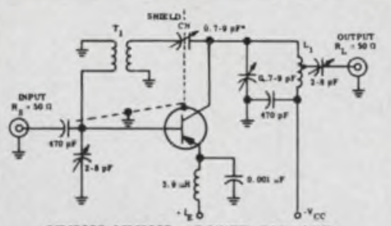
GRAPHIC RECORDERS



ON READER-SERVICE CARD CIRCLE 6

Semiconductor Report

NEW GERMANIUM DEVICES FOR HIGH PERFORMANCE DESIGNS



MM5000-MM5002 - POWER GAIN AND NOISE FIGURE TEST CIRCUIT

1.6 dB NF DEVICE WITH TINY PRICE TAG SOLVES RF FRONT END NEEDS

A NF as low as 1.6 dB at an operating frequency of 200 MHz makes the MM5000-02 germanium transistors just about the quietest, low-cost amplifier series you can design into your sensitive, front-end RF circuits . . . and with 100-up prices as low as $2.00, the best value. Nothing subdued about its performance — it furnishes up to 24 dB *minimum* power gain at 200 MHz, out-performing virtually every other low-priced RF unit you can call into play!

Superior performance in all HF operations is ensured through a collector-base time constant as low as 3.5 ps (max) and collector-base capacitance of 0.6 pF (max). These dynamic performers also feature an 800 MHz minimum f_T.

TYPE	LOW NOISE @ 200 MHz	HIGH GAIN @ 200 MHz	PRICE (100-UP)
MM5000	1.6 dB (max)	24 dB (min)	$4.75
MM5001	2.0 dB (max)	22 dB (min)	2.80
MM5002	2.2 dB (max)	20 dB (min)	2.00

Motorola's exclusive Selective Metal Etch‡ process permits greater freedom of geometry design and better definition and closer spacing of emitter/base areas to gain optimum device performance.

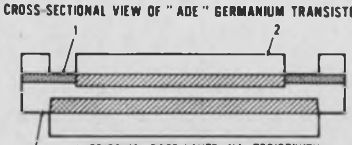
Production quantities of the TO-72 packaged (4-lead, TO-18) units can be delivered immediately.

ADE TRANSISTOR STRUCTURE DOUBLES YOUR "BRUTE POWER"

It's almost like having two power transistors for the price of one in demanding power conversion and high voltage switching applications!

The advanced ADE† (alloy diffused epitaxial) process upgrades performance capabilities by incorporating these significant advantages:

CROSS-SECTIONAL VIEW OF "ADE" GERMANIUM TRANSISTOR



1 EPITAXIAL BASE LAYER: N+ RESISTIVITY
2 INDIUM - ALUMINUM EMITTER CONTACT
3 WIDE PHYSICAL BASE WIDTH

- low resistivity diffused base for high h_{FE}
- aluminum doped emitter alloyed into die for sustained h_{FE} @ high I_C
- wide base width for good safe area

The diffused base structure minimizes switching losses ordinarily resulting from a wide base.

The first ADE transistors with these advantages are the MP2200A-2400A, 25 A switches, featuring peak power capability approximately twice that of present alloy units — 80 to 120 V (min) @ 8 A — at virtually the same prices. In addition, high current gain (25 min. @ 8 A), low saturation voltage (0.6 V @ 25 A) and good switching (9 μs t_{on} @ 10 A, typ.) advantages rank them as versatile, efficient, solid-state servants in "brute power" designs.

ADE units are ready now in TO-41 or TO-3 cases . . . send for data!

TYPE	V_{CE} Volts (sus)	I_C Amps (cont)	$V_{CE(sat)}$ Volts @ I_C (max)	h_{FE} @ I_C (min)	PRICE (100-UP)
MP2200A	80	25	0.6	25	$2.25
MP2300A	100			@	2.45
MP2400A	120			8 A	2.60

SME DEVICES OFFER "DROP IN" PERFORMANCE IN MADT SOCKETS WITH NO REDESIGN

Eight new Motorola germanium mesa transistors — including two popular JAN types — are available in quantity to electrically and mechanically fit neatly into original MADT®-type sockets without any redesign. In fact, besides meeting exact parameter-by-parameter specs of the older, conventional units, the inherent flexibility of the advanced SME process (see column 1) makes it possible for Motorola to closely approximate key MADT parameter distributions, ensuring both direct replacement and immediate availability.

Type	Use	Power Gain @ 200 MHz (min)	NF (max)	f (max)	Price (100-up)
2N502	VHF Ampl.	8 dB	10 dB	500 MHz	$2.15
2N502A JAN 2N502A	VHF Ampl.	10 dB	7 dB	620 MHz	2.50 2.75
2N502B JAN 2N502B	VHF Ampl.	10 dB	7 dB	620 MHz	2.80 3.05
2N1499A	HF Switch	N.A.	N.A.	100* MHz	1.05
2N1742	VHF Ampl.	14 dB	5.5 dB	980 MHz	2.15
2N2048	HF Switch	N.A.	N.A.	150* MHz	1.32

*fT (min)

For complete data on these new Motorola germanium developments, or, for details on *any* of your present or future germanium requirements — write: Box 955, Phoenix, Arizona 85001. There's no end to Motorola germanium semiconductors!

MOTOROLA Semiconductors
– where the priceless ingredient is care!

†Trademark Motorola Inc.
‡Patents Pending
®MADT is a trademark of Philco Corp.

ON READER-SERVICE CARD CIRCLE 8

Fairchild has produced a half-hour color television program, a briefing on integrated circuits. It's not a big state-of-the-art spectacular. In fact, it's pretty basic.

If this seems like an extraordinary move for a technical company, we agree. It's been an extraordinary decade.

BRIEFING OUTLINE

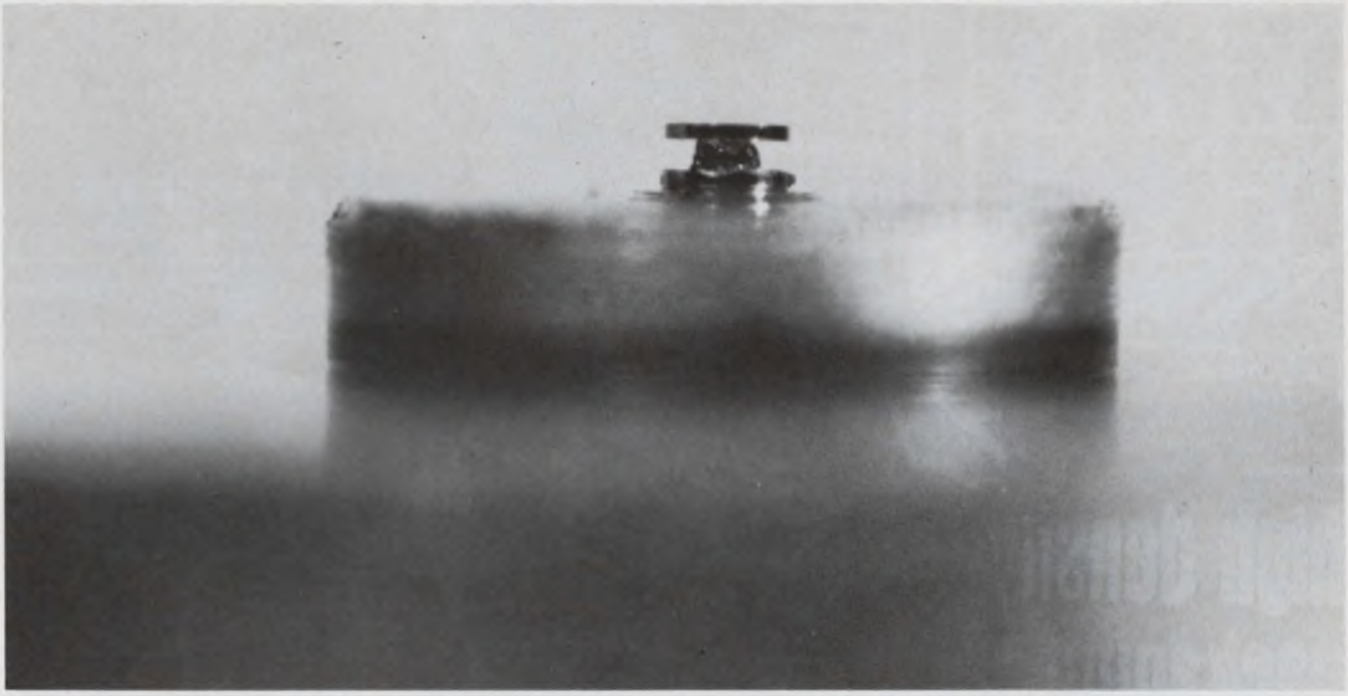
I. What is an Integrated Circuit?
  A. What it looks like
  B. What it does
  C. How it compares to other circuits
II. How an Integrated Circuit is made.
  A. Circuit design
  B. Masking
  C. Etching
  D. Diffusion
  E. Metallization
  F. Wafer testing
  G. Scribing
  H. Packaging
  I. Testing the completed circuit
III. Uses of Integrated Circuits.
  A. Functions now available
  B. Applications in industry
  C. Applications in research

CITY	CHANNEL	TIME
Albuquerque	KOB-4	7:00 AM
Baltimore	WMAR-2	7:00 AM
Boston	WNAC-7	6:30 AM
Chicago	WBKB-7	6:30 AM
Cincinnati	WKRC-12	7:00 AM
Cleveland	WEWS-5	7:00 AM
Dallas-Fort Worth	KTVT-11	6:30 AM
Dayton	WHIO-7	7:00 AM
Denver	KLZ-7	7:00 AM
Detroit	WWJ-4	6:30 AM
Fort Wayne	WANE-15	7:00 AM
Houston	KHOU-11	7:00 AM
Huntsville	WAAY-31	7:00 AM
Indianapolis	WISH-8	7:00 AM
Kansas City	KCMO-5	7:00 AM
Los Angeles	KHJ-9	7:00 AM
Miami	WCKT-7	6:30 AM
Milwaukee	WITI-6	7:00 AM
Minneapolis-St. Paul	WCCO-4	7:00 AM
New Orleans	WVUE-12	7:00 AM
New York	WPIX-11	6:30 AM
New York	WPIX-11	7:00 AM
New York	WPIX-11	7:30 AM
Orlando	WDBO-6	6:30 AM
Philadelphia	WFIL-6	7:00 AM
Phoenix	KTAR-12	9:00 AM*
Rochester	WHEC-10	7:00 AM
St. Louis	KPLR-11	7:00 AM
San Diego	KOGO-10	6:30 AM
San Francisco-Oakland	KPIX-5	6:30 AM
Seattle-Tacoma	KING-5	6:30 AM
Syracuse	WHEN-5	7:00 AM
Utica	WKTV-2	7:00 AM
Washington, D.C.	WTTG-5	7:00 AM

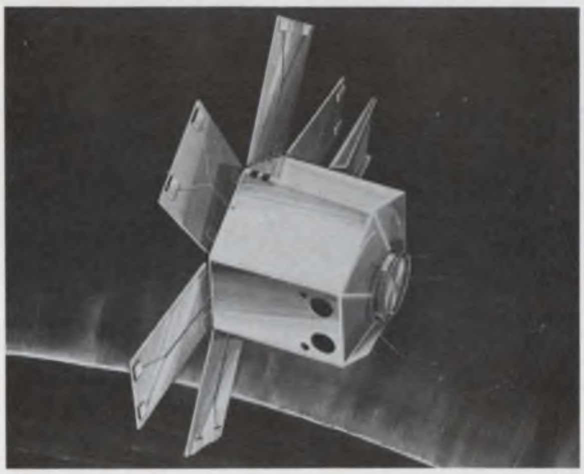
*Sunday, October 15.

FAIRCHILD
SEMICONDUCTOR
A Division of Fairchild Camera and Instrument Corp.
313 Fairchild Drive, Mountain View, Calif. 94040
(415) 962-5011 / TWX: 910-379-6435

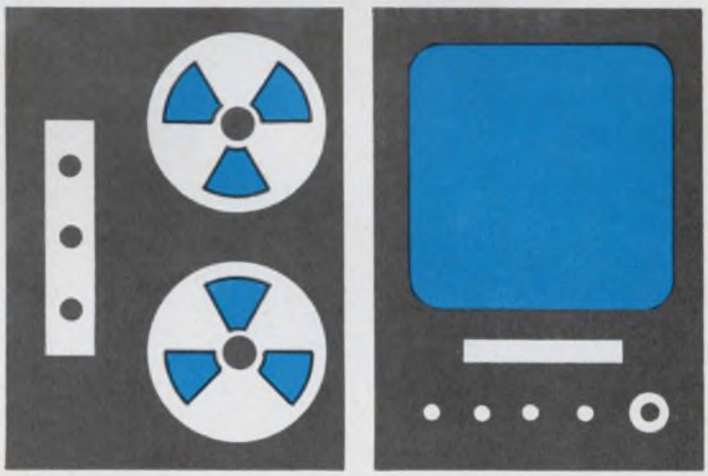
News



LSA diodes are in the forefront as solid-state microwave power sources; Gunn-effect units are not yet outmoded. GaAs devices are topic at Cornell conference on hf research. Page 17



Unmanned satellite may map Earth's IR horizon for space navigators. Page 22



Attachment to TV set allows sound movies to be watched on unused television channel. Page 36

Also in this section:

THE CONNECTOR thing

A periodical periodical, designed to further the sales of Microdot Inc. connectors and cables. Published entirely in the interest of profit.

high density packaging expert goes too far!

Let's face it. The reason our connectors lend themselves so superbly to high density packaging solutions is that they are – in and of themselves – outstanding examples of high density packaging. That's a long winded way of saying that we make smaller connectors than anybody. And it takes some pretty far out designers to jam 420 contacts on one teeny square inch of connector surface (see Twist/Con).

One of these far out types – Algonquin G. Squozen in our design group – has a hobby. In his spare time he dreams up all sorts of high density packaging solutions. Trouble is there isn't always a problem to fit the solution. A classic example of Algonquin's creative work is shown on this page. Study it carefully because it will help you to

WIN A WHOLE BASKET OF GOURMET FOODS!

(Everything from imported sardines and paté de foie gras to Beluga caviar. Shipped to you direct from Vendome's Gourmet Foods in Beverly Hills, Calif.)

Now that we've whetted your appetite, a few well chosen words about the entree – our connectors. You'll need to know about these before you can stuff yourself.

THE TWIST/CON CONCEPT—A LA CARTE

It all started like this: We eliminated the contact spring member normally found in socket contacts by creating a breathing helical spring principle on the pin contact. Smaller. More durable. More economical. The result was the best family of rack/panel and strip connectors on the market. *Some of the high density applications for TWIST/CON include connections for IC's, interconnecting of printed circuit boards, edge-on connections for p.c. boards, and on modules with connectors welded to hybrid circuits.* Single pins are being used for high density line splices. TWIST/CON is usable with 22 AWG to 30 AWG standard wires. ***Next, we applied the TWIST/CON principle to***

LEPRA/CON—WORLD'S SMALLEST FULL 50 OHM COAX

OD is 1/8 inch and mated length is about one inch. That makes it the smallest. And the completely protected contacts also make it the most reliable. The size means you can use a much smaller OD cable for even greater weight/size reduction in your package. ***The price is as low as $1.07 in nominal quantities.*** You can get straight plugs, jacks, bulkhead jacks, right angle plugs, or printed circuit receptacles. Screw-on or slide-on versions in entire line. ***That's the menu for today.***

5 BIG WINNERS!

But everybody who enters receives a photo of Squozen's high density packaging solution. Five lucky entrants will receive the cases of gourmet foods. All you have to do is (a) study the information about our Twist/Con and Lepra/Con connectors, and (b) write an appropriate caption or problem statement for the sardine can, working in at least one of the two connectors we've talked about. Contest closes October 1, and is not valid anyplace where it is considered illegal, immoral – or fattening.

MICRODOT INC.

MICRODOT INC., 220 Pasadena Avenue, South Pasadena, California 91030

Dear Microdot:

- ☐ Enclosed find my entry in your high density packaging contest
- ☐ Enough of this foolishness. Just send me literature on (circle) TWIST/CON LEPRA/CON *all* your connectors
- ☐ I have a connector application for high density packaging. Get somebody over here.

Name ______

Title ______

Firm ______

Address ______

City ______

State ______ Zip Code ______

Telephone ______ Ext.: ______

Lepra/Con and Twist/Con are registered trademarks of Microdot Inc.

ON READER-SERVICE CARD CIRCLE 9

U.S. plans 8 to 10 sites in its missile defense

The Nike-X anti-ballistic missile defense planned by the United States calls for spotting eight to 10 missile batteries across the country. The decision, approved by Defense Secretary Robert S. McNamara, follows seven years of in-fighting involving the Army, the Joint Chiefs of Staff, and the three military service Secretaries; all supported the program before Congress.

The proposed system will be limited, in that it will be designed to provide defense against first-generation Red-Chinese ICBMs and against the accidental launching of a Soviet ICBM. During his announcement of the new system, Secretary McNamara, in referring to the Chinese threat of the early 1970's, indicated that an attack by the Chinese would be "insane and suicidal". One could conceive, however, of conditions under which that country might make a catastrophic miscalculation, he said.

Of late referred to as the "thin Nike-X," the defense will require from four to five years to develop and install at a cost of about $5 billion. It will employ a mix of Spartan and Sprint ground-to-air weapons. Financing is expected to be at nearly the billion-dollar level for the next year, with nearly one-half this amount allocated for the operational system; the rest will go for continued research and development. Some $730 million has been authorized for fiscal 1968, and over $150 million of the funds for 1967 remain unspent.

The Spartan, traveling at Mach 4, is designed to intercept an incoming ICBM at a slant range of more than 400 nautical miles, when the missile is above the atmosphere. The Sprint, with higher but classified speed, is designed to intercept ICBMs near the terminal phase of their flight at a slant range of about 75 nautical miles, when their altitude is 18 to 22 miles. Both weapons are radio guided with inertial reference.

The entire Nike-X program is under direction of the Army Missile Command at Huntsville, Ala., and the prime contractor is Western Electric Co. McDonell-Douglas is developing Spartan and Martin-Marietta is developing Sprint.

The total financing would break down into $3.5 billion for protecting United States cities and $1.5 billion for defending U.S. ICBM complexes.

Spartan, a greatly improved version of what was once called Nike-Zeus, is scheduled for flight-testing early next year, probably over the Pacific from Kwajalein Atoll. Sprint has been undergoing rigid flight-testing at White Sands Missile Range in New Mexico.

Considerable pressure has been applied by Congress for the Dept. of Defense to install at least a minimal anti-ballistic missile system. Congressional reasoning has been based not only on the need for a practical anti-ballistic defense but also on the desire for another high card to play in international politics. The reasoning is based on the following: The Soviet Union has for some time had an acknowledged lead in operational large-payload ICBMs, while the U.S. has employed smaller, yet more, ICBMs. However, the Russians, during an extended high-altitude nuclear test series in 1961-62, exploded many weapons that could be used either as ICBMs or anti-ballistic missiles. In fact, it is known that on two occasions the Soviet launched an ICBM, then intercepted it with a nuclear blast, and then fired a second missile—probably an ICBM—through the blast zone to study the over-all effects on both missile and ground electronic subsystems. The U.S., as of this date, has never tested nuclear weapons of such magnitude.

It is believed that both the Soviet approach and the contemplated U.S. approach will employ an area defense that is largely dependent on highly intense x-ray and other pulse radiation effects of nuclear blasts to incapacitate the electronic components in incoming warheads (News Scope, ED 11, May 24, 1967, p. 14).

With the "thin" anti-ballistic missile system, Army informants have said that planned tests of multi-functional-array radar on Kwajalein Atoll will be scratched. The existing parameter-array radar, a VHF phased-array developed by General Electric, will be used to support the Spartan system in place of the multi-functional array. A scaled-down version will be used to provide the same accuracy, but it will track and discriminate fewer targets.

What's moon made of? Surveyor 5 may tell

A three-legged, 616-pound spacecraft resting on a 20-degree slope inside a small crater on the lunar Sea of Tranquility may soon tell man what the moon is made of.

The soft landing of Surveyor 5 earlier this month, despite inflight problems, marked an important shift in lunar exploration—from picture-taking and trench digging to a pioneering analysis of the moon's surface.

So far the spacecraft has transmitted to earth more than 5000 clear pictures of itself and its surroundings. Scientists consider the quality of the pictures superior to

Alpha scattering experiment on Surveyor 5 gets once over.

News Scope CONTINUED

the pictures returned by Surveyors 1 and 3.

What is significant about Surveyor 5, however, is a small six-inch square gold-plated metal box that, on radio command from earth, was lowered from the spacecraft to the moon's surface. Between picture-taking sessions it has bombarded the moon with atomic particles in an attempt to determine the chemical constituents of the lunar surface material.

The 5-1/4 pound unit contains six Curium-242 radioactive sources that emit streams of alpha particles to bombard four square inches of the lunar surface. The particles can penetrate to a depth of about one-thousandth of an inch. Two alpha sensors detect the scattered alpha particles reflected from atomic nuclei in the soil's elements, and four additional detectors measure the energy of reflected protons. (Known elements reflect alpha particles, protons or both at different velocities and comparison of the results against known values indicates the chemical composition of the soil.)

The instrument's sensor measures the velocity of the reflections, and the logic circuitry in the electronics package converts the data into binary form for on board processing and transmission to earth. Surface composition will be determined from a spectrum analysis of the telemetered data.

Scientists believe that experiments such as the soil analysis can provide a clue to the history and present stage of the moon's development. Of more immediate concern, however, is the fact that the experiment can aid scientists in determining how to build bases on the moon. If lunar building material can be used, less material will have to be transported from earth.

The alpha scattering experiment will be conducted again on Surveyor 6, scheduled for flight this fall, and on Surveyor 7, scheduled for launching early next year. These are the final two spacecraft in the Surveyor series.

Electronics to get watchdog war role

The increasing role of electronics in modern ground warfare has been emphasized anew by the Government's announcement that it will construct an anti-infiltration barrier between North and South Vietnam.

The barrier, which would rely heavily on sophisticated detection devices, would alert U.S. and South Vietnamese forces whenever the 15-mile-wide demilitarized zone was penetrated. There is considerable skepticism in Congress that it will work sufficiently well to warrant the millions in cost. But electronic companies are being asked, in secret, to press the development of detector devices. The Defense Dept.'s Advanced Research Projects Agency has asked for $11.7-million for work on advanced sensors alone.

Defense Secretary Robert S. McNamara, in announcing the barrier plan, warned that he did not want the enemy to know "what materials we will use, where they might be used or in what quantities." So details are not being made public at this time. However, there is speculation that acoustic, seismic and infrared scanning systems are being considered.

(Clues to military thinking about detection devices in Vietnam were presented by Electronic Design in an exclusive interview with the Green Berets in the issue of Aug. 2, 1966—"Electronics Needed for Guerrilla Warfare," pp. 36-47. Metallic detectors were among those strongly urged, on the theory that an attacker would be bound to carry some type of metal on his person.)

Vietnam buildup creates a million new jobs

Intensification of the Vietnam War in the last two years has created a million new jobs, according to a report by the Dept. of Labor.

The sharp rise in employment amounted to some 23 per cent of the total increase of more than four million jobs in the United States economy since 1965, the report says.

Defense work now accounts for 5.2 per cent of the nation's total civilian employment, up from 3.9 per cent two years ago.

The report says that civilian jobs in defense work rose from about three million to 4.1 million in the last two years, with the sharpest increases in the weapons, aircraft and communications industries.

In a companion report, the bureau's mobilization expert, Max Rutzick, says that about 18 per cent of all engineers in the nation are in defense work, as are some 22 per cent of electrical and electronic technicians.

He attributes a rise of more than 141,000 jobs in the aircraft industry to the Vietnam build-up, and he says 10,000 other jobs have been added in the communications equipment field.

A further expansion of war work could create shortages of skilled workers of "considerable magnitude," the report continues.

But "this should not be interpreted to mean that one million jobs would be lost if the conflict in Vietnam were to end," says the Bureau of Labor Statistics.

A switch of workers to the production of civilian goods and the timing of cuts in military expenditures would help cushion a drop in war work, according to the report, which was published in the Monthly Labor Review.

Satellite traffic control of ocean flights urged

The use of satellite to help traffic-control centers keep constant track of airliners flying the oceans of the world has been suggested by a Pan American World Airways' chief electronic engineer.

As the engineer, Ben F. McLeod, sees it, position reports from hundreds of airliners would be radioed to the satellites automatically. Navigation systems onboard the planes would furnish the data.

At present the pilots must radio their positions periodically by voice. Ground-based radar is also used, but only when the aircraft flies into range—about 250 miles from land.

McLeod made his proposal earlier this month in Milan, Italy, at a technical symposium held by the NATO Advisory Group for Aerospace Research and Development.

The satellite capability already exists, he noted, and many airliners are equipped with dual Doppler or inertial navigation systems.

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ON READER-SERVICE CARD CIRCLE 11

Solid-state microwave power growing up

Novel radar is shown as conference explores advances with LSA and Gunn-effect oscillators

Neil Sclater
East Coast Editor

An experimental radar, made from laboratory odds and ends and using a chip of gallium arsenide only 20-thousandths of an inch thick as a microwave oscillator, was placed at an open window in a building on the Cornell University campus. As engineers and scientists watched, it detected moving automobiles a fifth of a mile away.

The test was conducted at a recent Conference on High-Frequency Generation and Amplification, held at Ithaca, N. Y. A gallium-arsenide diode able to produce 60 watts of X-band power in the limited-space-charge-accumulation (LSA) mode was the power source in the radar.

The novel radar had been assembled by the Microwave Solid State Research Group at Cornell to demonstrate the dramatic advances in solid-state microwave generators.

The pulsed output power from the radar at the conference was far from the record 615 watts at about 8 GHz held by the Cornell researchers—the highest power level attained so far from a solid-state device at X band. But the range on the new experimental radar was impressive, and it demonstrated that the simple, small device could have practical uses as a primary microwave power source.

The conference explored the possibilities for using the LSA diode oscillator for power in millimeter-wave transmissions to and from communications satellites, and it also considered current plans to adapt Gunn diodes to existing radar systems as local oscillators.

Wide interest in research

Microwave engineers have been optimistic about replacing power tubes with smaller, lighter, solid-state devices ever since J.B. Gunn of the IBM Research Laboratory discovered four years ago that a simple crystal of gallium arsenide could produce microwave oscillations.

Two years ago Dr. John Copeland of Bell Telephone Laboratories, in extending Gunn's work, discovered a phenomena related to the Gunn domain—limited-space-charge accumulation—that could generate more power at even higher frequencies.

Dr. Copeland evolved a theory for LSA operation and predicted theoretical power and frequency limits. Laboratories around the world are anxious to exploit these significant advances.

Bell Telephone Laboratories at Murray Hill, N. J., and Cornell University have reported important advances in LSA technology. But the Radio Corporation of America has been improving Gunn-effect devices, and Britain's Royal Radar Establishment has reported successful application of Gunn devices as replacements for klystrons in radar systems. Improvements in materials were key factors in all these advancements.

Transit time avoided

The LSA oscillator, unlike the Gunn-effect device, is not power-limited at high frequencies by an effect called "transit time"—the time it takes for space-charge waves or domains to travel through the device.

The LSA device is a bulk gallium-arsenide diode that oscillates because it has negative resistance in a high dc bias field when part of a specially designed microwave resonant circuit. The negative resistance is used to convert dc power directly to rf power. However, this occurs only if the growth of the space charge within the diode is limited or dissipated.

The oscillating field in the LSA mode swings above the threshold field long enough to generate a negative resistance but not long enough for the carriers to rearrange themselves into domains. When the field swings below threshold, minor space-charge irregularities are smoothed before the next cycle.

Experimental X-band radar at Cornell uses a limited-space-charge-accumulation-(LSA) diode to obtain 60 watts of peak power. At left, Prof. Lester F. Eastman tunes the diode mount. At right, the transmitter assembly (the lower of the two arms) with the diode mount and antenna horn. The receiver horn assembly (the upper of the two arms) passes returned signals to an oscilloscope display. A traveling-wave tube amplified the returned signal.

(diode power, *continued)*

Accumulation of space charge is limited if the semiconductor doping-to-frequency relationship is held within limits and if the effective load resistance in parallel with the diode is greater than 10 times the diode's low voltage resistance.

According to Dr. Copeland, the ratio of the diode doping level (impurity atoms per cubic centimeter) to the operating frequency (in hertz), n/f, must be a number between 2×10^4 and 2×10^5 with an optimum value of about 6×10^4.

If the voltage across the LSA diode becomes concentrated in a high-field domain, it would swing into Gunn-effect oscillations at a lower frequency. Because of the higher applied voltages, this could lead to the destruction of the device by high-field breakdown.

The active material thickness in transit-time devices must be made thinner if the frequency is to be increased. This unfortunately increases the device capacitance, causing the power-impedance product to decrease.

Since no transit time phenomena is involved, the power from the LSA device is essentially independent of frequency. It can be as much as 20 times thicker than a Gunn device of the same frequency and can thus withstand relatively high applied voltages.

Efficiency limit predicted

Dr. Copeland told the Ithaca conference that power-conversion efficiencies of up to 20 per cent could be achieved below 100 GHz and that the drop-off would be reasonable up to several hundred GHz.

The LSA GaAs bulk chip used in the Cornell experimental radar was pressure-mounted in a modified 1N-23 ceramic crystal cartridge between a gold-plated brass post and a bellows. This convenient package gave electrical-mechanical contact with the chip and provided for heat dissipation. It was pulsed for 10 nanoseconds, 60 times a second at 600 volts. The setup was assembled by Prof. Lester F. Eastman of the engineering faculty and W. Keith Kennedy Jr., a doctoral candidate.

In a conference paper devoted largely to the theory of LSA operation in long, bulk GaAs samples, Kennedy reported that peak pulse power of 615 watts at X band had been attained with another device.

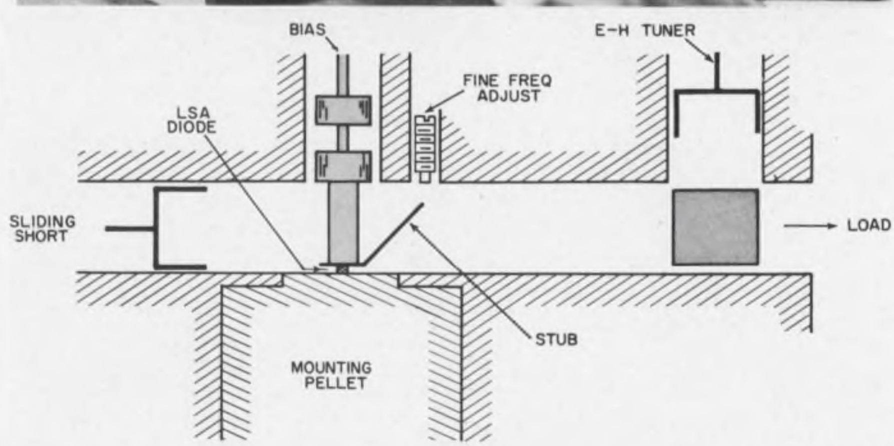
The work was supported by the U.S. Air Force Rome Air Development Center.

Communications uses foreseen

Bell Laboratories' Dr. Copeland pointed out the potential advantages of LSA in "short-haul and medium-haul" communications satellites. He said that within the next 10 years the demand for communications between cities like Chicago and New York would make millimeter-wave satellites desirable. These would be economically and technically feasible only if carrier frequencies of greater than 50 GHz were used. The higher frequencies permit the use of both wider bandwidths and a larger number of channels.

LSA devices, Dr. Copeland said, are the means to accomplish this goal. Because of the short range and the possibility of satellite redundancy, the scientist said, atmospheric attenuation would not pose a serious threat to millimeter-wave communication.

Bell Laboratories is already at work on devices for this application, Dr. Copeland reported. He said that the laboratory had successfully



An unpackaged LSA millimeter-wave oscillator is adjusted by Dr. John A. Copeland. The circuit produces 20 mw of cw power between 44 and 88 GHz. The waveguide short and tuner load the circuit for maximum output. Frequency is primarily determined by the tab-like stub.

Semiconductor Report

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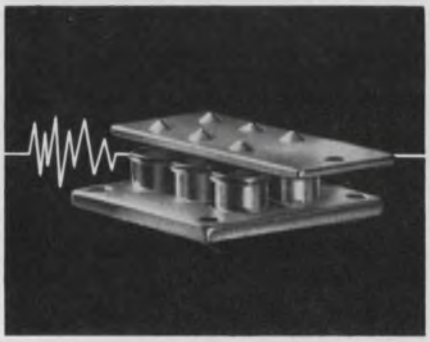

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MPZ5-16B & A MPZ5-32C, B, & A MPZ5-180C, B, & A	350 W	14 28 165	20, 24 40, 45, 50 205, 225, 250	200 A 100 A 20 A	16 @ 0.4 A 32 @ 0.2 A 180 @ 0.02 A

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MRD200 MRD300	0.5 1.6†	5.0 10†	0.025

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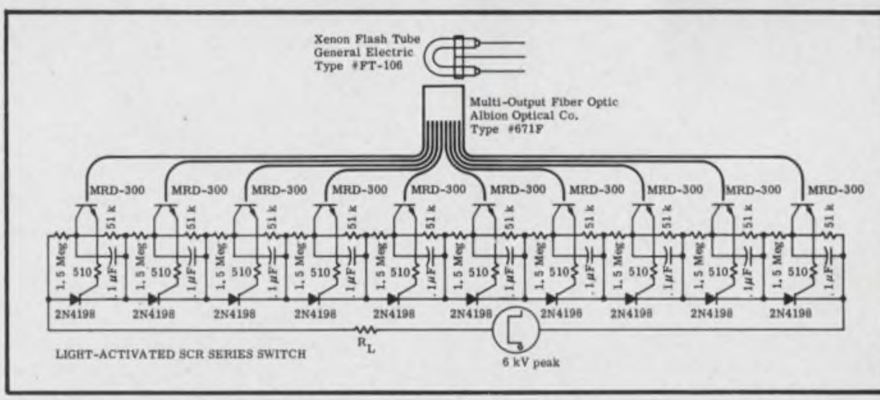

MRD300 combined with 2N4198 ELF* SCR (600 V) gives total t_{on} of 300 ns. Single light source coupled by multiple-output fiber optic bundle transmits light to photo transistors. Fast t_{on} is accompanied by gate isolation advantage.

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ON READER-SERVICE CARD CIRCLE 12

(**diode power,** *continued*)

incorporated cw LSA diodes into an experimental 50.4-GHz, guided-wave pulse code modulation transmission system. Continuous-wave power of 20 milliwatts has been produced in the 44-to-88-GHz region—still the record at this high frequency. The diodes have produced detectable power at 160 GHz. A special half-wave stub is used in the diodes' package.

The success of semiconductor microwave power sources has inspired two Cornell University professors to form a company for producing advanced prototypes. Cayuga Associates at Ithaca, N. Y., founded by Prof. Eastman and Prof. G. Conrad Dalman, plan to custom-make diode devices and develop improved circuit techniques.

Professor Dalman who was chairman of a Gunn-effect session at the conference, said in an interview that much higher power would be achieved when large slabs of more homogeneous materials became available. A novel slab geometry and scaling relationship worked out by Kennedy and Professor Eastman shows that peak powers as high as 400 kW at 10 GHz can ultimately be achieved, Professor Dalman reported.

Another Cornell researcher, Richard J. Gilbert, a graduate student, has investigated optimum device and circuit parameters for LSA operation, according to Professor Dalman. The parameters included the ratio of carrier density to operating frequency, circuit loading, applied fields and transient response of the sample. Among other things, the research verified computer simulations performed by Dr. Copeland.

Gunn power increasing

Despite the dramatic advances in the LSA devices, work on Gunn devices is continuing in many laboratories, the conference was told. Dr. S. Y. Narayan of RCA's Princeton, N. J., laboratory reported improvements in pulse power, efficiency and growth techniques for epitaxial GaAs Gunn diodes.

The RCA scientist said his laboratory had operated Gunn-effect devices with pulse power output up to 150 watts in the 1-to-2-GHz region with efficiencies as high as 24.7 per cent. These values, he said, represent the highest power x $(\text{frequency})^2$ product and efficiency reported for Gunn oscillators in non-LSA modes.

Progress in making a Gunn-effect device to replace reflex klystron local oscillators was discussed by an engineer from Britain's Royal Radar Establishment. Frank L. Warner of the group's Malvern laboratory said the device intended for use in existing radar systems was both mechanically and electronically tunable. Improved versions will be operating in British military radars within a year, he said.

A cavity, with standard connectors includes both a commercial encapsulated GaAs diode as the power source and a varactor diode for electronic tuning (see illustration).

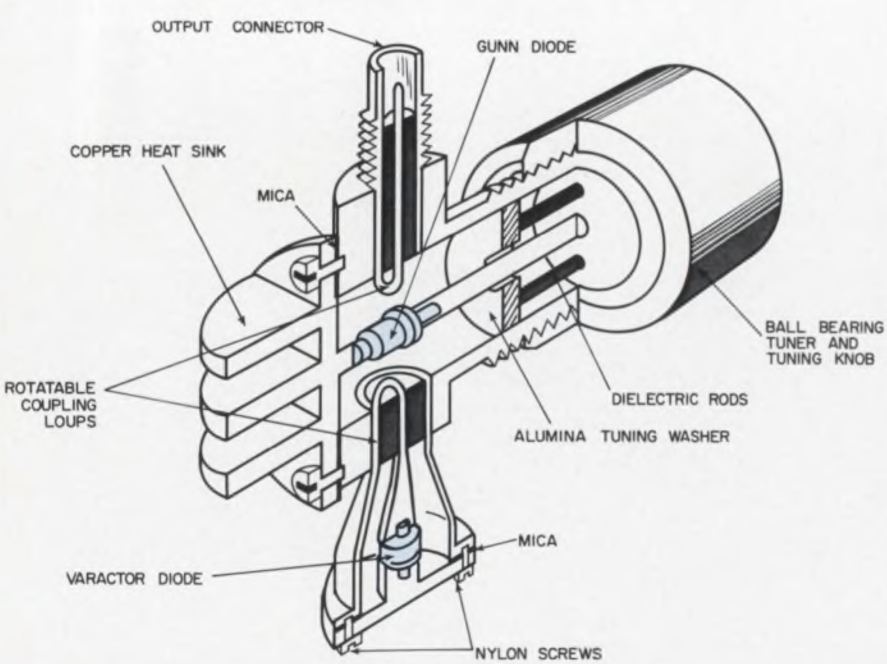
Warner said that mechanical tuning over a 20 per cent band has been obtained by moving a low-loss dielectric washer along the cavity. Electronic tuning over a range of 400 MHz is achieved by varying the bias voltage on the varactor diode, which is mounted in a side arm and loop-coupled into the main cavity.

The device, intended to replace some reflex klystrons, is small and light, and it has low operating voltage. Warner said, however, that it suffered from poor short-term frequency stability and that fm noise was a problem over a frequency range of less than 100 kHz away from the carrier. But Warner said that researchers at the British laboratory were solving these problems while improving the uniformity of electronic tuning over the mechanical-tuning range.

Dr. Peter Bulman of the British laboratory described a 1-watt peak, 5-nanosecond pulsed radar with a range discrimination of better than 3 feet at ranges as short as 10 feet. The transmitter oscillator, an unencapsulated epitaxial Gunn diode, was mounted across the waveguide rather than a half wavelength from a movable short. A sampling oscilloscope in the receiver gave an A scope display.

The Cornell conference attracted more than 350 representatives from industry, government and university research. It was co-sponsored by the Office of the Naval Research, with the cooperation of the IEEE. Other subjects among the 40 papers included parametric devices, avalanche effects, and quantum and optical effects.

The proceedings may be obtained by writing to Dr. Herbert Carlin, Director, School of Electrical Engineering, Cornell Univerity, Ithaca, N. Y. 14850. The price for members of IEEE is $5 a copy, and for nonmembers, $6. ■ ■



Gunn-effect device, to be used as a klystron replacement, contains a Gunn diode oscillator and a varactor diode for electronic tuning. This British device is about 1-1/2 inches long and uses a dielectric washer for mechanical tuning.

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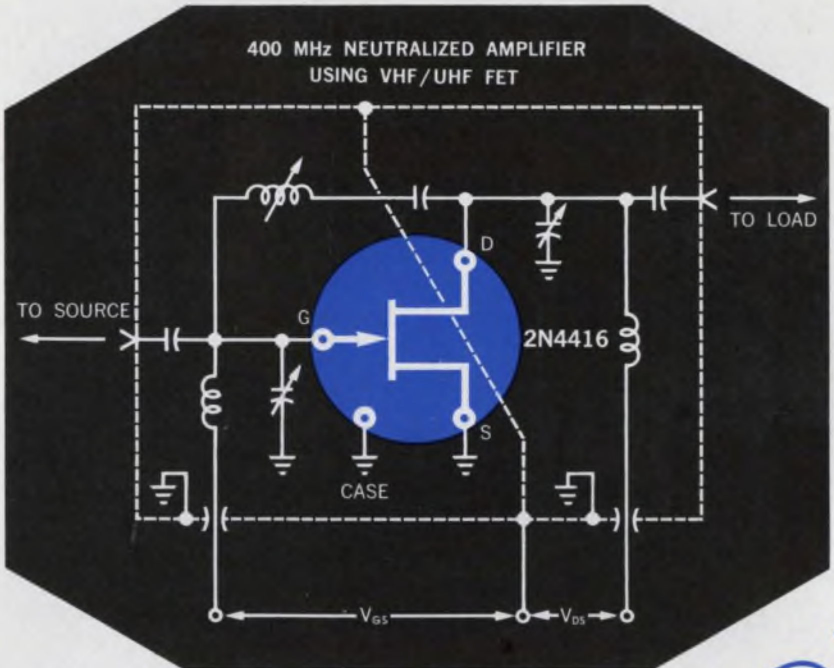

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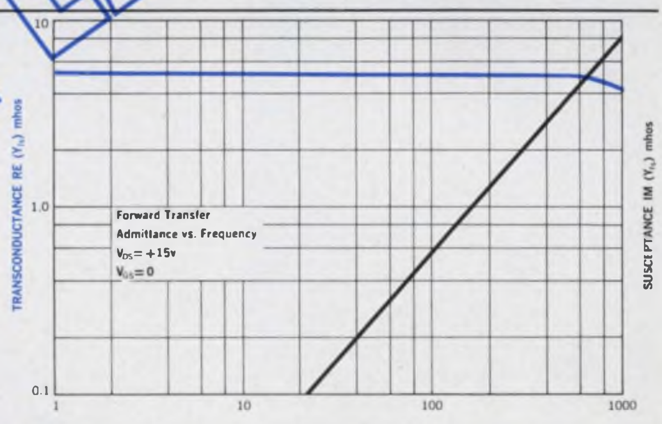
Reverse Transfer Capacitance, C_{rss} (max.)	0.8 pf	1.0 MHz
Spot Noise Figure (Neutralized), NF (max.)	4.0 dB	400 MHz
Spot Noise Figure, NF (max.) (Neutralized)	2.0 dB	100 MHz
Power Gain, G_{ps} (min.) (Neutralized)	10.0 dB	400 MHz



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ON READER-SERVICE CARD CIRCLE 13

Infrared horizon-mapping urged in space

Honeywell asks U.S. backing for project to help astronauts determine their positions accurately

Charles D. LaFond
Chief, Washington News Bureau

A concept for an unmanned infrared-scanning satellite has been offered to NASA by Honeywell, Inc., as a step toward solving a troublesome problem for both manned and unmanned space missions—accurate determination by the spacecraft of its position over the Earth.

The scanner would map the Earth's infrared horizon for future reference.

Before they can determine their precise position or even the attitude of the spacecraft, astronauts must know where the true horizon is. A sparse carbon-dioxide layer in the rare-atmosphere shell about the Earth produces a corona that makes observation by the usual optical instruments far too inaccurate for practical use. Infrared scanning in the 14-to-16-micron portion of the spectrum has been found to improve discrimination of the horizon.

The Honeywell satellite, being considered by NASA, would be launched into a 270-mile-high polar orbit for its mapping mission. Called Orbital Scanner, the 725-pound spin-stabilized satellite would draw energy for a continuous 70-watt demand from six large solar panels, fanned out like 12-foot-long flower petals.

Widespread use envisioned

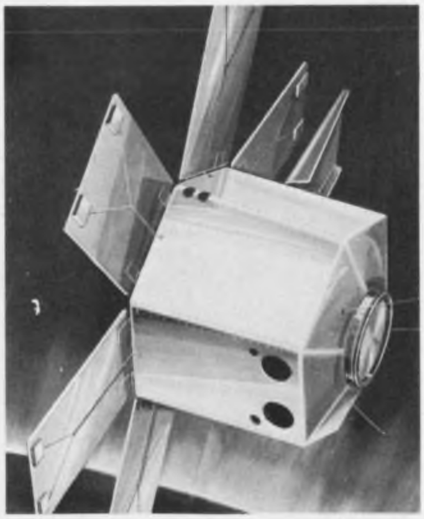
Despite the austerity of the nation's present scientific satellite effort, Honeywell, somewhat optimistically, has started a campaign for what could become a $10-million effort. Honeywell researchers believe that the technological payoff would far exceed the anticipated cost.

The primary mapping mission would be performed in 1972-73. Usable data would be available by 1974. This would be well within the deadlines for the Apollo Applications Program, the upcoming Earth Resources Orbiting Satellite, and the large meteorological satellite systems planned for the mid 1970s.

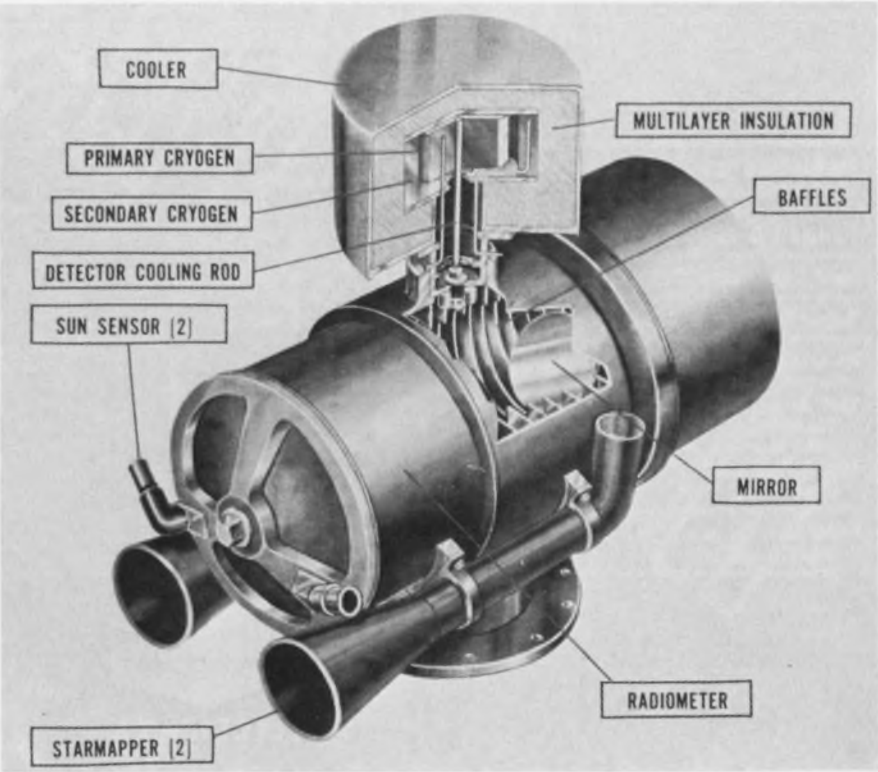
Although not mentioned by Honeywell, there are other obvious applications for improved navigation and attitude control in future military space programs, the Manned Orbiting Laboratory, reconnaissance-surveillance satellite systems, and possibly satellite-inspection vehicles.

The Air Force has already embarked on a similar effort called Project Profile. MIT's Instrumentation Laboratory is the prime systems contractor for development of two orbital spacecraft (see "News Scope," ED 18, Sept. 1, 1967, p. 14). Honeywell contends, however, that its proposed vehicle and over-all program are far more comprehensive.

The need for accurate horizon-



Infrared-scanning satellite (above) that would map the earth's infrared horizon, could lead to improved navigation and attitude control systems for future space missions. It would carry a measurement "package," such as shown on the right, containing an infrared radiometer and dual star mappers and sun sensors for attitude determination.



sensing is paramount, for if detectors could determine the true terrestrial horizons fore and aft of a spacecraft along its orbital path, then the bisector of this angle would be the true local vertical, or the position over the Earth. The need for complex on-board instrumentation would be eased.

While infrared horizon-scanning has been found promising, experience has shown that the amount and frequency of infrared radiation that can penetrate the layer of carbon-dioxide above the Earth varies with the location of the layer, time of day and season.

As early as 1958, when the first U.S. spacecraft encountered difficulty in maintaining accurate reference to local vertical, NASA's Langley Research Center at Hampton, Va., began an effort to improve horizon-sensor performance. By 1960 suborbital rocket probes proved the need for new concepts, not just improved detectors and data correlation.

Radiometric studies obtained in X-15 flights during 1964 and 1965 supported analytical studies, which concluded that the most promising spectral interval for use was the 14-to-16-micron CO_2 absorption band. Langley then began Project Scanner, with Honeywell as the prime contractor. The effort culminated in two ballistic-trajectory probes in August and December, 1966, in which highly instrumented payloads were hurled to an altitude of 400 miles.

Each of these flights lasted only 15 minutes, and they provided data associated only with the northern hemisphere and during only two seasons of the year. So in March, 1966, Langley selected Honeywell to perform a 15-month, $700,000 feasibility study for a long-term, global, 18-measurement program. The presently proposed Orbital Scanner concept evolved from this study, completed last July.

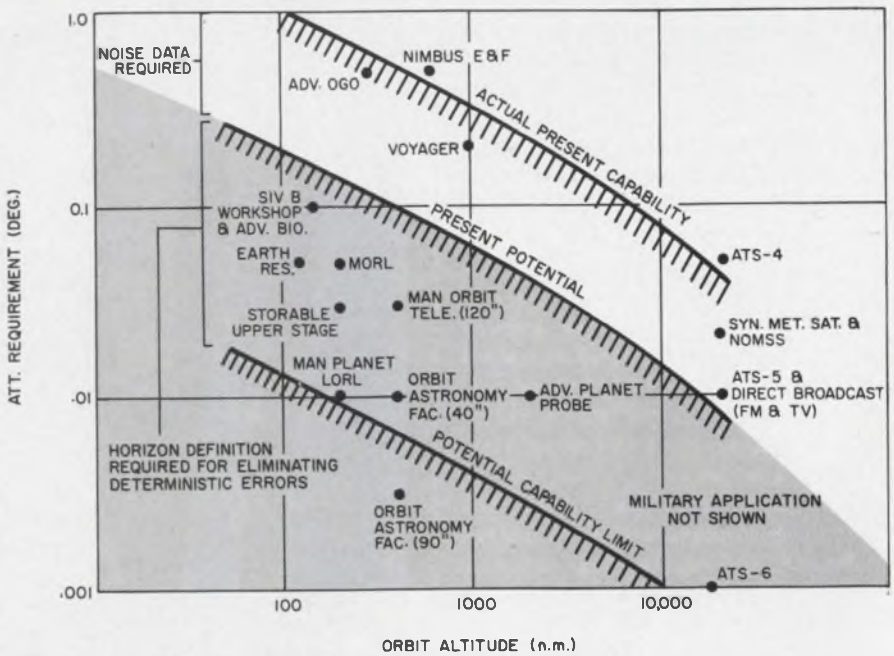
Subcontractors stand by

Honeywell's optimism is reflected in the fact that it has suggested a complete program team to design and fabricate major instrumentation for an Orbital Scanner project. The Company's Systems and Research Div. would serve as spacecraft developer and systems integrator under this arrangement.

(**scanner,** *continued*)

The hexagonal vehicle would measure 54 inches in diameter by 36 inches in length. In flight, the craft would roll about its longitudinal axis, perpendicular to the orbital plane. A major constraint placed on all subsystems design is the complete avoidance of any moving parts, with the exception of solar-panel deployment.

A key mission element would be launch time and orbital characteristics: the spacecraft would be launched at 3 p.m., nodal crossing, into a near polar orbit, and would then be sun-synchronous. This would be expected to yield a radiance profile based on near-maximum daily atmospheric temperature variations, and it would ensure efficient solar panel operation aboard the spacecraft.



Attitude pointing and stabilization requirements for present and proposed space missions show need for greater horizon definition. Proposed infrared-scanning satellite is intended to provide data needed to improve horizon-sensor performance.

Data Acquisition Network would be used for range and range-rate tracking (S band) and vhf communications. On-board telemetry and data-handling subsystems would be developed by RCA's Astro-Electronics Div. Data would be stored in a 500,000-bit memory and transmitted after each revolution about the earth by telemetry to NASA stations at either the University of Alaska or Rosman, N.C., for relay to the Goddard Space Flight Center in Greenbelt, Md. The data would include radiometric measurements, navigational star and sun positions, and timing signals.

The IR radiometer, which would peer through a 26-inch-diameter viewport, would be built by the Lockheed Missiles and Space Co. The cadmium-doped germanium detectors would encompass a 0.01° field of view and would operate in the 15-micron range. A 20°K neon cooler would be used with the detectors. Except for the primary optics, the radiometer design would employ dual redundancy.

For attitude determination, dual star mappers and sun sensors would be used to secure a pointing accuracy to 10 arc seconds with respect to the Earth's surface. Some 300 bodies in the celestial sphere would be used for attitude reference. The star telescopes would be protected automatically from exposure to the sun. The Control Data Corp. would provide the complete system.

Honeywell's Aerospace Div. would build an attitude-control system employing redundant magnetic-torquing coils that would interact with the Earth's magnetic field. Although the design is passive, operation could be redirected by ground command.

Gulton Industries, Inc., would provide the electrical power supply, and the Spectrolab Div. of Textron Electronics, Inc., would produce the solar panels.

Designed for a minimum of one year's operation in space, Orbital Scanner could provide the data necessary to achieve a twentyfold improvement over present horizon-sensing techniques, according to Honeywell. The best accuracies now obtained, its experts assert, are around 0.25°.

By using the 15-micron CO_2 band and data established in the IR mapping effort, astronauts could obtain accuracies of 0.01° to 0.02°. ■ ■

Red-hot arc furnaces tamed by computer

A Westinghouse process-control computer has been adapted to cut the electrical operating costs of arc furnaces. It does it by keeping tabs on demand and load factors.

The solid-state process-control computer controls the maximum rate at which electricity is used by the furnaces and the total energy consumption by means of time-sharing. The system also provides a heat log or record of temperatures, alloy composition control and other plant management information.

The computer receives power meter readings, transformer data and operating panel settings from each furnace being monitored and sends control orders to the furnaces.

Westinghouse spokesmen say that the control method is more versatile than previous wired-logic systems. They say that their process control computer can operate in an ambient temperature of 120°F and has filters to keep out the dust encountered in furnace shops. ■ ■

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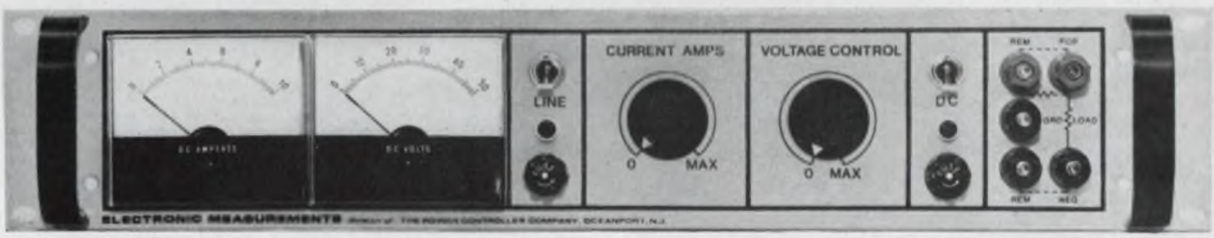

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RE SERIES SPECIFICATION TABLE

Model	Output volts	Output amps	Regulation line or load %*	Ripple MV RMS	Meters Ammeter Voltmeter	Terminals F - front R - rear	Size 19" panel	Weight	Price
RE 40 — 5	0 - 40	5	.01 or 2 MV	0.5	No	R	3½ H x 17¼ D	36#	$290.00
RE 40 — 5M	0 - 40	5	.01 or 2 MV	0.5	Yes	R	3½ H x 17¼ D	36#	315.00
RE 40 — 5ML	0 - 40	5	.01 or 2 MV	0.5	Yes	F & R	3½ H x 17¼ D	36#	320.00
RE 60 — 2.5	0 - 60	2.5	.01 or 2 MV	0.5	No	R	3½ H x 17¼ D	36#	290.00
RE 60 — 2.5M	0 - 60	2.5	.01 or 2 MV	0.5	Yes	R	3½ H x 17¼ D	36#	315.00
RE 60 — 2.5ML	0 - 60	2.5	.01 or 2 MV	0.5	Yes	F & R	3½ H x 17¼ D	36#	320.00

*whichever is greater. Input for all models 105-125, 50-63 HZ

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ON READER-SERVICE CARD CIRCLE 15

Sound-scanned semiconductor emits light

Applied field excites electrons that couple with lattice vibrations to produce glow at pn junctions

Richard N. Einhorn
News Editor

An engineer working at Bell Telephone Laboratories, Murray Hill, N. J., has demonstrated that sound waves produced in piezoelectric semiconductors can generate light. His method may lead to a new approach to flat-panel image display devices as well as to a new class of light detectors.

The laboratory development, known as a solid-state acoustoelectric light scanner, is claimed to offer the following advantages by its inventor, Basil W. Hakki:

- Energy lost in the process is rapidly restored, regardless of the number of light-emitting elements used in series.
- The effect is produced at room temperature.
- It operates over a convenient range of voltages (10 to 400 in Hakki's experiments.
- Quantities of devices can be produced with uniform properties.

Hakki explained his discovery as follows:

If a strong electrical field is applied to a semiconductor, it can excite drift electrons to a velocity greater than the speed of sound in that material. When this threshold is breached, strong electron coupling with phonons (lattice vibrations at the velocity of sound) can lead to the formation of an acoustic domain (see Fig. 1). As this acoustic domain, or sound field, passes under a pn junction, part of the acoustic energy is transformed into light. The light-emitting junction is formed by depositing a layer of p-cuprous sulfide on one surface of the n-cadmium sulfide strip.

Domain velocity is constant

A domain moves through the semiconductor at a constant velocity that is determined by the medium itself. Vary the applied bias or the carrier concentration, shine light on the semiconductor, chill or warm it, and the velocity still remains constant—a desirable feature considering that manufactured items should be uniform.

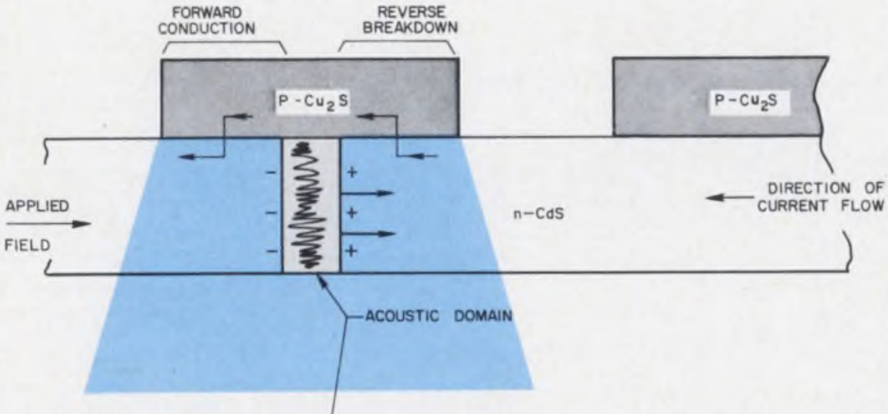
Sound propagates at different velocities along the three axes of a piezoelectric semiconductor. In cadmium sulfide (the material Hakki used in his experiments) the velocity of a longitudinal wave is about 4.5×10^5 cm/s; it is 1.75×10^5 cm/s in the shear direction, which is orthogonal to the longitudinal axis. When the applied voltage is sufficient to accelerate the drift electrons above 1.75×10^5 cm/s, an abrupt transition occurs, and the drift electrons couple to the sound domains in the shear mode through an electromechanical coupling coefficient. The scanning speed of the electrons is the same as the shear sound velocity.

Hakki used a 660-volt trigger pulse to form an acoustic domain at the cathode of the semiconductor. Once the domain is formed, it is sustained at 200 volts during its transit from cathode to anode by a 460-volt pulse.

The sound waves extract energy from the electron stream, so the device acts as a sound amplifier. If the gain is large enough, instability will result. A bulk negative conductivity effect is present; once the domain is formed, the current drops. The excess current is shunted across the domain.

Hakki says that the domain-voltage can be anywhere between 10 and 400 volts ("a hefty source"). As shown in Fig. 2, a great voltage across a narrow domain creates a high field intensity. The domain voltage V_D causes local breakdown in the heterojunction.

In a semiconductor, the domain voltage is equal to the anode voltage minus the product of field intensity and sample length. But this product is a constant, so the domain voltage increases with the voltage on the sample. This reveals another good feature: if the domain gives off energy to do a job, the applied voltage will restore that energy. This energy is constant regardless of the number of elements, provided that there is enough time for recovery. The recovery time is finite. Therefore the functional elements must



1. **Breaking the sound barrier** in a pn semiconductor produces light. An electrical field applied to cathode (at left) excites drift electrons to speed of sound. Electrons couple strongly with lattice vibrations to produce acoustic domain. As domain passes under each junction in turn, light is emitted.

be spaced far enough apart to permit recovery, but close enough to avoid needless delay.

This is what led Hakki to investigate a scanning array of pn junctions. A heterojunction (adjacent layers of dissimilar materials) is formed by coating n-cadmium sulfide with p-cuprous sulfide. Whenever the acoustic domain passes under a junction, minority carriers are given off. The radiative recombination of carriers gives off red light. Light is emitted chiefly because of reverse breakdown of the junction, but Hakki predicts that improvements in heterojunctions will lead to efficient forward-conduction luminescence.

The color obtained is due to the hole injected into n-CdS. The combination of holes and electrons gives off 2.5 eV (the energy difference between the valence and conduction bands), which ordinarily would produce green. But instead, the hole falls into the copper level of the cadmium sulfide and recombines radiatively with a free electron. The two copper impurity levels in the cadmium sulfide are 1.2 and 0.9 eV above the valence band.

The energy band is bent at the junction between the n-type semiconductor and the p-type semiconductor.[1] The transition from the cuprous sulfide to the cadmium sulfide represents a drop in the potential barrier for holes and an increase in the potential barrier for electrons, since reverse conduction occurs.

This suggests that either varying the way in which the material is produced (controlling the impurities) or varying the material itself (substituting semiconductors) will produce light of different colors.

Hakki allows approximately 100 ns spacing between elements. The delay is short enough to permit the eye to average or mix the primary colors to produce secondary colors. This is aided by two factors:

- There would be a decay time for the light pulses, producing mixing in the absolute physical sense.
- There would be aftereffects from the visual inputs, so that the eye would see the colors after the stimulus was removed.

The device might be used as a light detector by keeping the bias voltage below the junction breakdown level. The addition of photo-electrons would change the current drawn by the circuit, and this current change could be detected.

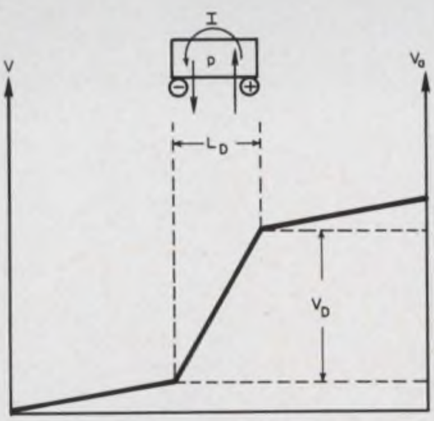
Homojunctions more efficient

When the device is used as an emitter, the light output is produced in a spectrum that peaks in the infrared but includes useful outputs in the visible region.

Hakki points out that heterojunctions do not emit light as efficiently as homojunctions, such as gallium arsenide in the infrared region or gallium phosphide in the visible region, but they are much easier to fabricate. Cadmium sulfide happens to "prefer" the n-state, hence the selection of p-cuprous sulfide to complete the heterojunction. Hakki says that up to now he has been more interested in proving the feasibility of the acoustoelectric light scanner than in optimizing it. His next step will consist of weighing the merits and demerits of other materials and then recommending whether products should be developed.

Operates at room temperature

One great advantage of heterojunctions such as n-cadmium sulfide coated with p-cuprous sulfide is the ease of operation at room temperature (300°K). Gallium arsenide must be cooled to the temperature of liquid nitrogen (77°K) if it is to lase. Cryogenic cooling of his own heterojunctions offers no immediately significant advantages, Hakki says.



V = VOLTAGE AT ANY GIVEN POINT
V_a = ANODE VOLTAGE
V_D = DOMAIN VOLTAGE = $V_a - E_s L$
$E_s = \frac{dv}{dx}$ = FIELD INTENSITY
L = LENGTH OF SAMPLE
L_D = DOMAIN WIDTH

2. **Great voltage across** a narrow domain creates high field intensity. Domain voltage can be $10 < V_D < 400$ volts, "a hefty source."

Hakki says that a typical solid-state acoustoelectric light scanner might be between 0.2 and 0.4 cm long, 400 microns wide, and between 12.5 and 100 microns thick. The light-emitting junction would be formed by depositing a layer (1 to 10 microns) of p-cuprous sulfide on the top surface of the cadmium sulfide. This is accomplished by a chemical process in which two cuprous ions substitute for each cadmium ion. The desired pattern of pn heterejunctions is obtained by means of photoresist techniques.

Mechanical strength is gained by sandwiching the semiconductor between two transparent glass plates (not shown in Fig. 1). Ohmic contacts are formed at the two ends of the cadmium sulfide strip using an indium-gallium mixture.

Earlier work at Bell described

Hakki says that his work is a logical outgrowth of experiments conducted at Bell Telephone Laboratories about five years ago by Andy Hutson. The latter was the first to discover the sound amplification effect in piezoelectric semiconductors. Hutson recognized that if an electrical field in a semiconductor propagates at the velocity of sound, the resulting sound wave may be considered as a surface stream.

Large arrays of experimental solid-state acoustoelectric light scanners have been built by Bell Telephone Laboratories. Hakki says he will describe a square array of 20,000 light-emitting junctions on October 19 at the International Electron Devices Meeting, Washington, D. C. The experimental matrix consists of 141 rows by 141 columns in a one-half-inch square. Integrated switching circuits are planned for this application, but have not been built.

The advantage of the square array is the same as that of computer memory arrays: the peripheral electronics increases by the square root of the number of elements. ■ ■

Reference:

1. Frederick F. Morehead, Jr., "Light-Emitting Semiconductors," *Scientific American*, CCXVI, No. 5 (May, 1967), 108-122.

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Honeywell

COMPUTER CONTROL DIVISION

Comsat labs hopes to rival BTL

Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

Comsat aims to lead the field

On completion early in 1969, Comsat Corp.'s new Clarksburg, Md., research laboratory will begin operation under a $5 million annual budget with nearly 350 personnel. Roughly one-third of these will be scientists and engineers engaged in advanced applied research for both ground and satellite subsystems and techniques. Comsat Corp. must lead in this technology and "not be at the mercy" of its suppliers, said Wilbur Pritchard, director of Comsat Laboratories. The corporation must be a sophisticated buyer, he declared, and in time the new organizer will rival the competency of the world-renowned Bell Telephone Laboratories, despite Comsat's greater specialization.

Early research by Comsat, Pritchard disclosed, will be directed toward such problems as the improvement of spectrum utilization through data compression and the use of the millimeter wave band. If the effective use of data compression obviated a single satellite launching, which costs $15-$17 million, the entire research effort of several years would pay for itself, he claimed. With present spectrum space nearly exhausted and bandwidth limitations a serious operational factor, the 18-GHz and 35-GHz bands will be studied for future use. (Present operating bands are at 4 GHz and 6 GHz.) Above 8 to 10 GHz, he said, atmospheric attenuation becomes an increasing problem but good windows do exist. Among the first devices to be studied, Pritchard stated, will be rf power emitters for use at these very high frequencies.
The complete design of future satellites by Comsat is not being considered, the laboratory director declared.

'This, gentlemen, is a fact of life'

Representative George P. Miller (D-Calif.), Chairman of the House Science and Astronautics Committee, recently gave some advice to an industry group, in describing the House's latest cut in NASA's budget, from a requested $5.1 billion to $4.6 billion. He said that industry should be aware of this as a clear enunciation of a political fact. It is a fact of life, Miller said, that firms in aerospace activity must live with. They must take it seriously into consideration when planning future operations.

Members of Congress on both sides of the aisle, he stressed, are deeply concerned with current national economic burdens. But, he said, "in no sense should the actions by the House on the authorization and appropriation bills be interpreted as hostility to space exploration." Congressman Miller castigated NASA for its apparent willingness to accept major program delays in the belief that those same programs can be picked up again at some indeterminate date without massive financial penalty. No program, said Congressman Miller, has ever been put aside and then resumed later without involving very heavy increases in expenditures. Technology, he stated, cannot be put on the shelf, because technology resides in the minds of people, not things.

AF computer contract rebid

Like a rerun of an earlier episode, proposals have again been submitted for an anticipated $120 million commercial-computer buy by the Air Force. The rebids supersede a contract previously awarded by the Air Force to IBM in the hotly contested program. Insiders, both in government and in industry, still maintain that IBM will be the ultimate winner.

The highly controversial procurement, the first award for which was upset by the U.S. General Accounting Office, is currently being sought by the same contractors as made the original bids —Honeywell, Inc., Burroughs Corp., and RCA. The real problem, informants say, was centered on IBM's costing approach—while IBM offered

Washington Report CONTINUED

more for its money over a five-year period, the total price of its bid was higher than either of its competitors'. IBM's current proposal is expected to approximate its former proposal closely both in details of dollars and of benefits provided on a long-term basis.

Exports finally exceed imports

For the first time in many years, U.S. electronic exports during the first five months of 1967 have exceeded imports with a record total of $737 million, representing an increase of 32.5% over $556 million during the same period last year, according to the latest Electronic Industries Association report. Imports actually increased some $300 million during this same period.

Major gains were achieved by radiotelegraphic and telephonic transmission and reception instrumentation (increased 337%); electrosurgical devices and parts (up 252%); and television cameras and parts (up 167%). Of major interest was the rise in military-industrial electronics exports which jumped more than 38% for a total of $517 million during this same period. Electronic-component exports surpassed the sales increase within the U.S., with a 22% increase.

Lasers as tunnel diggers—again?

For the umpteenth time in as many years, the proposal has been made to use "high-power lasers" for drilling tunnels, on this occasion by Alan F. Boyd, Secretary of Transportation.

Speaking recently before a group in Los Angeles, the Transportation Secretary was describing research needed to overcome the shortcomings of U.S. mass transportation systems. He indicated that radically different means of providing transportation facilities are within our grasp. As an example, he suggested that one project could be investigation of the use of laser beams to tunnel under cities "rapidly and at dramatically lower cost than present digging techniques." He did not suggest what laser would be used. Boyd commented that such techniques might ultimately make possible the use of high-speed, induction-driven trains between cities with little interference with surface life.

Continuing his blue-sky forecasting, Secretary Boyd indicated that current research has suggested that tracked air-cushion vehicles capable of 200 mi/h could be built in the near future, if the U. S. were able to concentrate more resources on such developments. He pointed out that less than 1% of the annual Federal research budget is presently applied to transportation and the majority of that input is spent on aircraft and associated air movement problems. He stated, moreover, that transportation companies in general spend less than 0.5% of their total revenues on research (typical aerospace R&D in-house research varies from 5% to 8% annually).

Pakistani satellite report erred

Let's set the record straight. A recent Reuters report in the national press that the Export-Import Bank was to provide a $10-million loan to the Pakistani government for a communications satellite to be synchronously orbited over the Indian Ocean was incorrect. The announcement was attributed in the story to the Pakistani Communications Secretary M. H. Zuberi.

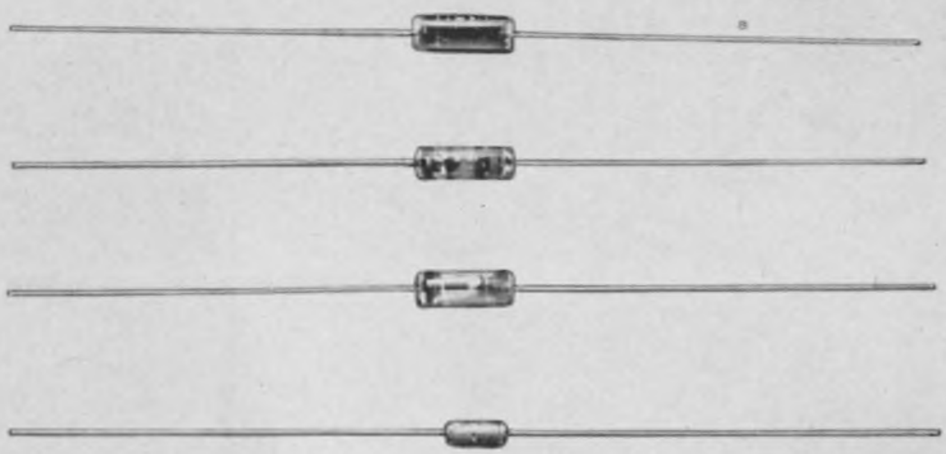
The facts are these. A letter of intent has been filed by the government with Comsat Corp. here for technical assistance to provide:

- A definition of specifications for use in a proposal request for two Earth stations compatible with the global Intelsat systems.
- Evaluations of such proposals to assist Pakistan in selecting ultimate contractors.

The Export-Import Bank will lend the $10 million but has stipulated that the procurement must be from U.S. firms. The program is scheduled for completion late in 1968.

Soviet computer efforts snagged

Centralization of power is supposed to be a dominant characteristic of dictatorships, but the reverse situation is reported causing difficulties in computer technology in the Soviet Union. Instead of one supervisor to direct the government's research, the efforts are said to be divided among many ministries. The result, according to Russian sources: "a fractured multitude of one-of-a-kind designs and programing principles." The reports, culled and translated by Electro-Optical Systems, Inc., of Pasadena, Calif., put the Soviet five to 10 years behind the U. S. in computer design and programing.



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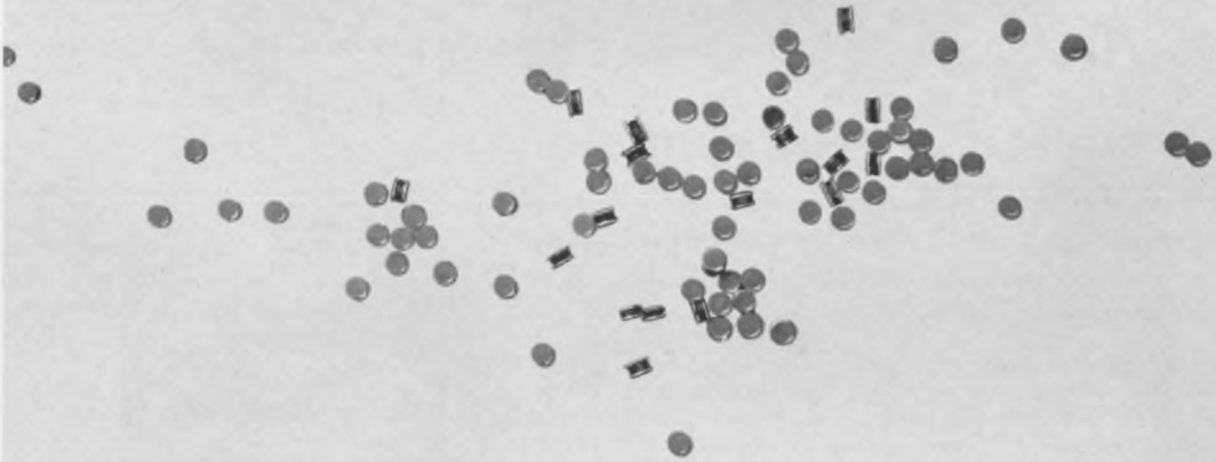

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ON READER-SERVICE CARD CIRCLE 18

Explosive pumping of lasers studied

Scientists in the Soviet Union are reported experimenting with rapidly moving bodies, accelerated by gunshot, as a possible method of pumping medium power lasers.

According to M. S. Rabinovich of the USSR Physics Institute, the shot energy from a modern weapon ranges from several kilojoules for an ordinary rifle to several thousand for an artillery piece. At a repetition frequency of 10 through 30 shots per second, an efficiency of 1 per cent would yield 10 joules to 1 kilojoule, he said.

The mechanism of converting the bullet energy into pump energy, according to Rabinovich, may be provided either by the flash of light produced by the compression wave in front of the bullet, or by magnetohydrodynamic generation of electric energy by the bullet.

In the case involving a flash of light, a bullet maintained at approximately 3 km/sec over a path length of about one meter produces a sufficiently intense pump flash, especially if it moves through a jet of gas having high emissivity, Rabinovich reports.

Energy provided by induction

In the magnetohydrodynamic case, the electric energy is produced by induction as the bullet moves transversley to a strong magnetic field. The necessary conducting circuit is provided by the gas that is ionized by the moving body.

Rabinovich has observed that the pulse power of several dozen megawatts can be produced at a velocity of about 3 km/sec and a path length of approximately 30 cm.

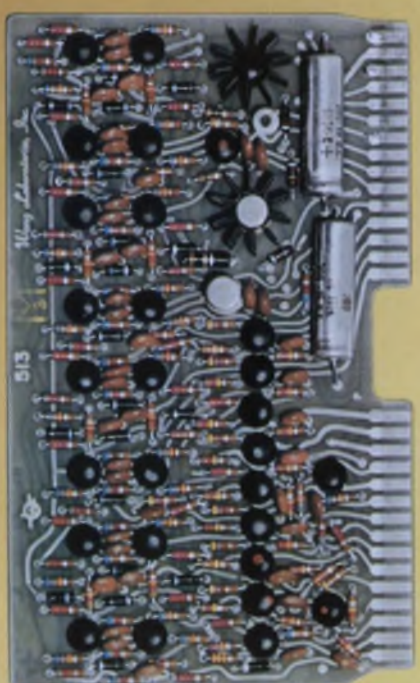
He concludes that the explosive-pumping method can be used to construct compact pump systems for laboratory lasers without resorting to capacitor banks.

The experiments were reported in the September, 1967, issue of Soviet Science in the News, published by Electro-Optical Systems, Inc., of Pasadena, Calif. ■ ■

"we have used many millions of Allen-Bradley hot molded resistors. The uniformity of quality from one shipment to the next is truly astounding. There can be no question about the reliability of these resistors."

Wang Laboratories

Model 320 Wang Electronic Calculator with 320K keyboard for scientific application. Readout provides 10-place accuracy with floating decimal point, and all calculations are displayed in one millisecond. Normally the 320 calculator is placed in a desk drawer rather than on the desk. It is shown here next to the keyboard to indicate compactness of the calculator.



One of the printed circuit cards from the Model 320 calculator. All resistors on this card are Allen-Bradley Type CB ¼ watt hot molded resistors.

To insure the extremely accurate and high speed operation of the 300 Series Wang Electronic Calculators, all components are selected with utmost care. Thus, it was only natural that Allen-Bradley hot molded resistors were chosen for this most exacting application.

Composition resistors, not produced by the technique of hot molding used by Allen-Bradley—using completely automatic machines—cannot equal the quality and uniformity of production for which the hot molded Allen-Bradley resistors have a worldwide reputation. The precise control during manufacture results in such uniformity of one A-B resistor to the next—million after million—that long term resistor performance can be accurately predicted. There is no record of any Allen-Bradley hot molded resistor having failed catastrophically.

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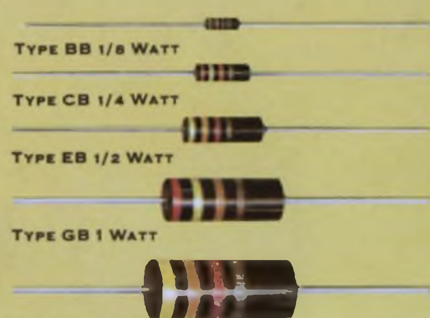

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Allen-Bradley Type BB resistors are available in standard resistance values from 2.7 ohms to 100 megohms with tolerances of ± 5%, ± 10%, and ± 20%. Maximum rated wattage is 1/8 watt at 70°C and can be derated linearly to zero watts at 130°C. The maximum continuous rated voltage is 150 volts RMS or DC. For complete specifications on the Type BB resistor, please write for Technical Bulletin B-5005. Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

**Theoretical packaging in cordwood arrangement.*

actual size
of Allen-Bradley Type BB
hot molded resistors

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

71-05-7E

Post Office looks to voiced mail-sorting

In a bid to speed the massive volume of parcel post, the U.S. Post Office has contracted with RCA's Advanced Technology Dept. in Camden, N. J., to develop a voice-operated sorting system (see "News Scope," ED 18, Sept. 1, 1967, p. 13).

To operate the system, a postal employee would read the ZIP Code number on a package into a head microphone, and place the package on a conveyor belt. Both hands would be free for package-handling.

The spoken number would be instantly flashed on a verifier screen in front of the operator as an accuracy check. The package would move along the belt until it reaches the bin assigned for that ZIP Code destination. There it would be automatically deposited.

An experimental Numeric Speech Translating System, according to RCA spokesman D. J. Parker, is capable of operating despite regional, ethnic and personal speech differences among operators and is sensitive enough to function in the noisy environment of a busy post office.

The translator employs circuitry which functions similar to neurons (nerve cells). These threshold-logic elements perform both digital and analog functions, Parker explained.

The equipment recognizes a continuous string of spoken digits by examining the speech energy as a function of both frequency and time. The relative values of speech energy in the various frequency bands and the changes in these values with time are abstracted from the microphone input signal. These data are then processed by several phoneme recognition networks that employ analog threshold-logic elements. (A phoneme is the smallest unit of speech essential for distinguishing one utterance from another, such as the "p" in pin as opposed to the "b" in bin). Delivery of a feasibility model is set for early 1968.

RCA officials declined to speculate on other specific uses for their system except to say that it most likely could find application for any numerically controlled machine. ■ ■

◄ ON READER-SERVICE CARD CIRCLE 245

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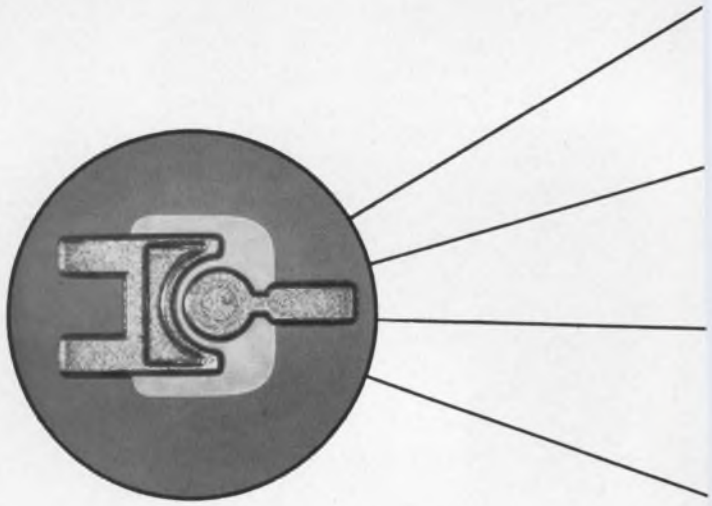

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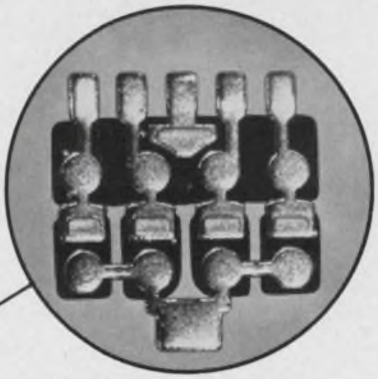

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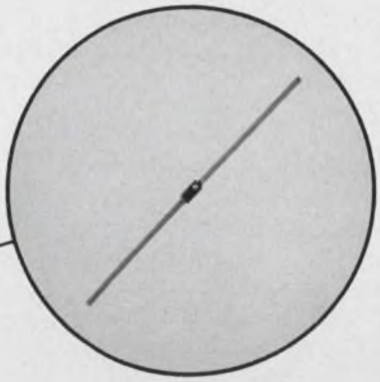

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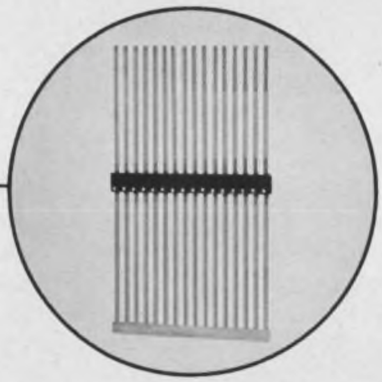
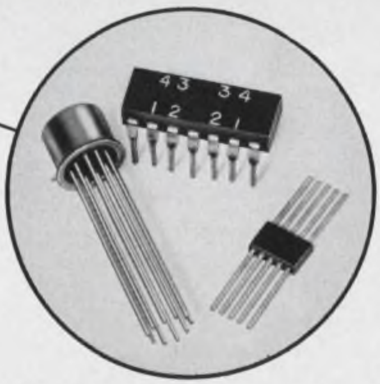
Beam Lead Microdiodes—in a small plastic axial-lead Microdiode which exceeds MIL moisture specifications. The Microdiode body measures only 40x40x80 mils. It has half inch long gold plated Kovar ribbon leads (5x20 mils). Life tests performed on General Instrument's Microdiode indicate a typical ΔI_r less than $1.5 x I_{r\ (orig.)}$ at PRV and 25°C after 2000 hours at 150°C operating conditions.



and in...

Beam Lead Microdiode Strips—as modular diode strips on 50 mil centers. The strip may comprise from two to twenty diodes in any combination of common anode, common cathode or discrete interconnections. They can be easily used to form large diode matrices for switching applications.



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Beam Lead Diode Modules and Arrays—in any circuit configuration and in plastic or hermetic packages—both flat pack and dual in-line. The extreme stability and long life provided by Beam Lead bonding is assured. The use of **Beam Lead** isolation between junctions allows the production of switching and core driver modules with faster response times than obtainable by the usual monolithic approaches.

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ON READER-SERVICE CARD CIRCLE 21

TV set plays prerecorded photographic film

Electron-beam scanning attachment extracts sound and color images from 7-inch cartridges

The Columbia Broadcasting System has officially announced its device that permits a home viewer to watch motion pictures on an unused TV channel. In March, 1966 the company denied its existence, but talk persisted. Now advances in home video tape recorders may have softened the impact of the CBS announcement.

A spokesman for CBS Laboratories, Stamford, Conn., explained the "new" system as a cartridge of special film that is loaded into an attachment, which feeds the antenna terminals of a standard television set. An electron beam scans the film and converts the light variations into audio and video, which modulate an rf carrier. Playback is identical to reception of a telecast.

Only plays back film

The playback unit is not a video tape recorder. It operates only with the specially processed film cartridges and it cannot record.

Playback of the film-cartridge requires a breadbox-size unit that can sit atop a TV set. It contains an electro-optical scanner instead of a light source for extracting the information stored on the film. The output of the optical converter is modulated rf. The film may be viewed on any vhf-channel. A switch on the unit can block incoming programs.

Operation of the unit is described as simple: the round cartridge is plopped onto a spindle. It is automatically threaded, played, rewound and rejected, much like a phonograph disk on a changer.

Film normally progresses through the unit at 5 in./s, but the user can stop it at will, so that he can freeze any frame.

Dr. Peter Goldmark, President and Director of Research, CBS Laboratories, maintains that a great deal more pictorial and sound information—one hour of black-and-white or one-half hour of color viewing—can be stored in a 7-inch-diameter by 1/2-inch-thick cartridge than on a comparable reel of magnetic tape. Moreover, he says, this can be done at a much lower cost. One estimate is $7 to $14.

As explained by CBS, a film-processing company would electronically transfer the information on film or video tape onto a special 8.75-mm-wide, unperforated thin film. This master film would be duplicated at high speed by multiple printers. The final processed film would be spooled onto the hubs of the 7-inch cartridges. Dr. Goldmark says that a 20-minute program can be duplicated in half a minute. He predicts that duplicating time can be halved in a year or two.

The convenience with which action can be stopped suggests an important application for the device: classroom or even home instruction. A teacher can dwell on a problem for as long as he desires.

Cost does not appear to be prohibitive. The playback unit can be manufactured for about $280, says a CBS spokesman. The price cited is for small-scale production in England. An expert on the television industry estimated that in quantity costs could be held to about $150 in the United States.

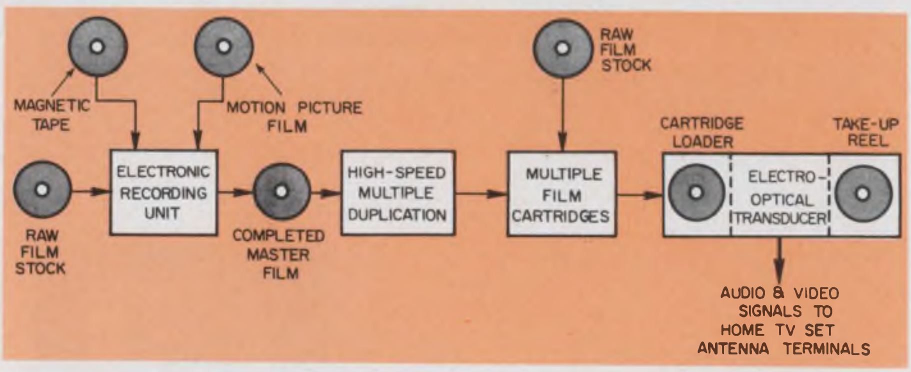
The same expert is less than enthusiastic about the future of the CBS unit vis-à-vis video tape recorders using the Newell tape transport (see "Low-cost tape transport records 50 MHz," ED 13, June 21, 1967 p. 38). Retail prices under $500 have been forecast for Newell-licensed units in a few years by various industry sources, but some spokesmen are skeptical.

Some call it 'reactionary'

Another expert likens the CBS device to "an electronic buggy whip" in that it uses photographic film instead of magnetic tape. He does admit, however, that despite cost reductions magnetic tape will still cost much more than the film cartridges for some time to come.

He thinks that CBS will reserve all rights on the film-duplicating process in order to remain the sole producer of the cartridges in the United States. The foreign partners of CBS are Imperial Chemical Industries Ltd (England) and CIBA Ltd (Switzerland).

Will the public accept passive playback? Arvin Industries, Columbus, Ind., is readying for fall demonstration an experimental color-television console embodying a video tape recorder that uses specially developed tape heads and electronics—and, it is rumored, a Newell transport. However, no product line is likely to appear before 1969—the CBS target date. ■ ■



Electron-beam scanning permits playback of monochrome or color motion pictures on home TV sets. Variations in light intensity are converted into audio and video signals that are coupled to the antenna terminals of a TV set. Commercial prerecorded film is packed in 7-inch cartridges.

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TURBOGLAS® Varnished Glass Sleeving	Strong; flexible; tear, moisture and chemical resistant.	B	To 7,000 volts	—10°C to +130°C	A-1 thru C-3	NEMA VS 1, Type 2 MIL-I-3190 ASTM D-372
TURBOTUF® Vinyl Coated Glass Sleeving	Abrasive resistant; highly flexible; retains dielectric strength under severe handling.	B	To 8,000 volts	—10°C to +130°C	A-1 thru C-1	NEMA VS 1, Type 3 MIL-I-3190 MIL-I-21557
TURBOCRYL® Acrylic Coated Glass Sleeving	Tough; flexible; moisture, abrasion and chemical resistant. Compatible with magnet wire coating.	F	To 7,000 volts	—10°C to +155°C	A-1 thru C-2	NEMA VS 1, Type 6 MIL-I-3190 ASTM D-372
TURBOSIL® Silicone Coated Glass Sleeving	Chemically inert; oil, moisture, abrasion and peel resistant. Compatible with magnet wire coating.	H	To 7,000 volts	—65°C to +200°C	A-1 thru C-3	NEMA VS 1, Type 4 MIL-I-3190
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TURBOLEX 105® High-temperature vinyl tubing	Flame and fungus resistant; retains clarity through use of light-stable fungicides.	—20° to +105°C	Clear and colors	MIL-I-631 Grade c, Class 1 Category 1 UL-105
TURBOLEX 85® General-purpose vinyl tubing	For use where moderate heat and occasional exposure to oil are encountered. Easily printed, retains legibility.	—32° to +60°C	Colors only	ASTM D-922 Grade a
TURBOLEX 76A® General-purpose and low temperature vinyl tubing	Good dielectric and low temperature properties. Fungus-resistant, noncorrosive.	—46° to +80°C	Clear and colors	MIL-I-621 Grades a & b, Class 1 Category 1
TURBOLEX 40® Low-temperature vinyl tubing	Low temperature tubing for military applications with excellent high temperature characteristics. Flame and fungus resistant.	—55° to +80°C	Clear and colors	MIL-I-22076
TURBOZONE 40® Low-temperature vinyl tubing	Flame retardant; fungus-resistant; noncorrosive; available in Types I and III in all sizes.	Class I: —90° to +80°C Class II: —67° to +80°C	Clear and colors	MIL-I-744C
TURBOTEMP® Teflon TFE tubing	Chemically inert; moisture-resistant; excellent dielectric.	—70° to +250°C	Natural and colors	MIL-I-22129

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ON READER-SERVICE CARD CIRCLE 22

Ape's panting gauged to 300 picostrain

A single-crystal silicon strain gauge, developed as a sensitive pressure transducer, has been implanted in the chest of a rhesus monkey to measure respiration during suborbital flights. It has also been inserted through the veins into a man's heart to detect irregularities, and used to measure fuel level in space vehicles.

The 80-by-6-by-0.5-mil device is adaptable to such applications as angle sensors, torque arms, load cells, pressure bays, traffic counters and phonograph cartridges.

In an industrial counter, the strain gauge can detect minute differentials in paper thickness caused by weight strain of stacking. It produces varying output signals from the output electronics that are translatable into an accurate sheet count.

The gauge has been tested down to 300 picostrain (a picostrain is 10^{-12} in./in. strain) by its manufacturer, Electro-Optical Systems, Inc., of Pasadena, Calif. The company says the device has a theoretical detection limit of 100 picostrain. It also reports a mean time between failures of 100,000 hours.

The gauge can be compensated for temperature over an operating range of $-100°F$ to $+500°F$. ■ ■

Microminiature pressure gauge inside monkey's chest measures respiration. Dimensions of device are 0.08 by 0.006 by 0.0005 inches.

SWITCH CRAFT FORUM

Oh, no! Not another "revolutionary new breakthrough in electronic science." Just what in the world is a "Glo-Annunciator"?*

It may not be as important as the invention of the transistor, but in it's own way, in it's own application, it's a pretty revolutionary product.

The Switchcraft "Glo-Annunciator" is a miniature, electromagnetically operated annunciator that appears to glow without the use of a lamp. A magnet-indicator panel simply slides back and forth behind a display screen, alternately exposing and hiding the reflective indicator as the device is actuated. The highly reflective material appears to glow, just as though there was a lamp behind it.

No power is needed to burn a lamp. In fact, the only power needed is a pulse signal to activate the slide magnet.

Sounds ingenious. But what does all this mean in terms of improved electrical efficiency? An annunciator board isn't all that complicated.

Oh, no? Add up the power consumption on a big board. And the heat. Not only from lamps. Buzzers or ring-down devices also use a lot of power and generate heat. What we have is a real cool device. The pulse signal feeds the annunciator coil which consumes only 0.7 watts at rated voltage. Even if you had an application where the annunciator coil must operate continuously, 0.7 watts is still a lot less than required for many indicator lamps.

And for extended life, we use a highly efficient ceramic magnet. Just for comparison, a ceramic magnet has 5 to 6 times greater magnetic retention than Alnico.

I'm used to lamps. At least with a lamp, when it's "on," you know it. Can your reflective material match the intensity of a lamp?

In the dark, no. It takes ambient light to reflect. But, here's one big advantage: the brighter the ambient light, the less a lamp appears to glow, by contrast. With our material, the brighter the ambient light, the brighter our reflected signal.

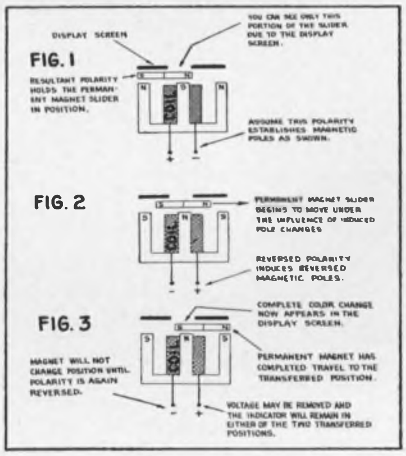
And here's another big advantage of the "Glo-Annunciator". A lamp is either "on" or "off". When a lamp is out, how do you know it isn't just **burned** out? Ours is a two-way signal. In one position it can glow green, in the other it can glow red . . . or many other combinations of colors. It is a positive signal in either position, and nomenclature may be imprinted on the indicator.

"Burn-out" brings us to another point. Lamps are relatively cheap, but how about the labor costs and down-time to replace them?

You claim infinite life characteristics. Just how long will the "Glo-Annunciator" continue to operate?

Practically forever. Here's why. The only moving part is the ceramic magnet slider. No pins, no bearings or latches to wear out. Secondly, the coil can't wear out and will continue to function electrically under the proper operating conditions. Finally, unlike lamps, the flourescent material just keeps on glowing as long as there is light to reflect.

The simplified operation of the "Glo-Annunciator" bears this out:



Sounds pretty exciting. How do I get complete details on mounting dimensions, circuit applications, etc? By the way, I've got some comments on your FORUM, too.

Good, just circle the Reader Service No. below. And, drop us a line on your company letterhead with your comments on any of our FORUM projects. We're anxious to have a lively exchange of ideas.

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*Patents pending.

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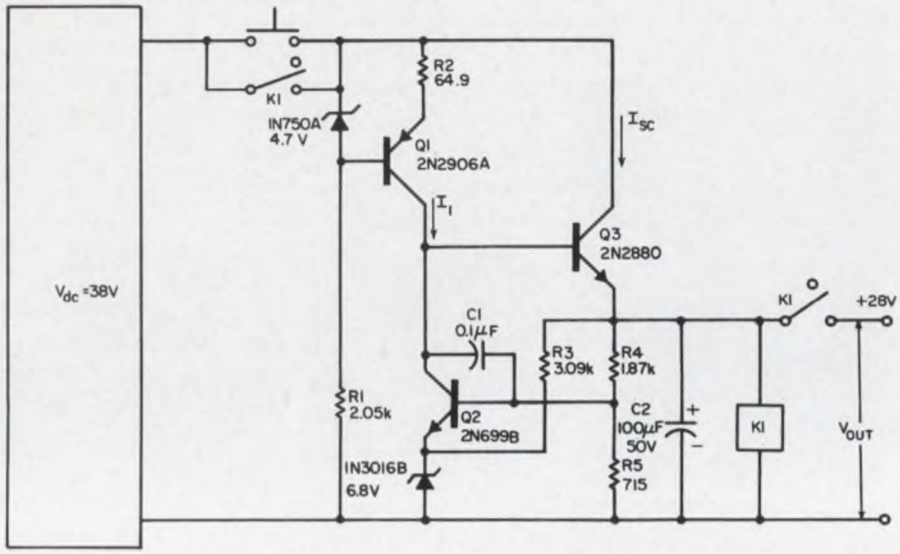
ON READER-SERVICE CARD CIRCLE 24

Letters

Simplify power-supply short-circuit protection

Sir:

ELECTRONIC DESIGN's March 1 issue shows a circuit in the Ideas for Design section that uses 18 components to provide short-circuit protection ["Protect power supply against overloading," ED 5, p. 110]. This function may be combined with the design of the regulator without the addition of another black box just for short-circuit protection. The regulator in the figure is designed for a predetermined maximum load current and simultaneously provides the specified regulation.



Relay protects regulator circuit against short-circuit overloads.

The conventional method of overload protection relies on an increase in voltage across a precision series resistor to turn off the power supply. Most overload protection circuits require several components owing to their complexity.

A more simple and economical method is to limit the output of the series control transistor to the desired short-circuit current. R_2 and CR_1 are chosen for a constant current, I_1. This limits the collector current of *Q3* to $I_{sc} = \beta_3 I_1$, with the output shorted and *Q2* off. *Q3* is then selected to have a rated collector dissipation of $V_{dc} I_{sc}$. Without the output shorted, the maximum collector dissipation is $V_{ce} I_{sc}$, which is less than the rated power of *Q3*. During normal operation when V_{out} is high, *Q2* is driven hard, allowing I_1 to be shunted through *Q2*. A relay may be added to disconnect the load when the output is shorted, to avoid continuous heating by *Q3*.

This same technique could be applied to other regulators by limiting the current of the source rather than implementing a complex detection/shut-off system downstream.

Nelson M. Nekomoto
Tasker Instrument Corp.
Van Nuys, Calif.

Three-phase generator made with 2 flip-flops

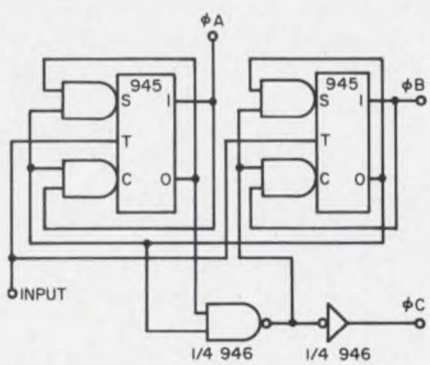
Sir:

Regarding the circuits on p. 106 of the April 12 issue of ELECTRONIC DESIGN ["Generation of 3 phase square waves simplified," ED 8] and p. 48 of the June 7 issue ["Three phase generator may lock in subsequence," ED 12], I submit another method.

[*In the former, John L. Nichols of Fairchild Semiconductor showed how three DTμL 946 packages could be used to generate three square-wave signals phased 120° apart. In the latter, Howard Hamer and Paul Holtzman of RCA contended that Nichols's design would lock up in a subsequence. They proposed two circuits that would not lock up. Nichols rebutted the RCA engineers' claim that his circuit was flawed in the Letters column of ED 15, July 19, p. 40.*—Ed.]

This method (see figure) uses only two 945 flip-flops and half a 946 quad two-input gate. It will not lock up into the one unused state. The spare half of the 946 gate could be used elsewhere.

E. G. Holm
Hughes Aircraft Co.
Culver City, Calif.



Three-phase square-wave generator can be realized with two flip-flops and half a quad 2-input gate.

Information inputs must be cleaned up

Sir:

I appreciated your editorial in the 5 July issue of ELECTRONIC DESIGN. ["It isn't the retrieval, it's what you retrieve"]. The intent of your comments clearly reflects a few basic rules I learned in a technical-report-writing course at the University of Michigan. We learned, for example, to exercise care in choosing a *title* for a report, because eventually the paper would be cataloged *and retrieved*. Moral: If the job is done right the first time (a good input) a lot of trouble will be avoided in the future.

Presently, I am working for the Navy as an electrical engineer and see poorly written, misleading reports every week. These "bad inputs" to the collection of informa-

(continued on p. 42)

Ohmite makes just about every kind. But you won't find axial-lead wirewounds anywhere that measure up to Series 99 and Series 88 resistors. Why? One big reason is their exclusive MOLDED jackets. MOLDING produces a thick, dense coating that gives superior electrical insulation (1,000 VAC minimum breakdown) . . . exceptional protection against abrasion and rough handling . . . size and shape uniformity which works beautifully in the mechanical feeds of automated assembly lines. Uniformity also facilitates mounting in metal clips for a heat-sink advantage of up to 100%. MOLDED Series 88 and 99 units are the most durable axial-lead resistors available today. Get all the facts in the Ohmite "Answer Book," Catalog 100. Ohmite Manufacturing Company, 3643 Howard St., Skokie, Illinois 60076. Phone: (312) OR 5-2600.

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ON READER-SERVICE CARD CIRCLE 25

(continued from p. 40)

tion pose a nearly meaningless, heavy burden to our libraries. Let's press to clean up the present and future "inputs."

Carter S. Rose
San Francisco

Article and editorial don't jibe, reader gibes

Sir:

I wonder whether the writer of the fine editorial, "It isn't the retrieval, it's what you retrieve" looked hard at the article, "Make IC digital frequency comparators," in the same issue on pp. 62-64.

What can one retrieve from that article? Well, there exist frequencies. What frequencies? Clearly these frequencies cannot be gigahertz. They must presumably be in the range of IC clock circuits, say, under 50 MHz. It is suggested that one may compare these frequencies. To what accuracy? It is hard to say. We are told that we will know when they are "equal," or when one is "higher" or "lower" than the other. How much higher or lower? How close to equal? Reading the article enables one to surmise that it must depend on the length of the "short, sharp" pulses used. One circuit, however, uses square waves. That one's accuracy must vary with the actual period of the square waves, and also with their rise times, and with the delay lines of the flip-flops.

What information can one retrieve from all this? That you preach more virtue than you manage to practice. This may often be so. But I still applaud your editorial.

Myron Pleasure
Physicist
Jackson Heights, N. Y.

The author to the defense

Sir:

Myron Pleasure certainly makes a valid point in saying that the frequency range and the accuracy of the systems have not been discussed.

Let me point out that the contents of the article concern the systems as such, not so much their implementation with actual devices. A fairly comprehensive description of the different possibilities for implementing them would have been too voluminous to be included in the one article.

The upper frequency limit depends on the logic elements used in the construction. If one succeeds in building logic elements that operate at frequencies in the gigahertz range, the discriminator description is still valid, as is the double pulse elimination circuit.

My response to Pleasure's inquiry about the circuit employing square waves falls into the same pattern. The rise time of the square waves is determined by the characteristics of the flip-flops. For example, the DTμL 950 pulse-triggered binary, which was used experimentally, responds to the negative slope of the input voltage if the slope is 1 V/ns. The rise time is immaterial.

The general condition that is necessary for the other two systems, which I should have included in the article, is that the pulse width used has to be equal to or shorter than the response time of the flip-flops. The accuracy is plainly ±0%. Either the frequencies are equal or they are not. One can, however, define an "indication response time" as the time that elapses while the circuit changes from one state to the other. This time is equal to or shorter than:

$$T = 1/(f_1 - f_2),$$

where f_1 and f_2 are the input frequencies. If both frequencies are, for instance, 1 hertz apart and the discriminator initially indicates f_2 to be greater than f_1 when the opposite is true, it will take two seconds in the worst case for the output of the discriminator to give the right answer. The actual time depends on the initial starting point of the discrimination, so the smaller the difference in frequencies, the slower the change will occur. But if the duty cycle of the square wave that appears at the output remains constant, then the frequencies are equal, plus or minus 0.0 hertz or per cent.

Hermann Ebenhoech
Consumer Application Engineer
Fairchild Semiconductor Div.
Mountain View, Calif.

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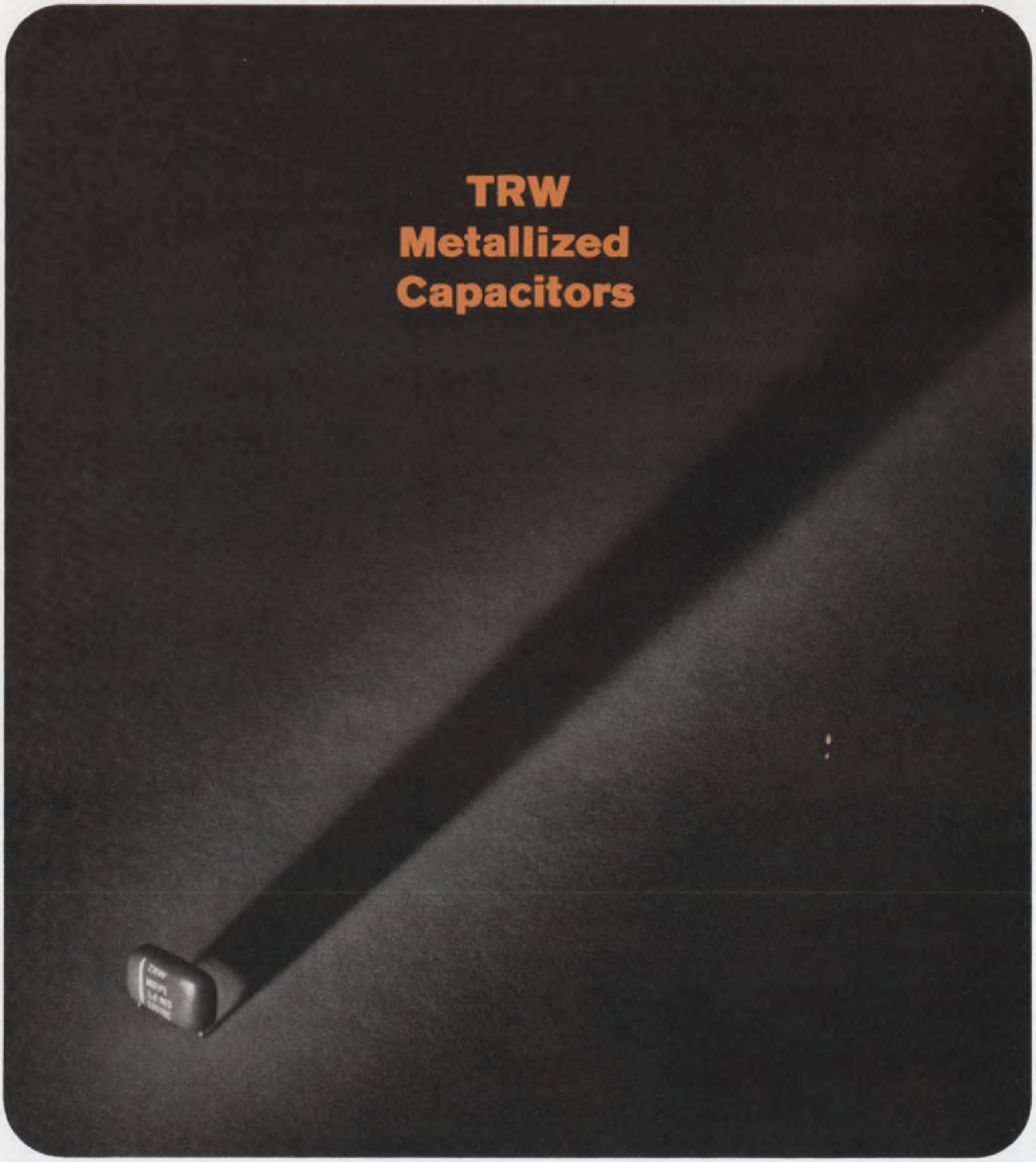
ON READER-SERVICE CARD CIRCLE 27



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EDITORIAL

Let's help the Post Office solve its problems

For years it has been a favorite pastime of politicians and the public to decry the many shortcomings of the U.S. Post Office Dept. Few such criticisms have ever suggested any realistic solutions. Now, at last, the POD, under the guidance of Postmaster General Lawrence F. O'Brien, has begun its own massive modernization program.

The most significant aspects of this program are the establishment of the Bureau for Research and Engineering in Washington, D. C., the creation of the Postal Institute of Technology (to be operational by the middle of next year) and general emphasis on a systems approach to postal problems.

The bureau is rapidly expanding its staff, so that it will include 965 specialists by 1972. Their main function will be to analyze, formulate and explain POD problems to industry. Their number will include experts in automatic control, operations research, data-handling, applied mathematics, communications and material-handling. They will form a technologically self-sufficient postal research organization, capable of holding a meaningful dialogue with private industry.

The Postal Institute of Technology will train post office personnel in every facet of postal technology and management, both on its future campus and at a number of extensions elsewhere in the U.S.

The Post Office research programs have been viewed favorably by Congress. The last R&D budget, one of the largest in POD history, sailed through without a single penny cut.

How can electronics engineers and companies help?

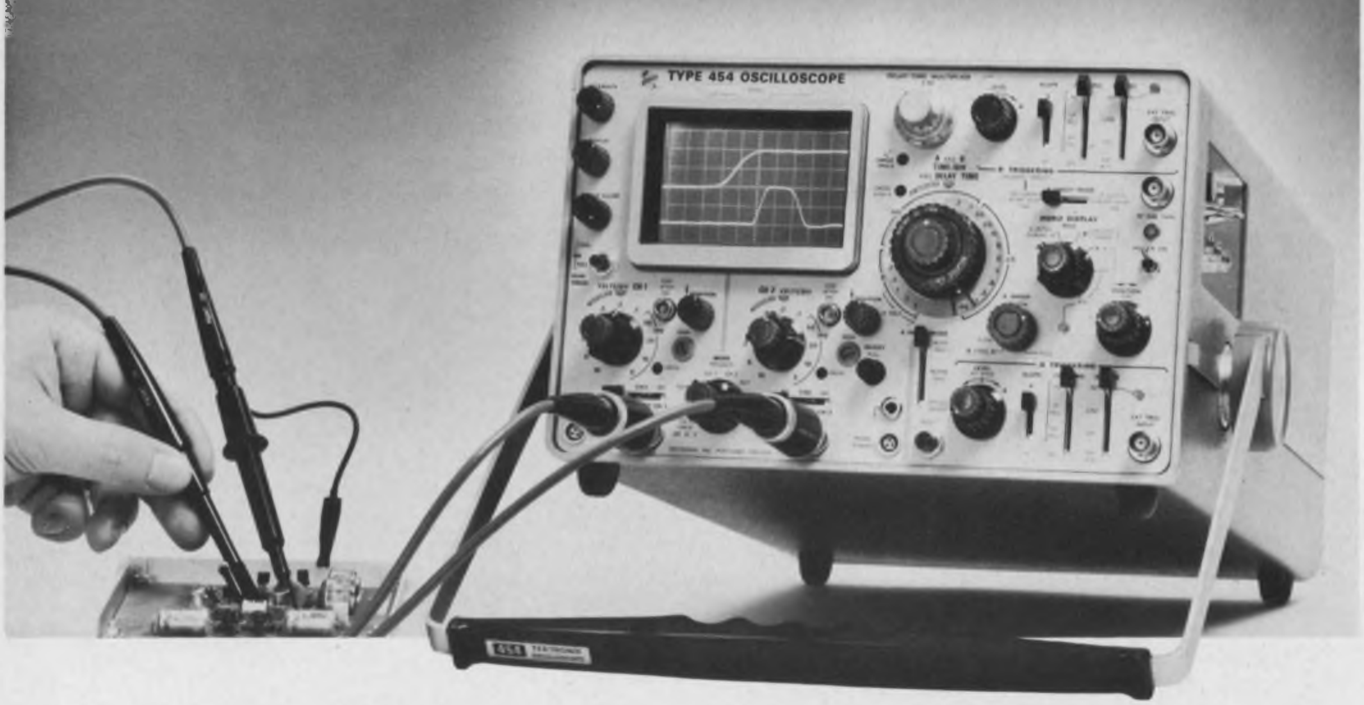
Firsthand knowledge of post office problems is a prime prerequisite. Dr. Leo S. Packer, director of the Bureau of Research and Engineering, is eager to give and receive every assistance in this direction. After obtaining the list of POD's needs from the bureau and comparing them with your company's product lines and capabilities, consider the possibility of submitting an unsolicited proposal to the POD.

The time for action is now. The POD is determined to modernize its operations, exploiting all the resources of today's technology. Let's stop crying about letters that take two weeks to arrive, and start working with the post office to make sure that the last increase in mailing rates will really be the last one.

PETER N. BUDZILOVICH

150 MHz, 2.4 ns

New performance from probe tip to CRT!



The Tektronix Type 454 is an advanced new portable oscilloscope with DC-to-150 MHz bandwidth and 2.4-ns risetime performance specified at the probe tip. The new P6047 10X Attenuator Probes and the optional FET and current probes are designed to solve your measurement problems.

The Type 454 has a dual-trace vertical, high-performance triggering, 5-ns/div delayed sweep and solid state design. You also can make 1 mV/div single-trace measurements and 5 mV/div X-Y measurements.

The dual-trace amplifiers provide the following capabilities with or without the P6047 probes:

Deflection Factor*	Risetime	Bandwidth
20 mV to 10 V/div	2.4 ns	DC to 150 MHz
10 mV/div	3.5 ns	DC to 100 MHz
5 mV/div	5.9 ns	DC to 60 MHz

*Front panel reading. With P6047 deflection factor is 10X panel reading.

The Type 454 can trigger to above 150 MHz internally, and provides 5 ns/div sweep speed in either normal or delayed sweep operation. The calibrated sweep range is from 50 ns/div to 5 s/div, extending to 5 ns/div with the X10 magnifier. Calibrated delay range is from 1 μs to 50 seconds.

For a demonstration, contact your nearby Tektronix field engineer, or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

Two P6047 Miniature 10X Attenuator Probes are included with the Type 454. They have a 10 MΩ input resistance and 10.3 pF input capacitance and provide DC-to-150 MHz bandwidth with 2.4-ns risetime performance when used with the Type 454.

The Optional P6045 FET Probe features unity gain with 10-MΩ input resistance and 4-pF input capacitance. With the Type 454 it provides a system risetime of 2.7 ns and a bandwidth of DC to 130 MHz from 20 mV/div to 10 V/div without signal attenuation. Probe power is obtained from a jack on the front panel of the Type 454.

The Optional P6020 Current Probe is easy to use with its clip-on feature and it provides up to 2.4-ns risetime and 150-MHz bandwidth when used with the Type 454.

Type 454/P6020 Characteristics (454 at 20 mV/div)

P6020	Deflection Factor	Risetime	Bandwidth
1 mA/mV	20 mA/div	3 ns	8.5 kHz to 120 MHz
10 mA/mV	200 mA/div	2.4 ns	935 Hz to 150 MHz

Type 454 (complete with 2-P6047 and accessories) $2600
Rackmount Type R454 (complete with 2-P6047 and accessories) . $2685
Type P6045 FET Probe (010-0204-00) . . . . $ 275
Type P6020 with Passive Termination (015-0066-00) . . . . $ 135
U. S. Sales Prices FOB Beaverton, Oregon

TEKTRONIX

Research and development

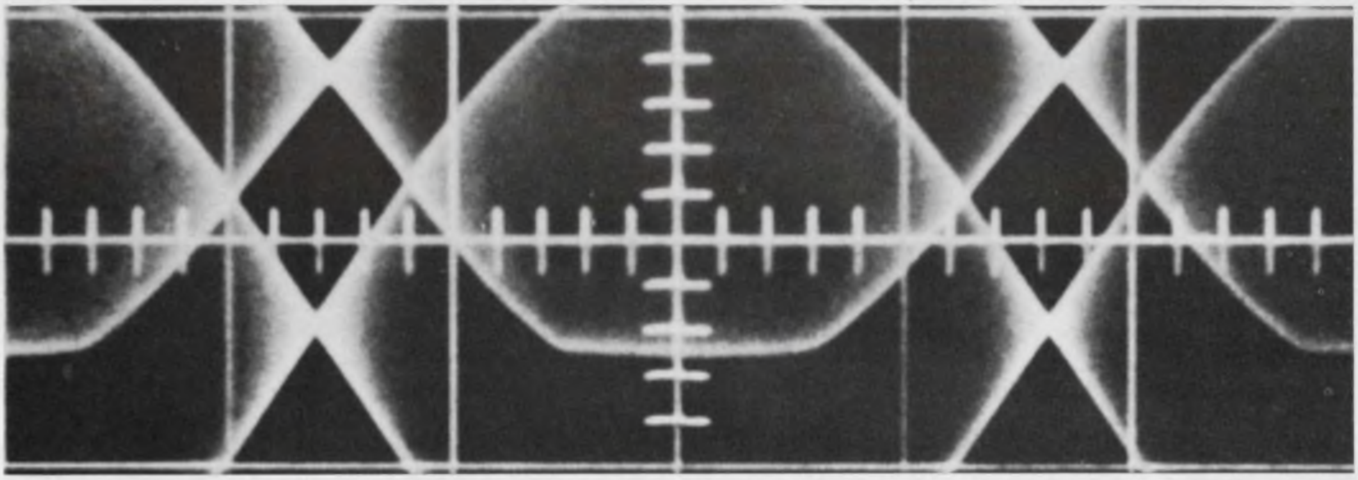
. . . part of the Tektronix commitment to progress in the measurement sciences

ON READER-SERVICE CARD CIRCLE 29

Technology

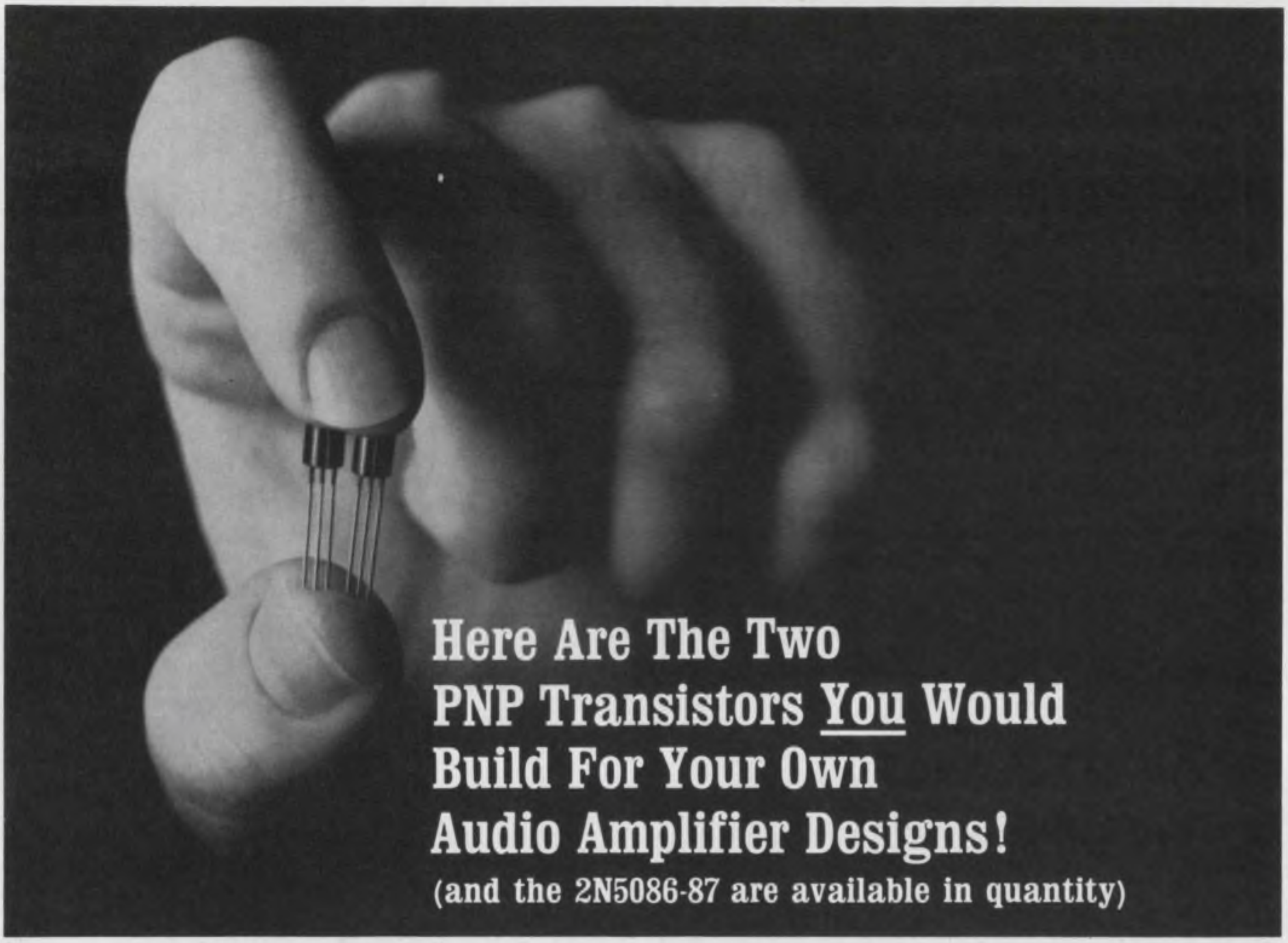
Courtesy of Cary Instruments, subsidiary of Varian Associates

The future direction of test instrumentation is keyed to integrated circuits and automation, but they are only part of the story. An analysis of trends in the reference insert on p. T6.



Distortion can be read in three ways that range from approximation to evaluation of all intermodulation products. The method used should be what best suits the system. Page 56

Also in this section:



Maybe you can't find transistors that have *all* the features you want for a design. But the new Motorola PNP 2N5086 and 2N5087 plastic packaged devices for audio amplifier applications come about as close as you can get to all-around versatility and performance perfection . . . just like *you* would build for yourself!

These devices offer such features as:

	2N5086	2N5087
High Voltage (BV_{CEO})	50 V (min)	50 V (min)
High, Stable Gain (h_{FE} @ $I_C = 100\ \mu A$)	150 (min)	250 (min)
Low Wideband Noise Figure ($I_C = 20\ \mu A$, $V_{CE} = 5$ Volts)	3 dB (max)	2 dB (max)
Low Current-Gain Bandwidth Product (f_T)	120 MHz (typ)	150 MHz (typ)
Prices (5,000-up)	\$0.35	\$0.38

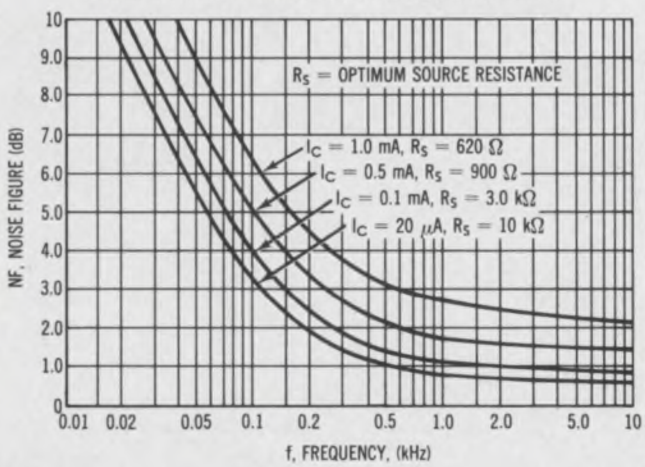
In addition, then, the 2N5086-87 transistors give you good gain linearity at low currents . . . excellent signal-to-noise ratio . . . good amplification of the wanted signal . . . extra flexibility in your choice of supply voltage . . . and less chance of parasitic oscillations – due to low f_T.

PLUS, you get additional benefits like low leakage current for good bias stability ($I_{CBO} = 10$ nA (max) at 10 V) . . . rugged TO-92 UNIBLOC* plastic package . . . and patented Annular device structure for extra stability and reliability.

AVAILABILITY UNLIMITED!. Production quantities of both devices are available, immediately. Contact your Motorola field representative or franchised Motorola distributor to fill your order – with no waiting. For detailed data, write Dept. TIC, Box 955, Phoenix, Arizona 85001.

*Trademark of Motorola Inc.

Excellent Noise Characteristics At Four Current Levels!



-where the priceless ingredient is care!

MOTOROLA Semiconductors

ON READER-SERVICE CARD CIRCLE 30

Electronic Design

Test Instrument Directory

1967 Test Instrument Reference Issue

Maria Dekany
Technical Editor

William Alvarez
Directory Editor

ELECTRONIC DESIGN's Test Instrument listing puts the whole spectrum of test equipment at the design engineer's fingertips.

The ten most widely used instrument groups are included in this Directory. In each group the devices are listed according to a key parameter. For example, digital voltmeters are listed by their maximum voltage ranges. In addition, at the end of each group you'll find a list of manufacturers with a cross index that helps locate instruments by their model number. For additional data, circle on the Reader Service card the number assigned to the manufacturer in the cross index. The card, located inside the back cover, is good for a whole year.

Data for this Test Instrument Directory were tabulated by Greg Guercio, president of Technical Information Corp., Smithtown, N. Y. The company publishes directories on electronic test instruments. A complete set of six volumes is available for $300.

Update Your Test Instrument File

...in two simple steps (at no charge)

Step 1

Discard obsolete data sheets and catalogs

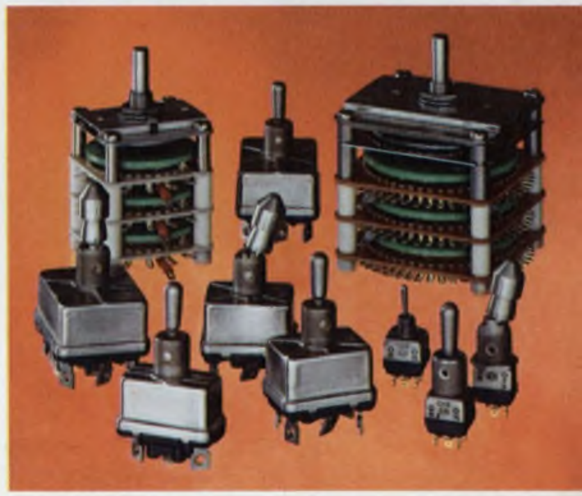
Step 2

Circle the appropriate numbers on the Reader Service card and receive the latest data sheets, notes on new measurement techniques and test procedures, price lists and catalogs from test instrument manufacturers.

Result

. . . a completely updated test instrument file.

Our military switches are sweeping the country!



A few of the thousands of military switches available from Cutler-Hammer: miniature, and standard-size positive-action toggle switches (MIL-S-8834), Shallcross rotary switches (MIL-S-3786).

Quick now, what's the first thing you think of when you think of Cutler-Hammer military switches?

We thought so: airborne equipment.

Not surprising. We created the first line of switches for airborne use back in the roaring 20's. Today, nearly everything that flies—from helicopters to space vehicles—uses Cutler-Hammer switches.

So what's new? Just that designers are discovering that these same switches work as well in ground support equipment, shipboard electronics, and ordnance as they do in the air.

That's because of the painstaking care we take in design and manufacture. The exhaustive in-process inspection. And our rigorous final testing.

The result? Unquestionable reliability, performance, and long life—under extreme environmental conditions.

On your next project—ground, marine, or airborne—specify Cutler-Hammer military switches. Call your local stocking distributor, or write for new catalog LL-291-K217.

Switch to No.1

More than just switches: prompt availability, field help, innovation, quality assurance too.

CONTROL

CUTLER-HAMMER

Milwaukee, Wisconsin 53201

What makes test instruments tick?

Automation and integrated circuits are the key concepts, but they don't solve all problems, as you'll find out here.

Test instrument designers are rallying to the aid of engineers who are being overwhelmed by floods of measured data. The test instruments of the future will help them to collect meaningful data in the simplest fashion and to extract as much information from the data as possible.

The key concept is electronic data-processing. Instruments will be designed to fit in with computers, to provide data in a form suitable for in-line processing, and to operate under software program. In short, equipment will be automated and programmable.

Increased complexity, however, must not bring increased costs; the changes have to be made at reasonable expense. This aim is well served by the growing interchangeability between analog and digital techniques, which affords an opportunity to take advantage of inexpensive digital integrated circuits.

These trends are leading toward a completely new class of test instrument—one that is wholly under software control.

These advances will not be unaccompanied by problems and are bound to affect the technical thinking and approach of both instrument design engineers and users. As the engineer begins to control the system from a keyboard or some other simple, conversational input, large parts of earlier experimental circuit synthesis and component-optimizing work are likely to be reduced to a few rapid measurements or calculations based purely on his instructions.

Where do linear ICs fit in?

All these development hinge on adroit use of various integrated circuits—monolithic, hybrid, thick- and thin-film types.

Integrated circuits first found a home in digital instruments, primarily because digital ICs are much simpler, cheaper, more versatile and more readily available than linear units. Nowadays, however, some instrument manufacturers are developing digital and linear ICs for specific instruments, to improve and expand on those instruments' processing abilities.

An exclusive interview with Robert Brunner, Corporate Engineering Manager, Hewlett-Packard, Palo Alto, Calif., edited by **Maria Dekany**, Technical Editor.

Even in the most typically digital of instruments, DVMs and counters, a considerable amount of signal-conditioning must be performed with linear circuits. This is especially notable in the plug-in models, which are the most popular types.

At present, linear circuits are hard to devise as direct replacements for established solid-state circuits. Even though tremendous progress is reported with linear ICs,[1] they are still costlier and less versatile than digital types or their discrete counterparts.

The design of the Hewlett-Packard loudness analyzer[2] illustrates the point. It contains 20 third-order filters, which use a total of 60 operational amplifiers. In these circuits, some cost or performance shortcoming precluded the use of integrated operational amplifiers.

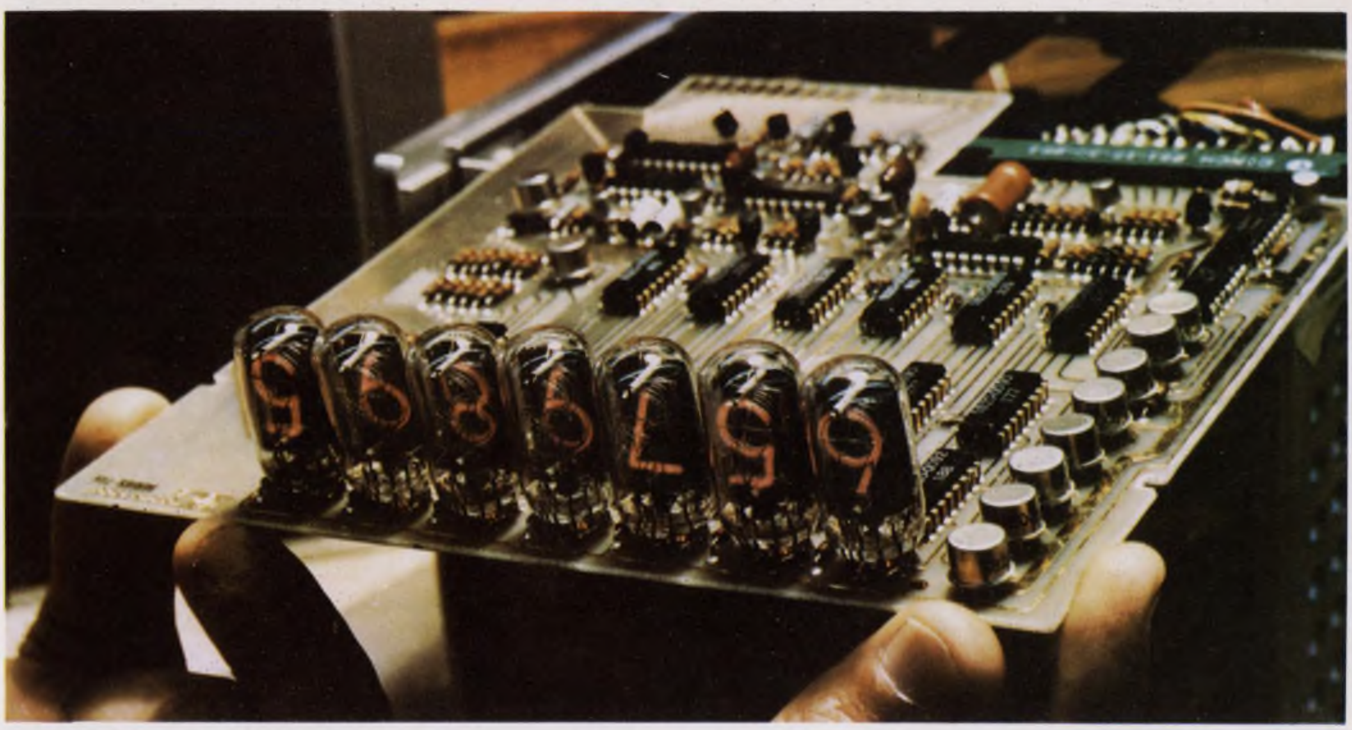
This situation may change in the future. The present difficulty may be somewhat lessened, but not overcome altogether, by use of hybrid circuits. Since the number of units needed for signal-conditioning is typically rather small, a special integrated or hybrid circuit must yield a significant improvement in performance over a discrete circuit to justify its development cost.

Finally, thick- and thin-film hybrids may also find a place in test instruments that use only a few digital circuits, such as oscilloscopes, spectrum analyzers, and sweep generators. The payoff will not be in cost, but in the improvement of some vital parameter—for example high-frequency capability due to the smaller size of the circuit.

It is safe to predict, then, that the emergence of instruments with many integrated circuits will be rapid where the instrument is primarily digital, somewhat slower where it is analog.

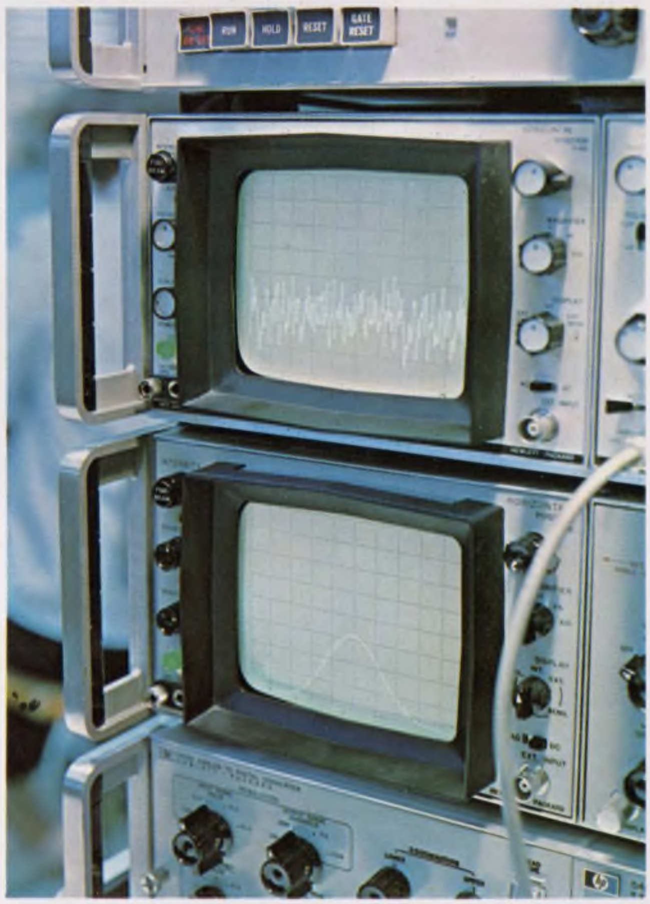
The trend toward instruments that are simpler on the outside, even if not on the inside, is enhanced by ICs but is only marginally related to them. This simplicity is required because man prefers it and the computer virtually demands it.

Another aspect of this question of simplicity is the form of the measured data. Why should an engineer have to read volts and then translate them into appropriate physical units such as pounds, inches, or degrees of temperature? Certainly, modern instruments should be expected to read out in appropriate units, to simplify their use as separate instruments or as



See a frequency counter on a card; add the case and the power supply and the counter is ready to operate up to 12.5 MHz, according to Hewlett-Packard. It uses integrated-circuit counter decades, buffers and nixie drivers.

Subject loudness is plotted on the scope face while the meter shows the absolute loudness. Hewlett-Packard's loudness analyzer selects the proper spectrum with comb filters and performs complex analog signal processing to arrive at these data, which formerly had to be calculated manually. But there are no linear integrated circuits in the filter system.



Noise signals are replacing impulse trains in many tests. A typical noise signal from the Gaussian output of Hewlett-Packard's pseudo-random noise generator is shown on the general-purpose oscilloscope (top trace). A multichannel analyzer monitors the noise pattern and plots its probability density function, which verifies the Gaussian nature of the noise (bottom trace).

part of a system. That this may take additional internal circuitry is not germane to the instrument's external simplicity, so long as the circuitry requires no special controls or other inputs. Here, too, ICs can make these features economically feasible.

How large a part should computers have?

It has already been stated that the key concept is electronic data-processing. The big debate is how much of it should be done on a general-purpose computer and how much should be built into the instrument.

There are many instances of complex computation where the temptation is to take the output data as they emerge from the measuring device and either process them with an on-line computer or record them for later off-line processing. In some cases the computational process can best be done right inside the measuring instrument. There is no clear choice but the desire for near-instantaneous display of processed data would shift the balance in favor of self-sufficient instruments.

To those who believe that the digital computer may inherit the earth, the most useful instrument is a programmable, high-speed, high-accuracy, high resolution A/D converter with a large choice of signal-conditioning front ends. This would allow a tremendous range of measurements, all of which would be represented by raw digital data requiring processing by a computer. Unfortunately, the accuracy, convenience and range of the measurements would still be limited by the capability of the analog input stages.

At the other end of the scale are self-sufficient instruments that comprise measuring circuits, computational facilities and display systems.

Hewlett-Packard's loudness analyzer, for example, has a cathode-ray tube and a meter display which provides the desired information on loudness in several forms, each of which previously required tedious data-manipulating and -graphing processes. The instrument is designed as a purely analog, discrete-component machine that processes the measured data into meaningful display and output. The analog approximation circuits are adequate and their processing time constants are compatible with subjective response to noise transients as well as repetitive sounds. The information display is in real time.

New instrumentation techniques

How does one predict new instrumentation techniques? The simplest way is to examine the evolution of the methods in use today. It was, for instance, the voltage tunability of backward-wave oscillators that made swept-frequency testing at microwave frequencies popular. Very high-frequency sampling scopes and related fast pulse techniques led to time-domain reflectometry. Sampling capability from dc through X band enabled convenient phase and amplitude measurements to be made at microwave frequencies. Such precedents suggest that the development of a new instrument or an improvement in the versatility of an existing one may give rise to a new class of testing methods.

Test engineers have long been interested in an instrument that allows them to switch conveniently from the time domain to the frequency domain and back. The exploding popularity of spectrum analyzers since the introduction of models with measuring convenience and calibration accuracy, which complements the time-domain oscilloscope, is a clear indication of this. While the ability to view signals and make measurements in either domain does not exactly represent a true transform capability, the popularity of the devices suggest that further development on spectrum analyzers is warranted.

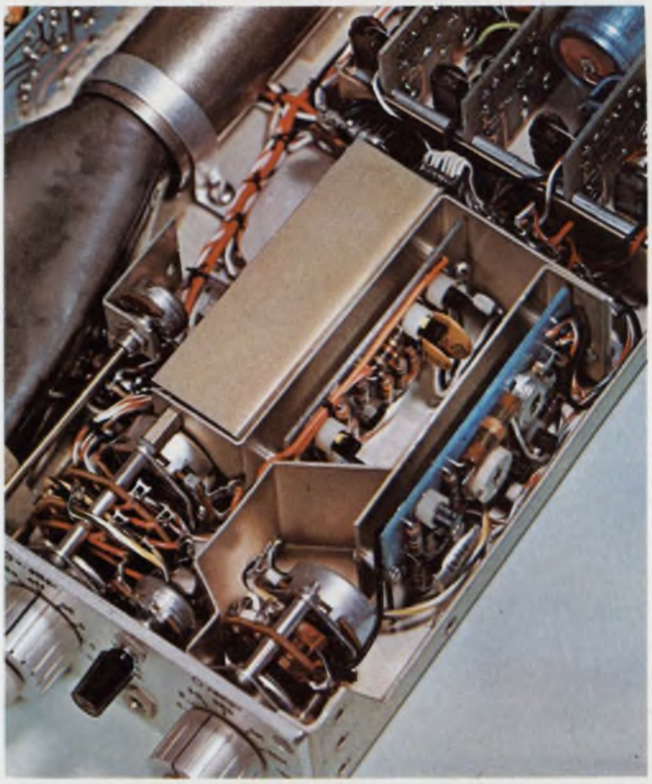
Other signs of interest in true transform ability include the preparation of computer programs that provide the Fourier transform of time-varying data. These programs are generally not fast enough yet for real on-line touch and read capability using an A/D converter, general-purpose computer and display. But several hard-wired special-purpose machines that provide essentially real-time transforms have been built.

Pseudo-random noise as test signal

New instrument capabilities lead to new testing techniques. From a mathematical viewpoint, noise has been recognized for some time as a good test signal. Its obvious application was for low-frequency systems, where such signal techniques as frequency response, square wave, and impulse testing fall short for one reason or another. The evolution of techniques to put it to use depended on the development of a noise source that not only had spectral and amplitude statistics typical of noise but was also controlled and repetitive, so that the ramdom nature of noise could be eliminated.

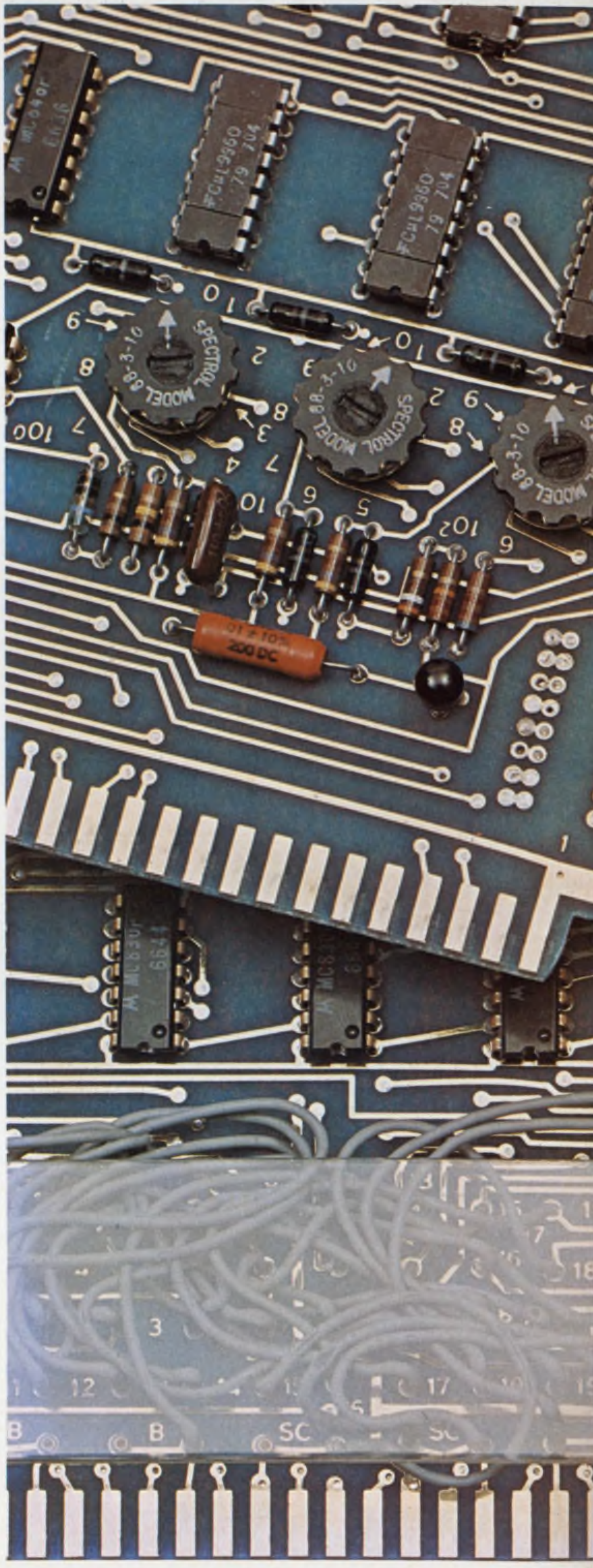
The pseudo-random noise generator provides a signal with just these qualities. Based on digital techniques, it has a clock-driven logic system that ensures an absolutely repetitive binary pattern. Pattern length and clock rate are adjustable over wide ranges but the spectral power density of the output is absolutely defined. In addition to the binary pattern output, there is further internal digital processing and conversion to analog. This produces an output with a Gaussian probability density function. The process also adjusts the power density spectrum to be very nearly rectangular. Absolute control, statistics, and repeatability of the analog pattern are retained.

For low frequencies, an impulse train is often suggested as a test signal, because its broad flat spectrum exercises the item under test over a wide



Digital ICs in a dual NAND-NOR gate configuration replace operational amplifiers in oscilloscopes of Measurement Control Devices, Inc. (on blue card).

What's in the box? A portable test instrument, that can function as a digital voltmeter, a digital time, frequency or period counter, or as an ac converter. The modular construction permits this flexibility, as Thomas Laugesen points out to Art Hoyt, both from Electronic Associates, Inc.



Printed-circuit cards help combine versatile systems with off-the-shelf output devices. The upper card has miniature switches to provide preset work-counting and the lower unit has miniature patch board for format flexibility.

frequency range all at once. Moreover, the impulse response contains complete information about the system, so long as it is not driven out of its linear range by the impulse. The technique's main limitation is its inability to put much broadband energy into the system, because it has to use a low-duty-cycle impulse train. It must not be of an amplitude great enough to drive the system beyond its linear range. Providing greater sensitivity in the system-measuring instrument is generally ruled out by inherent system noise.

As a test signal, noise has distinct advantages over an impulse. Its only real limitations are the need to control its randomness and the difficulty of generating a known flat spectrum down to essentially dc.

Pseudo-random noise specifically overcomes these problems. Because its autocorrelation function approximates an impulse, the system output can be cross-correlated with the input signal to yield the desired system impulse response. Noise inherent in the system is suppressed in the measurement result because it is not correlated with the input noise. The continuous-wave nature of the noise enables the system to be driven with appreciable energy evenly distributed throughout the spectrum of interest without danger of driving it out of its linear range.

It is arguable that this is not true noise because it repeats, but if the sequences last a bit longer than the period of interest for a given measurement, then the fact that they repeat later is of no consequence. After all, consider the analogy between pseudo-random noise and an impulse train. The length of the noise sequence controls the density of lines in the frequency spectrum just as does the impulse repetition rate. The band width of the spectrum is controlled by the random-noise clock rate while the bandwidth for an impulse is dependent on the impulse width.

Once the response to an impulse input is known, the engineer can anticipate the system's responses to other stimuli in either the time or the frequency domain. This makes cross-correlated noise measurement particularly appealing. It has been implemented by recording both the input and output noise, and then digitizing and performing the cross-correlation in a general-purpose computer on an off-line basis. Several hard-wired instruments have also been built. The existence of the pseudo-random noise generator will ultimately simplify building either a correlation instrument or arranging a computer system for the purpose.

Computer-controlled design is wave of the future

The use of programmable signal sources for stimulus, and programmable instruments for measuring the response of a circuit or device under test, is best illustrated by military systems, such as GPATS (General-Purpose Automatic Test System), which routinely test a wide variety of airborne electronic systems. But such systems will only become suitable for R&D if the ability to change parameters, modify test conditions, and vary computational procedures to suit a wide variety of problems can be built into them.

The shape of the future for designers is typified by an experimental system in one of Hewlett-Packard's engineering laboratories. It is an instrument system, controlled by a small computer, which greatly shortens design time on complex devices.

The system contains several elements. A network analyzer is connected through precision rf hardware to a mounting fixture, to which many different devices may readily be connected in several configurations. These devices may be passive or active, simple or complex—usually they are high-frequency transistors.

The interconnecting hardware is calibrated at many frequencies. Errors have been determined and recorded in vector form in the computer's memory. Dc sources and sweep oscillators are programed, so swept measurement may be commanded by the computer under many different conditions of bias and at many dynamic levels. Only information corrected according to the stored errors is retained for calculation, so the system combines the accuracy of tedious, point-by-point, calibration-corrected measurements with the speed of swept measurements.

For a quick look, the engineer might, for example, ask to see an oscilloscope display of maximum available gain under optimum matching conditions over a range of interest, perhaps up above X bands. A series of closely-spaced dots quickly appear on an ordinary laboratory oscilloscope. He may then ask for a presentation of optimum matching conditions for maximum gain. This will be a vector display, giving both magnitude and phase angle for each frequency. He may command the system to derive a full set of *s* parameters on the device and to type them out. These may be stored, if desired, and the engineer may then have the computer convert them into *y*, *z*, or *h* parameters by a three-character command.[3]

Much equipment is still needed

The focus hitherto has been on trends rather than specific needs, successes, and problems. This is not to imply that all sensing, generating, measuring, memory, and readout techniques have been perfected.

There are still some specific requirements for which answers are just beginning to evolve or are still distant. More convenient and pleasing readout devices are needed, along with better visual recording media with improvements in speed, cost, and quality. There is great need for good voltage-tunable solid-state microwave signal sources that operate at

Random notes from elsewhere

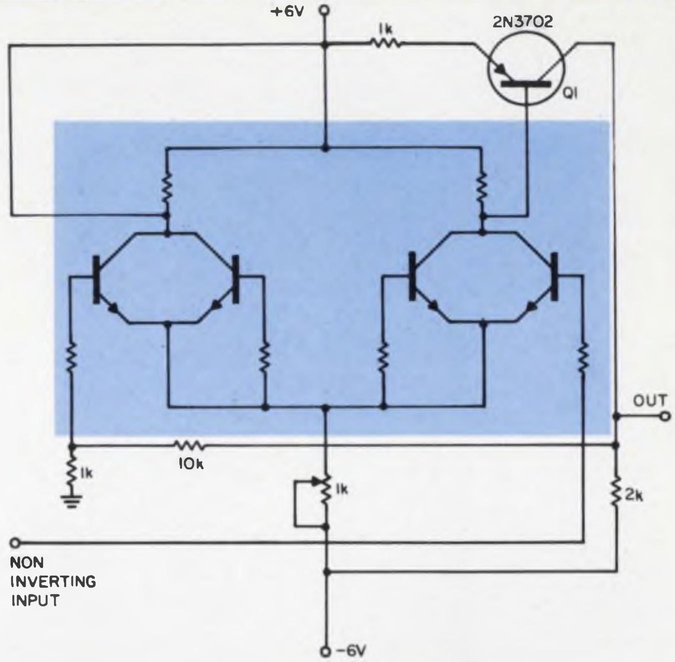
It is all but impossible to examine every new advance in instrumentation and measurement techniques. So a couple of examples, which appeared to represent a trend, a school of thought, were selected:

- The application of digital integrated circuits in place of linear ones. (For a special report on this theme, see "Digital chips shift into analog territory," ED 18, Sept. 1, 1967, pp. 41-64.
- The sophisticated use of random events.

The uphill battle facing linear integrated circuits is illustrated by the experience of Measurement Control Devices, Inc. The company needed operational amplifiers in the vertical channel of one of its oscilloscopes. But, says president Nathan Bylock, digital integrated circuits proved to be a better solution. A dual RTL 914-type NAND-NOR gate was connected as a dual transistor, to achieve the symmetry of a multiple device on a single chip. The dual transistor was then connected as a differential amplifier, fed by the −6-volt source through a resistor (see circuit diagram). The output is inverted by *Q*1, which is a gain-of-two amplifier. The total cost was 94 cents—12 per cent of the cost of a discrete-component approach. The integrated circuits occupy less space—11 per cent of what the discrete versions would take—and have improved thermal stability.

Integrated operational amplifiers were considered and discarded, says Bylock. They cost twice as much as their discrete counterparts and offered no better performance than the digital gated approach.

As Bob Brunner pointed out previously, random noise is becoming an accepted test signal, because practical instruments are now available at reasonable costs. The same is true of random sampling, according to a Tektronix project engineer, Al Zimmerman.



A 914-type dual RTL NAND-NOR gate is connected as a dual transistor on a single chip. The other components make the chip perform as an operational amplifier.

Random sampling needs no pretrigger

The principles of random sampling have been known for years, but only recently have the proper instruments become available.

The random sampler displays a repetitive waveform much as a conventional sampling oscilloscope does, but with one difference: no delay line or pretrigger is required for lead time in the display. This confers a host of benefits:

- The inherent distortions and rise-time limitation of bulky signal delay lines are eliminated.
- It is no longer necessary to work into the 50-characteristic impedance of a delay line.
- Direct sampling probes may be used for convenient high-impedance, in-circuit signal pickup.
- Triggers may occur prior to, coincident with, or even after the displayed signal without sacrificing lead time in the display.
- Display jitter caused by pretrigger-to-signal jitter or by signal-period uncertainty is eliminated.
- Signals with no convenient source of pretrigger can be observed.

low voltages and over ever-increasing bandwidths.

Although remarkably high accuracy has been achieved in dc voltage generation and measurement, there is room in ac measurement for considerable improvement—about an order of magnitude.

The advantages of converting physical quantities into digital signals that are more immune to noise and capable of a higher degree of resolution than transducers of the analog type are evident. For this, a higher impedance probing capability is necessary at higher frequencies and, if this capability requires an active circuit, it will be equally important for the need for wide dynamic range to be satisfied.

Finally, one area that demands considerable attention is that of interface standards. There should be some assurance that instruments, computers, and peripherals can be conveniently programed and interrogated and that the data involved can be passed between elements of a system with some uniformity of codes, impedance levels, and polarity. Not nearly as much has been done in this regard as might be deduced from the present proliferation of systems-oriented instrumentation. ■ ■

References:

1. R.K. Field, "The Tiny Exploding World of Linear Microcircuits", Electronic Design XV, No. 15 (July 19, 1967), 49-72.

2. "Loudness Analyzer Imitates the Ear's Response", Electronic Design , XV, No. 12, (June 7, 1967), 36.

3. John A. Young, "With New Measurement Methods, the Future Is Almost Here", *The Microwave Journal*, X, No.6 (May, 1967).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IGITAL MULTIMETER MODEL 7000

Multitesters

					VOLTAGE RANGES				CURRENT RANGES				RESISTANCE RANGES					
	Manufacturer	Model		Sensitivity kΩ/V	Min. V	Max. kV	No.	Acc. %	Min. mA	Max. A	No.	Acc. %	Min. kΩ	Max. MΩ	No.	Meter Calib. in: VΩA	Type C-Cab. P-Port. R-Rack	Price Approx $
M 1	Hartmann	Elavi J	dc	0.1	60	0.6	3	2.5	none	none	none	none	none	none	none	VA	P	ina
			ac	0.1	60	0.6	3	2.5	1500	30	3	2.5				(d)		
	Avo Ltd	PA	dc	0.1	1.5	1.5	9	0.3	1.5	15	9	0.5	none	none	none	VA	C	555
			ac	0.1	3	1.5	8	0.75	3	15	8	0.75				(ie)		
	Hartmann	Multavi 2	dc	0.333	6	0.6	5	ina	3	6	6	ina	none	none	none	VA	P	68
			ac	0.333	6	0.6	5	ina	3	6	6	ina				(de)		
	Hartmann	Multavi S	dc	0.333	0.06	0.6	6	ina	ina	ina	ina	ina	none	none	none	VΩ	P	90
			ac	0.333	6	0.6	5	ina	1.2	150	12	ina				(de)		
	Hartmann	Elavi 1	dc	0.333	0.06	0.6	6	2.5	3	30	5	2.5	ina	0.01	ina	VΩ A	P	ina
			ac	0.333	6	0.6	5	2.5	300	30	4	2.5				(d)		
	Hartmann	Elavi 11	dc	0.333	0.06	0.6	6	2.5	3	30	5	2.5	ina	0.05	ina	VΩ A	P	ina
			ac	0.333	6	0.6	5	2.5	300	30	4	2.5				(d)		
M 2	Hartmann	Elavi 12	dc	0.333	0.6	0.6	6	2.5	3	30	5	2.5	0.05	0.005	2	VΩ A	P	ina
			ac	0.333	6	0.6	5	2.5	300	30	4	2.5						
	Avo Ltd	40	dc	0.333	0.06	1.2	12	1	6	12	8	1	1	1	4	VΩ A	P	99
			ac	0.333	6	1.2	8	2.25	6	12	8	2.25				(de)		
	Barnett	431-AN	dc	1	15	3	6	ina	1.5	7.5	3	ina	10	1	3	VΩ A	P	25
			ac	1	15	3	6	ina	none	none	none	none						
	Triplett	666-R	dc	1	10	5	5	3	10	1	3	3	3	3	3	VΩ A	P	42
			ac	1	10	5	5	4	none	none	none	none				(d)		
	Simpson	240-4	dc	1	15	3	5	3	15	0.75	3	3	3	0.3	2	VΩ A	P	40
			ac	1	15	3	4	5	none	none	none	none				(d)		
	Simpson	230-2	dc	1	10	1	4	3	10	0.25	3	3	1	0.1	2	VΩ A	P	40
			ac	0.4	10	1	3	5	none	none	none	none				(d)		
M 3	Assoc-RE	205	dc	1	150	1.5	3	2	none	none	none	none	20	200	2	ina	C	195
			ac	1	150	0.75	3	2.5	none	none	none	none				(df)		
	Assoc-RE	210	dc	1	150	0.75	3	2	none	none	none	none	2	200	2	ina	C	175
			ac	1	150	0.75	3	2.5	none	none	none	none				(df)		
	Assoc-RE	208	dc	1	150	0.6	3	2	none	none	none	none	2	200	3	VΩ	C	190
			ac	1	150	0.6	3	2.5	none	none	none	none				(df)		
	Assoc-RE	201	dc	1	150	0.6	3	2	none	none	none	none	2	200	2	VΩ	C	148
			ac	1	150	0.6	3	2.5	none	none	none	none				(df)		
	Assoc-RE	204	dc	1	150	0.6	3	2	none	none	none	none	2	200	2	VΩ	C	185
			ac	1	150	0.6	3	2.5	none	none	none	none				(df)		
	Inst-Lab	102	dc	1	0.05	0.5	8	2	1	25	6	2	0.01	1	2	VΩ A	C, R	195
			ac	1	5	0.5	5	3	1	25	4	3				(d)		
M 4	Assoc-RE	233	dc	1	30	0.3	3	2	none	none	none	none	2	200	2	VΩ	C	192
			ac	1	150	0.6	3	2.5	none	none	none	none				(df)		
	Hartmann	Multavi B	dc	1	6	0.6	4	1	15	15	6	1	10	1	2	VΩ A	P	235
			ac	1	1.5	0.6	5	1.5	15	6	5	1.5				(de)		
	Avo Ltd	7	dc	1	0.05	1	12	1	1	10	10	1	10	40	5	VΩ A	P	99
			ac	1	5	1	8	2.25	5	10	8	2.25				(dehij)		
	Hartmann	Multavi 5	dc	3.333	0.06	0.6	8	ina	0.3	6	9	ina	0.01	60	ina	ina	P	80
			ac	0.666	0.3	0.6	7	ina	1.5	6	8	ina				(d)		
	Hartmann	Multavi 5L	dc	3.333	0.006	0.6	8	ina	0.3	6	9	ina	0.01	60	ina	ina	P	108
			ac	0.666	0.3	0.6	7	ina	1.5	6	8	ina				(d)		
	Hartmann	Multavi P	dc	3.333	0.006	0.6	8	ina	0.3	6	9	ina	0.01	60	ina	ina	P	82
			ac	0.666	0.3	0.6	7	ina	1.5	6	8	ina				(d)		
M 5	Hartmann	Elavi 2	dc	3.333	0.15	0.6	7	2.5	0.3	1.5	6	2.5	1	0.1	2	ina	P	ina
			ac	3.333	6	0.6	5	2.5	0.3	1.5	6	2.5						
	Physics	226211p	dc	3.333	0.012	1.2	10	1	0.3	30	9	1	0.0001	10	4	VΩ A	P	113
			ac	3.333	0.012	1.2	10	1.5	0.3	30	9	1.5				(d)		
	Simpson	355	dc	10	3	1.2	5	3	none	none	none	none	0.12	10	4	VΩ	P	47
			ac	10	3	1.2	5	5	none	none	none	none				(df)		
	Avo Ltd	MM4	dc	10	2.5	1	6	2.25	0.1	1	5	2.25	20	2	2	ina	P	35
			ac	1	10	1	5	2.75	none	none	none	none				(d)		
	Heath	MM-1	dc	20	1.5	5	7	ina	0.15	15	5	ina	2	20	3	VΩ A	P	30
			ac	5	1.5	5	7	ina	none	none	none	none				(dk)		(kit)
	E-Measur	109A	dc	20	6	3	5	ina	6	0.6	3	ina	20	20	3	VΩ A	P	28
			ac	10	12	3	5	ina	30	3	3	ina				(h)		

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Multitesters *(continued)*

					VOLTAGE RANGES				CURRENT RANGES				RESISTANCE RANGES					
	Manufacturer	Model		Sensitivity kΩ/V	Min. V	Max. kV	No.	Acc. %	Min. mA	Max. A	No.	Acc. %	Min. kΩ	Max. MΩ	No.	Meter Calib. in.: VΩ A	Type C-Cab. P-Port. R-Rack	Price Approx $
	RCA	WV-38A	dc	20	2.5	5	6	3	0.05	10	6	3	2	20	3	VΩ A	P	50
			ac	5	2.5	5	6	5	none	none	none	N/A				(d)		
	Simpson	262-2	dc	20	1.6	4	7	3	0.08	16	7	3	0.5	50	6	VΩ A	P	75
			ac	5	3	0.8	5	5	none	none	none	N/A				(dk)		
M	Internat	VOM-22	dc	20	5	1.5	5	3	0.5	0.5	4	3	2	2	4	VΩ A	P	40
6			ac	15.5	15	1.5	5	5	none	none	none	N/A				(d)		
	Simpson	268	dc	20	3	1.2	6	3	0.06	12	5	3	2	20	3	VΩ A	P	65
			ac	5	3	1.2	6	5	none	none	none	N/A				(dk)		
	Triplett	631	dc	20	3	1.2	5	3	0.06	12	6	3	1.5	150	4	VΩ A	P	78
			ac	5	3	1.2	5	4	none	none	none	N/A				(dk)		
	Triplett	310	dc	20	3	1.2	5	3	0.6	0.6	4	3	20	20	4	VΩ A	P	42
			ac	5	3	1.2	5	5	none	none	none	N/A				(d)		
	Hickok	455A	dc	20	3	1.2	6	3	0.05	10	6	3	5	100	4	VΩ A	P	90
			ac	20	3	1.2	6	5	none	none	none	N/A				(d)		
	Simpson	160	dc	20	2.5	1	8	3	0.05	0.5	5	3	3	30	5	VΩ A	P	ina
			ac	5	2.5	1	5	4	none	none	none	N/A				(k)		
M	Triplett	310-C	dc	20	3	0.6	5	3	0.6	0.6	4	3	20	20	4	VΩ A	P	53
7			ac	15	3	0.6	5	5	none	none	none	N/A				(d)		
	Connolly	651	dc	20	2.5	1	6	2.25	0.05	1	5	2.25	2	20	3	VΩ A	P	40
			ac	2	2.5	1	6	2.75	none	none	none	N/A				(dfh)		
	Triplett	630	dc	20	3	6	6	2	0.06	12	5	2	1	100	4	VΩ A	P	58
			ac	5	3	6	6	3	none	none	none	N/A				(dk)		
	Triplett	630-PLK	dc	20	2.5	5	6	2	0.1	10	5	3	1	100	4	VΩ A	P	89
		(c)	ac	5	3	5	6	3	none	none	none	N/A				(dk)		
	Triplett	630-PL	dc	20	2.5	5	6	2	0.1	10	5	3	1	100	4	VΩ A	P	58
			ac	5	3	5	6	3	none	none	none	N/A				(dk)		
	Simpson	260-5P	dc	20	0.25	5	7	2	0.05	10	6	2	2	20	3	VΩ A	P	88
			ac	5	2.5	5	6	3	none	none	none	N/A				(dk)		
M	Simpson	260-5	dc	20	0.25	5	7	2	0.05	10	6	2	2	20	3	VΩ A	P	58
8			ac	5	2.5	5	6	3	none	none	none	N/A				(dk)		
	Triplett	630-L	dc	20	0.25	5	7	2	0.1	10	5	2	1	100	4	VΩ A	P	60
			ac	5	3	5	6	3	none	none	none	N/A				(dek)		
	Weston	980Mk2	dc	20	1.6	4	7	2	0.08	8	6	2	1	10	5	VΩ A	P	57
			ac	1	1.6	1.6	6	3	none	none	none	N/A				(dfh)		
	Avo Ltd	9Mk2	dc	20	3	3	7	2	0.05	10	7	1	2	20	3	VΩ A	P	99
			ac	1	10	3	6	2.25	10	10	4	2.25				(de)		
	Avo Ltd	8Mk111	dc	20	2.5	2.5	8	2	0.05	10	7	1	0.0025	200	5	VΩ A	P	99
			ac	1	2.5	2.5	7	2.25	100	10	4	2.25				(deh)		
	Weston	779-8	dc	20/1	2.5	1	5	2	0.1	10	7	2	3	30	4	VΩ A	P	207
			ac	1	2.5	1	5	3	none	none	none	N/A				(dfh)		
M	Simpson	250	dc	20	0.05	1	8	2	0.05	10	6	2	2	20	3	VΩ A	P	63
9			ac	5	2.5	1	6	3	none	none	none	N/A				(dk)		
	Simpson	255/0531	dc	20	0.05	1	8	2	0.05	0.5	5	2	2	20	3	VΩ A	P	90
			ac	5	2.5	1	5	3	5000	250	4	ina				(dk)		30
	Simpson	263	dc	20/10	0.15	6	18	1.5	0.075	15	12	1.5	0.5	50	6	VΩ A	P	88
			ac	10/5	2.5	1.5	10	3	none	none	none	N/A				(dk)		
	Triplett	800	dc	20	0.12	6	14	1.5	0.06	12	12	1.5	1	100	6	VΩ A	P	105
			ac	10	1.5	6	12	3	none	none	none	N/A				(dek)		
	Triplett	630-APL	dc	20	2.5	5	6	1.5	0.1	10	5	1.5	1	100	4	VΩ A	P	68
			ac	5	3	5	6	3	none	none	none	N/A				(dek)		
	Simpson	261	dc	20	0.25	5	7	1.5	0.05	10	6	1.5	0.002	20	3	VΩ A	P	68
			ac	5	2.5	5	6	3	none	none	none	N/A				(defh)		
M	Triplett	630-APLK	dc	20	0.25	5	7	1.5	0.1	10	ina	1.5	1	100	4	VΩ A	P	100
10		(c)	ac	5	3	5	6	3	none	none	none	N/A				(dek)		
	Triplett	630-A	dc	20	3	6	6	1.5	0.06	12	5	1.5	1	100	4	VΩ A	P	68
			ac	5	3	6	6	3	none	none	none	N/A				(dek)		
	Simpson	270-3	dc	20	0.25	5	7	1.25	0.05	10	6	1.25	2	20	3	VΩ A	P	70
			ac	5	0.5	5	6	2	none	none	none	N/A				(dek)		
	Connolly	50	dc	20	0.25	2.5	8	1	50	10	8	1	2	20	3	VΩ A	P	80
			ac	2	2.5	2.5	7	2.25	25	10	6	2.25				(df)		

(tables continued on page T16)

Multitester index starts on page T19.
Reader-service cards are good all year.
Reader-service numbers are given in the index.

Multitesters *(continued)*

					VOLTAGE RANGES				CURRENT RANGES				RESISTANCE RANGES					
	Manufacturer	Model		Sensitivity kΩ/V	Min. V	Max. kV	No.	Acc. %	Min. mA	Max. A	No.	Acc. %	Min. kΩ	Max. MΩ	No.	Meter Calib. in: VΩ A	Type C-Cab. P-Port. R-Rack	Price Approx $
	Hartmann	Elavi 3	dc	25	0.1	5	10	1.5	0.1	5	8	1.5	0.001	50	4	VΩ A	P	ina
			ac	2	0.5	5	9	1.5	0.5	5	7	1.5						
	Physics	226213p	dc	25	0.1	5	10	1	0.1	5	8	1	0.001	50	4	VΩ A	P	113
			ac	2	0.5	5	9	1.5	0.5	5	7	1.5				(dehi)		
M 11	Hartmann	Elavi HO	dc	33	0.3	0.6	7	2.5	0.03	0.6	7	2.5	10	10	3	VΩ A	P	ina
			ac	10	6	0.6	5	2.5	0.3	6	7	2.5						
	Hartmann	Multavi HO	dc	33	0.3	0.6	7	ina	0.03	0.6	7	ina	10	10	3	VΩ A	P	105
			ac	10	0.3	0.6	5	ina	0.3	6	7	ina				(de)		
	Hartmann	Elavi 4	dc	100	0.1	5	9	1.5	0.01	1	8	1.5	0.001	500	5	VΩ A	P	ina
			ac	20	10	1	4	2.5	none	none	none	none				(i)		
	Physics	226214p	dc	100	0.1	5	9	1.5	0.01	1	8	1.5	0.001	500	5	VΩ A	P	113
			ac	20	0.1	5	4	2.5	none	none	none					(dehi)		
	Simpson	269-2	dc	100	1.6	4	8	2	0.016	8	7	2	2	200	6	VΩ A	P	90
			ac	5	3	0.8	6	3	none	none	none	none				(dk)		
	Yokogawa	L-22	dc	100	0.3	1.2	8	2	0.012	1.2	6	2	2	20	3	VΩ A	P	55
			ac	10	3	1.2	6	3	none	none	none	none				(de)		
M 12	Triplett	630-NS	dc	200	0.15	1.2	14	1.5	0.005	12	13	1.5	1	100	6	VΩ A	P	105
			ac	20	0.15	1.2	10	3	none	none	none	none				(defh)		
	Avo Ltd	H1 108	dc	1000	0.1	1	9	3	0.03	3	6	3	2	20	3	VΩ A	C	350
			ac	ina	0.1	1	9	4	0.03	3	6	4				(k)		
	Triplett	630-M	dc	1000	0.6	1.2	12	1.5	0.001	12	11	1.5	1	100	6	VΩ A	P	210
			ac	20	1.5	1.2	10	3	none	none	none	none				(de)		
	Millivac	MV-77B (b)	dc	1000	0.001	1	13	1	0.001	1	13	2	1000	5000	16	VΩ A (def)	C, R	395
	Avo Ltd	CT471A	dc	120M	0.012	1.2	11	2	0.012	1.2	11	2	0.012	120	8	VΩ A	C	825
			ac	10M	0.012	1.2	11	3	0.012	1.2	11	3				(de)		
	Heath	IM-25	dc	ina	0.15	1.5	9	ina	0.015	1.5	11	ina	0.01	1	7	VΩ A	P	80
			ac	ina	0.15	1.5	9	ina	0.015	1.5	11	ina				(dk)		(kit)
M 13	Triplett	600	dc	ina	0.4	1.6	10	3	none	none	none	none	1	100	6	VΩ	P	78
		(c)	ac	ina	4	0.8	7	3	none	none	none	none				(d)		
	RCA	WV-98C	dc	ina	0.01	1.5	8	3	none	none	none	none	0.0002	1000	7	VΩ	P	80
			ac	ina	0.1	1.5	7	3	none	none	none	none				(d)		
	RCA	WV-77E	dc	ina	0.02	1.2	7	3	none	none	none	none	0.0002	1000	7	VΩ	P	50
			ac	ina	0.1	1.2	7	5	none	none	none	none				(d)		
	AUL	TVOM 4	dc	ina	0.15	1.5	9	3	0.1	1.5	9	3	0.001	1	5	VΩ A	P	ina
		(c)	ac	ina	1.5	1.5	7	5	none	none	none					(dh)		
	AUL	TVM 4	dc	ina	0.15	1.5	9	3	0.15	1.5	9	3	0.001	1	5	VΩ A	P	ina
			ac	ina	1.5	1.5	7	5	none	none	none	none				(dh)		
	Edwin	CT471	dc	ina	0.012	1.2	12	3	0.012	1.2	12	3	0.0001	1000	10	VΩ A	P	ina
			ac	ina	0.012	1.2	12	3	0.012	1.2	12	3				(de)		
M 14	R & S	URI	dc	ina	0.02	1	8	2	2 nA	1	13	3	0.005	1000	6	VΩ A	P	ina
			ac	ina	0.01	0.3	6	3	0.1	1	8	4				(dh)		
	E-Measur	103A	dc	ina	6	3	5	2	6	1.2	4	3	1	1	2	VΩ A	P	20
			ac	ina	12	3	5	2	30	0.6	3	2				(h)		
	E-Measur	102A	dc	ina	6	3	5	2	6	1.2	4	2	1	1	2	VΩ A	P	16
			ac	ina	12	3	5	2	30	0.6	3	2						
	Millivac	MV-07C	dc	ina	0.00001	1	17	2	10 pA	0.001	17	2	none	none	none	VΩ A (def)	C, R	395
	Aerometrics	MM100 (bc)	dc	ina	0.0001	1.5	15	1	1.5	0.5 nA	18	1	0.0015	50	16	VΩ A (de)	P	450
	Millivac	MV-864A (c)	dc	ina	0.001	1	15	1	100	1 pA	15	2	1000	100	9	VΩ A (def)	C, R	495
M 15	Rawson	5012AA	dc	ina	0.002	1	9	0.05	0.2	1	5	0.05	none	none	none	VA	P	465
			ac	ina	0.3	1	8	0.05	10	3	6	0.05				(de)		
	Rawson	5012AD	dc	ina	0.002	1	9	0.05	0.2	1	5	0.05	none	none	none	VA	P	495
			ac	ina	2	0.5	8	0.05	2	0.5	8	0.05				(de)		
	Rawson	5012LC	dc	ina	0.15	1.5	9	0.05	0.15	1.5	9	0.05	none	none	none	VA	P	515
			ac	ina	5	1.5	6	0.05	1.5	0.5	6	0.05				(de)		
	Rawson	5012AE	dc	ina	0.002	1	9	0.05	0.2	1	5	0.05	none	none	none	VA	P	455
			ac	ina	2	1	6	0.05	2	1	6	0.05				(de)		

(tables continued on page T18)

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Monsanto®

ELECTRONICS

ON READER-SERVICE CARD CIRCLE 75

Multitesters *(continued)*

					VOLTAGE RANGES				CURRENT RANGES				RESISTANCE RANGES					
	Manufacturer	Model		Sensitivity kΩ/V	Min. V	Max. kV	No.	Acc. %	Min. mA	Max. A	No.	Acc. %	Min. kΩ	Max. MΩ	No.	Meter Calib. in: VΩA	Type C-Cab. P-Port. R-Rack	Price Approx $
M 16	Rawson	5012LB	dc	(g)	0.15	1.5	9	0.05	0.15	1.5	9	0.05	none	none	none	VA (de)	P	540
			ac	(g)	0.5	1.5	8	0.05	15	5	6	0.05						
	Motorola	S1063A (a)	dc	Zin = 10-11M	0.1	1	9	3	0.001	0.3	12	5	0.0002	50	6	VΩA (d)	P	285
	Motorola	S1052B (c)	dc	Zin = 10-11M	0.1	1	9	3	0.001	0.3	12	5	0.0002	50	6	VΩA (d)	P	250
	Dynamics	504 504R	dc	Zin = 10-100M	0.0001	1	15	1	100 nA	1	15	1	0.01	100	8	VΩA (de)	P R	760 785
	Leeds & N	5620	dc	Zin = 7.5×10^{11}	0.5	0.5	4	5	0.005	50 μA	6	5	0.2	200	6	VΩA (de)	P	request
	Keithley	601	dc	Zin = $10\text{-}10^{14}$	0.001	0.01	9	1	0.1 pA	0.3	28	2	0.1	10^{-14}	25	VΩA (dm)	C	595
M 17	Keithley	610B	dc	Zin = $10\text{-}10^{14}$	0.001	0.1	11	1	0.1 pA	0.3	28	2	0.1	10^{-14}	25	VΩA (dm)	C	565
	Keithley	600A	dc	Zin = $10\text{-}10^{14}$	0.01	0.01	7	2	0.1 pA	0.3	28	2	0.1	10^{-14}	25	VΩA (dm)	C	395

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Multitester Notes

a. Battery or line power.
b. Requires 105-125V ac, 60 Hz.
c. Solid-state.
d. Linear
e. Mirror
f. Logarithmic
g. Internal resistance varies with range and function.
h. dB
i. Capacitance
j. Power
k. dBm
l. Null with zero center
m. Charge in coulombs

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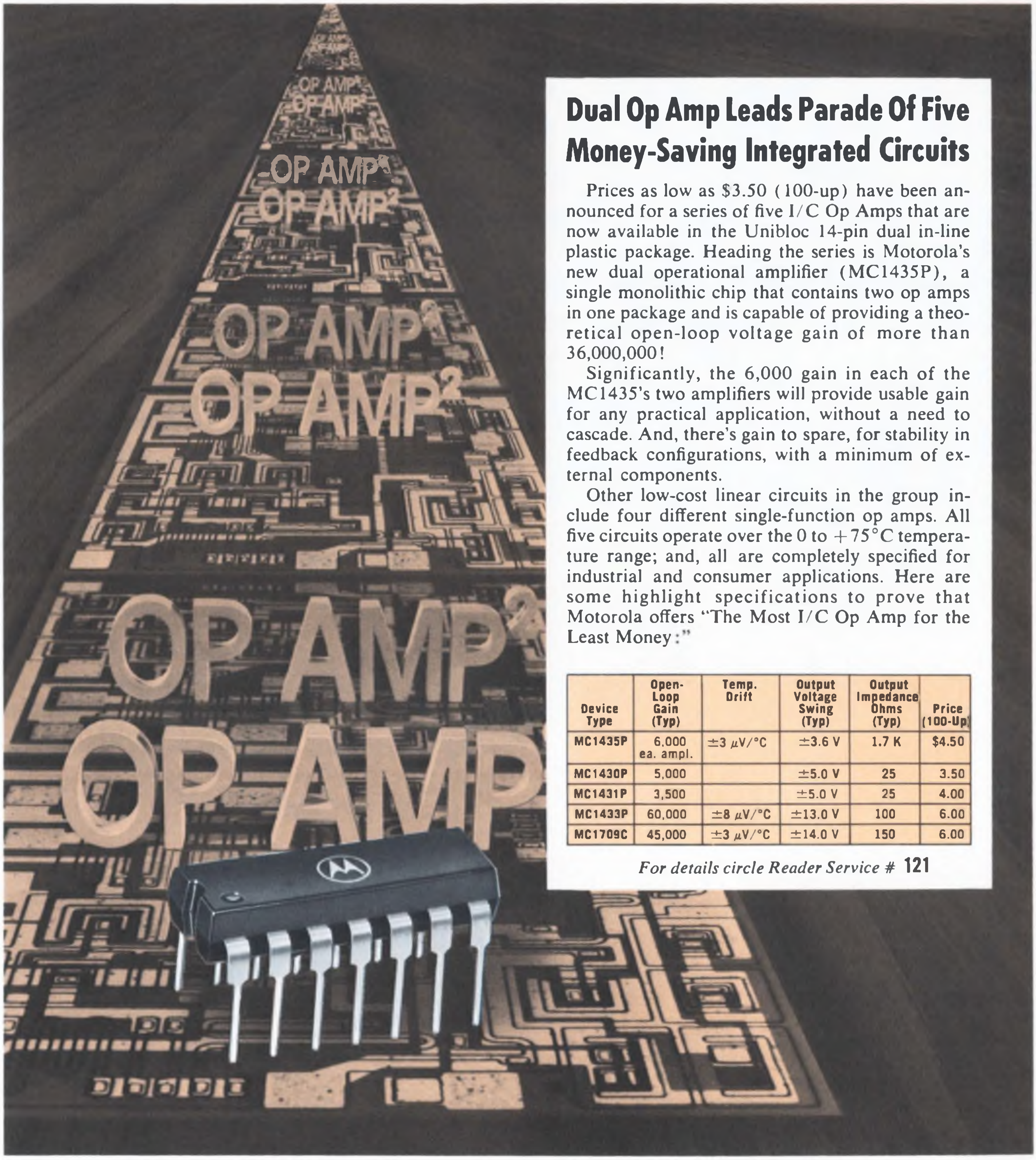


Dual Op Amp Leads Parade Of Five Money-Saving Integrated Circuits

Prices as low as $3.50 (100-up) have been announced for a series of five I/C Op Amps that are now available in the Unibloc 14-pin dual in-line plastic package. Heading the series is Motorola's new dual operational amplifier (MC1435P), a single monolithic chip that contains two op amps in one package and is capable of providing a theoretical open-loop voltage gain of more than 36,000,000!

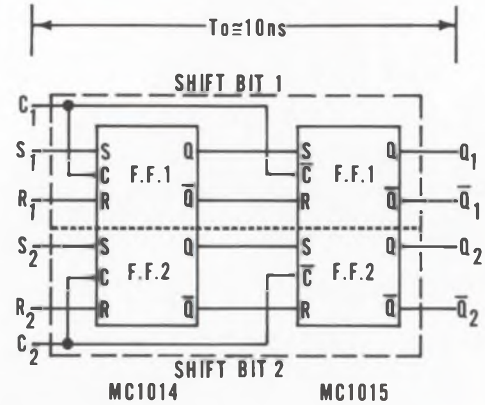
Significantly, the 6,000 gain in each of the MC1435's two amplifiers will provide usable gain for any practical application, without a need to cascade. And, there's gain to spare, for stability in feedback configurations, with a minimum of external components.

Other low-cost linear circuits in the group include four different single-function op amps. All five circuits operate over the 0 to +75°C temperature range; and, all are completely specified for industrial and consumer applications. Here are some highlight specifications to prove that Motorola offers "The Most I/C Op Amp for the Least Money:"

Device Type	Open-Loop Gain (Typ)	Temp. Drift	Output Voltage Swing (Typ)	Output Impedance Ohms (Typ)	Price (100-Up)
MC1435P	6,000 ea. ampl.	±3 μV/°C	±3.6 V	1.7 K	$4.50
MC1430P	5,000		±5.0 V	25	3.50
MC1431P	3,500		±5.0 V	25	4.00
MC1433P	60,000	±8 μV/°C	±13.0 V	100	6.00
MC1709C	45,000	±3 μV/°C	±14.0 V	150	6.00

For details circle Reader Service # **121**

Featured In This Issue:



Logic diagram and truth table show how MC1014 and MC1015 are con-connected to form two Master-Slave shift register elements.

TRUTH TABLES

MC1014			
R	S	C	Q n+1
Ø	Ø	0	Q
0	0	1	Q
0	1	1	1
1	0	1	1
1	1	1	U

MC1015			
R	S	C	Q n+1
Ø	Ø	1	Q
0	0	0	Q
0	1	0	1
1	0	0	1
1	1	0	U

Ø = EITHER STATE MAY BE PRESENT
U = UNDERFINED LOGIC STATE (COMMON TO ALL DUAL-RAIL INPUT R-S FLIP FLIPS)

MECL II Dual R-S Flip-Flops Combine To Achieve Two Gating Levels; 2 ns Prop. Delay Increase

Two new additions to the growing MECL II line of integrated circuits MC1014 and MC1015P, may be used as positive-gated and negative-gated R-S Flip-Flops, respectively. The two levels of gating are accomplished with only 2 ns increase in propagation delay. As a result, a single phase, clocked Master-Slave type of shift register may be obtained as shown.

The MC1014P, in addition to teaming with MC1015P for shift register functions, is also useful as a dual storage element. It contains two dc Set-Reset Flip-Flops with a positive clock input provided for each flip-flop. The counterpart, MC1015P, operates with a negative clock input. Both circuits exhibit a typical propagation delay of 5.0 ns, operating over the 0 to +75°C temperature range. Both provide typical power dissipation of 125 mW at an operating frequency of 80 MHz. Minimum dc fan-out of 25 for each output is guaranteed. Prices for the MC1014P and MC1015P are $4.25 (1,000-up), in the 14-pin dual in-line plastic package.

The MECL II family of logic integrated circuits now includes 27 functional elements in the limited temperature range MC1000P series and a comparable number in the full temperature range MC1200F series. All of these circuits are fully compatible with the MECL 300/350 series types.

For details, circle Reader Service # **122**

MDTL Presettable Decade Counters Feature 20 MHz Operation

A new series of MDTL circuits, types MC938F, MC838F and MC838P, all offer individual direct-sets for each stage as well as a common reset and buffered inputs (a standard MDTL loading factor of 1). These monolithic ripple counters operate in excess of 20 MHz at ± 20% of the nominal 5.0 V power supply.

The three new devices are composed basically of four MC950 pulse-triggered binaries. All have standard MDTL inputs and use active pull-up devices in the outputs to increase capacitive drive capabilities. Typical dc noise immunity is better than 1.0 volt.

All three new circuits are fully compatible with the Motorola MC930/830 series MDTL and Motorola MC500/400 series MTTL.

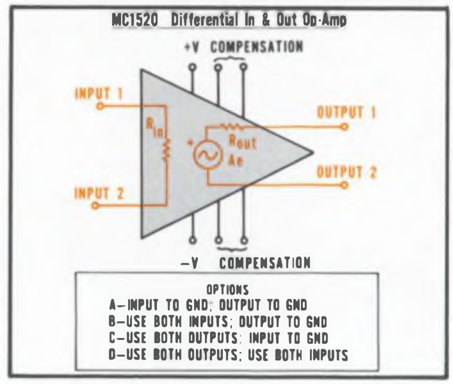
Circuit Type	Package	Temp. Range	Price (100-Up)
MC938F	14-Pin Ceramic Flat Pack	(−55 to +125°C)	$18.00
MC838F	14-Pin Ceramic Flat Pack	(0 to +75°C)	10.00
MC838P	14-Pin Unibloc Plastic	(0 to +75°C)	6.70 (1,000-up)

For details, circle Reader Service # **123**

Differential "In" and "Out" I/C Ideal For Wide-Band Amplifier Applications

Motorola's new MC1520, a monolithic Op Amp integrated circuit, provides both differential input and differential output characteristics. Because of the latter capability, this new circuit exhibits an extremely good common-mode rejection ratio of 90 dB (typ) — making it ideal for use in instrumentation, communication and computer equipment.

The MC1520 also provides a high differential gain of 74 dB (max) — numerically 7,200 — and, as a result, is also a good general purpose operational amplifier. It is particularly useful in wide-band applications requiring large output-voltage swings at high frequencies, especially those calling for differential outputs. The MC1520's gain of 7,200 compares with gains of less than 1,000 for comparable circuits.



New linear I/C boasts differential outputs as well as differential inputs . . . making it a good universal operational amplifier.

Other outstanding typical characteristics of the MC1520 are:

- Wide Closed-Loop Bandwidth — 10 MHz
- High Input Impedance — 2 MΩ
- Low Output Impedance — 50Ω
- Full Output Voltage Swing to Greater than 1 MHz

Available in both the TO-99 10-pin metal can and TO-91 ceramic flat pack, the MC1520G is 100-up priced at $10.00; and the MC1520F is $15.00 (100-up).

For details, circle Reader Service # **124**

One ounce of ZenGard protects against kW "spikes"

New ZenGard Transient Suppressors Provide 12 kW Surge Protection

Electrical Characteristics for MPZ5 Transient Suppressors (At $T_C = 25°C$):

Type Numbers	Nominal Operating Voltage $V_{OP(DC)}$	Nominal Operating Voltage $V_{OP(RMS)}$	Clamping Factor C_F*	Maximum Zener Voltage PW = 1 ms V_Z	@ I_{ZT}	Minimum Zener Voltage V_Z	@ I_Z
MPZ5-16B MPZ5-16A	14	10	1.25 1.5	20V 24V	200A	$16V_{DC}$	$0.4A_{DC}$
MPZ5-32C MPZ5-32B MPZ5-32A	28	20	1.25 1.4 1.56	40V 45V 50V	100A	$32V_{DC}$	$0.2A_{DC}$
MPZ5-180C MPZ5-180B MPZ5-180A	165	117	1.14 1.25 1.39	205V 225V 250V	20A	$180V_{DC}$	$0.03A_{DC}$

$^*C_F = \frac{V_{Z(MAX)}}{V_{Z(MIN)}}$

The MPZ5 series of ZenGard suppressors are designed to protect transistors, SCR's, rectifiers and other sensitive components in danger of destruction from circuit transients above their ratings. They can easily absorb up to 12 kW for 0.1 ms in applications as 14 V military automotive ignition, 28 V aircraft equipment and 110 V ac line-operated circuits. They are more-than-equal replacements for mechanically or electrically-limited selenium cells, silicon carbide varistors, RC networks and electro-mechanical relay systems.

Besides providing sharp, controlled reverse breakdown characteristics, the new series exhibits clamping factors as low as 1.25 — a figure of merit which means lower overshoot voltages and less chance of component degradation and burn-out — and is less temperature and age-sensitive than conventional stacked cells. Costs can also be reduced by allowing the safe use of lower voltage-rated rectifiers.

Weighing only 1 ounce and occupying less than 2 cubic inches, the devices feature low leakage (50 μA max @ V_R) which affords negligible power losses. They are oxide-passivated for top reliability and performance and will operate over a -65 to $+175°C$ range.

Non-standard voltages, tight-tolerance and higher power units (200 kW units have been supplied) can be developed for specific requirements.

For details, circle Reader Service # **125**

SME Transistors Replace "Old-Workhorse" MADT Types

Eight new germanium SME (Selective Metal Etch) mesa transistors – including 2 popular JAN types – are now available in volume quantities to provide a leading second-source for MADT® devices in military and industrial communications equipment.

The SME process, an exclusive Motorola development, is considered a breakthrough in germanium mesa devices. Higher-frequency, lower-noise performance is obtainable due to complete freedom of transistor geometry and much better definition and closer spacing of emitter/base areas to gain optimum device performance.

In addition to meeting *exact* parameter-by-parameter specs, the inherent flexibility of the advanced SME process makes it possible to achieve nearly identical key MADT *parameter distributions.* Thus the user can now count on second-source *direct replacement* availability for essentially all MADT-type sockets.

Motorola's MADT replacement types are furnished in the popular TO-5 case (with "tab" removed) which meets all EIA-specified dimensions of the older, TO-9 package, including exact lead configurations.

Type	Use	Power Gain @ 200 MHz (min)	NF (max)	$V_{CE(sat)}$ @ I_C = 10 mA (max)	F (max)
2N502	VHF ampl.	8 dB	10 dB	N.A.	500 MHz
2N502A JAN2N502A	VHF ampl.	10 dB	7 dB	N.A.	620 MHz
2N502B JAN2N502B	VHF ampl.	10 dB	7 dB	N.A.	620 MHz
2N1499A	HF switch	N.A.	N.A.	0.20 Volt	100* MHz
2N1742	VHF ampl.	14 dB	5.5 dB	N.A.	980 MHz
2N2048	HF switch	N.A.	N.A.	0.14 Volt	130* MHz

$^*f_t$ (min)

For details, circle Reader Service # **126**

Fast Photo Sensors Aid Light-Activated Designs

A tiny photo detector—type MRD200 — and a sensitive photo-transistor — type MRD300 — now provide opportunities to simplify light-activated designs!

Functional and compact (only 0.060″ diameter), the MRD200, two-terminal unit serves where small size and high density positioning is required such as high-speed tape and card readers and rotating shaft information encoders.

It displays linear characteristics over the dynamic range — ideal for reading film sound tracks. Maximum t_{on}/t_{off} is only 6.5 μs allowing faster reading than any mechanical contacts. And, its extremely narrow field of view minimizes cross-talk.

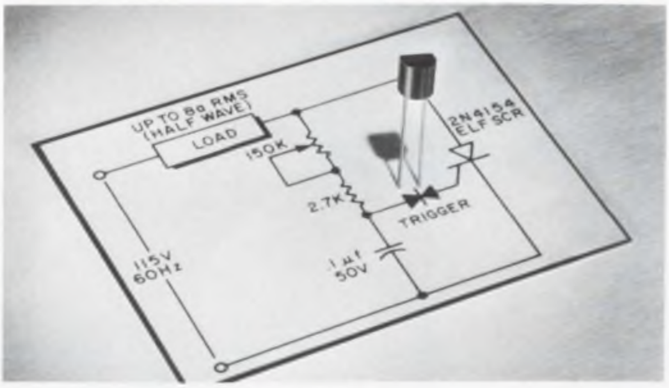
With equally fast rise/fall time, the MRD300 utilizes a TO-18 case with external connections for added control and excels in applications where high sensitivity is essential. It responds to modulation well above the audio spectrum providing a useful means of data transfer from laser light sources.

Both units operate from 1 to 50 Volt power supplies and are compatible with most transistor circuits. Low leakage permits use in direct-coupled designs for low-signal-level operation.

Type	Radiation Sensitivity mA/mW/cm² (typ)	Illumination Sensitivity μA/lum/ft² (typ)	Dark Current μA (max)
MRD200 MRD300	0.5 1.6†	5.0 10†	0.025

†Base open

For details, circle Reader Service # **127**



Low-cost MPT28/32/36 silicon plastic bilateral triggers now make it possible to use all solid-state design in economy power control circuits.

New Bilateral Triggers Trigger New Low-Cost Power Control Designs

Another layer of cost has been peeled from already-economical, all-solid-state power control circuitry with the introduction of the MPT 28/MPT32/MPT36 series of silicon bilateral triggers.

These 28-, 32-, and 36-volt (nom) devices are housed in the Unibloc plastic package — well-known for its rugged,

Trigger Type	V_{BR}† (nom) Volts	I_{BR}‡ (typ) μA	ΔV‡ (typ) Volts	I_{pulse} (max) Amps
MPT28	28	20	10	2
MPT32	32			
MPT36	36			

† ±4 volts, both directions
‡ Both directions

void-free case integrity that has consistently withstood 3,000-hour severe environmental testing. The new series furnishes symmetrical switching characteristics, low 50 μA (max) switching current, which reduces capacitor size . . . and a large, 10-volt (typ) switchback voltage which allows higher energy pulses-to-gate for faster "turn-on," lower switching losses and reliable thyristor operation.

In addition, use of these lower voltage, solid-state devices in place of short-lived, high-breakover-voltage neon triggering devices affords broader conduction angle control plus easier triggering of less sensitive thyristors through higher pulse current.

And exclusive Annular construction ensures stable operation over a −40 to +100°C operating temperature range.

How can you best use them in consumer/industrial designs . . . *at below-25¢ volume prices?*

Tie this new bilateral trigger series together with more than 270 different thyristors now available from the industry's broadest up-to-35-Amp line including these preferred 8-Amp Motorola favorites: 50 to 400-volt TRIACS, 50 to 600-volt THERMOPAD plastic SCR's and the ever-popular, metal "can," 25 to 600-volt ELF SCR's.

For details, circle Reader Service # **128**

Low-cost, Complementary Chopper Designs With New Plastic MOSFETS

Low-level, low-frequency complementary chopper designs at a low, low cost . . . that's the essence of the story about Motorola's new plastic-encapsulated MOSFET types — MPF159-160. But then, what more could one want?

Low-level (low-power) complementary chopper applications? They've been almost impossible to accomplish with bipolars because bipolars exhibit excessive leakage. MPF159-160 boast an I_{GSS} value in the picoamp region. Low-cost? The 100-up price for these devices in the Unibloc plastic package (that meets MIL standards) is just $2.75 — about one-third the cost of comparable metal "can" types.

The two new devices are both silicon, type C, triode-connected field-effect transistors that utilize the MOS process. MPF159 offers an R_d "on" rating of 100 ohms, while the complementary p-channel device, MPF160, provides 200 ohms of drain-source resistance in the "on" condition. Both are 15-volt devices that provide 200 mW of continuous power dissipation.

Other ratings for the two devices are:

Characteristic	Symbol	Max. Rating	Unit
Gate Reverse Current	I_{GSS}	100	pA
Zero-Gate Voltage Drain Current	I_{DSS}	10.0	nA
Input Capacitance	C_{iss}	3.0 4.0	pF (MPF159) pF (MPF160)
Reverse Transfer Capacitance	C_{rss}	1.0	pF (Both)

For details, circle Reader Service # **130**

800 mA SCRs Spark New Economy Designs

With prices pegged substantially below 40¢ in volume quantities, the 2N5060-63 SCR series is sure to be a boon to the designer of low-level, power controls.

Housed in the rugged Unibloc plastic package, these 30 to 150-volt units can be plugged directly into existing TO-18 pin circles without confusing lead crossing. Only 200 μA is necessary to trigger these devices — making them ideal for low-level sensing and triggering designs.

Low-power consumer/industrial/military applications are virtually limitless: military fuzes (squib-firing and safety circuits), flame detectors, automatic warning systems, lamp and relay drivers, fractional H.P. motor controls, sensing, detecting and process controls, vending machines, touch switches, ring-counters, shift registers, flip-flops, gate drivers for larger SCR's, ad-infinitum!

The exclusive Annular construction affords stable, reliable operation over a wide −65 to + 125°C operating temperature range.

Other features are: 6-A peak surge rating, 1.7-V peak forward "on" voltage and 5 mA max. holding-current, at 25°C.

TYPE	I_F (AMPS)	V_{FXM}/V_{RXM} (VOLTS)	PRICE (100-Up)
2N5060	0.8	30	$.51
2N5061		60	.55
2N5062		100	.64
2N5063		150	.85

For details, circle Reader Service # **129**

When you think "low-level power control," think 2N5060-63 SCR's. They're naturals for virtually all low-cost, high-volume designs.

"Surmetic" First Plastic Rectifier To Count Cadence To MIL-S-19500/228D

Now — the most popular, industry-accepted standard in plastic rectifiers — the Surmetic — is the first of its kind to meet rigid military requirements! . . . an above-and-beyond "call to *reliability* duty" that you can expect in your consumer/industrial designs, too.

Motorola doesn't have a special production line for mil-type Surmetic rectifiers . . . Rather, identical devices for both military acceptance as well as *your* particular requirements are from the same production runs — your assurance that all quality designed into the Surmetic is available to all users.

You get these important design advantages too:

- Improved HV avalanche characteristics through advanced die fabrication
- Superior lead and seal capabilities through double nail head construction
- Excellent reliability through high-temperature passivation

And a minimum guard-band of 20% on all voltages means that I_R will be maintained at 120% of PIV — an automatic safety factor which assures you that units rated at 400 volts, for example, are actually capable of 480 volts operation!

The complete line of Surmetic rectifiers covers a reverse voltage range of 50 to 1000 volts. They are rated to carry a full amp at 75°C and 30-amp surges.

Type	V_{RM} (Volts)	Io @ 75°C (Amps)	I_R (A)	$I_{FM (SURGE)}$ (Amps)	Prices (100-up)
JAN1N3611	200	1	5	30	$ .99
JAN1N3612	400	1	5	30	1.30

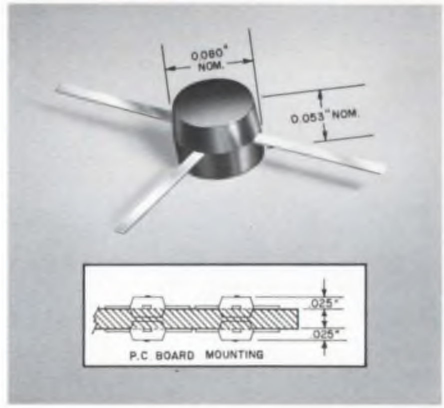
For details, circle Reader Service # **131**

Unibloc "Micro-T" Debut Spurs New High-Density Concepts

The advent of Motorola's Micro-T molded Unibloc plastic transistors now provides the ultra-small devices you've needed to make those high-density, miniaturized equipment design dreams come true. Besides being roughly only one-tenth the volume of standard plastic or TO-18 transistors, the Micro-T's leads radiate from the center of its body, making it particularly well suited to "drop in" automatic strip-line PC board mounting.

The new Micro-T also lets you design circuits having discrete device performance while achieving the component densities and space reductions approaching that of integrated circuits. In addition, its unique structure allows for a wide latitude of mounting flexibility and circuit-layout design. For example, it makes an ideal device for use in thick-film and unitized circuit assemblies.

The first Micro-T transistors available are Motorola PNP/NPN complementary MMT3903-06 silicon Annular switching and amplifier types. They feature a host of premium specs including BV_{CEO}'s of as high as 40 V min., C_{ob} of only 4.0 pF max., current gain speced in two ranges — 100 μA to 1 mA, and 1 mA to 10 mA — with saturation voltages as low as 0.2 V at $I_C = 10$ mA. They dissipate a full 225 mW at $T_A = 25$°C and operate over a wide junction temperature of from −55 to +135°C.



Micro-T Unibloc plastic transistors make high-performance ultra-miniature designs economically practical.

Prices are moderate *too* — only $1.60 for the MMT3903 and MMT3905 and $2.00 for the MMT3904 and MMT3906 — in 100-up quantities.

For details, circle Reader Service # **132**

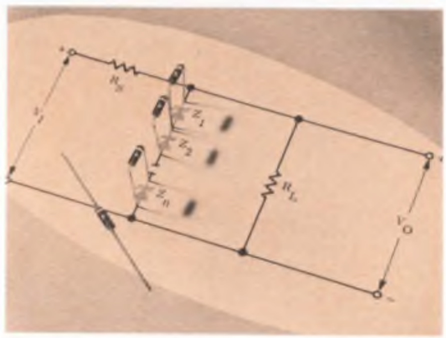
Surmetic-20 Gives Body Blow To Zener Diode Prices

The new ½-watt Surmetic 20 zener diodes now place reliable, economical, voltage regulation within the reach of every circuit designer.

Priced as low as 36¢ (10% tolerance, 5,000-up), the 1N5221-81 units will replace more than 450 older, more costly DO-7 devices from 2.4 to 200 volts . . . and give an extra "capability cushion" besides.

Surmetic-20's are conservatively rated at 500mW under normal mounting conditions. Production-line units have demonstrated "no-failure" resistance to greatly overstressed, 1-watt, 1,000-hour testing. In addition, nanoampere reverse leakage current ratings indicate cleanliness of the passivated junctions and assure low-power drain and sharper knees in all applications.

As a result of flame and distortion-proof silicone polymer packaging, a 200°C operating temperature and repeated defiance of 50-day moisture resistance tests (5 times the exposure period required in standard mil-type case integrity tests), it can be designed with more confidence – and less heat sinking – into virtually all high-temperature, high-humidity environments.


Their low-cost makes it economically practical to employ Surmetic-20 zener diodes in multiple arrays ("strings") to provide greater design flexibility.

Both demanding industrial and military circuits which require solid-state devices to be completely spec'd (Surmetic 20's are 100% oscilloscope-tested and characterized at 4 critical points including $i_{z(surge)}$), or non-critical commercial-type applications are a natural for ultra-economical Surmetic-20 types.

For details, circle Reader Service # **133**

NEW PRODUCT BRIEFS

ADE GERMANIUM POWER-SWITCHING TRANSISTORS

— Double "Brute-Power" Capability Over Alloy Types

It's almost like having two power transistors for the price of one! Motorola's new Alloy-Diffused-Epitaxial (ADE) die structure boosts peak power-switching capability to nearly twice that of conventional alloy units, yet carries a low price tag.

The MP2200A-2400A switching transistors are ideal for core driver, power conversion and HV switching applications where high power capability — 80 to 120 V min @ 8 A — is needed at low cost. In addition, high current/gain (25 min @ 8 A), low saturation voltage (0.6 V @ 25 A) and good switching speed (9 μs t_{on} @ 10 A typ) advantages rank them as efficient, solid-state servants in "brute-power" designs. They are available in TO-41 or TO-3 all-aluminum cases.

Type	V_{CE} Volts (sus)	I_C Amps (Cont)	$V_{CE(sat)}$ Volts (max)	h_{FE} @ I_C (min)	Price (100-up)
MP2200A	80	25	0.6	25 @ 8 A	$2.25
MP2300A	100				2.45
MP2400A	120				2.60

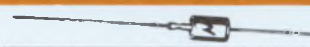
For details circle Reader Service # **134**

TIGHT-VOLTAGE-TOLERANCE REFERENCE DIODES

— Spec'd To ±2% Limits, 0.0005%/°C; Yet Cost 30% Less!

You can now specify *either* a ±0.2 V ("A" type, ±2%) or a ±0.4 V (non-suffix, ±4%) tolerance over the nominal 9.4-volt rating for tight voltage range considerations in critical test equipment, meter, satellite and instrumentation designs with Motorola's 1N2163 reference diode series. And where economy is a factor (where *isn't* it!) you can realize savings up to 30% over published prices for comparable units. These 750 mW units feature maximum voltage change spec'd over test temperature range and temperature coefficients guaranteed over three operating temperatures.

For details circle Reader Service # **135**



DO-13

Type Number	Max ΔV_Z (Volts)	Test Temperature (°C)	Temperature Coefficient (%/°C)	Price (100-up) Std.	Price (100-up) "A" Types
1N2163,A	0.033	0, +25, +70	0.005	$ 2.50	$ 2.60
1N2164,A	0.086	−55, 0, +25, +75, +125	0.005	3.40	4.15
1N2165,A	0.115	−55, 0, +25, +75, +125, +185	0.005	4.25	5.50
1N2166,A	0.007	0, +25, +70	0.001	5.10	6.10
1N2167,A	0.017	−55, 0, +25, +75, +125	0.001	6.50	8.30
1N2168,A	0.023	−55, 0, +25, +75, +125, +185	0.001	8.95	12.00
1N2169,A	0.004	0, +25, +70	0.0005	12.75	18.80
1N2170,A	0.009	−55, 0, +25, +75, +125	0.0005	18.00	27.80
1N2171,A	0.012	−55, 0, +25, +75, +125, +185	0.0005	26.20	33.50

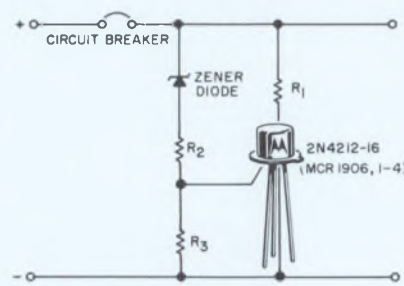
SENSITIVE GATE SCR's

— Reduce Triggering Requirements to μA Levels

Only 100 μA (@ T_C = 25°C) is needed to turn on the new 2N4212-16 series of SCR's — a current level many orders of magnitude less than that needed by conventional SCR's and one that virtually eliminates the necessity for elaborate pre-triggering (using transistors or high output triggers). This low-level sensing capability also minimizes the complexity of amplifier stages needed to fire larger power SCR's. The 1.6 amp family is packaged in the space-saving, hermetic TO-5 case and includes both premium and economy units.

Type	V_{RXM} Volts	I_{FM} (Surge) Amps	Max at 25 C I_{GT}	Max at 25 C I_{HX} (R_{GK} = 1 k)	Prices (100-up)
2N4212	25	15	100 μA	3.0 μA	$1.80
2N4213	50				2.00
2N4214	100				3.30
2N4215	150				4.10
2N4216	200				5.40
MCR1906-1	25	15	1 mA	5.0 μA	1.05
MCR1906-2	50				1.10
MCR1906-3	100				1.25
MCR1906-4	200				1.35

For details circle Reader Service # **136**



SCR Crowbar Over-Voltage Protection for DC Operation

UNIBLOC PLASTIC UNIJUNCTION TRANSISTORS

— Combine Low Price And High Performance . . . With Availability

You can select from *two* narrow-range eta spreads with the 2N4870-71 series UJT's, reducing the necessity of tight tolerance resistor/capacitor selection and *two* valley current characteristics, allowing wider latitude in sawtooth oscillator and frequency divider circuit design. And, ultra-low leakage, resulting from the Annular structure, reduces pulse-width variations. In addition, their low (2.5 V) typical emitter saturation-voltage allows greater output to the following circuit stage — particularly useful in triggering applications.

Use them in consumer/industrial applications such as timers, lamp dimmers/flashers, sawtooth generators, motor-speed controls, fuse circuits, pulse generators, multivibrators, oscillators . . . ad infinitum!

Type	Package	Peak Point Current (Typ)	Emitter Reverse Current (Typ)	Intrinsic Standoff Ratio Min.	Intrinsic Standoff Ratio Max.	Price (100-up)
2N4870	TO-92 UNIBLOC PLASTIC	1 μA	0.05 μA	0.56	0.75	$ .64
2N4871				0.70	0.85	$ .68

For details circle Reader Service # **137**

1-AMP PNP DARLINGTON AMPLIFIERS

— Provide High Current Gain Even at Cryogenic Temperatures

The designer is assured of a minimum gain of 15,000 at −55°C and gains up to 60,000 at +25°C (typ) with two new PNP Darlington amplifiers—making them highly suited for very-low-temperature designs—types 2N4974 and 2N4975. They operate over a wide dc current range from 1 μA to 1.0 A with characteristics specified at 8 separate points over the complete operating current range. Both units carry a high P_D rating of 800 mW at 25°C.

Motorola's patented annular semiconductor structure assures unusually low leakage currents—I_{CBO} = 10 nA(max) at V_{CBO} = 30 V. They have a maximum noise figure of only 6.0 dB at 1.0 mA and a typical f_T of 275 MHz at 20 mA. Typical gain specifications for these PNP Darlington amplifiers are:

TYPE	−55°C	+25°C
2N4974	15,000	60,000
2N4975	10,000	30,000

For details circle Reader Service # **138**

HIGH-GAIN 2N4416 — VHF/UHF JFET

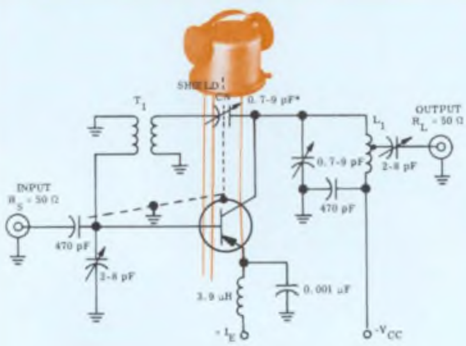
— Fits 8 Out Of Every 10 Sockets!

There's little doubt that most designers will find this new n-channel JFET so versatile that it will soon become the most useful device in the "designer's tool box."

Even though the 2N4416 is characterized as a VHF/UHF amplifier, it will work equally well in low-noise, high-gain amplifiers from dc to above 400 MHz. At 100 MHz, noise figure is specified at 2.0 dB and power gain is 18.0 dB at the same frequency. In addition, the device features input capacitance of 4.0 pF at 1 MHz and transconductance of 4,000 μmhos at 400 MHz.

Motorola's 2N4416 JFET is available now in the TO-72 (4-lead TO-18) package, with isolated chip. The 100-up price is $3.35.

For details circle Reader Service # **139**



MM5000-MM5002 - POWER GAIN AND NOISE FIGURE TEST CIRCUIT

GERMANIUM VHF AMPLIFIER TRANSISTORS

—Break 2 dB Noise-Figure Barrier — 1.6 dB max. at 200 MHz!

Low-noise, low-price and high power-gain make the MM5000 PNP VHF amplifier transistor series a natural choice for the value vs. performance conscious engineer. The units also feature an f_T of 800 MHz min., and a collector-base capacitance of only 0.6 pF max. They are fabricated using Motorola's exclusive Selective Metal Etch process, which permits greater freedom of geometry design. The result . . . better definition and closer spacing of emitter/base areas to provide optimum performance chracteristics. Case type: TO-72.

Type	Low Noise @ 200 MHz	Power Gain @ 200 MHz	Prices (100-up)
MM5000	1.6 dB max	24 dB min	$4.75
MM5001	2.0 dB max	22 dB min	2.80
MM5002	2.2 dB max	20 dB min	2.00

For details circle Reader Service # **140**

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NPN/PNP HIGH-VOLTAGE SILICON HIGH-FREQUENCY TRANSISTORS

— Offer An Outstanding Combination of Key Parameters

Combining leakage currents in the nanoamp range with low saturation voltages and dc betas (h_{FE}) up to 200 at $I_C = 10$ mA — all this at very high f_T's — Motorola's NPN 2N4924-27 and PNP 2N4928-31 complementary high-voltage silicon Annular transistors provide the peak-efficiency parameters you need to avoid expensive "overspecing" often encountered with devices of this type.

Packaged in the TO-39 case, they dissipate up to 5 watts at $T_C = 25°C$. Both polarity types are available in production quantities to serve a broad scope of high-voltage, high-frequency amplifier applications.

NPN 2N4924-27 and PNP 2N4928-31 Silicon Annular Transistors

Types		BV_{CEO} @ 10 mA (V)	I_{CBO} @ V_{CB} (A)			$V_{CE(sat)}$ @ 10 mA max. (V)		f_T @ 20 mA; 20 V (MHz)		Prices (100-up)	
NPN	PNP		NPN	PNP	(V)	NPN	PNP	NPN min/max	PNP min/max	NPN	PNP
2N4924	2N4928	100	0.1	0.5	50	0.25	0.5	100/500	100/1000	$1.35	$2.70
2N4925	2N4929	150	0.1	0.5	75	0.25	0.5	100/500	100/1000	1.65	3.30
2N4926	2N4930	200	0.1	1.0	100	1.00	5.0	30/300*	20/200	1.95	3.95
2N4927	2N4931	250	0.1	1.0	150	1.00	5.0	30/300*	20/200	2.10	4.50

*f_T @ $I_C = 10$ mA

For details, circle Reader Service # **141**

HIGH-EFFICIENCY POWER VARACTOR MULTIPLIERS

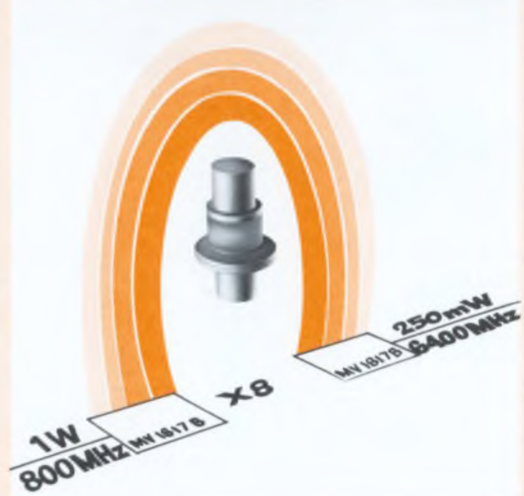
— Boost Frequencies Eight Times in a Single Step!

With the advent of four new step-recovery power multipliers (varactors), the microwave designer can say goodbye to the expensive prospect of two, three, and sometimes four multiplication steps in order to reach regions as high as 6 GHz. Motorola types MV1816B-17B . . . and their tighter tolerance "1" versions (with superior thermal resistance) multiply a frequency 8 times — e.g. from 800 MHz to 6400 MHz — in a single step, with a minimum 20-25% efficiency. Other significant parameters for the MV1816B-17B are:

Device Type	P_{in} (W)	Eff. % (min)	f_{in}/f_{out} (MHz)	θ_{JC} (°C/W max)	C_r @ 6 V 1 MHz (pF)	BV_R @ 10 μA (Volts, min)
MV1816B	3	20	300/2400	23	2.4 - 3.6	75
MV1816B1		25		15	2.7 - 3.3	
MV1817B	1	20	800/6400	35	0.8 - 1.2	35
MV1817B1		25		25	0.9 - 1.1	

These universal devices can be employed in a wide range of local oscillator and transmitter designs requiring a variety of frequencies and multiplication steps. Both types are available in "pill" and "pill/prongs" packages.

For details, circle Reader Service # **142**



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Physics	Physics Research Labs Inc. Box 555 Hempstead, N.Y.	226211p 226213p 226214p	M5 M11 M11	274
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Design decisions belong in the hands of the systems designer.

DCL (Designers' Choice Logic) can start you on your way toward design freedom again. With Signetics' DCL you can optimize your system's performance without drawn-out calculations, expensive and time-consuming ground-plane designs or extensive use of outboard components. DCL is the only family that can offer all of these advantages:

WIDEST CHOICE OF FLIP-FLOPS—Four dual and two single flip-flops provide optimum choices in logic design and speed/power ratio. DCL offers the only dual low power RS/T binary in the industry, four flexible J-K types, and a dual high speed "D" type. The selection includes DC clocked, AC clocked, leading edge-triggered and trailing edge triggered binaries.

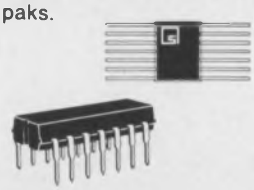
FULLY COMPATIBLE LARGE ARRAYS—Monolithic arrays (containing four binaries and thirteen gates) for counting and storage applications.

THREE RANGES OF GATE SPEED/POWER TRADE-OFFS—6ns/20mW, 10ns/15mW and 25ns/7mW.

FULLY COMPATIBLE INTERFACE ELEMENTS—Gates designed to match DCL levels to system levels up to 30 volts.

DTL FLEXIBILITY AND TTL SPEEDS—DCL includes high noise immunity DTL gates that are compatible with the high speed TTL members of the family. These gates provide a variety of AND-NOR functions to enhance design flexibility.

THE FIRST FULL MIL RANGE SILICONE DIP—All elements are available for either MIL or industrial temperature ranges in silicone DIPs or 14-lead glass/kovar flat paks.



TYPICAL CHARACTERISTICS

TYPE NUMBER	DESCRIPTION	FAN-OUT FUNCTION	Tpd (ns) AND TOGGLE RATE	AVG. PWR. Function (mW) 50% Duty	DC NOISE MARGIN (V)
8162	MONOSTABLE MULTIVIBRATOR (delay from 80 ns to 2 seconds)	12	35	65	1.0
8280	DECADE COUNTER/STORAGE REGISTER	8	25 MHz	25	1.0
8281	BINARY COUNTER/STORAGE REGISTER	8	25 MHz	25	1.0
8415	DUAL 5-INPUT NAND GATE (bare output collector)	9	30	10.0	1.0
8416	DUAL 4-INPUT NAND GATE (input expansion node)	9	25	10.0	1.0
8417	DUAL 3-INPUT NAND GATE (expansion node and optional output resistor)	9	30	9.5	1.0
8424	DUAL, LOW POWER, RS/T BINARY (trailing edge triggered)	9	11 MHz	15.5	1.0
8440	DUAL AND-OR-INVERT GATE (2 AND Gates wide)	9	25	12.0	1.0
8455	DUAL 4-INPUT NAND GATE DRIVER	25	28	11.0	1.0
8470	TRIPLE 3-INPUT NAND GATE	9	25	7.0	1.0
8471	TRIPLE 3-INPUT NAND GATE (bare output collector)	9	30	7.0	1.0
8480	QUADRUPLE 2-INPUT NAND GATE	9	25	7.0	1.0
8481	QUADRUPLE 2-INPUT NAND GATE (bare output collector)	9	30	7.0	1.0
8731	QUADRUPLE 2-INPUT DIODE EXPANDER	—	—	—	—
8806	DUAL 4-INPUT EXPANDER	—	—	—	—
8808	8-INPUT NAND GATE	20	12	13	1.0
8816	DUAL 4-INPUT NAND GATE	20	12	13	1.0
8825	SINGLE PHASE, AND Input J-K BINARY (leading edge triggered)	20	25 MHz	90	1.0
8826	DUAL HIGH SPEED J-K BINARY (trailing edge triggered)	10	30 MHz	40	1.0
8827	DUAL HIGH-SPEED J-K BINARY (full asynchronous entry, trailing edge triggered)	10	30 MHz	40	1.0
8828	DUAL HIGH SPEED "D" TYPE BINARY (leading edge triggered)	20	25 MHz	55	1.0
8829	SINGLE PHASE AND INPUT J-K BINARY (trailing edge triggered)	20	20 MHz	90	1.0
8840	DUAL AND-OR-INVERT GATE (2 AND gates wide)	20	10	15	1.0
8848	AND-OR-INVERT GATE (4 AND gates wide)	20	10	30	1.0
8855	DUAL 4-INPUT POWER GATE	60	10	24	1.0
8870	TRIPLE 3-INPUT NAND GATE	20	10	15	1.0
8880	QUADRUPLE 2-INPUT NAND GATE	20	10	15	1.0
8H16	DUAL 4-INPUT NAND GATE (high-speed)	30	6	20	1.0
8H70	TRIPLE 3-INPUT NAND GATE (high-speed)	30	6	20	1.0
8H80	QUADRUPLE 2-INPUT NAND GATE (high-speed)	30	6	20	1.0
8T18	DUAL 2-INPUT NAND INTERFACE GATE (high voltage to low voltage)	9	15	45	7.0
8T80	QUADRUPLE 2-INPUT NAND INTERFACE GATE (low voltage to high voltage)	9	25	10.0	1.0
8T90	HEX INVERTER INTERFACE ELEMENT (low voltage to high voltage)	9	25	10.0	1.0

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	Manufacturer	Model	Channel (notes)	FREQUENCY Min. Hz	Max. MHz	Resp. dB	SENSITIVITY Max. mV/cm	Min. V/cm	Input Imp. MΩ(pF)	Signal Delay µs	SWEEP SPEED Max. µs/cm	Min. s/cm	Trigger V(p-p)	Type C-Cab R-Rack P-Port.	Price Approx $
	H-P	H41-1208	vert (s)	0.15	0.001	ina	0.5	0.005	1 (150)	none	25mm/s	50mm/s	free run	C, R	625
	ITT	KP704 (17 inch)	vert 4	dc	0.005	ina	20	-	100 k	none	2.5mm/s	500mm/s	none	C, R	2650
	ITT	KP404 (14 inch)	vert 4	dc	0.005	ina	20	-	100 k	none	2.5mm/s	500mm/s	none	C, R	2550
	ITT	KP704-8 (17 inch)	vert 8	dc	0.005	ina	20	-	100 k	none	2.5mm/s	500mm/s	none	C, R	2950
	Texscan	DU-17	(e)	dc	0.01	3	1	1	1	none	ina	ina	ina	C	1375
S 1	Texscan	DU-88M	vert	dc	0.015	3	1 (h)	1 (h)	1 (30)	none	ina	ina	ina	C	595
			horz	dc	0.001	3	100 (h)	ina	1						
	Meas-Con	349	vert	dc	0.02	ina	1v (i)	-	1 (100)	none	none	none	yes	C	200
	ITT	KS307	vert	dc	0.05	3	100	-	1	none	0.5	10µs	yes	C, R	2950
		(23 inch)	horz	dc	0.05	3	500	-	100 k						
	ITT	KS407	vert	dc	0.05	3	100	-	1	none	0.5	10µs	yes	C, R	2570
		(14 inch)	horz	dc	0.05	3	100	-	100 k						
	ITT	KS707	vert	dc	0.05	3	100	-	1	none					
		(17 inch)	horz	dc	0.05	3	100	-	1		0.5	10µs	yes	C, R	2650
	ITT	KM910S	vert (s)	dc	0.05	3	0.2	-	1	none	none	none	none	C	1175
		(9 inch)	horz	dc	750 Hz	ina	100	-	100 k						
	ITT	KM302	vert (s)	dc	0.05	3	100	10	1	none	none	none	none	C, R	2595
		(23 inch)	horz	dc	0.05	3	100	-	100 k						
	ITT	KM302S4	vert (s)	dc	0.05	3	1 (i)	-	1	none	none	none	none	C, R	2990
		(23 inch)	horz	dc	0.05	3	100	-	100 k						
	ITT	KM402S4	vert (s)	dc	0.05	3	1 (i)	-	1	none	none	none	none	C, R	2560
		(14 inch)	horz	dc	0.05	3	100	-	100 k						
	ITT	KM402	vert	dc	0.05	3	100	10	1	none	none	none	yes	C, R	2195
		(14 inch)	horz	dc	0.05	3	100	-	100 k						
S 2	ITT	KM702	vert (s)	dc	0.05	3	100	10	1	none	none	none	none	C, R	2295
		(17 inch)	horz	dc	0.05	3	100	-	100 k						
	ITT	KM702S4	vert (s)	dc	0.05	3	1 (i)	-	1	none	none	none	none	C, R	2690
		(17 inch)	horz	dc	0.05	3	100	-	100 k						
	ITT	KM-708 (17 inch)	vert (s)	dc(3)	0.05	3	100	-	1	none	none	none	none	C, R	6000
	H-P	H40-1208	vert (s)	dc	0.05	ina	100	1	1 (150)	none	25mm/s	50mm/s	free run	C, R	525
	ITT	KM910	vert (s)	dc	0.05	3	100	-	100 k	none	none	none	none	R	950
		(9 inch)	horz	dc	750 Hz	ina	100	-	100 k						
	Fairchild	304A	vert 1	dc	0.1	-1	25 (i)	250(i)	2 (50)	none	30 kHz	2 Hz	yes	C	550
		304AR	vert 2	dc	0.3	-6									
			horz 1	dc	0.1	-1	300 (i)	30 (i)	2.2 (50)	none	none	none	none	R	575
			horz 2	dc	0.3	-6									
	Meas-Con	300	(f)	dc	0.1	-3	10 (h)	-	0.5 (100)	none	20 kHz	10 Hz	yes	C, R	160
	Millen	90905B/90921	vert	15	0.125	2	500	50	0.5	none	40 kHz	15 Hz	yes	R	234
			horz	15	0.125	2	700	70	0.5						
	Millen	90905/90921	vert	15	0.125	2	750	50	0.5	none	40 kHz	15 Hz	yes	R	204
			horz	15	0.125	2	900	90	0.5						
	Millen	90902/90921	vert	15	0.125	2	1100	50	0.5	none	40 kHz	15 Hz	yes	R	149
			horz	15	0.125	2	1700	ina	0.5						
S 3	Millen	90903/90921	vert	15	0.125	2	550	55	0.5	none	40 kHz	15 Hz	yes	R	162
			horz	15	0.125	2	710	71	0.5						
	Benrus	1100/700	(f)	dc	0.15	3	0.1	20	2 (50)	ina	1	5 (j)	0.5 cm	C	950
		1100R/700												R	960
	Benrus	1100/600	vert	dc	0.15	3	0.1	20	2 (50)	ina	1	5 (j)	0.5 cm	C	860
		1100R/600	horz	dc	0.5	3	40	ina	ina					R	870
	Benrus	1120/600	vert 1 (d1)	dc	0.15	3	0.1	20	2 (50)	ina	1	5 (j)	0.5 cm	C	955
		1120R/600	vert 2	dc	0.5	3	40	ina	ina					R	965
	Benrus	1120/700	(f)	dc	0.15	3	0.1	20	2 (50)	ina	1	5 (j)	0.5 cm	C	1045
		1120R/700												R	1055

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General Purpose Oscilloscopes *(continued)*

	Manufacturer	Model	Channel (notes)	FREQUENCY Min. Hz	Max. MHz	Resp. dB	SENSITIVITY Max. mV/cm	Min. V/cm	Input Imp. MΩ(pF)	Signal Delay μs	SWEEP SPEED Max. μs/cm	Min. s/cm	Trigger V(p-p)	Type C-Cab R-Rack P-Port	Price Approx $
	Roberts	627BR	vert	dc	0.15	1	22 (i)	ina	2 (50)	ina	30 kHz(j)	2 Hz	ina	R	486
			horz	dc	0.15	1	30 (i)	ina	2 (50)						
	H-P	122A	vert (d1)	dc	0.2	-3	10	10	1 (50)	none	5 (j)	0.2	5 mm	C	695
		122AR	horz	dc	0.2	-3	100	10	1 (100)					R	695
	Heath	10-21	(f)	2	0.2	±2	250	15	10 (20)	none	100 kHz	20 Hz	yes	C	50 (kit)
	Heath	10-10	(f)	dc	0.2	2	120	12	3.6 (35)	none	50 kHz	5 Hz	yes	C	80 (kit)
	Millen	90915	vert	dc	0.2	3	120	1200	5 (45)	none	30 kHz	2 Hz	yes	C	465
			horz	dc	0.2	3	170	1700	5 (45)						
S 4	Waterman	OCA-11A	(f)	dc	0.2	ina	10 (h)	50 (h)	1 (30)	none	30 kHz	3 Hz	yes	P	269
	Waterman	OCA-11B	(f)	dc	0.2	ina	10 (h)	50 (h)	1 (60)	none	1 (h)	10 (h)	yes	P	295
	Waterman	OCA-12A	vert (d1)	dc	0.2	ina	20 (h)	50 (h)	1 (60)	none	ina	ina	yes	P	295
	Simpson	466	vert	15	0.25	6	30	3.3	0.1 (40)	none	80 kHz(j)	15 Hz	yes	C	180
			horz	15	0.1	6	700	7.7	ina						
	Millen	90923	vert	dc	0.275	±0.3	430	41	0.5	none	30 kHz	2 Hz	yes	R	245
			horz	dc	0.25	±0.3	0.001	40	0.5						
	Gen-Atro	K-10-R	vert	dc	0.3	3	11	197	2 (40)	none	4.3	0.066(j)	ina	R	525
			horz	dc	0.1	ina	118	ina	2 (40)						
	Gen-Atro	K-11-R	(f)	dc	0.3	ina	0.5	150	1 (225)	none	1	1 (j)	1 cm	R	620
	Gen-Atro	K-13-R	(f)	dc	0.3	3	30 (i)	ina	1 (ina)	none	30 kHz	10 Hz	0.5	C	640
	H-P	120B	vert	dc	0.45	-3	10	10	1 (50)	none	5 (j)	0.2	5 mm	C, R	495
			horz	dc	0.3	-3	100	10	1 (100)						
	Tektronix	503	(f)	dc	0.45	-3	1	20	1 (47)	none	1	5	0.5	C	640
		RM503												R	655
S 5	Benrus	1100/100	(f)	dc	0.5	3	40	0.04	1 (100)	none	none	none	none	C	550
		1100R/100												R	560
	Benrus	1100/200	vert	dc	0.5	3	1	50	2 (45)	none	1	0.5 (j)	0.2	C	725
		1100R/200	horz	dc	0.5	ina	40	50	0.25					R	735
	Benrus	1100/300	(f)	dc	0.5	3	1	50	2 (45)	none	1	0.5 (j)	0.2	C	735
		1100R/300												R	795
	Benrus	1120/100	(f) (d1)	dc	0.5	3	40	0.04	1 (100)	none	none	none	none	C	645
		1120R/100												R	655
	Benrus	1120/300	(f) (d1)	dc	0.5	3	1	50	2 (45)	none	1	0.5 (j)	0.2	C	890
		1120R/300												R	900
	Benrus	1120/200	vert 1 (d1)	dc	0.5	3	1	50	2 (45)	none	1	0.5 (j)	0.2	C	820
		1120R/200	vert 2	dc	0.5	3	30	50						R	830
	Fairchild	701	vert	dc	0.5	-3	10	100	1 (40)	none	0.5 (j)	1	0.5 v	C, R	495
			horz	dc	0.35	-3	100	100	1 (50)						
	Fairchild	702	vert (d1)	dc	0.5	-3	10	100	1 (44)	none	0.5 (j)	1	0.5	C, R	850
			horz	dc	0.35	-3	100	100	1 (44)						
	Fairchild	704A	(f)(n)	dc	0.5	-3	0.2	50	1 (50)	none	0.2 (j)	15	0.5	C, R	850
	Fairchild	708A	vert (d2)(n)	dc	0.5	-3	0.01	25	1 (50)	none	0.1 (j)	6	0.5	C, R	995
			horz (0)	dc	0.5	-3	20	1	1 (50)						
S 6	H-P	130C	(f)	dc	0.5	-3	0.2	20	1 (45)	none	1 (j)	5	0.5 cm	C, R	695
	H-P	132A	vert (d2)	dc	0.5	-3	0.1	20	1 (50)	none	1 (j)	5	0.5 cm	C, R	1395
			horz	dc	0.3	-3	5	2	1 (50)						
	Tektronix	567/6R1A/3A2/3B2	vert (d1) (4)	dc	0.5	-3	10	10	1 (47)	none	2	1	0.5	C	4450
														R	4550
	Gen-Atro	K-12-R	(f)	dc	0.75	3	100	ina	1 (ina)	none	none	none	ina	C	ina
	Fairchild	737A	(f) (k) (s)	dc	1	-3	100 (h)	0.5 (h)	1 (45)	none	none	none	none	C, R	2995
	Meas-Con	701	(f) (s)	dc	1	-3	1 (h)	ina	1 (100)	none	none	none	none	C	595
	Tektronix	502A	vert (d2) (f)	dc	1	-3	0.1	20	1 (47)	none	1 (j)	5	0.2	C	1050
		RM502A	horz	dc	0.1	ina	100	2	1 (70)					R	1150
	Millen	90952	vert	10	1	3	400	120	2	none	2.4	0.12ms	yes	C	385
	Honeywell	270	vert (up to 7 per day)	dc	1.5	3	250 rms	2.5 rms	1 (200)	none	300 kHz	100 Hz	yes	R	request
	Grundig	W2/13	vert	3	2.5	ina	100	30	1 (36)	none	1	0.01	yes	C	363
			horz	2	0.5	ina	1500	ina	1 (36)						
S 7	Heath	10-12	vert	8	2.5	±1	28	2.8	3 (21)	none	500 kHz	10 Hz	yes	C	77 (kit)
			horz	1	0.4	±3	320	ina	30 (31)						
	Grundig	G3/13	vert	dc	3	ina	30	30	1 (36)	none	1	0.01	yes	C	447
			horz	dc	1	ina	1500	ina	1 (36)						
	Tektronix	310A	vert	dc	4	3	10 (h)	50 (h)	1 (40)	none	0.5(h)(j)	0.2 (h)	0.2	P	675
			horz	dc	0.5	ina	1500	ina	ina						
	Hickok	770A	vert (d1)	dc	4	3	10	50	1 (40)	none	0.2 (j)	1.5	0.5	C	635
			horz	dc	0.6	3	75 (i)	ina	ina						
	Grundig	W4/7	vert	5	4	ina	100	30	1 (36)	none	ina	ina	yes	C	199
			horz	1	0.4	ina	700	ina	1 (36)						

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Circle as many numbers on the reader-service card as you like.
Reader-service cards are good all year.

General Purpose Oscilloscopes *(continued)*

	Manufacturer	Model	Channel (notes)	FREQUENCY Min. Hz	FREQUENCY Max. MHz	FREQUENCY Resp. dB	SENSITIVITY Max. mV/cm	SENSITIVITY Min. V/cm	Input Imp. MΩ(pF)	Signal Delay µs	SWEEP SPEED Max. µs/cm	SWEEP SPEED Min. s/cm	Trigger V(p-p)	Type C-Cab R-Rack P-Port.	Price Approx $
S 8	Hickok	675A	vert	dc	4.5	3	20	ina	ina	none	100kHz(j)	10 Hz	sync	C	395
			horz	1	0.45	3	250	45 (i)							
	Hickok	677	vert	5	4.5	3	35 (i)	ina	3 (10)	none	500kHz(j)	10 Hz	ina	C	220
			horz	5	0.35	3	ina	ina	ina						
	RCA	WO-91A	vert	10	4.5	±1	20	58	1 (40)	none	100 kHz	10 Hz	yes	C	250
			horz	10	0.5	-6	600	ina	2.2 (30)						
	Waterman	OCA-16A	vert	dc	5	ina	50 (h)	ina	1	none	0.1 (h)	ina	yes	P	request
	Honeywell	275	vert	dc	5	3	700	2	100k (180)	none	1 MHz	100 Hz	yes	R	2600
				50	5	3	p-p	p-p							
	Grundig	MO5/7	vert	dc	5	ina	30	10	1 (36)	none	1	0.1	yes	C	558
			horz	dc	2	ina	1000	ina	1 (36)						
	Cal-Inst	7000	vert	dc	5	-1	100 (i)	10 (i)	1 (100)	none	1 MHz	10 Hz	yes	R	3150
	Binary	5Mc2P	(f)	dc	5	3	100	100	1 (30)	none	1	1	yes	C, R	950
	Aul	055	vert	dc	5	ina	50 (h)	20 (h)	1 (45)	none	1 (h)	0.3 (h)	yes	P	435
			horz	dc	0.45	ina	500 (h)	ina	50 k						
	Allied R	KE-2100	vert	dc	5	-3	50	20	1 (40)	none	0.2	0.05	0.2	C	250 (kit)
			horz	dc	0.8	±3	40	ina	1						
S 9	Allied R	KG-630	vert	5	5	±3	20 (i)	ina	2.9 (21)	none	600 kHz	15 Hz	yes	C	80 (kit)
			horz	ina	ina	ina	ina	ina	100 k						
	Simpson	458	vert	10	5	±2	55	55	3.3 (20)	none	250kHz(j)	15 Hz	yes	C	390
			horz	20	0.2	±1	175	1.5	1.1						
	Allied R	KG-635	vert	dc	5.2	±1.5	7	ina	3 (35)	none	400 kHz	10 Hz	0.15	C	110 (kit)
			horz	1	0.4	±1.5	600 (i)	ina	7 (25)						
	Sencore	PS127	vert	10	5.2	±1	170 (i)	ina	27 (9)	none	500 kHz	5 Hz	ina	C	200
			horz	10	0.65	3	ina	ina	ina						
	RCA	WO-33A	vert	5.5	5.5	3	120	1.1	1 (50)	none	75 kHz	15 Hz	yes	C	130
			horz	20	0.15	3	100	ina	ina						
	Grundig	TO6/7	vert	dc	6	ina	30	10	1 (36)	none	1	0.1	yes	C	841
			horz	dc	1	ina	1000	ina	1 (36)						
	Tektronix	321A	vert	dc	6	-3	10 (h)	20 (h)	1 (35)	none	0.5 (h)(j)	500 µs	1	P	900
			horz	dc	1	-3	1000 (h)	ina	0.1 (30)						
	Roberts	622A	vert	6	6	±3	10 (i)	ina	1 (50)	ina	300 kHz	10 Hz	ina	C	260
			horz	1.5	0.5	±3	75 (i)	ina	0.1 (25)						
	Heath	10-14	vert	dc	8	-3	0.05	ina	1 (15)	0.25	1 (j)	0.5	yes	C	259 (kit)
	Tektronix	317	vert	dc	10	-3	10 (h)	50 (h)	1 (40)	0.25	0.2 (h)(j)	2 (h)	0.5	C	875
		R317	horz	dc	0.5	-3	1400 (h)	ina	0.1					R	950
S 10	Meas-Con	100	vert	dc	10	-3	50 (h)	ina	1 (75)	none	500 kHz	0.5 Hz	ina	C	275
				10	10	-3	50 (h)	ina	ina						
	Gen-Atro	K-14-R	vert	dc	10	3	10 (h)	50 (h)	1 (ina)	0.025	0.02 (j)	0.02	2 mm	C, R	ina
			horz	dc	0.5	ina	ina	ina	ina						
	Amer-El	725	vert	dc	10	ina	10 (h)	50	1 (47)	none	0.02 (j)	0.2	±30	P, R	ina
			horz	dc	0.5		500 (h)	5	ina						
	H-P	193A	vert (w)	100	10.5	-3	ina	ina	ina	ina	(2)	(2)	yes	C, R	1350
	H-P	191A	vert (w)	100	10.5	-3	ina	ina	ina	ina	(1)	(1)	yes	C	1475
	Tektronix	422	vert (d1)	dc	15	-3	10 (h)	20 (h)	1 (30)	0.15	0.5(h)(j)	0.5 (h)	0.125	P	1325
		R422	vert 2	2	5	-3	1 (h)	2 (h)	1 (30)	0.15					
	Marconi	TF2203	vert	dc	15	-3	50	20	1 (28)	none	0.2	0.1	0.2	P	595 (7)
			horz	dc	4	-3	0.0015	-	ina						
	Grundig	MO15/10	vert	dc	15	ina	30	10	1 (36)	none	0.1	0.1	yes	C	1210
			horz	dc	2	ina	100	ina	1 (36)						
	Grundig	1O16/13	vert	dc	15	ina	30	10	1 (36)	none	0.1	0.3	yes	C	1630
			horz	dc	2	ina	100	ina	1 (36)						
	Grundig	1O2	vert	dc	20	ina	30	10	1 (36)	none	0.1	1	yes	C	2378
			horz	dc	1	ina	1000	2.5	1 (36)						
S 11	H-P	155A/1550A	vert (t)	dc	25	-3	5	20	1 (50)	yes	0.1 (j)	0.05	0.5 cm	C	2450(u)
				2	25	-3									
	Tektronix	453	vert (d1)	dc	50 (5)	-3	20 (h)	10 (h)	1 (20)	yes	0.1 (h)	5 (h)	0.2	P	1950
			vert (d1)	dc	45 (5)	-3	10 (h)	-	1 (20)	yes				R	2035
			vert (d1)	dc	40 (5)	-3	5 (h)	-	1 (20)	yes	(6)	(6)			
			vert	dc	25	-3	1 (h)	-	1 (20)	yes					
			horz	dc	5	-3	5 (h)	10 (h)	1 (20)	yes					
	Fairchild	977A	vert 2	dc (v)	100	-3	25 (q)	2.5	50Ω	0.04	0.2	0.01	0.2	C	8200(r)
	Tektronix	454	vert (d1)	dc	150 (5)	-3	20 (h)	10 (h)	1 (20)	yes	0.05 (h)	5 (h)	0.375	P	2550
		R454	vert (d1)	dc	100 (5)	-3	10 (h)	-	1 (20)	yes				R	2635
			vert (d1)	dc	60 (5)	-3	5 (h)	-	1 (20)	yes	(6)	(6)			
			vert	dc	35	-3	1 (h)	-	1 (20)	yes					
			horz	dc	2	-3	5 (h)	10 (h)	1 (20)	yes					
	EGG	707	vert	dc	2000	3	55	10	50Ω (ina)	0.06	0.005	5 ns	55mV	C	4090

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Sampling Oscilloscopes

	Manufacturer	Model	Channel (notes)	FREQUENCY dc to GHz	FREQUENCY Resp. dB	Rise Time ps	SENSITIVITY Max. mV/cm	SENSITIVITY Min. mV/cm	Input Imp. Ω(pF)	Noise mV	Delay Line ns	dc Offset V	SWEEP SPEED Max. ns/cm	SWEEP SPEED Min. µs/cm	CRT, Details	Price Approx $
	Tektronix	567/3S76/3T4/6R1A	(e) (c)	0.875	-3	400	2	200	(50)	2 p-p	yes	±1	1 (k)	200	5 in., 3.5kV(i)	5700
	Tektronix	RM567/3S76/3T4/6R1A	(e) (c)	0.875	-3	400	2	200	(50)	2 p-p	yes	±1	1 (k)	200	5 in., 3.5kV(i)	5800
	Tektronix	564/3S76/3T4	(e) (c)	0.875	-3	400	2	200	(5)	2 p-p	yes	±1	1 (k)	200	5 in., 3.5kV(h)	3275
	Tektronix	RM564/3S76/3T4	(e) (c)	0.875	-3	400	2	200	(5)	2 p-p	yes	±1	1 (k)	200	5 in., 3.5kV(h)	3360
	Tektronix	561A/3S76/3T4	(e) (c)	0.875	-3	400	2	200	(50)	2 p-p	yes	±1	1 (k)	200	5 in. 3.5kV	2900
S 12	Tektronix	RM561A/3S76/3T4	(e) (c)	0.875	-3	400	2	200	(50)	2 p-p	yes	±1	1 (k)	200	5 in., 3.5kV	2950
	Tektronix	561A/3S76/3T77A	(e) (c)	0.875	-3	400	2	200	(50)	2 p-p	55	-1 to +1	0.2	10	5 in., 3.5kV(f)	2250
	Tektronix	RM561A/3S76/3T77A	(e) (c)	0.875	-3	400	2	200	(50)	2 p-p	55	-1 to +1	0.2	10	5 in., 3.5kV(f)	2300
	Tektronix	564/3S76/3T77A	(e) (c)	0.875	-3	400	2	200	(5)	2 p-p	55	-1 to +1	0.2	10	5 in., 3.5kV(h)	2625
	Tektronix	RM564/3S76/3T77A	(e) (c)	0.875	-3	400	2	200	(5)	2 p-p	55	-1 to +1	0.2	10	5 in., 3.5kV(h)	2710
	Tektronix	567/3S76/3T77A/6R1A	(e) (c)	0.875	-3	400	2	200	(50)	2 p-p	55	-1 to +1	0.2	10	5 in., 3.5kV(i)	5050
	Tektronix	RM567/3S76/3T77A/6R1A	(e) (c)	0.875	-3	400	2	200	(50)	2 p-p	55	-1 to +1	0.2	10	5 in., 3.5kV(i)	5150
	Tektronix	1S1 (plug-in)	vert (g)	1	-3	350	2	200	(50)	1	yes	±1	0.1	50	(g)	1100
	Tektronix	561A/3S3/3T77A	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.2	10	5 in., 3.5kV	2650
	Tektronix	RM561A/3S3/3T77A	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.2	10	5 in., 3.5kV	2700
S 13	H-P	141A/1410A/1424A	vert (c)	1	-3	350	1	200	100k (2)	1	ina	ina	0.01	500	10 x 10 cm 7.3kV, P31(h)	4195
	Tektronix	564/3S3/3T77A	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.2	10	5 in., 3.5kV(h)	3025
	Tektronix	RM564/3S3/3T77A	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.2	10	5 in., 3.5kV(h)	3110
	H-P	140A/1410A/1424A	vert (c)	1	-3	350	1	200	100k (2)	1	ina	ina	0.01	500	10 x 10 cm 7.3kV, P31(f)	3395
	Tektronix	567/3S3/3T77A/6R1A	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.2	10	5 in., 3.5kV(i)	5450
	Tektronix	RM567/3S3/3T77A/6R1A	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.2	10	5 in., 3.5kV(i)	5550
	H-P	141A/1410A/1425A	vert (c)	1	-3	350	1	200	100k (2)	1	ina	ina	1	10	10 x 10 cm 7.3kV, P31(h)	4595
	Tektronix	661/4S1/5T3	(e) (c)	1	-3	350	2	200	(50)	1	yes	±1	0.01	5s	5 in., 3kV(f)	3380
	H-P	140A/1410A/1425A	vert (c)	1	-3	350	1	200	100k (2)	1	ina	ina	1	10	10 x 10 cm 7.3kV, P31(f)	3795
	Tektronix	661/4S3/5T3	(e) (c)	1	-3	350	2	200	100k (2)	1	none	±1	0.01	5s	5 in., 3kV	4400
S 14	Tektronix	567/3S3/3T4/6R1A	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	1 (k)	200	5 in., 3.5kV(i)	6100
	Tektronix	RM567/3S3/3T4/6R1A	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	1 (k)	200	5 in., 3.5kV(i)	6200
	Tektronix	564/3S3/3T4	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	1 (k)	200	5 in., 3.5kV(h)	3675
	Tektronix	RM564/3S3/3T4	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	1 (k)	200	5 in., 3.5kV(h)	3760
	Tektronix	561A/3S3/3T4	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	1 (k)	200	5 in., 3.5kV	3300

(tables continued on page T26)

Sampling Oscilloscopes *(continued)*

	Manufacturer	Model	Channel (notes)	FREQUENCY dc to GHz	Resp. dB	Rise Time ps	SENSITIVITY Max. mV/cm	Min. mV/cm	Input Imp. Ω (pF)	Noise mV	Delay Line ns	dc Offset V	SWEEP SPEED Max. ns/cm	Min. us/cm	CRT, Details	Price Approx $
	Tektronix	RM561A/ 3S3/3T4	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	1 (k)	200	5 in., 3.5kV	3400
	Tektronix	564/3S3/ 3T2	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.02	100	5 in., 3.5kV(h)	3325
	Tektronix	RM564/3S3/ 3T2	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.02	100	5 in., 3.5kV(h)	3410
	Tektronix	561A/3S3/ 3T2	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.5	0.02	100	5 in., 3.5kV	2950
	Tektronix	RM561A/3S3/ 3T2	(e) (c)	1	-3	350	5	100	100k (2)	2	none	±0.05	0.02	100	5 in., 3.5kV	3000
S 15	Tektronix	1S2 (plug-in)	vert (g) vert (j)	3.9	-3	90	5	500	(50)	2	none	±2	10	1	(g)	1300
	Tektronix	661/4S2A/ 5T3	(e) (c)	3.9	-3	90	2	200	(50)	4	none	±1	0.01	5s	5 in., 3kV	4400
	H-P	140A/1411A/ 1425A	vert (c)	12.4	ina	(1)	1	200	ina	ina	ina	ina	1	10	10 x 10 cm 7.3kV, P31(f)	(m)
	H-P	141A/1411A/ 1425A	vert (c)	12.4	ina	(1)	1	200	ina	ina	ina	ina	1	10	10 x 10 cm 7.3kV, P31(h)	(n)
	H-P	141A/1411A/ 1424A	vert (c)	12.4	ina	(1)	1	200	ina	ina	ina	ina	0.01	500	10 x 10 cm 7.3kV, P31(h)	(p)

General Purpose Oscilloscope Notes

d1. Dual-trace instrument.
d2. Dual-beam instrument.
e. Multi-channel scope.
f. Identical vertical and horizontal amplifiers.
h. Per division.
i. Per inch.
j. Time base expansion.
n. Selectable 5, 50 and 500 kHz bandwidth.
q. Thry 30 MHz preamp.
r. Includes 2 vertical preamps and sweep plug-ins, camera and film transport (35 mm).
s. Monitoring scope.
t. Programmable.
u. Option 01: Without programming capability $2150.
v. Two high writing rate fiber optic CRT's – common sweep.
w. Television scope.

1. Internal sweep: 2V: (2.5 ms/cm); ±5% for X1, X10 and X25.
   2H: (10μs/cm); ±3% for X1, X10; ±5%, X25.
   H-Line select: (10μs/cm)-Line selection for lines 16–21; variable line for all lines in the field.
2. Internal sweep: H-Line select: 0.125 H/cm.
   2V: (0.175 V/cm); 5% X1, X5 and X25.
   2H: (0.125 H/cm); 3% X1, X5; 5%, X25.
3. Horizontal axis: 15 kHz sawtooth waveform full screen.
4. Includes digital readout plug-in.
5. Indicated bandwidth is with X10 probe, included.
6. Bandwidths, 45, 40, 25 and 5 MHz, 1μs-50s calibrated sweep delay.
7. TF2203 with rechargeable batteries $695.

Sampling Oscilloscope Notes

c. Dual-trace instrument.
e. Identical vertical and horizontal amplifiers.
f. Other tube phosphors available.
g) Single-trace sampling plug-in fits 530, 540 and 550 series main frames, also 580 series with adapter.
h. Storage scope.
i. Includes digital readout plug-in.
j. Operates as a reflectometer, system rise time of 140 ps, vertical scale calibrated in p (rho) from 0.005 p/div. to 0.5 p/div., horizontal scale calibrated in time from 10 m to 10 km full scale. X1 to X100 magnifier. Lighted digital readout of time or distance/division.
k. Programmable.
m. Price 140A main frame $595; 1411A sampling amplifier $700; 1425A sampling time base $1600, 1432A, 90 ps sampler $1000; 1430A dc-12.4 GHz sampler $3000; 1431A dc to 12.4 GHz, $3000.
n. Price 141A main frame $1395. Price of plug-ins same as note m.
p. Price: 141A main frame $1395; 1411 sampling amplifier $700; 1424A sampling time base $1200; 1432A 90 ps sampler $1000; 1430A dc-12.4 GHz sampler $3000; 1431A dc to 12.4 GHz $3000.

Main Frame Oscilloscopes

	Manufacturer	Model	Channel (notes)	FREQUENCY			SENSITIVITY		SWEEP SPEED		Int Calib	Mounting	Price Approx $
				Min. Hz	Max. MHz	Resp. dB	Max. mV/cm	Min. V/cm	Max. ns/cm	Min. s/cm			
S 16	Tektronix	567	(a)	dc	0.5	-3	(a)	(a)	(a)	(a)	yes	C	3300
		RM567										R	3400
	Benrus	RA850	vert	dc	0.5	ina	(a)	(a)	(a)	(a)	ina	C, R (g)	395
			horz	dc	0.5								
	Benrus	RA840B	vert (j)	dc	0.5	ina	(a)	(a)	(a)	(a)	ina	C, R	295
			horz	dc	0.5								
	Gen-Atro	K-270	vert (c)	dc	5	-3	(a)	(a)	(a)	(a)	yes	C	1700
			horz	dc	5	-3							
	Gen-Atro	K-105	vert	dc	6	-3	(b)	(b)	100	0.1	yes	C	696
			horz	dc	0.5	-3	500	5					
	Gen-Atro	K-106	vert	dc	6	-3	(b)	(b)	100	0.1	yes	C	995
			horz	dc	0.5	-3	500 (h)	5 (h)					
	Tektronix	565	vert (c)	dc	10	-3	(b)	(b)	1000	5	yes	C	1400
		RM565	horz	dc	0.35	-3	100	30				R	1500
	Tektronix	536	(e)	dc	11	-3	(a)	(a)	(a)	(a)	yes	C	1085
	Tektronix	564	(a) (h)	dc	15	-3	(a)	(a)	(a)	(a)	yes	C	875
		RM564										R	960
	Gen-Atro	GA-151	vert (i)	dc	15	3	(a)	(a)	(a)	(a)	yes	C	795
			horz	dc	1	3							
S 17	Gen-Atro	GA-255	vert (j)	dc	15	3	(a)	(a)	(a)	(a)	yes	C	1530
			horz	dc	1	3							
	Gen-Atro	K-115	vert	dc	15	3	(b)	(b)	100	0.1	yes	C	1275
	Tektronix	561A	(a)	dc	15	-3	(a)	(a)	(a)	(a)	yes	C	500
		RM561A										R	550
	Tektronix	531A	vert	dc	15	-3	(b)	(b)	100	5	yes	C	995
		RM531A	horz	dc	0.35	-3	200	20				R	1095
	Tektronix	533A	vert	dc	15	-3	(b)	(b)	100	5	yes	C	1125
			horz	dc	0.5	-3	100	10					
	Tektronix	535A	vert	dc	15	-3	(b)	(b)	100	5	yes	C	1400
		RM535A	horz	dc	0.35	-3	200	20				R	1500
	H-P	140A	(a)	dc	20	-3	(a)	(a)	(a)(k)	(a)	yes	C, R	595
	H-P	141A	(a) (h)	dc	20	-3	(a)	(a)	(a)	(a)	yes	C, R	1395
	Tektronix	551	vert (s)	dc	27	-3	(b)	(b)	100	5	yes	C	1850
			horz	dc	0.4	-3	200	50					
	Hickok	1805A	vert	dc	30	(b)	(b)	(b)	(b)	(b)	yes	C	1340
				dc	0.24								

(tables continued on page T28)

Plug-In and Main Frame Oscilloscope Notes

a. Both horizontal and vertical amplifiers are plug-ins. For complete specifications, see plug-in tables.

Vertical amplifier is a plug-in. Specifications are for main frame and built-in horizontal amplifier. See plug-in tables for vertical amplifier specifications.

Multi-channel scope.

d. Other tube phosphors are available.

e. Identical vertical and horizontal amplifiers.

g. Two units fit into 5-1/4 inch rack.

h. Storage scope with split screen.

i. Single trace scope.

j. Dual trace scope.

Time base is also delay generator.

n. Sweep switching.

q. Differential unit.

r. Uses 9571 vertical plug-in and any horizontal plug-in.

s. Dual-beam.

t. Accepts two vertical plug-ins.

u. Higher sensitivity at reduced bandwidth.

v. CRT can be digitized and recorded.

x. Includes internal delay line.

y. Carrier amplifier: 10µ strain - 10,000µ strain/division.

z. Automatic programmable unit.

Main Frame Oscilloscopes *(continued)*

	Manufacturer	Model	Channel (notes)	FREQUENCY Min. Hz	FREQUENCY Max. MHz	FREQUENCY Resp. dB	SENSITIVITY Max. mV/cm	SENSITIVITY Min. V/cm	SWEEP SPEED Max. ns/cm	SWEEP SPEED Min. s/cm	Int Calib	Mounting	Price Approx $
	Marconi	TF2201	vert (j)	dc	30	3	(a)	(a)	(a)	(a)	ina	C, R	1975
			horz	2	30	3							
	Tektronix	555	vert	dc	33	-3	(a)	(a)	100 (k)	5	yes	C	2650
			horz	dc	0.35	-3							
	Tektronix	543B	vert	dc	33	-3	(b)	(b)	100	5	yes	C	1300
		RM543B	horz	dc	0.5	-3	100	10				R	1400
	Tektronix	545B	vert	dc	33	-3	(b)	(b)	100 (k)	5	yes	C	1550
		RM545B	horz	dc	0.35	-3	200	20				R	1650
	Tektronix	549	vert (h)	dc	33	-3	(b)	(b)	100	5	yes	C	2375
			horz	dc	0.35	-3	200	20					
S 18	Marconi	TF2200A	vert	dc	36	ina	(b)	(b)	50	2	ina	C	1950
			horz	2	2.4	ina	70	3.5					
	Fairchild	765MH	vert (j)	dc	50	-3	(a)	(a)	(a)	(a)	yes	P	985
		(MIL)	horz	dc	5	-3							
	Fairchild	766H	vert	dc	50	-3	(a)	(a)	(a)	(a)	yes	C	650
			horz (j)	dc	5	-3							
	Fairchild	767H	vert	dc	50	-3	(a)	(a)	(a)	(a)	yes	R	695
			horz	dc	5	-3							
	H-P	175A	vert	dc	50	-3	(a)	(a)	(a)	(a)	yes	C	1325
			horz	dc	0.5	-3							
	H-P	180A	vert	dc	50	-3	(a)	(a)	(a)	(a)	yes	C	825
		180AR	horz	dc	5	-3						R	900
	Tektronix	556	vert (t)	dc	50	-3	(b)	(b)	100	5	yes	C	3150
		R556	horz	dc	0.4	-3	100	10				R	3250
	Tektronix	547	vert	dc	50	-3	(b)	(b)	100	5	yes	C	1875
		RM547	horz	dc	0.4	-3	100	10	(k) (n)			R	1975
	Tektronix	546	vert	dc	50	-3	(b)	(b)	100 (k)	5	yes	C	1750
		RM546	horz	dc	0.4	-3	100	10				R	1850
	Tektronix	544	vert	dc	50	-3	(b)	(b)	100	5	yes	C	1550
		RM544	horz	dc	0.4	-3	100	10				R	1650
S 19	Tektronix	585A	vert	dc	85	-3	(b)	(b)	50	2	yes	C	1725
		RM585A	horz	dc	0.35	-3	200	15				R	1825
	Tektronix	581A	vert	dc	85	-3	(b)	(b)	50	2	yes	C	1475
			horz	dc	0.35	-3	200	15					
	Fairchild	765MH/F	vert (j)	dc	100	-3	(a)	(a)	(a)	(a)	yes	P	1060
		(MIL)	horz	dc	5	-3							
	Fairchild	766H/F	vert (j)	dc	100	-3	(a)	(a)	(a)	(a)	yes	C	720
			horz	dc	5	-3							
	Fairchild	767H/F	vert	dc	100	-3	(a)	(a)	(a)	(a)	yes	R	770
			horz	dc	5	-3							
	Fairchild	9570	vert	dc	100	-3	20 (r)	100 (r)	(r)	(r)	yes	R	1030
			horz	dc	5	-3	(r)	(r)					
S 20	Fairchild	777	vert 2 (s)	dc	100	-3	(a)	(a)	(a)	(a)	yes	C, R	1600
			horz 2 (s)	dc	5	-3							
	Tektronix	647A	vert	dc	100	-3	(a)	(a)	(a)	(a)	yes	C	1500
		R647A	horz	dc	3	-3						R	1625

Vertical Amplifier Plug-Ins (Single Trace)

	Manufacturer	Model	FREQUENCY Min. Hz	FREQUENCY Max. MHz	FREQUENCY Resp. dB	SENSITIVITY Max. mV/cm	SENSITIVITY Min. V/cm	Input Impedance MΩ(pF)	Common Mode Rej.	Main Frames for Plug-In	Price Approx $
	Tektronix	3C66	dc	0.05	-3	(y)	(y)	AC Bridge	no	561A, 564, 565	400
	Tektronix	Q	dc	0.06	-3	(y)	(y)	AC Bridge	no	530, 540, 550, 580 Series	325
	Tektronix	E	0.06	0.06	-3	0.05	0.01	10 (50)	yes	530, 540, 550 & 580	190
	Hickok	1825	0.06	0.06	3	50 nV	0.025	ina	yes	1805A	190
	Benrus	VA227	dc	0.1	ina	40	ina	0.04 (ina)	no	RA840B, RA850A	125
S 21	Benrus	VA228	dc	0.1	ina	10	ina	0.01 (ina)	no	RA840B, RA850A	135
	Benrus	VA226	dc	0.1	ina	100	ina	0.1 (ina)	no	RA840B, RA850A	120
	Benrus	VA2252	dc	0.1	ina	400	ina	0.4 (ina)	no	RA840B, RA850A	110
	Benrus	VA224	dc	0.1	ina	2V	ina	1 (ina)	no	RA840B, RA850A	105
	Benrus	VA217	10	0.1	ina	4	ina	1 (ina)	no	RA840B, RA850A	105

(tables continued on page T30)

Vertical Amplifier Plug-Ins (Single Trace) *(continued)*

	Manufacturer	Model	FREQUENCY Min. Hz	Max. MHz	Resp. dB	SENSITIVITY Max. mV/cm	Min. V/cm	Input Impedance MΩ (pF)	Common Mode Rej.	Main Frames for Plug-In	Price Approx $
	Benrus	VA216	10	0.1	ina	10	ina	0.5 (ina)	no	RA840B, RA850A	90
	Benrus	VA212	10	0.1	ina	400	ina	1 (ina)	no	RA840B, RA850-A	65
	Tektronix	2A63	dc	0.3	-3	1	20	1 (47)	yes	561A, 564, 565	150
	Tektronix	2A61	0.06	0.3	-3	0.01	0.02	10 (50)	yes	561A, 564, 565	385
	H-P	1407A	dc	0.4	-3	0.1	20	1 (90)	yes	140A, 141A	625
S 22	H-P	1406A	dc	0.4	-3	0.05	20	1 (100)	yes	140A, 141A	850
	H-P	1400A	dc	0.4	-30	0.1	20	1 (45)	yes	140A, 141A	250
	H-P	1403A	0.1	0.4	-3	0.01	0.1	1 (60)	yes	140A, 141A	475
	H-P	1401A	dc	0.45	-3	50	10	1 (45)	yes	140A, 141A	425
	Tektronix	1A7	dc	0.5	-3	0.01	10	1 (47)	yes	530, 540, 550, 580 Series	425
	Gen-Atro	80-C	dc	0.5	-3	2	ina	1 (40)	yes	K-480	348
	Benrus	VA214	10	0.5	ina	100	ina	1 (ina)	no	RA840B, RA850A	80
	Benrus	VA215	10	0.5	ina	40	ina	1 (ina)	no	RA840B, RA850A	85
	Benrus	VA213	10	0.5	ina	400	ina	0.5 (ina)	no	RA840B, RA850A	75
	Benrus	VA211	10	0.5	ina	2V	ina	1 (ina)	no	RA840B, RA850A	45
S 23	Fairchild	74-12	dc	0.85	-3	1	25	1 (37)	yes	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	145
	Tektronix	2A60	dc	1	-3	50	50	1 (47)	no	561A, 564, 565	105
	Fairchild	74-15	dc	1	-3	20	200	1 (33)	no	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	89
	Gen-Atro	80-B	dc	1	-3	10	ina	1 (40)	no	K-480	282
	Tektronix	1A6	dc	2	-3	1	50	1 (33)	yes	530, 540, 550, 580 Series	230
	Tektronix	D	dc (v)	2	-3	50	50	1 (47)	yes	530, 540, 550, 580 Series	170
	Hickok	1824	350 kHz	2	ina	1	50	ina	yes	1805A	150
	Tektronix	3A8 (OP AMP)	dc	3.5	-3	20	10	1 (47)	no	561A, 564, 565	600
	Tektronix	3A75	dc	4	-3	50	20	1 (47)	no	561A, 564, 565	175
	Fairchild	76-08	dc (x)	5	-3	0.5	50	1 (23)	yes	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777	650
S 24	Fairchild	74-19	dc	5	-3	50	60	1 (40)	no	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	175
	Gen-Atro	80-A	dc	5	-3	50	ina	1 (40)	no	K-480	242
	Gen-Atro	MX2996	dc	6	-3	0.1	50	1 (47)	no	K-106	ina
	Tektronix	3A7	dc (u)	10	-3	50	50	1 (20)	yes	561A, 564, 565	635
	Tektronix	Z	dc	13	-3	50	25	1 (24)	yes	530, 540, 550, 580 Series	525
	Tektronix	3A5	dc (z)(u)	15	-3	10	50	1 (24)	no	561A, 564	760
	Tektronix	H	dc	15	-3	5	20	1 (47)	no	530, 540, 550, 580 Series	185
	Gen-Atro	GA-15	dc	15	3	10	20	1 (47)	no	GA-151, GA-255	228
	Gen-Atro	ST-106	dc (h)	15	ina	10	20	1 (47)	no	K-105, K-106, K-115, K-270, K-480	395
S 25	Hickok	1827	dc	20	ina	50	20	ina	yes	1805A	180
	Hickok	1822	dc	20	ina	5	50	ina	no	1805A	130
	Tektronix	B	dc (u)	20	-3	50	20	1 (47)	no	530, 540, 550, 580 Series	145
	Tektronix	G	dc	20	-3	50	20	1 (47)	yes	530, 540, 550, 580 Series	190
	H-P	1752A	dc	22	-3	5	20	1 (35)	yes	175A	225
	Tektronix	W	dc (u)	23	-3	50	50	1 (20)	yes	530, 540, 550, 580 Series	550

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Vertical Amplifier Plug-Ins (Single Trace) *(continued)*

	Manufacturer	Model	FREQUENCY Min. Hz	FREQUENCY Max. MHz	FREQUENCY Resp. dB	SENSITIVITY Max. mV/cm	SENSITIVITY Min. V/cm	Input Impedance MΩ(pF)	Common Mode Rej.	Main Frames for Plug-In	Price Approx $
S 26	Fairchild	76-01A	dc	25	-3	5	25	1 (40)	no	765MH, 766H, 765MH/F 766H/F, 767H/F, 777	315
	Fairchild	79-02A	dc (x)	25	-3	1	50	1 (14)	no	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777	930
	Tektronix	0 (OP AMP)	dc	25	-3	50	20	1 (47)	no	530, 540, 550, 580 Series	525
	Hickok	1832	dc (u)	30	ina	50	50	ina	no	1805A	178
	Tektronix	L	dc (u)	30	-3	50	20	1 (20)	no	530, 540, 550, 580 Series	210
	Hickok	1831	dc	30	ina	50	50	ina	no	1805A	126
	Tektronix	K	dc	30	-3	50	20	1 (20)	no	530, 540, 550, 580 Series	145
	Marconi	TM6457A	dc	34	ina	50	50	1 (30)	yes	TF2200A	495
	Tektronix	1A5	dc (q)	50	-3	5	20	1 (20)	yes	530, 540, 550, 580 Series	550
			dc	45	-3	2	N/A	1 (20)	yes		
			dc	40	-3	1	N/A	1 (20)	yes		
	Marconi	TM6455A	dc	55	ina	50	50	1 (30)	no	TF2200A	220
S 27	Tektronix	10A1	dc (u)	55	-3	5	20	1 (20)	yes	647A, R647A	900
	Tektronix	86	dc (u)	85	-3	100	20	1 (15)	no	581A, 585A	350
	Fairchild	76-05	dc (x)	100	-3	5000	8	50Ω	no	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777	225

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Vertical Amplifier Plug-Ins (Dual Trace)

	Manufacturer	Model	FREQUENCY dc to MHz	FREQUENCY Resp. dB	SENSITIVITY Max. mV/cm	SENSITIVITY Min. V/cm	Input Imp. MΩ(pF)	Common Mode Rej.	Main Frames for Plug-In	Price Approx $
S 28	Gen-Atro	70-E	0.05	-3	0.05	0.05	2 (25)	no	K-270	ina
	Gen-Atro	70-D	0.25	-3	0.5	0.5	2 (25)	no	K-270	245
	H-P	1401A	0.45	-3	1	10	1 (45)	yes	140A, 141A	425
	Gen-Atro	70-C	0.5	-3	2	2	2 (25)	no	K-270	235
	Tektronix	3A2	0.5	-3	10	10	1 (47)	no	561A, 564, 565, 567, 568	500
	Tektronix	3A3	0.5	-3	0.1	10	1 (47)	yes	561A, 564, 565, 567, 568	790
	Tektronix	3A72	0.65	-3	10	20	1 (47)	no	561A, 564, 565, 567, 568	275
	Tektronix	3A74 (4 Trace)	2	-3	20	10	1 (47)	no	561A, 564, 565, 567	590
	Gen-Atro	70-A	5	-3	50	50	2 (25)	no	K-270	215
	H-P	1405A	5	-3	5	10	1 (43)	yes	140A, 141A	325
S 29	Gen-Atro	DT-106	6	ina	50/div	50/div	1 (47)	no	K-105, K-106, K-115, K-270	590
	Tektronix	3A6	10 (x)	-3	10	10	1 (47)	no	561A, 564, 565, 567	525
	Tektronix	3A1	10	-3	10	10	1 (47)	no	561A, 564, 565, 567	490
	Gen-Atro	GA16	15	-3	50/div	20/div	1 (47)	no	GA-151, GA-255	514
	Fairchild	76-06 (4 Trace)	20	-3	20	20	1 (37)	no	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777	695
			1	-3	2	2	1 (37)	no		
	H-P	1402A	20	-3	5	10	1 (43)	yes	140A, 141A	575
	Tektronix	M	20	-3	20	10	1 (47)	no	530, 540, 550, 580	525
	Tektronix	C-A	24	-3	50	20	1 (20)	no	530, 540, 550, 580	260
	Hickok	1823A	24	-3	50	20	1 (20)	no	1805	220
	Fairchild	76-02A	25	-3	5	25	1 (40)	no	765MH, 766H, 767H, 765MH/F, 766MH/F, 777	475

(tables continued on page T32)

Circle as many numbers on the reader-service card as you like.
Reader-service cards are good all year.

Vertical Amplifier Plug-Ins (Dual Trace) *(continued)*

	Manufacturer	Model	FREQUENCY dc to MHz	FREQUENCY Resp. dB	SENSITIVITY Max. mV/cm	SENSITIVITY Min. V/cm	Input Imp. M (pF)	Common Mode Rej.	Main Frames for Plug-In	Price Approx $
	Marconi	TM6456A	33	ina	50	50	1 (27)	no	TF2200A	395
	H-P	1754A	40	-3	50	20	1 (22)	no	175A	595
	Tektronix	1A4 (4 Trace)	50	-3	10	20	1 (20)	yes	530, 540, 550, 580	750
	Tektronix	1A2	50	-3	50	20	1 (15)	yes	530, 540, 550, 580	325
	H-P	1750B	50	-3	50	20	1 (23)	yes	175A	325
	H-P	1755A	50	-3	1	5	1 (22)	yes	175A	575
	Fairchild	76-08	50 (x) 25	-3 -3	50 5	50 5	1 (23) 1 (23)	yes yes	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777	650
S 30	Tektronix	1A1	50 (x) 28 (x)	-3 -3	50 5	20 20	1 (15)	yes	530, 540, 550, 580	600
	Tektronix	82	85	-3	100	50	1 (15)	no	581A, 585A	650
	Fairchild	79-02A	100 50	-3 -3	100 10	50 5	1 (14) 1 (14)	no no	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777	930
	Tektronix	10A2A	100	-3	10	20	1 (20)	yes	647A, R647A	775

Circle as many numbers on the reader-service card as you like.

Horizontal Amplifier Plug-Ins

	Manufacturer	Model	FREQUENCY Min. Hz	FREQUENCY Max. kHz	FREQUENCY Resp. dB	SENSITIVITY Max. mV/cm	SENSITIVITY Min. V/cm	Input Imp. MΩ(pF)	Main Frames for Plug-In	Price Approx $
	Benrus	HA312	10	100	ina	400	ina	1	RA840B, RA850	65
	Benrus	HA316	10	100	ina	10	ina	0.5	RA840B, RA850	90
	Benrus	HA317	10	100	ina	4	ina	0.5	RA840B, RA850	95
	Benrus	HA324	dc	100	ina	2000	ina	1	RA840B, RA850	105
	Benrus	HA325	dc	100	ina	400	ina	0.4	RA840B, RA850	110
S 31	Benrus	HA326	dc	100	ina	100	ina	0.1	RA840B, RA850	120
	Benrus	HA327	dc	100	ina	40	ina	0.01	RA840B, RA850	120
	Benrus	HA328	dc	100	ina	10	ina	0.01	RA840B, RA850	135
	Benrus	HA311	10	500	ina	2000	ina	1	RA840B, RA850	45
	Benrus	HA313	10	500	ina	400	ina	0.5	RA840B, RA850	75
	Benrus	HA314	10	500	ina	100	ina	1	RA840B, RA850	80
	Benrus	HA315	10	500	ina	40	ina	1	RA840B, RA850	85
	Fairchild	74-12	dc	850	-3	1	25	1 (37)	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	145
S 32	Fairchild	74-15	dc	1000	-3	20	200	1 (33)	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	89
	Fairchild	74-19	dc	5000	-3	50	60	1 (40)	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	175

Get detailed data: use the reader-service card.

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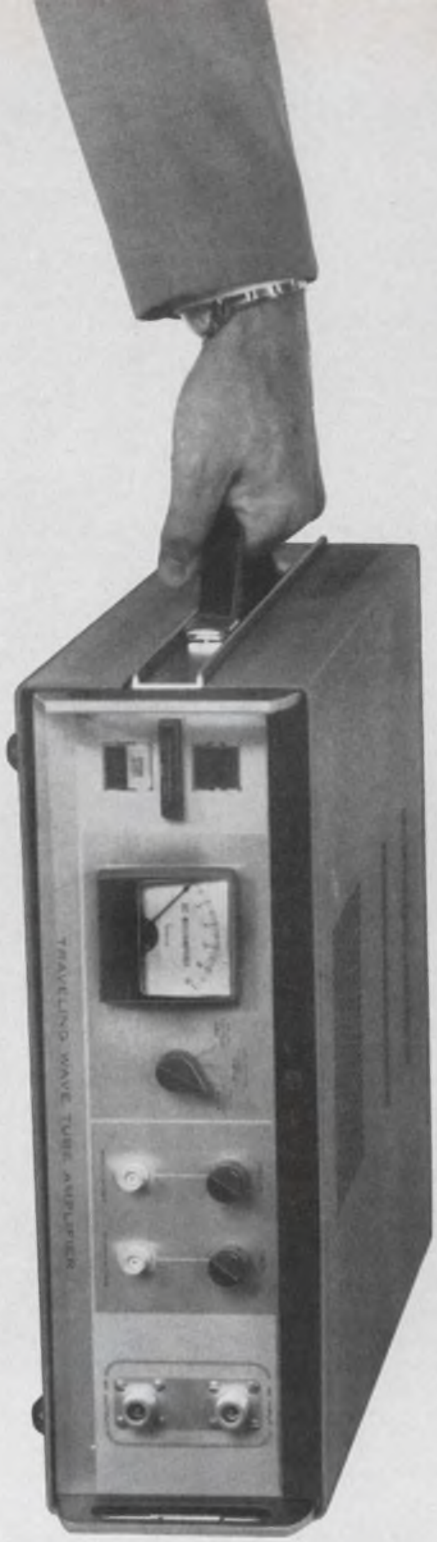
Horizontal Amplifier Plug-Ins (Time Base)

	Manufacturer	Model	SWEEP SPEED Max. µs/cm	SWEEP SPEED Min. s/cm	SWEEP SPEED Acc. %	TRIGGER Input Defl.	TRIGGER Output V	Main Frames for Plug-In	Price Approx $
	Benrus	SC411	0.12 cm/s	0.6 cm/s	ina	yes	yes	RA840B, RA850	145
	Benrus	SC415	0.12 cm/s	75 cm/s	ina	yes	yes	RA840B, RA850	180
	Benrus	SC412	0.3 cm/s	3 cm/s	ina	yes	yes	RA840B, RA850	140
	Benrus	SC413	3 cm/s	15 cm/s	ina	yes	yes	RA840B, RA850	135
	Benrus	SC414	15 cm/s	75 cm/s	ina	yes	yes	RA840B, RA850	135
S 33	Benrus	SC442	10/div	10 ms/div	ina	none	none	RA850	145
	Benrus	SC462	10/div	10 ms/div	ina	0.3 cm	none	RA840B	135
	Benrus	SC437	10/div	55/div	ina	none	none	RA850	125
	Benrus	SC457	10/div	55/div	ina	0.3 cm	none	RA840B	125
	Benrus	SC456	55/div	333 ms/div	ina	0.3 cm	none	RA840B	125

(tables continued on page T34)



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ON READER-SERVICE CARD CIRCLE 487

Horizontal Amplifier Plug-Ins (Time Base) *(continued)*

	Manufacturer	Model	SWEEP SPEED Max. µs/cm	SWEEP SPEED Min. s/cm	SWEEP SPEED Acc. %	TRIGGER Input Defl.	TRIGGER Output V	Main Frames for Plug-In	Price Approx $
	Benrus	SC436	55/div	333 ms/div	ina	none	none	RA850	125
	Benrus	SC455	278/div	1.66 ms/div	ina	0.3 cm	none	RA840B	125
	Benrus	SC435	278/div	1.66 ms/div	ina	none	none	RA850	125
	Benrus	SC454	1.66 ms/div	10 ms/div	ina	0.3 cm	none	RA840B	125
	Benrus	SC434	1.66 ms/div	10 ms/div	ina	none	none	RA850	125
S 34	Benrus	SC433	8 ms/div	0.04 s/div	ina	none	none	RA850	125
	Benrus	SC453	8 ms/div	0.04 s/div	ina	0.3 cm	none	RA840B	125
	Benrus	SC441	166 ms/div	1 s/div	ina	none	none	RA850	135
	Benrus	SC461	166 ms/div	1 s/div	ina	0.3 cm	none	RA840B	135
	Benrus	SC432	0.04 s/div	0.2 s/div	ina	none	none	RA850	115
	Benrus	SC452	0.04 s/div	0.2 s/div	ina	0.3 cm	none	RA840B	125
	Benrus	SC431	0.2 s/div	1 s/div	ina	none	none	RA850	125
	Benrus	SC451	0.2 s/div	1 s/div	ina	0.3 cm	none	RA840B	125
	Fairchild	74-13C	0.1 0.01	5 0.5	3 5	0.5 cm	2.5 (gate)	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	750
	Fairchild	74-17A	0.05 0.005 (k)	5 0.5	3 5	0.3 cm	14 (gate)	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	890
S 35	Fairchild	74-03A	0.05 0.005	5 0.5	3 5	0.3 cm	4 (gate)	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	395
	Gen-Atro	GA-24	0.1 (k)	0.1	3	0.5 cm	+10	GA-151, GA-155	225
	Gen-Atro	80-A	1	5	±5	2 mm	0.2-35	K-480	469
	Gen-Atro	70A	1	1	±3	2 mm	gate	K-270	395
	H-P	1423A	0.2	5	±3	0.5 cm	none	140A, 141A	450
	H-P	1420A	0.5	5	±3	0.5 cm	none	140A, 141A	325
	H-P	1422A	1	5	±3	0.5 cm	none	140A, 141A	225
	Tektronix	11B1	0.1	2	3	2-10mm	+14 (gate)	647A, R647A	650
S 36	Tektronix	3B5	0.1(z)	5	3	5 mm	none	561A, 564	890
	Tektronix	2B67	1	5	3	4 mm	none	561A, 564	210
	Tektronix	T	0.2/div	2/div	3	0.2V	+20 (gate)	536	240
	Tektronix	3B4	0.2/div	5/div	3	2 mm	+20 (gate)	561A, 564, 567	400

Reader-service numbers are given in the index.
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Horizontal Amplifier Plug-Ins (Delay)

	Manufacturer	Model	DELAY TIME Min. µs	DELAY TIME Max. s	Acc. %	SWEEP SPEED Max. µs/cm	SWEEP SPEED Min. s/cm	Acc. %	Jitter parts	TRIGGER Input Defl.	TRIGGER Output V	Main Frames for Plug-In	Price Approx $
	Gen-Atro	GA-25	1	1	3	0.1	0.1	3	1/10K	0.5 cm	+10 (gate)	GA-255	595
	Gen-Atro	GA-26	1	10	3	0.2	1	3	1/10K	0.5 cm	+10 (gate)	GA-151	559
	Tektronix	3B3	0.5	10	1	0.5	1	3	1/20K	4 mm	none	561A, 564	585
	Tektronix	3B1	0.5	10	uncal	0.5	1	3	1/20K	4 mm	none	561A, 564	535
	H-P	1421A	0.5	10	±1	0.2	1	3	1/50K	0.5 cm	+4	140A, 141A	625
S 37	H-P	1781B	0.5	10	±1	2	1	±3	1/50K	2 mm	+10	175A	325
	Tektronix	3B2	5	10.5	1	2/div	1/div	3	1/20K	2 mm	+15 (gate)	561A, 564, 567, 568	650
	Fairchild	74-13A	0.25	50	1	0.1 0.01	5 0.5	3 5	±1/40K	0.5 cm 0.5V	2.5 (gate)	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	750
	Fairchild	74-17A	0.25	50	1	0.05 0.005	5 0.5	3 5	±1/40K	0.3 cm 0.25V	14 (gate)	765MH, 766H, 767H, 765MH/F, 766H/F, 767H/F, 777, 9570	890
	Tektronix	11B2A	1	50	2.5	0.1	5	3	1/20	3 mm	gate	647A, R647A	850

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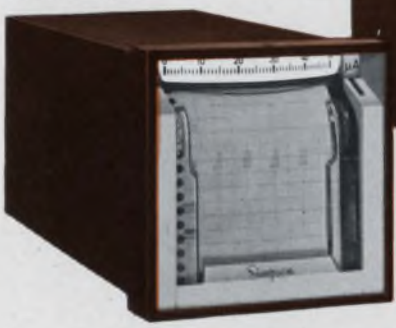
22 BUILT-IN RANGES
MODEL 604

1½% ACCURACY
MODEL 2750



10 CHANNEL EVENT
MODEL 2755

SINGLE RANGE—4 SPEED
MODEL 603

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write for further information

SPECIFICATIONS	603	604	2750	2755
Accuracy of recording	DC models: ±2.5%FS AC models: ±4.0%FS	±2.5%FS on all ranges	±1.5%, any model	(Event channels only)
Number of ranges built-in	1	22	1	—
Ranges available from stock.	DC μA: 0-50/100/250 DC mA: 0-1/5/50/500 DC A: 0-5 AC A: 0-5 DC mV: 0-50 DC V: 0-15/50/150 AC V: 0-5/150/300, 100-130	DC μA: 0-50/250* DC mA: 0-1/5/25 DC A: 0-.1/.25/1 AC mA: 0-.2 DC V: 0-.1/.5/2.5/10/25/100/250/500 AC V: 0-10/25/100/250/500	DC μA: 0-10/25/50/100/500 DC mA: 0-1/10/100 DC A: 0-1/5/10 AC μA: 0-250/500 AC mA: 0-1/10/100 AC A: 0-5 DC mV: 0-50 DC V: 0-1/5/10/15/25/50/100/150/250/500 AC V: 0-10/15/25/50/100/150/250/500	—
Number of event channels built-in	1	none	none	10
Event indicator voltage	120 volts/60Hz.	—	—	120 volts/60Hz. (optional: 24VDC)
Built-in chart speeds	3/12/24/36" per hr.	1/3/12" per hr.	20/120 mm per hour	
Optional speeds	¼/1/2/3" per hr.**	30/60/90" per hr.***	30/180; 60/360; 100/600; 300/1800;*** 600/3600 mm per hr.	
Clamp rate	2 seconds	2 seconds	3 seconds	Continuous
Chart Paper	3" wide, pressure sensitive	2⁹⁄₁₆" wide, pressure sensitive		
Motor drive	Self-starting, synchronous. 120 volts @ 60 Hz.			
Price	$90.00-$120.00 From Electronics Parts Distributors	$200.00	$138.00-$167.00 FROM YOUR SIMPSON REPRESENTATIVE	$175.00

*Note: 604 has all ranges listed built-in one unit.
**Gearbox not interchangeable. Stocked in both low and high speed ranges.
***With interchangeable Gearboxes.

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ON READER-SERVICE CARD CIRCLE 79

Oscilloscope Cross Index

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
AUL	AUL Inc 24-13 Bridge Plaza N. Long Island City, N.Y.	055	S8	282
Allied-R	Allied Radio Corp. 100 N. Western Ave. Chicago, Ill.	KG-630	S9	283
		KG-635	S9	
		KG-2100	S8	
Amer-El	American Electronic Labs Inc Box 552H Lansdale, Pa. 19446	725	S10	284
Benrus	Benrus Technical Products Div. 30 Cherry Ave. Waterbury, Conn. 06720	1100/100	S5	285
		1100/200	S5	
		1100/300	S5	
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Binary	Binary Electronics of Calif. 1429 N. State College Blvd. Anaheim, Calif. 92805	5Mc2P	S8	286

Oscilloscope Cross Index *(continued)*

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Cal-Inst	California Instrument Corp. 3511 Midway Drive San Diego, Calif. 92110	7000	S8	287
EGG	Edgerton Germeshausen & Grier 160 Brookline Ave. Boston, Mass.	707	S11	288
Fairchild	Fairchild Instruments 475 Ellis St. Mountain View, Calif.	74-03A	S35	289
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		76-02A	S29	
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		304AR	S3	
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Gen-Atro	General Atronics Corp. Electronic Tube Div. 1200 E. Mermaid Ave. Philadelphia, Pa.	70-A	S28	290
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Heath	Heath Company Sub. Daystrom Inc. Benton Harbor, Mich.	10-10	S4	266
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H-P	Hewlett-Packard Co.	120B	S5	Contact
	1501 Page Mill Road	122A	S4	Local
	Palo Alto, Calif.	122AR	S4	Rep.
		130C	S6	
		132A	S6	
		140A	S17	
		140A/1410A/1424A	S13	
		140A/1410A/1425A	S14	
		140A/1411A/1424A	S15	
		140A/1411A/1425A	S15	
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Hickok	Hickok Electrical Instr. Co.	675A	S8	292
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	Cleveland, Ohio 44108	770A	S7	
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Honeywell	Honeywell	270	S7	293
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	4800 E. Dry Creek Rd.			
	Denver, Colo.			
ITT	ITT Industrial Products Div.	KM302 (23 inch)	S2	294
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	San Fernando, Calif. 91342	KM402 (14 inch)	S2	
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		KM702 (17 inch)	S2	
		KM702S4 (17 inch)	S2	
		KM708 (17 inch)	S2	
		KM910 (9 inch)	S2	
		KM910S (9 inch)	S2	
		KP404 (14 inch)	S1	
		KP704 (17 inch)	S1	
		KP704-8 (17 inch)	S1	
		KS307 (23 inch)	S1	
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Marconi	Marconi Instruments	TF2200A	S18	295
	Div. English Electric Corp.	TF2201	S18	
	111 Cedar Lane	TF2203	S10	
	Englewood, N.J. 07631	TM6455A	S26	
		TM6456A	S30	
		TM6457A	S26	

Oscilloscope Cross Index *(continued)*

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
Meas-Con	Measurement Control Devices 2445 Emerald St. Philadephia, Pa.	100 300 349 701	S10 S3 S1 S7	296
Millen	James Millen Mfg. Co. Inc. 150 Exchange St. Malden, Mass. 02148	90902/90921 90903/90921 90905/90921 90905B/90921 90915 90923 90952	S3 S3 S3 S3 S4 S4 S7	297
RCA	Radio Corp. of America Electronic Components Harrison, N. J. 07029	WO-33A WO-91A	S9 S8	298
Roberts	Robertson Instrument Co. 1760 West First Azusa, Calif.	622A 627BR	S9 S4	299
Sencore	Sencore 42 S. Westgate Drive Addison, Ill.	PS127	S9	311
Simpson	Simpson Electric Co. 5200 W. Kinzie St. Chicago, Ill. 60644	458 466	S9 S4	312
Tektronix	Tektronix Inc. Box 5000 Beaverton, Oregon 97005	1A1 1A2 1A4 (4 trace) 1A5 1A6 1A7 1S1 (plug-in) 1S2 (plug-in) 2A60 2A61 2A63 2B67 3A1 3A2 3A3 3A5 3A6 3A7 3A8 (op amp) 3A72 3A74 (4 trace) 3A75 3B1 3B2 3B3 3B4 3B5 3C66 10A1 10A2A 11B1 11B2A 82 86 310A 317 321A 422 453 454 502A 503 531A 533A 535A 536 543B 544 545B 546 547 549 551 555 556	S30 S30 S30 S26 S23 S22 S13 S15 S23 S22 S22 S36 S29 S28 S28 S25 S29 S24 S24 S28 S28 S24 S37 S37 S37 S36 S36 S21 S27 S30 S36 S37 S30 S27 S7 S9 S9 S10 S11 S11 S7 S5 S17 S17 S17 S16 S18 S19 S18 S19 S19 S18 S17 S18 S19	313

Oscilloscope Cross Index *(continued)*

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
Tektronix		561A	S17	313
		561A/3S3/3T2	S15	
		561A/3S3/3T4	S14	
		561A/3S3/3T77A	S13	
		561A/3S76/3T4	S12	
		561A/3S76/3T77A	S12	
		564	S16	
		564/3S3/3T2	S15	
		564/3S3/3T4	S14	
		564/3S3/3T77A	S13	
		564/3S76/3T4	S12	
		564/3S76/3T77A	S12	
		565	S16	
		567	S16	
		567/3S3/3T4/6R1A	S14	
		567/3S3/3T77A/6R1A	S13	
		567/3S76/3T4/6R1A	S12	
		567/3S76/3T77A/6R1A	S13	
		567/6R1A/3A2/3B2	S6	
		581A	S19	
		585A	S19	
		647A	S20	
		661/4S1/5T3	S14	
		661/4S2A/5T3	S15	
		661/4S3/5T3	S14	
		B	S25	
		C-A	S29	
		D	S24	
		E	S21	
		G	S25	
		H	S25	
		K	S26	
		L	S26	
		M	S29	
		O (op amp)	S26	
		Q	S21	
		R317	S9	
		R422	S10	
		R453	S11	
		R454	S11	
		R647A	S20	
		RM502A	S7	
		RM503	S5	
		RM531A	S17	
		RM535A	S17	
		RM543B	S18	
		RM544	S19	
		RM545B	S18	
		RM546	S19	
		RM547	S19	
		RM556	S19	
		RM561A	S17	
		RM561A/3S3/3T2	S15	
		RM561A/3S3/3T4	S15	
		RM561A/3S3/3T77A	S13	
		RM561A/3S76/3T4	S13	
		RM561A/3S76/3T77A	S12	
		RM564	S16	
		RM564/3S3/3T2	S15	
		RM564/3S3/3T4	S14	
		RM564/3S3/3T77A	S13	
		RM564/3S76/3T4	S12	
		RM564/3S76/3T77A	S12	
		RM565	S16	
		RM567	S16	
		RM567/3S3/3T4/6R1A	S14	
		RM567/3S3/3T77A/6R1A	S14	
		RM567/3S76/3T4/6R1A	S12	
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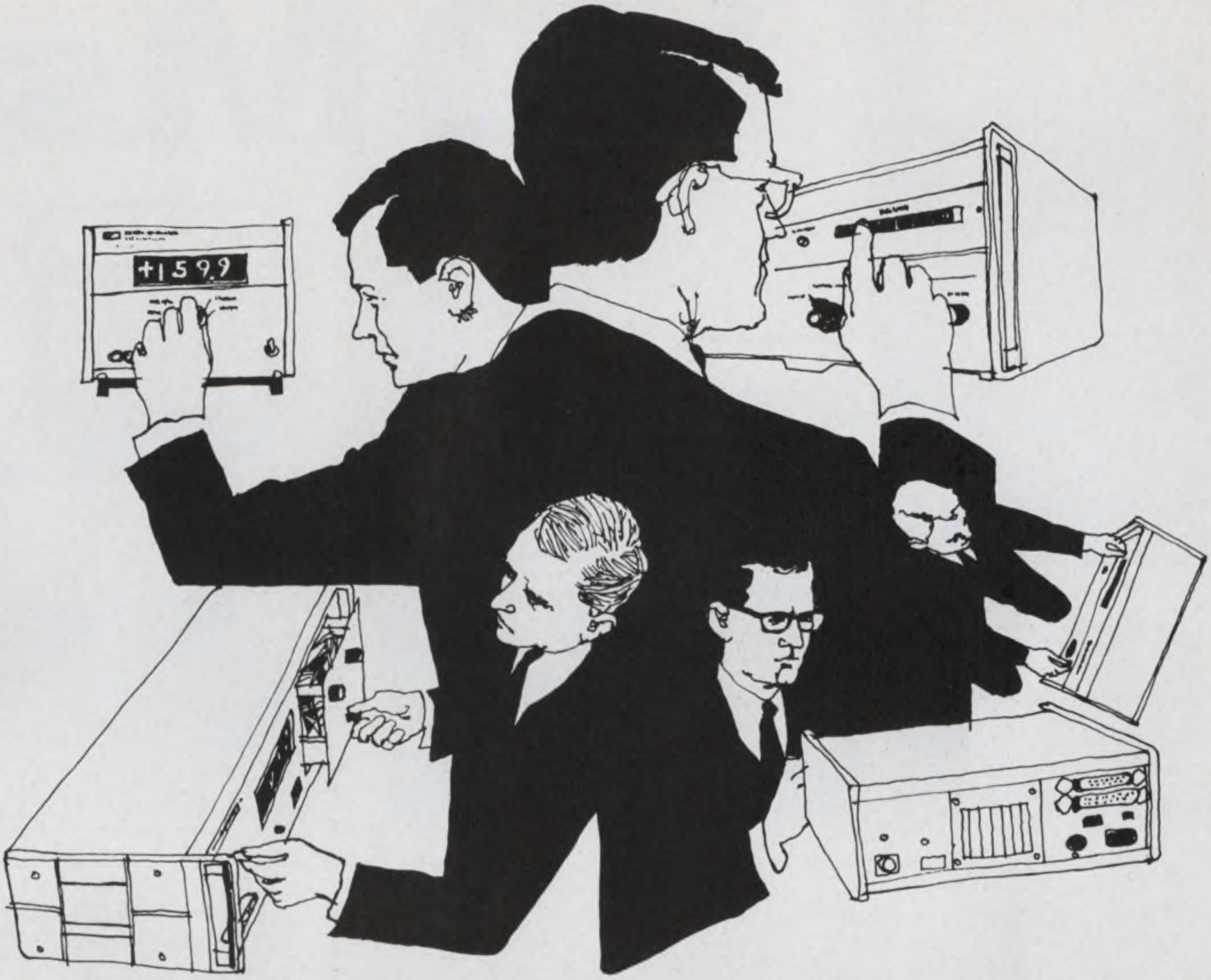
		RM585A	S19	
		T	S36	
		W	S25	
		Z	S24	
Texscan	Texscan Corp. 51 Koweba Lane Indianapolis, Ind.	DU-17 DU-88M	S1 S1	314
Waterman	Waterman Instrument Corp. 1919 E. Boston Ave. Philadelphia, Pa. 19125	OCA-11A OCA-11B OCA-12A OCA-16A	S4 S4 S4 S8	315

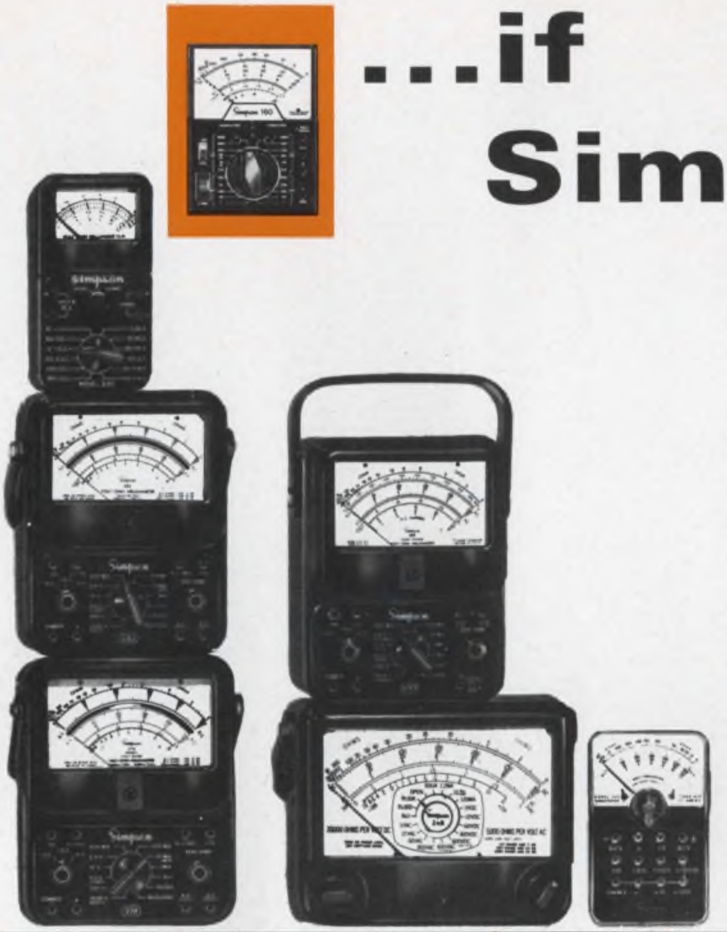

+1 5 9.9

VOMs

RANGES and SPECIFICATIONS	160	230	240	250	255	260-5	260-5M	260-5P	261	270-3
DC Volts	0-0.25/1.0/2.5/10/ 50/250/500/1000	0-10/50/250/1000	0-15/75/300/750/ 3000	0-0.05/0.25/2.5/10/ 50/250/500/1000	0-0.05/0.25/1/2.5/ 10/50/250/1000	0-0.25/2.5/10/50/250/1000/5000				
AC Volts	0-2.5/10/50/2507 500/1000	0-10/250/1000	0-15/150/750/3000	0-2.5/10/50/250/ 500/1000	0-2.5/10/50/250/ 1000	0-2.5/10/50/250/1000/5000				
DC Microamperes	0-50 (250 mV drop)	NONE	NONE	0-50 (Both 50 and 250 mV drop)		0-50 (250 mV drop)				
DC Milliamperes	0-1/10/100/500 (250 mV drop)	0-10/50/250 (150 mV drop)	0-15/150/750 (150 mV drop)	0-1/10/100/500 (50 mV drop)		0-1/10/100/500 (250 mV drop)				
DC Amperes	NONE	NONE	NONE	0-10 (50 mV drop)	NONE	0-10 (250 mV drop)				
AC Amperes	NONE	NONE	NONE	NONE*	0-5/25/100/250 (w/ adapter No. 0531)	NONE*	NONE*	NONE*	NONE*	NONE*
DB Scale ("0" = 1 mw into 600)	−20 to +10/−8 to +22/+6 to +36/ +20 to +50	NONE	NONE	−20 to +10/−8 to +22/+6 to +36/ +20 to +50	NONE	−20 to −10/−8 to −22/−6 to −36/−20 to −50				
Output Ranges	NONE	NONE	NONE	NONE	NONE	0.1 ufd in series with all AC voltage ranges through 250 volts.				
Resistance Ranges	RX1 (30 Ω ctr.)/RX10/ RX100/RX1K/RX10K	RX1 (12 Ω center)/ RX100	RX1 (30 Ω center)/ RX100	RX1 (12 Ω center)/RX100/RX10K						
Temperature Range	NONE	NONE	NONE	NONE*	+100°F. to +1050°F.	NONE*	NONE*	NONE*	NONE*	NONE*
Accuracy (% of Full Scale)		±3% DC, ±4% AC		±2% DC, ±3% AC					±1.5% DC, ±3% AC	±1.25% DC, ±2% AC
Temperature Compensated	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
Meter Movement Protection	YES	NO	NO	YES	YES	YES	YES	YES	YES	YES
Resettable Tester Circuit Protection	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO
Mirror Scale	NO	NO	NO	NO	NO	NO	YES	NO	YES	YES
Scale Length	2.9 inches	2.36 inches		4.2 inches						
Dimensions	4 9/16″ x 3 5/16″ x 1 3/4″	3″ x 5 1/8″ x 2 1/2″		5 1/4″ x 7″ x 3 1/8″						
Net Weight	12 oz.	1 1/2 lbs.		3 1/2 lbs.						
Price	$50.00	$40.00	$40.00	$63.00	$90.00	$58.00	$60.00	$88.00	$68.00	$70.00
Movement Type	Self Shielding Annular —Taut Band	Self Shielding Annular—Pivot and Jewel		Self Shielding Annular—Taut Band		Self Shielding Annular—Pivot and Jewel				Self Shielding Annular —Taut Band
Sensitivity	20,000 Ω/V DC, 5000 Ω/V AC	1000 Ω/V DC, 1000 Ω/V AC		20,000 Ω/V DC, 5000 Ω/V AC						

*Temperature, AC current, and other ranges can be added with exclusive Simpson Add-A-Tester adapters.

Simpson makes other specialized VOMs, adapters and accessories, too! And if we can't fill your needs from stock . . . we'll build it! Send your specifications, or write for test equipment **brochure 2076.**



...if Simpson doesn't have it... forget it!

Simpson is the one place to look when you need a VOM. We pioneered the multitester®, and today we offer the widest selection. All with Simpson's "Stay Accurate" dependability.

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262-3	263	267	268	269-2	355	2700
0-1.6/8/40/160/400/1600/4000	0-0.15/0.3/0.75/1.5/3/6/7.5/15/30/60/75/150/300/600/750/1500/3000/6000	0-0.25/2.5/10/50/250/500/1000	0-3/12/60/300/600/1200	0-1.6/8/40/160/400/800/1600/4000	0-3/12/60/300/1200	0-1/10/100/1000
0-3/8/40/160/400/800	0-2.5/5/7.5/15/30/60/150/300/750/1500	0-2.5/10/50/250/500/1000	0-3/12/60/300/600 1200	0-3/8/40/160/400/800	0-3/12/60/300/1200	0-1/10/100/1000‡
0-80/160 (267 mV drop)	0-75/150 (150 and 300 mV drops)	0-50 (250 mV drop)	0-60 (264 mV drop)	0-16/160 (215 mV drop)	NONE	NONE
0-1.6/16/160 (267 mV drop)	0-0.75/1.5/7.5/15/75/150/750 (150 and 300 mV drops)	0-1/10/100/500 (250 mV drop)	0-1.2/12/120 (264 mV drop)	0-1.6/16/160 (215 mV drop)	NONE	0-1/10/100‡
0-1.6/8 (267 mV drop)	0-1.5/7.5/15 (150 and 300 mV drops)	0-10 (250 mV drop)	0-12 (264 mV drop)	0-1.6/8 (215 mV drop)	NONE	NONE
NONE	NONE	NONE	NONE	NONE	NONE	NONE
−12 to +11/ −3.5 to +19.5/ +10.5 to +33.5/ +22.5 to +45.5	−20 to +10/−14 to +16/−10.5 to +19.5/ −4.5 to +25.5/+1.5 to +31.5/+7.5 to +37.5/+15.5 to +45.5/+21.5 to +51.5/ +29.5 to +59.5/+45.5 to +75.7	−20 to +10/ −8 to +22/ +6 to +36/ +20 to +50	−12 to +11/ −1 to +22/ +13 to +36/ +27 to +50	−12 to +11/ −3.5 to +19.5/ +10.5 to +33.5/ +22.5 to +45.5	NONE	NONE
0.1 ufd through 160 volts	0.1 ufd in series with all AC voltage ranges through 300 volts			0.1 ufd through 160 volts	NONE	NONE
RX1 (4.5 Ω center)/RX10/RX100/RX1K/RX10K/RX100K		RX1 (12 Ω center)/RX100/RX10K		RX1 (12 Ω center)/ RX10/RX100/RX1K/ RX10K/RX100K	RX1 (120 Ω center)/ RX10/RX100/RX1K	RX1K (0-1K Ω)/ RX100K/RX10Meg/ RX100Meg‡
NONE	NONE	NONE	NONE	NONE	NONE	NONE
±3% DC, ±4% AC	±1.5% DC, ±2.5% AC	±3% DC, ±5% AC		±2% DC, ±3% AC	±3% DC, ±5% AC	±0.05%, ±1 digit, DCV
NO	NO	NO	NO	NO	NO	YES
NO	YES	NO	NO	YES	NO	YES (digital)
NO	NO	NO	NO	NO	NO	NO (not needed)
NO	NO	NO	NO	NO	NO	DIGITAL READOUT
6.2 inches					2.24 inches	4 digits
6" x 7¼" x 3"					2¾" x 4½" x 1"	8¼" x 11" x 4"
4 lbs.					8 oz.	8 lbs.
$75.00	$88.00	$65.00	$65.00	$90.00	$47.00	Under $550.00 for basic unit
Self Shielding Annular—Pivot and Jewel						Digital; Integrated Circuits
20,000 Ω/V DC, 5000 Ω/V AC	20,000 and 10,000 Ω/V DC, 10,000 and 5000 Ω/V AC	20,000 Ω/V DC, 5000 Ω/V AC		100,000 Ω/V DC, 5000 Ω/V AC	10,000 Ω/V AC-DC	10 Meg Ω, DC

‡With optional plug-in adapters.

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AGM DIVISION

ON READER-SERVICE CARD CIRCLE 87

Digital Voltmeters (dc)

	Manufacturer	Model	Voltage Ranges No.	Minimum mV	Maximum V	Accuracy %	Speed readings per sec	Input Impedance MΩ	Output Signal	Output Printer	Mounting	Misc. Features	Price Approx. $
D1	Un-Syst	451	1	0.01	0.01	0.1	4	0.05	BCD	i extra	C	x	430
	Un-Syst	452	1	0.02	0.02	0.1	5	0.05	BCD	i extra	C	x	440
	Un-Syst	454	1	0.02	0.04	0.1	7	0.05	BCD	i extra	C	x	445
	NLS	6001	1	0.01	0.0999	0.1	1	10	none	none	R	nu	1840
	Trymetrics	4100-105	1	+0.1	0.1	0.05	2	10	extra	extra	C, R	t(a)	905
	Trymetrics	4000-105	1	+0.1	0.1	0.05	2	10	extra	extra	C, R	(a)	805
	Un-Syst	401	1	0.1	0.1	0.1	4	0.05	BCD	i extra	C	x	325
	Un-Syst	402	1	0.2	0.2	0.1	5	0.05	BCD	i extra	C	x	385
	Un-Syst	404	1	0.2	0.4	0.1	7	0.05	BCD	i extra	C	x	390
	Trymetrics	4000-104	1	0.1	1	0.01	2	10	extra	extra	C, R	(a)	690
D2	Trymetrics	4100-105	1	0.1	1	0.01	2	10	extra	extra	C, R	(a)	790
	NLS	4808	3	1	9.999	0.01	ina	1000	none	none	R	u	885
	Trymetrics	4100-103	1	0.1	10	0.01	10	10	extra	extra	C, R	t(a)	740
	Trymetrics	4000-103	1	0.1	10	0.01	10	10	extra	extra	C, R	(a)	640
	Dynamics	6539	1	0.1	11	0.012	30,000	1000	BCD	yes	R		3200
	Adage	V16-AD	3	0.1	100	0.01	1400	0.001/V	BCD	yes	R	(a)	5600
	Adage	VR12-AD	3	1	100	±0.05	8000	0.001/V	BCD	dec	R	(a)	5600
	Adage	V12-AD	3	1	100	±0.05	8000	0.01/V	BCD	dec	R	(a)	5600
	NLS	15	3	1000	100	0.01	15,000	625Ω/V	BCD	ina	R	u	4985
	Par	CS-3.1	4	1	999	±1 dig	1	10	10 line	defi	C	(a)	995
D3	North Hills	DSV.1	4	1	999	0.1	20	100k-10	none	none	C	u	495
	H-P	3440A/3444A	5	0.01	999.9	±0.05	5-1/5	10.2	4 line	defghi	C	o(a)	1735
	NLS	X-2/4/OPC	5	0.01	999.9	±0.02	ina	ina	BCD	yes	C	acu	1430
	NLS	X-2/4/AC3/ OPC	5	0.01	999.9	±0.02	ina	ina	BCD	yes	C	alu	1880
	Trymetrics	4100-500M	5	0.1	999.9	0.01	2	10	extra	extra	C, R	t(a)	980
	Trymetrics	4000-500M	5	0.1	999.9	0.01	2	10	extra	extra	C, R	(a)	880
	Trymetrics	4100-500A	5	0.1	999.9	0.01	2	10	extra	extra	C, R	t(a)	7120
	Trymetrics	4000-500A	5	0.1	999.9	0.01	2	10	extra	extra	C, R	(a)	1020
	Trymetrics	4000-400A	4	0.1	999.9	0.01	2	10	extra	extra	C, R	(a)	820
	Trymetrics	4100-400A	4	0.1	999.9	0.01	2	10	extra	extra	C, R	t(a)	920
D4	Trymetrics	4000-400M	4	0.1	999.9	0.01	2	10	extra	extra	C, R	(a)	735
	Trymetrics	4100-400M	4	0.1	999.9	0.01	2	10	extra	extra	C, R	t(a)	835
	Trymetrics	4100-300M	3	0.1	999.9	0.01	2	10	extra	extra	C, R	t(a)	760
	Trymetrics	4100-300A	3	0.1	999.9	0.01	2	10	extra	extra	C, R	t(a)	835
	Trymetrics	4000-300A	3	+0.1	999.9	0.01	2	10	extra	extra	C, R	(a)	735
	Trymetrics	4000-300M	3	0.1	999.9	0.01	2	10	extra	extra	C, R	(a)	670
	Trymetrics	4100/430A	4	0.1	999.9	0.01	2	10	extra	extra	C, R	lt(a)	990
	Trymetrics	4000/430M	4	0.1	999.9	0.01	2	10	extra	extra	C, R	l(a)	890
	Trymetrics	4240	4	0.1	999.9	0.01	10	10	ina	ina	C, R	(a)	595
	Trymetrics	4243	4	0.1	999.9	0.01	ina	10	ina	ina	C, R	l(a)	795
D5	Micro-Inst	5600	4	0.1	999.9	0.05	ina	10-1	none	none	C, R	j(a)	1195
	Cohu	510	4	0.1	999.9	0.01	ina	10	extra	i	C, R	kz	request
	Weston	4000	4	0.1	999.9	±1 dig	9.9	1G-10	extra	defghi	C, R	t(a)	2000
	NLS	3010	4	0.1	999.9	±1 dig	1/1.9	10	dei	defhi	R	knu	3585
	NLS	2019	4	0.1	999.9	±1 dig	1/0.33	10	yes	defhi	R	klnu	5390
	Trymetrics	4230	3	1	999.9	0.01	10	10	ina	ina	C, R	(a)	549
	3M	4102	3	1	999.9	±1 dig	ina	1G-10	extra	extra	C, R	cv	4295
	3M	4100	3	1	999.9	±1 dig	ina	1G-10	extra	extra	C, R	v	3495
	H-P	3440A/3442A	3	1	999.9	±0.05	5-1/5	10.2	4 line	defghi	C	op(a)	1160
	H-P	3440A/3441A	3	1	999.9	±0.05	5-1/5	10.2	4 line	defghi	C	o(a)	1200

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Reader-service numbers are given in the index.
See reader-service card for valuable FREE reprints.
DVM index starts on page T52.

Digital Voltmeters (dc) *(continued)*

	Manufacturer	Model	Voltage Ranges No.	Minimum mV	Maximum V	Accuracy %	Speed readings per sec	Input Impedance MΩ	Output Signal	Printer	Mounting	Misc. Features	Price Approx. $
D6	R&S	UGZ/BN1100	3	1	999.9	0.05	ina	10	contacts	i	C	u	2605
	NLS	RS2	3	1	999.9	0.01	ina	10	dec	i	R	knu	3685
	NLS	91D4	3	1	999.9	0.01	ina	10	ina	ina	R	u	2985
	NLS	4814	3	1	999.9	0.01	1	10	contacts	defghi	R	ju	1560
	NLS	5005	3	1	999.9	0.01	1.3	10	none	none	R	u	985
	NLS	4206	3	1	999.9	±0.02	20	10	dec	i	R	u	1785
	NLS	4401	3	1	999.9	0.01	200	10	dec	efghi	R	nu	6185
	NLS	4409	3	1	999.9	0.01	200	10	dec	efghi	R	jnou	6185
	NLS	4810	3	1	999.9	0.02	11/3	10	none	none	R	jnu	925
	NLS	X-2/4/AC3	3	1	999.9	±0.02	ina	ina	BCD	yes	C	aju	1430
D7	H-P	3439A/3442A	3	1	999.9	±0.05	2,3	10.2	4 line	defghi	C	o(a)	1085
	H-P	3439A/3441A	3	1	999.9	±0.05	2,3	10.2	4 line	defghi	C	o(a)	990
	NLS	X-2/4	3	1	999.9	±0.02	ina	ina	BCD	yes	C	au	980
	Cohu	412(MIL-E-4158A)	3	1	999.9	0.01	4	10	dec	i	R	jqv	10,000
	Behl-Invar	MIL-V-72	3	1	999.9	0.01	ina	10	none	none	C	(a)	3500
	Behl-Invar	MIL-VR-2100	3	1	999.9	0.01	1/2	10	none	none	C	(a)	4450
	Honeywell	85	4	0.01	999.99	0.004	ina	10G-10	10 line	defghi	C, R	klot(a)	request
	Honeywell	881	4	0.01	999.99	0.002	20	10	10 line	efghi	R	cko(a)	5175
	Honeywell	883	4	0.01	999.99	0.002	20	10	10 line	efghi	R	klo(a)	6400
	Cohu	533-2210	5	0.01	999.99	0.005	ina	1G-10	BCD	i	C, R	mz	2195
D8	Cohu	531-1000	5	0.01	999.99	0.005	ina	1G-10	BCD	i	C, R	kz	1495
	Cohu	533-2810	7	0.012	999.99	0.005	ina	1G-10	BCD	i	C, R	cmrz	2750
	Cohu	533-2310	7	0.012	999.99	0.005	ina	1G-10	BCD	i	C, R	mrz	2295
	3M	5100M07	5	0.1	999.99	0.002	ina	10G-10	extra	extra	C, R	kv	4895
	3M	5100M02	5	0.1	999.99	0.002	ina	10G-10	extra	extra	C, R	cv	5795
	3M	5100	5	0.1	999.99	0.002	ina	10G-10	extra	extra	C, R	v	4845
	Cimron	7650 Multi-meter	3	0.1	999.99	0.001	ina	1G-10	10 line	yes	C, R	kl(a)	4290
	Cimron	7630 Multi-meter	3	0.1	999.99	0.001	ina	1G-10	none	none	C, R	kl(a)	4040
	Cimron	7650	3	0.1	999.99	0.001	ina	1G-10	10 line	yes	C, R	k(a)	2990
	Cimron	7630	3	0.1	999.99	0.001	ina	1G-10	none	none	C, R	k(a)	2740
D9	Cimron	E9500B-355	3	0.1	999.99	0.001	ina	10G-10	10 line	yes	C, R	ks(a)	7750
	Cimron	E9300B-355	3	0.1	999.99	0.001	ina	10G-10	none	none	C, R	ks(a)	7165
	Cimron	P9500B	3	0.1	999.99	0.001	ina	10G-10	10 line	yes	C, R	k(a)	3990
	Cimron	P9400B	3	0.1	999.99	0.001	ina	10G-10	10 line	yes	C, R	(a)	3840
	Cimron	P9300B	3	0.1	999.99	0.001	ina	10G-10	none	none	C, R	k(a)	3340
	Cimron	P9200B	3	0.1	999.99	0.001	ina	10G-10	none	none	C, R	(a)	3190
	Honeywell	880	4	0.1	999.99	0.01	ina	1G-10	10 line	efghi	R	ko(a)	4500
	Honeywell	882	4	0.1	999.99	0.01	ina	1G-10	10 line	efghi	R	mo(a)	4550
	NLS	X-1	3	0.1	999.99	0.005	50	10G	BCD	yes	C, R	u	2450
	NLS	3130	3	0.1	999.99	0.01	1/2.3	1000-10	contacts	defghi	R	jku	4290
D10	NLS	3020	3	0.1	999.99	0.01	1/2.3	1000-10	contacts	defghi	R	jku	3985
	NLS	2021	3	0.1	999.99	0.01	1/1.1	10	dec	defhi	R	klu	5690
	H-P	2401C	5	0.001	1000	request	ina	10	BCD	i direct	R	(a)	3950
	Data-Tec	DVX-315A/DT-615	6	0.001	1000	0.003	5	1000	BCD	i direct	C, R	a(a)	3940
	Systron	6413	5	0.001	1000	0.025	5	10	BCD	i	C, R	(a)	1875
	Systron	1033/1936	6	0.001	1000	0.025	5	10	BCD	i	C, R	(a)	1870
	Fairchild	7100A	5	0.01	1000	0.01	20	1G	BCD	yes	C, R	akl(b)	2075
	H-P	3439A/3444A	5	0.01	999.9	±0.05	2,3	10.2	4 line	defghi	C	o(a)	1525
	Fairchild	7200	4	0.01	1000	0.005	100	1G	yes	yes	C, R	ac(a)	3500
	Weston	1420	6	0.01	1000	±1 dig	10	5G-10	BCD	defghi	C	a(a)	1500

(tables continued on page T46)

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Digital Voltmeters (dc) *(continued)*

	Manufacturer	Model	Voltage Ranges No.	Minimum mV	Maximum V	Accuracy %	Speed readings per sec	Input Impedance MΩ	Output Signal	Output Printer	Mounting	Misc. Features	Price Approx. $
D11	Data-Tec	DT-323	5	0.01	1000	0.01	5	1000	BCD	i direct	C, R	ak(a)	1445
	Data-Tec	DVX-315A	4	0.01	1000	0.003	5	1000	BCD	i direct	C, R	a (a)	2750
	Fairchild	7000	4	0.1	1000	0.01	2-5	1G	BCD	yes	C, R	ac (a)	1150
	Monsanto	2000	4	0.1	1000	0.01	2	10	BCD	defghi	C, R	at (a)	1975
	Weston	1423	6	0.1	1000	0.02	ina	10G-10	BCD	defghi	C, R	a (a)	1950
	Vidar	500	5	0.1	1000	0.1	30	10-0.1	BCD	defghi	C, R	ab(b)	985
	Systran	1235-1	4	0.1	1000	0.1	8.3	1	BCD	i	R	j (a)	request
	Systran	1234	4	0.1	1000	0.01	300	10	BCD	i	R	(a)	2000
	Roback	305	5	0.1	1000	0.1	250	10-1	BCD	yes	C	(b)	445
	Roback	304	5	0.1	1000	0.1	4	10-1	none	none	C	(b)	375
D12	EAI	6001	4	0.1	1000	0.01	1000	10	dec	efghi	C, R	ov	3450
	EAI	6200/6201	5	0.1	1000	0.1	6	10	none	none	C, R	(a)	580
	Behl-Invar	IS2500	5	0.1	1000	0.005	5	10	10 line	i	R	jkp(a)	3690
	Cohu	541-1000	5	0.1	1000	0.01	1.5	10	BCD	i	C, R	az	1495
	Cohu	543-2810	7	0.1	1000	0.01	1.5	10	BCD	i	C, R	alrz	2750
	Cohu	543-2310	7	0.1	1000	0.01	1.5	10	BCD	i	C, R	alrz	2295
	Cohu	543-2210	5	0.1	1000	0.01	1.5	10	BCD	i	C, R	ajrz	2195
	Cohu	502B	4	0.1	1000	0.01	1/4	10	contacts	yes	R	lv	4245
	Cohu	507D	4	0.1	1000	0.01	1/4	10	contacts	yes	R	jv	3835
	Cohu	501B	4	0.1	1000	0.01	1/4	10	contacts	yes	R	jv	2995
D13	Data-Tec	DVX-315A	4	0.1	1000	0.01	50	1000	BCD	i direct	C, R	a(a)	2750
	Electrolab	100	4	1	1000	0.1	3	10	none	none	C	t	495
	Technology	DM5000	5	1	1000	0.1	ina	10	none	none	C	ab(a)	950
	Simpson	111	4	1	1000	0.1	ina	11	none	none	C	v	500
	Fairchild	7050	3	1	1000	0.1	6	1G	none	none	C, R	ac(a)	299
	Ballantine	355	4	1	1000	0.25	ina	2	none	none	C	jx	620
	Ballantine	353	4	1	1000	0.02	ina	10	none	none	C	x	490
	Cal-Inst	8004	3	1	1000	0.03	ina	10	extra	extra	C	v	725
	Cal-Inst	8002	3	1	1000	0.03	ina	10	extra	extra	C	cv	775
	Cal-Inst	8001	3	1	1000	0.03	ina	10	extra	extra	C	jv	795
D14	Cal-Inst	8000	3	1	1000	0.03	ina	10	extra	extra	C	iv	845
	Cal-Inst	8104	5	1	1000	0.03	ina	10-1	extra	extra	C	v	request
	Cal-Inst	8101	5	1	1000	0.03	ina	10-1	extra	extra	C	jv	request
	Un-Syst	201	4	1	1000	0.1	1/4	2.2	BCD	i extra	C	x	350
	Systran	1234-4	4	1	1000	0.01	1000	10	BCD	i	R	j(a)	request
	Roback	35	4	1	1000	±1 dig	400	10	dec	defghi	R	co(b)	875
	Roback	34	4	1	1000	±1 dig	0.2-3	10-1	yes	yes	C	c(b)	695
	Behl-Invar	DV-271	3	1	1000	0.01	2	10	none	i	R	jk(a)	1395
	Data-Tec	DT-322	3	1	1000	0.01	5	10	BCD	i direct	C, R	ak(a)	1225
	Data-Tec	DT-321	3	1	1000	0.01	5	10	none	none	C, R	a(a)	995
D15	H-P	3439A/3443A	5	100	1000	±0.05	2.3	10.2	4 line	defghi	C	o(a)	1400
	H-P	3430A	5	100	1000	±0.1	ina	10	ina	ina	C	t(a)	595
	H-P	3440A/3443A	5	100	1000	±0.05	5-1/5	10.2	4 line	defghi	C	o(a)	1610
	CMC	810/835A	5	100	1000	±0.1	ina	0.1-1	BCD	P	R	av	2635
	CMC	800A/835A	5	100	1000	±0.1	ina	0.1-1	BCD	P	C	av	3095
	Roback	33	3	10	1000	0.1	0.2-3	10-1	yes	yes	C	c(b)	595
	Dana	5600/11	6	10	1000	±0.005	30	10G	BCD	yes	R	m(a)	4475
	Hickok	DMS3200/ DP100	5	99.9	1000	0.1	2	10	10 line	p extra	C, R	bc(a)	495
	H-P	2402A	5	100	1000	0.01	40	10	4 line	defghi	C	a(a)	4800
	H-P	H04-3460A	4	1V	1000	±0.005	ina	10	4 line	defghi	C	ot(a)	4250

(tables continued on page T48)

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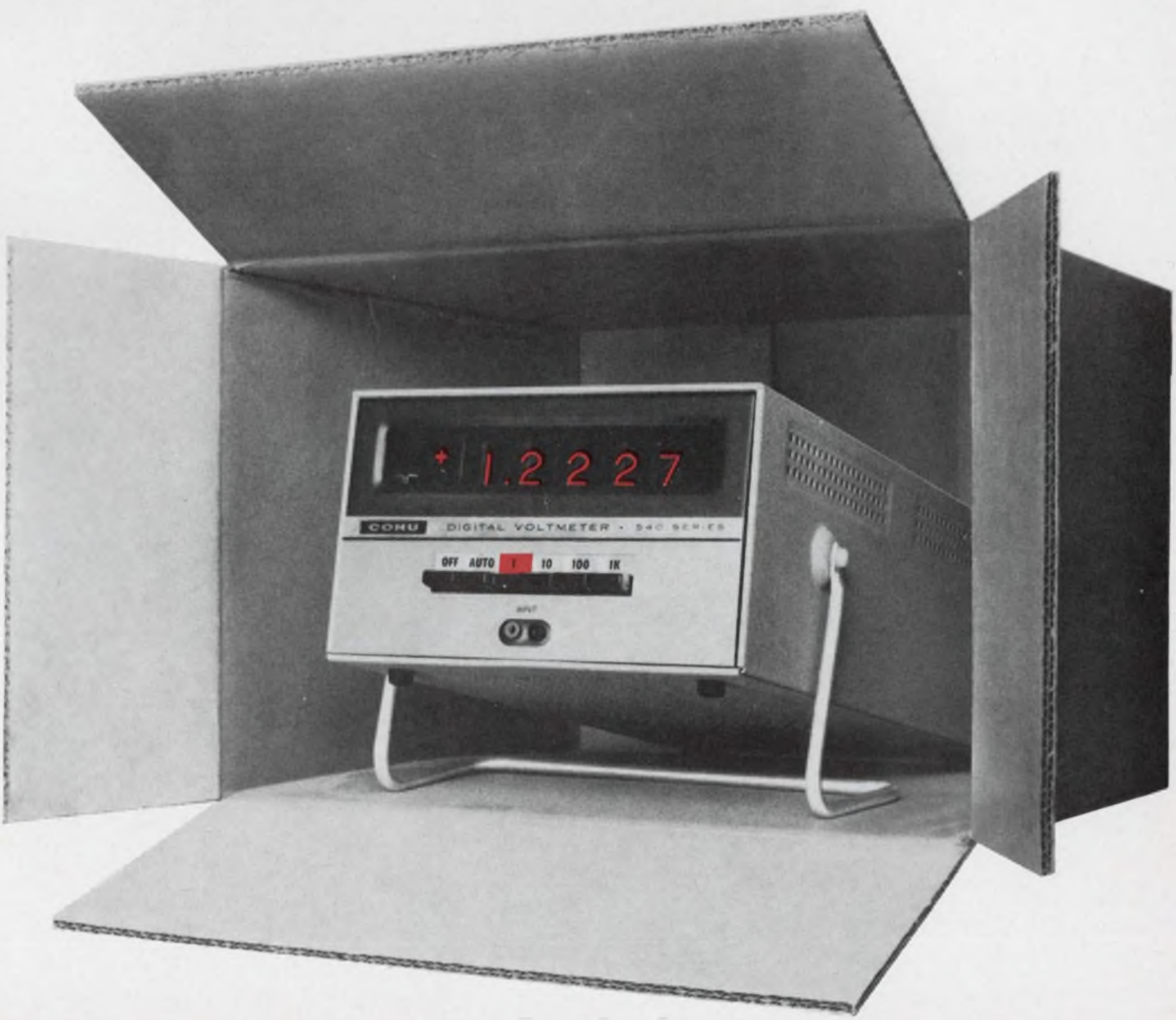

ON READER-SERVICE CARD CIRCLE 88

Digital Voltmeters (dc) *(continued)*

	Manufacturer	Model	Voltage Ranges No.	Minimum mV	Maximum V	Accuracy %	Speed readings per sec	Input Impedance MΩ	Output Signal	Output Printer	Mounting	Misc. Features	Price Approx. $
D16	H-P	3460B	4	1V	1000	±0.004	15	10	BCD	i direct	C, R	(r)	3600
	Dana	5600	3	1V	1000	±0.005	30	10G	BCD	yes	R	m(a)	3675
	H-P	3459A	3	10V	1000	±0.008	1.7-1/5	10	4 line	defghi	C	o(a)	2850
	Cimron	6600	3	1	1099.9	0.01	2-20	1G-10	10 line	yes	C, R	kop(a)	1490
	Cimron	4651	3	0.1	1099.99	0.001	ina	10G-10.1	10 line	yes	C, R	mop(a)	4740
	Cimron	4631	3	0.1	1099.99	0.001	ina	10G-10.1	none	none	C, R	m(a)	4590
	Cimran	4652	3	0.1	1099.99	0.001	ina	10G-10.1	10 line	yes	C, R	kop(a)	4540
	Cimron	4632	3	0.1	1099.99	0.001	ina	10G-10.1	none	none	C, R	k(a)	4390
	Dana	5700/11A	7	10	1100	±0.004	50	10G	BCD	yes	R	k(a)	4750
	Dana	5400/020	5	110	1100	±0.01	80	1000	BCD	defghi	R	k(a)	1995
D17	Dana	5500/112	5	110	1100	±0.005	2	10G	BCD	defghi	R	k(a)	2850
	Dana	5700	4	1V	1100	±0.004	50	10G	BCD	yes	R	k(a)	3950
	Dana	5400/005	3	11V	1100	±0.01	80	1000	BCD	defghi	R	(a)	1695
	Dana	5400/010	3	11V	1100	±0.01	80	1000	BCD	defghi	R	k(a)	1795
	NLS	2917	5	0.001	1200	0.01	1,10,100	1G-1	dec	i	R	au	3720
	Vidar	520	6	0.005	1200	0.01	100	1G-10	BCD	defghi	C, R	ab(b)	3925
	EAI	6000	4	0.1	1200	±0.01	1000	10	dec	efghi	C, R	ov	2950
	EAI	6101	4	0.1	1200	0.01	1000	10	dec	efghi	C, R	cov	4350
	Janus	401	4	1	1300	0.1	8	10	BCD	defghi	C	au	396
	Janus	400	4	1	1300	0.1	8	100k-10	BCD	defghi	C	au	350
D18	Janus	403	4	0.1	1300	0.05	1	100k-10	BCD	defghi	C	au	450
	Janus	404	4	0.1	1300	0.05	3	10	BCD	defghi	C	au	496
	Un-Syst	202	4	2	2000	0.1	1/5	2.2	BCD	i extra	C	x	365
	NLS	X-3	6	0.01	10,000	0.1	3	100	analog	none	P	u	695

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DVM index starts on page T52.

Digital Voltmeters (ac)

	Manufacturer	Model	Frequency Minimum Hz	Frequency Maximum kHz	Voltage Ranges Minimum mV	Voltage Ranges Maximum V	Voltage Ranges Accuracy %	Voltage Ranges No.	Readout Type	Speed readings per sec	Input Impedance MΩ	Output Type	Output Printer	Mounting	Misc. Features	Price Approx. $
D20	Cohu	412	60	1	1	999.9	0.1	3	v	1/4	1	contacts	i	R	jq	10,000
	NLS	4401	dc	10	1	999.9	0.1	3	u	ina	10	dec	defhi	C,R	j	6185
	NLS	3024	30	10	1	0999.9	0.1	3	u	3	10	dec	defghi	C,R	m	4350
	NLS	3026	30	10	1	0999.9	0.1	3	u	3	10	none	none	C,R	m	4920
	NLS	3134	30	10	1	999.9	0.1	4	u	3	10	dec	defhi	C,R	m	4990
	NLS	3135	30	10	1	0999.9	0.1	3	u	3	10	dec	defhi	C,R	m	5500
	NLS	4408	30	10	1	999.9	0.1	3	u	3	10	dec	defhi	C,R	jn	7400
	NLS	3023	30	10	1	999.9	0.1	4	u	3	10	dec	defghi	C,R	m	4900
	NLS	2022	30	10	1	0999.9	0.1	3	u	3	10	dec	defhi	C,R	in	6970
	NLS	9128	30	10	1	999.9	0.1	3	u	3	10	dec	defhi	C,R	m	4850
D21	NLS	4820	30	10	1	999.9	0.1	3	u	3	10	dec	defhi	C,R	m	2490
	NLS	9126	30	10	1	999.9	0.1	3	u	3	10	dec	defghi	C,R	j	5075
	NLS	9127	30	10	1	999.9	0.1	3	u	3	10	none	none	C,R	j	4450
	NLS	4129	30	10	1	999.9	0.1	3	u	3	10	dec	defghi	C,R	m	5150
	NLS	RS2/125B	30	10	1	999.9	0.1	3	u	3	10	dec	i	C,R	m	4615
	NLS	2020	30	10	1	999.9	0.1	4	u	3	10	dec	defhi	C,R	in	6720
	Cohu	507D/452B	30	10	1	999.9	0.1	4	v	1/4	1	contacts	i	R	-	5085
	Cohu	502B	30	10	1	999.9	0.1	3	v	1/4	10	contacts	i	R	l	4245
	Honeywell	882	30	10	0.1	999.9	±0.1	4	nixie	ina	10, 1	10 line	defghi	C,R	mo	4550
	Honeywell	883	30	10	0.1	999.9	±0.02	4	nixie	ina	10, 1	10 line	defghi	R	cmo	6400
D22	Cimron	P9200B/6980B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	none	none	C,R	l	5015
	Cimron	P9300B/6980B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	none	none	C,R	cm	5265
	Cimron	P9400B/6980B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	BCD	defghi	C,R	l	5765
	Cimron	P9500B/6980B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	BCD	defghi	C,R	cm	5915
	Cimron	P9200B/6700B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	none	none	C,R	j	3945
	Cimron	P9300B/6700B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	none	none	C,R	m	4090
	Cimron	P9400B/6700B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	BCD	defghi	C,R	j	4590
	Cimron	P9500B/6700B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	BCD	defghi	C,R	m	4740
	Cimron	P9200B/6710B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	none	none	C,R	j	4180
	Cimron	P9300B/6710B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	none	none	C,R	m	4330
D23	Cimron	P9400B/6710B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	BCD	defghi	C,R	j	4830
	Cimron	P9500B/6710B	30	10	0.1	999.99	±0.02	3	nixie	ina	5	BCD	defghi	C,R	m	4980
	Cimron	P9200B/6701B	30	10	0.01	999.99	±0.02	4	nixie	ina	10, 1	none	none	C,R	j	4180
	Cimron	P9300B/6701B	30	10	0.01	999.99	±0.02	4	nixie	ina	10, 1	none	none	C,R	m	4330
	Cimron	P9400B/6701B	30	10	0.01	999.99	±0.02	4	nixie	ina	10, 1	BCD	defghi	C,R	j	4830
	Cimron	P9500B/6701B	30	10	0.01	999.99	±0.02	4	nixie	ina	10, 1	BCD	defghi	C,R	m	4980
	Fairchild	7100A-DM-03A	30	10	0.1	1000	±0.05	4	amperex	ina	5	extra	extra	C,R	aj	2575
	Behl-Invar	152500	35	10	0.1	500	0.07	3	u	3	1	decimal	i	C,R	jo	4710
	Cimron	E9300B/6770-943	30	15	0.1	999.99	±0.02	3	nixie	ina	1	none	none	C,R	m	8139
	Cimron	E9500B/6770-943	30	15	0.1	999.99	±0.02	3	nixie	ina	1	BCD	defghi	C,R	m	8724
D24	NLS	X-1/5/AC/1	50	10	0.01	500,000	0.1	4	u	ina	10	BCD	defghi	C,R	j	3250
	NLS	X-1/5/OAC/1	50	10	0.01	500,000	0.1	4	u	ina	10	BCD	defghi	C,R	i	3850
	NLS	X-2/4/AC3	50	10	0.1	500	0.1	4	nixie	ina	1	extra	extra	C,R	ajt	1430
	NLS	X-2/4/AC3/OPC	50	10	0.1	500	0.1	4	nixie	ina	1	extra	extra	C,R	ait	1880
	3M	4101	50	10	1	999.9	0.1	3	v	ina	10, 1	extra	extra	C,R	j	4195
	3M	4103	50	10	1	999.9	0.1	3	v	ina	10, 1	extra	extra	C,R	i	4995
	NLS	3317	50	10	1	999.9	0.1	4	u	3	1	dec	defghi	C,R	j	4740
	NLS	3316	50	10	1	999.9	0.1	4	u	3	1	none	none	C,R	i	4190
	NLS	3320	50	10	1	999.9	0.1	4	u	3	1	dec	defghi	C,R	l	5190
	NLS	3326	50	10	1	0999.9	0.1	3	u	3	1	none	none	C,R	j	4490
D25	NLS	3330	50	10	1	0999.9	0.1	3	u	3	1	dec	defghi	C,R	l	5490
	NLS	3327	50	10	1	0999.9	0.1	3	u	3	1	dec	defghi	C,R	j	5040
	NLS	4924	50	10	1	0999.9	0.1	3	u	3	1	dec	defhi	C,R	i	4250
	NLS	4922	50	10	1	0999.9	0.1	3	u	3	1	dec	defhi	C,R	i	3950
	NLS	9109	50	10	1	999.9	0.1	3	u	3	1	dec	defhi	C,R	j	4635

(tables continued on page T50)

Digital Voltmeters (ac) *(continued)*

	Manufacturer	Model	Frequency Minimum Hz	Frequency Maximum kHz	Voltage Ranges Minimum mV	Voltage Ranges Maximum V	Voltage Ranges Accuracy %	Voltage Ranges No.	Readout Type	Speed readings per sec	Input Impedance MΩ	Output Type	Output Printer	Mounting	Misc. Features	Price Approx. $
	NLS	9110	50	10	1	999.9	0.1	3	u	3	1	dec	defhi	C, R	i	5335
	NLS	9119	50	10	1	0999.9	0.1	3	u	3	1	dec	defhi	C, R	j	5300
D25 cont	NLS	9124	50	10	1	999.9	0.1	3	u	3	1	none	none	C, R	m	4375
	NLS	9120	50	10	1	0999.9	0.1	3	u	3	1	dec	defhi	C, R	i	5990
	NLS	5005/1100	50	10	1	999.9	0.05	3	u	2	10	none	none	C, R	j	2235
	NLS	4206/1100	50	10	1	999.9	0.05	3	u	2	10	dec	i	C, R	j	3035
	NLS	2917/1100	50	10	1	999.9	0.05	3	u	2	10	dec	i	C, R	j	4970
	NLS	3307	50	10	1	999.9	0.1	3	u	3	1	dec	defghi	C, R	i	4690
	NLS	3250	50	10	1	999.9	0.1	3	u	3	1	none	none	C, R	j	3250
	NLS	3254	50	10	1	999.9	0.1	3	u	3	1	none	none	C, R	i	3640
D26	NLS	3252	50	10	1	999.9	0.1	3	u	3	1	none	none	C, R	m	3345
	NLS	3237	50	10	1	999.9	0.1	3	u	3	1	dec	defghi	C, R	m	3970
	NLS	3239	50	10	1	999.9	0.1	3	u	3	1	none	none	C, R	j	3100
	NLS	3305	50	10	1	999.9	0.1	3	u	3	1	dec	defghi	C, R	j	3990
	NLS	3248	50	10	1	999.9	0.1	3	u	3	1	none	none	C, R	j	3245
	NLS	2023	50	10	1	999.99	0.02	3	u	3	1	dec	defghi	C, R	m	7070
	Data-Tec	DVX-315A/ DT 1404	50	10	10	1000	0.03	4	nixie	5	1	BCD	i	C, R	a	3945
	Data-Tec	DT-325	50	10	1	1000	0.5	3	nixie	5	1	BCD	i	C, R	-	2355
	EPSCO	DVP1-803	20	20	1	1000	±3	4	v	0.20	2	dec	i	C, R	o	475
	Cimron	7630	30	20	0.1	999.99	±0.02	3	nixie	ina	1	none	none	C, R	cm	4040
D27	Cimron	7650	30	20	0.1	999.99	±0.02	3	nixie	ina	1	BCD	defghi	C, R	cm	4290
	Cimron	4632/6775	30	20	0.1	999.99	±0.02	3	nixie	ina	1	none	none	C, R	m	4815
	Cimron	4652/6775	30	20	0.1	999.99	±0.02	3	nixie	ina	1	10 line	defghi	C, R	mo	4965
	Cimron	6600/6770	30	20	0.1	999.99	±0.05	3	nixie	ina	1	none	none	C, R	jw	1915
	Cimron	6600/6770	30	20	0.1	999.99	±0.05	3	nixie	ina	1	BCD	defghi	C, R	j	ina
	Cimron	P9500B/6760B	30	20	1Vrms	999.99	±0.1	3	nixie	ina	5	BCD	defghi	C, R	m	5480
	Cimron	P9200B/6760B	30	20	1Vrms	999.99	±0.1	3	nixie	ina	5	none	none	C, R	j	4680
	Cimron	P9300B/6760B	30	20	1Vrms	999.99	±0.1	3	nixie	ina	5	none	none	C, R	m	4830
	Cimron	P9400B/6760B	30	20	1Vrms	999.99	±0.1	3	nixie	ina	5	BCD	defghi	C, R	j	5330
	3M	5100-M01	50	20	0.1	999.9	±0.05	4	v	ina	1	extra	extra	C, R	j	5445
D28	Un-Syst	201/900	50	20	1	1000	±0.3	4	y	4	2.2	BCD	avail	C	j	725
	Cohu	533-2210	50	20	1	1000.0	0.3	3	z	ina	1	BCD	i	C, R	m	2195
	Cohu	533-2810	50	20	1	1000.0	0.3	3	z	ina	1	BCD	i	C, R	klr	2750
	Cohu	543-2810	50	20	1	1000.0	0.3	3	z	ina	1	BCD	i	C, R	alr	2750
	Cohu	543-2210	50	20	1	1000.0	0.3	3	z	ina	1	BCD	i	C, R	aj	2195
	Un-Syst	202/900	50	20	2	1000	±0.3	4	y	4	2.2	BCD	avail	C	j	700
	Un-Syst	204/900	50	20	4	1000	±0.3	4	y	4	2.2	BCD	avail	C	j	730
	Dana	5600/20	50	20	1V	1000	0.1	4	nixie	2	1	BCD	ina	R	-	4575
	Dana	5700/26	50	20	1.1V	1100	0.09	4	nixie	15	1	BCD	ina	R	-	4850
	Ballantine	350	50	20	100	1199.9	0.25	4	nixie	ina	2	none	none	C, R	-	720
D29	Trymetrics	4000-430M	50	20	0.1	999.9	0.1-0.25	4	nixie	ina	ina	none	none	C, R	i	890
	Trymetrics	4100-430M	50	20	0.1	999.9	0.1-0.25	4	nixie	ina	ina	none	none	C, R	it	990
	Trymetrics	4243	50	20	0.1	999.9	0.1-0.25	4	nixie	ina	ina	none	none	C	it	795
	Systron	1235-1	5	100	1	750	±0.5	4	nixie	8.3	1	BCD	i	C, R	a	request
	EAI	6200/6203	20	100	1	300	±0.2	4	nixie	6	1	none	none	C, R	i	830
	Fairchild	7200/DM-10	30	100	0.01	1000	±0.05	4	nixie	ina	5	yes	yes	C, R	ajw	4495
	Cal-Inst	8000	30	100	1	1000	0.9	3	u	ina	10	extra	extra	C	i	845
D30	Cal-Inst	8001	30	100	1	1000	0.9	3	u	ina	10	extra	extra	C	j	795
	Cal-Inst	8101	30	100	1	1000	0.9	5	u	ina	10, 1	extra	extra	C	j	1095
	NLS	X-2/4/AC4	50	100	0.1	500	0.1	4	nixie	ina	1	extra	extra	C, R	ajt	1580

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Digital Voltmeters (ac) *(continued)*

	Manufacturer	Model	Frequency Minimum Hz	Frequency Maximum kHz	Voltage Ranges Minimum mV	Voltage Ranges Maximum V	Voltage Ranges Accuracy %	Voltage Ranges No.	Readout Type	Speed readings per sec	Input Impedance MΩ	Output Type	Output Printer	Mounting	Misc. Features	Price Approx. $
D30 cont	NLS	X-2/4/AC4/ OPC	50	100	0.1	500	±0.3+ 0.1fs	4	nixie	ina	1	extra	extra	C, R	ait	2030
	NLS	X-1/5/AC/2	50	100	0.01	500.000	0.1	4	u	ina	10	BCD	defghi	C, R	i	4150
	NLS	X-1/5/AC/2	50	100	0.01	500.000	0.1	4	u	ina	10	BCD	defghi	C, R	j	3550
	H-P	2401C/2410B	50	100	100	750	0.05	5	nixie	9	1	BCD	i	C, R	i	6100
	H-P	3460B/2410B	50	100	100	750	0.2	5	nixie	9	10	BCD	i	C	j	5850
D31	Micro-Inst	5600	50	100	1	999	0.5	6	nixie	ina	10-10k	none	none	C	it	1195
	H-P	3440A/3445A	50	100	10V	999.9	±0.1	3	nixie	5	10.2	4 line	defghi	C	jn	1685
	H-P	3439A/3445A	50	100	10V	999.9	±0.1	3	nixie	3	10.2	4 line	defghi	C	jn	1475
	Honeywell	85	50	100	0.01	999.99	0.02-0.1	4	nixie	ina	1	10 line	defghi	C, R	cmo	request
	Fairchild	7000-02	50	100	0.1	1000	0.1-1	4	nixie	ina	1	extra	extra	C, R	aj	1400
	Honeywell	623	50	100	0.01	1000	0.04-1	3	u	ina	1	10 line	defghi	C, R	i	1345
	Dana	5600/25	50	100	1v	1000	0.1	4	nixie	2	1	BCD	ina	R	-	4875
	Dana	5100/24	50	100	1.1V	1100	0.09	4	nixie	15	1	BCD	ina	R	-	5150
	Dana	5400/020/27	50	100	11V	1100	0.1	3	nixie	3	1	BCD	ina	R	-	2490
	Dana	5500/130/28	50	100	11V	1100	0.1	3	nixie	3	1	BCD	ina	R	-	3445
D32	H-P	3440A/3443A/ 3400A	10	10,000	1	300	±5	3	nixie	2	10	4 line	defghi	3	jn	2135
	NLS	X-3	20	1GHz	10	300	3	3	nixie	3	10	analog	none	P		695

AC and DC Digital Voltmeter Notes

a. Integrating digital voltmeter.
b. Also measures frequency, period and interval.
c. DC/ohmmeter.
d. Clary printer.
e. Flexowriter.
f. Electric typewriter.
g. Card punch.
h. Tape.
i. Digital recorder.
j. Ac/dc meter.
k. Dc/ratio.
l. Ac/dc/ohmmeter.
m. Ac/dc/ratiometer.
n. FOB destination.
o. Also BCD.
p. Contacts.
q. 5-10 units.
r. Also current.
s. Built to environmental requirements of MIL-T-21200.
t. Incorporates a storage register for absolute display stability.
u. In-line plastic plates.
v. In-line, single plane projection.
w. Of reading + or − 0.02% fs, 30Hz to 10kHz. Accuracy varies with range, check factory.
x. In-line, mechanical number wheel.
y. Vertical neon decades, counter type.
z. Glow-discharge tubes.
(a) Burroughs nixie tube.
(b) Amperex tube.

Digital Voltmeter Cross Index

CODE	COMPANY	MODEL NO.	TABLE LOCATION	READER SERVICE NO.
ADAGE	Adage Inc. 1079 Commonwealth Ave. Boston, Massachusetts	V12-AD V16-AD VR12-AD	D 2 D 2 D 2	316
BALLANTINE	Ballantine Labs Inc. Box 97 Boonton, New Jersey	350 353 355	D 29 D 13 D 13	317
BEHL-INVAR	Behlman-Invar Electronics Corp. 1723 Cloverfield Boulevard Santa Monica, California	DV-271 IS 2500 IS 2500 MIL-V-72 MIL-VR-2100	D 14 D 12 D 23 D 7 D 7	318
CAL-INST	California Instruments Corp. 3511 Midway Drive San Diego, Calif. 92110	8000 8000 8001 8001 8002 8004 8101 8101 8104	D 14 D 30 D 13 D 30 D 13 D 13 D 14 D 30 D 14	319
CIMRON	Cimron Division 1152 Morena Boulevard San Diego, Calif. 92110	4631 4632 4632/6775 4651 4652 4652/6775 6600 6600/6770 7630 7630 7650 7650 E9300B-355 E9300B/6770-943 E9500B-355 E9500B/6770-943 P9200B P9200B/6700B P9200B/6701B P9200B/6710B P9200B/6760B P9200B/6980B P9300B P9300B/6700B P9300B/6701B P9300B/6710B P9300B/6760B P9300B/6980B P9400B P9400B/6700B P9400B/6701B P9400B/6710B P9400B/6760B P9400B/6980B P9500B P9500B/6700B P9500B/6701B P9500B/6710B P9500B/6760B P9500B/6980B	D 16 D 16 D 27 D 16 D 16 D 27 D 16 D 27 D 8 D 27 D 8 D 27 D 9 D 23 D 9 D 23 D 9 D 22 D 23 D 22 D 28 D 22 D 9 D 22 D 23 D 22 D 28 D 22 D 9 D 22 D 23 D 23 D 28 D 22 D 9 D 22 D 23 D 23 D 28 D 22	320

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COHU	Cohu Electronics Inc. 5725 Kearny Villa Road San Diego, Calif. 92112	412	D 20	321
		412(MIL-E-4158A)	D 7	
		501B	D 12	
		502B	D 12	
		502B	D 21	
		507D	D 12	
		507D/452B	D 21	
		510	D 5	
		531-1000	D 8	
		533-2210	D 7	
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		533-2310	D 8	
		533-2810	D 8	
		533-2810	D 28	
		541-1000	D 12	
		543-2210	D 12	
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		543-2310	D 12	
		543-2810	D 12	
		543-2810	D 28	
CMC	Computer Measurements Co. Div. Pacific Ind. Inc. 12970 Bradley Avenue San Fernando, Calif. 91342	800A/835A	D 15	322
		810/835A	D 15	
DANA	Dana Labs Inc. Irvine California	5100/24	D 31	323
		5400/005	D 17	
		5400/010	D 17	
		5400/020	D 16	
		5400/020/27	D 31	
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		5500/130/28	D 31	
		5600	D 16	
		5600/11	D 15	
		5600/20	D 29	
		5600/25	D 31	
		5700	D 17	
		5700/11A	D 16	
		5700/26	D 29	
DATA-TEC	Data Technology Corp. 2370 Charleston Road Mountain View, Calif.	DT-321	D 14	324
		DT-322	D 14	
		DT-323	D 11	
		DT-325	D 27	
		DVX-315A	D 11	
		DVX-315A	D 13	
		DVX-315A/DT-615	D 10	
		DVX-315A/DT-1404	D 27	
DYNAMICS	Dynamics Instrumentation Co. 583 Monterey Pass Road Monterey Park, California	6539	D 2	325
EPSCO	Epsco Inc. Data System Prods. Div. 411 Providence Highway Westwood, Massachusetts	DVM-803	D 27	326
ELECTRO-LAB	Electrolab Inc. 18271 Parthenia Street Northridge, Calif. 91324	100	D 13	327

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CODE	COMPANY	MODEL NO.	TABLE LOCATION	READER SERVICE NO.
EAI	Electronic Associates Inc. Long Branch Avenue Long Branch, New Jersey	6000 6001 6101 6200/6201 6200/6203	D 17 D 12 D 17 D 12 D 29	328
FAIR-CHILD	Fairchild Instrument 475 Ellis Street Mountain View, California	7000 7000-02 7050 7100A 7100A-DM-03A 7200 7200/DM-10	D 11 D 31 D 13 D 10 D 23 D 10 D 30	329
H-P	Hewlett-Packard Co. 1501 Page Mill Road Palo Alto, California	2401C 2401C/2410B 2402A 3430A 3439A/3441A 3439A/3442A 3439A/3443A 3439A/3444A 3439A/3445A 3440A/3441A 3440A/3442A 3440A/3443A 3440A/3443A/3400A 3440A/3444A 3440A/3445A 3459A 3460B 3460B/2410B H04-3460A	D 10 D 30 D 15 D 15 D 7 D 7 D15 D 10 D 31 D 5 D 5 D 15 D 32 D 3 D 31 D 16 D 16 D 30 D 15	Contact Local Rep.
HICKOK	Hickok Electrical Instr. Co. 10555 DuPont Avenue Cleveland, Ohio 44108	DMS3200/DP100	D 15	330
HONEY-WELL	Honeywell Test Instrument Div. 4800 East Dry Creek Road Denver, Colorado	85 85 623 880 881 882 882 883 883	D 7 D 31 D 31 D 9 D 7 D 9 D 21 D 7 D 21	331
JANUS	Janus Control Corp. Div. Tyco Labs Inc. 296 Newton Street Waltham, Mass. 02154	400 401 403 404	D 17 D 17 D 18 D 18	332
3M	3M Co. Instrument Department 300 South Lewis Road Camarillo, Calif. 93010	4100 4101 4102 4103 5100 5100-M01 5100-M02 5100-M07	D 5 D 24 D 5 D 24 D 8 D 28 D 8 D 8	333
MICRO-INST	Micro Instrument Co. 13100 Crenshaw Boulevard Gardena, California	5600 5600	D 5 D 31	334
MON-SANTO	Monsanto Electronics Technical Center 620 Passaic Avenue West Caldwell, N. J. 07006	2000	D 11	335

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NLS	Non-Linear Systems Inc.	15	D 2	336
	Del Mar Airport	2019	D 5	
	Box 728	2020	D 21	
	Del Mar, California 92014	2021	D 10	
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		2023	D 27	
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		2917/1100	D 26	
		3010	D 5	
		3020	D 10	
		3023	D 20	
		3024	D 20	
		3026	D 20	
		3130	D 9	
		3134	D 20	
		3135	D 20	
		3237	D 26	
		3239	D 26	
		3248	D 26	
		3250	D 26	
		3252	D 26	
		3254	D 26	
		3305	D 26	
		3307	D 26	
		3316	D 24	
		3317	D 24	
		3320	D 24	
		3326	D 24	
		3327	D 25	
		3330	D 25	
		4206	D 6	
		4206/1100	D 26	
		4401	D 6	
		4401	D 20	
		4408	D 20	
		4409	D 6	
		4808	D 2	
		4810	D 6	
		4814	D 6	
		4820	D 21	
		4922	D 25	
		4924	D 25	
		5005	D 6	
		5005/1100	D 25	
		6001	D 1	
		9104	D 6	
		9109	D 25	
		9110	D 25	
		9119	D 25	
		9120	D 25	
		9124	D 25	
		9126	D 21	
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		X-1/5/OAC/1	D 24	
		X-1/5/AC/2	D 30	
		X-2/4	D 7	
		X-2/4/AC3	D 6	
		X-2/4/AC3	D 24	
		X-2/4/AC3/OPC	D 3	
		X-2/4/AC3/OPC	D 24	
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CODE	COMPANY	MODEL NO.	TABLE LOCATION	READER SERVICE NO.
NORTH HILLS	North Hills Electronics Inc. Glen Cove New York	DSV. 1	D 3	337
PAR	Princeton Applied Research Corp. Box 565 Princeton, N. J. 08540	CS-3. 1	D 2	338
ROBACK	Roback Corp. Huntington Valley Pennsylvania	33 34 35 304 305	D 15 D 14 D 14 D 11 D 11	339
R&S	Rohde & Schwarz Sales Co. 111 Lexington Avenue Passaic, New Jersey 07056	UGZ/BN1100	D 6	340
SIMPSON	Simpson Electric Co. 5200 West Kinzie Street Chicago, Illinois 60644	111	D 13	341
SYSTRON	Systron-Donner Corp. 888 Galindo Street Concord, Calif. 94520	1033/1936 1234 1234-4 1235-1 1235-1 6413	D 10 D 11 D 14 D 11 D 29 D 10	342
TECH-NOLOGY	Technology Inc. 7400 Colonel Glenn Hwy. Dayton, Ohio 45431	DM5000	D 13	343
TRY-METRICS	Trymetrics Corp. 204 Babylon Turnpike Roosevelt, New York	4000-103 4000-104 4000-105 4000-300A 4000-300M 4000-400A 4000-400M 4000-430M 4000-430M 4000-500A 4000-500M 4100-103 4100-105 4100-105 4100-300A 4100-300M 4100-400A 4100-400M 4100-430M 4100-430M 4100-500A 4100-500M 4230 4240 4243 4243	D 2 D 1 D 1 D 4 D 4 D 3 D 4 D 4 D 29 D 3 D 3 D 2 D 1 D 2 D 4 D 4 D 3 D 4 D 4 D 29 D 3 D 3 D 5 D 4 D 4 D 29	344
UN-SYST	United Systems Corp. 918 Woodley Road Dayton, Ohio	201 201/900 202 202/900 204/900 401 402 404 451 452 454	D 14 D 28 D 18 D 29 D 29 D 1 D 1 D 1 D 1 D 1 D 1	345
VIDAR	Vidar Corp. 77 Ortega Avenue Mountain View California 94041	500 520	D 11 D 17	346
WESTON	Weston Inst. & Electronics Div. Daystrom Inc. 614 Frelinghuysen Avenue Newark, New Jersey	1420 1423 4000	D 10 D 11 D 5	347

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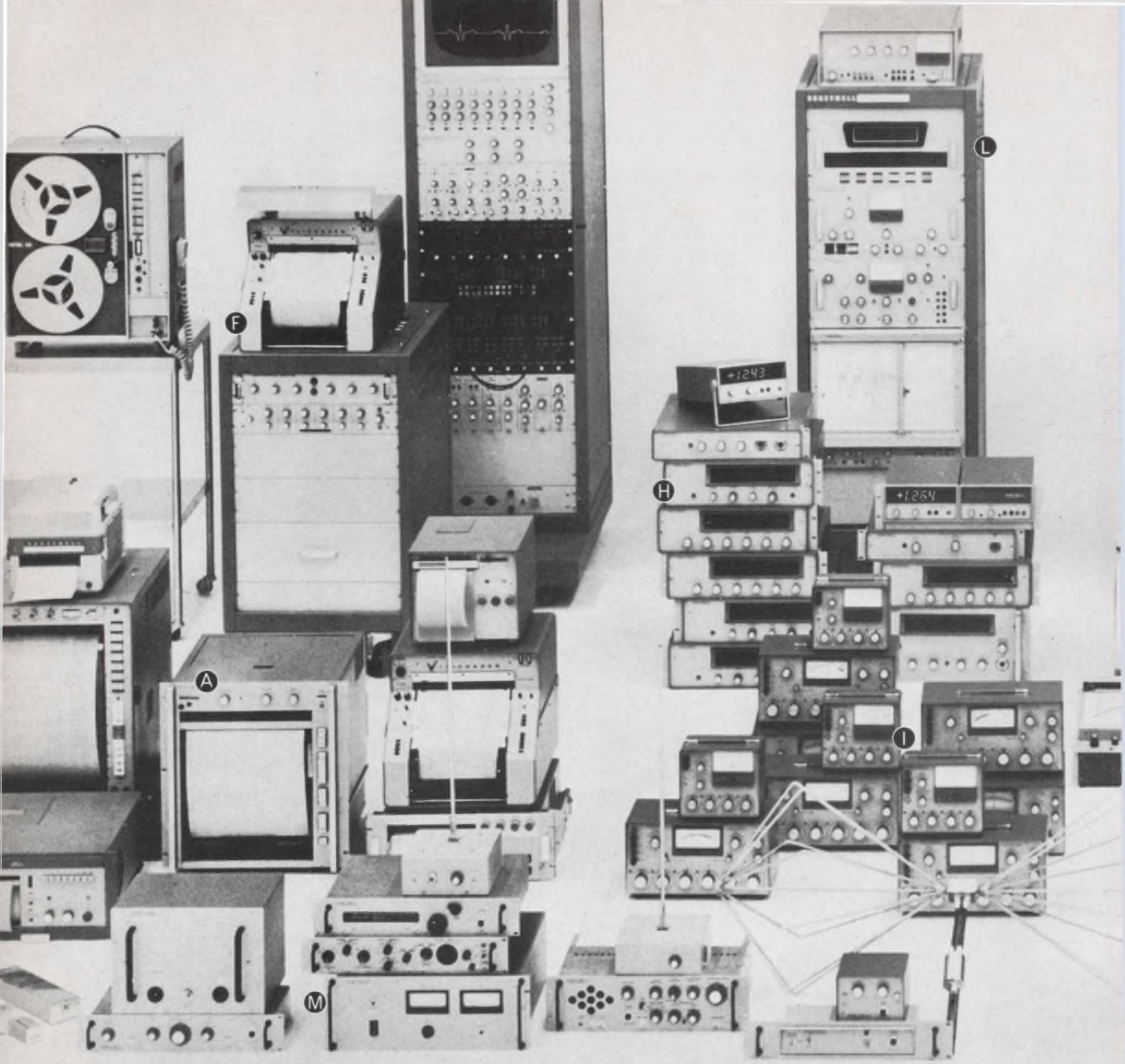

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Spectrum Analyzers

			Frequency			Voltage Sensitivity				Sweep		Input Impedance kΩ	Type C Cab R Rack P Port	Price Approx. $
	Manufacturer	Model	Minimum Hz	Maximum MHz	Accuracy %	dBm(µV)	Minimum V	Maximum mV	Accuracy %	Width kHz	Rate Hz			
A1	Rantec	EA-100	dc	70Hz	±0.5Hz	ina	ina	ina	ina	ina	ina	50	R	ina
	N-Ross	PSA-016	0.5	0.002	ina	ina	ina	2/cm	ina	0.01-0.6	10-120sec	1000	C, R	950
	N-Ross	PSA-026	0.5	0.002	ina	ina	ina	2/cm	ina	0.01-0.6	2-200 sec	1000	kr	1100
	N-Ross	PSA-036	0.5	0.002	ina	ina	ina	2/cm	ina	0.01-0.6	2-200 sec	1000	ar	1100
	Panoram	LF-2B	0.5	0.0025	1	(1 mV)	100	10	±5	0.002-0.5	30sec-16 hrs	5000	C, R	4950
	Quan-Tec	304	1	0.005	±1	ina	100	0.03	±5	0.005-5	18-18k sec	100	R	2480
	Quan-Tec	304	1	0.005	±1	ina	100	0.03	±5	0.005-5	18-18k sec	100	C	2450
	Probescp	SS-5	1	0.0053	2	(500)	500	5	±1 dB	0.02-0.6	1.3 sec	1000	C	2550
	Kay	6051A	85	0.008	±2 dB	ina	ina	ina	ina	N/A	2.4	0.2, 0.6, 10	C	2950
	Kay	6061A	85	0.008	±2 dB	ina	ina	ina	ina	0.045-0.3	2.4 sec	0.05, 0.6, 10	C	3130
A2	Gulton	OCF-1	10	0.01	±2.5	ina	20	20	ina	ina	2-64	1000	2C	ina
	Spectran	40-0.6	1.5	0.012	ina	(250)	30	30	ina	0.02	real time	50	R	8800m
	Kay	675	5	0.015	ina	ina	ina	3	ina	0.002-0.6	0.8-2.4 sec	1800	C	3130
	Spectran	480-0.6	0.6	0.015	ina	(250)	30	30	ina	0.02	real time	50	R	42,500m
	Spectran	240-0.6	0.6	0.015	ina	(250)	30	30	ina	0.02	real time	50	R	26,500m
	Spectran	100-0.6	0.6	0.015	ina	(250)	30	30	ina	0.05	real time	50	R	14,350m
	Kay	7029A	5	0.016	±2 dB	ina	ina	ina	ina	N/A	1.2, 2.4, 4.8, 38.4	0.05, 0.6, 10	C	3950
	Spectran	40-1.3	3	0.016	ina	(250)	30	30	ina	0.04	real time	50	R	8450m
	Spectran	100-1.3	3	0.016	ina	(250)	30	30	ina	0.04	real time	50	R	12,800m
	Spectran	240-1.3	3	0.016	ina	(250)	30	30	ina	0.04	real time	50	R	22,700m
A3	Spectran	480-1.3	3	0.016	ina	(250)	30	30	ina	0.04	real time	50	R	34,800m
	R-S	FNA BN48301	30	0.02	±1 (±10Hz)	(100nV)	100	0.001	±5	0.01-0.2	20 sec	100 (40pF)	C	6800
	B&K Inst	2107	20	0.02	1	ina	1000	0.1	±0.5 dB	full range	ina	2200	C	1680
	N-Ross	PSA-011	10	0.02	ina	ina	ina	85µV/cm	ina	0.1-6	10-50 sec	1000	cr	650
	N-Ross	PSA-021	10	0.02	ina	ina	ina	85µV/cm	ina	0.1-6	2-10 sec	1000	kr	800
	N-Ross	PSA-031	10	0.02	ina	ina	ina	85µV/cm	ina	0.1-6	5-50 sec	1000	ar	800
	Panoram	LP-1aZM	20	0.0225	±2 (±10Hz)	(50mV)	500	0.5	±10	0.2-5	1 sec-16 hrs	250	C, R	2200
	Panoram	SY-1-S4-2	5	0.0225	±2 (±10Hz)	(50mV)	500	0.5	±10	0.02-5	1 sec-16 hrs	250	C, R	4635
	Probescp	SS-20	6	0.023	±2	(50)	500	0.5	±1 dB	0.1-6	2 sec	50	C, R	1875
	Probescp	SS-20L	6	0.023	ina	(50)	500	0.5	±10	0.1-6	2 sec/sweep	50	C, R	1950
A4	Polarad	2736	10	0.03	ina	(10)	ina	ina	ina	full range	ina	100	R	2300
	Spectran	40-3.6	8	0.03	ina	(250)	30	30	ina	0.12	real time	50	R	6940m
	Spectran	100-3.6	8	0.03	ina	(250)	30	30	ina	0.12	real time	50	R	8800m
	Spectran	240-3.6	8	0.03	ina	(250)	30	30	ina	0.12	real time	50	R	12,230m
	Spectran	480-3.6	8	0.03	ina	(250)	30	30	ina	0.12	real time	50	R	17,250m

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Spectrum Analyzers *(continued)*

	Manufacturer	Model	Frequency: Minimum Hz	Frequency: Maximum MHz	Frequency: Accuracy %	Voltage Sensitivity: dBm(µV)	Voltage Sensitivity: Minimum V	Voltage Sensitivity: Maximum mV	Voltage Sensitivity: Accuracy %	Sweep: Width kHz	Sweep: Rate Hz	Input Impedance kΩ	Type: C Cab, R Rack, P Port	Price Approx. $
	Gulton	OR-WA/1	3	0.03	±2	ina	36	36	ina	0.001-0.5	10-2400 sec	1000	R	ina
A4 cont	Panoram	TA-2/AL-2	20	0.035	1	-90	3	0.002	1	0.2-20h	1	100	C	3000
	Panoram	TA-2/AR-1	20	0.035	1	-90	3	0.002	1	0.2-20	1	100	C	2750
	Gulton	OCF-3	5	0.04	ina	ina	100	50	ina	ina	ina	100	R	ina
	Honeywell	9300 Series	2	0.04	±10Hz	ina	10	100	±0.1	full range	ina	100	C	ina
	B&K Inst	2112	22	0.045	1	ina	1000	0.1	±0.5dB	full range	0.2-720	2200	C	2495
	Quan-Tec	305	10	0.05	±0.5	ina	1000	0.03	±5	ina	0.5-500 sec	1000	R	2580
	Quan-Tec	305	10	0.05	±0.5	ina	1000	0.03	±5	ina	0.5-500 sec	1000	C	2550
	Probescp	SS-50-S	0	0.05	ina	ina	500	500	±1dB	50, 5, 1, 0.5	1g	50	C, R	3335
	Spectran	40-5	10	0.06	ina	(250)	30	30	ina	0.16	real time	50	R	6800m
A5	Spectran	100-5	10	0.06	ina	(250)	30	30	ina	0.16	real time	50	R	8510m
	Spectran	240-5	10	0.06	ina	(250)	30	30	ina	0.16	real time	50	R	11,530m
	Spectran	480-5	10	0.06	ina	(250)	30	30	ina	0.16	real time	50	R	15,850m
	Spectran	40-15	30	0.075	ina	(250)	30	30	ina	0.5	real time	50	R	6800m
	Spectran	100-15	30	0.075	ina	(250)	30	30	ina	0.5	real time	50	R	8510m
	Spectran	240-15	30	0.075	ina	(250)	30	30	ina	0.5	real time	50	R	11,530m
	Spectran	480-15	30	0.075	ina	(250)	30	30	ina	0.5	real time	50	R	15,850m
	Spectran	40-12	25	0.075	ina	(250)	30	30	ina	0.400	real time	50	R	6800m
	Spectran	100-12	25	0.075	ina	(250)	30	30	ina	0.400	real time	50	R	8510m
	Spectran	240-12	25	0.075	ina	(250)	30	30	ina	0.400	real time	50	R	11,530m
A6	Spectran	480-12	25	0.075	ina	(250)	30	30	ina	0.4	real time	50	R	15,850m
	Spectran	40-10	20	0.075	ina	(250)	30	30	ina	0.320	real time	50	R	6800m
	Spectran	100-10	20	0.075	ina	(250)	30	30	ina	0.320	real time	50	R	8510m
	Spectran	240-10	20	0.075	ina	(250)	30	30	ina	0.320	real time	50	R	11,530m
	Spectran	480-10	20	0.075	ina	(250)	30	30	ina	0.320	real time	50	R	15,850m
	Panoram	TMI-1b	350	0.085	±5(±3Hz)	(200)	10	2	±10	0.1-20	1	50	R	4100
	LFE	190A	500	0.09	ina	ina	0.1	0.001	±2dB	0.07-1	ina	ina	C	ina
	Spectran	40-25	50	0.1	ina	(250)	30	30	ina	0.8	real time	50	R	6800m
	Spectran	100-25	50	0.1	ina	(250)	30	30	ina	0.8	real time	50	R	8510m
	Spectran	240-25	50	0.1	ina	(250)	30	30	ina	0.5	real time	50	R	11,530m
A7	Spectran	480-25	50	0.1	ina	(250)	30	30	ina	0.8	real time	50	R	15,850m
	N-Ross	PSA-012(c)	30	0.1	ina	ina	ina	85µV/cm	ina	0.5-30	10-50 sec	1000	cr	650
	N-Ross	PSA-022(k)	30	0.1	ina	ina	ina	85µV/cm	ina	0.5-30	2-10 sec	1000	kr	800
	N-Ross	PSA-032(a)	30	0.1	ina	ina	ina	85µV/cm	ina	0.5-30	5-50 sec	1000	ar	800
	Spectran	40-50	100	0.11	ina	(250)	30	30	ina	1.6	real time	50	R	6800m

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Spectrum Analyzers *(continued)*

	Manufacturer	Model	Frequency Minimum Hz	Frequency Maximum MHz	Frequency Accuracy %	Voltage Sensitivity dBm(μV)	Voltage Sensitivity Minimum V	Voltage Sensitivity Maximum mV	Voltage Sensitivity Accuracy %	Sweep Width kHz	Sweep Rate Hz	Input Impedance kΩ	Type C Cab R Rack P Port	Price Approx. $
	Spectran	100-50	100	0.11	ina	(250)	30	30	ina	1.6	real time	50	R	8510m
	Spectran	240-50	100	0.11	ina	(250)	30	30	ina	1.6	real time	50	R	11,530m
	Spectran	480-50	100	0.11	ina	(250)	30	30	ina	1.6	real time	50	R	15,850m
	Probescp	SS-100	13.5	0.11	2	(50)	500	0.5	±1	0.2-20	1	50	C,R	1840
A8	Panoram	TMI-1b/120	350	0.12	±5(±30Hz)	(200)	10	2	±10	0.1-5	1	50	R	4100
	Panoram	TMI-4/120	350	0.12	±5(±30Hz)	(200)	10	2	±10	0.1-5	1	50	R	3450
	Probescp	TA-100L	350	0.12	5	(50)	500	0.5	±1 dB	0.35-120	1	50	R	2225
	Panoram	TMI-23	25	0.12	5	(500)	500	0.5	±10	0.1-20	1	0.050	R	4325
	Probescp	LL-120	11	0.12	ina	ina	500	0.5	±10	0.2-22	1	55	C,R	3750
	Probescp	TA-120L	1	0.12	2	(50)	500	0.5	±1 dB	0.1-22	1	50	R	1775
	Probescp	TA-1200	11	0.132	ina	ina	500	0.5	ina	0.1-24	1-30	5	C,R	1875
	Spectran	40-100	200	0.16	ina	(250)	30	30	ina	3.2	real time	50	R	7000
	Spectran	100-100	200	0.16	ina	(250)	30	30	ina	3.2	real time	50	R	8930
	Spectran	240-100	200	0.16	ina	(250)	30	30	ina	3.2	real time	50	R	12,530
	Spectran	480-100	200	0.16	ina	(250)	30	30	ina	3.2	real time	50	R	17,850
A9	Spectran	480-125	250	0.2	ina	(250)	30	30	ina	3.2	real time	50	R	18,400
	Panoram	TMI-4/200	25	0.2	±5(±30Hz)	(200)	10	2	±10	0.1-5	1	50	R	3800
	Panoram	TMI-23/200	25	0.2	5	(500)	500	0.5	±10	0.1-20	1	0.050	R	6770
	Allison	540	2.5	0.2	±5	140 dB	300	0.001	±1 dB	ina	10	10-100	C,R	3000-8000
	Probescp	TA-165L	350	0.215	ina	ina	500	0.5fs	ina	full range	1	50	C,R	2325
	Probescp	LL-190	350	0.215	ina	ina	500	0.5	±1 dB	full range	1	55	C,R	3995
	Probescp	TA-190L	11	0.215	ina	ina	500	0.5	ina	0.1-50	1	50	C,R	1875
	Probescp	SS-300	25	0.335	ina	ina	500	0.5	±5	0.5-70	1	55	C,R	1860
	N-Ross	PSA-033(a)	150	0.5	ina	ina	ina	85μV/cm	ina	2.5-150	5-50 sec	1000	ar	800
	N-Ross	PSA-023(k)	150	0.5	ina	ina	ina	85μV/cm	ina	2.5-150	2-10 sec	1000	kr	800
A10	N-Ross	PSA-013(c)	150	0.5	ina	ina	ina	85μV/cm	ina	2.5-150	10-50 sec	1000	cr	650
	Probescp	LCA-1	100	0.6	2	(20)	250	0.2	±5	1-200	30 sec	55	C,R	2025
	Panoram	SB-15a	100	0.6	2(±100Hz)	(20)	200	0.2	±0.5 dB	1-200	1-60 g	55(25 pF)	C,R	2200
	Probescp	SS-500	75	0.6	2	(25)	250	0.25	±1 dB	2-200	0.33 sec	50	C,R	1875
	Panoram	TA-2/UR-3	100	0.7	1	-90	3	0.002	1	0-400	1-60	100	C	3250
	Tektronix	1L5	50	1	±5	N/A	2V/cm	10μV/cm	3	10Hz-1MHz	N/A	1000	cr	1000d
	Tektronix	3L5	50	1	±5	N/A	2V/cm	10μV/cm	3	10Hz-1MHz	N/A	1000	cr	1100
	N-Ross	PSA-014(c)	1000	2	ina	ina	ina	85μV/cm	ina	10-600	10-50 sec	1000	cr	850
	N-Ross	PSA-024(k)	1000	2	ina	ina	ina	85μV/cm	ina	10-600	10-55 sec	1000	kr	1000
	N-Ross	PSA-034(a)	1000	2	ina	ina	ina	85μV/cm	ina	10-600	5-50 sec	1000	ar	1000
A11	FED-SCI	UA-7B	1	10	ina	ina	ina	ina	ina	ina	real time	50	C	ina
	Panoram	SPA-3d	20	15	2(±300Hz)	(2)	1.4	0.025	±15	0-3000	1-60 g	0.072	C,R	3325
	Panoram	TA-2/VR-4	1000	25	1	-90	3	0.002	1	0-5000	1-60	0.05	C	4250
	N-Ross	PSA-205	1000	25	ina	-90	ina	ina	ina	full range	5-30 sec	0.05, 0.075	r	1400d
	N-Ross	PSA-235	1000	25	ina	-90	ina	ina	ina	full range	5-30 sec	0.05, 0.075	r	1500d

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Spectrum Analyzers *(continued)*

			Frequency			Voltage Sensitivity				Sweep			Type	
	Manufacturer	Model	Minimum Hz	Maximum MHz	Accuracy %	dBm(μV)	Minimum V	Maximum mV	Accuracy %	Width kHz	Rate Hz	Input Impedance kΩ	C Cab R Rack P Port	Price Approx. $
A12	Panoram	SPA-3/25a	200	25	2(±300Hz)	(2)	1.4	0.025	±15	0-3000	1-60 g	0.072	C, R	3600
	Panoram	SA-8b2/T-1000	30MHz	30	10	(150)	0.1	0.15	f	0-10,000	1-60 g	0.05	C	1570
	Panoram	SA-3/T-2000NC	30MHz	30	10	(10)	0.001	0.01	f	0-2000	30 sec	0.05	C	580
	Tektronix	1L10(c)	1MHz	36	ina	-100	N/A	N/A	ina	10Hz/ 2kHz/ div	N/A	0.05	cr	1150
	Tektronix	3L10	1MHz	36	ina	-100	N/A	N/A	ina	10Hz- 2kHz/ div	N/A	0.05	cr	1260
	N-Ross	PSA-201	0.6	36	ina	-106	ina	ina	ina	10Hz- 10kHz	10-50 sec	0.05	cr	1600
	N-Ross	PSA-221	0.6	36	ina	-106	ina	ina	ina	10Hz- 10kHz	8-15 sec	0.05	kr	2060
	N-Ross	PSA-231	0.6	36	ina	-106	ina	ina	ina	10Hz- 10kHz	8-15 sec	0.05	ar	1700
	Probescp	MD-50B	2MHz	40	1	m	ina	0.02	10	0-100	1-30	0.05	R	3575
	Panoram	SSB-3b	2MHz	40	1	m	3	0.02	±5	0-100	0.1-30	0.05	C	4400
A13	Polarad	2836	10	40	±1	ina	0.001	0.1	ina	0.15-30	1-30	0.05	C	4800p
	Polarad	2936	10	40	±1	ina	0.001	0.1	ina	0.15-30	1-30	0.05	C	5700p
	Panoram	SSB-50	10	40	±3	m	ina	ina	ina	0-100	0.1-30 g	0.05, 0.6	C, R	ina
	Wiltek	PAN-5F	50MHz	100	0.5	ina	0.005	0.5	ina	5M, 10M, 50M	22	0.05	C, R	15,000
	N-Ross	PSA-200	0.5	100	ina	-106	ina	ina	ina	10Hz- 10kHz	10-50 sec	0.05	cr	800
	N-Ross	PSA-230	0.5	100	ina	-106	ina	ina	ina	10Hz- 10kHz	8-15 sec	0.05	ar	900
	Wiltek	PAN-1F	100MHz	150	0.5	ina	0.005	0.5	ina	5000	22	0.05	C, R	15,000
	N-Ross	PSA-311	1MHz	300	ina	-90	ina	ina	ina	full range	1-30 sec	0.05	cr	1300d
	N-Ross	PSA-321	1MHz	300	ina	-90	ina	ina	ina	full range	1-30 sec	0.05	kr	1400d
	N-Ross	PSA-331	1MHz	300	ina	-90	ina	ina	ina	full range	1-30 sec	0.05	ar	1400d
A14	N-Ross	PSA-315	400MHz	550	ina	-90	ina	ina	ina	full range	1-30 sec	0.05	cr	1400d
	N-Ross	PSA-325	400MHz	550	ina	-90	ina	ina	ina	full range	1-30 sec	0.05	kr	1500d
	N-Ross	PSA-335	400MHz	550	ina	-90	ina	ina	ina	full range	1-30 sec	0.05	ar	1500d
	Wiltek	PAN-6	30MHz	600	1	-107	0.005	0.001	ina	10M, 100M, 570M	22	0.05	C	25,000
	Wiltek	PAN-7	500MHz	1000	1	-107	0.005	0.001	ina	10M, 100M, 500M	22	0.05	C	ina
	Polarad	TSA-W/STU-1B	10MHz	1000	±1	-85 to -90	ina	ina	ina	200-5000	1-30	0.05	C	4335
	Panoram	SB-12b/T-100	450,000	1000	1	m	3	0.02	±0.5 dB	0-100	0.1-30 g	0.05	C, R	2150
	ELD	PN1010	120MHz	1200	ina	-38 to -45	N/A	N/A	ina	1200 MHz	20-70	0.05	r	2195
	ELD	DU-501/TU-VL501	120MHz	1200	ina	-38 to -45	N/A	N/A	ina	1200 MHz	20-70	0.05	C	4975
	LFE	306S1	2.7GHz	3300	1	120	ina	ina	ina	ina	5, 25	ina	R	13,737
A15	Tektronix	1L20	10MHz	4200	ina	-90 to -110	N/A	N/A	ina	1kHz, 10MHz /cm	N/A	0.05	cr	1925
	Polarad	TSA/STU-2B	10MHz	4560	±1	-85 to -95	ina	ina	ina	400-25,000	1-30	0.05	C	4290
	Polarad	TSA-W/STU-2BW	10MHz	4560	±1	-85 to -95	ina	ina	ina	200-5000	1-30	0.05	C	4685
	ELD	PN1012	500MHz	5000	ina	-42 to -55	N/A	N/A	ina	5GHz	20-70	0.05	r	1995
	LFE	306C1	5GHz	6500	1	120	ina	ina	ina	ina	5, 25	ina	R	13,867

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Spectrum Analyzers *(continued)*

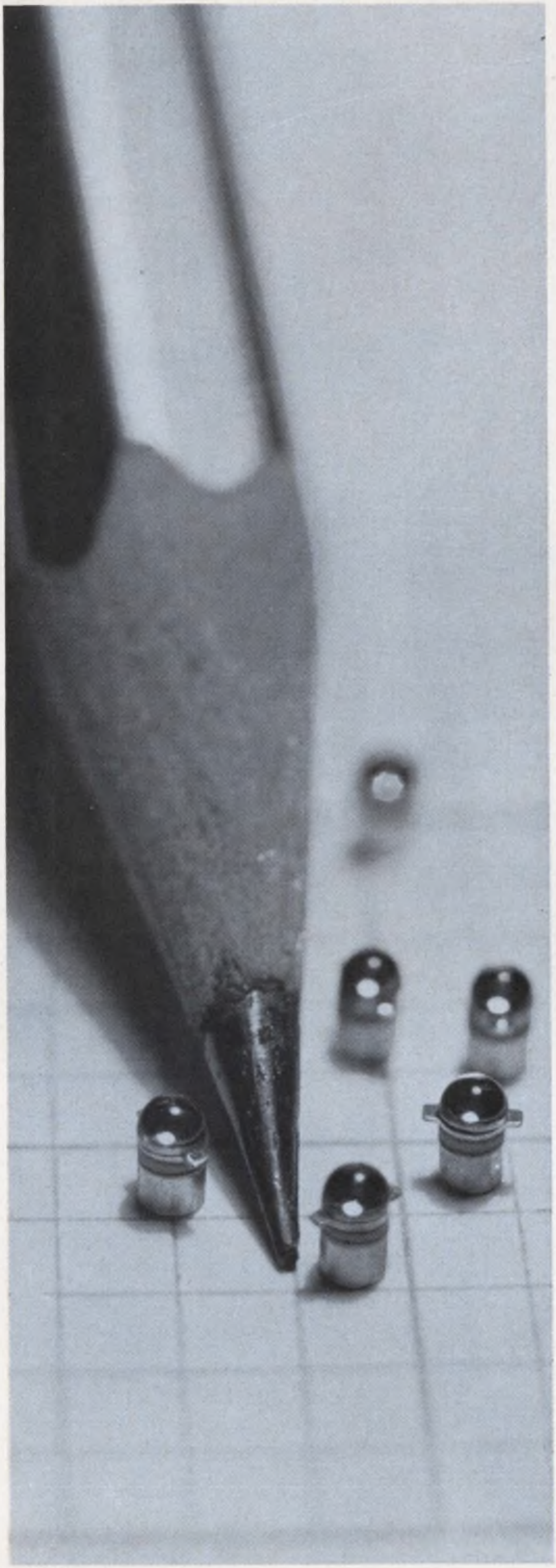
	Manufacturer	Model	Frequency Minimum Hz	Frequency Maximum MHz	Frequency Accuracy %	Voltage Sensitivity dBm(μV)	Voltage Sensitivity Minimum V	Voltage Sensitivity Maximum mV	Voltage Sensitivity Accuracy %	Sweep Width kHz	Sweep Rate Hz	Input Impedance kΩ	Type C Cab R Rack P Port	Price Approx. $
A15 cont	LFE	306X1	8.2GHz	9600	1	(120)	ina	ina	ina	ina	5, 25	ina	R	13, 982
	NE-ENGR	11-20-S	8.47GHz	9630	±5MHz	-80 to -50	ina	ina	ina	1.5-20, 000	10-30	ina	R	2125
	Tektronix	1L30(c)	925MHz	10, 500	ina	-75 to -105	N/A	N/A	ina	1kHz-10MHz /cm	N/A	0.05	cr	1925
	ELD	DU-501/TU-LX501	1200MHz	12, 000	ina	-45 to -58	N/A	N/A	ina	12GHz	20-70	0.05	C	4975
	ELD	PN1011	1200MHz	12, 000	ina	-45 to -58	N/A	N/A	ina	12GHz	20-70	0.05	r	1995
A16	N-Ross	PSA-510	10MHz	15, 000	±5MHz	-95 to -75	ina	ina	ina	0-1GHz	1-30	0.05	acr	1250d
	N-Ross	PSA-530	10MHz	15, 000	±5MHz	-95 to -75	ina	ina	ina	0.1GHz	1-30	0.05	acr	1350d
	Polarad	TSA/STU-3B	4.37GHz	22, 000	±1	-77 to -90	ina	ina	ina	400-25M	1-30	0.05	C	4590
	Polarad	TSA-W/STU-3BW	4.37GHz	22, 000	±1	-77 to -90	ina	ina	ina	200-5M	1-30	0.05	C	4985
	Polarad	TSA/STU-4B	21GHz	33, 000	±1	-57 to 75	ina	ina	ina	500-100M	1-30	0.05	C	5040
	Polarad	TSA-W/STU-4BW	21GHz	33, 000	±1	-57 to 75	ina	ina	ina	200-5M	1-30	0.05	C	5435
	H-P	8551B/851B	10MHz	40, 000	±1	-65 to -100	ina	ina	ina	0-2G	3ms-1s/cm	ina	C, R	9950
	Panoram	SPA-100	10MHz	40, 000	±1	-90 to -75	ina	ina	ina	0-70M	1μs-1s/div	ina	C	5470d
	Tektronix	491	10MHz	40, 000	ina	-70 to -110	N/A	N/A	ina	1kHz, 10MHz /div b	N/A	0.05	C	4450d
	Tektronix	R491	10MHz	40, 000	ina	-70 to -100	N/A	N/A	ina	1kHz, 10MHz /div b	ina	0.05	R	4500
A17	Polarad	SA-84	10MHz	40, 880	±1	-40 to -90	ina	ina	ina	10-10M	1-30	ina	C	5000
	Polarad	SA-84T	10MHz	40, 880	±1	-55 to -105	ina	ina	ina	500-5M	1-30	ina	C	5850
	Polarad	SA-84W	10MHz	40, 880	±1	-70 to -95	ina	ina	ina	10-10M	1-30	0.05	C	6290
	Polarad	2882	10MHz	42, 240	±1	-55 to -100	ina	ina	ina	10-100M	0.1-33 sec		C, R	6300
	Panoram	SPA-10	10MHz	43, 000	±1 ±1MHz	-50 to -105	ina	ina	ina	200-80M	1-60	0.05	C	4500
	Polarad	TSA/STU-5B	33GHz	44, 000	±1	-50 to -65	ina	ina	ina	400-25M	1-30	0.05	C	5040
	Polarad	TSA-W/STU-5BW	33GHz	44, 000	±1	-50 to -65	ina	ina	ina	200-5M	1-30	0.05	C	5435
	Polarad	SA-84WA	10MHz	63, 680	±1	-45 to -115	ina	ina	ina	10-10M	1-30	ina	C	6490
	Polarad	SA-84WAB	10MHz	63, 680	±1	-45 to -115	ina	ina	ina	10-10M	1-30	ina	C	6665i
	Panoram	SPA-12	10MHz	73, 000	1	-40 to -115	ina	0.001	3 dB	0-80 MHz	1-60	0.05	C, R	6400
A18	Polarad	2992B	10MHz	91, 000	±1	-40 to -95	ina	ina	ina	10	ina	ina	C, R	9250
	Polarad	SA-84WC	10MHz	91, 040	±1	-40 to -115	ina	ina	ina	10-10M	1-30	ina	C	6790
	Polarad	SA-84WCB	10MHz	91, 040	±1	-40 to -115	ina	ina	ina	10-10M	1-30	ina	C	6965i

Spectrum Analyzer Notes

a. Any Hewlett-Packard 140A/141A oscilloscope.
b. Internal sawtooth.
c. Any Tektronix oscilloscope using letter series plug-in units and 530, 540, 550 and 580 series with type 81 adapter.
d. Solid state.
f. Depends on receiver.
g. Sweeps per second.
h. Also log 25Hz-25kHz.
i. Depends on signal generator.
k. Any Tektronix 560 series oscilloscope.
l. Has phase lock.
m. Family has a varying number of filters.
r. Plug-in unit.

Spectrum Analyzer Cross Index

CODE	COMPANY	MODEL NO.	TABLE LOCATION	READER SERVICE NO.
ALLISON	Allison Labs Inc. 11301 Ocean Avenue La Habra, California 09631	540	A 9	348
B&K INST	B & K Instruments Inc. 5111 West 164th Street Cleveland, Ohio 44124	2107 2112	A 3 A 5	349
ELD	Electro/Data Inc. 3121 Benton Street Garland, Texas 75040	DU-501/TU-LX501 DU-501/TU-VL501 PN 1010 PN 1011 PN 1012	A 15 A 14 A 14 A 15 A 15	350
FED-SCI	Federal Scientific Corp. 615 West 131st Street New York, N.Y. 10027	UA-7B	A 11	351
GULTON	Gulton Industries Inc. Metuchen New Jersey	OCF-1 OCF-3 OR-WA/1	A 2 A 4 A 4	352
H-P	Hewlett-Packard Co. 1501 Page Mill Road Palo Alto, California	8551B/851B	A 16	Contact Local Rep.
HONEY-WELL	Honeywell Test Instr. Div. 4800 E. Dry Creek Road Denver, Colorado	9300 Series	A 4	353
KAY	Kay Electric Co. Maple Avenue Pine Brook, N. J. 07058	675 6051A 6061A 7029A	A 2 A 1 A 1 A 2	354
LFE	LFE Electronics Instrument Division 985 Commonwealth Avenue Boston, Massachusetts	190A 306C1 306S1 306X1	A 7 A 15 A 14 A 15	355
N-ROSS	Nelson-Ross Electronics, Inc. 5-05 Burns Avenue Hicksville, New York 11801	PSA-011 PSA-012 PSA-013 PSA-014 PSA-016 PSA-021 PSA-022 PSA-023 PSA-024 PSA-026 PSA-031 PSA-032 PSA-033 PSA-034 PSA-036 PSA-200 PSA-201 PSA-205 PSA-221 PSA-230 PSA-231 PSA-235 PSA-311 PSA-315 PSA-321 PSA-325 PSA-331 PSA-335 PSA-510 PSA-530	A 3 A 7 A 10 A 11 A 1 A 3 A 7 A 10 A 11 A 1 A 3 A 7 A 10 A 11 A 1 A 13 A 12 A 11 A 12 A 13 A 12 A 11 A 13 A 14 A 13 A 14 A 13 A 14 A 16 A 16	356



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Specifications 4107

Total Output Power P	Modulation Rise Time	Price
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Specifications 4205

Response at 7700Å	Sensitive Area	Speed of Response	Dark Current	Price
1.5 μA/mW/cm^2	3.0x10^{-3} cm^2	<1 nsec	150 pA(max)	\$16.00(1-9) 13.60(10-99)

HEWLETT PACKARD

HP ASSOCIATES

01706

ON READER-SERVICE CARD CIRCLE 101

Spectrum Analyzer Cross Index *(continued)*

CODE	COMPANY
NE-ENGR	Northeastern Engineering Div. of LaPointe Industries Inc. 130 Silver Street Manchester, N. H.
PANORAM	Panoramic Instruments Singer Co., Metrics Div. 915 Pembroke Street Bridgeport, Conn. 06608
POLARAD	Polarad Electronic Instrument Div. 34-02 Queens Boulevard Long Island City New York 11101
PROBESCP	Probescope Co. 211 Robbins Lane Syosset, New York

Spectrum Analyzer Cross Index *(continued)*

MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
11-20-S	A 15	357
LF-2B	A 1	358
LP-1aZM	A 3	
SA-3/T-2000NC	A 12	
SA-8bz/T-1000	A 12	
SB-12b/T-100	A 14	
SB-15a	A 10	
SPA-3/25a	A 12	
SPA-3A	A 11	
SPA-10	A 17	
SPA-12	A 17	
SPA-100	A 16	
SSB-3b	A 12	
SSB-50	A 13	
SY-1	A 3	
SY-2	A 3	
TA-2/AL-2	A 4	
TA-2/AK-1	A 4	
TA-2/UR-3	A 10	
TA-2/VR-4	A 11	
TMI-1b	A 7	
TMI-1b/120	A 8	
TMI-4/120	A 8	
TMI-4/200	A 9	
TMI-23	A 8	
TMI-23/200	A 9	
2736	A 4	359
2836	A 13	
2882	A 17	
2936	A 13	
2992B	A 18	
SA-84	A 17	
SA-84T	A 17	
SA-84W	A 17	
SA-84WA	A 17	
SA-84WAB	A 17	
SA-84WC	A 18	
SA-84WCB	A 18	
TSA/STU-2B	A 15	
TSA/STU-3B	A 16	
TSA/STU-4B	A 16	
TSA/STU-5B	A 17	
TSA-W/STU-1B	A 14	
TSA-W/STU-2BW	A 15	
TSA-W/STU-3BW	A 16	
TSA-W/STU-4BW	A 16	
TSA-W/STU-5BW	A 17	
LCA-1	A 10	360
LL-120	A 8	
LL-190	A 10	
MD-50B	A 12	
SS-5	A 1	
SS-20	A 3	
SS-20L	A 3	
SS-50-S	A 5	
SS-100	A 8	
SS-300	A 10	
SS-500	A 10	
TA-100L	A 8	

Spectrum Analyzer Cross Index *(continued)*

CODE	COMPANY
PROBESCP (cont)	
QUAN-TEC	Quan-Tech Labs Inc. 45 South Jefferson Road Whippany, New Jersey
RANTEC	Rantec Corporation 24003 Ventura Boulevard Calabasas, Calif. 91302
R-S	Rohde & Schwarz Sales Co. 111 Lexington Avenue Passaic, New Jersey 07056
SPECTRAN	Spectran Electronics Corp. 146 Main Street Monard, Massachusetts 01754
TEKTRON-IX	Tektronix Inc. Box 500 Beaverton, Oregon 97005
WILTEK	Wiltek Inc. 59 Danbury Road Wilton, Connecticut

Spectrum Analyzer Cross Index *(continued)*

MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
TA-120L	A 8	
TA-165L	A 9	
TA-190L	A 10	
TA-1200	A 9	
304	A 1	361
305	A 5	
EA-100	A 1	362
FNA BN48301	A 3	363
40-0.6	A 2	364
40-1.3	A 2	
40-3.6	A 4	
40-5	A 5	
40-10	A 6	
40-12	A 6	
40-15	A 5	
40-25	A 7	
40-50	A 7	
40-100	A 9	
100-0.6	A 2	
100-1.3	A 2	
100-3.6	A 4	
100-5	A 5	
100-10	A 6	
100-12	A 6	
100-15	A 5	
100-25	A 7	
100-50	A 8	
100-100	A 9	364
240-0.6	A 2	
240-1.3	A 2	
240-3.6	A 4	
240-5	A 5	
240-10	A 6	
240-12	A 6	
240-15	A 6	
240-25	A 7	
240-50	A 8	
240-100	A 9	
480-0.6	A 2	
480-1.3	A 3	
480-3.6	A 4	
480-5	A 5	
480-10	A 6	
480-12	A 6	
480-15	A 6	
480-25	A 7	
480-50	A 8	
480-100	A 9	
480-125	A 9	
1L5	A 11	365
1L10	A 12	
1L20	A 15	
1L30	A 15	
3L5	A 11	
3L10	A 12	
491	A 16	
R491	A 16	
PAN-1F	A 13	366
PAN-5F	A 13	
PAN-6	A 14	
PAN-7	A 14	

Vacuum Tube Voltmeters (dc)

	Manufacturer	Model	Volts: Minimum mV	Volts: Maximum V	Volts: Ranges No.	Meter: Scale	Meter: Calibration	Amplifier	Ohms: Minimum	Ohms: Maximum	Type C-Cab R-Rack P-Port.	Misc. Features	Price Approx. $
V1	Applied	70	(100 nv)	0.003	10	1 in.	V, 0-ctr	yes	none	none	C, R	t	880
	Keithley	148	(10nv)	0.1	18	1 in.	V, 0-ctr	yes	none	none	C	t	1375
	Keithley	149	(100 nv)	0.1	13	1 in.	V, 0-ctr	yes	none	none	R	t	895
	Wilk	L-6	0.001	0.2	17	1 in.	µV, mV	none	none	none	C	t	675
	H-P	425A	±0.01	±1	11	1 in.	0-ctr	yes	none	none	C	t	500
	H-P	425AR	±0.01	±1	11	1 in.	0-ctr	yes	none	none	R	t	505
	Keithley	150B	0.3	1	14	1 in.	V, 0-ctr	yes	none	none	C	rt	825
	Keithley	600A	10	10	7	1 in.	ina	yes	10K	10T	P	bt	425
	Keithley	200B	8	±20	8	1 in.	V, 0-ctr	yes	none	none	P	bt	440
V2	R-S	UVG BN12061	100	30	14	1 in.	V, 0-ctr	yes	none	none	C	t	900
	IB	300	1	30	10	1 in.	V, 0-ctr	none	none	none	P	t	175
	Decker	410-1	±300	±100	6	1 in.	V, 0-ctr	yes	none	none	C	t	375
	Keithley	610B	1	100	11	1 in.	VΩA	yes	100	100T	C, R	ft	565
	Keithley	621	100	100	7	1 in.	VΩA	yes	100K	1T	C	t	425
	J-Omega	35A	0	110	1	1 in.	V	none	none	none	C, R	t	885
	Triplett	631	1200	120	4	1 in. log	V	none	1.5K	150M	P	bt	78
	Trio	105-1	1000	300	1	1 in.	V, 0-1	yes	ina	ina	R	t	85
	Trio	105-2	500	300	1	1 in.	V, 0-ctr	yes	ina	ina	R	t	85
	Trio	105-3	1000	300	6	1 in.	V, 0-1	yes	ina	ina	R	t	100
V3	Trio	105-4	1000	300	6	1 in.	V, 0-ctr	yes	ina	ina	R	t	100
	Trio	106-1	1000	300	1	1 in.	V, 0-1	yes	ina	ina	R	t	140
	Trio	106-2	500	300	1	1 in.	V, 0-ctr	yes	ina	ina	R	t	140
	Trio	106-3	1000	300	6	1 in.	V, 0-1	yes	ina	ina	R	t	150
	Trio	106-4	1000	300	6	1 in.	V, 0-ctr	yes	ina	ina	R	t	150
	Trio	107-1	10	300	10	1 in.	V, 0-ctr	yes	ina	ina	R	t	450
	Trio	305-1	1000	300	1	1 in.	V, 0-ctr	yes	ina	ina	R	t	225
	Trio	305-2	500	300	1	1 in.	V, 0-1	yes	ina	ina	R	t	225
	Trio	110-1	3	300	11	1 in.	V	none	none	none	1/2R	t	285
	Keithley	662	±500	±500	4	1 in.	V, 0-ctr	yes	none	none	C	t	1075
V4	Fluke	801B	±10	±500	8	1 in.	V, 0-ctr	yes	none	none	C	t	485
	Fluke	801B	±10	±500	8	1 in.	V, 0-ctr	yes	none	none	R	t	505
	Fluke	821A	±1	±500	9	1 in.	V, 0-ctr	yes	none	none	C	t	795
	Fluke	821A	±1	±500	9	1 in.	V, 0-ctr	yes	none	none	R	t	815
	Fluke	825A	1	500	9	1 in.	V, 0-ctr	yes	none	none	C	t	590
	Fluke	825A	1	500	9	1 in.	V, 0-ctr	yes	none	none	R	t	610
	Keithley	630	300	500	4	1 in.	V	ina	none	none	C		1615
	Keithley	660A	500	500	4	1 in.	V, 0-ctr	yes	none	none	C	t	650
	Keithley	662	500	500	4	1 in.	V, 0-ctr	yes	none	none	C	t	1075
	Trio	310-1	100	500	12	1 in. expend	V	yes	ina	ina	R	t	250
V5	Ballant	365	0.01	1000	9	log	V, A, dB	yes	none	none	C	t	620
	Dynamics	502	±0.1	±1000	15	1 in.	V, 0-ctr	yes	none	none	C	bft	575
	Dynamics	502R	±0.1	±1000	15	1 in.	V, 0-ctr	yes	none	none	R	bft	600
	Dynamics	503	±0.1	±1000	15	1 in.	V, A, 0-ctr	none	none	none	C	bft	625
	Dynamics	503R	±0.1	±1000	15	1 in.	V, A, 0-ctr	yes	none	none	R	bft	650
	Dynamics	504	±0.1	±1000	15	1 in.	V, A, 0-ctr	yes	10	1M	P	bft	760
	Dynamics	504R	±0.1	±1000	15	1 in.	V, A, 0-ctr	yes	10	1M	R	bft	785
	Dynamics	505	±1	±1000	13	1 in.	V, 0-ctr	yes	none	none	C	t	550
	Dynamics	505R	±1	±1000	13	1 in.	V, 0-ctr	yes	none	none	R	t	575
	Metronix	PM-502A	10	1000	11	1 in.	V	ina	none	none	P	fkt	ina
	Metronix	PM-502A-C	10	1000	11	1 in.	V, 0-ctr	ina	none	none	P	fkt	ina

VTVM index starts on page T82.

Vacuum Tube Voltmeters (dc) *(continued)*

	Manufacturer	Model	Volts: Minimum mV	Volts: Maximum V	Volts: Ranges No.	Meter: Scale	Meter: Calibration	Amplifier	Ohms: Minimum	Ohms: Maximum	Type C-Cab R-Rack P-Port.	Misc. Features	Price Approx. $
V6	Metronix	PM-301A	10	1000	11	1 in.	V	ina	none	none	P	kt	
	Metronix	PM-301A-C	10	1000	11	1 in.	V, 0-ctr	ina	none	none	P	kt	ina
	Metronix	PM-504A	0.1	1000	15	1 in.	V	ina	none	none	P	fkt	ina
	Metronix	PM-504A-C	0.1	1000	15	1 in.	V, 0-ctr	ina	none	none	P	fkt	ina
	Metronix	PM-503A	1	1000	13	1 in.	V	ina	none	none	P	fkt	ina
	Metronix	PM-503A-C	10	1000	13	1 in.	V, 0-ctr	ina	none	none	P	fkt	ina
	Millivac	MV-127B-L	0.1	1000	15	1 in.	V	ina	none	none	C	t	ina
	Millivac	MV-127B-M	0.1	1000	15	1 in.	V	ina	none	none	C	t	ina
	Millivac	MV-852A	0.01	1000	17	1 in.	V-0-ctr	yes	none	none	C, R	ft	ina
	Millivac	MV-952A	0.01	1000	17	1 in.	V, 0-ctr	yes	none	none	C, R	frt	ina
V7	Fluke	895A	0.1	1000	8	1 in.	V, 0-ctr	ina	none	none	C	f	1095
	Medistor	A-75	0.01	1000	5	1 in.	V, 0-ctr	yes	none	none	C	bft	690
	Medistor	A-60C	0.003	1000	9	1 in. log	V, 0-ctr	yes	none	none	C, R	bft	495
	Medistor	A161RB	0.003	1000	5	1 in. log	V, 0-ctr	yes	none	none	R	bft	595
	Millivac	MV-17C	1	1000	13	1 in. log	V, 0-ctr, 0-I	none	none	none	C	t	325
	Millivac	MV-17C	1	1000	13	1 in. log	V, 0-ctr, 0-I	none	none	none	R	t	350
	Millivac	MV-127BL	0.25	1000	14	1 in.	V, 0-ctr	yes	none	none	C	t	395
	Millivac	MV-127BM	0.25	1000	14	1 in.	V, 0-ctr	yes	none	none	R	t	420
	Millivac	MV-07C	0.01	1000	17	1 in.	V, 0-ctr	yes	none	none	C	t	550
	Medistor	A-71B	0.001	1000	5	1 in.	V, 0-ctr	yes	none	none	C, R		1695
V8	Medistor	A-71C	0.001	1000	5	1 in.	V, 0-ctr	yes	none	none	C, R	t	2000
	H-P	412A	1	1000	13	1 in.	V, Ω, A	yes	1	100M	C	t	400
	H-P	412AR	1	1000	13	1 in.	V, Ω, A	yes	1	100M	R	t	405
	H-P	413A	1	1000	13	1 in.	V, 0-ctr, null	yes	none	none	C	t	350
	H-P	413AR	1	1000	13	1 in.	V, 0-ctr, null	yes	none	none	R	t	355
	H-P	740B	0.001	1000	10	1 in.	V-0-ctr	yes	none	none	C	ft	2350
	IB	600	100	1000	5	1 in.	V, 0-ctr	none	none	none	C	ft	450
	Fluke	871A	1	1000	7	1 in.	V, 0-ctr	yes	none	none	C	ft	565
	Fluke	871AB	1	1000	7	1 in.	V, 0-ctr	yes	none	none	C	bft	695
	Fluke	881A	0.1	1000	8	1 in.	V, 0-ctr	yes	none	none	C	ft	825
V9	Fluke	881AB	0.1	1000	8	1 in.	V, 0-ctr	yes	none	none	C	bft	955
	Fluke	885A	0.1	1000	8	1 in.	V, 0-ctr	yes	none	none	C	ft	965
	Fluke	885AB	0.1	1000	8	1 in.	V, 0-ctr	yes	none	none	C	bft	1095
	Ballant	365-S/2	0.01	1000	9	log	V, c, dB	yes	none	none	R	t	640
	Boonton	95A	0.001	1000	17	1 in.	0-ctr	yes	none	none	C	t	550
	Boonton	95A	0.001	1000	17	1 in.	0-ctr	yes	none	none	R	t	575
	Medistor	A-61	0.003	3000	9	1 in.	V, 0-ctr	yes	none	none	R	ft	595
	Sweeney	1170ETVM	200	50,000	7	1 in.	V	none	none	none	P	bft	260

(tables continued on page T74)

Reader-service numbers are given in the index.
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Vacuum Tube Voltmeters (ac)

	Manufacturer	Model	Frequency Minimum Hz	Frequency Maximum kHz	Volts Minimum mV	Volts Maximum V	Volts Ranges No.	Meter Scale	Meter Calibration	Amplifier	Ohms Minimum	Ohms Maximum	Type C-Cab R-Rack P-Port.	Misc. Features	Price Approx. $
V10	Simpson	303	(dc)	(ac)	1200	1200	5	1 in. log	V, Ω	none	1K	1G	P	s	85
	Ballant	303	1	0.006	300μV	350	12	1 in. log	ina	yes	none	none	C	fru	320
	GR	1230-A	(dc)	0.010	±30	±10	6	1 in.	V, Ω	yes	300K	10T	C		525
	Ballant	323	10	0.020	300μV	330	12	1 in. log	V, dB	ina	none	none	C	fru	520
	Infrared	601	1	1	(10μV)	1	9	1 in. log	V, dB	none	none	none	C, R	s	1775
	Trio	302-1	380	2	10	300	1	1 in.	V, 0-ctr	yes	ina	ina	R	y	275
	Trio	141-1	50	2	10	300	1	1 in.	V, 0-ctr	yes	ina	ina	R	y	185
	Trio	144-1	50	2	10	300	1	1 in.	V, 0-ctr	yes	ina	ina	R	y	125
	Trio	143-1	50	2	10	300	10	1 in.	V, 0-ctr	yes	ina	ina	R	y	300
	Trio	149-1	50	2	1	300	12	1 in.	V, 0-ctr	yes	ina	ina	R	y	225
V11	Fluke	883AB	50	5	0.1	1000	8	1 in.	V, 0-ctr	ina	none	none	C	bf	1375
	Fluke	883A	30(&dc)	5	0.1	1000	8	1 in.	V, 0-ctr	ina	none	none	C	f	1215
	Fluke	887A	20	5	0.1	1000	8	1 in.	V, 0-ctr	ina	none	none	C	fk	1375
	Fluke	887AB	20	5	0.1	1000	8	1 in.	V, 0-ctr	ina	none	none	C	fkr	1535
	Ind-Test	300PB	60	10	1	300	12	1 in.	V, 0-ctr, deg	none	none	none	P	fx	1200
	Gertsch	PAV-1A	50	10	1	300	12	1 in.	V, 0-ctr	ina	none	none	C	s	1160
	Gertsch	PAV-1AR	50	10	1	300	12	1 in.	V, 0-ctr	ina	none	none	R	s	1095
	Gertsch	PAV-2A	50	10	1	300	2	1 in.	V, 0-ctr	ina	none	none	C	s	1350
	Gertsch	PAV-2AR	50	10	1	300	2	1 in.	V, 0-ctr	ina	none	none	R	s	1285
	Fluke	803B	20	10	10	500	9	1 in.	V, 0-ctr	none	none	none	C		875
V12	Fluke	803B	20	10	10	500	9	1 in.	V, 0-ctr	none	none	none	R		895
	Fluke	873A	20	10	0.001	1000	6	1 in.	V, null	yes	none	none	C	fks	875
	Fluke	873AB	20	10	0.1	1000	7	1 in.	V, 0-ctr	ina	none	none	C	fkr	1035
	Infrared	600	10	10	(10μv)	1	9	1 in.	V, 0-ctr	none	none	none	C, R		1675
	Ballant	350	50	20	100	1199.9	4 dec.	ina	V, null	none	none	none	C	fu	1200
	Gertsch	PAV-3AR	50	20	1	300	12	1 in.	V, 0-ctr	ina	none	none	C	s	1720
	B&K Inst	2410	20	20	10	1000	11	1 in., log	V, db	yes	none	none	C	u	210
	Instr-EL	253-S4	20	20	0.15	500	12	1 in., log	V, rms	yes	none	none	C, R	s	350
	Instr-EL	253-S5	20	20	0.15	500	12	1 in., log	V, rms	yes	none	none	C, R	s	375
	B&K Inst	2417	2	20	10	1000	11	1 in., log	V, dB	yes	none	none	C	u	445
V13	Ind-Test	300A	15	30	1	300	12	1 in.	V, 0-ctr, deg	none	none	none	R	x	1400
	Ind-Test	300B	15	30	1	300	12	1 in.	V, 0-ctr, deg	none	none	none	R	x	1675
	Ballant	316	0.01	30	20	200	4	1 in., log	p-p, dB	none	none	none	C	w	375
	Ballant	316-S/2	0.01	30	20	200	4	1 in., log	p-p, dB	none	none	none	C	w	395
	B&K Inst	2603A	2	40	0.1	1000	11	1 in., log	V, dB	yes	none	none	C	suw	745
	B&K Inst	2603B	2	40	0.1	1000	11	1 in., log	V, dB	yes	none	none	C	suw	830
	B&K Inst	2603C	2	40	0.1	1000	11	1 in., log	V, dB	yes	none	none	R	suw	830
	Trio	309-1	50	50	10	500	15	1 in., expan	V, rms	yes	ina	ina	R	s	325
	Trio	102-1	20	50	10	300	1	1 in.	V, rms	yes	ina	ina	R	s	160
	Trio	103-1	20	50	10	300	10	1 in.	V, rms	yes	ina	ina	R	s	275

(tables continued on page T76)

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VTVM index starts on page T82.

BOONTON ELECTRONICS CORPORATION

Model 75D

Capacitance Bridge—1 MHz

A new capacitance bridge directly replacing the Boonton 75A and 75B series. Embodies a phase sensitive detector which provides capacitance measurements independent of conductance. Amplitude sensitive detector is included for conventional capacitance/loss studies. 3-terminal arrangement permits remote measurements without errors resulting from cable capacitance to ground. 2-terminal measurements also possible. Provision for measurement of equivalent inductance. Low test signal level. Internal or external dc bias.
Capacitance Measurement: 0 to 1000 pF; accuracy, ±0.25%; resolution, 0.00005 pF with phase sensitive detector; 0.0005 pF with amplitude sensitive detector
Conductance Measurement: 0 to 1000 μmhos; accuracy, ±5%; resolution, 0.01 μmho
Inductance Measurement: 25 μH to ∞; basic accuracy, ±0.25%
Test Signal: 1 MHz, crystal controlled; level adjustable from 1 mV to 300 mV
Dual External DC Bias: HI to GND and/or LO to GND; differential ±400 V, max
Internal DC Bias: HI to LO; —6 V to +150 V
Price: $1,595.00

Model 35A

Q Bridge—100 KHz to 50 MHz

Dramatically new, non-resonant 3-terminal bridge. Provides direct reading measurements of capacitance up to large values and Q over wide ranges with continuously adjustable test frequency. Low test signal levels. No external work coils. Internal or external dc bias.
Capacitance Measurement: 20 to 1,000 pF (100 KHz to 50 MHz); 2 to 10,000 pF (100 KHz to 10 MHz); indirectly 0.005 to 20 pF; basic accuracy 0.5%
Q Measurements: 5 to 10,000; basic accuracy, 5% for Q's up to 30, (10 + Q/500)% for Q's up to 10,000
Test Signal: Frequency continuously adjustable from 100 KHz to 50 MHz; levels < 50 mV; continuously adjustable
Dual External DC Bias: HI to GND and/or LO to GND; differential ±200 V
Internal DC Bias: HI to LO; 0 to 150 V
Price: $3,000.00

Model 71A

Capacitance/Inductance Meter—1 MHz

Quick, convenient, direct reading, 3-terminal measurements of capacitance or 2-terminal measurements of inductance. Internally supplied 1 MHz test signal. Operates with low test signal level, permitting semi-conductor tests. Linear meter scales. Provision for dc bias. Linear dc output proportional to capacitance or inductance reading for display on dvm, x-y plotter, for data logging, or, with suitable voltage comparator, for go/no go testing.
Capacitance Measurement: 0 to 1000 pF in 7 ranges; accuracy, ±(0.5% fs + 0.5% reading); resolution, 0.25% fs
Inductance Measurement: 0 to 1000 μH in 7 ranges; accuracy, ±(0.5% fs + 0.5% reading) resolution 0.25% fs
Test Signal: Frequency 1 MHz; level, 15 mV rms for capacitance measurements, < 1 mV for inductance measurements
Q Range: Specified accuracies apply for test specimens having Q's of 3 or more; lower with readjustment
DC Bias: Externally supplied up to ±200 V
DC Analog Output: 0 to 100 mV or 300 mV fs depending on range numerics; also > 1 V fs for loads > 10 MΩ; linearity, 0.1% of reading; response time, 10 ms
Price: $795.00; rack-mounting version with built-in standard, Model 71AR, $870.00

RF MICROWATTMETER

Model 41A

RF Microwattmeter

Exceptionally stable microwave power meter providing reliable measurements over a 70 dB range with one power detector. Use of full wave diode detector overcomes limitations of stability, sensitivity and overload of thermal types. No zero balancing except for fractional microwatt measurements. Can be calibrated from low frequency rf source. Stable dc output.
Power Range: 0.01 μW (—50 dBm) fs to 10 mW (+10 dBm) fs
Power Sensitivity: 0.001 μW (—60 dBm)
Frequency Range: 0.1 MHz to 7 GHz
Basic Accuracy: ±0.5 dB
Drift: Less than 0.001 μW per hour
VSWR: 1.3 to 3 GHz; 1.5 to 7 GHz
Overload Limit: Input of 300 mW cw does not cause damage
Price: 41A: $695.00; rack mounting Model 41AR, $720.00

SENSITIVE RF VOLTMETERS

Model 91DA

Sensitive RF Voltmeters

The 91 Series RF Voltmeters provide reliable, reproducible voltage measurements from the low radio frequencies to the gigahertz region over a wide range of amplitudes. The versatility of these instruments plus their accuracy and convenience of operation have established them as standards of performance for the industry. The primary differences between the Models 91DA, 91H and 91C are indicated in the specification table below. All three models are characterized by low noise, excellent stability, and input impedance, and low input capacitance.

Model 91H

	Model 91DA	Model 91H	Model 91C
Voltage Range:	1 mV fs to 3 V fs*	1 mV fs to 3 V fs*	3 mV fs to 3 V fs*
	(*to 300 V with Model 91-7C 100:1 Voltage Divider)		
Voltage Sensitivity:	300 μV	100 μV	1 mV
Power Sensitivity, (50 Ω):	0.0018 μW	0.0002 μW	0.02 μW
Basic Accuracy:	±2%, fs	±3%, fs	±5%, fs
Frequency Range:	20 KHz to 1200 MHz, with uncalibrated response to 4000 MHz		
VSWR:	Less than 1.2 to 1200 MHz for all Models		
Waveform Response:	True rms up to 0.03V (to 3 V with accessory 100:1 Voltage Divider) gradually approaching peak-to-peak (calibrated in rms) above this level		
DC Output	yes	yes	no
dB Range	80 dB	80 dB	70 dB
Price:	$650.00** $750.00†	$595.00**	$495.00**

**Includes 91-12E RF Probe, 91-13B RF Probe Tip, and 91-8B 50 ohm Adapter
†With complete Accessory Kit, consisting of 91-12E RF Probe 91-13B RF Probe Tip, 91-6C Unterminated BNC Adapter, 91-7C 100:1 Voltage Divider, 91-8B 50 ohm Adapter, 91-14A Tee Adapter, 91-15A 50 ohm Termination, all in 91-18A Accessory Storage Box.

Accessories for RF Voltmeters:

		Price
91-4C	1 KHz to 250 MHz Probe	$65.00
91-6C	Undeterminated BNC Adapter	20.00
91-7C	100:1 Voltage Divider (50 KHz to 700 MHz)	35.00
91-8B	50 Ω BNC Adapter (20 KHz to 600 MHz) (other impedances also available)	25.00
91-12E	20 KHz to 1200 MHz Probe	45.00
91-13B	RF Probe Tip	3.00
91-14A	Type N "Tee" Adapter (20 KHz to 1200 MHz)	35.00
91-15A	50 Ω Type N Termination (20 KHz to 1200 MHz)	25.00
91-16A	Unterminated Type N Adapter	20.00
91-18A	Accessory Storage Box	10.00

DC VOLTAGE INSTRUMENTATION

Model 56A

Sensitive DC Null Detector

Electronic galvanometer providing exceptionally high sensitivity and high input impedance. Especially valuable as indicator in conjunction with Wheatstone Bridge. Zero-center scale. 60 dB scale compression in Hunt Mode virtually eliminates range switching when measuring specimens of unknown value. Provision for remote mode switching. Amplifier output available at front panel terminals. Either floating or grounded operation.
Voltage Sensitivity: 1 μV to 100 V end scale in 8 ranges
Current Sensitivity: 0.1 pA to 10 μA, es
Input Resistance: 10 MΩ, all ranges
Operating Modes: Hunt (60 dB meter scale compression); Calibrate (linear meter scale)
Amplifier Output Capability: ±1 mA into 1000 Ω
Amplifier Gain: —40 to +100 dB
Price: $495.00 (rack mounted Model 56AR, $520.00)

Model 95A

Sensitive DC Microvolt/Picoammeter

Unusually broad range of dc voltage and current measurements covered in 42 ranges. Front panel range and function switching uniquely simple and convenient. Zero-center meter. Fast response. Exceptionally stable amplifier output at front panel. Amplifier output gain and reference level adjustable without interaction with meter. Either floating or grounded operation for voltage; floating for current.
Voltage Range: 10 μV to 1000 V end scale; Accuracy, ±3%; sensitivity, 1 μV
Current Range: 1 pA to 1 A es; Accuracy, ±4%; sensitivity, 0.1 pA
Voltmeter Input Resistance: 10 MΩ, all ranges
Amplifier Output: ±1 V es across 1000 Ω
Amplifier Gain: 100,000 max.
Price: $550.00 (rack mounted Model 95A-R, $575.00)

ROUTE 287 AT SMITH RD., PARSIPPANY, N.J. 07054 · TEL.: 201-887-5110 TWX: 710-986-8241

ON READER-SERVICE CARD CIRCLE 106

Vacuum Tube Voltmeters (ac) *(continued)*

	Manufacturer	Model	Frequency Minimum Hz	Frequency Maximum kHz	Volts Minimum mV	Volts Maximum V	Volts Ranges No.	Meter Scale	Meter Calibration	Amplifier	Minimum
V14	Trio	104-1	20	50	10	300	1	1 in.	V, rms	yes	ina
	Instr-EL	247	10	50	0.05	500	13	1 in., log	V, rms, dB	yes	none
	Instr-EL	247	10	50	0.05	500	13	1 in., log	rms, dB	yes	none
	Instr-EL	247B	10	50	0.05	15	10	1 in., log	V, rms	yes	none
	Instr-EL	247B	10	50	0.05	15	10	1 in., log	V, rms	yes	none
	Dytron	240	10	50	1	300	12	1 in.	V, 0-ctr	ina	none
	Dytron	240	10	50	1	300	12	1 in.	V, 0-ctr	ina	none
	Dytron	241	10	50	1	300	12	1 in.	V, 0-ctr	none	none
	Houston	HLVC-150	(dc)	50	1	316	3	log	V	none	none
	Houston	HLVC-150B	(dc)	50	1	316	3	log	V	none	none
V15	Houston	HLVC-150R	(dc)	50	1	316	3	log	V	none	none
	Dytron	242	20	60	1	300	12	ina	V, 0-ctr	yes	none
	Trio	109-1	20	80	1	300	12	1 in.	V, rms	yes	ina
	Dytron	211	100	100	1	30	12	1 in.	V, 0-ctr	yes	none
	Simpson	311	30	100	1500	1500	7	1 in., log	V, 0	none	1K
	H-P	741B	20(&dc)	100	1	1000	7	1 in.	V, 0-ctr	yes	none
	Acton	365-A	20	100	1	300	12	1 in.	V, deg	none	none
	Simpson	312	15	100	ac 500 dc 1500	1500 1500	7 8	1 in.	rms, p-p, aug.	yes	1K
	Millivac	MV-45A	10	100	0.01	1000	17	1 in.	V	yes	none
	Millivac	MV-45A	10	100	0.01	1000	17	1 in.	V	yes	none
V16	Fluke	803D	5	100	1	500	10	1 in.	V, 0-ctr	yes	ina
	Fluke	803D	5	100	1	500	10	1 in.	V, 0-ctr	yes	ina
	Fluke	823A	5	100	1	500	10	1 in.	V, 0-ctr	yes	ina
	Fluke	823A	5	100	1	500	10	1 in.	V, 0-ctr	yes	ina
	Muirhead	D-930-C	5	100	1	300	6	1 in.	0-ctr	ina	none
	Dynamics	501	(dc)	100	0.001	±1000	13	1 in., dB	V, 0-ctr, 0-I	yes	none
	Dynamics	501R	(dc)	100	0.001	±1000	13	1 in., dB	V, 0-ctr, 0-I	yes	none
	Millivac	MV-45AS	10	150	0.01	1000	17	1 in.	V	yes	none
	Millivac	MV-45AS	10	150	0.01	1000	17	1 in.	V	yes	none
	Ballant	302C	2	150	0.1	1000	7	1 in., log	V, dB	yes	none
V17	Ballant	302C-S/2	2	150	0.1	1000	8	1 in., log	V, dB	yes	none
	Ballant	300E	30	200	0.3	300	6	1 in., log	V, dB	yes	none
	Ballant	300E-S/2	30	200	0.3	300	6	1 in., log	V, dB	yes	none
	B&K Inst	2604A	10	200	0.1	1000	11	1 in., log	V, dB	yes	none
	B&K Inst	2604B	10	200	0.1	1000	11	1 in., log	V, dB	yes	none
	B&K Inst	2604C	10	200	0.1	1000	11	1 in., log	V, dB	yes	none
	B&K Inst	2409	2	200	10	1000	11	1 in., log	V, dB	yes	none
	B&K Inst	2416	2	200	10	1000	11	1 in., log	V, dB	yes	none
	Metronix	PM-311A	20	250	10	300	10	1 in.	V, dB	yes	none
	Metronix	PM-311A-1	20	250	10	300	10	1 in.	V, dB	yes	none

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VTVM index starts on page T82.

Vacuum Tube Vo

	Manufacturer	Model	Frequency Minimum (Hz)	Frequency Max (k
V23	RCA	WV-77E	40(&dc)	500
	Marconi	TF2600	10	500
	Ballant	310B	10	600
	Ballant	310B-S/2	10	600
	Ballant	314A	10	600
	Ballant	314A-S/2	10	600
	Fluke	910A	10	700
	Fluke	910A	10	700
	Radiomtr	RV31	20	10,
	R-S	UVF BN12015	10	10,
V24	H-P	3400A	10	10,
	Ballant	317	10	11,
	Ballant	317-S/2	10	11,
	R-S	URI B 1050	30(&dc)	20,
	Jennings	J-1003	10	20,
	R-S	USVH BN1521	10,000	30,
	Ballant	393	25	30,
	Micro-In	5201B	(dc)	50,
	Micro-In	5202	(dc)	50,
	Radiomtr	RV23	20	100
V25	Hickok	209C	10(&dc)	200
	Meas'mts	162	20(&dc)	350
	Meas'mts	162-R	20(&dc)	350
	R-S	USWV BN1522	30	400
	R-S	USVV BN1522	30	480
	H-P	410B	20(&dc)	700
	H-P	410BR	20(&dc)	700
	H-P	410C	20(&dc)	700
	Radiomtr	RV13	10(&dc)	700
	R-S	URU BN1080	10(&dc)	800
V26	H-P	411A	500,000	1,0
	H-P	411AR	500,000	1,0
	Ballant	340	100,000	1,0
	Ballant	340-S/2	100,000	1,0
	Ballant	345	20(&dc)	1,0
	Ballant	345-S/2	20(&dc)	1,0
	Boonton	91DA	20,000	1,2
	Boonton	91DAR	20,000	1,2
	Millivac	MV-38B	10,000	1,2
	Millivac	MV-38B	10,000	1,2

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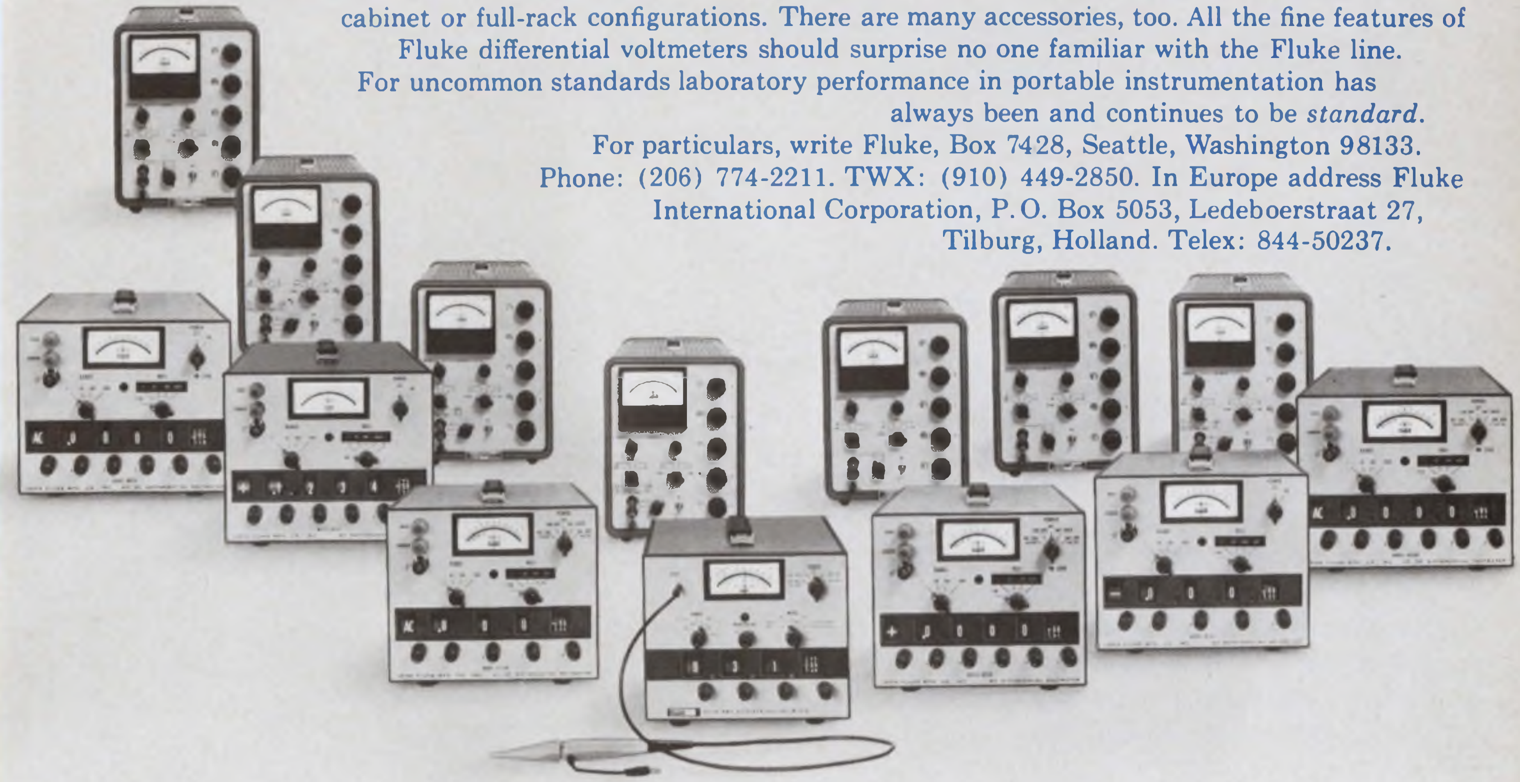
Even though Fluke differential voltmeters feature dc accuracies high as 0.0025%, ac accuracies of 0.05%, and 100 microvolts full scale sensitivity, they are so well designed that use is both simple and easy. Solid state bench top models are adaptable for half- or full-rack mounting... Many are offered in both line and rechargeable battery operated versions. Vacuum-tube models are available in cabinet or full-rack configurations. There are many accessories, too. All the fine features of Fluke differential voltmeters should surprise no one familiar with the Fluke line. For uncommon standards laboratory performance in portable instrumentation has always been and continues to be *standard*.

For particulars, write Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211. TWX: (910) 449-2850. In Europe address Fluke International Corporation, P.O. Box 5053, Ledeboerstraat 27, Tilburg, Holland. Telex: 844-50237.



Count 'em. It's the world's largest, most sophisticated line of differential voltmeters. And what a line! You can buy a solid state dc, ac/dc, or true rms voltmeter. Or our vacuum tube version. You'd think Fluke invented the differential voltmeter. (Well, we did.)

MODEL	INPUT VOLTAGE	ACCURACY % OF INPUT	INPUT IMPEDANCE	MAX. METER RESOLUTION	PRICE	NOTES
DC DIFFERENTIAL VOLTMETERS						
801B	0-500 VDC	±0.05%		50 uV	$ 485.00	
825A	0-500 VDC	±0.02%	Infinite at null	5 uV	$ 590.00	+$20 for rack models
821A	0-500 VDC	±0.01%		5 uV	$ 795.00	
871A*	0-1100 VDC	±0.02%	Infinite at null	10 uV	$ 565.00	+$130.00 for
881A*	0-1100 VDC	±0.005%	to ±11V 10 Meg	1 uV	$ 825.00	rechargeable
885A*	0-1100 VDC	±0.0025%	above ± 14V	1 uV	$ 965.00	battery pack
895A*	0-1100 VDC	±0.0025%	Infinite at null to ±1100V	1 uV	$1,195.00	
AC/DC DIFFERENTIAL VOLTMETERS						
803B	0-500V AC or DC	±0.05% DC, ±0.2% AC	Infinite at null DC	50 uV	$ 875.00	
803D	0-500V AC or DC	±0.02% DC, ±0.1% AC	1 Meg, 35-50 pf AC	5 uV	$1,055.00	+$20 for rack models
823A	0-500V AC or DC	±0.01% DC, ±0.1% AC		5 uV	$1,215.00	
873A*	0-1100V AC or DC	±0.02% DC, ±0.2% AC	Infinite at null to 10	10 uV	$ 875.00	+$160.00 for
883A*	0-1100V AC or DC	±0.005% DC, ±0.1% AC	Meg above 11 VDC	1 uV	$1,215.00	rechargeable
887A*	0-1100V AC or DC	±0.0025% DC, ±0.05% AC	1 Meg, 40 pf AC	1 uV	$1,375.00	battery pack
TRUE RMS DIFFERENTIAL VOLTMETER						
931A*	0-1100V AC	±0.05% AC	1 Meg, 8 pf with BNC Input; 1 Meg, 5 pf with probe	20 ppm of dial setting	$ 895.00	+$ 50.00 for permanent probe; +$100.00 for rechargeable battery pack

*Solid State

FLUKE

ON READER-SERVICE CARD CIRCLE 107

Vacuum Tube Voltmeters (ac) *(continued)*

			Frequency		Volts			Meter			Ohms		Type		
	Manufacturer	Model	Minimum Hz	Maximum kHz	Minimum mV	Maximum V	Ranges No.	Scale	Calibration	Amplifier	Minimum	Maximum	C-Cab R-Rack P-Port.	Misc. Features	Price Approx. $
V27	Millivac	MV-928A	10,000	1,200,000	1	3	8	1 in.	V, 0-ctr, dB	yes	none	none	C	frx	ina
	Metronix	PM-520A	10,000	1,200,000	3	3	7	1 in.	V, 0-ctr, dB	yes	none	none	P	fkx	ina
	Marconi	2604	20(&dc)	1,500,000	ac 25 dc 10	300 1000	7 8	1 in., log	n, V, Ω	none	500	500M	C	s	395
	Boonton	91C	10,000	1,200,000	1	3	7	1 in., log	V, dB	none	none	none	C	uw	495
	Boonton	91H	10,000	1,200,000	0.3	3	8	1 in., log	V, dB	none	none	none	C	uw	595
	Millivac	MV-28B	10,000	1,200,000	1	3	8	1 in., log	V, dB	yes	none	none	R	uw	575
	Millivac	MV-28B	10,000	1,200,000	1	3	8	1 in., log	V, dB	yes	none	none	C	uw	550
	Millivac	MV-828A	10,000	1,200,000	1	3	8	1 in.	V, 0-ctr, dB	yes	none	none	C	fx	ina
	GR	1806-A	20(&dc)	1,500,000	1500	1500	4	log	V, Ω	none	200M	1G	C	w	595
	R-S	URV BN10913	10,000	1,600,000	2	10	7	1 in., log	V	none	none	none	C	s	1170

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AC and DC VTVM Notes

b. Battery operated
f. Solid state
k. Also works off 400 Hz power lines
q. Amplifier output
r. Battery and line operated
s. Responds to average meter
t. Responds to dc meter
u. Responds to rms meter
w. Responds to p/t meter
x. Responds to true rms meter
y. Responds to phase meter

There are two kinds of spectrum analyzers

This kind has a swept first LO and high frequency first IF to permit viewing of wide (2 GHz) spectra, free from images, spurious and residual responses; calibrated 60 dB display range for accurate comparison of signals widely different in amplitude; RF attenuator for detecting overdriven input and for setting level; just one wideband (0.01-12 GHz), sensitive (−100 to −85 dBm) mixer with extremely flat response (±1 dB on fundamental mixing, < ±3 dB for harmonics) over full 2 GHz sweeps. These and other unique features come to almost $10,000.

The other kind of spectrum analyzer does not offer any of these performance features. That's why it costs half as much.

To find out more about 1967-style spectrum analysis, call your Hewlett-Packard field engineer for complete data on the 8551B/851B, or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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VTVM Cross Index

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AVO-LTD	Avo Ltd. Amacoil Instrument Division 750 Saint Anns Avenue Bronx, New York 10456	Electronic Test Meter	V 20	369
B&K INST	B & K Instruments Inc. 5111 West 164th Street Cleveland, Ohio 44124	2409 2410 2416 2417 2603A 2603B 2603C 2604A 2604B 2604C	V 17 V 12 V 17 V 12 V 13 V 13 V 13 V 17 V 17 V 17	370
BALLANT	Ballantine Labs Inc. Box 97 Boonton, New Jersey	300E 300E-S/2 300G 300G-S/2 300H 300H-S/2 300M 302C 302C-S/2 303 305A 305A-S/2 310B 310B-S/2 314A 314A-S/2 316 316-S/2 317 317-S/2 320A 320-S/2 321 321-S/2 323 340 340-S/2 345 345-S/2 350 365 365-S/2 393	V 17 V 17 V 18 V 18 V 19 V 19 V 18 V 16 V 17 V 10 V 19 V 19 V 23 V 23 V 23 V 23 V 13 V 13 V 24 V 24 V 22 V 22 V 22 V 22 V 10 V 26 V 26 V 26 V 26 V 12 V 1 V 9 V 24	371
BOONTON	Boonton Electronics Corp. Route 287 at Smith Road Parsippany, New Jersey	91C 91DA 91DAR 91H 95A	V 27 V 26 V 26 V 27 V 9	372
BURR-BR	Burr-Brown Research Corp. Box 6444 Tucson 16, Arizona	300	V 19	373
DYNAMICS	Dynamics Instrumentation Co. 383 Monterey Pass Road Monterey Park, California	501 501R 502 502R 503 503R 504 504R 505 505R	V 16 V 16 V 5 V 5 V 5 V 5 V 5 V 5 V 5 V 5	374

CODE	COMPANY	MODEL NO.	TABLE LOCATION	READER SERVICE NO.
DYTRON	Dytronics Co. Inc. 5566 North High Street Columbus, Ohio 43214	211 240 241 242	V 15 V 14 V 14 V 15	375
FLUKE	John Fluke Mfg. Co. Inc. Box 7428 Seattle, Washington	801B 803B 803B 803D 821A 823A 825A 871A 871AB 873A 873AB 881A 881AB 883A 883AB 885A 885AB 887A 887AB 895A 910A 931A 931AB	V 4 V 11 V 12 V 16 V 4 V 16 V 4 V 8 V 8 V 12 V 12 V 8 V 9 V 11 V 11 V 9 V 9 V 11 V 11 V 7 V 23 V 20 V 20	376
GR	General Radio Co. 22 Baker Avenue West Concord, Mass. 01781	1230-A 1806-A	V 10 V 27	377
GERTSCH	Gertsch Products Inc. Singer Co., Metrics Div. 3211 S. LaCienega Blvd. Los Angeles 16, California	PAV-1A PAV-1AR PAV-2A PAV-2AR PAV-3AR	V 11 V 11 V 11 V 11 V 12	
HEATH	Heath Co. Sub Daystrom Inc. Benton Harbor, Michigan	1M-13 1M-21 1MW-11	V 19 V 18 V 19	266
H-P	Hewlett-Packard Co. 1501 Page Mill Road Palo Alto, California	400D 400DR 400H 400HR 400L 400LR 403A 403B 410B 410BR 410C 411A 411AR 412A 412AR 413A 413AR 425A 425AR 740B 741B 3400A	V 21 V 21 V 21 V 21 V 21 V 22 V 20 V 20 V 25 V 25 V 25 V 26 V 26 V 8 V 8 V 8 V 8 V 1 V 1 V 8 V 15 V 24	Contact Local Rep.
HICKOK	Hickok Elec. Instr. Co. 10555 DuPont Avenue Cleveland, Ohio 44108	209C 470A	V 25 V 20	379
HOUSTON	Houston Instrument Corp. 4930 Terminal Avenue Bellaire, Texas 77401	HLVC-150 HLVC-150B HLVC-150R	V 14 V 15 V 15	380
IB	IB Instruments Inc. 7016 Euclid Avenue Cleveland, Ohio	300 600	V 2 V 8	381
IND-TEST	Industrial Test Equip. Co. 20 Beechwood Avenue Port Washington, N.Y. 11050	300A 300B 300PB	V 13 V 13 V 11	382

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
INFRARED	Infrared Industries Inc. Box 989 Santa Barbara, California	600 601	V 12 V 10	383
INSTR-EL	Instrument Electronics Corp. Box 830 Port Washington, N.Y. 11050	247 247B 253-S1 253-S4 253-S5	V 14 V 14 V 18 V 12 V 12	384
INSTR-LAB	Instrument Labs Corp. 315 West Walton Place Chicago, Illinois 60610	TR2 TR4	V 20 V 21	385
J-OMEGA	J. Omega Co. 2278 Mora Drive Mountain View, California	35A	V 2	386
JACKSON	Jackson Elect. Instr. Co. 124 McDonough Street Dayton, Ohio 45402	806	V 21	387
JENNINGS	Jennings Radio Mfg. Corp. 970 McLaughlin Avenue San Jose, California	J-1003	V 24	388
KEITHLEY	Keithley Instruments Inc. 12415 Euclid Avenue Cleveland, Ohio 44106	148 149 150B 200B 600A 610B 621 630 660A 662 662	V 1 V 1 V 1 V 1 V 1 V 2 V 2 V 4 V 4 V 3 V 4	389
MARCONI	Marconi Instruments Div. English Electric Corp. 111 Cedar Lane Englewood, New Jersey 07631	2604 TF2600	V 27 V 23	390
MEAS'MTS	Measurements McGraw-Edison Division Box 180 Boonton, New Jersey 07005	162 162-R	V 25 V 25	391
MEDISTOR	Medistor Instrument Co. 1443 N. North Lake Way Seattle, Washington	A-60C A-61 A-61RB A-71B A-71C A-75	V 7 V 9 V 7 V 7 V 8 V 7	392
METRONIX	Metronix Div. Millivac Instrument, Inc. 75 Wilson Mills Road Chesterland, Ohio	PM-301A PM-301A-C PM-311A PM-311A-1 PM-502A PM-502A-C PM-503A PM-503A-C PM-504A PM-504A-C PM-502A	V 6 V 6 V 17 V 17 V 5 V 5 V 6 V 6 V 6 V 6 V 27	393
MICRO-IN	Micro Instrument Co. 13100 Crenshaw Boulevard Gardena, California	5201B 5202	V 24 V 24	394
MILLIVAC	Millivac Instruments Inc. 1100 Altamount Avenue Box 997 Schenectady, N.Y. 12301	MV-07C MV-17C MV-28B MV-38B MV-45A MV-45AS MV-127BL MV-127BL MV-127BM MV-127BM MV-828A MV-852A MV-928A MV-952A	V 7 V 7 V 27 V 26 V 15 V 16 V 6 V 7 V 6 V 7 V 27 V 6 V 27 V 6	395

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
MOTOR-OLA	Motorola Communications & Electronics Inc. Precision Frequency Prods. 4501 Augusta Boulevard Chicago, Illinois 60651	S1051C S1053C	V 19 V 19	396
MUIRHEAD	Muirhead Instruments Inc. 1101 Bristol Road Mountainside, N. J. 07092	D-930-C	V 16	397
RCA	Radio Corp. of America Electronic Components & Devices Harrison, N. J. 07029	WV-76A WV-77E WV-98C	V 20 V 23 V 20	398
RADIO-MTR	Radiometer The London Co. 811 Sharon Drive Westlake, Ohio	RV13 RV23 RV31 RV33 RV34	V 25 V 24 V 23 V 21 V 18	399
ROBERTS	Robertson Instrument Co. 1760 West First Azusa, California	614	V 21	400
R-S	Rohde & Schwarz Sales Co. 111 Lexington Avenue Passaic, New Jersey 07056	URI B1050 URU BN1080 URV BN10913 USVH BN1521 USVV BN1522 USWV BN15221 UVF BN12015 UVG BN12061 UVM BN12011 UVN BN1200	V 24 V 25 V 27 V 24 V 25 V 25 V 23 V 2 V 19 V 20	401
SENCORE	Sencore 42 South Westgate Drive Addison, Illinois	SM112	V 22	402
SIMPSON	Simpson Electric Co. 5200 West Kinzie Street Chicago, Illinois 60644	303 311 312 715	V 10 V 15 V 15 V 18	403
SWEENEY	B K Sweeney Mfg. Co. 6300 East 44th Avenue Monaco Boulevard Denver 16, Colorado	1170ETVM	V 9	404
TRIO	Trio Labs Inc. 80 DuPont Street Plainview, New York	102-1 103-1 104-1 105-1 105-2 105-3 105-4 106-1 106-2 106-3 106-4 107-1 109-1 110-1 141-1 143-1 144-1 149-1 301-1 302-1 305-1 305-2 308-1 309-1 310-1	V 13 V 13 V 14 V 2 V 2 V 2 V 3 V 3 V 3 V 3 V 3 V 3 V 15 V 3 V 10 V 10 V 10 V 10 V 18 V 10 V 3 V 3 V 18 V 13 V 4	405
TRIPLETT	Triplett Elect. Instr. Co. 286 Harmon Road Bluffton, Ohio 45817	631 850	V 2 V 21	406
WAVE-FORM	Waveforms Inc. 333 6th Avenue New York 14, New York	520A 520L	V 22 V 22	407
WILK	Wilk Instruments 3700 South Broadway Los Angeles 7, California	L-6	V 1	408

Frequency Meters

	Manufacturer	Model	Frequency Minimum MHz	Frequency Maximum MHz	Frequency Bands No.	Accuracy %	Sensitivity mV	Power Required to Operate	Circuit Type	Type C-Cab R-Rack P-Port	Price Approx. $
T1	R-S	FZN BN47092	50Hz	50Hz	2	±0.0025Hz	ina	115/230Vac	ina	C	1765
	R-S	FZN BN47092/60	60Hz	60Hz	2	±0.003Hz	ina	115/230Vac	ina	C	1765
	Weston	339	20Hz	900Hz	9	0.14-4	ina	line	LC	C	850
	H-P	500C	3Hz	0.1	9	2	200	115/230Vac	COC	C, R	345
	H-P	500B	3Hz	0.1	9	2	200	115/230Vac	COC	C, R	335
	EL-RES	Freq Meter	10Hz	0.2	6	±1	ina	line	ina	C	ina
	R-S	FKM BN47051	10Hz	0.5	9	1.5	100	line	COC	C	1765
	Sell-Trn	401A	10Hz	1	9	2	100	line	ina	C	249
	GR	1142-A	3Hz	1.5	5	±0.2	20	line	COC	C	595
	Measurements	59LF	0.100	4.5	4	±2	ina	line	b	C	168
T2	GR	1142-A/1156-A	30Hz	15	5	±0.2	20	line	COC	C	1085
	R-S	WEN BN435	0.01	30	7	±0.5	5	line	m	C	500
	Measurements	700	25	50	1	±20Hz	100	line	d	2C	1500
	Lampkin	105-B MFM	0.100	175	1	0.02	ina	line	d	C	295
	Lampkin	103-B MFM	0.100	175	1	0.02	ina	line	d	C	240
	Radiomtr	GD01	2	220	5	±2	ina	115/230Vac	be	P	114
	Barker & W	600	1.75	260	5	ina	ina	line	b	P	55
	Millen	90651	1.7	300	7	2	ina	line	be	P	69
	Millen	90661	1.7	300	7	0.5	ina	line	be	P	100
	Millen	90662	0.225	300	11	0.5	ina	line	be	P	155
T3	Millen	90662-A	0.225	300	11	0.5	ina	line	bep	P	195
	Measurements	59	2.2	420	7	±2	ina	line	b	C	168
	Radar	D828-1	400	450	1	0.1	ina	none	i	COAX	245
	Radar	D828-10	400	450	1	0.1	ina	none	m	COAX	285
	Fairchild	5890-B	25	470	1	ina	250	e	d	C	435
	Measurements	760	25	475	3	0.0004	1mW	line	d	C	980
	Motorola	T-1021A	25	475	3	±100Hz	25	line	d	C	983
	Gertsch	FM-9U	150	486	2	±0.0001	ina	115/230Vac	RC	C	1645
	Gertsch	FM-9	150	486	2	±0.000	ina	115/230Vac	RC	C	1495
	Narda	804	200	500	1	0.5MHz	0.5mW	ina	i	C	400
T4	R-S	WAM BN4312/2	30	500	8	±0.5	10	e	m	C	500
	Fairchild	Mark 111-A	0.005	500	1	±0.0002	ina	line	k	C	436
	Measurements	59UFH	420	940	1	±2	ina	line	b	C	198
	FEL	WC-510-1N	500	1000	1	±0.01	20μA/mW	none	h	COAX	920
	FEL	WCF510-4N	500	1000	1	0.01	3μA/mW	none	ina	C	960
	R-S	XUC BN44467	470	1000	2	10^{-9}	1	line	ei	C	7705
	PRD	587-A	250	1000	1	±0.2	ina	none	h	COAX	350
	Gertsch	FM-6	20	1000	1	0.0001	0.5	line	d	C	2140
	Gertsch	FM-6R	20	1000	1	0.0001	10	line	d	R	2100
	Gertsch	FM-3A	20	1000	1	0.001	ina	e	d	C	1260
T5	Gertsch	FM-7	20	1000	1	0.0002	0.5	line	d	C	1625
	Gertsch	FM-3	20	1000	1	0.001	ina	e	d	C	850
	Gertsch	FM-3R	20	1000	1	0.001	ina	line	d	R	900
	Gertsch	SSG-1	0.010	1000	12	$1/10^7$	ina	115/230Vac	d	C	12,500
	FEL	WC912-1N	900	1200	1	±0.01	20μA/mW	none	h	COAX	560
	FEL	WC912-3N	900	1200	1	±0.01	20μA/mW	none	i	COAX	560
	FEL	WCF912-4N	900	1200	1	0.01	20μA/mW	none	ina	C	525
T6	Doug-MW	440L	1100	1400	1	2MHz	ina	none	hi	COAX	350
	Diamond	2090	900	1450	1	1	ina	none	i	COAX	275
	Narda	805	500	1500	1	1MHz	0.5mW	ina	i	C	400
	FEL	WC-1217-1N	1200	1700	1	±0.01	20μA/mW	none	h	COAX	560
	FEL	WC1217-3N	1200	1700	1	±0.01	20μA/mW	none	i	COAX	560
	FEL	WCF1217-4N	1200	1700	1	0.01	20μA/mW	none	ina	C	525
	FEL	WDS1020-1N	1000	2000	1	±0.05	ina	none	h	COAX	395
	Gen -MW	N687	950	2000	1	0.1	ina	none	hi	COAX	325
	Diamond	2091	1400	2300	1	1	ina	none	h	COAX	490
	Narda	806	1500	2400	1	2MHz	0.5mW	ina	i	C	400

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Frequency meter index starts on page T86.

Frequency Meters *(continued)*

	Manufacturer	Model	Frequency Minimum MHz	Frequency Maximum MHz	Frequency Bands No.	Accuracy %	Sensitivity MV(fs)	Power Required to Operate	Circuit Type	Type C-Cab R-Rack P-Port	Price Approx. $
T7	R-S	WAL BN4321/2/50	500	2500	1	±0.08	3V	e	m	COAX	900
	FEL	WC-1628-1N	1600	2800	1	±0.01	20μA/mW	none	h	COAX	560
	FEL	WC-1628-3N	1600	2800	1	±0.01	20μA/mW	none	i	COAX	560
	FEL	WCF1628-4N	1600	2800	1	0.01	20μA/mW	none	ina	C	525
	Narda	12L1	600	3000	1	0.1	5mW	ina	i	C	975
	PRD	560	2400	3400	1	±0.3MHz	5mW	none	h, i	C	ina
	Doug-MW	440S	2400	3400	1	2MHz	ina	none	h, i	COAX	285
	FEL	WC-2335-1N	2300	3500	1	±0.01	20μA/mW	none	h	COAX	560
	FEL	WCF2335-4N	2300	3500	1	0.01	20μA/mW	none	ina	C	600
	PRD	560-S1	2700	3700	1	±0.3MHz	5mW	line	m	C	ina
T8	PRD	583-D	2400	3700	1	±0.3	ina	none	h	C	ina
	FEL	WDB2040-1N	2000	4000	1	±0.05	ina	none	h	COAX	395
	FXR/MLAB	N410A	1000	4000	1	0.1	ina	none	h	COAX	475
	Gen-MW	N604	1900	4000	1	0.1	ina	none	h, i	COAX	300
	Radar	D719-1	2000	4000	1	0.1	ina	none	i	COAX	250
	Radar	D719-2	2000	4000	1	0.1	ina	none	m	COAX	275
	Radar	D959-0	2000	4000	1	0.1	ina	none	h, o	COAX	345
	Radar	D959	2000	4000	1	0.1	ina	none	h	COAX	320
	R-S	WAT BN4322/50	1200	4200	2	±0.1	500	none	m	COAX	895
	H-P	536A	960	4200	1	±0.17	N/A	none	m	COAX	550
T9	FEL	WDS-3645-1N	3600	4300	1	±0.01	ina	none	h	COAX	1200
	Diamond	2092	2200	4300	1	1	ina	none	i	COAX	200
	FEL	WC-3545-1N	3500	4500	1	±0.01	20μA/mW	none	h	COAX	575
	FEL	WC-3545-3N	3500	4500	1	±0.01	20μA/mW	none	i	COAX	575
	FEL	WCF3545-4N	3500	4500	1	0.01	20μA/mW	none	ina	C	650
	Radar	D1048	2300	5000	1	0.1	ina	none	h	COAX	475
	Radar	D1048-1	2300	5000	1	0.1	ina	none	h	COAX	375
	FEL	WCF4458-4N	4400	5800	1	0.01	20μA/mW	none	ina	C	650
	Doug-MW	440C	4000	5850	1	2MHz	ina	none	h, i	COAX	350
	Diamond	2093	3500	6500	1	1	ina	none	i	COAX	ina
T10	Radar	D819-2	4000	8000	1	0.1	ina	none	m	COAX	290
	Radar	D945-0	4000	8000	1	0.1	ina	none	h	COAX	345
	Radar	D945	4000	8000	1	0.1	ina	none	h	COAX	320
	Radar	D819-1	4000	8000	1	0.1	ina	none	i	COAX	275
	FEL	WDB4080-1N	4000	8000	1	±0.05	ina	none	h	COAX	395
	FEL	WCF5882-4N	5800	8100	1	0.01	20μA/mW	none	ina	C	575
	Gen-MW	N608A	3950	8200	1	0.1	ina	none	h, i	COAX	350
	PRD	504	100	10000	1	0.03	5dBm	line	d	C	835
	Narda	802B	2340	10500	1	0.2	5mW	ina	i	C	785
	FEL	WCF8211-4N	8200	11000	1	0.01	20μA/mW	none	ina	C	9/5
T11	Radar	D1047-1	7000	11000	1	0.1	ina	none	h	COAX	385
	Radar	D1047	7000	11000	1	0.1	ina	none	h	COAX	475
	Gen-MW	N610	7000	12400	1	0.1	ina	none	e, h, i	COAX	365
	FXR/MLAB	N414A	3950	11000	1	0.1	ina	none	m	COAX	475
	H-P	540B	12400	1	0.1	1×10^{-7}	-20dBm	line	j	C, R	1050
	H-P	537A	3700	12,400	ina	0.1	ina	Ina	ina	COAX	550

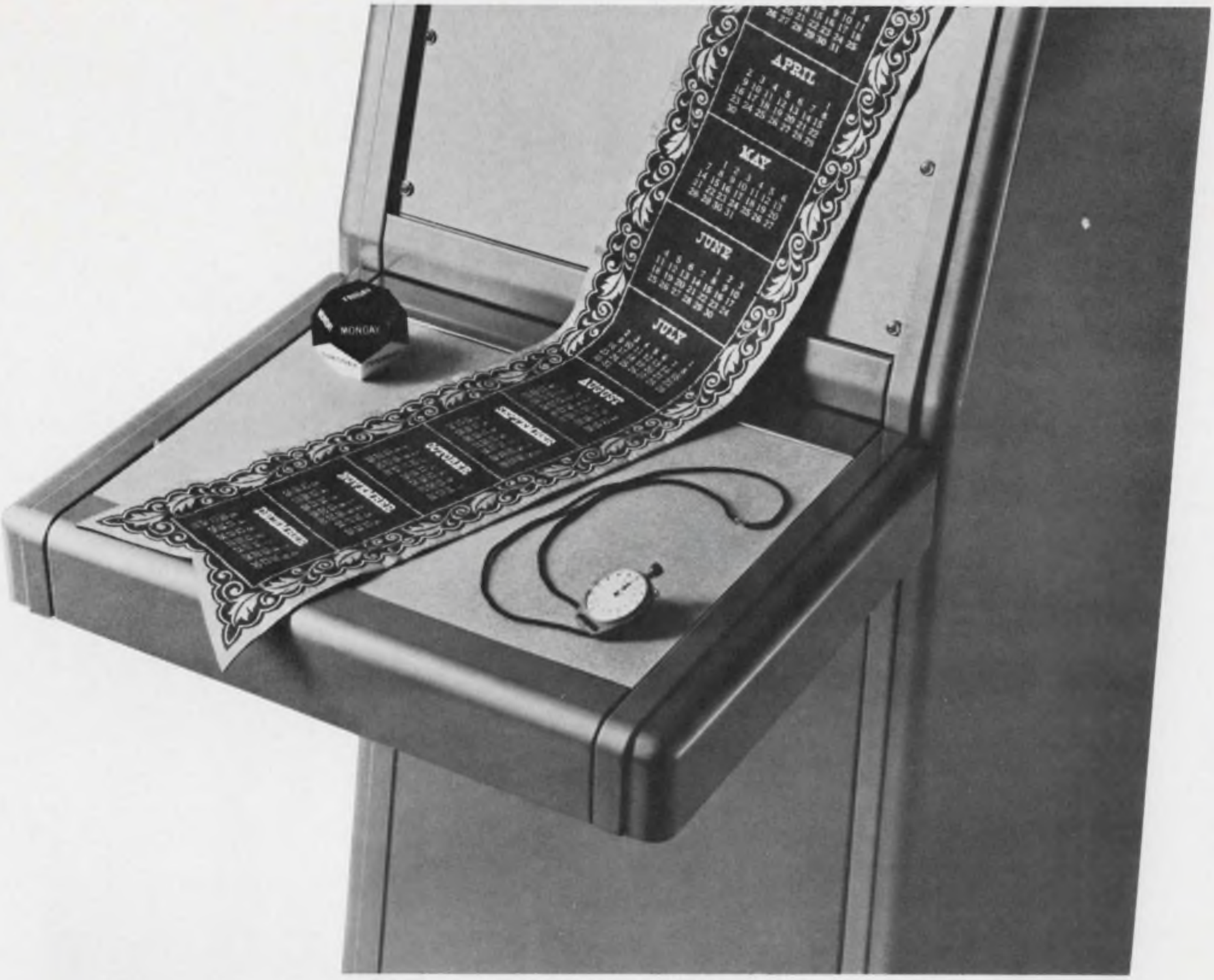
Frequency Meter Notes

b. Grid-dip oscillator.
d. Crystal Master oscillator.
e. Battery operated.
h. Absorption type.
i. Transmission type.
j. Transfer oscillator.
k. Heterodyne.
m. Absorption feedthru.
o. With crystal calibrator.
p. Transistor modulator and amplifier.

Frequency Meter Cross Index

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
BARKER & W	Barker & Williamson Inc. Canal St. at Beaver Dam Rd. Bristol, Pennsylvania 19007	600	T 2	409
DIAMOND	Diamond Antenna & Microwave Corp. 35 River Street Winchester, Mass. 01890	2090 2091 2092 2093	T 6 T 6 T 9 T 9	410
DOUG-MW	Douglas Microwave Corp. 252 East Third Street Mount Vernon, N.Y. 10550	440C 440L 440S	T 9 T 6 T 7	411
EL-RES	Electronic Research Co. Div. Textron Electronics Inc. 10,000 West 75th Overland Park, Kansas	Freq Meter	T 1	412
FAIR-CHILD	Fairchild Instrument 475 Ellis Street Mountain View, California	Mark 111-A 5890-B	T 4 T 3	413
FEL	Frequency Engineering Labs Div. Harvard Inds. Box 527 Farmingdale, New Jersey	WC-510-1N WC-912-1N WC-912-3N WC-1217-1N WC-1217-3N WC-1628-1N WC-1628-3N WC-2335-1N WC-3545-1N WC-3545-3N WCF-510-4N WCF-912-4N WCF1217-4N WCF-1628-4N WCF-2335-4N WCF-3545-4N WCF-4458-4N WCF-5882-4N WCF-8211-4N WDB1020-1N WDB2040-1N WDB4080-1N WDC-3645-1N	T 4 T 5 T 5 T 6 T 6 T 7 T 7 T 7 T 9 T 9 T 4 T 5 T 6 T 7 T 7 T 9 T 9 T 10 T 10 T 6 T 8 T 10 T 9	414
FXR/ MLAB	FXR (Microlab/FXR) Div. Microlab Livington, New Jersey	N410A N414A	T 8 T 11	415
GEN-MW	General Microwave Corp. 155 Marine Street Farmingdale, N.Y. 11735	N604 N608A N610 N687	T 8 T 10 T 11 T 6	416
GR	General Radio Co. 22 Baker Avenue West Concord, Mass. 01781	1142-A 1142-A/1156-A	T 1 T 2	417
GERTSCH	Gertsch Products Inc. Singer Co., Metrics Div. 3211 S. LaCienega Blvd. Los Angeles, California	FM-3 FM-3A FM-3R FM-6 FM-6R FM-7 FM-9 FM-9U SSG-1	T 5 T 4 T 5 T 4 T 4 T 5 T 3 T 3 T 5	418
H-P	Hewlett-Packard Co. 1501 Page Mill Road Palo Alto, California	500B 500C 536A 537A 540B	T 1 T 1 T 8 T 11 T 11	Contact Local Rep.

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
LAMPKIN	Lampkin Labs Inc. Perico Road Bradenton, Florida 33505	103-B MFM 105-B MFM	T 2 T 2	419
MEAS'MTS	Measurements McGraw-Edison Division Box 180 Boonton, New Jersey 07005	59 59LF 59UFH 700 760	T 3 T 1 T 4 T 2 T 3	420
MILLEN	James Millen Mfg. Co., Inc. 150 Exchange Street Malden, Mass. 02148	90651 90661 90662 90662-A	T 2 T 2 T 2 T 3	421
MOTOR-OLA	Motorola Communications & Electronics Inc. Precision Frequency Prod. 4501 Augusta Boulevard Chicago, Illinois 60651	T-1021A	T 3	422
NARDA	Narda Microwave Corp. Commercial Street Plainview, N.Y. 11803	12L1 802B 804 805 806	T 7 T 10 T 3 T 6 T 6	423
PRD	PRD Electronics Inc. Sub Harris-Intertype Corp. 202 Tillary Street Brooklyn, N.Y. 11201	504 560 560-S1 583-D 587-A	T 10 T 7 T 7 T 8 T 4	424
RADAR	Radar Design Corp. 105 Pickard Drive Syracuse, N.Y. 13211	D719-1 D719-2 D819-1 D819-2 D828-1 D828-10 D945 D945-0 D959 D959-0 D1047 D1047-1 D1048 D1048-1	T 8 T 8 T 10 T 10 T 3 T 3 T 10 T 10 T 8 T 8 T 11 T 11 T 9 T 9	425
RADIO-MTR	Radiometer The London Co. 811 Sharon Drive Westlake, Ohio	GD01	T 2	426
R-S	Rohde & Schwarz Sales Co. 111 Lexington Avenue Passaic, N.J. 07056	FKM BN47051 FZN BN47092 FZN BN47092/60 WAL BN4321/2/50 WAM BN4312/2 WAT BN4322/50 WEN BN435 XUC BN44467	T 1 T 1 T 1 T 7 T 4 T 8 T 2 T 4	427
SELL-TRN	Sell-Tronic Products Co. 1973 Hughes Avenue Bronx, NewYork 10457	401A	T 1	428
WESTON	Weston Instr. & Electronics Div. Daystrom Inc. 614 Frelinghuysen Ave. Newark, New Jersey	339	T 1	429



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ON READER-SERVICE CARD CIRCLE 301

Waveguide Frequency Meters

	Manufacturer	Model	Frequency Minimum GHz	Frequency Maximum GHz	Frequency Accuracy %	Circuit Type	Q Loaded K	Minimum Dip dB	Resolution MHz	Connector Type	Price Approx. $
W1	Narda	12S1	2.6	3.95	0.05	ina	18	ina	ina	ina	600
	DE-MOR	DBL-720-2	2.6	3.95	0.01	e	8	1.5	1	53	904
	DE-MOR	DBL-715-1	2.6	3.95	0.01	g	13	ina	0.200	53	839
	DE-MOR	DBL-715-2	2.6	3.95	0.01	e	8	1.5	0.200	53	883
	DE-MOR	DBL-710-3	2.6	3.95	0.01		8	1.5	1	53	460
	DE-MOR	DBL-715-3A	2.6	3.95	0.01		8	N/A	Ref, Type	53	855
	DE-MOR	DBL-720-3	2.6	3.95	0.01		8	N/A	1	53	915
	DE-MOR	DBL-715-1A	2.6	3.95	0.01	g	13	N/A	Ref, Type	53	800
	DE-MOR	DBL-720-1	2.6	3.95	0.01	g	13	N/A	1	53	860
	DE-MOR	DBL-710-1	2.6	3.95	0.01	g	13	N/A	1	53	425
W2	DE-MOR	DBL-715-2A	2.6	3.95	0.01	e	8	1.5	Ref, Type	53	844
	DE-MOR	DBL-710-2	2.6	3.95	0.01	e	8	1.5	1	53	455
	DE-MOR	DBL-715-3	2.6	3.95	0.01		8	N/A	0.200	53	894
	FEL	WDC-3645-1W	3.6	4.3	±0.01	cg	3	1	ina	ina	1200
	FEL	WC-3545-3W	3.5	4.5	±0.01	cf	3	N/A	ina	149	575
	FEL	WC-3545-1W	3.5	4.5	±0.01	cg	3	1.5	ina	149	575
	Diamond	592-1	3.95	4.85	0.05	f	ina	N/A	0.02%	ina	250
	Diamond	590-1	3.95	4.85	0.05	g	ina	15%	0.02%	ina	250
	Diamond	591-1	3.95	4.85	0.05	e	ina	15%	0.02%	ina	250
	FEL	WC-4458-3W	4.4	5.8	±0.01	cf	3	N/A	ina	149	575
W3	FEL	WC-4458-1W	4.4	5.8	±0.01	cg	3	1.5	ina	149	575
	Diamond	592-2	4.85	5.85	0.05	f	ina	N/A	0.02%	ina	240
	Diamond	590-2	4.85	5.85	0.05	g	ina	N/A	0.02%	ina	240
	Diamond	591-2	4.85	5.85	0.05	e	ina	15%	0.02%	ina	240
	H-P	G532A	3.95	5.85	0.065	e	ina	1	1	407	400
	Waveline	398-DR	3.95	5.85	0.07	f	ina	N/A	1	149A	ina
	DE-MOR	DBR-715-2A	3.95	5.85	0.01	e	6	1.5	Ref, Type	149A	630
	DE-MOR	DBR-720-1	3.95	5.85	0.01	g	7	N/A	1	149A	635
	DE-MOR	DBR-720-2	3.95	5.85	0.01	e	6	1.5	1	149A	668
	DE-MOR	DBR-715-3	3.95	5.85	0.01		5	N/A	1	149A	657
W4	DE-MOR	DBK-715-1	3.95	5.85	0.01	g	7	ina	1	149A	613
	DE-MOR	DBK-715-2	3.95	5.85	0.01	e	6	1.5	1	149A	646
	DE-MOR	DBK-720-3	3.95	5.85	0.01	f	5	N/A	1	149A	679
	DE-MOR	DBK-707-1	3.95	5.85	0.01	g	7	N/A	0.400	149A	225
	DE-MOR	DBK-707-2	3.95	5.85	0.01	e	6	1.5	0.400	149A	250
	DE-MOR	DBK-710-2	3.95	5.85	0.01	e	6	1.5	1	149A	325
	DE-MOR	DBK-707-3	3.95	5.85	0.01		5	N/A	0.400	149A	255
	DE-MOR	DBK-710-1	3.95	5.85	0.01	g	7	1.5	1	149A	300
	DE-MOR	DBK-710-3	3.95	5.85	0.01		5	N/A	1	149A	330
	DE-MOR	DBK-715-1A	3.95	5.85	0.01	g	7	N/A	Ref, Type	149A	597
W5	DE-MOR	DBK-715-3A	3.95	5.85	0.01		5	N/A	Ref, Type	149A	641
	Microlab	H410B	3.95	5.85	0.08	g	8	7	1.5	ina	320
	PRD	532	3.95	5.85	±0.08	g	6	N/A	ina	149	399
	Narda	12C1	3.95	5.85	0.06	ina	10	ina	ina	ina	320
	Doug-MW	E450C	3.95	5.85	±0.03	e	ina	20%	ina	149	165
	FEL	WDC-5459-3W	5.4	5.9	±0.01	cf	7	N/A	ina	344	1200
	FEL	WDC-5459-1W	5.4	5.9	±0.01	cg	7	1	ina	344	1100
	PRD	590-A	5.1	5.9	0.08	g	ina	N/A	1	149	ina
	FEL	WC-5264-1W	5.2	6.4	±0.01	cg	4	1.5	ina	344	575
	FEL	WC-5264-3W	5.2	6.4	±0.01	cf	4	N/A	ina	344	575
W6	FEL	WDC-5965-1W	5.85	6.5	±0.01	cg	7	1	ina	344	1100
	FEL	WDC-5965-3W	5.85	6.5	±0.01	cf	7	N/A	ina	344	1200
	PRD	555-AS3	5.4	6.5	0.015	g	ina	N/A	1	344	ina
	FEL	WDC-5465-1W	5.4	6.5	±0.01	cg	7	1	ina	344	1200
	FEL	WDC-5465-3W	5.4	6.5	±0.01	cf	7	N/A	ina	344	1250

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Waveguide Frequency Meters *(continued)*

			Frequency								
	Manufacturer	Model	Minimum GHz	Maximum GHz	Accuracy %	Circuit Type	Q Loaded K	Minimum Dip dB	Resolution MHz	Connector Type	Price Approx. $
W6 cont	PRD	588-A	5.3	6.7	0.08	e	6.5	40%	1	344	ina
	Diamond	690-1	5.85	7.05	0.05	g	ina	N/A	0.02%	ina	235
	Diamond	692-1	5.85	7.05	0.05	f	ina	N/A	0.02%	ina	235
	Diamond	691-1	5.85	7.05	0.05	e	ina	15%	0.02%	ina	235
	PRD	555-B	5.85	7.05	0.015	f	ina	N/A	1	344	ina
W7	PRD	555-A	5.85	7.05	0.015	g	ina	N/A	1	344	ina
	FEL	WC-5882-1W	5.8	8.1	±0.01	cg	3	1.5	ina	344	575
	FEL	WC-5882-3W	5.8	8.1	±0.01	cf	3	N/A	ina	344	575
	Diamond	691-2	7.05	8.2	0.05	e	ina	15%	0.02%	ina	230
	Diamond	792-1	7.05	8.2	0.05	f	ina	N/A	0.02%	ina	215
	Diamond	791-1	7.05	8.2	0.05	e	ina	15%	0.02%	ina	215
	Diamond	790-1	7.05	8.2	0.05	g	ina	N/A	0.02%	ina	215
	Diamond	690-2	7.05	8.2	0.05	g	ina	N/A	0.02%	ina	230
	Diamond	692-2	7.05	8.2	0.05	f	ina	N/A	0.02%	ina	230
	PRD	557-A	7.05	8.2	0.015	g	ina	N/A	1	51	ina
W8	PRD	557-B	7.05	8.2	0.015	f	ina	N/A	1	51	ina
	DE-MOR	DB J-720-3	5.85	8.2	0.02	f	4	N/A	1	344	629
	DE-MOR	DB J-720-1	5.85	8.2	0.02	g	6	N/A	1	344	585
	DE-MOR	DB J-720-2	5.85	8.2	0.02	e	4	1.5	1	344	615
	DE-MOR	DB J-715-3	5.85	8.2	0.02		4	N/A	1	344	608
	DE-MOR	DB J-715-2	5.85	8.2	0.02	e	4	1.5	1	344	587
	DE-MOR	DB J-715-3A	5.85	8.2	0.02		4	N/A	Ref, Type	344	591
	DE-MOR	DB J-715-2A	5.85	8.2	0.02	e	4	1.5	Ref, Type	344	580
	DE-MOR	DB J-715-1A	5.85	8.2	0.02	g	6	N/A	Ref, Type	344	547
	Narda	12G1	5.85	8.2	0.065	ina	8.5	ina	ina	ina	325
W9	Doug-MW	RH450A	5.85	8.2	±0.03	e	ina	20%	ina	344	225
	Doug-MW	RE450A	5.85	8.2	±0.03	e	ina	20%	ina	344	160
	Doug-MW	H450A	5.85	8.2	±0.03	e	ina	20%	ina	344	195
	Doug-MW	E450A	5.85	8.2	±0.03	e	ina	20%	ina	344	135
	Microlab	C410B	5.85	8.2	0.08	e	8	30%	ina	344	280
	Microlab	C402A	5.85	8.2	0.01	e	8	35%	250	344	ina
	PRD	533	5.85	8.2	±0.08	g	4	N/A	ina	344	378
	DE-MOR	DB J-707-3	5.85	8.2	0.02	f	4	N/A	1	344	ina
	DE-MOR	DB J-715-1	5.85	8.2	0.02	g	6	N/A	1	344	564
	DE-MOR	DB J-710-2	5.85	8.2	0.02	e	4	1.5	1	344	299
W10	DE-MOR	DB J-710-1	5.85	8.2	0.02	g	6	N/A	1	344	275
	DE-MOR	DB J-707-1	5.85	8.2	0.02	g	6	N/A	1	344	ina
	DE-MOR	DB J-710-3	5.85	8.2	0.02	f	4	N/A	1	344	303
	Waveline	498-DR	5.85	8.2	0.07	f	ina	N/A	2	344	ina
	H-P	J532A	5.3	8.2	0.065	e	ina	1	2	441	375
	FEL	WDC-7585-1W	7.5	8.5	±0.01	cg	7	1	ina	51	1200
	FEL	WDC-7585-3W	7.5	8.5	±0.01	cf	7	N/A	ina	51	1300
	PRD	556-B	7.05	8.6	0.015	f	ina	N/A	1	344	ina
	PRD	556-A	7.05	8.6	0.015	g	ina	N/A	1	344	ina
	FEL	WDC-9095-1W	9	9.5	±0.01	cg	7	1	ina	39	1070
W11	FEL	WDC-8596-1W	8.5	9.6	±0.01	cg	7	1	ina	39	1200
	Doug-MW	E460B	8.5	9.6	±3MHz	e	ina	20%	ina	51	325
	Doug-MW	E460X	8.5	9.6	±3MHz	e	ina	20%	ina	39	250
	Doug-MW	H460B	8.5	9.6	±3MHz	e	ina	20%	ina	51	350
	FEL	WDC-9197-1W	9.1	9.7	±0.01	cg	7	1	ina	39	1070
	FEL	WC-8397-1W	8.3	9.7	±0.01	cg	7	1.5	ina	39	575
	FEL	WC-8397-3W	8.3	9.7	±0.01	cf	7	N/A	ina	39	575
	Doug-MW	H460X	8.5	9.9	±3MHz	e	ina	20%	ina	39	325
	Diamond	990-2	15	10	0.05	g	ina	N/A	0.02%	ina	180
	PRD	558-B	8.2	10	0.015	f	ina	N/A	1	51	ina

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	Manufacturer	Model	Frequency Minimum GHz	Frequency Maximum GHz	Frequency Accuracy %	Circuit Type	Q Loaded K	Minimum Dip dB	Resolution MHz	Connector Type	Price Approx. $
W12	PRD	559-B	8.2	10	0.015	f	6	N/A	1	39	ina
	PRD	559-A	8.2	10	0.015	g	7	N/A	1	39	1295
	PRD	585-A	8.2	10	0.08	e	8.5	20%	1	39	ina
	PRD	586-A	8.2	10	0.08	g	ina	N/A	1	51	ina
	PRD	586-B	8.2	10	0.08	f	ina	N/A	1	51	ina
	PRD	558-A	8.2	10	0.015	g	ina	N/A	1	51	ina
	PRD	585-B	8.2	10	0.08	f	ina	N/A	1	39	ina
	Diamond	792-2	8.2	10	0.05	f	ina	N/A	0.02%	ina	205
	Diamond	791-2	8.2	10	0.05	e	ina	15%	0.02%	ina	205
	Diamond	892-1	8.2	10	0.05	f	ina	N/A	0.02%	ina	195
W13	Diamond	890-1	8.2	10	0.05	g	ina	N/A	0.02%	ina	195
	Diamond	790-2	8.2	10	0.05	g	ina	N/A	0.02%	ina	205
	Diamond	891-1	8.2	10	0.05	e	ina	15%	0.02%	ina	195
	DE-MOR	DBH-720-2	7.05	10	0.02	e	6	1.5	1	51	575
	DE-MOR	DBH-720-3	7.05	10	0.02	f	5	N/A	1(j)	51	581
	DE-MOR	DBH-710-3	7.05	10	0.05	f	5	N/A	1(k)	51	284
	DE-MOR	DBH-720-1	7.05	10	0.02	g	8	N/A	1	51	542
	DE-MOR	DBH-707-2	7.05	10	0.02	e	6	1.5	1.4	51	208
	DE-MOR	DBH-715-3	7.05	10	0.02	f	5	N/A	3	51	564
	DE-MOR	DBH-707-1	7.05	10	0.02	g	8	N/A	1.4	51	187
W14	DE-MOR	DBH-707-3	7.05	10	0.02	f	5	N/A	1.4	51	211
	DE-MOR	DBH-710-1	7.05	10	0.05	g	8	N/A	1	51	260
	DE-MOR	DBH-710-2	7.05	10	0.05	e	6	1.5	1	51	281
	DE-MOR	DBH-715-1	7.05	10	0.02	g	8	N/A	3	51	525
	Microlab	W410B	7.05	10	0.08	e	8	30%	ina	51	280
	Narda	12H1	7.05	10	0.070	ina	8	ina	ina	ina	290
	Doug-MW	RE450B	7.05	10	±0.03	e	ina	20%	ina	51	145
	Doug-MW	E450B	7.05	10	±0.03	e	ina	20%	ina	51	120
	Doug-MW	H450B	7.05	10	±0.03	e	ina	20%	ina	51	165
	Doug-MW	RH450B	7.05	10	±0.03	e	ina	20%	ina	51	195
W15	H-P	H532A	7.05	10	0.075	e	ina	1	2	138	325
	DE-MOR	DBH-715-2	7.05	10	0.02	e	6	1.5	3	51	558
	DE-MOR	DBH-715-1A	7.05	10	0.02	g	8	N/A	Ref, Type	51	509
	DE-MOR	DBH-715-2A	7.05	10	0.02	e	6	1.5	Ref, Type	51	542
	DE-MOR	DBH-715-3A	7.05	10	0.02	f	5	N/A	Ref, Type	51	547
	Waveline	598-DR	7.05	10	0.08	f	ina	N/A	2	51	290
	FEL	WC-7010-1W	7	10	±0.01	cg	3	1.5	ina	51	575
	FEL	WC-7010-3W	7	10	±0.01	cf	3	N/A	ina	51	575
	PRD	534	7	10	±0.08	g	3.5	N/A	ina	51	347
	FEL	WC-9611-3W	9.6	11	±0.01	cf	6	N/A	ina	39	575
W16	FEL	WC-9611-1W	9.6	11	±0.01	cg	6	1.5	ina	39	575
	FEL	WCF9611-4W	9.6	11	0.01	cd	6	ina	ina	39	975
	FEL	WC-8211-3W	8.2	11	±0.01	cf	3	N/A	ina	39	575
	FEL	WC-8211-1W	8.2	11	±0.01	cg	3	1.5	ina	39	575
	Diamond	890-2	8	11	0.05	g	ina	N/A	0.02%	ina	195
	FEL	WDC-8011-1W	8	11	±0.01	cg	4	1	ina	39	1295
	Diamond	891-2	8	11	0.05	e	ina	15%	0.02%	ina	195
	Diamond	892-2	8	11	0.05	f	ina	N/A	0.02%	ina	195
	FEL	WDC-10110-3W	10	11.5	±0.01	cf	5	N/A	ina	39	1300
	FEL	WDC-10110-1W	10	11.5	±0.01	cg	5	1	ina	39	1200
W17	Microlab	X411A	8.2	11.5	0.1	f	5	N/A	ina	39	250
	FEL	WC-11120-3W	11	12	±0.01	cf	6	N/A	ina	39	575
	FEL	WC-11120-1W	11	12	±0.01	cg	6	1.5	ina	39	575
	FEL	WCF11120-4W	11	12	0.01	cd	6	ina	ina	39	975
	Diamond	890-3	10	12.4	0.05	g	ina	N/A	0.02%	ina	195
	Diamond	891-3	10	12.4	0.05	e	ina	15%	0.02%	ina	195
	Diamond	892-3	10	12.4	0.05	f	ina	N/A	0.02%	ina	195
	PRD	565-A	10	12.4	0.03	g	ina	N/A	1	39	ina
	PRD	565-B	10	12.4	0.03	f	ina	N/A	1	39	ina
	H-P	X532B	8.2	12.4	0.075	e	ina	1	5	39	200

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			Frequency								
	Manufacturer	Model	Minimum GHz	Maximum GHz	Accuracy %	Circuit Type	Q Loaded K	Minimum Dip dB	Resolution MHz	Connector Type	Price Approx. $
W18	Waveline	698-DR	8.2	12.4	0.08	f	ina	N/A	5	39	200
	DE-MOR	DBG-720-2	8.2	12.4	0.03	e	8	1.5	2.5 (j)	39	541 j
	DE-MOR	DBG-707-1	8.2	12.4	0.03	g	13	N/A	2	39	175
	DE-MOR	DBG-720-3	8.2	12.4	0.03	f	8	N/A	2.5	39	546
	DE-MOR	DBG-715-3	8.2	12.4	0.03	f	8	N/A	5	39	525
	DE-MOR	DBG-710-2	8.2	12.4	0.05	e	8	1.5	2.5 (k)	39	269 k
	DE-MOR	DBG-707-3	8.2	12.4	0.03	f	8	N/A	2	39	199
	DE-MOR	DBG-715-2	8.2	12.4	0.03	c	8	1.5	5	39	520
	DE-MOR	DBG-707-2	8.2	12.4	0.03	e	8	1.5	2	39	196
	DE-MOR	DBG-710-1	8.2	12.4	0.05	g	13	N/A	2.5	39	248
W19	DE-MOR	DBG-710-3	8.2	12.4	0.05	f	8	N/A	2.5	39	272
	DE-MOR	DBG-715-1	8.2	12.4	0.03	g	13	N/A	5	39	487
	DE-MOR	DBG-715-3A	8.2	12.4	0.03	f	8	N/A	Ref, Type	39	509
	DE-MOR	DBG-715-1A	8.2	12.4	0.03	g	13	N/A	Ref, Type	39	470
	DE-MOR	DBG-715-2A	8.2	12.4	0.03	e	8	1.5	Ref, Type	39	503
	FEL	WDB8212-1W	8.2	12.4	±0.05	ag	5	1	ina	39	395
	PRD	535	8.2	12.4	0.08	g	4	N/A	ina	39	200
	Narda	12X1	8.20	12.4	0.075	ina	7.5	ina	ina	ina	195
	Doug-MW	E450X	8.2	12.4	±0.03	e	ina	20%	ina	39	110
	Doug-MW	RH450X	8.2	12.4	±0.03	e	ina	20%	ina	39	185
W20	Doug-MW	RE450X	8.2	12.4	±0.03	e	ina	20%	ina	39	135
	Doug-MW	H450X	8.2	12.4	±0.03	e	ina	20%	ina	39	155
	DE-MOR	DBG-720-1	8.2	12.4	0.03	g	13	N/A	2.5	32	504
	Microlab	X410B	8.2	12.4	0.08	e	8	30%	ina	39	210
	Microlab	X402A	8.2	12.4	0.015	e	8	35%	500	39	ina
	PRD	566-B	12.4	15	0.03	f	ina	N/A	1	419	ina
	PRD	566-A	12.4	15	0.03	g	ina	N/A	1	419	ina
	Diamond	990-1	12.4	15	0.02	g	ina	1.5	0.02%	ina	180
	Diamond	992-1	12.4	15	0.02	f	ina	N/A	0.02%	ina	180
	FEL	WCF12150-4W	12	15	0.01	cd	4	ina	ina	419	975
W21	FEL	WC-12150-3W	12	15	±0.01	cf	4	N/A	ina	419	575
	FEL	WC-12150-1W	12	15	±0.01	cg	4	1.5	ina	419	575
	DE-MOR	DBFA-710-3	10	15	0.05	f	5	N/A	2.5	ina	284
	DE-MOR	DBFA-710-1	10	15	0.05	g	5	N/A	2.5	ina	260
	DE-MOR	DBFA-710-2	10	15	0.05	e	4	1.5	2.5	ina	281
	DE-MOR	DBFA-715-1	10	15	0.03	g	13	N/A	0.5	39	503
	DE-MOR	DBFA-707-2	10	15	0.04	e	4	1.5	5	ina	208
	DE-MOR	DBFA-720-3	10	15	0.04	f	5	N/A	2.5	ina	542
	DE-MOR	DBFA-707-1	10	15	0.04	g	5	N/A	5	ina	187
	DE-MOR	DBFA-715-3	10	15	0.03	f	8	N/A	0.5	39	542
W22	DE-MOR	DBFA-715-2	10	15	0.03	e	8	1.5	0.5	39	536
	DE-MOR	DBFA-707-3	10	15	0.04	f	5	N/A	5	ina	211
	DE-MOR	DBFA-720-2	10	15	0.04	e	4	1.5	2.5	ina	536
	DE-MOR	DBFA-720-1	10	15	0.04	g	5	N/A	2.5	ina	503
	DE-MOR	DBFA-715-2A	10	15	0.04	e	4	1.5	Ref, Type	WR75	520
	DE-MOR	DBFA-715-1A	10	15	0.04	g	5	N/A	Ref, Type	WR75	487
	DE-MOR	DBFA-715-3A	10	15	0.04	f	5	N/A	Ref, Type	WR75	525
	H-P	M532A	10	15	0.085	e	ina	1	5	ina	350
	Diamond	991-2	15	16	0.05	e	ina	15%	0.02%	ina	180
	Diamond	992-2	15	16	0.05	f	ina	N/A	0.02%	ina	180
W23	FEL	WDC-16170-1W	15.8	17.2	±0.01	cg	5	1	ina	419	1250
	FEL	WDC-15180-1W	15	18	±0.01	cg	5	1	ina	419	1250
	FEL	WCF15180-4W	15	18	0.01	cd	3	ina	ina	419	975
	PRD	567-A	15	18	0.03	g	ina	N/A	2	419	ina
	FEL	WC-15180-3W	15	18	±0.01	cf	3	N/A	ina	419	575

(tables continued on page T94)

See reader-service card for valuable FREE reprints.
Reader-service numbers are given in the index.
Reader-service cards are good all year.
Need a FREE copy of this directory? Circle number 255.
Waveguide frequency meter index starts on page T96.


CLARE / Optimity in control
MERCURY WETTED CONTACT RELAY
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Waveguide Frequency Meters *(continued)*

			Frequency								
	Manufacturer	Model	Minimum GHz	Maximum GHz	Accuracy %	Circuit Type	Q Loaded K	Minimum Dip dB	Resolution MHz	Connector Type	Price Approx. $
W23 cont	PRD	567-B	15	18	0.03	f	ina	N/A	2	419	ina
	FEL	WC-15180-1W	15	18	±0.01	cg	3	1.5	ina	419	575
	PRD	536	12.4	18	0.1	g	2	N/A	ina	419	310
	Narda	12U1	12.4	18	0.095	ina	5	ina	ina	ina	250
	Doug-MW	E450G	12.4	18	±0.03	e	ina	20%	ina	419	120
W24	Doug-MW	RH450G	12.4	18	±0.03	e	ina	20%	ina	419	195
	Doug-MW	H450G	12.4	18	±0.03	e	ina	20%	ina	419	165
	Doug-MW	RE450G	12.4	18	±0.03	e	ina	20%	ina	419	145
	DE-MOR	DBF-707-2	12.4	18	0.04	e	4	1.5	5	419	208
	DE-MOR	DBF-720-1	12.4	18	0.04	g	5	N/A	2.5	419	503
	DE-MOR	DBF-715-3	12.4	18	0.04	f	5	N/A	1	419	542
	DE-MOR	DBF-710-3	12.4	18	0.05	f	5	N/A	2.5	419	284
	DE-MOR	DBF-715-2A	12.4	18	0.04	e	4	1.5	Ref, Type	419	520
	DE-MOR	DBF-710-1	12.4	18	0.05	g	5	N/A	2.5	419	260
	DE-MOR	DBF-707-3	12.4	18	0.04		5	N/A	5	419	211
W25	DE-MOR	DBF-715-2	12.4	18	0.04	e	4	1.5	1	419	536
	DE-MOR	DBF-707-1	12.4	18	0.04	g	5	N/A	5	419	187
	DE-MOR	DBF-715-1	12.4	18	0.04	g	5	N/A	1	419	503
	DE-MOR	DBF-710-2	12.4	18	0.05	e	4	1.5	2.5	419	281
	DE-MOR	DBF-720-2	12.4	18	0.04	e	4	1.5	2.5	419	536
	DE-MOR	DBF-720-3	12.4	18	0.04		5	N/A	2.5	419	542
	DE-MOR	DBF-715-3A	12.4	18	0.04		5	N/A	Ref, Type	419	525
	DE-MOR	DBF-715-1A	12.4	18	0.04	g	5	N/A	Ref, Type	419	487
	Diamond	991-1	12.4	18	0.02	e	ina	15%	0.02%	ina	180
	TRG	KU551	12.4	18	0.11	g	ina	0.5-1.0	ina	419	300
W26	H-P	P532A	12.4	18	0.1	e	ina	1	5	419	275
	Waveline	798-DR	12.4	18	0.1	f	ina	N/A	5	419	270
	Microlab	Y410A	12.4	18	0.1	e	4.5	30%	ina	419	250
	FEL	WDB12180-1W	12	18	±0.05	ag	3	1	ina	419	395
	PRD	568-B	18	22	0.05	f	ina	N/A	2	425	ina
	PRD	568-A	18	22	0.05	g	ina	N/A	2	425	ina
	West Eleven	K2203	22	25	±0.03	df	5	N/A	ina	595	341
	PRD	569-A	22	26.5	0.05	g	ina	N/A	5	425	ina
	PRD	569-B	22	26.5	0.05	f	ina	N/A	5	425	ina
	Microlab	K410AF	18	26.5	0.1	e	4	30%	ina	595	280
W27	DE-MOR	DBE-715-3A	18	26.5	0.06		3.7	N/A	Ref, Type	595	565
	DE-MOR	DBE-715-1	18	26.5	0.06	g	4.8	N/A	2.5	595	541
	DE-MOR	DBE-715-3	18	26.5	0.06		3.7	N/A	2.5	595	580
	DE-MOR	DBE-715-2A	18	26.5	0.06	e	2.8	1.5	Ref, Type	595	560
	DE-MOR	DBE-720-1	18	26.5	0.06	g	4.8	N/A	5	595	ina
	DE-MOR	DBE-720-3	18	26.5	0.06		3.7	N/A	5	595	ina
	DE-MOR	DBE-720-2	18	26.5	0.06	e	2	1.5	5	595	ina
	DE-MOR	DBE-715-1A	18	26.5	0.06	g	4.8	N/A	Ref, Type	595	525
	FEL	WDB18260-1W	18	26.5	±0.05	ag	2	1	ina	595	550
	DE-MOR	DBE-715-2	18	26.5	0.06	e	2	1.5	2.5	595	575
W28	Waveline	898-DR	18	26.5	0.11	f	ina	N/A	10	595	335
	TRG	K551	18	26.5	0.11	f	ina	0.5-1.0	ina	595	375
	H-P	K532A	18	26.5	0.11	e	ina	1	10	595	350
	Doug-MW	RH-450K	18	26.5	±0.03	e	ina	20%	ina	595	225
	Doug-MW	E450K	18	26.5	±0.03	e	ina	20%	ina	595	145
	Doug-MW	H450K	18	26.5	±0.03	e	ina	20%	ina	595	195
	Doug-MW	RE450K	18	26.5	±0.03	e	ina	20%	ina	595	175
	PRD	537	18	26.5	0.1	g	2.5	N/A	ina	425	310
	PRD	537-F1	18	26.5	0.1	g	2.5	N/A	ina	595	310
	Narda	12K1	18	26.5	0.105	ina	4	ina	ina	ina	280

Circle as many numbers on the reader-service card as you like.
Get detailed data: use the reader-service card.
Waveguide frequency meter index starts on page T96.

Waveguide Frequency Meters *(continued)*

	Manufacturer	Model	Frequency Minimum GHz	Frequency Maximum GHz	Frequency Accuracy %	Circuit Type	Q Loaded K	Minimum Dip dB	Resolution MHz	Connector Type	Price Approx. $
W29	West Eleven	K2210	18	26.5	±0.14	ae	4	5%	ina	595	301
	West Eleven	K2201	18	26.5	±0.07	dg	4	5%	ina	595	ina
	PRD	570-A	26.5	32	0.075	g	ina	N/A	5	381	ina
	PRD	570-B	26.5	32	0.075	f	ina	N/A	5	381	ina
	West Eleven	R2203	32.5	37.5	±0.03	df	5	N/A	ina	381	341
	PRD	571-AF1	32	39	0.075	g	ina	N/A	10	599	ina
	PRD	571-B	32	39	0.075	f	ina	N/A	10	381	ina
	PRD	571-A	32	39	0.075	g	ina	N/A	10	381	ina
	Microlab	U410AF	26.5	39.5	0.3	e	3	30%	ina	599	320
	FEL	WDB26400-1W	26.5	40	±0.05	ag	2	1	ina	599	700
W30	Narda	12V1	26.5	40	0.115	ina	3	ina	ina	ina	300
	H-P	R532A	26.5	40	0.12	e	ina	1	10	599	400
	Doug-MW	RE450T	26.5	40	±0.03	e	ina	20%	ina	599	195
	DE-MOR	DBD-715-3A	26.5	40	0.09	t	2.5	N/A	Ref, Type	599	565
	DE-MOR	DBD-720-3	26.5	40	0.09	t	2.5	N/A	5	599	ina
	DE-MOR	DBD-715-3	26.5	40	0.09	t	2.5	N/A	5	599	580
	DE-MOR	DBD-715-2	26.5	40	0.09	e	3.1	2	5	599	575
	DE-MOR	DBD-715-2A	26.5	40	0.09	e	3.1	1.5	Ref, Type	599	560
	DE-MOR	DBD-715-1A	26.5	40	0.09	g	3.8	N/A	Ref, Type	599	525
	DE-MOR	DBD-720-2	26.5	40	0.09	e	3.1	2	5	599	ina
W31	DE-MOR	DBD-715-1	26.5	40	0.09	g	3.8	ina	5	599	541
	DE-MOR	DBD-720-1	26.5	40	0.09	g	3.8	N/A	5	599	ina
	Doug-MW	RH450T	26.5	40	±0.03	e	ina	20%	ina	599	270
	Doug-MW	H450T	26.5	40	±0.03	e	ina	20%	ina	599	235
	Doug-MW	E450T	26.5	40	±0.03	e	ina	20%	ina	599	165
	PRD	538	26.5	40	0.3	g	1	N/A	ina	381	331
	TRG	A551	26.5	40	0.12	e	ina	0.5-1.0	ina	599	450
	Waveline	1098-DR	26.5	40	0.12	f	ina	N/A	10	599	385
	West Eleven	R2210	26.5	40	±0.14	ae	3	5%	ina	381	360
	West Eleven	R2201	26.5	40	±0.09	dg	3	5%	ina	381	440
W32	West Eleven	Q2203	37	43	±0.07	df	4	N/A	ina	383	374
	DE-MOR	DBC-715-3A	33	50	0.13	t	2	N/A	Ref, Type	383	565
	DE-MOR	DBC-715-3	33	50	0.13	f	2	N/A	7.5	383	580
	DE-MOR	DBC-715-1	33	50	0.13	g	3.2	N/A	7.5	383	541
	DE-MOR	DBC-715-2	33	50	0.13	e	2.5	1	7.5	383	575
	DE-MOR	DBC-715-1A	33	50	0.13	g	3.2	N/A	Ref, Type	383	525
	DE-MOR	DBC-715-2A	33	50	0.13	e	2.5	1.5	Ref, Type	383	560
	TRG	B551	33	50	0.2	g	ina	0.5-1.0	ina	383	650
	TRG	B550	33	50	0.2	g	3.2	1-2	ina	383	460
	Microlab	Q410X	33	50	0.15	e	1.5	30%	ina	383	330
W33	West Eleven	Q2201	33	50	±0.14	dg	2.5	5%	ina	383	440
	West Eleven	Q2210	33	50	±0.23	ae	2.5	5%	ina	383	530
	West Eleven	F2203	45.5	53.5	±0.07	df	3	N/A	ina	383	398
	West Eleven	F2201	40	60	±0.16	dg	2	5%	ina	383	462
	West Eleven	F2210	40	60	±0.25	ae	2	5%	ina	383	746
	West Eleven	M2203	57	65	±0.08	df	3	N/A	ina	385	549
	TRG	V550	50	70	0.2	g	2.1	1-2	ina	385	300
	West Eleven	E2203	60	71	±0.09	df	3	N/A	ina	387	711
	DE-MOR	DBB-715-3A	50	75	0.17	t	1.3	N/A	Ref, Type	385	565
	DE-MOR	DBB-715-2	50	75	0.17	e	1.4	1	15	385	575
W34	DE-MOR	DBB-715-3	50	75	0.17	t	1.3	N/A	15	385	580
	DE-MOR	DBB-715-1	50	75	0.17	g	2.1	N/A	15	385	541
	DE-MOR	DBB-715-1A	50	75	0.17	g	2.1	N/A	Ref, Type	385	525
	DE-MOR	DBB-715-2A	50	75	0.17	e	1.4	1.5	Ref, Type	385	560
	TRG	V551	50	75	0.2	g	ina	0.5-1.0	ina	385	975

(tables continued on page T96)

Waveguide Frequency Meters *(continued)*

	Manufacturer	Model	Frequency Minimum GHz	Frequency Maximum GHz	Frequency Accuracy %	Circuit Type	Q Loaded K	Minimum Dip dB	Resolution MHz	Connector Type	Price Approx. $
W34 cont	Microlab	M410X	50	75	0.1	e	1.5	30%	ina	385	330
	West Eleven	M2201	50	75	±0.19	dg	1.5	5%	ina	385	522
	West Eleven	M2210	50	75	±0.33	ae	1.5	5%	ina	385	775
	TRG	E550	60	90	0.2	g	2.1	1-2	ina	387	500
	DE-MOR	DBA-715-3	60	90	0.2	f	1.1	N/A	25	387	580
W35	DE-MOR	DBA-715-2	60	90	0.2	e	1.4	1	25	387	575
	DE-MOR	DBA-715-1	60	90	0.2	g	1.8	N/A	25	387	541
	DE-MOR	DBA-715-2A	60	90	0.2	g	2.1	1-2	ina	387	500
	DE-MOR	DBA-715-3A	60	90	0.2	1	1.1	N/A	Ref, Type	387	565
	TRG	E551	60	90	0.2	g	ina	0.5-1.0	ina	387	1200
	MCS	Y390	60	90	0.25	e	1.4	1	20	ina	1700
	Microlab	E410X	60	90	0.25	e	1	30%	ina	387	450
	West Eleven	E2210	60	90	±0.34	ae	1	5%	ina	387	960
	West Eleven	E2201	60	90	±0.22	dg	1	5%	ina	387	547
	West Eleven	W2203	88.5	102	±0.13	df	2.5	N/A	ina	387	811
W36	TRG	W550	75	110	0.2	g	2	1-2	ina	387	625
	TRG	W551	75	110	0.2	g	ina	0.5-1.0	ina	387	1600
	West Eleven	W2210	75	110	±0.47	ae	1	5%	ina	387	1122
	West Eleven	W2201	75	110	±0.32	dg	1	5%	ina	387	588
	DE-MOR	DBA-715-1A	60	110	0.2	g	2	1-2	ina	387	625
	Microlab	F412A	90	140	0.5	g	0.5	N/A	ina	special	600
	TRG	F550	90	140	0.2	g	1	1-2	ina	TRG714	750
	Microlab	G412A	140	220	0.5	g	0.5	N/A	ina	special	630
	TRG	G550	140	220	0.2	g	1	1-2	ina	TRG715	750
	DE-MOR	DBW-715-2	90	140	0.2	e	1	1.5	100	DBW1000	1220
W37	DE-MOR	DBW-715-1	90	140	0.2	g	1	N/A	100	DBW1000	1109

Waveguide Frequency Meter Notes

a. Direct-reading dial
c. Micrometer.
d. Calibration chart furnished.
e. Absorption feed-in.
f. Transmission.
g. Reaction.
j. Temperature coefficient 0.075MHz/°C.
k. Temperature coefficient 0.25MHz/°C.

Waveguide Frequency Meter Cross Index

CODE	COMPANY	MODEL NO.	TABLE LOCATION	READER SERVICE NO.
DE-MOR	DeMorney-Bonardi Div. Datapulse Inc. 780 South Arroyo Parkway Pasadena, California	DBA-715-1	W 35	430
		DBA-715-1A	W 36	
		DBA-715-2	W 35	
		DBA-715-2A	W 35	
		DBA-715-3	W 34	
		DBA-715-3A	W 35	
		DBB-715-1	W 34	
		DBB-715-1A	W 34	
		DBB-715-2	W 33	
		DBB-715-2A	W 34	
		DBB-715-3	W 34	
		DBB-715-3A	W 33	
		DBC-715-1	W 32	
		DBC-715-1A	W 32	
		DBC-715-2	W 32	
		DBC-715-2A	W 32	
		DBC-715-3	W 32	
		DBC-715-3A	W 32	
		DBD-715-1	W 31	
		DBD-715-1A	W 30	
		DBD-715-2	W 30	
DE-MOR (cont)		DBD-715-2A	W 30	
		DBD-715-3	W 30	
		DBD-715-3A	W 30	
		DBD-720-1	W 31	
		DBD-720-2	W 30	
		DBD-720-3	W 30	
		DBE-715-1	W 27	
		DBE-715-1A	W 27	
		DBE-715-2	W 27	
		DBE-715-2A	W 27	
		DBE-715-3	W 27	
		DBE-715-3A	W 27	
		DBE-720-1	W 27	
		DBE-720-2	W 27	
		DBE-720-3	W 27	
		DBF-707-1	W 25	
		DBF-707-2	W 24	
		DBF-707-3	W 24	
		DBF-710-1	W 24	
		DBF-710-2	W 25	
		DBF-710-3	W 24	

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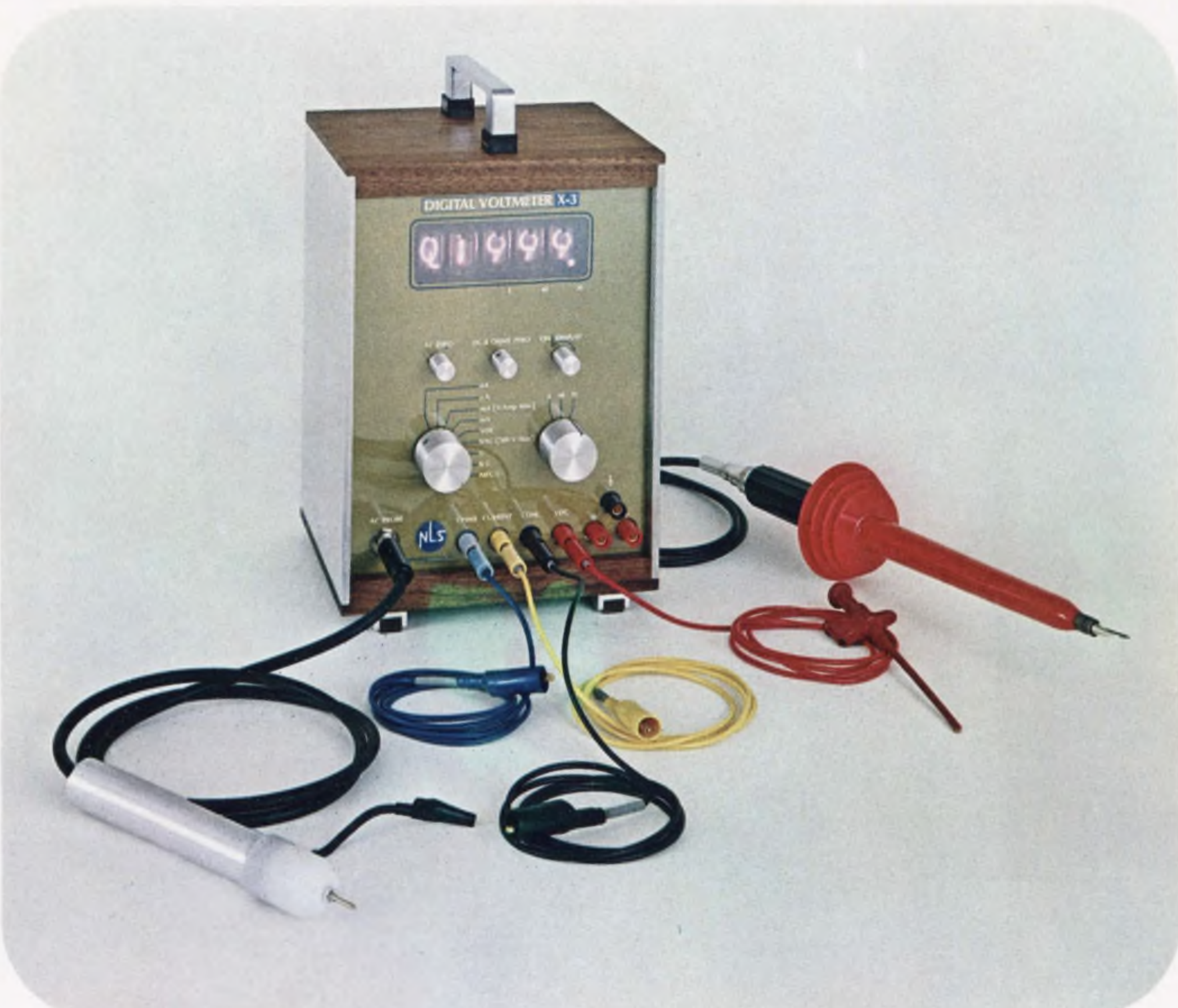

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10 Microvolts resolution

AC Volts:
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10 Millivolts resolution
3% Accuracy
20 Hz to 500 MHz
10 Megohms Input Impedance

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.1% ± 1 digit to 200K

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ON READER-SERVICE CARD CIRCLE 303

Waveguide Frequency Meter Cross Index *(continued)*

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
DE-MOR (cont)		DBF-715-1	W 25	430
		DBF-715-1A	W 25	
		DBF-715-2	W 25	
		DBF-715-2A	W 24	
		DBF-715-3	W 24	
		DBF-715-3A	W 25	
		DBF-720-1	W 24	
		DBF-720-2	W 25	
		DBF-720-3	W 25	
		DBFA-707-1	W 21	
		DBFA-707-2	W 21	
		DBFA-707-3	W 22	
		DBFA-710-1	W 21	
		DBFA-710-2	W 21	
		DBFA-710-3	W 21	
		DBFA-715-1	W 21	
		DBFA-715-1A	W 22	
		DBFA-715-2	W 22	
		DBFA-715-2A	W 22	
		DBFA-715-3	W 21	
		DBFA-715-3A	W 22	
		DBFA-720-1	W 22	
		DBFA-720-2	W 22	
		DBFA-720-3	W 21	
		DBG-707-1	W 18	
		DBG-707-2	W 18	
		DBG-707-3	W 18	
		DBG-710-1	W 18	
		DBG-710-2	W 18	
		DBG-710-3	W 19	
		DBG-715-1	W 19	
		DBG-715-1A	W 19	
		DBG-715-2	W 18	
		DBG-715-2A	W 19	
		DBG-715-3	W 18	
		DBG-715-3A	W 19	
		DBG-720-1	W 20	
		DBG-720-2	W 18	
		DBG-720-3	W 18	
		DBH-707-1	W 13	
		DBH-707-2	W 13	
		DBH-707-3	W 14	
		DBH-710-1	W 14	
		DBH-710-2	W 14	
		DBH-710-3	W 13	
		DBH-715-1	W 14	
		DBH-715-1A	W 15	
		DBH-715-2	W 15	
		DBH-715-2A	W 15	
		DBH-715-3	W 13	
		DBH-715-3A	W 15	
		DBH-720-1	W 13	
		DBH-720-2	W 13	
		DBH-720-3	W 13	
		DBJ-707-1	W 10	
		DBJ-707-3	W 9	
		DBJ-710-1	W 10	
		DBJ-710-2	W 9	
		DBJ-710-3	W 10	
		DBJ-715-1	W 9	
		DBJ-715-1A	W 8	
		DBJ-715-2	W 8	
		DBJ-715-2A	W 8	
		DBJ-715-3	W 8	
		DBJ-715-3A	W 8	
		DBJ-720-1	W 8	
		DBJ-720-2	W 8	
		DBJ-720-3	W 8	
		DBK-707-1	W 4	
		DBK-707-2	W 4	
		DBK-707-3	W 4	
		DBK-710-1	W 4	
		DBK-710-2	W 4	
		DBK-710-3	W 4	
		DBK-715-1	W 4	
		DBK-715-1A	W 4	
		DBK-715-2	W 4	
		DBK-715-2A	W 3	
		DBK-715-3	W 3	
		DBK-715-3A	W 5	
		DBK-720-1	W 3	
		DBK-720-2	W 3	
		DBK-720-3	W 4	
		DBL-710-1	W 2	
		DBL-710-2	W 2	
		DBL-710-3	W 1	
		DBL-715-1	W 1	
		DBL-715-1A	W 1	
		DBL-715-2	W 1	
		DBL-715-2A	W 2	
		DBL-715-3	W 2	
		DBL-715-3A	W 1	
		DBL-720-1	W 1	
		DBL-720-2	W 1	
		DBL-720-3	W 1	
		DBW-715-1	W 37	
		DBW-715-2	W 36	
Diamond	Diamond Antenna & Microwave Corp. 35 River Street Winchester, Mass. 01890	590-1	W 2	431
		590-2	W 3	
		592-1	W 2	
		592-2	W 3	
		591-1	W 2	
		591-2	W 3	
		690-1	W 6	
		690-2	W 7	
		691-1	W 6	
		691-2	W 7	
		692-1	W 6	
		692-2	W 7	
		790-1	W 7	
		790-2	W 13	
		791-1	W 7	
		791-1	W 12	
		792-2	W 12	
		890-1	W 13	
		890-2	W 16	
		890-3	W 17	
		891-1	W 13	
		891-2	W 16	
		891-3	W 17	
		892-1	W 12	
		892-2	W 16	
		892-3	W 17	
		990-1	W 20	
		990-2	W 11	
		991-1	W 25	
		991-2	W 22	
		992-1	W 20	
		992-2	W 22	
Doug-MW	Douglas Microwave Co. 252 East Third Street Mount Vernon, N. Y. 01890	E450A	W 9	432
		E450B	W 14	
		E450C	W 5	
		E450G	W 23	
		E450K	W 28	
		E450T	W 31	
		E450X	W 19	
		E460B	W 11	
		E460X	W 11	
		H450A	W 9	
		H450B	W 14	
		H450G	W 24	
		H450K	W 28	
		H450T	W 31	
		H450X	W 20	
		H460B	W 11	
		H460X	W 11	
		RE450A	W 9	
		RE450B	W 14	
		RE450G	W 24	
		RE450K	W 28	
		RE450T	W 30	
		RE450X	W 20	
		RH450A	W 9	
		RH450B	W 14	
		RH450G	W 24	
		RH450K	W 28	
		RH450T	W 31	
		RH450X	W 19	
FEL	Frequency Engineering Labs Div. Harvard Ind. Box 527 Farmingdale, New Jersey	WC-3545-1W	W 2	433
		WC-3545-3W	W 2	
		WC-4458-1W	W 3	
		WC-4458-3W	W 2	
		WC-5264-1W	W 5	
		WC-5264-3W	W 5	
		WC-5882-1W	W 7	
		WC-5882-3W	W 7	

Waveguide Frequency Meter Cross Index *(continued)*

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
FEL (cont)		WC-7010-1W	W 15	
		WC-7010-3W	W 15	
		WC-8211-1W	W 16	
		WC-8211-3W	W 16	
		WC-8397-1W	W 11	
		WC-8397-3W	W 11	
		WC-9611-1W	W 16	
		WC-9611-3W	W 15	
		WC-11120-1W	W 17	
		WC-11120-3W	W 17	
		WC-12150-1W	W 21	
		WC-12150-3W	W 21	
		WC-15180-1W	W 23	
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		WCF-9611-4W	W 16	
		WCF-11120-4W	W 17	
		WCF-12150-4W	W 20	433
		WCF-15180-4W	W 23	
		WDB-8212-1W	W 19	
		WDB-12180-1W	W 26	
		WDB-18260-1W	W 27	
		WDB-26400-1W	W 29	
		WDC-3645-1W	W 2	
		WDC-5459-1W	W 5	
		WDC-5459-3W	W 5	
		WDC-5465-1W	W 6	
		WDC-5465-3W	W 6	
		WDC-5965-1W	W 6	
		WDC-5965-3W	W 6	
		WDC-7585-1W	W 10	
		WDC-7585-3W	W 10	
		WDC-8011-1W	W 16	
		WDC-8596-1W	W 11	
		WDC-9095-1W	W 10	
		WDC-9197-1W	W 11	
		WDC-10110-1W	W 16	
		WDC-10110-3W	W 16	
		WDC-15180-1W	W 23	
		WDC-16170-1W	W 23	
H-P	Hewlett-Packard Co. 1501 Page Mill Road Palo Alto, California	G532A	W 3	Contact Local Rep.
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		J532A	W 10	
		K532A	W 28	
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		R532A	W 30	
		X532B	W 17	
MCS	MCS Corp. 1001 South Mountain Ave. Monrovia, Calif. 91916	Y390	W 35	434
Microlab	Microlab/FXR Livingston New Jersey	C402A	W 9	435
		C410B	W 9	
		E410X	W 35	
		F412A	W 36	
		G412A	W 36	
		H410B	W 5	
		K410AF	W 26	
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		Q410X	W 32	
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		W410B	W 14	
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		Y410A	W 26	
Narda	Narda Microwave Corp. Commercial Street Plainview, N.Y. 11803	12C1	W 5	436
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		12H1	W 14	
		12K1	W 28	
		12S1	W 1	
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		12V1	W 30	
		12X1	W 19	
PRD	PRD Electronics Inc. Sub Harris-Intertype Corp. Prospect Avenue Westbury, N.Y. 11590	532	W 5	437
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		555-AS3	W 6	
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		556-B	W 10	
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		585-A	W 12	
		585-B	W 12	
		586-A	W 12	
		586-B	W 12	
		588-A	W 6	
		590-A	W 5	
TRG	TRG Inc. Control Data Corp. 400 Border Street East Boston, Mass. 02128	A551	W 31	438
		B550	W 32	
		B551	W 32	
		E550	W 34	
		E551	W 35	
TRG (cont)		F550	W 36	438
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		K551	W 28	
		KU551	W 25	
		V550	W 33	
		V551	W 34	
		W550	W 36	
		W551	W 36	
Waveline	Waveline Inc. Caldwell New Jersey	398-DR	W 3	439
		498-DR	W 10	
		598-DR	W 15	
		698-DR	W 18	
		798-DR	W 26	
		898-DR	W 28	
		1098-DR	W 31	
West Eleven	West Eleven Inc. 11836 San Vincente Blvd. Los Angeles, Calif. 90049	E2201	W 35	440
		E2203	W 33	
		E2210	W 35	
		F2201	W 33	
		F2203	W 33	
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		K2203	W 26	
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		M2201	W 34	
		M2203	W 33	
		M2210	W 34	
		Q2201	W 33	
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		Q2210	W 33	
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Frequency Counters

	Manufacturer	Model	FREQUENCY Min. Hz	FREQUENCY Max. MHz	Stability ppm	Digits No.	INPUT Sens. mV	INPUT Imp. MΩ(pF)	Gate Time s	DISPLAY Interval s	DISPLAY Type	Conn. Type	Solid State	Type C-Cab. R-Rack P-Port.	Price Approx $
F 1	Magtrol	4602	5	0.1	ina	4 (a)	(±0.5-50V)	ina	0.1, 1	ina	ina	ina	yes	C	575
	Avtron	T569	5	0.1	ina	5 (a)	1000	0.03	0.01-10	ina	ina	ina	yes	R	ina
	Avtron	T420	5	0.1	ina	5 (a)	ina	ina	0.01	ina	ina	ina	yes	R	ina
	Avtron	T572	1	0.1	ina	4	ina	ina	1	0.8-10	ina	MS	yes	C	1250
	Avtron	T734	1	0.1	ina	4	ina	ina	1	0.8-10	ina	MS	yes	C	ina
	H-P	522B	10	0.12	10/wk	5	200	1 (50)	0.001-10	0.1-10	e, f	BNC	no	R	1100
	H-P	521A	1	0.12	0.1%	4 (b)	200	1 (50)	0.1-1	0.1-15	none	BNC	no	R	650
	H-P	521C	1	0.12	0.01%	5 (b)	200	1 (50)	0.1-10	0.1-15	f	BNC	no	R	800
	H-P	521D	1	0.12	0.1%	4 (a)	200	1 (50)	0.1-1	0.1-15	none	BNC	no	R	900
	H-P	521E	1	0.12	±0.01%	5 (a)	200	1 (50)	0.1-10	0.1-15	f	BNC	no	C, R	1125
F 2	Beckman	6225	2	0.2	1000	4	100	0.1 (50)	0.1, 1, 10	0.1	g	BNC	(†)	C, R	575
	Beckman	6230	2	0.2	100	4	100	0.1 (50)	100μs-10	0.1	g	BNC	(†)	C	675
	Anadex	CF-500R	0	0.2	ina	5 (a)	100	100K (50)	0.01, 0.1, 1	0.2-6	d, e	BNC	yes	R	820
	Anadex	CF-500-4R	0	0.2	ina	4 (a)	100	100K (50)	0.01, 0.1, 1	0.2-6	d, e	BNC	yes	R	780
	Anadex	CF-500-6R	0	0.2	ina	6 (a)	100	100K (50)	0.01, 0.1. 1	0.2-6	d, e	BNC	yes	R	880
	Anadex	CF-501R	0	0.2	±2/wk	5 (a)	100	100K (50)	0.0001-10	0.2-6	d, e	BNC	yes	R	945
	Anadex	CF-501-4R	0	0.2	±2/wk	4 (a)	100	100K (50)	0.0001-10	0.2-6	d, e	BNC	yes	R	905
	Anadex	CF-501-6R	0	0.2	±2/wk	6 (a)	100	100K (50)	0.0001-10	0.2-6	d, e	BNC	yes	R	995
	Anadex	CF-503R	0	0.2	ina	5 (a)	100	100K (50)	0.1, 0.6, 1	0.2-6	d, e	BNC	yes	R	710
	Anadex	CF-503-4R	0	0.2	ina	4 (a)	100	100K (50)	0.1, 0.6, 1	0.2-6	d, e	BNC	yes	R	670
F 3	Anadex	CF-503-6R	0	0.2	ina	6 (a)	100	100K (50)	0.1, 0.6, 1	0.2-6	d, e	BNC	yes	R	770
	H-P	5211A	2	0.3	±0.1	4 (b)	100	1 (50)	0.1-1	0.2-5	d	BNC	yes	C, R	575
	H-P	5211B	2	0.3	±0.1	4 (b)	100	1 (50)	10, 1, 0.1	0.2-5	d	BNC	yes	C, R	675
	H-P	5212A	2	0.3	±2/wk	5 (b)	100	1 (50)	0.01-10	0.2-5	d, e	BNC	yes	C, R	875
	H-P	5214L	2	0.3	±2/wk	5 (a)	100	1 (50)	10μs-100	0.2-5	d. e	BNC	yes	C, R	1300
	H-P	5512A	2	0.3	±2/wk	5 (a)	100	1 (50)	0.1-10	0.2-5	d, e	BNC	yes	C, R	975
	Systron	1011	2	0.3	60 Hz line	4 (a)	100	0.1 (100)	ina	ina	ina	BNC	yes	C, R	850
	Systron	1013	2	0.3	±2	5 (a)	100	1 (50)	10μs	ina	ina	BNC	yes	C, R	1000
	Chad-Hel	423	2	0.3	60 Hz line	4 (a)	100	1 (50)	0.1-1	ina	ina	BNC	yes	R	1290
	Wang	2019	2	0.3	±2 (h)	5 (a)	100	1 (50)	10μs-100	0.2-5	d, e	BNC	yes	R	1250
F 4	Wang	2240	2	0.3	±2 (h)	5	100	1 (50)	10μs-1000	0.2-5	d, e	BNC	yes	R	1350
	H-P	5223L	0	0.3	±2/wk	5 (a)	100	1 (80)	10μs-10	0.2-5	d, e	BNC	yes	C, R	1275
	Wang	2026	0	0.3	±0.1%	4 (a)	100	1 (50)	0.1-10	0.2-5	ina	bp	yes	C	750
	Wang	5510	0	0.3	±2 (h)	5 (a)	100	1 (50)	10μs-10	0.2-5	d	BNC	yes	R	995
	Atec	5A15	2	0.35	60 Hz line	5 (a)	100	1 (50)	0.1-10	0.2-5	d, e, f	BNC	yes	C, R	915
	Atec	A525	2	0.35	±2/wk	5 (a)	100	1 (50)	10μs-10	0.2-5	d, f	BNC	yes	C, R	1095
	Atec	B535	2	0.35	±2/wk	5 (a)	100	1 (50)	10μs-100	0.2-5	d, e, f	BNC	yes	C, R	1275(r)
	Atec	A545	2	0.35	±2/wk	5 (a)	100	1 (50)	0.01-10	0.2-5	d, e, f	BNC	yes	C, R	1425
	Atec	C535	2	0.35	±2/wk	5 (a)	100	1 (50)	10μs-100	0.2-5	d, e, f	BNC	yes	C, R	1195
	Atec	5A35	0	0.35	±2/wk	5 (b)	100	0.1 (50)	0.01-10	0.2-5	d, e, f	BNC	yes	C	975
F 5	GR	1150-B	10	0.4	0.001%(i)	5 (c)	1	1 (100)	0.1-10	0.16-10.2	avail.	bp	yes	C, R	995
	GR	1151-A	0	0.4	0.5	5 (c)	100	0.1	0.1-10	0.16-10.25	avail.	bp	yes	C, R	1195
	GR	1150-BH	10	1	±1/wk	5 (c)	1000	1 (80)	0.1-10	0.16-10.2	avail.	bp	yes	C, R	1095
	Hickok	DMS-3200/DP-150	0.1	1	±0.005%	3	10	1 (24)	1μs-10	0.1-10	e	ina	yes	C	515
	TSI	361 & 361R	0.1	1	±3/10^7/wk	6 (a)	10	1 (40)	1μs-10	0.2-10	f	BNC	yes	C, R	995
	H-P	523C	10	1.2	2/wk	6 (a)	100	1 (50)	0.001-10	0.1-10	e, f	BNC	no	C, R	1950
	H-P	523D	10	1.2	2/wk	6 (b)	100	1 (50)	0.001-10	0.1-10	e, f	BNC	no	C, R	1700
	H-P	5232A	2	1.2	±2/10^7/mo	6 (b)	100	1 (50)	0.1-10	0.2-5	d, e	BNC	yes	C, R	1250
	H-P	5532A	2	1.2	±2/10^7/mo	6 (a)	100	1 (50)	0.1-10	0.2-5	d, e	BNC	yes	C, R	1350
	H-P	521G	1	1.2	±0.1	5 (b)	200	1 (50)	0.1-1	0.1-15	d, e, f	BNC	no	C, R	750
F 6	Atec	6B45	2	2	±2/wk	6 (a)	100	1 (50)	0.01-10	0.2-5	d, e, f	BNC	yes	C	1025
	Atec	6C46	2	2	±0.2/mo	6 (a)	100	1 (50)	0.01-10	0.2-5	d, e, f	BNC	yes	C, R	1125
	NLS	2807	2	2	5/10^7/mo	5 (c)	100	1 (60)	0.1-10	0.2-6	f	amp-henol	yes	C, R	1050
	NLS	2808	2	2	5/10^7/mo	5 (c)	100	1 (60)	0.1-10	0.2-6	dec, f	amp-henol	yes	C, R	1090
	NLS	2809	2	2	5/10^7/mo	6 (c)	100	1 (60)	0.1-10	0.2-6	f	amp-henol	yes	C, R	1200
	Beckman	6023	1	2	0.3	6	100	1 (70)	1μs-1	0.1	(c)	BNC	yes	C, R	945
	Wang	2029	0	2	1/10^3	7 (a)	1000	0.001 (50)	ina	ina	ina	BNC	yes	R	1400
	H-P	5233L	0	2	2/10^7/mo	6 (a)	100	1 (80)	10μs-10	0.2-5	d, e	BNC	yes	C, R	1600
	Beckman	6010A	0	2	0.3	5	100	0.02 (50)	(u)	(u)	g	BNC	yes	C, R	995
	Atec	6A75	0	2	±2/wk	5 (a)	100	1 (50)	10μs-10	0.2-5	d, e, f	BNC	yes	C, R	1275(r)

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Frequency Counters *(continued)*

	Manufacturer	Model	FREQUENCY Min. Hz	Max. MHz	Stability ppm	Digits No.	INPUT Sens. mV	Imp. MΩ(pF)	Gate Time s	DISPLAY Interval s	Type	Conn. Type	Solid State	Type C-Cab. R-Rack P-Port.	Price Approx $
F 7	Atec	6C86	0	2	±0.2/mo	6 (a)	100	1 (50)	1μs-10	0.2-5	d, e, f	BNC	yes	C, R	1595(r)
	CMC	600	2	2.5	60 Hz line	4 (b)	100	1	0.1, 1, 10	0.2-5	e, f	BNC	yes	C, R	865
	CMC	601	2	2.5	60 Hz line	4 (c)	100	1	0.1, 1, 10	0.2-5	e, f	BNC	yes	C, R	965
	CMC	602	2	2.5	2/wk	5 (b)	100	1	10μs-10	0.2-5	e, f	BNC	yes	C, R	1050
	CMC	603	2	2.5	2/wk	5 (c)	100	1	10μs-10	0.2-5	e, f	BNC	yes	C, R	1175
	CMC	604	0	2.5	2/wk	5 (b)	100	1	10μs-10	0.2-5	e, f	BNC	yes	C, R	1300
	CMC	605	0	2.5	2/wk	5 (c)	100	1	10μs-10	0.2-5	e, f	BNC	yes	C, R	1425
	IERC	3030/930	0	2.5	1/10^6/day	7 (a)	0.15V	1 (25)	1-10	0.2-5	ina	ina	yes	C, R	ina
	TSI	364 & 364-R	10	5	±3/10^7/wk	6 (a)	100	1 (40)	1μs-10	0.2-10	e, f	BNC	yes	C, R	1490
	Systron	6013	2	5	60 Hz line	4	100	10 (15)	1μs	0.1-10	c, f	BNC	yes(t)	C, R	1000
F 8	CMC	607A	0	5	±2/10^7/mo	6	100	1 (80)	ina	0.2-5	d, e	BNC	yes	C, R	1575
	Systron	1033	0	5	±3/10^7/wk	6 (a)	50	1 (j)	1μs	ina	ina	BNC	yes	C, R	1295
	Monsanto	1010	0	5	ina	6 (a)	100	1 (70)	1μs-100	0.2-5	d, e	ina	ina	C, R	1575
	Systron	6034	10	10	3/10^7/wk	6	100	10 (15)	100ns-10	0.1-10	e, f	BNC	yes(t)	C, R	1650
	TSI	373 & 373R	0.1	10		7 (a)	85	1 (40)	1μs-10	0.2-10	e, f	BNC	yes(t)	C, R	1495
	Systron	6014	0	10	3/10^7/wk	6	100	10 (15)	100ns-10	0.1-10	e, f	BNC	yes(t)	C, R	1450
	GR	1153-A	0	10	0.1/wk	5 (a)	100	0.1 (50)	0.001-10	0.16-10.4	avail.	b, p	yes	C, R	1495
	NE-Engr	40-60	0	10	3/10^7/wk	6 (a)	100	1 (40)	1μs-10	0.1-10	e, f	BNC	yes	C, R	1525
	Eldorado	1000/10	0	10	1/day	5 (a)	250	1 (40) (j)	1μs-10	0.1-10	d, e	BNC	yes	R	1190
	Eldorado	1000A	0	10	60 Hz line	5 (a)	250	ina	ina	1	d, e	BNC	yes	R	595
F 9	Eldorado	1000B	0	10	1	5 (a)	250	ina	ina	0.1-10	u, d, e	BNC	yes	R	795
	Aerometrics	7154	0	10	±0.02/wk	4	ina	0.2 (100)	ina	ina	e, f	ina	no	P, R	1250
	Aerometrics	7155	0	10	±0.02/wk	5	ina	0.2 (100)	ina	ina	e, f	ina	no	P, R	1400
	Aerometrics	7156	0	10	±0.02/wk	6	ina	0.2 (100)	ina	ina	e, f	ina	no	P, R	1550
	Aerometrics	7157	0	10	±0.02/wk	7	ina	0.2 (100)	ina	ina	e, f	ina	no	P, R	1700
	Aerometrics	7158	0	10	±0.02/wk	8	ina	0.2 (100)	ina	ina	e, f	ina	no	P, R	1925
	Wang	7716	0	10	r	7	250	0.001 (50)	r	r	d, e	BNC	yes	R	2000
	NE-Engr	14-20C	10	10.1	5/10^8/wk	8 (c)	500	1 (40)	0.001-100	0.1-10	e, f	BNC	no	C, R	1300
	NE-Engr	14-20CV	10	10.1	5/10^8/wk	8 (b)	500	1 (40)	0.001-100	0.1-10	e, f	BNC	no	C, R	1100
	Systron	1034	0	11	±3/10^7/wk	7 (a)	10	1 (50)	100μs-10	0.1-15	d, e, f	BNC	yes	C, R	2150
F 10	H-P	5216A	3	12.4	±2/10^6/mo	7 (a)	30	1 (50)	10, 0.1, 1	ina	d, e	BNC	no	C, R	
	H-P	5221A	1	12.4	ina	4 (a)	0.1V	1 (30)	1, 0.1	50μs-5	ina	ina	no	C, R	ina
	Monsanto	1000	0	20	ina	7 (a)	100	1 (20)	0.1μs-10	0.5-10	d, e	ina	ina	C, R	1975
	TSI	500A-LM/510A	0	20	±2/10^8/wk	7 (a)	100	0.01, 0.1, 1	100μs-10	0.2-10	e, f	BNC	yes	C, R	2395(r)
	TSI	500A-LM/511A	0	20	±2/10^8/wk	7 (a)	100	0.01, 0.1, 1	100μs-10	0.2-10	e, f	BNC	yes	C, R	2285
	TSI	500A-L/510A	0	20	±2/10^8/wk	8 (a)	100	0.01, 0.1, 1	100μs-10	0.2-10	e, f	BNC	yes	C, R	2650(r)
	TSI	500A-L/511A	0	20	±2/10^8/wk	8 (a)	100	0.01, 0.1, 1	100μs-10	0.2-10	e, f	BNC	yes	C, R	2540
	Systron	1038-4	10	25	±1/10^7	none	200	0.1 (50)	0.001-10	remote	d	ina	yes	R	ina
	Beckman	6120	10	25	0.3	6	150	0.02 (40)	10μs-1	0.1	n	BNC	yes	C, R	1750
	Systron	1038	5	25	±3/10^7/wk	8 (a)	200	1 (20)	1μs-10	0.1-15	d, e, f	BNC	yes	C, R	3450
F 11	CMC	800A/801A/831A	0.1	25	±3/10^9/day	8 (a)	100	1 (30)	1μs-100	0.1-10	d, e, f	BNC	no	C, R	2735(s)
	CMC	800A/801A/832A	0.1	25	±3/10^9/day	8 (a)	100	1 (30)	1μs-100	0.1-10	d, e, f	BNC	no	C, R	2875(s)
	CMC	800A/801A/833A	0.1	25	±3/10^9/day	8 (a)	100	1 (30)	1μs-100	0.1-10	d, e, f	BNC	no	C, R	2990(r)
	Atec	7898	0	25	±0.2/mo	8 (a)	100	1 (25)	1μs-10	0.2-5	d, e, f	BNC	yes	C, R	2010(r)
	Beckman	6126	0	25	0.003	8	100	0.02 (40)	1μs-10	0.1	n	BNC	yes	C, R	2495
	NE-Engr	40-70	10	50	3/10^7/wk	7 (a)	100	50/10K	0.1-10	0.1-10	f	BNC	yes	R	1575
	Beckman	6121	10	50	0.3	6	100	0.02 (40)	10μs-1	0.1	n	BNC	yes	C, R	1950
	Marconi	TF2401/TF7557/TF7558	1	50	±2/10^9(h)	8 (c)	100	0.5 (25)	1μs-100	ina	avail.	BNC	yes	C	ina
	CMC	800A/802A/831A	0.1	50	±3/10^9/day	8 (a)	100	1 (25)	1μs-100	0.2-10	d, e, f	BNC	no	C	3060(s)
	CMC	800A/802A/832A	0.1	50	±3/10^9/day	8 (a)	100	1 (25)	1μs-100	0.2-10	d, e, f	BNC	no	C	3185(s)

(tables continued on page T102)

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Frequency Counters *(continued)*

	Manufacturer	Model	FREQUENCY Min. Hz	FREQUENCY Max. MHz	Stability ppm	Digits No.	INPUT Sens. mV	INPUT Imp. MΩ (pF)	Gate Time s	DISPLAY Interval s	DISPLAY Type	Conn. Type	Solid State	Type C-Cab. R-Rack P-Port.	Price Approx $
F 12	CMC	800A/802A/833A	0.1	50	$3/10^{9}$/day	8 (a)	100	1 (25)	1μs-100	0.2-10	d, e, f	BNC	no	C	3300(r)
	Beckman	6127	0	50	0.003	8	100	0.02 (40)	4μs-1	0.1	n	BNC	yes	C, R	2895
	Beckman	6145	0	50	0.003	8	100	0.02 (40)	1μs-10	0.1	n	BNC	yes	C, R	2935
	CMC	727D	0	50	$\pm 5/10^{8}$/3 hrs	7 (a)	100	1 (50)	1μs-10	ina	d, e, f	BNC	yes	C, R	2190
	Atec	7B48	0	50	±0.2/mo	8 (a)	100	1 (50)	0.01-10	0.2-5	d, e, f	BNC	yes	C, R	1785
	H-P	5244L	0	50	$\pm 2/10^{7}$/mo	7 (a)	100	0.1 (40)	1μs-10	0.1-5	d, e	BNC	yes	C, R	1900
	H-P	5245L	0	50	$3/10^{9}$/day	8 (a)	100	1 (25)	1μs-10	0.1-15	d, e, f	BNC	yes	C, R	2950
	H-P	5246L	0	50	$\pm 2/10^{7}$/mo	6 (a)	100	1 (25)	1μs-1	ina	ina	BNC	yes	C, R	1800
	Systron	1037	0	50	$\pm 3/10^{7}$/wk	8 (a)	100	0.01, 0.1, 1	100μs-1	0.1-15	e, f	BNC	yes	C, R	2250
	NE-Engr	40-90A	0	50	$3/10^{7}$/wk	8 (a)	100	0.01 (40)	1μs-10	0.1-10	e, f	BNC	yes	R	2325
F 13	Beckman	6122	25	100	0.3	6	100	0.02 (40)	10μs-1	0.1	n	BNC	yes	C, R	1750
	CMC	738A	10	100	$\pm 5/10^{8}$/3 hrs	7 (a)	100	1-10	1-10	ina	d	BNC	yes	C, R	1925
	CMC	880	0	100	$1/10^{9}$	8	100	1	1μs-10	0.1-5	d, e, f	BNC	yes	C	ina
	Atec	8A18	0	100	±0.2/mo	8 (a)	100	50Ω (30)	1 fixed	0.2-5	e, f	BNC	yes	C, R	1920
	GR	114-A	0	100	0.1/wk	5 (c)	100	0.1	0.01-10	0.16/10.24	avail.	bp	yes	C, R	1995
	Systron	6018	0	100	$3/10^{7}$/wk	7	100	10 (15)	100μs-1	0.1-5	e, f	BNC	yes(t)	C, R	2950
	Systron	6038	0	100	$1/10^{9}$/24 hrs	9	100	10 (15)	100μs-1	0.1-5	e, f	BNC	yes(t)	C, R	3350
	TSI	1535	0	100	ina	7 (a)	100	50Ω	ina	ina	d	BNC	yes	R	2300
	TSI	600/690	0	100	$2/10^{9}$/24 hrs	8 (a)	100	50Ω	ina	0.2-6	d, e	ina	yes	R	2890
	Monsanto	1020	0	100	ina	7 (a)	100	1 (22)	0.1μs-10	0.2-5	d, e	ina	ina	C, R	2550
F 14	Monsanto	1021	0	100	ina	8 (a)	100	1 (22)	0.1μs-10	0.2-5	d, e	ina	ina	C, R	2950
	TSI	500A/513A	1	100	$\pm 2/10^{8}$/wk	8 (a)	5	50Ω	100μs-10	0.2-10	e, f	BNC	yes	C, R	2770
	CMC	800A/803A/831A	10	110	$3/10^{9}$/day	8 (a)	100	0.1(15)j	1μs-100	0.2-10	d, e, f	BNC	no	C	3735(s)
	CMC	800A/803A/832A	10	110	$3/10^{9}$/day	8 (a)	100	0.1(15)j	1μs-100	0.2-10	d, e, f	BNC	no	C	3860(s)
	CMC	800A/803A/833A	10	110	$3/10^{9}$/day	8 (a)	100	0.1(15)j	1μs-100	0.2-10	d, e, f	BNC	no	C	3975(r)
	TSI	385-R/83	0	125	$\pm 3/10^{7}$/wk	7 (a)	100	50Ω	100μs-10	0.2-10	e, f	ina	yes	R	1880
	TSI	385-R/85	0	125	ina	7 (a)	10	50Ω	100μs-10	0.2-10	e, f	ina	yes	R	2080
	TSI	500A/510A	0	125	$\pm 2/10^{8}$/wk	8 (a)	100	50Ω	100μs-10	0.2-10	e, f	BNC	yes	C, R	2900(r)
	TSI	500A/511A	0	125	$\pm 2/10^{8}$/wk	8 (a)	100	50Ω	100μs-10	0.2-10	e, f	BNC	yes	C, R	2790
	TSI	500A/512A	1 MHz	125	$\pm 2/10^{8}$/wk	8 (a)	100	50Ω	100μs-10	0.2-10	e, f	BNC	yes	C, R	2665
F 15	Systron	1038-12	0	150	$3/10^{9}$	8 (a)	100	0.1 (50)	0.1μs-10	0.1	e, f	BNC	yes	C, R	ina
	Motorola	S-10758	10	475	$\pm 2/10^{9}$/day	7 (c)	100	0.1 (50)	0.1, 1, 10	0.1-5	ina	BNC	yes	C	2595
	TSI	500A/520A	10 MHz	500	$\pm 2/10^{8}$/wk	8 (a)	100	50Ω	100μs-10	0.2-10	e, f	BNC	yes	C, R	3120
	Systron	6313	300	3000	$3/10^{9}$/24 hrs	7	100	50Ω	0.001-10	ina	e, f	BNC	yes(t)	C, R	4450
	Eldorado	945	20	4000	$5/10^{8}$/24 hrs	7 (a)	50	50Ω	0.1	0.3-10	d, f	N	yes	R	3950
	Eldorado	946	20	4000	$5/10^{9}$/24 hrs	9 (a)	50	50Ω	0.001-10	0.3-10	ina	N	yes	R	5020
	Eldorado	950	20	6000	$5/10^{8}$/24 hrs	7 (a)	50	50Ω	0.1	0.3-10	d, f	N	yes	R	5925
	Eldorado	951	20	6000	$5/10^{9}$/24 hrs	9 (a)	50	50Ω	0.001-10	0.3-10	d, f	N	yes	R	7250
	Systron	6314	2.96 GHz	8200	$3/10^{9}$/24 hrs	7	100	50Ω	0.001-10	ina	e, f	BNC	yes (t)	C, R	4450
	Systron	6315	8.2 GHz	12400	$3/10^{9}$/24 hrs	7	100	50Ω	0.001-10	ina	e, f	BNC	yes (t)	C, R	4450

Frequency Counter and Extender Notes

a. Nixie readout.
b. Vertical neon decades.
c. In-line readout.
d. Binary-coded output for recorder.
e. Time-base pulse output.
f. External frequency output.
g. Glow-transfer-tube readout.
h. Short-term accuracy.
j. Per volt.
k. Nixie readout available.
m. Maintains accuracy of counter.
n. Electroluminescent.
r. Has time interval.
s. Family has different trigger levels.
t. Integrated circuits.
u. Manual or remote programming.

Frequency Counter Extenders

	Manufacturer	Model	Counter Used With Model	FREQUENCY Min. Hz	FREQUENCY Max. MHz	Accuracy	INPUT Sensitivity mV	INPUT Impedance Ω	Type C-Cab. R-Rack P-Port.	Price Approx $
	NE-Engr	40-82	40-70, 40-90A	10	50	ina	k	(1M, 15pF)	P-I	350
	NE-Engr	1421C	14-20C, 14-20CV	ina	100	ina	ina	ina	P-I	325
	NE-Engr	40-97	40-70, 40-90A	50	100	ina	100	50	P-I	595
	H-P	5251A	5245L, 5246L	20	100	(m)	50	50	P-I	300
F 16	H-P	525A	524C, 524D	10.1	100	(m)	10	50	P-I	350
	TSI	1532	1511A	10	100	(m)	100	ina	R	1950
	TSI	1532A	1511A	10	100	(m)	100	ina	R	2150
	Systran	1979	1033, 1034, 1017, 1037	0.1	100	(m)	100	50	P-I	350
	NE Engr	14-40	14-20C, 14-20CV	dc	100	ina	ina	ina	P-I	425
	TSI	83	385R	0	125	(m)	100	50	P-I	440
	H-P	5258A	5245L, 5246L	1	200	(m)	k	50	P-I	825
	NE-Engr	40-84	40-70, 40-90A	dc	200	ina	ina	50	P-I	475
	NE-Engr	14-22C	14-20C, 14-20CV	100	220	ina	ina	ina	P-I	375
	H-P	525B	524C, 524D	100	220	(m)	200	50	P-I	425
F 17	NE-Engr	40-98	40-70, 40-90A	10	300	ina	100	50	P-I	675
	H-P	5252A	5245L, 5246L	dc	350	(m)	100	50	P-I	685
	CMC	735C	738A	100	500	ina	ina	ina	P-I	500
	TSI	520B	500 Series	100	500	(m)	100	50	P-I	500
	TSI	520A	500 Series	10	500	(m)	100	50	P-I	500
	GR	1133A	1153-A	0.1	500	ina	10	50	C	1525
	H-P	525A	524C, 524D	100	510	(m)	100	50	P-I	475
	H-P	5253B	5245L, 5246L	50	512	(m)	50	50	P-I	500
	Systran	1291	1034H, 1017, 1018, 1037, 1038	50	512	(m)	50	50	P-I	550
	NE-Engr	14-26E	14-20C, 14-20CV	100	600	ina	ina	ina	P-I	470
F 18	NE-Engr	40-95	40-70, 40-90A	50	600	ina	100	50	P-I	500
	NE-Engr	14-26C	14-20C, 14-20CV	200	1000	±1 count	100	50	P-I	525
	NE-Engr	40-85	40-70, 40-90A	200	1000	ina	100	50	P-I	550
	TSI	522	500 Series (P)	200	2500	(m)	100	50	P-I	230
	Systran	1253	1017, 1018, 1037, 1038	300	3000	(m)	100	50	P-I	975
	NE-Engr	40-96	40-70, 40-90A	300	3000	ina	50	50	P-I	825
	H-P	5254B	5254L, 5246L	200	3012	(m)	50	50	P-I	825
	Systran	1254	1017, 1018, 1037, 1038	2960	8200	(m)	100	50	P-I	1950
	Systron	1255	1017, 1018, 1037, 1038	8200	12400	(m)	100	50	P-I	1975
	Eldorado	680	950 & 951	6000	12400	(m)	50	50	R	1525
F 19	H-P	5255A	5245L	3000	12400	(m)	100	50	P-I	1650
	Systron	1292	1037	15	15000	(m)	100	50	P-I	1500
	Systron	1293	1038-12	150	18000	(m)	300	50	R	ina
	Eldorado	681	950 & 951	12000	18400	(m)	50	50	R	1525
	Systron	1297	1017, 1018, 1037, 1038	50	26000	(m)	100	50	P-I	1550

Frequency Counters Late Arrival

Manufacturer	Model	FREQUENCY Minimum Hz	FREQUENCY Maximum MHz	Stability ppm	Digits No.	INPUT Sens. mV	INPUT Imp. MΩ (pF)	Gate Time s	Display Interval s	Display Type	Conn. Type	Solid State	Type C-Cab. R-Rack P-Port.	Price Approx. $
Computer Logic	816	dc	3	ina	6	500	0.5(50)	0.01ms-10	0.1Hz-100kHz	ina	ina	†	C	1095
Computer Logic	815	dc	3	ina	5	500	0.5(50)	0.01ms-10	0.1Hz-100kHz	ina	ina	†	C	1030
Computer Logic	814	dc	3	ina	4	500	0.5(50)	0.01ms-10	0.1Hz-100kHz	ina	ina	†	C	975
Computer Logic	806	dc	3	ina	6	500	0.5(50)	0.01-1ms	1, 10, 100kHz	ina	ina	†	C	1055
Computer Logic	805	dc	3	ina	5	500	0.5(50)	0.01-1ms	1, 10, 100kHz	ina	ina	†	C	995
Computer Logic	804	dc	3	ina	4	500	0.5(50)	0.01-1ms	1, 10, 100kHz	ina	ina	†	C	935
Computer Logic	716	dc	3	ina	6	500	0.5(50)	0.01-10	0.1-10Hz	ina	C	†	C	1015
Computer Logic	715	dc	3	ina	5	500	0.5(50)	0.1-10	0.1-10Hz	ina	ina	†	C	955
Computer Logic	714	dc	3	ina	4	500	0.5(50)	0.1-10	0.1-10Hz	ina	ina	†	C	895
Computer Logic	706	dc	3	ina	6	100	1(50)	0.1	10Hz	ina	ina	†	C	975
Computer Logic	705	dc	3	ina	5	100	1(50)	0.1	10Hz	ina	ina	†	C	915
Computer Logic	704	dc	3	ina	4	100	1(50)	0.1	10Hz	ina	ina	†	C	855
EAI	6200/6202	0	10	±0.005%	4	100	1(30)	ina	1μs-1000	ina	BNC	yes	C	550
Amark	TSA6634	10	5	$\pm 5/10^6$	4g	75	250k	0.5-5	ina	avail	BNC	yes	C	ina
Amark	TSA6634A	10	7.5	$\pm 1/10^6$	4	75	250k(40)	1μs-10	ina	avail	BNC	yes	C	ina
Amark	TSA6636	10	12.5	$\pm 1/10^6$	6g	75	250k(40)	1μs-10	ina	avail	BNC	yes	C	ina

Frequency Counter Cross Index

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
Aerometrics	Aerometrics, Aerojet-General Corp. PO Box 216 San Ramon, Calif. 94583	7154 7155 7156 7157 7158	F9 F9 F9 F9 F9	441
Anadex	Anadex Instruments Inc. 7833 Haskell Ave. Van Nuys, Calif. 91406	CF-500R CF-500-4R CF-500-6R CF-501R CF-501-4R CF-501-6R CF-503R CF-503-4R CF-503-6R	F2 F2 F2 F2 F2 F2 F2 F2 F3	442
Atec	Atec Inc Box 19426 1125 Lumpkin Road Houston, Tex. 77024	5A15 5A35 6A75 6B45 6C46 6C86 7B48 7B98 8A18 A525 A545 B535 C535	F4 F4 F6 F6 F6 F7 F12 F11 F13 F4 F4 F4 F4	443
Avtron	Avtron Mfg. Inc. 10409 Meech Ave. Cleveland, Ohio, 44105	T420 T569 T572 T734	F1 F1 F1 F1	444
Beckman	Beckman Instruments Inc. Berkeley Div. 2200 Wright Ave. Richmond, Calif. 94804	6010A 6023 6120 6121 6122 6126 6127 6145 6225 6230	F6 F6 F10 F11 F13 F11 F12 F12 F2 F2	445
Chad-Hel	Chadwick-Helmuth Co. 111 E Railroad Ave. Monrovia, Calif. 91016	423	F3	446
CMC	Computer Measurements Co Div. Pacific Industries Inc 12970 Bradley Ave. San Fernando, Calif. 91342	600 601 602 603 604 605 607A 727D 738A 738C 800A/801A/831A 800A/801A/832A 800A/801A/833A 800A/802A/831A 800A/802A/832A 800A/802A/833A 800A/803A/831A 800A/803A/832A 800A/803A/833A 880	F7 F7 F7 F7 F7 F7 F8 F12 F13 F17 F11 F11 F11 F11 F11 F12 F14 F14 F14 F13	447
Eldorado	Eldorado Electronics 601 Chadomar Road Concord, Calif. 94520	680 681 945 946 950 951 1000/10 1000A 1000B	F19 F19 F15 F15 F15 F15 F8 F8 F9	448
GR	General Radio Co. 22 Baker Ave. West Concord, Mass. 01781	1133-A 1144-A 1150-B 1150-BH 1151-A 1153-A	F17 F13 F5 F5 F5 F8	449

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
H-P	Hewlett-Packard Co. 1501 Page Mill Road Palo Alto, Calif.	521A 521C 521D 521E 521G 522B 523C 523D 525A 525B 525C 5211A 5211B 5212A 5214L 5216A 5221A 5223L 5232A 5233L 5244L 5245L 5246L 5251A 5252A 5253B 5254B 5255A 5258A 5512A 5532A	F1 F1 F1 F1 F5 F1 F5 F5 F16 F17 F18 F3 F3 F3 F3 F10 F10 F4 F5 F6 F12 F12 F12 F16 F17 F18 F19 F19 F17 F3 F5	Contact Local Rep.
Hickok	Hickok Electrical Inst. Co. 10555 Dupont Ave. Cleveland, Ohio 44108	DMS-3200/DP-150	F5	450
Ierc	IERC 135 W Magnolia Blvd. Burbank, Calif.	3030/930	F7	451
Magtrol	Magtrol, Inc. 240 Seneca St. Buffalo, N. J. 14204	4602	F1	452
Marconi	Marconi Instruments Div. English Electric Corp. 111 Cedar Lane Englewood, N. J. 07631	TF2401/TF7557/T57558	F11	453
Monsanto	Monsanto Co. 620 Passiac Ave. West Caldwell, N. J. 07006	1000 1010 1020 1021	F10 F8 F13 F14	454
Motorola	Motorola Communications & Electronics Inc. Precision Frequency Products 4501 Augusta Blvd. Chicago, Ill. 60651	S-1075B	F15	455
NLS	Non-Linear Systems Inc. Delmar Airport Box 728 Del-Mar, Calif. 92014	2807 2808 2809	F6 F6 F6	456
Ne-Engr	Northeastern Engineering Div. of LaPointe Industries Inc. 130 Silver Street Manchester, N. H.	14-20C 14-20CV 14-21C 14-22C 14-26C 14-26E 14-40 40-60 40-70 40-82 40-84 40-85 40-90A 40-95 40-96 40-97 40-98	F9 F9 F16 F17 F18 F18 F16 F8 F11 F16 F17 F19 F12 F19 F19 F16 F17	457
Systron	Systron-Donner Corp. 888 Galindo St. Concord, Calif. 94520	1011 1013 1033 1034 1037	F3 F3 F8 F9 F12	458

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
		1038	F10	
		1038-4	F10	
		1038-12	F15	
		1253	F18	
		1254	F19	
		1255	F19	
		1291	F18	
		1292	F19	
		1293	F19	
		1297	F19	
		1979	F16	
		6013	F7	
		6014	F8	
		6018	F13	
		6034	F8	
		6038	F13	
		6313	F15	
		6314	F15	
		6315	F15	
TSI	Transistor Specialities Terminal Drive Plainview, N.Y.	83	F16	459
		361	F5	
		361R	F5	
		364	F7	
		364R	F7	
		373	F8	
		373R	F8	
		385-R/83	F14	
		385-R/85	F14	
		500A-L/510A	F10	
		500A-L/511A	F10	
		500A-LM/510A	F10	
		500A-LM/511A	F10	
		500A/510A	F14	
		500A/511A	F14	
		500A/513A	F14	
		500A/520A	F15	
		520A	F17	
		520B	F17	
		522	F18	
		600/690	F13	
		1532	F16	
		1532A	F16	
		1535	F13	
Wang	Wang Labs Inc. 836 North St. Tewksbury, Mass.	2019	F3	460
		2026	F4	
		2029	F6	
		2240	F4	
		5510	F4	
		7716	F9	

CODE	COMPANY	MODEL NO.	TABLE LOCA-TION	READER SERVICE NO.
Computer Logic	Computer Logic Corp. 1528 20th Street Santa Monica, Calif.	704 705 706 714 715 716 804 805 806 814 815 816	Late Arrival	483
Amark	Amark 31 Commercial Street Plainview, New York	TSA6634 TSA6634A TSA6636	Late Arrival	485
EAI	Electronic Associates Inc. 185 Monmouth Parkway West Long Branch, N. J.	6200/6202	Late Arrival	484

Field Strength Meters

	Manufacturer	Model	Frequency Minimum MHz	Frequency Maximum MHz	Field Strength Minimum µV	Field Strength Maximum V	IF MHz	Band-Width MHz	Image Ratio dB	Internal Calibration	Accuracy dB	Meter Calibration	Input Impedance Ω	Output Types	Mounting	Misc. Features	Price Approx. $
H1	Stoddart	NM-40A(URM-41)	30Hz	0.015	3m	200m	0.258	8-60 Hz	75	fork osc.	±1	µV, dB	50, 600, 1k, 10k, 100k	h	C, R	-	3585
	Empire	T-X/NF-105/BA-105	0.1/4	0.150	1	0.1	0.225	0.001	60	impulse gen.	±1	µV, dB	50	audio l	C	-	3630
	Stoddart	NM-12T	0.01	0.168	0.5m	100m	0.455	100Hz, 2kHz	100	impulse	±2	µV, dB	50	p	C, R	a c	3250
	Empire	NF-315	20Hz	0.025	0.005	10	0.1	7-800 Hz	80	400Hz BFO	±1%+5 Hz	µV, dB	50, 600 100k	h	C	e	3500
	FA/EL-M	EMC-10	20Hz	0.5	0.003	10	0.1	5, 50 250Hz	80	sine osc.	±0.5	µV, dB	50, 600, 10k, 100k	g	C	e	3950
	Vitro	135	0.540	1.6	10m	10m	0.455	0.007	80	osc.	3%	log	ina	audio l	C	c d e	950
	R-S	HFN BN15001	0.1	30	1m	1m	0.00165 0.46,62	100,500 Hz	75	osc.	±1.5	dB	60	osc recdr	C	d	8600
	Empire	T-A/NF-105/BA-105	0.15	30	1	0.1	0.455, 1.6	0.01	60	impulse gen.	±2	µV, db	50	audio l	C	d	3480
	Stoddart	NM-22A(URM-131)	0.15	32	1.2m	60m	1.6	0.003 0.01	60	impulse gen.	±1.5	µV. db	50	p	C, R	-	3250
	Stoddart	NM-25T	0.15	32	3.5m	60m	0.455	0.005	50	impulse gen.	±2	µV, dB	50	p	C, R	a c	3500
H2	Sadelco	FS-2	54	108	10	1	30	0.5	50	-	±1.75	µV, db	75	audio	P	e	295
	Jerrold	720	54 174	108 220	10	1	41.8	0.1	40	-	±1.75	µV, dB	75	phone	P	e	295
	Empire	T-1/NF-105/BA-105	20	200	1	0.1	10.7	0.1	ina	sine, impulse	ina	µV, dB	50	audio l	C	d	2960
	Jerrold	720	174 54	220 108	10	1	41.8	0.1	40	-	±1.75	µV, dB	75	phone	P	e	295
	Jerrold	704B	54	220	5	3	25	0.6	90	puts	±2	µV, dB %mod	75	audio video	C	-	395
	Jerrold	727 UH727	5 470	220 890	10	3	ina	0.1	45	yes	±1.5	µV, dB	75	video recdr	P	e	595 112
	R-S	HUZ BN15012/2	47	225	1	0.1	10.7	0.1	ina	osc	±6	log	60, 240	audio	C	d e	995
	Vitro	107-A	54	250	1.6m	16m	21.4	0.3	80	sig. gen.	1-2	log	51	audio l	C, R	d e	3750
	Empire	T-2/NF-105/BA-105	200	400	1	0.1	30	0.200	40	sine, impulse	±1.5	µv, dB	50	audio l	C	d	3140
	Stoddart	NM-30A(URM-47)	20	400	0.3m	60m	15	0.14-0.17	40	impulse gen.	±1.5	µv, dB	50	p	C, R	-	3250
H3	R-S	HUZE BN15015/2	470	850	30m	0.1m	150, 21.4	0.25	60	sine, gen.	±6	dB	60	audio recdr. l	C	e	2695
	R-S	HFU BN15002	25	900	1.5µVm	1m	21.4	0.125, 0.06	60	track osc.	±1.5	yes	60	h	C	-	13,755
	Empire	T-3/NF-105/BA-105	400	1000	1	0.1	42	0.300	ina	impulse gen.	ina	µV, dB	50	audio recdr. l	C	d	3580
	Stoddart	NM-52A(URM-17)	375	1000	10m	60m	60	0.540 ±3%	70	impulse gen.	±1.5	µV, dB	50	p	C, R	-	3250
	FA/EL-M	EMC-25	0.014	1000	0.01	1	0.175, 1.6, 8.7	50Hz-50kHz	60	impulse gen.	±2	µV, dB	50	g	C	e	14,000
	Teltrncs	LR-101	50	1500	0.1	ina	30	30Hz, 0.3, 3.8	ina	ina	0°-10⁵°k	ues	50	h	C	-	3900
	Teltrncs	LR-101/.05-1.5	50	1500	0.1	1	30b	10	ina	res. term.	±0.5	dB	50	h	C, R	o	3900
	Teltrncs	LR-101/1-2	1000	2000	0.1	1	30b	10	ina	res. term.	±0.5	db	50	h	C, R	o	5113
	Empire	T-1/NF-112/BA-112	1000	2000	10	1	348, 60, 42	1, 5	60	noise gen.	±1	µV, dB	50	h	C	d	6180
	Teltrncs	210-A	1	2000	0.1	1	0b	0.2	ina	diode	±0.5	dB	50	h	C, R	c d	2395

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Field strength meter index starts on page T108.
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Field Strength Meters *(continued)*

	Manufacturer	Model	Frequency Minimum MHz	Frequency Maximum MHz	Field Strength Minimum µV	Field Strength Maximum V	IF MHz	Band-Width MHz	Image Ratio dB	Internal Calibration	Accuracy dB	Meter Calibration	Input Impedance Ω	Output Types	Mounting	Misc. Features	Price Approx. $
H4	Polarad	CFI-L	1000	2040	-90dBm	ina	260, 140, 40	1,5,8	60	sig. gen.	±1%	µV, dB	50	h	C	d	7570
	Polarad	**FIM-L2**	1000	2240	20	3	260, 140, 40	5	60	ina	±1	µV, dB	50	h	C	d	6973
	R-S	HFA BN15003	900	2700	50µV m	0.5m	250, 25	2	30	ina	±3	dB	50	osc. recdr.	C	d	11,695
	Teltrncs	LR-101/2-4	2000	4000	0.1	1	30b	10	ina	res. term.	±0.5	dB	50	h	C, R	o	5113
	Teltrncs	LR-101A	1000	4000	0.1	ina	30	30Hz, 0.3, 3.8	ina	ina	$0°-10^{5}$°k	yes	50	h	C	-	4250
	Empire	T-2/NF-112/ BA-112	200	4000	10	1	348, 60,42	1,5	60	noise gen.	±1	µV, dB	50	h	C	-	6180
	Polarad	FIM-S2	2140	4340	20	3	260, 140, 40	5	60	ina	±1	µV, dB	50	h	C	d	6973
	Polarad	CFI-S	1900	4340	-90dBm	ina	260, 140, 40	1,5	60	sig. gen.	±1%	µV, dB	50	h	C	d	7570
	Empire	T-3/NF-112/ BA-112	4000	7000	10	1	348, 60,42	1,5	60	noise gen.	±1	µV, dB	50	h	C	-	6450
	Polarad	CFI-M	4.2GHz	7740	-860dBm	ina	260, 140, 40	1,5	60	sig. gen.	±1%	µV, dB	50	h	C	d	7570
H5	Polarad	FIM-M2	4200	7740	20	3	260, 140, 40	5	60	ina	±1	µV, dB	50	h	C	d	6973
	Teltrncs	LR-101/4-8	4000	8000	0.1	1	30b	10	ina	res. term.	±0.5	dB	50	h	C, R	o	8893
	Teltrncs	LR-101/2-8	2000	8000	0.1	1	30b	10	ina	res. term.	±0.5	dB	50	h	C, R	o	10,253
	Polarad	FIM-X2	7360	10,000	20	3	260, 140, 40	5	60	ina	±1	µV, dB	50	h	C	d	6973
	Polarad	CFI-X	7300	10,000	-85dBm	ina	260, 140, 40	1,5	60	ina	±1	µV, dB	50	h	C	d	6973
	Empire	T-4/NF-112/ BA-112	7000	10,000	10	1	348, 60,42	1,5	60	noise gen.	±1	µV, dB	50	h	C	-	6460
	Polarad	FIM-KS	9850	15,350	20	3	260, 140, 40	5	60	ina	±1	µV, dB	50	h	C	-	8673
	Polarad	CFI-KS	9850	15,350	-80dBm	ina	260, 140, 40	1,5	60	sig. gen.	±1%	µV, dB	50	h	C	-	8920
	Polarad	CFI-KU	15,000	21,000	-77dBm	ina	260, 140, 40	1,5	60	sig. gen.	±1%	µV, dB	50	h	C	-	9620
	Polarad	FIM-KU	14,800	21,000	20	3	260, 140, 40	5	60	ina	±1	µV, dB	50	h	C	-	8848

Field Strength Meter Notes

a. Rechargeable internal batteries; AC or battery operated.
b. Other IF's available.
c. Solid-state.
d. External tunable antenna included.
e. Battery operated.
g. Outputs: carrier, peak, quasi-peak, 60 db scan, FM deviation, slide back, audio, IF, AM and FM, video.
h. Outputs: audio, video, recorder.
j. Field-strength varies with bandwidth. At narrow band, it is 101 to 85 dbm. At broad band, it is 4 to 26µv/MHz.
k. Fixed.
l. Output: audio, recorder.
m. Per meter.
o. Switched radiometer or direct.
p. Outputs: audio, video, recorder, IF, "X".

Field Strength Meter Cross Index

CODE	COMPANY	MODEL NO.	TABLE LOCATION	READER SERVICE NO.
EMPIRE	Empire Devices Singer Co., Metrics Division 915 Pembroke Street Bridgeport, Connecticut 06608	NF-315 T-1/NF-105/BA-105 T-1/NF-112/BA-112 T-2/NF-105/BA-105 T-2/NF-112/BA-112 T-3/NF-105/BA-105 T-3/NF-112/BA-112 T-4/NF-112/BA-112 T-A/NF-105/BA-105 T-X/NF-105/BA-105	H 1 H 2 H 3 H 2 H 4 H 3 H 4 H 5 H 1 H 1	461
FA/EL-M	Fairchild/Electro Metrics Corp. 88 Church Street Amsterdam, New York	EMC-10 EMC-25	H 1 H 3	462
JERROLD	Jerrold Electronics Corp. Industrial Products Division 15th & Lehigh Philadelphia, Pennsylvania 19132	704B 720 727 UH 727	H 2 H 2 H 2 H 2	463
POLARAD	Polarad Electronic Instr. Division 34-02 Queens Boulevard Long Island City, New York 11101	CFI-KS CFI-KU CFI-L CFI-M CFI-S CFI-X FIM-KS FIM-KU FIM-L2 FIM-M2 FIM-S2 FIM-X2	H 5 H 5 H 4 H 4 H 4 H 5 H 5 H 5 H 4 H 5 H 4 H 5	464
R-S	Rohde & Schwarz Sales Co. 111 Lexington Avenue Passaic, New Jersey 07056	HFA BN15003 HFN BN15001 HFU BN15002 HUZ BN15012/2 HUZE BN15015/2	H 4 H 1 H 3 H 2 H 3	465
SADELCO	Sadelco Inc. 601 West 26th Street New York, New York	FS-2	H 2	466
STODDART	Stoddart Electro Systems Division Tamar Electronics Inds. Inc. 2045 West Rosecrans Avenue Gardena, California	NM-12T NM-22A(URM-131) NM-25T NM-30A(URM-47) NM-40A(URM-41) NM-52A(URM-17)	H 1 H 1 H 1 H 2 H 1 H 3	467
TELTRNCS	Teltronics Inc. 23-27 Main Street Nashau, New Hampshire 03060	210-A LR-101 LR-101/.05-1.5 LR-101/1-2 LR-101/2-4 LR-101/2-8 LR-101/4-8 LR-101A	H 3 H 3 H 3 H 3 H 4 H 5 H 5 H 4	468
VITRO	Vitro Electronics Division Vitro Corporation of America 919 Jesup-Blair Drive Silver Springs, Maryland	107-A 135	H 2 H 1	469

Coaxial Slotted Lines

	Manufacturer	Model	Frequency Minimum GHz	Frequency Maximum GHz	Residual VSWR	Characteristic Impedance Ω	Probe Travel cm	Price Approx. $
L1	R-S	LMM BN3916/50	0.08	0.3	1.03	50	193	1680
	R-S	LMM BN3916/75	0.08	0.3	1.03	75	193	1680
	Phe-Dodge	6-1/8" slotted line	0.3	0.9	1.010	75	450	ina
	Phe-Dodge	3-1/8" slotted line	0.3	1.35	1.010	50	450	ina
	Aircom	150-7/8-25	1	2	1.03	50	30d	965f
	Aircom	150-15/8-25	1	2	1.03	50	30d	965f
	Aircom	150-15/8-50	0.5	2	1.03	50	50d	1075g
	Aircom	150-1.5-50	0.5	2	1.01	50	50	1400
	Aircom	150-7/8-50	0.5	2	1.03	50	50d	1075g
	Phe-Dodge	1-5/8" slotted line	0.3	3	1.010	50	450	ina
L2	R-S	LMD BN3926/50	0.3	3	1.02	50	50	1280
	R-S	LMD BN3926/75	0.3	3	1.02	75	50	1280
	Alford	1026C-2	0.3	3	1.01	50	20 in.	1450
	Alford	1198A-2	0.3	3	1.01	75	20 in.	1700
	Alford	1026C-4	0.15	3	1.01	50	40 in.	1550
	Alford	1198A-4	0.15	3	1.01	75	40 in.	1800
	Alford	1026C-6	0.1	3	1.01	50	60 in.	1925
	Alford	1198A-6	0.1	3	1.01	75	60 in.	2175
	Alford	1026C-8	0.075	3	1.010	50	80 in.	2550
	Alford	1198A-8	0.075	3	1.010	75	80 in.	2800
L3	Alford	1026C-13	0.05	3	1.010	50	125 in.	3985
	Alford	1198A-13	0.05	3	1.010	75	125 in.	4235
	Alford	1026C-16	0.0375	3	1.010	50	160 in.	4785
	Alford	1198A-16	0.0375	3	1.010	75	160 in.	5035
	Radar	D4086	1.5	4	1.04	50	ina	ina
	Radar	D4087	1.5	4	1.06	50	ina	ina
	PRD	215A	1	4	ina	49.4	5 in.	575
	H-P	805C	0.5	4	1.04	50	36.8	550
	Alford	1300A-2	0.3	4	1.010	75	20 in.	1150
	Alford	1300A-3	0.2	4	1.010	75	30 in.	1275
L4	Alford	1300A-4	0.15	4	1.01	75	40 in.	1375
	Alford	1300A-6	0.1	4	1.01	75	60 in.	1590
	Alford	2181A-2	0.3	4.5	1.01	50	20 in.	915
	Alford	2181A-3	0.2	4.5	1.01	50	30 in.	1030
	Alford	2181A-4	0.15	4.5	1.01	50	40 in.	1140
	Alford	2181A-6	0.1	4.5	1.01	50	60 in.	1380
	Alford	3116A-1	0.6	6	1.01	50	10 in.	1060
	Alford	3116A-1.6	0.35	6	1.01	50	16 in.	1385
	R-S	LMC BN3931/50	1.65	6.35	1.007	50	a	2472
	Narda	6235	0.395	8.5	1.005	50	37.5	800
L5	GR	874-LBB	0.3	8.5	1.10	50	50	395
	GR	900-LB	0.3	9	1.001	50	50	675
	PRD	N231/230	4	10	ina	49.4	3.5 in.	438
	PRD	N233/232	2.5	10	ina	50	4 in.	370
	Radar	D1107	1.5	10	1.06	50	10	ina
	Radar	D2319	1.5	10	1.06	50	ina	590
	Alford	2288A-1	0.6	11	1.01	50	10 in.	750
	Omega	5350/520	3	12	1.10	50	10	275
	Radar	D2216	1.5	12	1.03	50	ina	660e
	Radar	D2554	1.5	12	1.08	50	ina	952e
L6	Radar	D4046	1.5	12	1.08	50	ina	ina e
	FXR/MLAB	N101B	2.6	12.4	1.01	50	ina	450
	Narda	231TNC	1.5	12.4	1.06	50	10	575e
	Narda	231N	1.5	12.4	1.04	50	10	440e
	Narda	4231	1.5	12.4	1.06	50	10	650e
	Alford	[illegible]20	2.5	17.5	1.025	50	4-1/4 in.	1050
	Omni-Spec	[illegible]010	2	18	1.10	ina	10	960
	H-P	816A/809C	1.8	18	1.04	50	10	450
	R-S	4561	1.2	18	1.030	50	ina	995
	Alford	2852-05	1.2	18	1.025	50	5.25 in.	1140
L7	Alford	2920-05	1.2	18	1.020	50	5.25 in.	1050

Reader-service numbers are given in the index.
Slotted lines index starts on page T114.
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Waveguide Slotted Lines

	Manufacturer	Model	Minimum GHz	Maximum GHz	Irregularity SWR	Slope SWR	Residual VSWR Maximum	Probe Travel cm	Waveguide Size inches	Flange Type	Price Approx. S
L8	Omega	1515	0.750	1.12	1.005	ina	1.01	71	9.750x4.850	CPR975F	2800
	Omega	1516	0.960	1.45	1.005	ina	1.01	54	7.700x3.850	CPR770F	1900
	Omega	510	1.12	1.7	1.005	ina	1.01	32	6.66x3.41	417	1700
	Aircom	150L/151L	1.12	1.7	ina	1.01	1.02	19-7/8 in.	6.66x3.41	417	1275
	FXR/MLAB	L101B	1.12	1.7	1.005	1.01	ina	ina	6.66x3.41	417	1100
	Narda	226C	1.12	1.7	1.01	ina	1.01	25	6.66x3.41	417	950
	Aircom	150LS/151LS	1.7	2.6	ina	ina	1.02	11-7/8 in.	4.46x2.31	435	1050
	Omega	511	1.7	2.6	1.005	ina	1.01	30	4.46x2.31	435	1500
	FXR/MLAB	R101B	1.7	2.6	1.005	1.01	ina	ina	4.46x2.31	435A	1600
	Omega	2074	2.3	2.7	1.005	ina	1.01	30	3.698x1.849	CPR369F	1800
L9	FXR/MLAB	S101A	2.6	3.95	1.005	1.01	ina	ina	3x1.5	53	445
	Aircom	150S/152	2.6	3.95	ina	1.01	1.01	ina	3x1.5	53	500
	Omega	512	2.6	3.95	1.005	ina	1.01	25	3x1.5	53	950
	Narda	224	2.6	3.95	1.01	ina	1.01	19.25	3x1.5	53	445
	Omega	523/520	3.3	4.9	1.005	ina	1.01	10	2.418x1.273	CHR229	255
	PRD	W233/232	3.3	4.9	ina	ina	1.005	6	2.418x1.273	WR229	425
	PRD	G233/232	3.95	5.85	ina	ina	1.005	6	2x1	149A	300
	Omega	524/520	3.95	5.85	1.005	ina	1.01	10	2x1	149A	250
	Aircom	150C/152	3.95	5.85	ina	1.01	1.01	ina	2x1	149A	395
	Omega	525/520	4.9	7.05	1.005	ina	1.01	10	1.718x0.923	CMR159	255
L10	Omega	526/520	5.85	8.2	1.005	ina	1.01	10	1.5x0.75	344	245
	FXR/MLAB	C115A/Z116A	5.85	8.2	1.005	1.01	ina	4-3/4 in.	1.5x0.75	344	105
	Aircom	150XC/152	5.85	8.2	ina	1.01	1.01	ina	1.5x0.75	344	385
	H-P	J810B/809C	5.3	8.2	1.01	ina	1.01	10	1.5x0.75	441	325
	Narda	222	5.3	8.2	1.01	ina	1.01	9.4	1.5x0.75	344	335
	PRD	C233/232	5.3	8.2	ina	ina	1.005	6	1.5x0.75	344	285
	FXR/MLAB	W101A	7.05	10	1.005	1.01	ina	ina	1.25x0.625	51	240
	H-P	H810B/809C	7.05	10	1.01	ina	1.01	10	1.25x0.625	138	310
	PRD	H233/232	7.05	10	ina	ina	1.005	6	1.25x0.625	51	285
	Aircom	150BL/152	7.05	10	ina	1.01	1.01	ina	1.250x0.625	51	375
L11	Omega	527/520	7.05	10	1.005	ina	1.01	10	1.25x0.625	51	240
	FXR/MLAB	W115A/2116A	7.05	10	1.005	1.01	ina	4-3/4 in.	1.25x0.625	51	105h
	H-P	X810B/809C	8.2	12.4	1.01	ina	1.01	10	1x0.5	135	290
	Somerset	X102	8.2	12.4	1.01	ina	1.01	fixed	1x0.5	39	65
	Somerset	X103	8.2	12.4	1.01	ina	1.01	1 in.	1x0.5	39	115
	PRD	X231/230	8.2	12.4	ina	ina	1.01	6	1x0.5	39	265
	PRD	X233/232	8.2	12.4	ina	ina	1.005	6	1x0.5	39	265
	Aircom	150X/152	8.2	12.4	ina	1.01	1.01	ina	1x0.5	39	362
	FXR/MLAB	X115A/2116A	8.2	12.4	1.005	1.01	ina	4-3/4 in.	1x0.5	39	105
	FXR/MLAB	X101A	8.2	12.4	1.005	ina	ina	ina	1x0.5	39	230
L12	Narda	220	8.2	12.4	1.01	ina	1.01	8.9	1x0.5	39	250
	Omega	528/520	8.2	12.4	1.005	ina	1.01	10	1x0.5	39	240
	Omega	3525/520	10	15	1.005	ina	1.01	10	0.850x0.475	ina	250
	PRD	U231/230	12.4	18	ina	ina	1.01	6	0.702x0.391	419	285
	H-P	P810B/809C	12.4	18	1.01	ina	1.01	10	0.702x0.391	419	310
	Omega	529/520	12.4	18	1.005	ina	1.01	10	0.702x0.391	419	250
	Narda	219	12.4	18	1.01	ina	1.01	8.9	0.702x0.391	419	350
	Omega	3526/520	15	22	1.005	ina	1.01	10	0.590x0.335	WR51	250
	H-P	K815B/814B	18	26.5	ina	ina	1.01	1/2 wave	0.500x0.250	595	625
	PRD	K231/230	18	26.5	ina	ina	1.01	6	0.500x0.250	425	435

(tables continued on page T112)

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Waveguide Slotted Lines *(continued)*

	Manufacturer	Model	Minimum GHz	Maximum GHz	Irregularity SWR	Slope SWR	Residual VSWR Maximum	Probe Travel cm	Waveguide Size inches	Flange Type	Price Approx. $
L13	PRD	A231/230	26.5	40	ina	ina	1.01	ina	0.360x0.220	381	435
	H-P	R815B/814B	26.5	40	ina	ina	1.01	1/2 wave	0.360x0.220	559	675
	TRG	A740	26.5	40	1.03	ina	ina	ina	0.280x0.140b	381	990
	FXR/MLAB	Q103A	33	50	1.03	ina	ina	ina	0.304x0.192	383	650
	TRG	B740	33	50	1.03	ina	ina	ina	0.244x0.112b	383	990
	TRG	V740	50	75	1.03	ina	ina	ina	0.148x0.074b	385	990
	FXR/MLAB	M103A	50	75	1.03	ina	ina	ina	0.228x0.154	ina	750
	FXR/MLAB	E103A	60	90	1.03	ina	ina	ina	0.202x0.141	387	1350
	TRG	E740	60	90	1.03	ina	ina	ina	0.122x0.061b	387	1050
	TRG	W740	75	110	1.03	ina	ina	ina	0.100x0.050b	387	1700
L14	FXR/MLAB	F105A	90	140	ina	ina	ina	2-1/16 in.	0.080x0.040	special	950
	TRG	F741	90	140	1.03	ina	ina	ina	0.080x0.040b	714	ina
	TRG	D741	110	170	1.03	ina	ina	ina	0.065x0.0325	716	1900
	FXR/MLAB	G105A	140	220	ina	ina	ina	2-1/16 in.	0.051x0.025	special	975
	TRG	G741	140	220	1.03	ina	ina	ina	0.051x0.0255	715	2100

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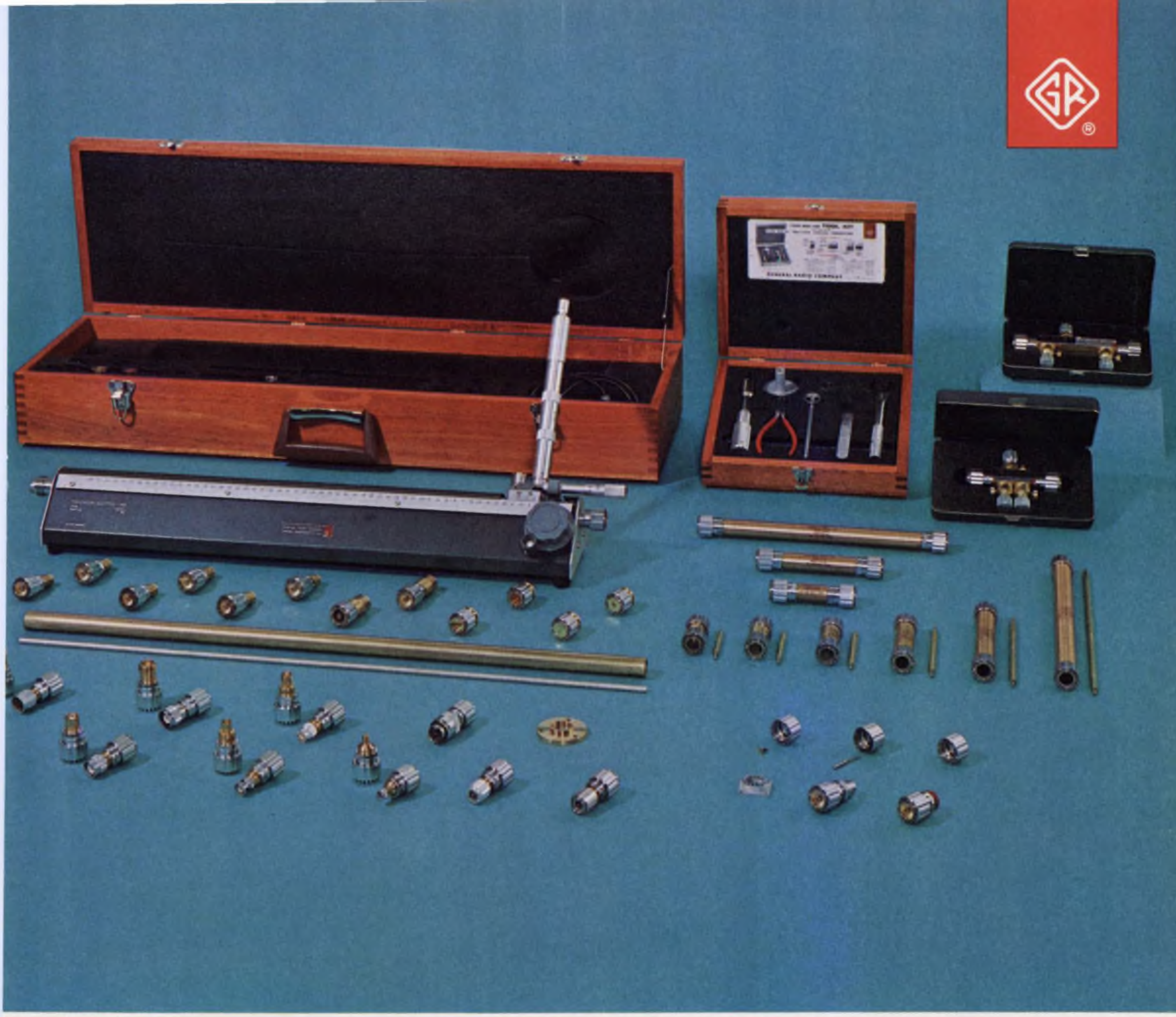
Coaxial Slotted Lines Late Arrival

Manufacturer	Model	Frequency Minimum (GHz)	Frequency Maximum (GHz)	Residual VSWR	Characteristic Impedance (Ω)	Probe Travel (cm)	Price Approx. ($)
Narda	5235	1.5	17	1.003+	50Ω±0.15Ω	15	request

Coaxial and Waveguide Slotted Line Notes

a. Piston with inductive loop.
b. Inner dimension.
d. Family has varying slotted-line lengths.
e. Family has different connectors.
f. Twenty-two-inch length.
g. Twenty-eight-inch length.
h. Comes in separate units.



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GENERAL RADIO

Slotted Line Cross Index

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AIRCOM	Aircom Inc. 48 Cummington Street Boston, Mass. 02115	150-1.5-50	L1	470
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		150-7/8-50	L1	
		150-15/8-25	L1	
		150-15/8-50	L1	
		150BL/152	L10	
		150C/152	L9	
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		150S/152	L9	
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ALFORD	Alford Mfg. Co. 120 Cross Street Winchester, Mass. 01890	1026C-2	L2	471
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		1198A-13	L3	
		1198A-16	L3	
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R-S	Rohde & Schwarz Sales Co. 111 Lexington Avenue Passaic, New Jersey 07056	4561	L6	480
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SOMER-SET	Somerset Radiation Lab Inc. Box 201 Edison, Pennsylvania 18919	X102	L11	481
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Speed up binary-to-decimal conversion

by using a simple design approach that minimizes the number of logic blocks you'll need.

Engineers use the decimal number system for their calculations. Digital devices prefer binary numbers. This dichotomy creates a nced for binary-to-decimal conversion. The dcsigner has a choice of methods to accomplish this. A quick comparison reveals which basic method is best suited to higher-speed operations with large numbers. He can:

- Use a logic matrix to convert all possible binary input states into their equivalent decimal states.
- Store the binary number in a clocked binary counter which is counted down to zero while simultaneously counting the clock pulses in a binary-coded decimal (BCD) counter.
- Shift the binary number, most significant bit (MSB) first, into a shift register divided into decades such that the number in each decade can have only the value 0 through 9.

The first method is economical when the number to be converted is small, say, binary *1111* (decimal 15). The second technique can be used with larger numbers but is relatively slow. A 24-bit number, for example, would require up to $2^{24} - 1$ clock pulses for conversion. At a 1-MHz clock rate, this would take almost two seconds.

The third method is limited only by the speed of the logic elements used in the decade shift registers. It is this approach that is to be considered here. The particular design to be presented uses a minimization technique that eliminates between-the-register elements and so reduces the number of parts needed and increases the speed of conversion.

Two decade registers are possible

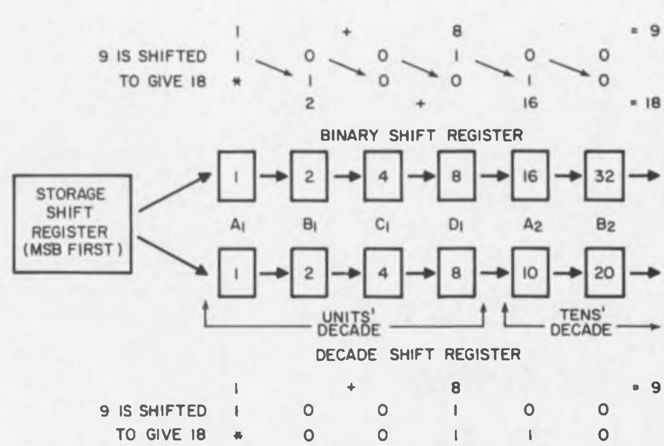
To see how the conversion works, consider a binary shift register and a shift register divided into decades (Fig. 1). If a binary number is shifted, most significant bit first, into the binary register, each shift in effect multiplies the previous contents by two and adds the next bit of the binary word being shifted in from the storage register:

$$X_i = 2X_{i-1} + B_i,$$

where X_i is the new number and B_i is the bit added in. For example, say that three bits of the binary number *10111* have been shifted into either register. Now *111* will be stored in each—equivalent to decimal 7. Another shift takes place, putting *0111* into each—decimal 14. In this case, $B = 0$, so the value was simply doubled.

In the decade shift register a problem arises at the fifth shift, where the decimal number should go from 8 to 10 while the binary shift register goes from 8 to 16, so that a 6 must be added into the first decade of the decade counter. If, for example, the old contents of the binary shift register are 9 (binary *1001*), as in Fig. 1, then a shift would double this to 18 (binary **1001*, where the asterisk represents the bit added in). In a decade shift register the 9 (binary *1001*) would also be doubled to 18, but this appears as an 8 in the first (units') decade and a 1 in the second (tens') decade (binary **001 1000*).

Thus to use a binary shift register as a decade shift register, each group of four binary elements must be reset whenever their count goes above 9 instead of above 15 as in a straight binary register.



1. **The binary number is shifted,** most significant bit first, into a decade shift register. In a binary register (upper) the old number is multiplied by two and a new bit added on each shift. In a decade shift register (lower) the number in any decade is limited to 9. Groups of four flip-flops are used for each decade.

Howard J. Gannes, Development Engineer, General Electric Co., Binghamton, N. Y.

ter. Effectively a 6 must be added in whenever the count is about to go over 9, that is, when the old number is 5 or more, so that a value of 10 or more is the result after shifting. This can be accomplished either by adding 3 before shifting for numbers of 5 or over, so that the 3 becomes 6 after shifting, or by using logic to generate the carry into the next decade and to leave the correct number in the previous decade.

Karnaugh maps simplify design

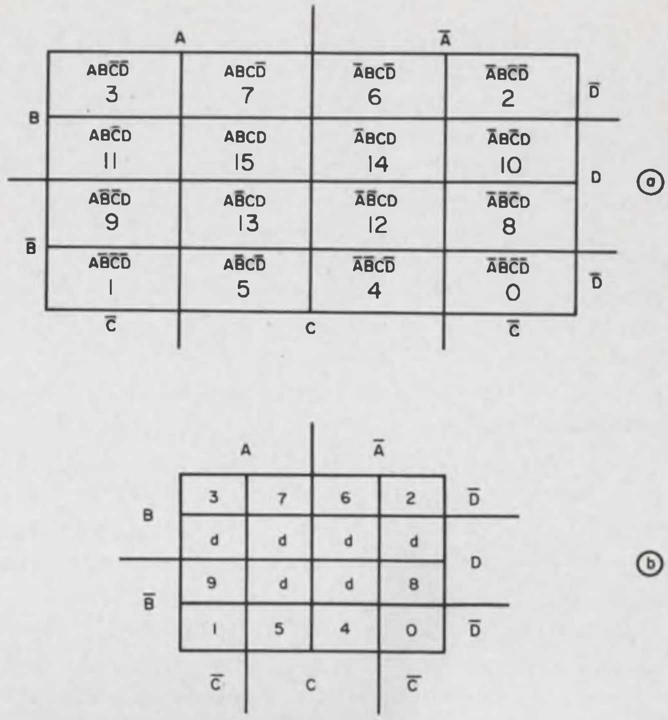
The latter process can be nicely represented in a truth table. The table shows the state of the units' decade before and after shifting for any possible old number. If the old number is 5 or more, a carry digit must be generated and logic used to guarantee that the correct number is left after the shift. If the old number were 6 (binary *0110*), for example, a shift would result in a multiplication by two—yielding 12 (*0011*)—before the next bit is added in. In BCD code, however, 12 is *0100* with a carry to the next decade, so a BCD converter must contain *0100* after the shift and pass a carry on to the next decade (see colored portion of the truth table). The logic equations needed to implement this design may be determined by using Karnaugh maps and minimizing the results.

Consider a four-stage binary shift register. This can yield 16 possible code combinations, which may be represented in a Karnaugh map (Fig. 2a). Since only ten of these, 0 through 9, are of interest, the rest may be indicated as "don't care" states (Fig. 2b). To find the Boolean equations for the converter, a Karnaugh map is drawn for each of the flip-flops *B*, *C* and *D*. Since the state of flip-flop *A* is always determined by the data shifted in, no logic will be performed on the inputs of flip-flop *A* and no Karnaugh map will be needed.

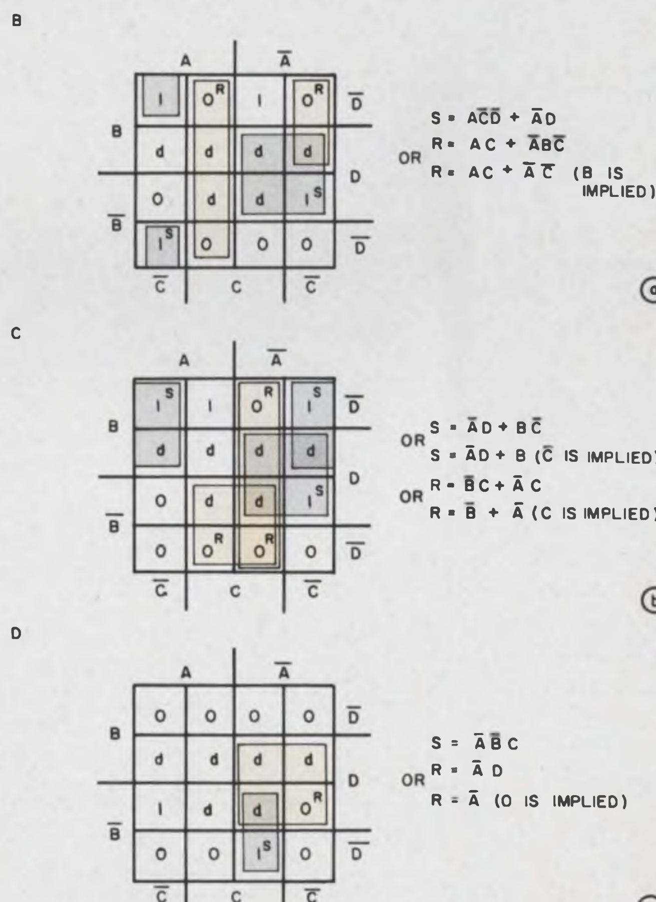
Truth table: storage element states.

BEFORE SHIFT					AFTER SHIFT				
DECIMAL VALUE	A	B	C	D	A'	B'	C'	D'	CARRY
	2^0	2^1	2^2	2^3	2^0	2^1	2^2	2^3	
0	0	0	0	0	*	0	0	0	0
1	1	0	0	0	*	1	0	0	0
2	0	1	0	0	*	0	1	0	0
3	1	1	0	0	*	1	1	0	0
4	0	0	1	0	*	0	0	1	0
5	1	0	1	0	*	0	0	0	1
6	0	1	1	0	*	1	0	0	1
7	1	1	1	0	*	0	1	0	1
8	0	0	0	1	*	1	1	0	1
9	1	0	0	1	*	0	0	1	1

* DEPENDS ON THE BIT SHIFTED IN



2. **The basic Karnaugh map** (a) has 16 possible states for a four-stage binary shift register. Each decade of the decade shift register is also made up of four flip-flops but is limited to only 10 possible states (b).



3. **The Boolean equations** for each flip-flop are found by enclosing the states that change on the next shift. The simplified equations hold if internally crossconnected J-K flip-flops are used.

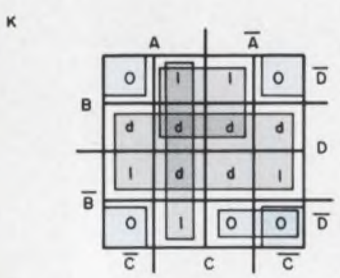
Take B as an example (Fig. 3a). A *1* or a *0* is placed in each square corresponding to the next state of B. The next state of B can be found for any decimal from 0 to 9 from the truth table. Thus if the old number is 6 (the colored strip in the truth table), the new state after shifting will be *1*. A *1* is therefore entered in the top left-hand corner of Fig. 3a. In the case of the number zero in the truth table, the new state would be *0* so a *0* would be entered in the lower right-hand corner. The same procedure is followed for all the states 0 through 9. Then *d*'s can be placed in the "don't care" positions.

The letters B and $\overline{B}$ outside the map of Fig. 3a represent the old states of B before the shift, that is, $B = 1$ and $\overline{B} = 0$. Now, if a *1* occurs in a B row, no change will take place in B with the shift, but if a *0* is located in a B row, a change does occur and an R (reset) is marked in the appropriate box. A *0* in a $\overline{B}$ row means no change of state for those numbers; a *1* indicates a change and is marked with an S (set).

The logic equations are now written by forming squares and rectangles inside the map to enclose the states that remain constant within the enclosure. Thus the two equations for B are:

$$\text{Set: } S = A\,\overline{C}\,\overline{D} + \overline{A}\,D,$$
$$\text{Reset: } R = A\,C + \overline{A}\,B\,\overline{C}.$$

The equations for C and D are also given in Fig. 3. In the case of the Karnaugh map for K (carry) in Fig. 4, all the terms must be included, since implementation of K will be by direct logic, not by a flip-flop.



$K = D + AC + BC$

$\overline{K} = \overline{C}\,\overline{D} + \overline{A}\,\overline{B}\,\overline{D}$

4. **All possible states are enclosed** on this Karnaugh map since the carry digit (K) is generated by gates and not by a flip-flop.

J-K flip-flops simplify logic needs

The flip-flop equations may be further simplified if J-K flip-flops are used because their outputs are normally cross-coupled. The B output of the B flip-flop, for example, is connected to the reset input (K terminal), enabling the B reset equation (Fig. 3a) to be reduced to $R = A\,C + \overline{A}\,\overline{C}$, because B is implicit. The same is true for both C equations and the D reset equation. The implementation of these simplified equations appears in Fig. 5a for the first decade.

Generation of the carry may be performed in two ways. Of the two, Fig. 5b shows a method that employs some of the input gates of the next decade, and Fig. 5c shows an alternative. The former is preferable because fewer parts are used and speed is slightly increased. ■ ■

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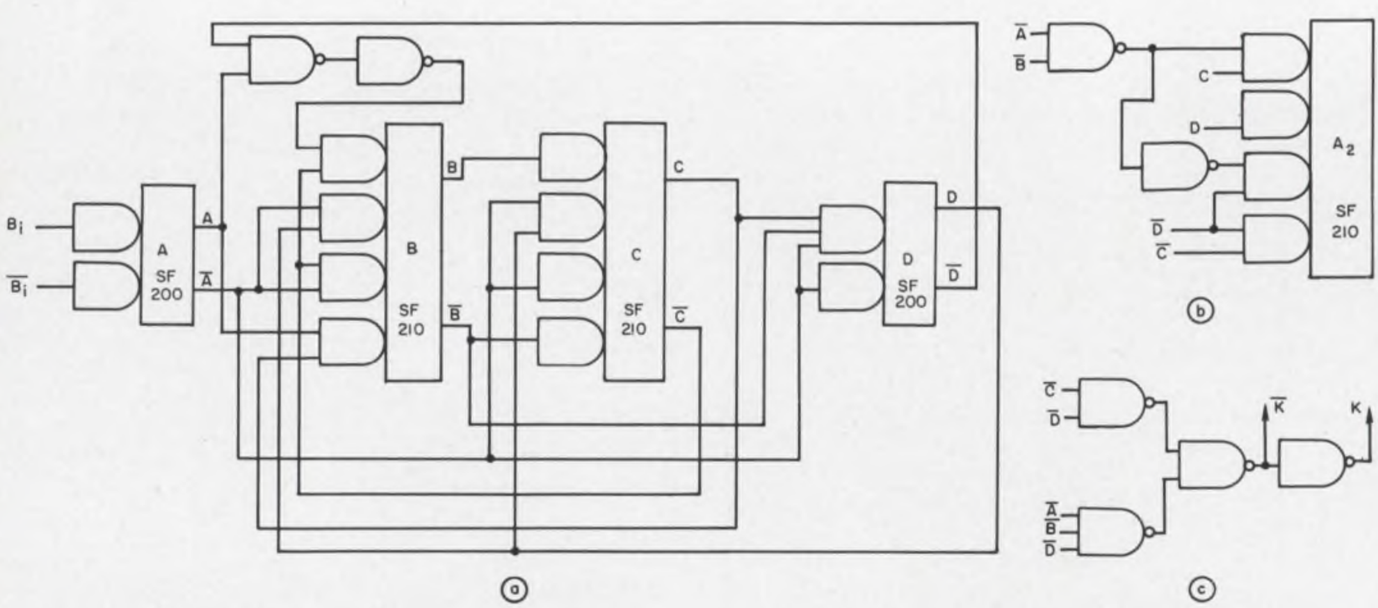

5. **Four flip-flops and one quad gate** are needed to implement one decade of the converter (a). The carry may be generated by using the two spare gates and some of the gates of the next decade (b), or by using a further pair of gates (c). The first method (b) is slightly faster than the second (c).

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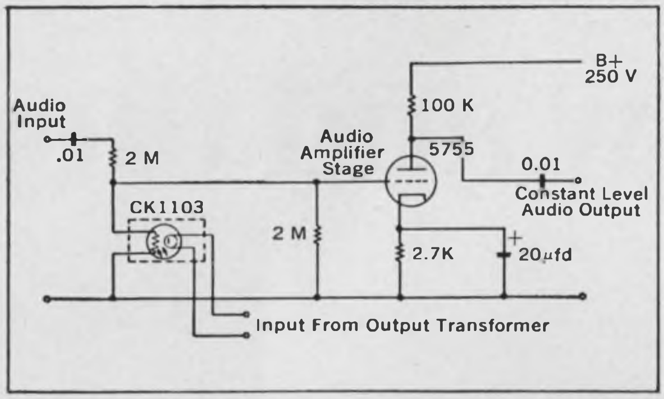
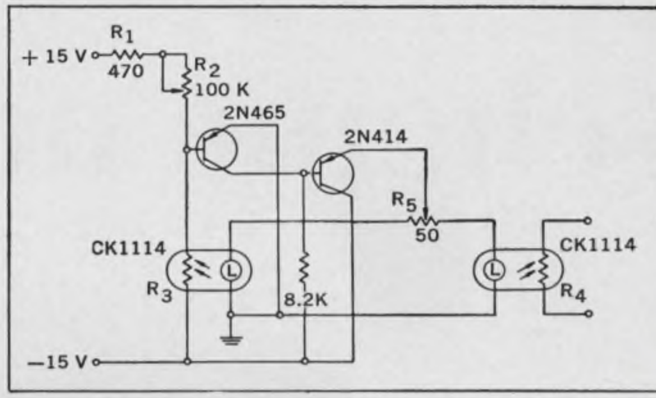
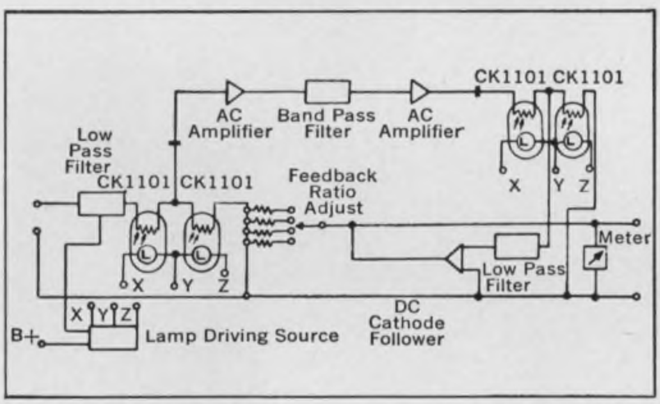


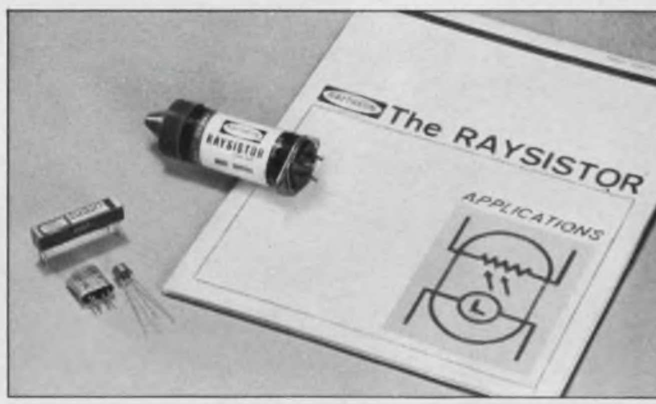
1. Use the Raysistor® as a simple remote or automatic volume control in SSB suppressed carrier receivers. Feeding part of the audio output into the control light source varies the resistance of the Raysistor's photocell, making it usable in place of a normal volume control.



2. As a remotely controlled linear potentiometer. The Raysistor can be used as a remotely controlled linear potentiometer when used in the circuit shown above. Here the Raysistor forms a voltage divider between the positive and negative voltages.



3. As a photochopper stabilized D-C microvoltmeter. Raysistors, used as photochoppers in both modulator and demodulator circuits, enable d-c levels to be measured to a fraction of a microvolt. They facilitate synchronous detection and demodulation with simple electrical coupling, have less noise than transistor choppers, while avoiding maintenance problems of mechanical choppers. Other photochopper applications: photochopper relay, series or shunt chopper, modulator circuit, and as a stabilizer to reduce long-term drift.



Many more ways you can use the Raysistor. Send for *The Raysistor Applications Manual* which describes ways you can use this unique optoelectronic component as a photochopper, variable resistor, solid-state switch, relay, voltage or signal isolator, nonlinear potentiometer, etc. For complete specifications and prices, call your Raytheon distributor or regional sales office. For a copy of this 28-page manual, circle the reader service card or write directly to *Raytheon Company, Components Division, Quincy, Massachusetts 02169.*

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ON READER-SERVICE CARD CIRCLE 32

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MM500 50 bit shift register $9.85 in 100 lots— It's very fast, uses low power, and, similar to all our other shift registers, has the lowest operating voltage around. It's organized as a dual 25 bit element. The unit uses −10 volt VDD supply voltage and 16 volt clock amplitudes. Power dissipation at 10kc is a typical 28 μw/bit. And guaranteed operation is at 1 MHz in a temperature range of 0°C to 70°C.

MM502 100 bit shift register $14.80 in 100 lots— Power dissipation for this one at 10kc is a typical 16 μw/bit. Otherwise, specs are about the same, except there are 50 more bits. This one is organized as a dual 50 bit unit.

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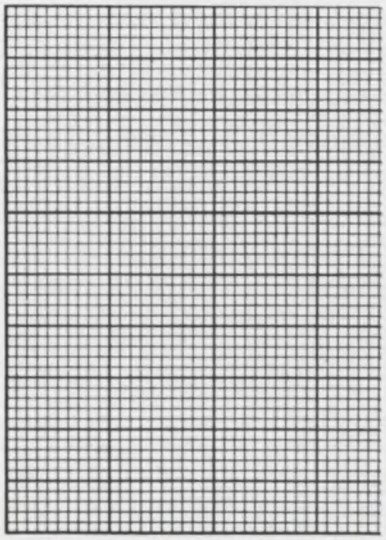
Wild scheme goes here.



ON READER-SERVICE CARD CIRCLE 33

Three ways to read distortion range from approximation to precise evaluation of all intermodulation products. Choose the method that suits your system best.

How do you read signal distortion in single-sideband (ssb) systems? Do you waste time getting very precise values for higher-order harmonics, when a quick comparison of input and output waveshapes would do? In most cases there are three options for the read-out device: an oscilloscope, a spectrum analyzer and a wave analyzer. Because they do not give equivalent results, the choice should be made carefully.

Distortion results when power amplifiers generate enough odd-order products to garble the transmitted information or interfere with adjacent channels. The ratio of these distortion products to the test-signal amplitude is measured by the two-tone test; the results are used to specify a distortion limit.

To be able to establish a yardstick of linearity, the engineer must come up with a method that can be easily reproduced during all tests, from vendor to user. The two-tone test is proved to be satisfactory, but the engineer must ensure that the same technique is used in all tests.

A typical example where the choice of read-out is important occurs in production-testing of tubes and transistors. The oscilloscope is not precise enough and the wave analyzer is too slow for high-production units. The major tube manufacturers have therefore adopted the spectrum-analyzer technique.

In some cases precise and involved laboratory procedures are needed to determine the best choice among the three alternatives. Sometimes more than one is needed; a combination of spectrum analyzer and wave analyzer is frequently used.

Two-tone test needs careful setup

Briefly the two-tone test (see Fig. 1) uses a composite signal of two equal-amplitude sine waves the frequencies of which differ by a very small percentage. For the usual communications bands this means a multitone generator that can supply signals in the megahertz range and frequency differences of only 1 to 3 kilohertz. Its special purity should be much greater than the requirements of the device under test. If the test signal's third-order products are below the amplitude of the fundamental by more than 50 dB, and the fifth-order products are below by more than 60 dB, it will satisfy most present-day requirements.

The drive level must be sufficient to ensure that the device under test can be driven to full power without degrading the test signal's quality. For electron-tube amplifiers, this means an ability to deliver a large voltage swing. For transistors, this means an ability to deliver considerable power, since the drive level may have to be only 10 dB below the output power.

Two factors to consider simultaneously

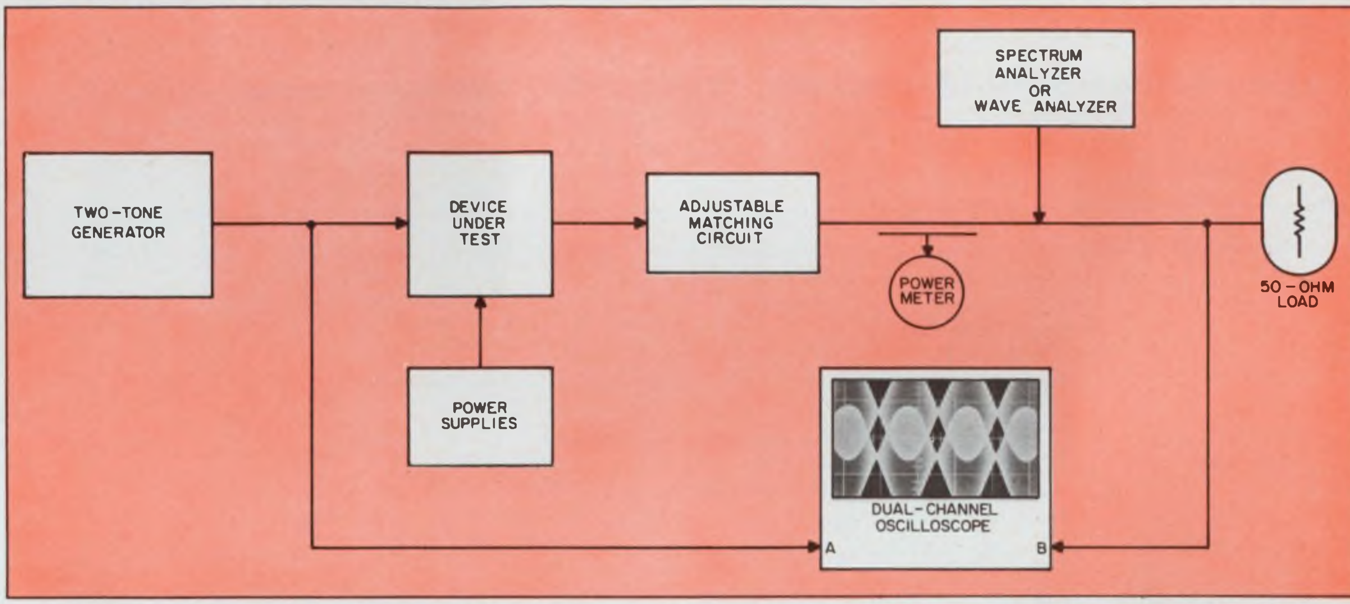
The adjustment for minimum distortion must be made at the given power level, specified by the particular application. Single-sideband distortion specifications are meaningless unless they relate to the power output.

Therefore the measurement should consider simultaneously the following two factors: the importance of higher-order harmonics and the magnitude of the output power level during the test.

Some manufacturers prefer to make a power output measurement with the circuit optimized for maximum power output, for example, disregarding the effect of distortion. Then the distortion is checked while the circuit is optimized for minimum distortion, which results in a lower power level. Therefore the resultant values do not reflect performance under actual operating conditions.

Whenever it is necessary to obtain values of intermodulation products, bear in mind that knowledge of only one product may lead you to accept poor performance. Both the upper and lower third- and fifth-order products should be checked for typical ssb applications. In many cases even seventh-order products may be significant. Consider, for example, the output envelopes with severe peak-flattening in Figs. 2a and b. This usually indicates a high third-order distorting. In this instance, however, the measured fifth-order products are actually worse than the third-order products, which the seventh-order ones closely approach. Thus, the usual inverse relation between order number and order amplitude is not

Malvin L. Shar, Electronic Engineer, U.S. Army Electronics Command, Fort Monmouth, N.J.



1. **Basic setup for two-tone test** may use one of three popular read-out devices—oscilloscope, spectrum analyzer and wave analyzer. Each should be chosen according to the specific application, for each has its advantages and its drawbacks. To obtain meaningful data, the designer should use the same instrument for all tests.

always true. A good envelope waveform has a shape as in Fig. 3.

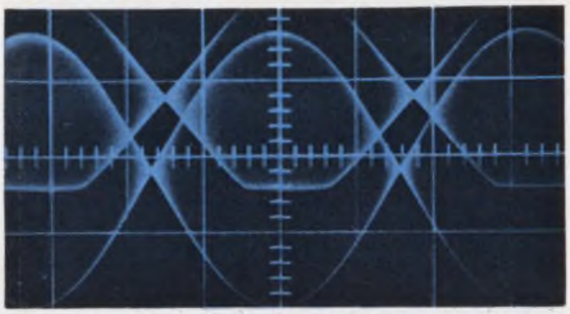
The power meter should be of the true rms type. Although most power meters in use read average power, peak envelope power (PEP) has become the accepted term for ssb use. An undistorted signal yields PEP that is considered equal to twice the average power. However, severe distortion and meter accuracy limit the precision of this assumed relationship. The recent appearance of new power meters designed to read both average and PEP values may simplify correlation.

The rest of the output circuitry of the test setup should afford a range of load impedance adjustment and still maintain a Q similar to that of typical applications.

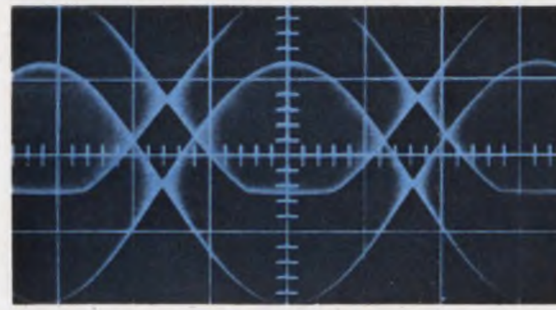
Scopes offer 'quick-and-dirty' results

Oscilloscope waveforms are convenient to observe. The input and output envelope waveshapes can be compared for a quick check of linearity distortion. The drive signal level and the amplitudes of both

While author Shar stands by analyzer that'll show the distortion product, another engineer checks test signal.



(a)



(b)

2. **Flattened peaks of output envelope** (top traces) are often taken to indicate large third-order intermodulation (imd) products. In fact, the fifth-order imd product is larger for (a) and the seventh-order is significant, too. (36, 30 and 39 dB below the fundamental was measured for the third-, fifth- and seventh-order products for (a), and 27, 30 and 45 dB for (b), respectively.) The lower traces are the inputs.

Table: Comparison of read-out devices for two-tone measurements

Technique	Accuracy	Type of distortion	Resolution	Interpretive flexibility	Maximum frequency
Oscilloscope	Intermodulation not measured, peak envelope voltage depends on scope used.	Envelope waveform peak flattening, crossover	Not available	Qualitative (proportional to experience)	No serious limit
Spectrum analyzer	±2 dB	Intermodulation products, harmonics where applicable	Fair to excellent	Good	Microwave
Wave analyzer	±0.5 dB	Intermodulation products, harmonics where applicable	Good	Best (most suited for mathematical analysis)	Hf band (13 m)

test tones can be checked rapidly. The crossover null is a clearly defined zero when both tones of the multitone generator have equal amplitudes (Fig. 4). The level at which the human eye can perceive distortion, however, depends in part on the relative distribution of the intermodulation products. In general, distortion becomes noticeable when the third-order product is numerically less than about 25 dB below the test tone. It is better therefore not to use scopes above this level.

The oscilloscope method may be looked on as a distortion threshold indicator. Its value lies in perception rather than measurement. Although distortion cannot be determined better than on a good, fair or bad basis, the waveform indicates possible reasons for distortion. Effects such as peak-flattening and crossover distortion can be spotted readily and can help to fix a system's optimum operating conditions.[1,2,3] The direct measurement of the peak output voltage makes it easy to distinguish the peak envelope power, independent of average power readings.

Spectrum analyzers help check spectral response

With a spectrum analyzer, the relative amplitudes of each tone and their intermodulation products are observable at a glance. The odd-order products are separated from the test tones and from each other by the same frequency difference, Δf, as that between the two tones. Thus if $\Delta f = 1$ kHz, the third-order products are 1 kHz apart from each tone, the fifth-order products are 1 kHz away from the third-order, and so forth. Logarithmic scales and calibrated attenuators enable distortion in decibels to be read out directly.

But the spectrum analyzer has its drawbacks. The major one is that its accuracy may vary with model and age. A joint effort by several tube manufacturers showed variations in test results up to 7 dB in measuring distortion products.[4] Since then, equipment manufacturers have indicated improvements so that ±2 dB appears representative of recent models. Factors that may limit the instrument's accuracy are:

■ Trace width.
■ Vertical sensitivity deviations along the horizontal axis.
■ Operator skill.

Resolution, the ability to distinguish or resolve closely spaced spectral lines, varies according to the model and the adjustment. For a given dynamic response this involves optimizing the frequency dispersion, i-f bandwidth and sweep rate.

Manufacturers' specifications for spectrum analyzers do not always depict resolution clearly, since it varies with adjustment and signal ratios. They usually define it as the minimum discernible frequency difference between two tones of equal amplitude. Since intermodulation measurement is a comparison of very unequal signals (test-tone-to-distortion-product ratio), the analyzer specification may not always apply. Dynamic range and minimum full-scale dispersion are sometimes the only specifications relating to resolution.

Typical published dynamic ranges for most instruments lie between 40 and 60 dB. Recently specialized analyzers designed for ssb have dispersion ratings down to 150 Hz and a resolution specification of 7 Hz.

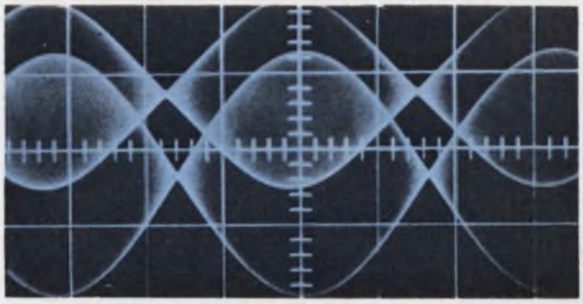
The spectrum-analyzer display is self-explanatory. The entire spectrum of test tone, distortion products and their frequency amplitude relationships forms one thorough, compact presentation. No time-consuming tabulation of data is necessary. But specific measurements such as absolute voltage or power per tone are feasible only with indirect calibration.

The popularity of spectrum analyzers makes this an easy method to implement with existing equipment. Although not a precision technique, this method is a good production tool where correlation requirements are not severe. Future analyzer changes may improve accuracy limitations. The excellent frequency range is almost unmatched by any other laboratory instrument.

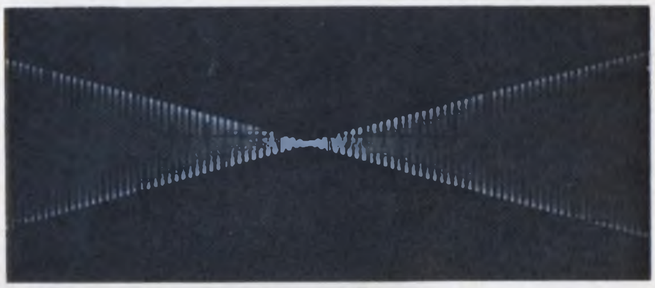
Wave analyzers are slow but accurate

Wave analyzers can be considered as electronic voltmeters with narrow-band radio receivers and calibrated frequency dials. The rms voltage for each tone and each product is directly measured. An accurately calibrated decibel meter-scale measures the distortion level referenced to each tone. This permits measurement of undistorted average power output for each signal tone, and hence the comparison of individual tone power with total average power (the sum of both tones and distortion). Comparison of high-amplitude ratios does not degrade resolution.

Available rf wave analyzers have rated accuracies of $\pm$ 0.5 dB. This accuracy, plus the ease of read-out and the ability to measure each tone and product voltage directly, contrasts sharply with the largely



3. **Good output envelope** (top trace) shows no distortion. The bottom trace is the input. The measured third-, fifth- and seventh-order imd products are 30, 49 and 53 dB below the fundamental, respectively.



4. **Crossover null on scope display** helps to establish the equal-amplitude test signals.

qualitative and relative nature of the other two techniques.

Although the wave analyzer may yield more information with greater precision than the other instruments, it is a slow method. Each tone and each distortion product must be tuned separately and measured singly. The over-all picture is not obtained until all the data have been tabulated.

Selection of the filter passband determines the wave analyzer's resolution. A typical resolution is better than 1 kHz for signals with a 70-dB ratio. While there are no serious maximum-frequency limitations to the oscilloscope or spectrum-analyzer techniques, the wave-analyzer technique is restricted at present to about 22 MHz. But low-distortion frequency converters should extend the wave-analyzer range into the vhf region. ■ ■

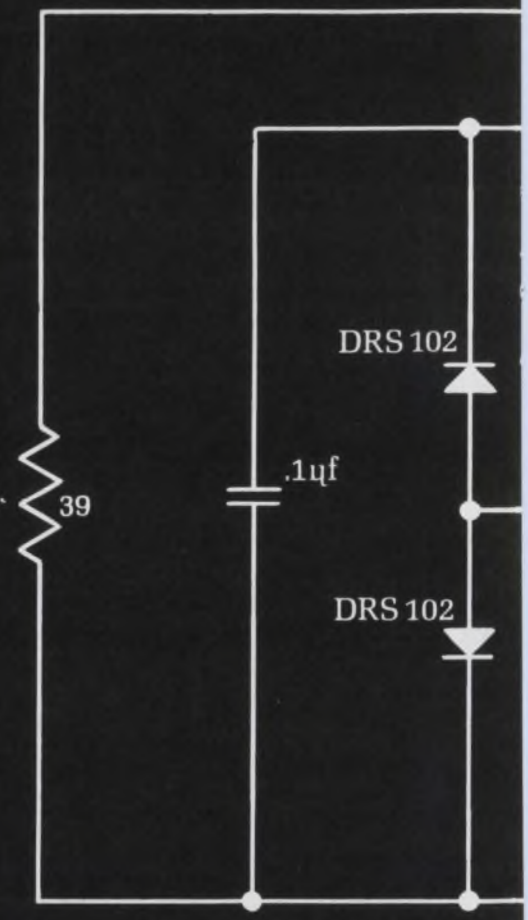
Acknowledgments:

To my assistant, G. Infosino, for collection of data and circuit modification; to J. Falcone, who constructed the test sets; to L. E. Scharmann and G. Fincke, for helpful discussion of tubes; and to O. Pizalis, for useful discussion of transistors.

References:

1. E. W. Pappenfus, Warren B. Bruene and E. O. Schoenike, *Single Sideband Principles and Circuits* (New York: McGraw-Hill Book Co., 1964).
2. D. Stoner, *New Sideband Handbook* (New York: Cowan Publishing Corp., 1958).
3. Byron Goodman (ed.), *The Radio Amateur's Handbook* (44th ed.; Newington, Conn.: American Radio Relay League, 1967).
4. *TG Report on Single-Sideband Specifications* (No. JT-1-b) (Washington, D. C.: JEDEC, 1963).

Want to convert high energy at high efficiency?



Convert to circuit designs using Delco high voltage silicon power.

The DC to DC converter above operates directly from a 150V DC source and delivers 180 watts to the load at an efficiency of over 94 percent. The 1.1 kHz circuit operates over a temperature range of $-65°C$ to $100°C$. Frequencies of up to 25 kHz may be obtained with selected transformer core materials. And the switching job is handled easily by just two Delco NPN DTS-423 silicon transistors—priced at just $4.95 each in 1,000 and up quantities.

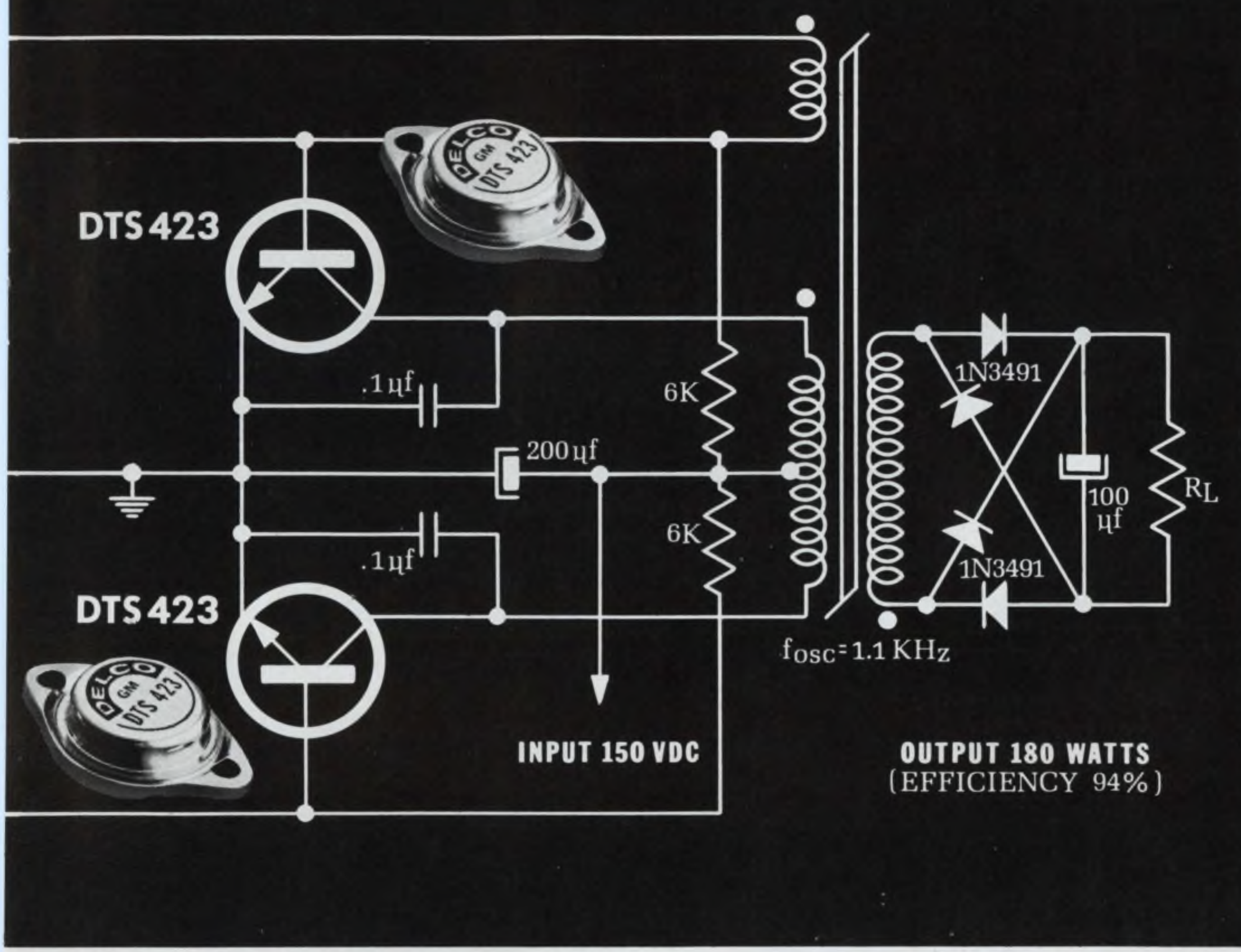
Delco pioneered the development of high voltage silicon power transistors to provide you high energy capability at the lowest cost. Among the many circuit benefits you get are: high reliability, reduced assembly time, and a reduction in the number, weight and complexity of the electronic components needed. Coupled with the low prices of the Delco silicon power line, these benefits mean real cost advantages to you.

Other applications? They've proven their capability in such high energy circuits as: DC and switching regulators, ultrasonic power supplies, VLF class C amplifiers, off-line class A audio output and CRT deflection (several major TV manufacturers use them for big screen horizontal and vertical deflection).

Availability? With Delco's lead in know-how and plant facilities it's no problem. Samples or production quantities can be shipped promptly. Contact one of our distributors or a Delco sales office right now and see.

For more details on the DC-DC converter circuit—ask for application note number 32.

Application of Delco high voltage silicon power transistors: the DC to DC Converter.



DEVICE TYPE	V_{CEX}	V_{CEO}/sus (min.)	h_{FE} min. @ I_C V_{CE}=5 V		I_C max.	P_D max.
DTS-410	200	200	10	2.5A	3.5A	80W
DTS-411	300	300	10	2.5A	3.5A	100W
DTS-413	400	325	15	1.0A	2.0A	75W
DTS-423	400	325	10	2.5A	3.5A	100W
DTS-430	400	300	10	3.5A	5.0A	125W
DTS-431	400	325	10	3.5A	5.0A	125W

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ON READER-SERVICE CARD CIRCLE 34

Dielectric constants are quickly found

with this simple nomogram. Twelve of the most common foam plastics are tabulated.

Electronic applications of foamed plastics, or even the choice of a foam for a particular application, often require a close approximation of the substance's dielectric constant. These values vary with changes in foam density and the frequency of operation of the device in which the foam will be used. The nomogram provides an easy, convenient method of determining these values without reference to handbooks.

Where are foams used?

Low-density foams are widely used for creating the lowest possible weight encapsulated electronic packages. While not as good environmentally as low-density resins, foams do provide maximum weight reduction and very adequate environmental protection in many applications. Polyurethane foams are most widely used because of their relative ease of handling. Silicone foams are also in wide use, although they are not available in as uniform a range of densities as the polyurethanes.

To determine the dielectric constant, select the foam density (lb/ft^3) on the right-hand scale of the nomogram. Determine the correct code for the desired material and frequency from the table and locate the code. Then, simply align a straight edge to intersect the dielectric constant at the left. The code may be found as a number on the center scale, or as an isolated point, depending on the plastic.

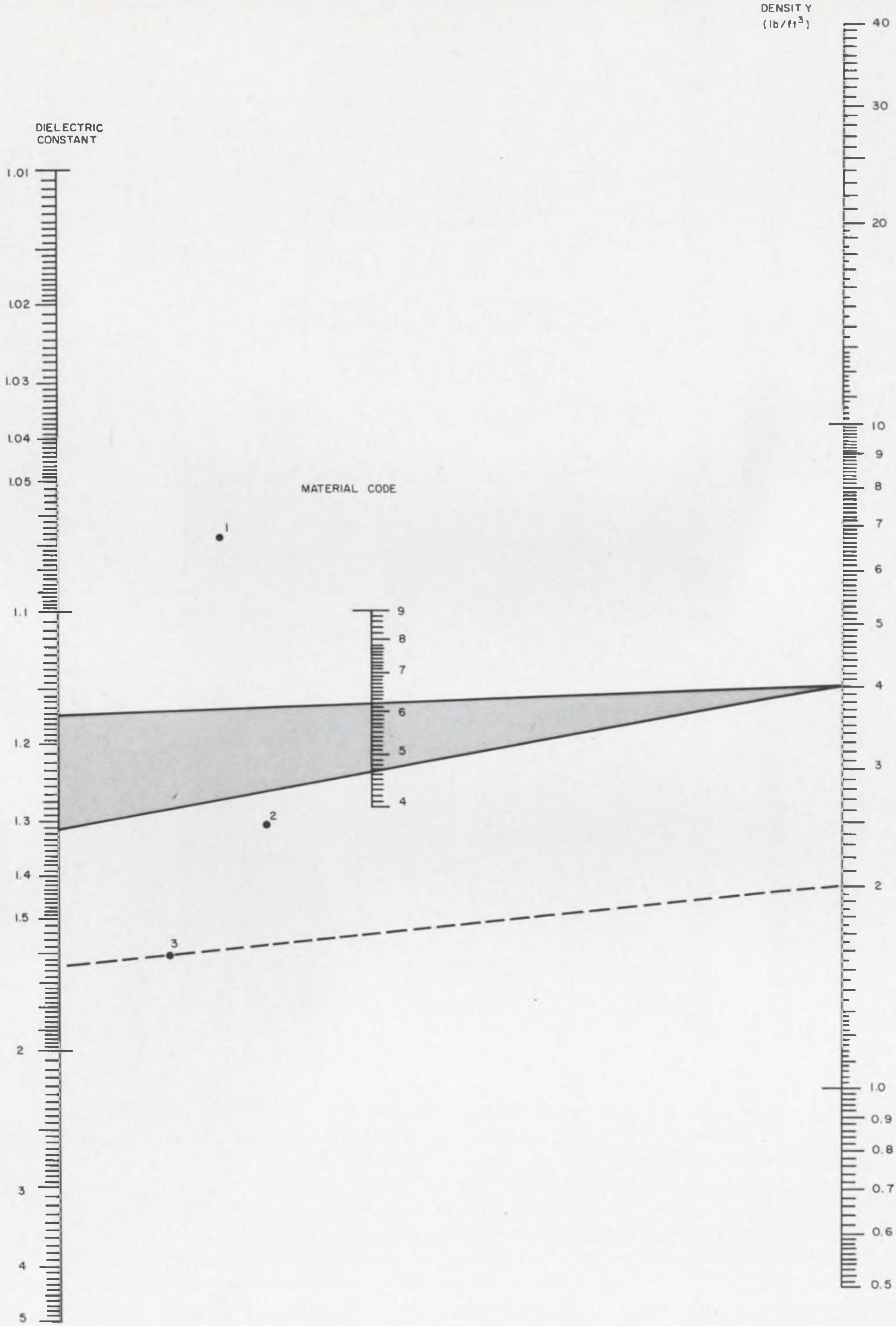
The accuracy of the nomogram should suffice for most engineering needs. Some variation in the values may be expected from batch variations, plasticizers and variants of foaming agents.

To illustrate the use of the method, determine the dielectric constant of a 4-lb/ft^3 silicone foam for operation at 1 MHz. Referring to the table, the correct code for silicone is seen to be 4.7 to 6.2. By joining the 4-lb/ft_3 point on the right-hand (density) scale with the 4.7 and 6.2 points on the center scale, the dielectric constant is read out on the left-hand scale as ranging over 1.173 to 1.35. Or, find the dielectric constant of a castor oil urethane foam having a density of 2 lb/ft^3. Frequency of operation is to be 60 Hz. From the table, the code is 3. A straight edge joining 2 on the right-hand scale to the point 3 gives the dielectric constant as 1.65.

Dr. Robert L. Peters, Consultant, New York.

Table. Materials code for nomogram

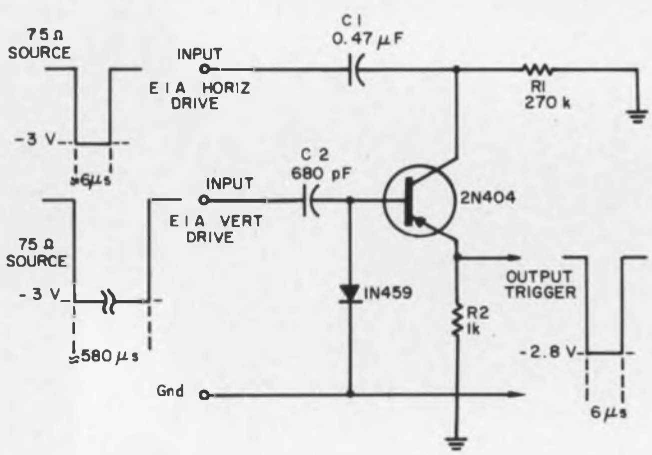
Parent resin	Frequency (Hz)	Code
Cellulose acetate	60	5.5 to 6.5
	10^3	4.8 to 7.0
	10^6	6.9 to 7.5
Epoxy	60	5.8 to 6.5
	10^3	5.8 to 6.5
	10^6	5.8 to 6.5
Phenolic	60	4.5 to 5.0
	10^3	5.3 to 5.8
	10^6	5.8 to 6.5
Polyethylene	60	7.3 to 7.9
	10^3	7.3 to 7.9
	10^6	7.3 to 7.9
Polyvinyl (rigid, semirigid & flexible)	60	7.5 to 7.8
	10^3	7.8 to 8.1
	10^6	8.0 to 9.0
Silicone (flexible & rigid)	60	7.3 to 8.0
	10^3	4.7 to 6.2
	10^6	4.7 to 6.2
Styrene	60	7.5 to 8.3
	10^3	7.5 to 8.3
	10^6	7.5 to 8.3
Styrene acrylonitrile copolymer	60	7.5
	10^3	7.5 to 8.3
	10^6	7.5 to 8.3
Urea	60	4.2 to 4.5
	10^3	4.4 to 4.5
	10^6	4.1 to 4.4
Urethane (castor oil)	60	3
	10^3	3
	10^6	3
Urethane (polyester)	60	2
	10^3	2
	10^6	2
Urethane (polyether)	60	1
	10^3	1
	10^6	1



DIELECTRIC CONSTANT
1.01
1.02
1.03
1.04
1.05
1.1
1.2
1.3
1.4
1.5
2
3
4
5
MATERIAL CODE
1
2
3
9
8
7
6
5
4
DENSITY (lb/ft³)
40
30
20
10
9
8
7
6
5
4
3
2
1.0
0.9
0.8
0.7
0.6
0.5

Coincidence gate generates first field reference trigger

In interlaced television scanning systems, the delayed sweep feature of certain oscilloscopes is sometimes used to provide a means of TV line-selection. The use of the Electronics Industries Association (EIA) Standard vertical-drive pulses to trigger the oscilloscope's delayed time-base may give rise to an undesirable situation. Because the scope cannot distinguish between the first and second field-pulses, it may lock to one or the other at random. In order to avoid this condition, a novel gate-circuit was designed to produce a stable frame-rate trigger, coincident with the first field of each frame (see figure).



1. **"Powerless" coincidence gate** ensures that the output trigger pulse is generated only when both inputs are present.

In a specific application, the device plugs directly into existing test jacks of a monoscope chassis and is immediately operable, since it requires no external power. Three small pins mate with the test jacks, establishing the appropriate drive and ground connections. A small wire loop used as a handle for inserting and withdrawing the unit also functions as a low-impedance output connector. The simplicity of the actual circuit is obvious, and all parts are of the "junk-box" variety.

It should be noted that in the differentiation of the vertical drive pulse too long a time-constant will result in a multipulse output.

Orville Harper, Electronic Components Laboratory, U.S. Army Electronics Command, Fort Monmouth, N. J.

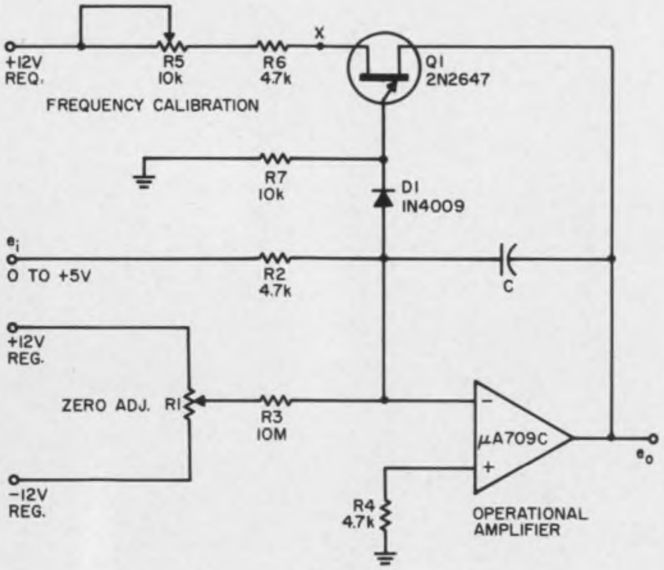
VOTE FOR 110

Ultrawide-range VCO uses op amp and UJT

This circuit, developed as a source of pulses for a stepping motor drive in a servo system, is capable of producing a sawtooth waveshape over a frequency range approaching 100,000:1. For the component values shown, the input control signal range is from 0 to +5 volts.

Resistors R_1 through R_4, together with the operational amplifier and capacitor C, form a usual dc integrator circuit with offset zeroing adjustment. Unijunction transistor (UJT) *Q1* discharges capacitor C at the end of each timing period. Diode D_1 and resistor R_7 disconnect the UJT emitter from the integrator summing point until the firing threshold has been attained. This prevents the UJT trigger current from placing a lower limit on the integrating current supplied to the timing capacitor. Potentiometer R_5 serves as a frequency calibration control by setting the amplitude of the output voltage at which the UJT triggers.

The extreme operating range possible with this



Voltage-controlled oscillator with an extremely wide range (100,000 to 1) is possible with this circuit. Q1, R_5, R_6 can be replaced with a four-layer diode.

circuit makes it necessary to keep operating temperatures constant and/or to use an operational amplifier with low drift characteristics.

In a bench setup, a Fairchild μA 709C operating at room temperature and a 1-μF timing capacitor produced a frequency range greater than 50,000:1 with an upper frequency of 250 Hz and an output signal amplitude of 5 volts pk-pk.

The voltage-controlled oscillator (VCO) may be used as a wide-range cathode-ray oscilloscope (CRO) sweep circuit with points *X* and *Y* used as either synchronizing signal injection points or as CRO blanking signal sources.

R_5, R_6 and *Q1* may be replaced by a four-layer diode (1N5188) connected from the junction of R_7 (change to 4.7 K) and D_1 to the output terminal. In this case, frequency calibration may be obtained with a potentiometer placed in series with R_2. A similar frequency range was obtained for this configuration.

W. F. Ball, AURA, Inc., Tucson, Ariz.

VOTE FOR 111

FET is used to give simple timing circuit

This timing circuit gives a delayed response both when applying and removing a signal. Both delay times may be chosen independently of each other by means of two separate resistors. A transistor ensures the circuit's low output resistance.

Prior to application of a signal to point *A*, capacitors C_1 and C_2 are uncharged, the voltage at point *H* is high and all the transistors are cut off.

As soon as +48 volts appears at *A*, capacitor C_2 rapidly charges to a voltage, the value of which is determined by the divider chain R_1, R_2, R_3 at the junction of R_2 and R_3. This value is lower than at point *H*, so FET *Q1* remains cut off.

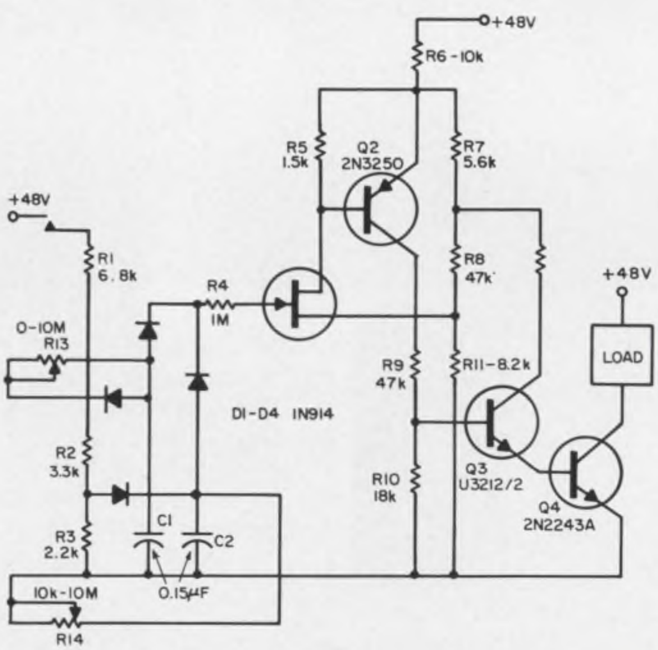
Capacitor C_1 charges through resistors R_{13} toward a voltage that is higher than that at point *H*. When the voltage at the capacitor is equal or slightly higher than that at *H*, *Q1* starts conducting. The delay time t_1 is determined by the time constant R_{13}, C_1. As C_1 is chosen to be constant, the time may be determined by resistor R_{13}.

When *Q1* starts conducting, base current is provided to *Q2*, which also starts conducting. This in turn causes *Q3* and *Q4* to conduct. The collector of *Q4* is the output terminal of the circuit and, when conducting, it connects the load to minus as shown in the figure. When *Q3* is conducting, the voltage at point *H* is lowered.

On removal of the signal, C_1 discharges through D_1 and R_2 and R_3. D_3 prevents C_2 from discharging over the same path as C_1.

The charge on C_2 now provides gate signal for *Q1* because voltage at *H* is lower than that at C_2. C_2 discharges through R_{14}, however, and when the voltage of C_2 is reduced to a value lower than at *H*, *Q1* ceases to conduct. Delay time t_2 is determined by the time constant C_2, R_{14}. C_2 is chosen to be constant, so the time may be determined by R_{14}.

When *Q1* stops conducting, *Q2* and *Q4* also cut



Two independent delay times are obtained with this circuit. The switching of the load by applying +48 V to the input is delayed by the amount determined by R_{13} and C_1. Off delay is determined by R_{14} and C_2.

In.Out.

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PUT YOUR IDEAS INTO ACTION WITH THE HELP OF AMP ENGINEERING . . . WORLDWIDE off and the load is disconnected. Thus, when the input voltage is removed, the delay in response at output is represented by time t_2.

If the pulse width of the input signal is less than the delay time t_1 of the circuit, C_1 will not attain a voltage level higher than that at H, so the circuit will not be activated. C_1 and C_2 will dispose of the charge obtained in the manner described. If the time between removal of one signal from the input and the application of a subsequent signal is less than delay time t_2, C_2 will still keep *Q1* conducting and it will be impossible to separate the end of the previous pulse from the start of the subsequent pulse.

O. Tedenstig, Laboratory Engineer, L.M. Ericsson, a.-b., Stockholm, Sweden. VOTE FOR 112

On-off solid-state switch is simple and inexpensive

A snap-action switch is often used for on-off controls. Such switches are often realized by feeding a relay coil through a bistable circuit.

Among well-known bistable switches, a very useful circuit is a silicon complementary pair behaving like the Schmitt circuit.

In the circuit of Fig. 1a, positive feedback takes place as soon as the input signal amplitude, V_{in}, is large enough to produce unity gain in the loop Q_1, Q_2, R_2, R_3.

Snap switching takes place when the loop gain is larger than unity, or approximately when:

$$h_{fe1}\, h_{fe2} (R_3/R_2) > 1. \quad (1)$$

The input threshold levels for the values shown in Fig. 1a are approximately equal to:

$$V_{in(on)} = 0.6(R_1+R_2)/R_2 = 1.4\text{ V}; \quad (2)$$

$$V_{in(off)} = [0.6(R_1+R_2)/R_2] - [V_{CC}\, R_3\, R_1/(R_3+R_L)R_2] = 1.1\text{ V}. \quad (3)$$

$V_{CE(sat)}$ of Q_1 and Q_2 are not considered.

From the above equations a wide choice of threshold and hysteresis is readily obtainable. In order to have input signal V_{in} control switching to either the on or the off state, it is necessary to satisfy:

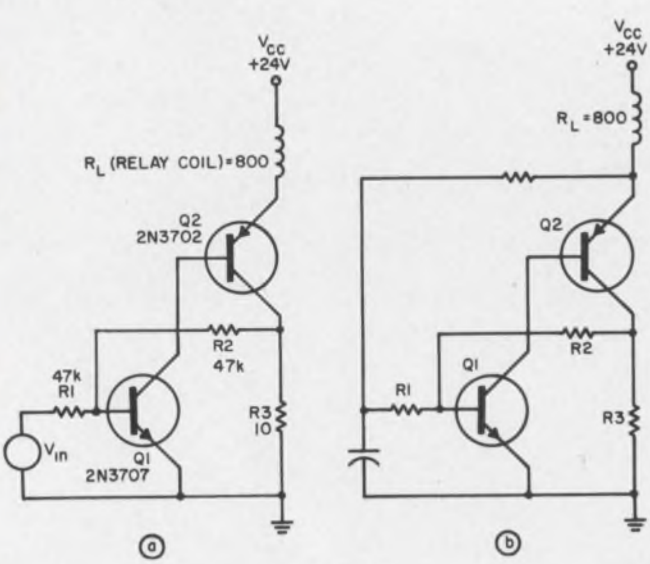
$$V_{in(off)} > V_{in(min)}. \quad (4)$$

An interesting feature of the above circuit is that there is no current drain in the off state.

Should input signal V_{in} be the voltage drop across a resistive transducer, such as negative- or positive-temperature- coefficient resistors and light- or magnetic-dependent resistors, or the voltage across a discharging capacitor, this circuit can be used as a very simple and reliable temperature, light, magnetic-field or time control.

A flasher is possible with another feedback loop including a lag network (Fig. b).

Alberto Anzani, Electronic Consultant Engineer, Varese, Italy. VOTE FOR 113



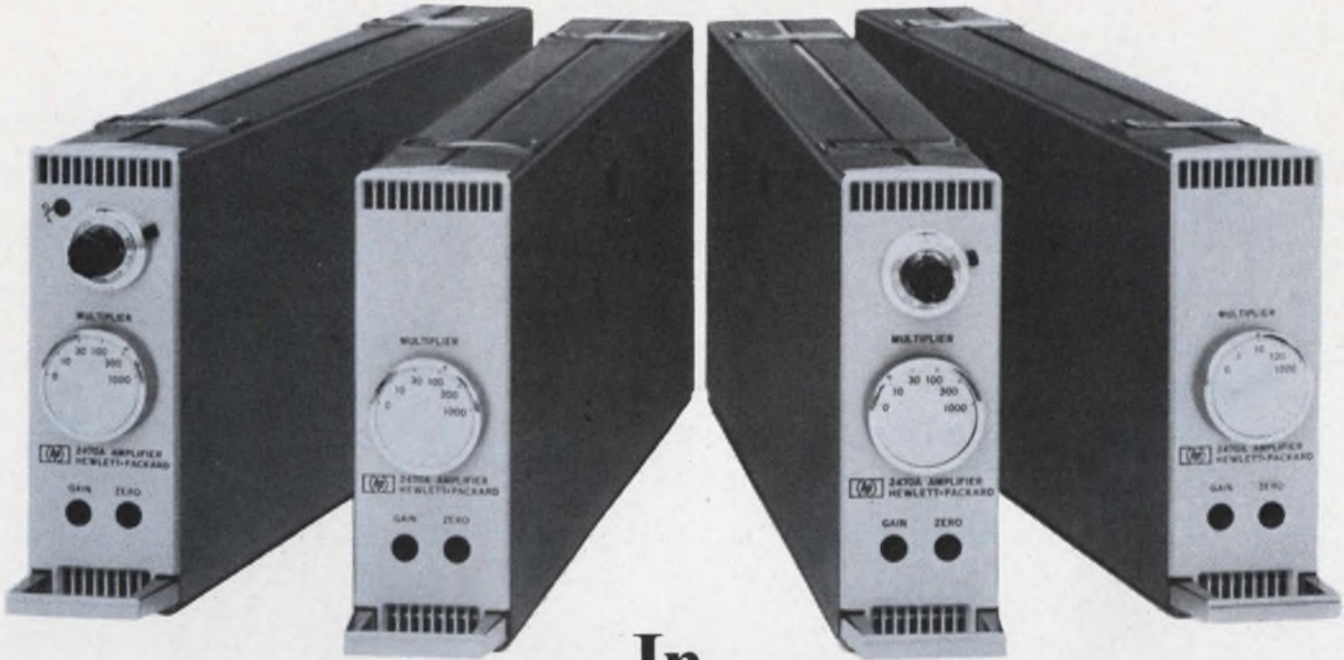
Solid-state snap switch uses two complementary silicon transistors (a). It turns on for V_{in} = 1.4 V and turns off when V_{in} = 1.1 V. A simple oscillator is shown in (b).

IC in logic one-shot ends contact bounce

Many digital systems require a logical single-shot. Such a circuit, on receipt of a changing input waveform, produces a single pulse with a duration of a clock period. The single pulse is used to activate flip-flops to start a process, or to single-shot through a digital sequence when commissioning or debugging. The changing input waveform may be obtained from a mechanical switch or relay, where electrical noise is often present because of bouncing during closing.

The logic circuit in the figure removes such noise and produces a single-shot waveform when the switch is closed. Only one dual flip-flop integrated circuit (μL 9994) is required. The switch should be a break-before-make type—normal for a toggle switch. The inputs of the first flip-flop are held high with 640-ohm resistors to V_{CC}, since open inputs to the flip-flops act as a logical 0. The output of the second flip-flop is the bounce-free version of the switch waveform and is often required in addition to the single pulse.

The circuit operates as follows. When the switch is in position A, both flip-flops are storing a logic 1. No change will occur until the switch is moved and arrives at position B. Flip-flop 1 is



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Any other questions? Contact your local Hewlett-Packard field engineer. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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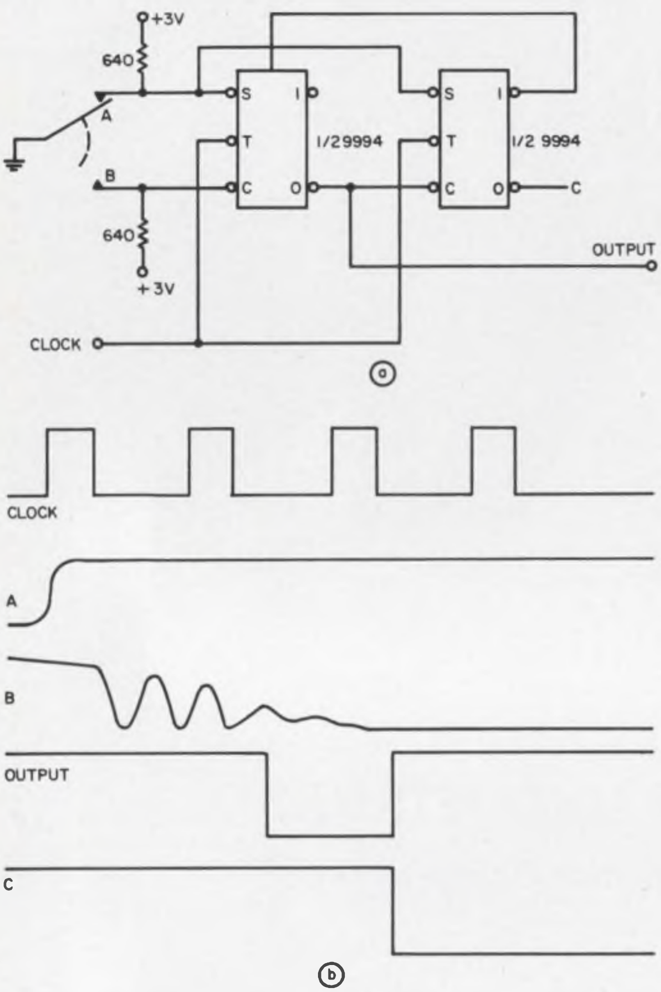
ON READER-SERVICE CARD CIRCLE 38



1. **Switch contact noise** is eliminated by a single IC dual flip-flop.

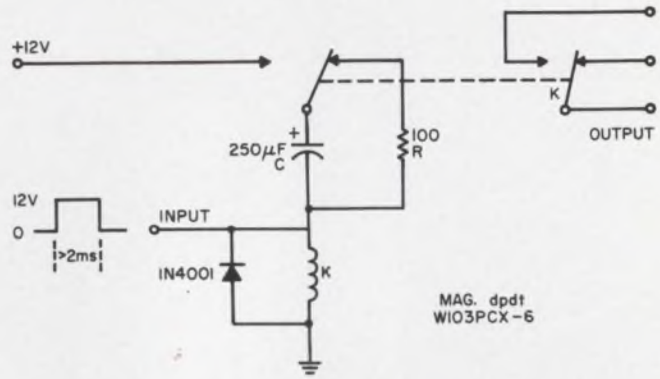
then reset on arrival of a clock pulse. Bouncing from B will not affect the resetting of flip-flop 1; sooner or later it will be reset. When it does become reset, the following clock pulse will reset flip-flop 2. This immediately sets flip-flop 1 and holds it set by means of the asynchronous set input. The flip-flops remain in this state until the switch is moved back to position A. Then flip-flop 2 is set. As long as the switch does not bounce all the way between positions A and B, a single pulse is obtained at the output shown and a bounce-free version of the switch waveform is available from flip-flop 2.

R. C. Ghest, Integrated Circuit Engineer, Fairchild Semiconductor, Mountain View, Calif.

VOTE FOR 114

Reed relay one-shot uses three components

The circuit in the figure affords extended relay contact closure in response to a short input pulse. The input pulse cannot be less than 2 ms while the



Variable-width pulse is obtained at the reed relay output by varying the value of C. With the components shown the width of the output pulse is 100 ms.

output pulse width may be adjusted over a wide range by varying the value of capacitor C.

In operation, a 700-mW, 12-volt positive pulse of at least 2-ms duration is applied to the input, causing reed relay K to energize. This relay is latched through its own contacts and is held on by the charging current through the series capacitor. It will stay energized until the capacitor charging current drops below the hold current of the relay. When the relay drops out, the capacitor is discharged through R. The one-shot is now ready to accept another input pulse.

A capacitor value of 250 mF results in a 100-ms output with the 200-ohm reed relay coil shown.

Leonard A. Daley, Electronics Technician, Pavlovian Lab., The Johns Hopkins University, Baltimore.

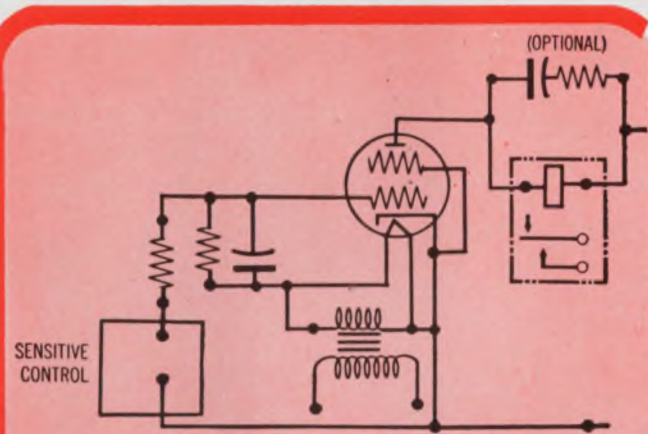
VOTE FOR 115

Stabilize voltage regulator by replacing Zener with a FET

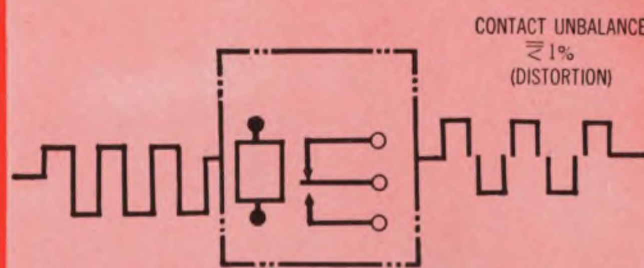
A p-channel FET used as a constant-current source in combination with a resistor serves as a voltage reference in a low-voltage regulated power supply. The use of either a Zener diode (for $V_z < 5$ volts) or a string of forward-biased silicon diodes as a voltage reference in a low-voltage regulator generally results in rather large changes in voltage output with temperature. This is because both Zeners and forward-biased diodes have a large negative temperature coefficient. Using a FET (see figure) biased to operate near its zero TC current point (adjusted by changing R_1) improves temperature stability.

The circuit itself is designed to use off-the-shelf, inexpensive components; all the semiconductors are of the plastic-encapsulated type except the 2N1540 which is an inexpensive germanium type. The use of choke-input yields low ripple (<1 mV) with a small capacitor. The shunt regulator allows

New Mercury Relay Applications From Adlake



MERCURY DISPLACEMENT RELAYS



MERCURY WETTED CONTACT RELAYS

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In applications having extremely sensitive controls, this circuit illustrates how very small currents are capable of controlling an Adlake "Heavy Duty" load relay. Resistive loads of 35, 50 or 75 amperes at 120 volts, 60 cycles, are easily met up to 44 operations per minute. 100 ampere loads at the rate of 6 operations per minute.

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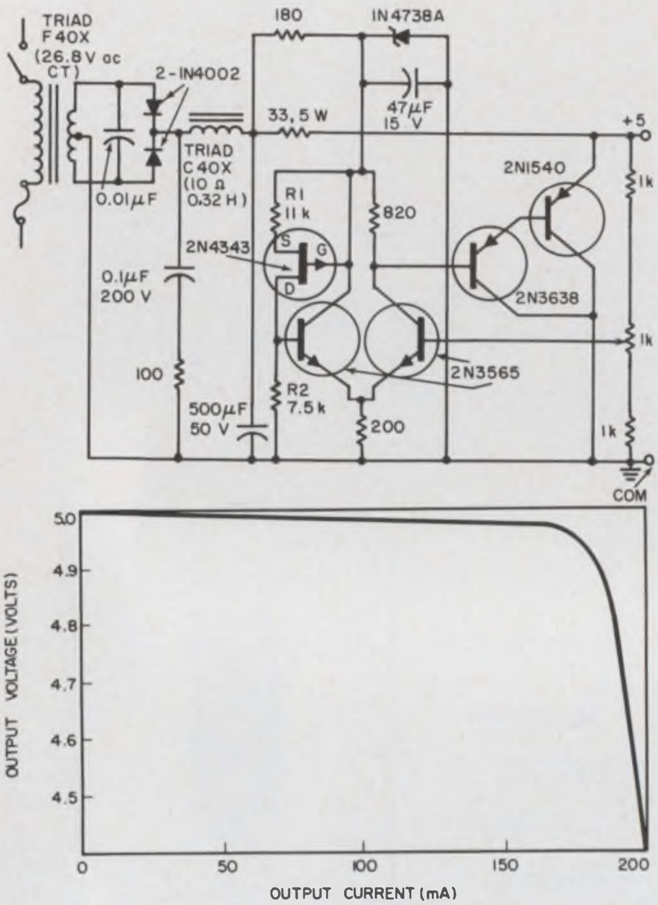


Improved temperature stability is the result when a p-channel FET is used as a reference element in this low-voltage, regulated power supply capable of delivering up to 18 mA.

the collector of the 2N1540 to be grounded to the chassis. The internal impedance of the regulated supply is less than 0.1 ohm over its output range of zero to 180 mA.

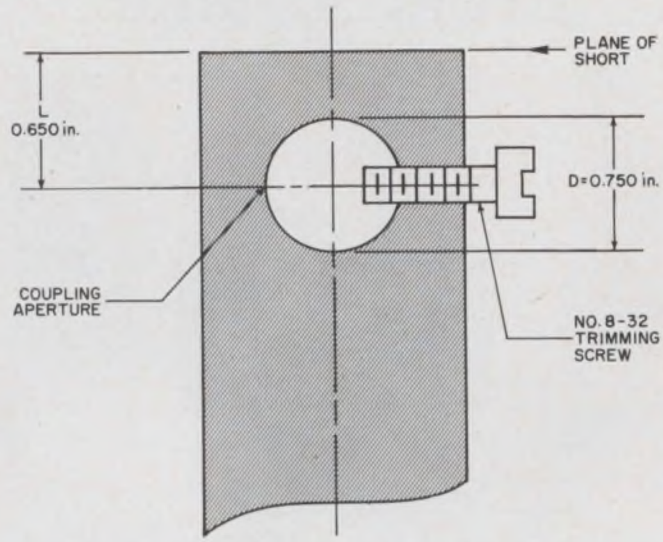
Henry Olson, Research Engineer, Stanford Research Institute, Menlo Park, Calif.

VOTE FOR 116

Trimming screw adjusts TEM resonators' coupling

Bandpass filters that use transverse electromagnetic quarter-wave resonators often have apertures for interstage coupling between adjacent resonators. These apertures are usually circular openings in thin metallic plates. If somewhat thicker partitions are used, the coefficients of coupling can be adjusted with trimming screws.

A bandpass filter structure was built (see figure) on a slab transmission line basis. Round-rod center conductors, 3/8 inch in diameter, were used between 1-3/8-inch ground planes. Center-to-center spacing between center conductors was



Trimming screw increases coupling bandwidth from 71 to 96 MHz at a center frequency of 2 GHz.

0.843 inch. A 3/16-inch-thick partition was located midway between adjacent center conductors. With a circular aperture 0.750 inch in diameter (D) located 0.650 inch (L) from the plane of the short, a coupling bandwidth of 71 MHz was obtained at a center frequency of 2.0 GHz. (The coefficient of coupling is equal to the coupling bandwidth divided by the center frequency.) Insertion of a No. 8-32 transverse trimming screw enables the coupling bandwidth to be increased:

Screw penetration	Coupling bandwidth
0	71 MHz
0.250 inch	75 MHz
0.437 inch	80 MHz
0.625 inch	91 MHz
0.750 inch	96 MHz

The variation of coupling bandwidth between conditions of zero and maximum screw penetration is 25 MHz. This is a 35.2 per cent change from the initial coupling bandwidth.

Richard M. Kurzrok, New York.

VOTE FOR 117

IFD Winner for June 21, 1967

John H. Cone, General Manager, Electronic Enterprises, Pasadena, Calif.

His Idea, "Build a square-wave generator with $3 worth of components," has been voted the $50 Most Valuable of Issue Award.

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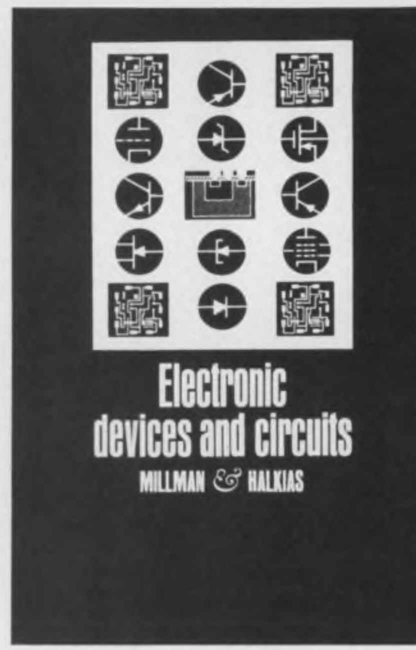

Electronic Components

Electronic Devices and Circuits, Jacob Millman and Christos C. Halkias ("Electrical and Electronic Engineering Series" [McGraw-Hill Book Co., New York]), 752 pp. $12.50.

This book describes the fundamentals of a variety of active electronic components—diodes (vacuum and semiconductor), tubes, transistors, FETs, and ICs.

In addition to thorough coverage of the physical properties of the devices, the discussion of components is supplemented with good circuit examples employing commercially available transistors and tubes. In this fashion, a reader is given some practical hints that can be used to advantage in circuit design.

Since the book is intended as a text for engineering students, no answers to the problems are given. It is mentioned in the text that they

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are available from the publisher. Moreover, the value of the book would be greatly enhanced if one could freely obtain the problem solutions manual which is also available from the publisher. It is available however, only to those college instructors who adopt the text for their use. For a practicing engineer such a manual would be invaluable in working specific design problems.

Peter N. Budzilovich

CIRCLE NO. 600

Waveguide junction theory

Basic Theory of Waveguide Junctions and Introductory Microwave Network Analysis ("International Series of Monographs in Electromagnetic Waves," Vol. XIII), D. M. Kerns and R. W. Beatty (Pergamon Press, New York and London), 164 pp. $5.50.

Written by two scientists of the Radio Standards Laboratory of the U.S. National Bureau of Standards, this book focuses on the basic theory and analytical techniques for waveguide junctions. Definitions of modal characteristic impedance and an impedance normalization scheme lead toward generalized expressions for reciprocity, realizability, losslessness and symmetry of waveguide junctions. It specifically deals with two-ports and touches on three- and four-ports. It is solidly based on Maxwell's equations and includes a few practical applications. The level is graduate.

Medical electronics

Medical Electronic Laboratory Equipment 1967-68, G. W. A. Dummer and J. Mackenzie Robertson (eds.) (Pergamon Press, London), 1305 pp. $30.00.

This volume is a compilation of brochures, releases and reports contributed by manufacturers of medical electronics equipment. It covers a variety of instruments, including transducers, amplifiers, telemetry equipment and display devices. The equipment is indexed both by manufacturer and by category.

The task of collating so large a number of documents is no mean one. The sheer convenience of hav-

ing all this material in one volume justifies its publication. However, one wishes that the collation had been approached more critically. There is no attempt at evaluation; the manufacturers' words are permitted to stand without comment. Some of the releases are informative, while others are unabashedly promotional. Nor is there any bridging text. It is not self-evident why some devices for measuring blood pressure are classed with transducers, others with blood flow meters, and still others with monitors, blood flow/pressure.

Aside from the variation in quality and quantity of information, there is also a wide range in the legibility of the material. The manufacturers' releases were apparently photo-offset, regardless of their quality. This means that some of the originals were typeset, others Xeroxed, still others mimeographed. In places the reproduction is poor.

On balance, the book is worth while. Even allowing the limited sales potential for such a publication, however, thirty dollars is a steep price to pay.

—*Richard N. Einhorn*

Communications propagation

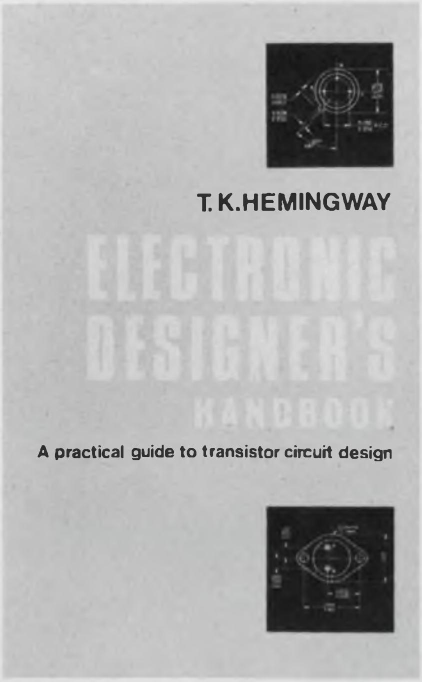
Modern Communication Principles, Seymour Stein and J. Jay Jones (McGraw-Hill, New York), 377 pp. $15.00.

The authors of this tutorial book present the major principles and theoretical results that form the basis of modern digital communications design.

The early chapters enable the reader, with little more than a working recollection of calculus and Fourier series, to grasp the material in later chapters. Separate chapters deal with a-m, pulse modulation, multiplexing, binary frequency- and phase-shift keying, matched filters, M-ary signaling and channel control.

The book is aimed at engineers in the communications field as well as those involved in peripheral fields who want to learn more about communications.

CIRCLE NO. 601



Practical transistor circuits

Electronic Designer's Handbook, T. K. Hemingway (Business Publications, Ltd., London), 296 pp. $8.95.

Here is a book on transistor circuit design really devoted to just that—circuit design. Unlike many other books allegedly on the same subject that dedicate half their expensive pages to treatises on electron holes, Boltzmann's constants, etc., this one wastes no time on interesting but pretty useless sidetracks. The author seems correctly to have assumed that engineers mastered these subjects in their college days.

All 296 pages are devoted exclusively to practical design procedures and explanations. For instance, instead of deriving a complicated expression for I_{co} dependence on temperature, the author simply says that the I_{co} will double for every 10°C rise in ambient temperature.

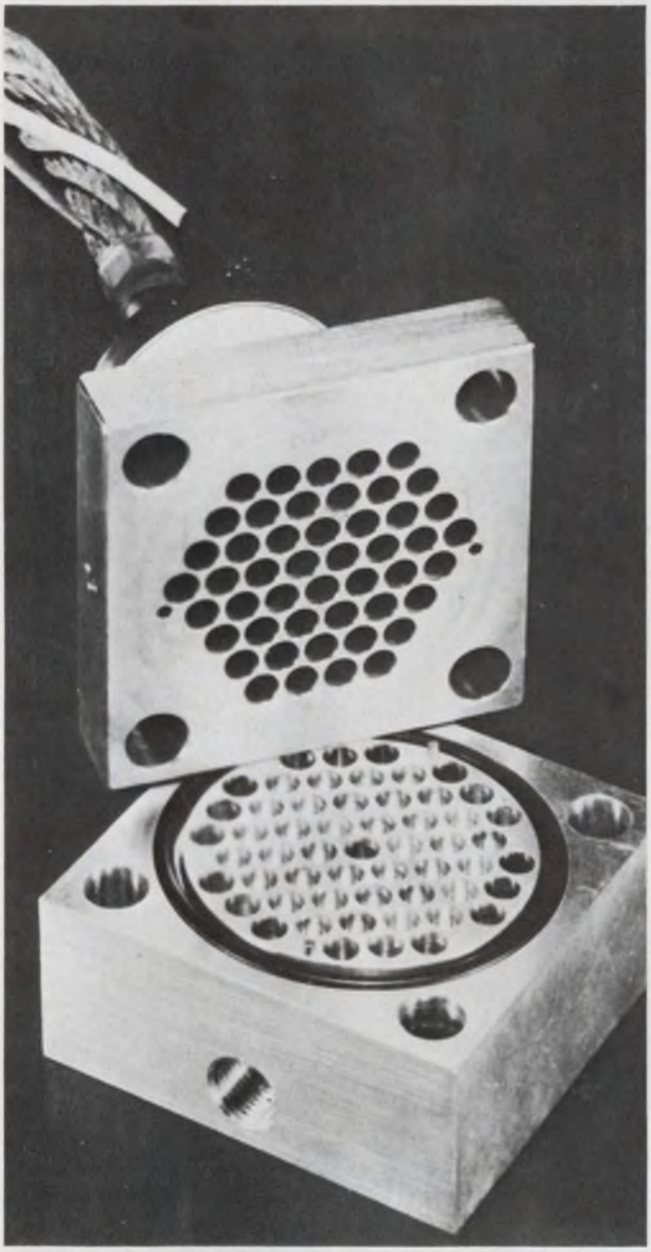
Numerous circuit examples include component values and detailed explanations of how they operate and how they are designed.

All in all, the practicality of this book coupled with its relatively low price should make it widely acceptable to practicing circuit designers, in spite of the fact that it does not cover the latest semiconductor toys—FETs and MOS FETs.

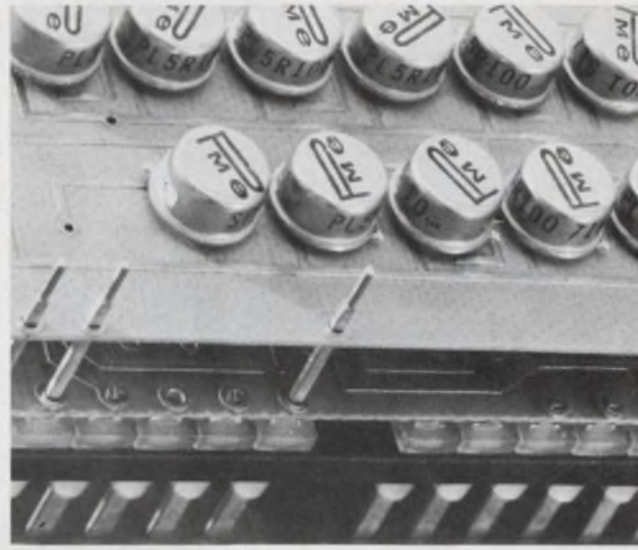
—*Peter N. Budzilovich*

CIRCLE NO. 602

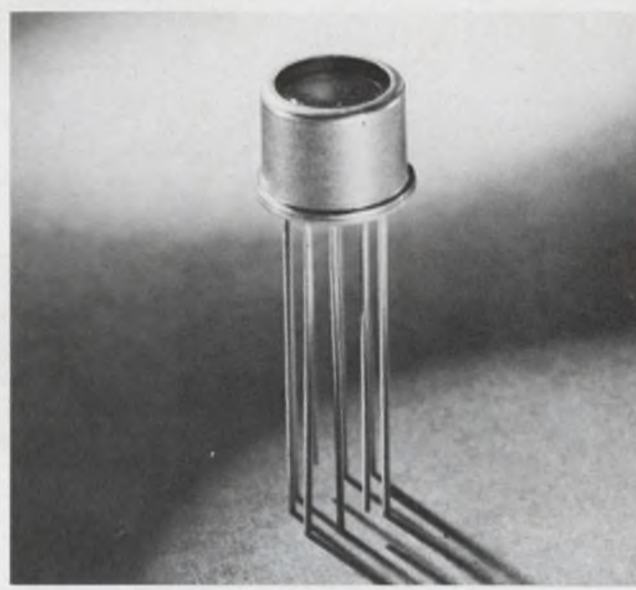
Products



Liquid-cooled thyristor handles 630 A and uses 1-1/2 gallons per minute. Page 92

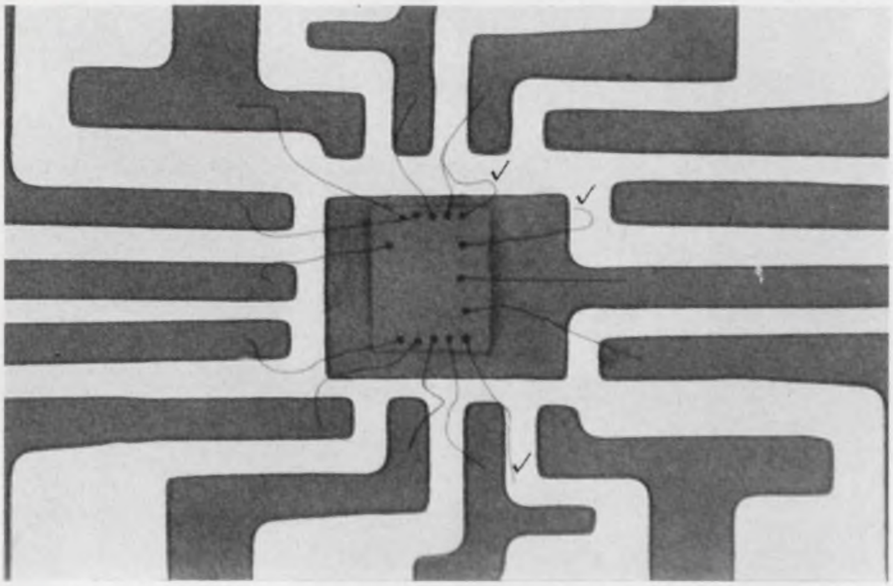


MOS register handles 1,024 bits and operates from 10 kHz to 1.0 MHz. Page 95



Hybrid op amp ranges to 200 kHz and is packaged in a TO-5 can. Page 90

Also in this section:



Instant X-ray uses Polaroid film to give insight on your project

Field Emission Corp., Melrose Ave. at Linke St., McMinnville, Ore. Phone: (503) 472-5101. Price: $1970.

This instrument permits you to take your own X-rays when and where you wish. You can locate, define and modify your project with a quick inside look any time the need arises. Just insert the subject into the machine, select the exposure time and voltage, and push a button. With Polaroid land film, the Faxitron 804 delivers clear, sharp radiographic prints in seconds.

The illustrated IC was radiographed on Type 55 film. Optical magnification (about 10 times) reveals broken wires, indicated by the arrows. The wires are clearly visible, even though they are about 1 mil thick and are buried in potting.

The small source size of the unit minimizes blur due to penumbra. This makes possible very sharp images with high information content. The penumbra is about a thousandth of the distance from the object to the film—that is, about one-ten-thousandth of an inch for objects closer than one-tenth of an inch. Thus the highest-resolution film can be used effectively when maximum information is desired.

The beryllium window in the X-ray tube transmits soft, low-voltage X-rays with minimum attenuation. This conserves X-ray intensity, and shortens exposure times.

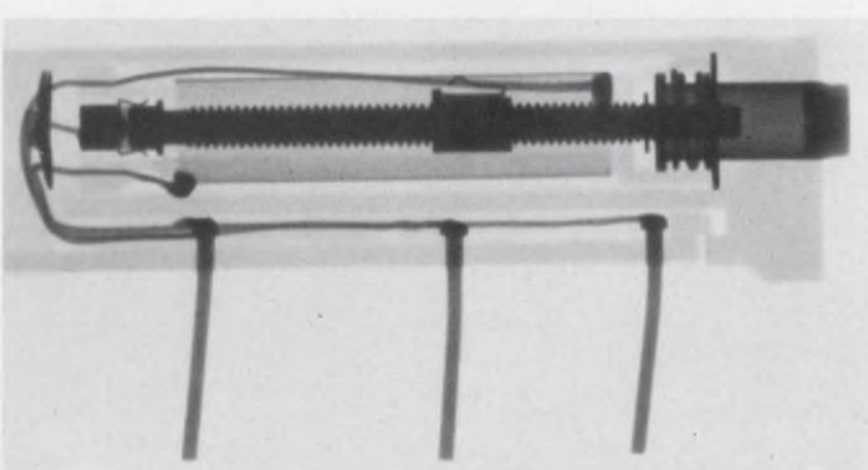
An accessory tube without a window is available for applications using only high voltages. The Faxitron 804 qualifies as an exempt installation according to the National Bureau of Standards because the radiation is completely enclosed in a lead-lined chamber. Interlocks prevent operation with the door open. Extension collar 804008 increases the distance from tube to film from the standard 25.5 in. to 48 in. for MIL SPEC work. It minimizes parallax but requires exposure times approximately four times longer than the standard model. Another accessory collar is available to increase distance to 36 in.

Screens convert X-rays into light which exposes the film. They shorten the exposure time and accommodate thick objects. Resolution of the screens is typically 4 to 15 line pairs per mm.

The power requirements are 110-120-V ac, at 60 Hz 600 V/A or 220 V ac at 50 Hz 600 V/A. The unit weighs 355 lb and is 33 in. high, 21.5 in. wide and 20 in. deep.

Wet films have high contrast, large areas and thick emulsions which tend to shorten exposure times. In some applications they are preferred. Specific areas can easily be shown in even greater detail by photographic enlargement or optical magnification of any area.

CIRCLE NO. 609



Polaroid negatives reproduce fine detail and do it in a hurry. You can take advantage of the high information content of the film by using optical magnification. Wet-film cassettes can also be used.

The table-top unit has interlocks on the door and exposure will stop if the door is pulled open.

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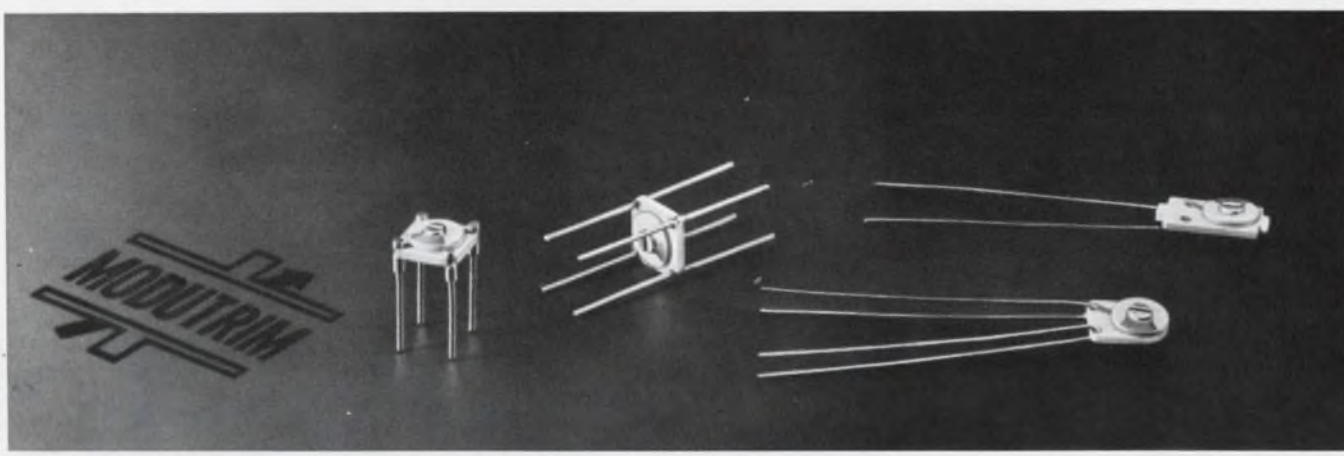

Capacitors shown enlarged 30%

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MT 100 Series' design is specifically for channel-mount and cordwood applications, as well as many other micromodule packages.

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MT 400 Series is designed for cordwood and module applications. This configuration has 8 terminations for easy connection above and below the capacitor substrate.

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ON READER-SERVICE CARD CIRCLE 44

Capacitance manometer uses digital readout

MKS Instruments, 45 Middlesex Trnpke., Burlington, Mass. Phone: (617) 272-9255.

This instrument employs solid-state logic circuits and a tapped binary-ratio transformer to achieve automatic high-accuracy, ac-null-balance readout of a variable capacitance sensor. Absolute or differential pressures, to as low as 1 x 10^{-5} torr, are directly displayed on a 5-place Nixie readout, with a sixth place provided for overrange indication. Parallel electrical outputs are supplied in either BCD or 18-bit straight binary form. The series 100 features a repeatability of 0.02% of reading plus 1 digit. Maximum resolution, including use of a residual voltage interpolator meter, is one part in 10^7. The instrument is capable of preselected sampling speeds, manual command, or remote electrical command operation. Multiplexers are separately available for automatic multichannel scanning of many sensor heads.

CIRCLE NO. 610

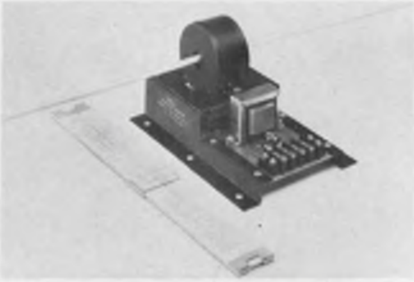
Electrostatic voltmeter ranges 1 to 2000 V

Monroe Electronics, Inc., Vernon St., Middleport, N. Y. Phone: (716) 735-3721.

This all solid-state voltmeter utilizes a non-contacting probe to permit drift-free measurement of dc electrostatic potential on a small area with an accuracy of 0.1%. The instrument's measurement range is ± 1 to ± 2000 V full scale at $> 10^{18}$ Ω input impedance. Applications are in materials research and evaluation, including voltage acceptance and decay voltage measurements in electrophotography, and radioactive effects.

CIRCLE NO. 611

Current sensor to 150 A

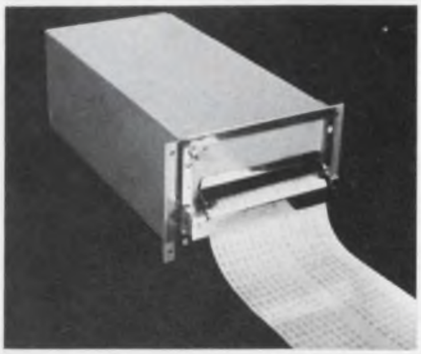


ADC Products, 6405 Cambridge St., Minneapolis. Phone: (612) 929-7881. P&A: $41; stock.

This dc-current sensor is designed for industrial control applications and provides a proportional dc-voltage output from a dc-current signal with complete isolation. One basic unit permits you to choose and valve up to 150 A-dc for full-scale current by simple adjustment. The output linearity of this device is $\pm 1\%$ over the full-scale current range. The unit will accept a current carrying conductor inserted through a physical orifice in the device case. This provides a complete physical and electrical isolation between the monitored and monitoring circuits.

CIRCLE NO. 612

Digital, BCD printers wth 10-line feedback



Hecon Corp., 31 Park Rd., New Shrewsbury, N. J. P. O. Box 247, Eatontown, N. J. Phone: (201) 542-9200. Price: $232 and up.

This complete serial pulse count printer is available with or without 10-line feedback. The parallel-entry printer is completely interfaced for coupling to most electronic counters and digital voltmeters. Special printers with BCD-to-ten-line conversion are also available.

CIRCLE NO. 613

Voltage standard has 8 outputs

The Bailey Co. 5919 Massachusetts Ave., Washington, D. C. Phone: (301) 656-2625. Price: $30.

The model 303113 is designed for checking calibration and scale shape of voltmeters, VTVM's and oscilloscopes. No potentiometer or accessory circuits are needed as it has eight calibrated outputs from 1.35 to 10.8 V and can supply small currents whenever the calibration of a meter may be suspect. Accuracy without corrections is within 0.5% for at least three years and its useful life is 10 years or more.

CIRCLE NO. 614

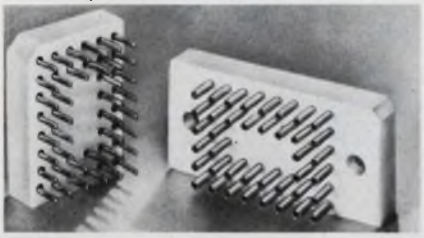
IC tester uses lamps and meter

Microdyne Instruments Inc., Waltham Engineering Center, 225 Crescent St. Waltham, Mass. Phone: (617) 893-8210. Price: $995.

This integrated tester may be used as a manually operated instrument or as a programed functional tester. The analyzer is used for incoming inspection, small-run production, and laboratory and failure analysis. All dc parameters of micrologic circuits and most microlinear circuits may be tested, using the front panel controls of the model 710. Functional tests may be made by patch-plug programming.

CIRCLE NO. 615

Teflon test sockets for A/D converters



Barnes Development Co., Lansdowne, Pa. Phone: (215) 622-1525. P&A: $4-9; stock.

Both of the units are 40-lead sockets with Ni/Au plated beryllium copper contacts on a 0.1000 inch grid. The MGX-101 socket is designed for chassis mounting and has tubular contacts embedded in a body which has been over-sized in order to provide mounting holes. The smaller MGSX-101 socket is designed to be incorporated into printed circuit boards and features flat ribbon-type contacts. Both models are constructed of DuPont TFE teflon for continuous operation over the range of −65°C to 200°C and utilize low resistance wiping-type contacts for easy device insertion or removal without lead damage. Contact resistance is less than 10 mΩ and typical insertion life exceeds 50,000 insertions. Both sockets feature a polarization notch and will accept leads with diameters from 0.016 to 0.24-inch with a minimum length of 0.140 inch.

CIRCLE NO. 616

Time-interval generator with up to 6 channels

Electronic Counters, Inc., 235 Jackson St., Englewood, N. J. Phone: (201) 567-5300. P&A: $1500; 6 to 8 wks.

This unit uses 3 sets of thumbwheel switches to generate intervals of from 1 μs to 10 seconds in duration on 3 separate channels. Associated with each of the 3 output channels are 2 banks of thumbwheel switches. Settings of these banks of thumbwheel switches determines the length of the output pulse, as well as the point in time in which the time-interval starts. The unit is housed in a 19-inch rack mounted chassis.

CIRCLE NO. 617

Frequency meters to 100 kHz

Solid-State Electronics, 15321 Rayen Street, Sepulveda, Calif. Phone: (213) 364-2271.

A series 400-M panel-mounted frequency meter. provides a means of obtaining a visual readout of the frequency of electrical signals over any range from zero to 100 kHz. A solid-state silicon semiconductor design is used. Four standard models are available in the 100-kHz range.

The units are insensitive to variations of supply voltage.

CIRCLE NO. 618

Carrier and contactor for flatpack IC's

Barnes Development Co., 24 N. Lansdowne Ave., Lansdowne, Pa. Phone: (215) 622-1525. P&A: 55¢ to $6.25; stock.

The carrier and contractor, both precision molded of temperature resistant polysulfone, allow long period aging and burn-in applications for environmental and ambient testing of flat-packs over −65°C to 150°C temperature ranges. The carrier has notches for alignment with the polarization studs of the new contactor. The contacts are wiping type Ni/Au plated copper with a service life in excess of 50,000 insertions.

CIRCLE NO. 619

Multifunction test unit covers 27 MHz to 18 GHz

Rantec, 24003 Ventura Blvd., Calabasas, Calif. Phone (213) 347-5446.

This line of automatic multifunction test equipment, has interchangeable broadband coaxial and waveguide rf units for frequency coverage from 27 MHz to 18 GHz.

The equipment measures the swept frequency transmission/reflection characteristics (scattering matrix) of a microwave device in terms of its phase, amplitude (insertion loss or gain and return loss), and impedance or admittance (Smith chart or polar reflection coefficient). Meter, oscilloscope, and recorder displays of all parameters are provided simultaneously or in succession with no connection changes to the device under test.

CIRCLE NO. 620

Low-current meters use MOS FETs

EG&G, Inc., 680 Sunset Rd., Las Vegas. Phone: (702) 736-8111. P&A: $3945; 90 days.

A series of solid-state instruments for measuring extremely low current with repeatability is capable of being calibrated internally. The picometer, with digital readout and automatic-polarity indicator, is for use by standards and calibration laboratories. An optional feature is a current suppressor for discrimination of signals from fixed offset currents. The model ME-1035 of the series has a MOS FET input, temperature-controlled feedback resistors and selectable summing point voltage-current offset monitors and adjustment. The internal calibration procedure requires no external standards or sources.

CIRCLE NO. 621

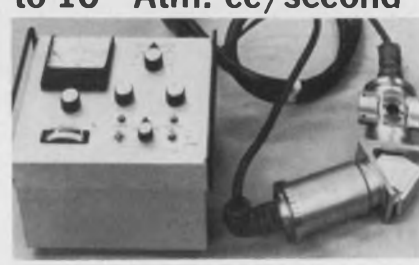
Rate-of-turn table has a million to 1 range

Genisco Technology, Systems Div., 18435 Susana Rd., Compton, Calif. Phone: (213) 774-1850.

This unit is a test instrument for calibrating and evaluating rate gyros, accelerometers, inertial guidance systems, rate sensitive servos and other instruments. The system is available in a MIL-packaged version qualification tested to MIL-T-21200. The digital servo-controlled electronic drive allows the operator to pre-select table rate through use of a direct reading thumb-wheel switch that reads directly in degrees of angular rotation per second. The hydrostatic bearing allows the entire rotating member to float in a film of oil.

CIRCLE NO. 622

Leak detector sensitive to 10^{-10} Atm. cc/second



Varian, 611 Hansen Way., Palo Alto, Calif. Phone: (415) 326-4000.

A portable helium leak detector, capable of a sensitivity of 10^{-10} Atm cc/sec, is composed of a lightweight control module connected to an analyzing tube by a 7′ cable. The analyzing tube attaches to any vacuum system by means of an O-ring sealed or customer-specified metal-gasket flange. The unit can be used for the leak detection of vacuum systems or components, furnaces, and helium-pressurized components. Long filament life is assured in the self-cleaning ion gun by use of pure rhenium as the filament material. The portable electronics module contains all operation controls.

CIRCLE NO. 623

Data simulator with 16-bit cycle lengths

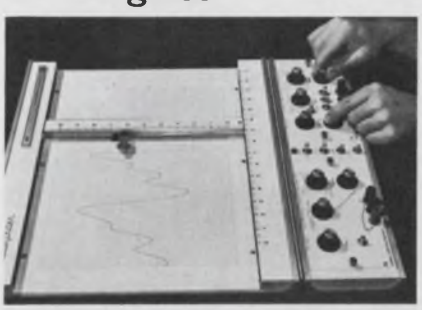
Datapulse Inc., Subsidiary of Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, Calif. Phone: (213) 836-6100. P&A $1075; stock.

This digital data-simulation system is capable of producing variable parameter return and no-return to zero format.

The system consists of a Model-201 data generator and a Model-101 pulse generator. The system provides 16-bit cycle lengths, bit rates to 10 MHz and outputs to 10V.

CIRCLE NO. 624

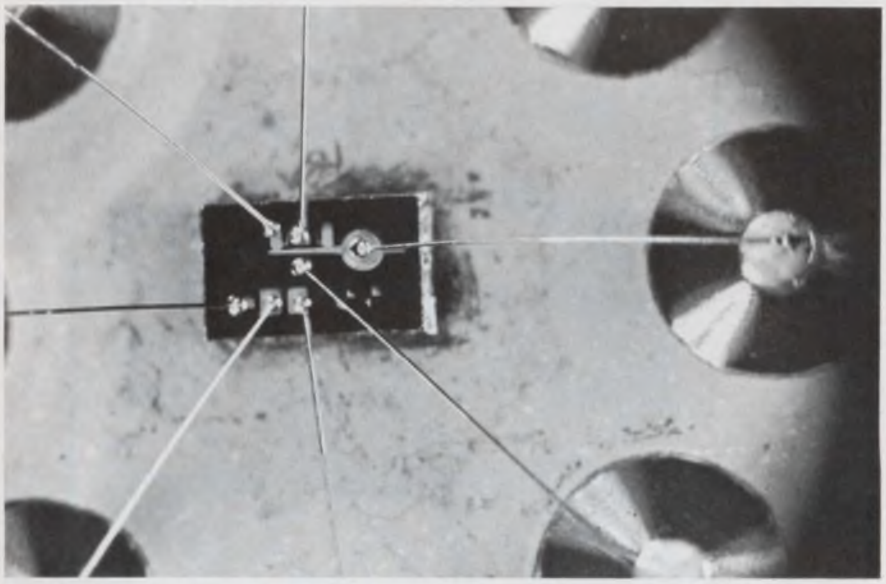
X-Y recorder in fiberglass



Texas Instruments, 3609 Buffalo Speedway, Houston. Phone: (713) 526-1411. P&A: $1600; 90 days.

Either vertical or horizontal mounting of this recorder is possible. When the instrument is used as a tabletop unit the recording surface may be angled to 45° or 90°. Both 8-1/2-x-11-inch and 11-x-17-inch charts can be used. Either X or Y axes may be geared to time function, while the interchangeable "function modules" permit modification for the job at hand. Three modules are available: a single-range signal input module, a time-sweep/signal attenuator module and a multirange attenuator module. Terminals for remote control of time sweep are standard, as are pen-lifters. Inking is provided by disposable plug-in ink cartridges. A nonconductive case of mar-resistant fiberglass encloses the recorder.

CIRCLE NO. 625

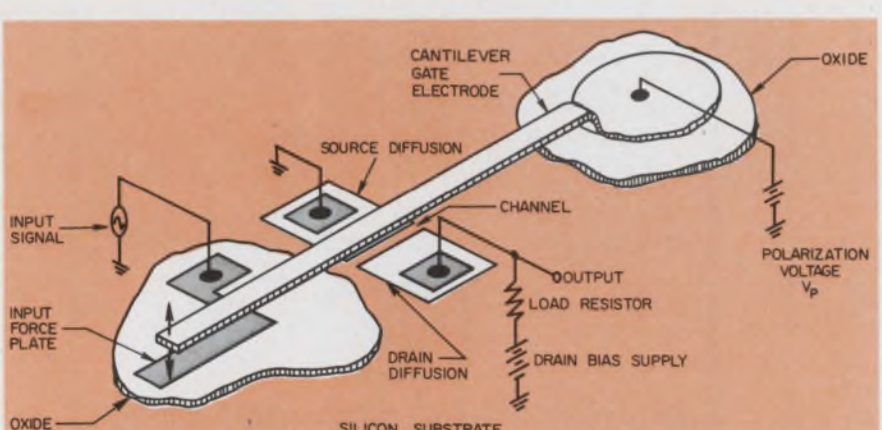


Resonant-gate transistor spans 3 to 30 kHz

Westinghouse Electric Corp., P. O. Box 2278, Pittsburgh. Phone: (412) 391-2800. Price: $67 ea.

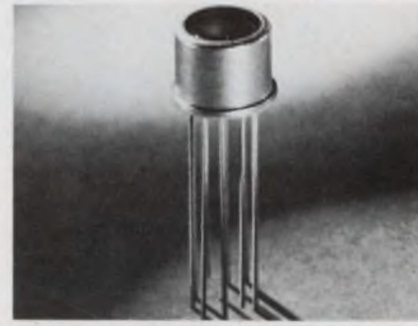
A solid-state device, called a resonant-gate transistor, is now available in evaluation quantities. The unit is a frequency-selective device capable of Qs from 20 to 200 and its availability offers a solution to the problem of building tuned circuits without depending on inductors. The operation results from a mechanical resonating beam or "tuning fork" of minute proportions actuated by electrostatic forces, which are provided by an input signal voltage. This signal voltage, when superimposed upon a larger, constant polarization voltage, sets in motion the resonating, cantilevered beam. Vibration of the beam is sensed by a conventional MOS field-effect transistor for which the beam serves as the gate. The applicable frequency range of the units is presently limited to about 3 kHz to 30 kHz, but higher frequencies can be obtained by using an over-tone mode of vibration.

CIRCLE NO. 626



Westinghouse plans production of its resonant-gate transistor, a microcircuit filter element. As its biased gold beam moves, the MOS channel depletes the current path, causing an output. Evaluation units are available.

Hybrid op amp ranges to 200 kHz



EG&G, Inc., 160 Brookline Ave., Boston, Phone: (617) 267-9700.

The model HA-100 is packaged in a TO-5 configuration and is specifically designed for low-current–high-gain amplification with good linearity at low current. A feedback resistor is externally connected facilitating resistance selection for the application. The resistor is also available mounted in the same package as the SGD-100 photodiode. This combination, referred to as the HAD-130, results in a compact photodiode-amplifier. Major uses for the units include most medium frequency, low light level detection and measurement applications.

CIRCLE NO. 627

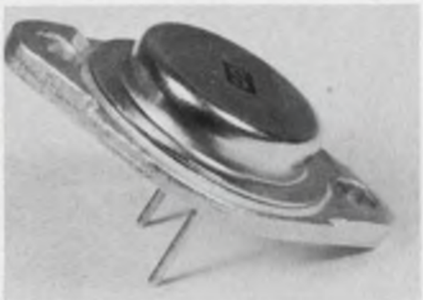
Plastic transistors to 300 mA

Sprague Electric Co., North Adams, Mass. Phone: (413) 664-4411. Price: $1.00 ea. 1000 or more.

Dual, low-cost plastic transistors in a one-piece molded package will be offered as PNP and NPN differential amplifiers or complementary dual transistors (NPN/PNP types). The differential amplifiers will be known as the TD-100 with NPN polarity and as the TD-400 family with PNP polarity. The units feature a base-to-emitter voltage match within 2.5 mV and the base-to-emitter voltage will temperature track within 6μV/°C. Minimum beta gain is 120 at 100 μA current. The complementary dual transistors, designated as the TD-600 series, are similar to the 2N2222 and 2N2907 metal-clad types in their electrical characteristics. They are specified for use over the range of 10 μA to 300 mA.

CIRCLE NO. 628

Germanium transistor carries 25 A



Solitron Devices, Transistor Div., Riviera Beach, Fla. Phone: (305) 848-4311.

This 25-A pnp germanium power transistor is available in a TO-3 to TO-41 package. This high-current device is capable of 106 W. Typical specifications for the series include minimum gain of 10 at 25 A, V_{CBO} of 40 to 80 V, V_{CEX} of 40 to 80 V and V_{CEO} of 30 to 50 V. This device is a general-purpose transistor for use in military and industrial inverters, converters, switches, regulators, control circuitry and audio-amplifier applications.

CIRCLE NO. 629

Power transistors to 50 W

ITT Semiconductors, 3301 Electronics Way, W. Palm Beach, Florida. Phone: (305) 842-2411. P&A: $2.05-22.80; stock.

These silicon planar epitaxial transistors cover the rf-amplifier range from one mW to fifty W. Four interdigitated geometry transistors (devices that utilize diffusion patterns more complicated than ICs) include the 2N3632, 2N3732, 2N3866 and 2N4012. The 2N3732 offers 10 W output at 400MHz and a common emitter power gain of 4.0 dB. The 2N3632 has 13.5 W at 175 MHz and a gain of 5.8 dB. The 2N4012 provides 2.5 W output to 1002 MHz as a tripler; and 3 W typical output as a doubler to 800 Hz. It comes packaged in a TO-60 case.

The 2N3866 is packaged in a TO-39 case and has 1 W output at 400 MHz, a common emitter power gain of 10 dB, and a gain-bandwidth cut-off frequency of >800 MHz.

CIRCLE NO. 630

Liquid-cooled thyristor handles 630 A

Westinghouse Electric Corp., P.O. Box 2278, Pittsburgh. Phone: (412) 391-2800.

Featuring a thermodynamically-designed water-cooled heat sink, this type 224 thyristor is used for welding applications, power supplies, and large motor controls. The heat sink creates low-velocity eddy currents for transfer of heat away from the device. This design permits high-current capability in a 3-in.-sq. by 6-in. high package. This high-power thyristor, or SCR, is rated at 400-A half-wave average, 630-A rms through 1200 V. The liquid-cooled heat sink requires a water flow of 1-1/2 gallons per minute.

CIRCLE NO. 631

Edgewise meter is 1/2-inch high

Voltron Products, 1020 Arroyo Parkway, Pasadena, Calif. Phone: (213) 682-3377. P&A: $12.50; stock.

The meters measure 1.75 x 0.50 x 2.51-inches and have flush sides to permit stacking of two or more. Models are available for ac or dc volts, amps and milliamps. The dc meters are D'Arsonval type movements; ac meters use a rectifier. The units are enclosed in a plastic case with snap-off cover. Scale length is 1-5/16 inches. Accuracy is ±2% in standard versions or ±5% in expanded scale models. An illuminated version will soon be marketed.

CIRCLE NO. 632

V-to-I transducer handles picoamps

Washington Technological Associates, Inc., 979 Rollins Ave., Rockville, Md. Phone: (301) 427-7550.

This picoammeter is a 6-decade (120 dB) current-to-voltage transducer capable of processing currents in the micro- to picoampere range. Output is 0 V at minimum input current and 5 V at maximum. Maximum rise time is 9 ms and noise is less than 50 mV p-p at 1 pA. Current drain of 3.1 mA is typical, using ±1%, positive and negative 12-V power supplies. Used in measurement and control applications having current sources that include photocells, photomultiplier tubes and electron and ion probes, the unit is suitable for flight and oceanographic applications.

CIRCLE NO. 633

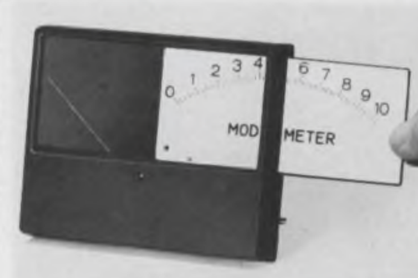
Low-volt lamps square and round

Mura Corp., 380 Great Neck Rd., Great Neck, N.Y. Phone: (516) 487-0430.

Both shapes come in assorted colors of red, green, white and amber and the round lamp also comes in blue. Temperature rating for both is 120°C. Lamps ranging from 2 to 28 V in various currents, are sold as a complete unit with caps and leads. Free samples may be obtained.

CIRCLE NO. 634

Multifunction meter has many scales



API Instruments, Inc., Chesterland, Ohio, Phone: (216) 729-1611.

A versatile panel meter allows measurement of many different variables simply by changing scales. It need not be dismantled when scales are changed. Scales are inserted in the slide after removing two screws. Alignment and fastening of the slide are so positive that a meter with 0.5% tracking will maintain its precision when scales are changed. A glass dial capsule seals off the movement from contamination and damages.

CIRCLE NO. 635

Power supplies for digital IC's

RO Associates, 917 Terminal Way, San Carlos, Calif. Phone: (415) 591-9443. P&A: $125-157; stock.

Two power supplies specifically designed for digital IC's produce 5 and 10 A respectively with adjustable outputs from 4.5 to 5.5 V. Ripple is 1 mV peak to peak; regulation is 0.25% zero to full load, and ±0.1% for ±10% change in input. Crow bar overvoltage protection and current limiting short circuit protection are built in. Construction is open frame and cooling is by convection only. Card cage mounting units are also available.

CIRCLE NO. 636

Photocontrolled resistors use 12-V lamp

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $6.80-8.00; stock.

This resistor uses a cadium-sulfoselenide photocell to obtain stability in a changing temperature environment. The photocell resistance, when illuminated, changes by a factor of 1.5 with a change in temperature from 25° to 65°C.

It contains a 12-V incandescent lamp that illuminates the photocell. The illumination level controls the cell resistance over a 5-decade range, from 100 mΩ with the lamp dark to less than 1 kΩ with the maximum permitted input power of 12 V at 45 mA. Photocontrolled resistors are useful wherever high isolation is required between controlled and controlling circuits, such as current monitoring in high-voltage power supplies, or silent swtching of channels in a communication system. Electrical isolation between lamp and photocell in the unit is greater than 10^{12} Ω and coupling capacitance is less than 0.01 pF. For low speed switching applications the incandescent lamp responds to on-off signals at rates up to 10 Hz. The lamp has an operating life of 40,000 hours at 10 V.

CIRCLE NO. 637

Ac-dc power source has twin outputs

Elasco Inc., 33 Simmons St., Boston. Phone: (617) 442-1600. Price: $95 and up.

Op-amp power supplies featuring twin outputs incorporate two separate sources in a 3-5/16 x 3-7/8 x 4-1/2-inch case. Fully automatic recovery from any overload or short is guaranteed. The units may be obtained with either of two options. The first has individual output voltage adjustments, while the other, with a voltage-tracking option, permits a single control to operate both.

CIRCLE NO. 638

Decade counter runs on 5 V dc

United Computer Co., Unit 8, 930 W. 23rd St., Tempe, Arizona 85281. Phone: (602) 967-9122. P&A: $90; 2 wks.

The Model F1850E decade counter combines a segmented display with a 5-MHz IC counter. It requires a single supply voltage of 5-V dc. The input is +1 V level change. The outputs include a 4-line BCD and drive line for other counters. The removable lamps are rated at 5 V for 100,000 hours. Its size is 7/8 x 1-3/4 x 2-3/8 in. Six front and six side 4-40 inserts are provided for mounting. It weighs 2 oz.

CIRCLE NO. 639

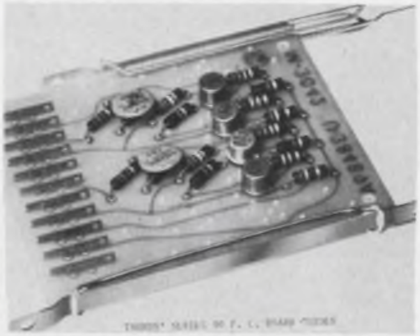
Bandpass filters vary ±0.01 dB

Electro-Mechanical Research, P. O. Box 130, Van Nuys, Calif. Phone: (213) 782-1974.

The small variation of less than ±0.01 dB in passband amplitude response suits these filters to reference system and signal conditioning applications requiring amplitude fidelity. Filters are available with center frequencies in the range of 100 Hz to 50 kHz and passband of ±5% of center frequency. These filters meet applicable portions of MIL-F-18327.

CIRCLE NO. 640

Circuit-board guides are all steel



Taurus Corp., Academy Hill, Lambertville, N. J. Phone: (609) 397-2390.

These all-steel pc-boards guides provide a positive grip for either vertical or horizontal mounting. They are supplied in a wide variety of sizes in increments of one inch. These guides are available with one, two, or three wires and with an extra mounting hole in the center. The effective grip is two or three inches per wire. The finish is cadium plate. Other finishes are also available. Snap rivets can be supplied. Samples are available.

CIRCLE NO. 641

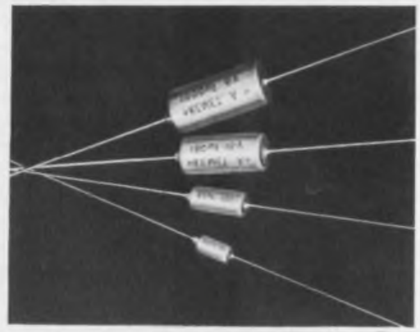
Mini oscillator uses microcircuits

Fork Standards, Inc., P. O. Box 177, W. Chicago. Phone: (312) 231-3511. P&A: $90 to 495; 4 wks.

Frequencies as low as 0.1 Hz can now be supplied in a case 1.5-inch square by 0.6-inch for PC board mounting. A frequency accuracy of 0.01% is maintained over a 0° to 65° temperature range. Greater accuracies or wider operating temperature ranges are available. Long-term frequency accuracy is assured by a temperature-compensated bimetallic tuning fork operating between 1 and 10 kHz. Supply voltage is 5-V dc and the output is a square wave.

CIRCLE NO. 642

Tantalum capacitors to 1000 μF

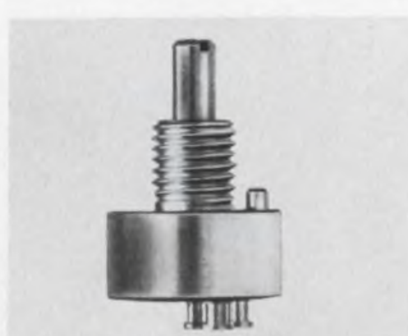


Union Carbide Corp., P. O. Box 5928, Greenville, S. C. Phone: (803) 963-7421.

Offered with ratings of 100 μF, 6-V dc, 10 V-dc, 300 μF, 15-V dc, and other ratings, these capacitors come in standard military style a, b, c and d cases. The a series is produced in capacitance values ranging from 0.82 to 1000 μF and in working voltages from 6 to 60 V. They meet the environmental and mechanical requirements of MIL-C-39003A. In addition, the devices display low impedance characteristics from −55°C to 125°C and can be used for dc power supply filtering and decoupling.

CIRCLE NO. 643

Potentiometer conforms to MIL R-39002

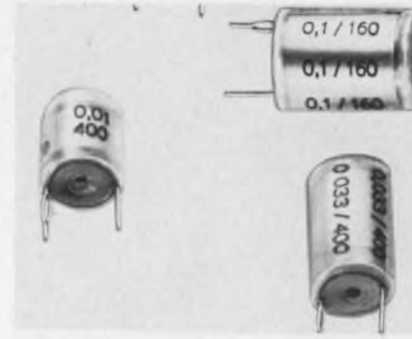


Waters Manufacturing, Boston Post Rd., Wayland, Mass. Phone: (617) 358-2777.

The type JP/2 potentiometer conforms to the requirements of MIL-R-39002/1A. The type JP/2 is 1/4 x 1/2 inch and weighs 1/2 ounce. Resistance ranges are from 100 Ω to 10 KΩ with resistance tolerance ±10%. It comes encased in corrosion-resistant metal. Custom shafts and bushings are available.

CIRCLE NO. 644

Film capacitors from 0.01 to 0.1 μF



Aerovox Corp., New Bedford, Mass., Phone: (617) 994-9661.

The V170 capacitors use a welded lead construction. They can be subjected to 100% relative humidity for 72 hours at 75°C and suffer 1/3 loss in insulation resistance after exposure and drying. The units meet the moisture resistance test of MIL-STD-202, method 106A. The largest capacitor measures 0.413 x 0.669 inches and is available in six types with capacitances ranging from 0.01 to 0.1 μF and dissipation factor not exceeding 1% (at 25°C). Standard tolerance is ±10%, although ±5% units can be supplied.

CIRCLE NO. 645

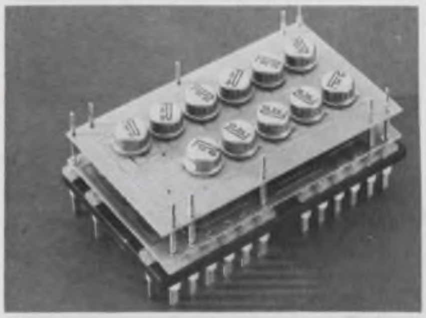
Overvoltage protector up to 45 V

Power/Mate Corp., 163 Clay St., Hackensack, N. J. Phone: (201) 343-6294.

This solid-state device, connected across the dc output of a power supply, prevents damage to the load caused by excessive voltage. With this protector, improper adjustment, improper connection or failure of the power supply are no danger to equipment. The OVP-1 has two voltage ranges; 3 to 24 and 24 to 45 V, both adjustable throughout the range. Continuous rating is 12 A when used with a heat sink and 2 A in free air. Response time is 3μs.

CIRCLE NO. 646

MOS shift register handles 1,024 bits



Philco-Ford Corp., 3939 Fabian Way, Palo Alto, Calif. Phone: (415) 326-4350.

The unit features a standard voltage amplifier with a very high input impedance and a transfer characteristic similar to that of a pentode vacuum tube. It has 1,024 bits of delay with interface and a clock register. It has an operation range from 10 kHz to 1 MHz.

CIRCLE NO. 647

Unattended transmitter to 1200 bits per second

Digitronics Corp., 1 Albertson Avenue, Albertson, N. Y. Phone: (516) 484-1000.

Designed to read and transmit data from magnetic-tape cartridges prepared on any Data-verter digital recorder, the Model-802 transmitter sends data over the standard dial telephone network, using a Bell System 202E Data Set. The 802 may be operated manually to transmit data, or may be placed in the unattended mode to enable automatic, unattended transmission of data when called. The transmitter is available in two versions: 802-1 and 802-2. Except for speed (the 802-1 transmits at 600 bits per second; the 802-2 at 1200 bits per second) the two units are identical.

CIRCLE NO. 648

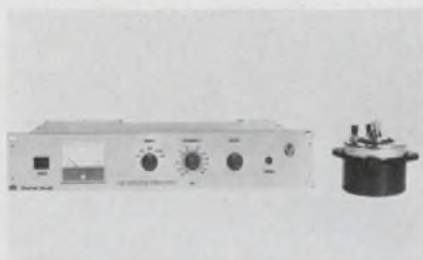
Digital system measures 4 ways

Electronic Associates, Inc. West Long Branch, N. J. Phone: (201) 229-1100. P&A: $340, modules $210 to $250; stock.

A choice of mix-and-match modules allows this unit to function as a digital voltmeter, a digital frequency, period, or time interval counter or an ac converter. Two modules can be plugged in simultaneously. The desired measurement is selected by a switch on the front panel.

CIRCLE NO. 649

Vibration system uses 2.5 force pounds



Agac-Derritron, 600 N. Henry Street, Alexandria, Va. Phone: (703) 836-4641. Price: $448.

A sine-wave vibration system with a wide-band, sine-wave oscillator, 25-W amplifier, and an exciter is suited for component testing, structure-resonant studies and transducer calibration. The VP-2 system is capable of delivering 2.5 force pounds over the frequency range of 5-10,000 Hz as limited by its maximum displacement of 0.2 in. double amplitude and a maximum acceleration of 60 g. Other features include over-current limiting, output-current metering, thermal protection of the output transistors and a provision for use with an external-signal source.

CIRCLE NO. 650

Low-VSWR slotted line spans 0.395 to 8.5 GHz

Narda Microwave Corp., Plainview, N. Y. Phone: (516) 433-9000.

The model 6235 can be used for precise measurements of the impedance, VSWR and reflection coefficient of distributed and lumped elements of rf frequencies from 0.395 to 8.5 GHz. With an impedance of 50 Ω, ±0.1%, it meets all requirements for testing of missiles, space vehicles and similar advanced coaxial systems employing 50-Ω components. It converts quickly to type N, TNC or NPM line with low-VSWR adapters. The line is fitted with a movable carriage and a detector probe mount. The probe has a 37.5-cm travel and is driven by a fixed-position knob.

CIRCLE NO. 651

Double-balanced mixer to 200 MHz

Relcom, 2329 Charleston Rd., Mountain View, Calif. Phone: (415) 961-6265. P&A: $70 to $90; stock.

This double-balanced mixer has MIL reliability and RFI shielding. It is a component for a-m with suppressed carrier, PCM, PPM, phase detection, frequency converting, etc. in radar, communications and test equipment. It has a noise figure of 5.5 dB (SSB) at 50 MHz, 45-dB isolation between ports at 200 MHz, conversion loss of 5 dB (SSB) at 50 MHz, and a 120-dB dynamic range. The unit is 0.6 x 1.95 x 0.94 in. and meets environment requirements of MIL-E-16400F, Class 1.

CIRCLE NO. 652

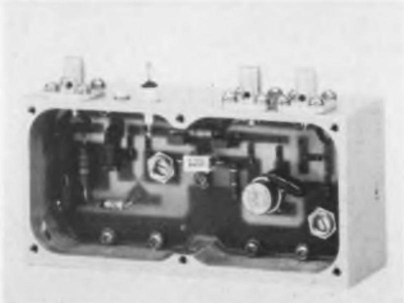
C-band magnetron rises to 1 MW

SFD Labs., 800 Rahway Ave., Union, N. J. Phone: (201) 687-0250.

The SFD-313 is a mechanically tuned coaxial magnetron which develops 1 MW of peak power over a range of 5450 to 5825 MHz. Efficiency is 50% minimum. Weighing 56 pounds and cooled by forced air, the tube resists damage from waveguide arcs or high VSWR, because the outlook window is ceramic. Dimensions of the unit are 14.625 x 13.75 x. 13.75 x 7.062 inches, including the tuning shaft and the rf waveguide output flange.

CIRCLE NO. 653

Fm oscillators to 380 MHz



RHG Electronics Lab., 94 Milbar Blvd., Farmingdale, N. Y. Phone: (516) 694-3100. P&A: $995, 30 days.

This wideband fm oscillator can be frequency-modulated at baseband rates to 12 MHz. The oscillators are designed for use as the basic exciter unit in wideband microwave relay systems. They are available from 250 to 380 MHz and can be deviated over 9 MHz with a linearity of 2%. Operating in the uhf region, they contain a varactor-tuned oscilloscope, a buffer stage and output pad.

CIRCLE NO. 654

Waveguide switches operate to 20 g

Transco Products, Inc., 4241 Glencoe Ave. Venice, Calif. Phone: (213) 391-7291.

A family of solenoid-operated, light-weight waveguide switches is now available in type WR-62, WR-102, and WR-112. They are designed for high performance in extreme environmental conditions. VSWR is 1.1:1, with an isolation of 60 dB. The insertion loss is 0.2 dB with a −54° to 100°C operating temperature. The switches can withstand a 20-g vibration. These units are pressurized and have an anti-bounce braking device for switching action.

CIRCLE NO. 655

X-band mixer uses barrier diodes

Sylvania Electric Products, 730 Third Ave., New York. Phone: (212) 655-2173.

This microwave IC balanced X-band mixer has two matched beam-leaded Schottky barrier diodes mounted in a hybrid configuration. Developed for airborne and space radar and communications applications, the unit contains an IC formed on a ceramic wafer, 0.7 inch long x 0.5 inch wide and 0.02 inch thick, that can be removed from the holder and replaced.

CIRCLE NO. 656

Fundamental oscillator spans 1200 to 1500 MHz

Consolidated Airborne Systems, Inc., 115 Old Country Rd. Carle Pl., N. Y. Phone: (516) 741-1500.

This 1.2 to 1.8 GHz range fundamental oscillator is voltage-tunable over half an octave. The model ETS 3152 offers 50 mW of output power. Its control voltage is 0-20 V. It measures 1 x 1-1/8 x 2-1/4 inches. The product will meet specifications in −50 to 70°C environments.

CIRCLE NO. 657

HeNe gas laser radiates 6328 Å

Electro-Nuclear Labs., 115 Independence St., Menlo Park, Calif. Phone: (415) 322-8451. Price: $285.

This HeNe gas laser provides highly collimated radiation at 6328 angstroms. This output is still in the visible range. The model LS-32 features a plasma tube based on the coaxial principle, externally mounted Brewster windows that adjust yet remain securely in place during operation, and a stable output typically 1.5 mW single mode. The laser housing, measuring 13 by 1-3/4 in. is drilled and tapped for mounting either on an optical bench or on an accessory tripod, available at extra cost. The power supply occupies 8 x 4-1/2 x 7 in. The unit including the plasma tube is waranteed for one-year shelf life or 2000 hours actual operation.

CIRCLE NO. 658

Hydrogen thyratron rises to 14 kV

EG&G, Inc., 160 Brookline Ave., Boston. Phone: (617) 267-9700. P&A: $250; 2-4 wks.

This hydrogen thyrstron is for spark-chamber and linear-accelerator applications. The HY-62 will operate up to 14-kV (max) anode voltage with less than a 40-ns delay time when driven by a 600-V peak 15-ns rise-time-grid drive pulse. The unit is 2 x 1-3/8 in. Shorter delay times can be achieved by operating tube at higher reservoir voltages.

CIRCLE NO. 659

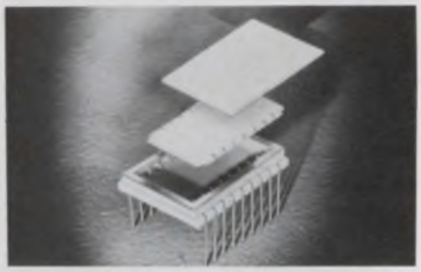
Ultraviolet laser responds in 1 μs

Avdo-Everett Research Laboratory, A Div. of Avco Corp., 2385 Revere Beach Parkway, Everett, Mass. Phone: (617) 389-3000. P&A: $12,000; 90 days.

This ultraviolet-pulsed nitrogen laser has a peak power output of 20 kW and a pulse repetition rate of 1 to 10 pps and an average power output of 20 mW. It operates in the second positive band of molecular nitrogen and produces 10-ns self-terminating pulses in the near ultraviolet at 3371 A.

CIRCLE NO. 660

Plug-in package has 18 leads



American Lava Corp., Manufacturer's Rd., Chattanooga, Tenn. Phone: (615) 265-3411.

Designed for monolithic circuits, the ceramic plug-in features a good inside device area in relation to overall size. The notched, high-alumina ceramic substrate accurately matches the inside area of the package. Since leads can be soldered directly to conductor lines which run into the notched areas, it is possible to eliminate wire bonding from device area to leads. This direct soldering also holds the substrate to base. The plug-in package is 0.75 x 1 in. and has 18 leads. The matching substrate is 0.51 x 0.855 in. and the area is almost 100% useable.

CIRCLE NO. 661

Foam fluxes speed PC manufacture

Alpha Metals, Inc., 56 Water St., Jersey City, N. J. Phone: (201) 434-6778.

This foam flux permits the "trimming" and electronic balancing of radio and TV PC boards immediately after soldering while they are still warm. The flux produces a steady foam that does not break when it contacts hot surfaces. This characteristic eliminates any need for pallet or fixture cooling. Reliafoam 811-13 is a rapid, high-rising foam flux requiring low air pressures for a constant, adjustable head of white bubble foam. It consists of a stable, homogeneous solution of pure, water-white rosin in a multicomponent solvent to which a small amount of activating agent has been added. It provides instant wetting, excellent capillary properties and leaves only small residues. It maintains its foaming, fluxing and wetting properties during continuous exposure to aeration.

CIRCLE NO. 662

Silicone encapsulant withstands 600°F

Emerson & Cuming, Inc. Canton, Mass. Phone: (617) 823-3300. P&A: $3.50 to $4 per pound; stock.

Eccosil 4966 is a pourable, room temperature curing, red silicone encapsulant that has service temperatures up to 600°F. Its viscosity of about 21,000 cps renders it capable of filling complex cavities. This behavior coupled with its flexible character makes it ideal for encapsulating or coating electronic components whose performance is altered when subjected to pressure. Where adhesion to metal, glass or other substrates is desired, surfaces should be treated. For unit use above 250° F a post cure is recommended.

CIRCLE NO. 663

Copper-filled epoxy has low resistance

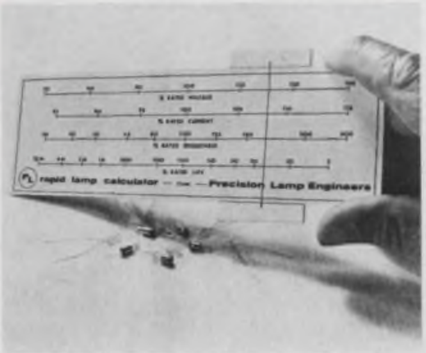
Ablestik Adhesive Company, 833 W. 182 St., Gardena, Calif. Phone: (213) 321-6252.

A copper-filled conductive epoxy adhesive exhibits a resitivity of less than 0.01 Ω-cm with electrical properties comparable to most silver conductive adhesives. Although copper is an excellent conductor, epoxy compounds filled with pure copper powder have been electrically nonconductive. This is due primarily to an insulating oxide layer on the exposed surface of the copper powder.

This adhesive requires no pretreatment of the copper powder and retains much of the conductivity of solid copper. When cured 2 hours at 150°F, resistivity it is only 0.007 Ω-em. Since copper is the filler, the compound eliminates the migration problem encountered in silver compounds. This compound is designed for use in conductive joints, rf shielding, and other conductive adhesive applications.

CIRCLE NO. 664

Design Aids



Lamp calculators

This calculator is designed to assist the designers of circuits when they use any incandescent lamp. It is now possible to determine lamp life, brightness and current at applied voltages from 70% to 130% of rated voltage. With this new calculator, the life of an incandescent lamp can be doubled by a 5% reduction of applied voltage. Precision Lamp Engineers.

CIRCLE NO. 665

Transformer laminations

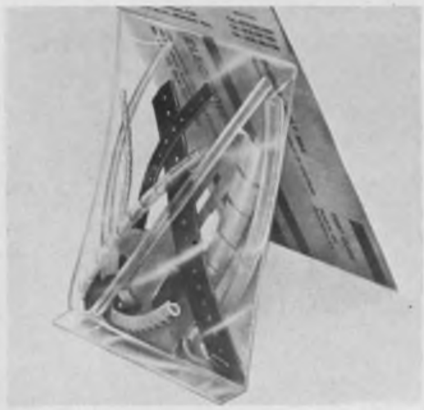
A comprehensive 144-page catalog provides complete electrical and mechanical data on high-performance electromagnetic transformer core laminations. The catalog includes dimensional diagrams of available shapes, magnetic design formulas, magnetic path dimensions, and indicates the various materials and gauges in which each lamination type is available. In addition cross-references of lamination types and shapes are provided as well as technical information and data of value to design engineers involved in the specification of laminations for assembly of magnetic cores. Magnetic Metals Company.

CIRCLE NO. 666

Microwave wall chart

This is a 30 x 40-inch three-color wall chart of engineering reference information. It is useful for engineering departments, test labs and drafting rooms. The chart covers often-used spectrum analysis data, signal and transmission data and receiver and RI/FI information. The offering contains tables, nomographs and charts. Polarad.

CIRCLE NO. 667



Evaluation kit

A free sample kit for evaluation of wire-cable harnesses and markers is available for engineers, draftsmen and contractors. It includes: the Cradleclip, Spiroband, Strapping, Cable-Tie and Adjustable P-Clip Harnessing Systems; three different types of markers for coding of wires and cables; and Grommet-Strip, the "snip-n-fit" grommeting material. Because there is no one best method of solving all wire and cable harnessing and marking problems (individual requirements will determine the approach utilized) users will find this kit an indispensible aid in the selection of a product to meet their specific requirements. Electrovert.

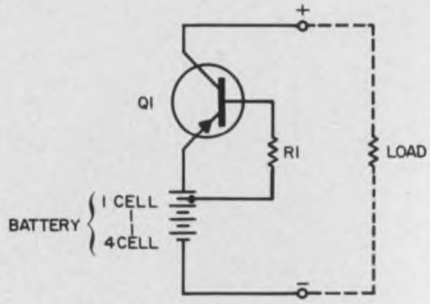
CIRCLE NO. 668

Conversion factors

A reference table in wall chart form is useful for engineers and shop men. Included are common conversions such as inches to centimeters or watts to H.P. as well as many conversions that are difficult to locate in reference manuals. Some such examples are atmospheres to Kgs/sq. cm., cm/sec to miles/hr., cu. ft. to liters, microns to meters, quintals to pounds, etc. Precision Equipment Co.

CIRCLE NO. 669

Application Notes



Q1 - PNP GERMANIUM POWER TRANSISTOR
R1 - BIAS RESISTOR

NiCad battery tips

The rechargeable, sealed nickel-cadmium battery cell . . . How is it made? What are its electrical characteristics? How fast can you charge it? How do you specify? These questions and many more are answered in the booklet, "The Sealed Nickel-Cadium Battery Cell." The booklet has packaging ideas, charging and discharging curves, and a table of Sonotone's line of sealed cells, listing all physical and electrical data. To aid the engineer in specifying and designing, simple charging circuits are illustrated. Included is the anti-reversal circuit shown above. This system utilizes a single transistor and base-bias resistor. Only one transistor is required for each multicell battery. Sonotone Corp.

CIRCLE NO. 670

Thermoelectric cooling

The principles, applications, and design possibilities of thermoelectric cooling are discussed in this booklet. Like conventional refrigeration, thermoelectrics obey the basic laws of thermodynamics, and in the latter section of the booklet, these laws are more fully discussed. Both in result and principle, then, thermoelectric cooling has much in common with conventional refrigeration methods—only the actual system for cooling is different. The difference between the two refrigeration methods is that a thermoelectric cooling system refrigerates without use of mechanical devices, except perhaps in the auxilliary sense and without refrigerant. Borg-Warner.

CIRCLE NO. 671

Complementary transistor

A four-page bulletin describes how complementary circuits operate using matched pairs of npn and pnp transistors. It gives examples of practical amplifier and power-converter circuits using complementary pairs. Some of the characteristics that make use of complementary power transistors practical and economically desirable are pointed out and illustrated with curves. KSC Semiconductor Corp.

CIRCLE NO. 672

Precious metals

A 24-page brochure shows how precious metal materials and fabricated products are providing greater efficiency and economy to today's industrial processes. The brochure presents the story of the platinum metals, and devotes individual pages to the platinum group metals, gold and silver with illustrations and descriptions of different uses. Tables listing the properties of each of the precious metals are included, along with information on research and development, refining activities and a products guide. Engelhard Industries.

CIRCLE NO. 673

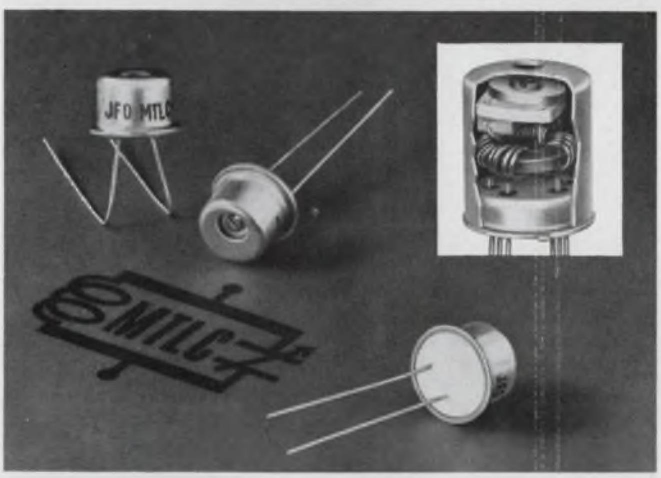
Encyclopedia of connectors

The second edition of the Encyclopedia of connectors has been expanded to include physical drawings of connectors to dimensions and includes additional manufacturers and additional types of connectors. Directed to engineers, planners, buyers, expediters, etc., the publication contains illustrations and cross referencing charts with Bendix, Cannon, Amphenol, Flight, Deutsch, Winchester, Continental, and U.S. Components. The encyclopedia of connectors is designed to assist in the selection of connectors and enables quick cross reference. It explains nomenclature and illustrates Mil-C-26482 and Mil-C-5015. It also explains how to select connectors and contains an index of all inserts and contact configurations plus other information. Spacecraft Components Corp.

CIRCLE NO. 674

The micro-miniature tuned-circuit package.

JFD TO-5 Enclosed MTLC Tuners



Capacitors shown enlarged 20%

JFD MTLC tuners enable circuit designers to shrink various LC circuits into TO-5 configurations completely compatible with today's miniaturized or hybrid circuitry. The tuning element is a subminiature variable ceramic capacitor measuring: .208 x .280 x .120 inch thick. These variable ceramic capacitors offer high capacitance plus a choice of wide △ Cs in extra small, ultra stable units.

JFD builds these miniature circuits with high quality ferrite and iron inductor toroidal cores, providing maximum Q for any given frequency. Where necessary, special JFD Uniceram fixed capacitors are used with Modutrim units to yield lower center frequencies or to satisfy special circuit requirements.

Ten standard tunable LC networks are available for a wide range of applications. Variations of these standard units, or special designs, will satisfy most other requirements. Write for bulletin MTLC 65-2.

JFD "TODAY'S COMPONENTS BUILT FOR TOMORROW'S CHALLENGES"

JFD ELECTRONICS CO. / COMPONENTS DIVISION 15th Avenue at 62nd Street Brooklyn, N. Y. 11219 / Phone 212-331-1000 • **Sales Offices**—Arcadia, Calif. Chi., Ill. / Balt., Md. / Saxonville, Mass. / Bklyn., N. Y. / New Hartford, N. Y. Cinn., Ohio / Phila., Pa. / Pitts., Pa. / Paris, France / Azor, Israel

ON READER-SERVICE CARD CIRCLE 55

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A series of complete 5-day programs researched by RCA Institutes, Inc., for engineers and other technical personnel faced with the challenging new areas of expanding technologies and systems refinements.

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DIGITAL SYSTEMS ENGINEERING	Atlanta	9/18
	Denver	9/25
	Washington, D.C.	10/16
	Rochester	10/23
	Long Island	11/6
	Los Angeles	12/4
DIGITAL ELECTRONICS	Washington, D.C.	9/11
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	Dallas	10/16
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ON READER-SERVICE CARD CIRCLE 56

New Literature

Electrolytic listing

This six-page brochure lists all color electrolytics by capacitance value. The listing includes over 250 wide-range lytics of the single, dual, triple and quadruple section types. These units are designed to replace over 2500 different exact replacements according to the wide-range principle of broad capacitance tolerances. The listing provides a blank space beside each rating which is useful for inventory and price notations. Cornell-Dubilier Electronics.

CIRCLE NO. 675

Cinch-Jones catalog

This 12-page illustrated catalog lists PC connectors, rack and panel connectors, sockets, terminal blocks and accessory hardware. About 1400 individual items are listed. The catalog shows suggested prices for quantities from 1 to 499. Essential electrical information is included for every part. The catalog includes a quick-reference tube socket chart which lists dozens of sockets in a new format showing, at a glance, construction materials, mounting type, mounting centers and applicable MIL specs. Sockets and accessories for all transistor types are also featured. Cinch-Jones.

CIRCLE NO. 676

Ceramics in electronics

The article is a review of a number of technical ceramics and compares relevant electronic properties in a number of graphs and charts. Beryllium oxide is compared to alumina, fosterite, magnesia and steatite. The Brush Beryllium Co.

CIRCLE NO. 677

Vibration testing of relays

This treatise deals with terminology and parameters of the various functions of random vibration testing. It discusses in particular the test equipment and related philosophies and methods that might be employed by a relay user or manufacturer. The paper is illustrated with explanatory diagrams and equations. Potter & Brumfield.

CIRCLE NO. 678

"Doorbell" modules

A four-page data sheet covers Unitrode's larger UG series of high voltage, high-current silicon "doorbell" rectifier modules as well as its older, smaller UD series. These modules are listed in both regular and fast-recovery versions, with current and voltage ratings given at typical operating temperatures. Unitrode Corp.

CIRCLE NO. 679

Dc measuring

A 12-page brochure describes JRL's instrumented concept for measuring dc resistance, voltage, current, and ratio with accuracies on the order of a few parts-per-million. Included is data covering measuring systems and devices such as bridges and potentiometers, precision current and voltage sources, voltage dividers and null detectors, voltage references and calibrator systems, and primary standards such as resistors and resistor networks. A full line of computer, instrument and production resistors, resistor networks and other components are also described. Julie Research Labs. Inc.

CIRCLE NO. 680

Microwave catalog

A 44 page catalog contains over 1000 models of directional couplers, circulators and isolators, RF loads and terminations, power and VSWR meters, switches, filters, and integrated devices. Bendix Microwave Devices.

CIRCLE NO. 681

Hybrid microcircuit

"The Making of a Hybrid" is the title of a new thin microcircuit brochure. The 12 pages tell the story about the making of a hybrid microcircuit, step-by-step, from the engineer schematic to the final package. The Wems manufacturing process is covered in detail as you are guided pictorially through the plant. Wems, Inc.

CIRCLE NO. 682

Ceramic magnet material

This bulletin presents demagnetization and energy product curves, discusses applications, temperature resistance and magnetization. Typical magnetic properties are listed, and such material characteristics as dimensional tolerances, ring-magnet tolerances and density are described. Indiana General Corp.

CIRCLE NO. 683

Name-plate catalog

Showing more than 100 different identification products, this 32-page catalog is designed to offer helpful layouts, technical data and price information. Special pages are devoted to advertising posters, truck signs, decals, name plates, warning tags, employee and visitor badges, parking-control labels, property identification tags and other identification products. Requests should be made on your company letterhead. Seton Name Plate Corp.

CIRCLE NO. 684

COULD YOU SLICE THIS ANGLE INTO 300 EQUAL PARTS?

OR MAKE A CRYSTAL FILTER HAVING 0.1% PHASE LINEARITY OVER 1500° PHASE SHIFT?

OR MAKE AN OSCILLATOR ACCURATE TO .001% OR ±.00001% AT AMBIENT TEMPERATURE?

McCOY DOES IT EVERY DAY!

McCoy makes precision crystal oscillators—in a variety of designs—covering the 400 Hz-150 MHz range.

One example is the completely-packaged HC-6 crystal oscillator shown above. Designs vary from economical commercial units for use in limited environments to highest reliability components and techniques for use in severe aerospace environments. McCoy oscillators give optimum performance even under severe changes in temperature, shock and vibration.

McCoy engineers and production people apply years of experience to give you many types of oscillators without expensive engineering costs. McCoy offers oven-oscillator assemblies...controlled thermostatically or proportionally; crystal oscillators...temperature-compensated (TCXO's) or voltage-controlled (VCXO's).

McCoy also makes the most complete line of precision crystal filters covering 5KHz to 125 MHz, withstanding severe shock and vibration at ambients of −55 to +105°C.

Precision of these oscillators and filters results from using McCoy-made quartz crystals with proper combinations of inductance, capacity, Q and frequency stability. Specify McCoy and get the highest quality available! For full details, write for new catalog.

McCOY ELECTRONICS COMPANY
A Subsidiary of OAK ELECTRO/NETICS CORP
Mt. Holly Springs, Pennsylvania 17065

ON READER-SERVICE CARD CIRCLE 57

Temperature test chambers

To assist the potential user in choosing the test chamber ideal for his particular purpose, Statham has produced a package entitled "Temperature Test Chambers and Accessories," which sets forth the qualities peculiar to each chamber, features of particular interest, suggestions for general, and special-purpose applications, and accessories available for each model. A reference chart summarizes the features of each chamber, and includes such specification data as temperature range, test area, control accuracy, heating and cooling rate, coolant used, outside dimensions, and weight. A temperature conversion chart is also included. Statham Instruments, Inc.

CIRCLE NO. 689

Temperature transducers

This 32-page illustrated catalog covers temperature measurements in the range of −452°F to +2000°F for fluids, gases, and surface measurements. The brochure provides resistance versus temperature graphs for nickel, balco, tungsten and platinum element materials, as well as resistance versus temperature tables for platinum both in centigrade and fahrenheit. Scientific Engineering & Mfg. Co.

CIRCLE NO. 690

Solid-state converters

A 30-page catalog describes a line of frequency-to-dc converters and oscillators. Coverters cover a frequency range from 0 to 100 Hz and oscillators range from 25 Hz to 20 MHz. All units are of solid-state design and modular construction, and can be utilized for military and industrial applications. Solid State Electronics Corp.

CIRCLE NO. 691

Solderless terminals

Nearly 50 new solderless wiring devices have been incorporated in this 28-page catalog containing complete descriptions, electrical and mechanical specifications, and dimensional data for the product line. The products described include straight and right-angle receptacles, tabs, insulating sleeves, splices, multi-position connectors and special-purpose items. The terminals described in this catalog can be crimped individually or automatically applied at rates up to 11,400 per hour. AMP Inc.

CIRCLE NO. 692

Electrical connection terms

This 10-page glossary will help you to understand the language peculiar to connectors in the aerospace industries. The terms are from the SAE aerospace recommended practice specifications Schweber Electronics.

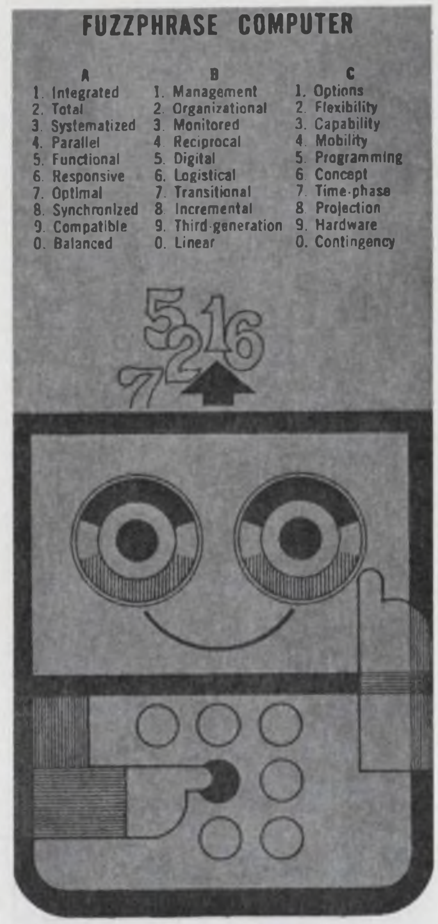
CIRCLE NO. 693

Digital building blocks

This 100-page two-color booklet describes the functions, testing, over-all reliability and support hardware of the many modules available. It contains more than 40 pages of specifications of modules in such family types as flip-flops, passive gates, active gates, lamp/relay drivers and multifunctional types. The booklet is useful to circuit engineers who are designing systems in the areas of numerical control, machine tool, highway traffic control, railroad control, biomedical, chemical and water and air pollution. Philco-Ford.

CIRCLE NO. 694

NEW LITERATURE



Fuzzphase computer

When at a loss for words use this semi-automatic device for generating striking or memorable phrases in memoranda, telephone conversations, proposals, spec negotiations, or other occasions requiring obfuscatory capability. Take any random 3-digit number, and choose from columns A, B, or C, respectively, the words corresponding to each digit (e.g. the number 792 is optimal third-generation flexibility). Signetics Corp.

CIRCLE NO. 695

Waveguide reference

This brochure describes the product line and includes a waveguide reference chart and flange guide. The waveguide reference chart covers the frequency range from 0.490 to 260 kHz and includes M85/1 MIL spec. cross-reference information. All products are described in detail—waveguide-to-waveguide transitions, waveguide terminations, waveguide-to-coaxial transitions, flanges, straight sections, twists, waveguide bends, accessories and special configurations. Specialty Waveguide Corp.

CIRCLE NO. 696

Wiring systems

This bulletin presents the basic elements and techniques of Signaflo wiring systems as well as applications for signal transmission, control wiring, flexing wires, and interconnection and structural systems designed for memory devices. Illustrated are wiring systems designed for controlled impedance valves, propagation velocity, crosstalk, capacitance, and other physical and electrical parameters. Also shown are single and multi-layered systems as well as systems shielded on one or two sides with various shielding materials such as metal foil, deposited metal, wire mesh, and special dielectrics. ACI division of Kent Corp.

CIRCLE NO. 697

Servo designs

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Oct. 9-10
'Managing Engineering Manpower' Conference (San Francisco) Sponsor: ASME; R. J. Wilson, Muller, Jordan & Herrick, 125 East 50 St., New York, N. Y. 10022.
CIRCLE NO. 603

Oct. 16-19
Users of Automatic Information Display Equipment Meeting (Washington, D. C.) Sponsor: UAIDE; G. E. Perez, UAIDE Program Chairman, P. O. Box 6749, Fort Davis Station, Washington, D. C. 20020.
CIRCLE NO. 604

Oct. 18-20
International Electron Devices Meeting (Washington, D. C.) Sponsor: IEEE; W. S. Patton, Publicity Chairman, Litton Industries, 960 Industrial Way, San Carlos. Calif. 94070.
CIRCLE NO. 605

Oct. 23-27
AIAA Meeting and Technical Display (Anaheim, Calif.) Sponsor: American Institute of Aeronautics and Astronautics; A. G. Kildow, AIAA, 1290 Sixth Avenue, New York, N. Y. 10019.
CIRCLE NO. 606

Oct. 23-25
National Electronics Conference and Exhibition (Chicago) Sponsor: IEEE; National Electronics Conference, 228 N. La Salle St., Chicago, Ill. 60601.
CIRCLE NO. 607

Oct. 23-27
Business Equipment Exposition and Conference (New York) Sponsor: BEMA; L. C. Messick, BEMA, 235 East 42 St., New York, N. Y. 10017.
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Power Rating	4 Watts	8 Watts	12 Watts	2 Watts	5 Watts	4 Watts
Volume	0.064 in.³	0.123 in.³	0.320 in.³	0.242 in.³	0.600 in.³	0.145 in.³
Power Density (25° C)	62.0 w/in.³	65.0 w/in.³	37.5 w/in.³	8.3 w/in.³	8.3 w/in.³	27.6 w/in.³
Power Density (125° C)	20.4 w/in.³	21.4 w/in.³	12.4 w/in.³	8.3 w/in.³	2.1 w/in.³	13.8 w/in.³
Life Stability (Typical) *	.1%	.1%	.1%	0.5%	0.5%	3%
Temp. Coefficient	25 or 50 ppm/° C			50 ppm/° C	500 ppm/° C	300 ppm/° C
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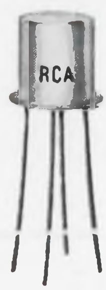

TO-72

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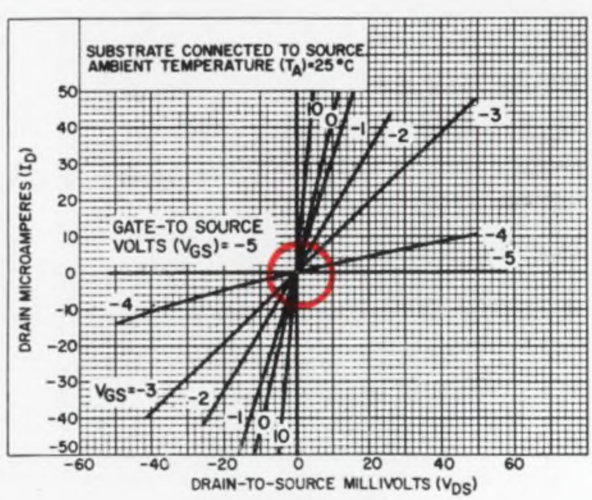

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