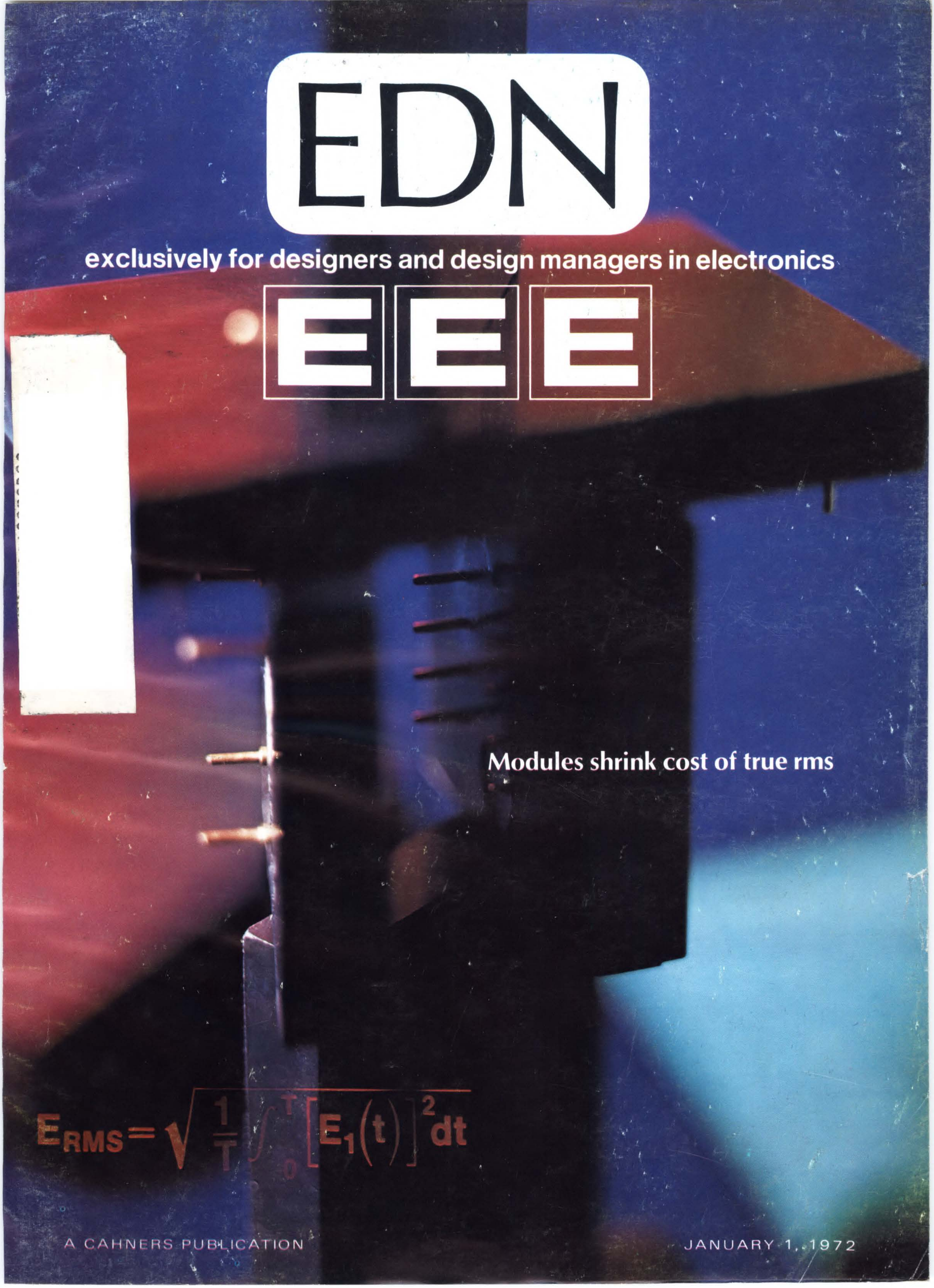
EDN

exclusively for designers and design managers in electronics

EEE



Modules shrink cost of true rms

$$E_{RMS} = \sqrt{\frac{1}{T}\int_0^T \left[E_1(t)\right]^2 dt}$$

A CAHNERS PUBLICATION

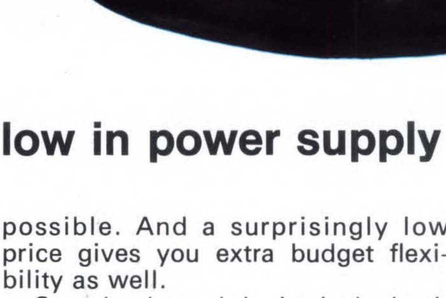
JANUARY 1, 1972

A new low in power supply design.

Acopian's new low profile power supply offers outstanding performance. Line and load regulation is .005% or 1 mv. Ripple is 250 microvolts. Prolonged short circuits or overloads won't damage it. And built-in overvoltage protection is available as an option.

Yet, it's the thinnest, flattest, most "placeable" 4.0 amp series regulated power supply ever offered . . . just 1.68" low. This low profile makes it perfect for mounting on a $1\frac{3}{4}$" high panel, or vertically in a narrow space. Acopian's new flat package gives you design flexibility never before possible. And a surprisingly low price gives you extra budget flexibility as well.

Standard models include both wide and narrow voltage ranges. Outputs from 0 to 48 volts. Current ratings from 1 to 4 amp. Prices from $80.00.



For the full low-down on the new low-down power supply, write or call Acopian Corp., Easton, Pa. 18042. Telephone: 215-258-5441. And remember, Acopian offers 82,000 other power supplies, each shipped with this tag . . .

CIRCLE NO. 1

A full-function digital multimeter + A lab-quality digital AC voltmeter

...both for $595

HP's new 3469A gives you a general-purpose digital multimeter *plus* a lab-quality digital AC voltmeter—for the price of the AC voltmeter alone. Now, you don't have to buy two (or more) instruments to get the capabilities you need—or compromise on quality to stay within your budget.

As a general-purpose multimeter, the 3469A gives you exceptional capabilities. Its 1Ω range lets you measure low-resistance components and even contact resistances of a few milliohms, with an accuracy of ±0.25% reading ±0.5% range. To make the low range easily useable, a unique offset adjustment lets you compensate for lead resistance. In the higher ranges (100Ω to 10 MΩ), accuracy is ±0.3% reading ±0.2% range. The 3469A also gives you five DC voltage ranges (100 mV to 1000 V) and six DC ampere ranges (1 μA to 100 mA), with accuracy of ±0.2% reading ±0.2% range or better, depending on range.

As an AC voltmeter, the 3469A is unmatched at any price. You get seven voltage scales, ranging from 1000 V full-scale down to 1 mV full-scale—100 times the sensitivity of other digital meters. You also get a 10 MHz bandwidth capability—100 times greater than other digital multimeters—with a basic accuracy of ±0.3% reading ±0.3% range. And you get a bright, ultra-reliable, shaped-character GaAsP display, that's easier to read than tubes or bar-segment numerals.

Compare the 3469A's specs with any other meter's — and you'll agree that there's no better value, at any price. For further information on the 3469A, contact your local HP field engineer, or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

091/16

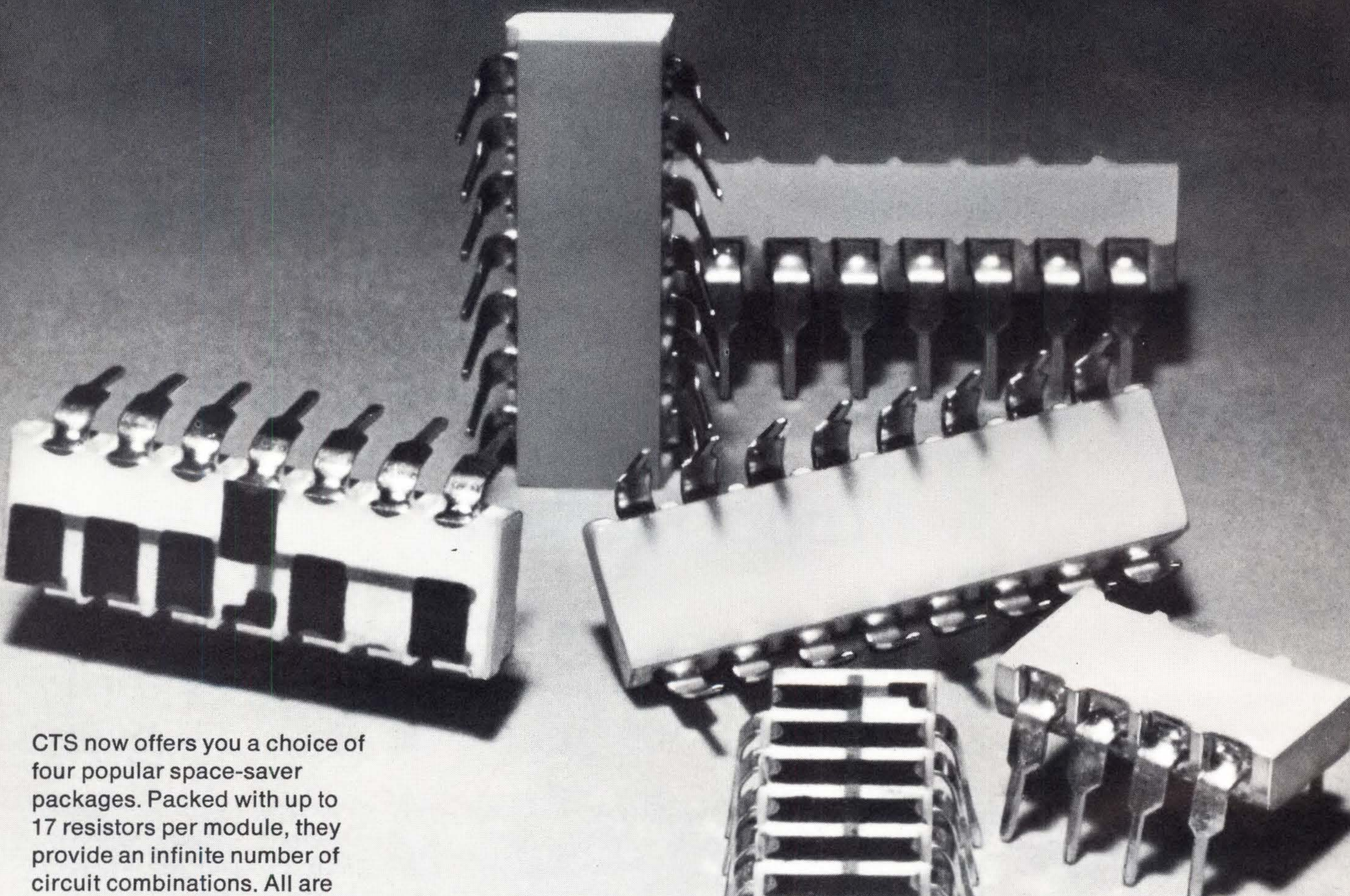
HEWLETT hp PACKARD

DIGITAL VOLTMETERS

CIRCLE NO. 2

We packed even more circuitry into CTS cermet resistor networks.

8,-14,-16 and -18 lead styles Series 760 Dual In-Line Packages.



CTS now offers you a choice of four popular space-saver packages. Packed with up to 17 resistors per module, they provide an infinite number of circuit combinations. All are designed to simplify automatic insertion along with IC's and other DIP products for reduced costs. Easy to hand-mount, too. Available without inorganic cover coat, so you can trim for circuit balance in your own plant. 5 lbs. pull strength on all leads; .100″ lead spacing; rated up to 2 watts on 18 lead style. Choose from standard circuit available for immediate delivery (see data sheet 3760 . . . or custom design to specifications).

CTS of Berne, Inc., Berne, Indiana 46711. (219) 589-3111.

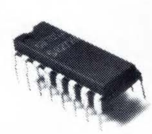
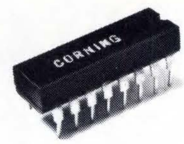
Series 750 edge mount cermet resistor packages available in infinite number of resistor patterns and wide selection of package configurations.

CTS CORPORATION
Elkhart, Indiana

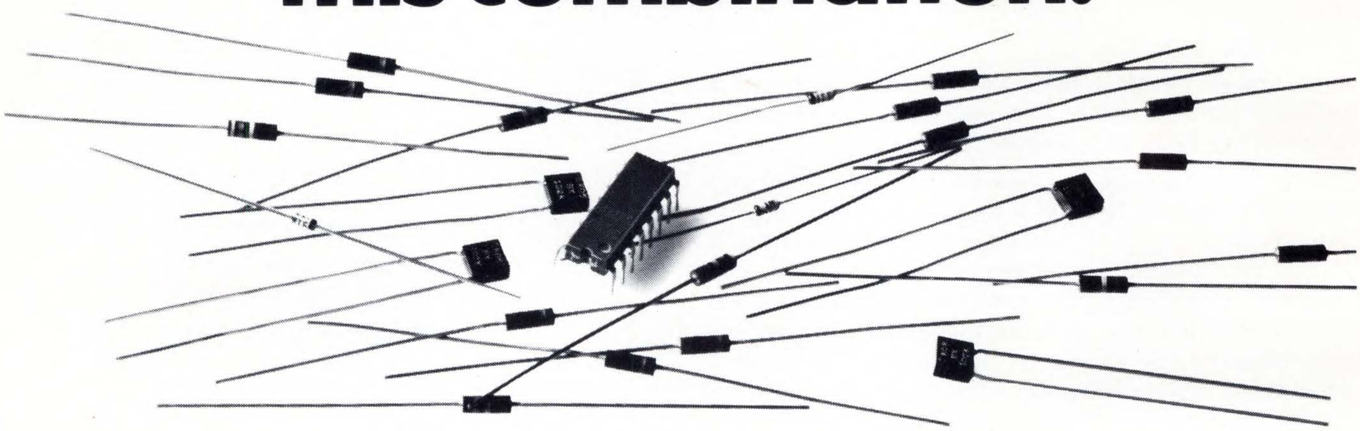
A world leader in cermet and variable resistor technology

CIRCLE NO. 3

This Combination

Integrated circuit   CORDIP™ Component Network

replaces this combination.



Integrated circuit plus 23 discrete resistors, capacitors, and diodes

Corning's new CORDIP™ component networks take in much of what IC's leave out—outboard discretes.

Unlike screened thick/thin film networks, CORDIP component networks give you custom combinations of discrete resistors, capacitors, and diodes in a dual in-line package.

With combinations of up to 20 components in a standard 14-pin package. Up to 23 in a 16-pin package.

With virtually unlimited circuit complexity. With all inter-connections inside the pretested package.

Which gives you greater reliability and fewer production losses.

Combinations of resistors, capacitors and diodes with different tolerances, temperature coefficients and ratings are available in one package.

Which makes it possible to give you almost any custom combination you specify.

Large orders or small.

And we can make prototypes quickly for you, with almost any combination you specify.

CORDIP component networks are ready to plug in and are fully compatible with IC sequencing and insertion equipment.

CORDIP component networks. You'll save a lot of board space and production costs; you'll gain a lot more reliability and flexibility.

Call or send us your circuit requirements.

Corning Glass Works, Electronic Products Division, Corning, New York 14830.
(607) 962-4444 Ext. 8684.

SPECIFICATIONS

	Resistors	*Capacitors*	*Diodes*
Range	10Ω-150K	10-27,000 pF	Low Signal Silicon Planar Types
Tolerance	from 1%	from 5%	
TC	from 50 ppm	+ 2%, −10%	
Ratio	>15,000:1	>2,700:1	

CORDIP™ COMPONENT NETWORKS
From

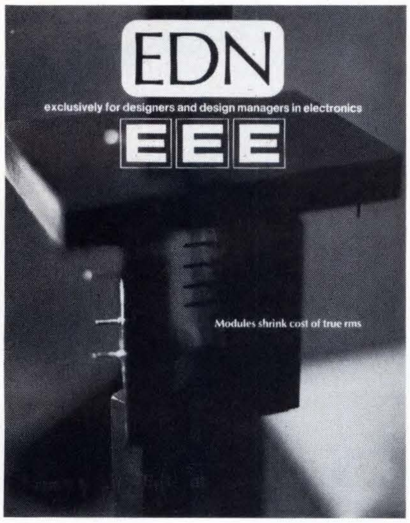
CORNING
ELECTRONICS

CIRCLE NO. 5

JANUARY 1, 1972
VOLUME 17, NUMBER 1

EDN/EEE

EXCLUSIVELY
FOR DESIGNERS
AND DESIGN MANAGERS
IN ELECTRONICS



COVER

Cover photo by EDN/EEE's Art Director, Ray Lewis, stacks up several Intronics "True RMS" Modules. (For the story, see p. 34).

DESIGN NEWS

DESIGN FEATURES

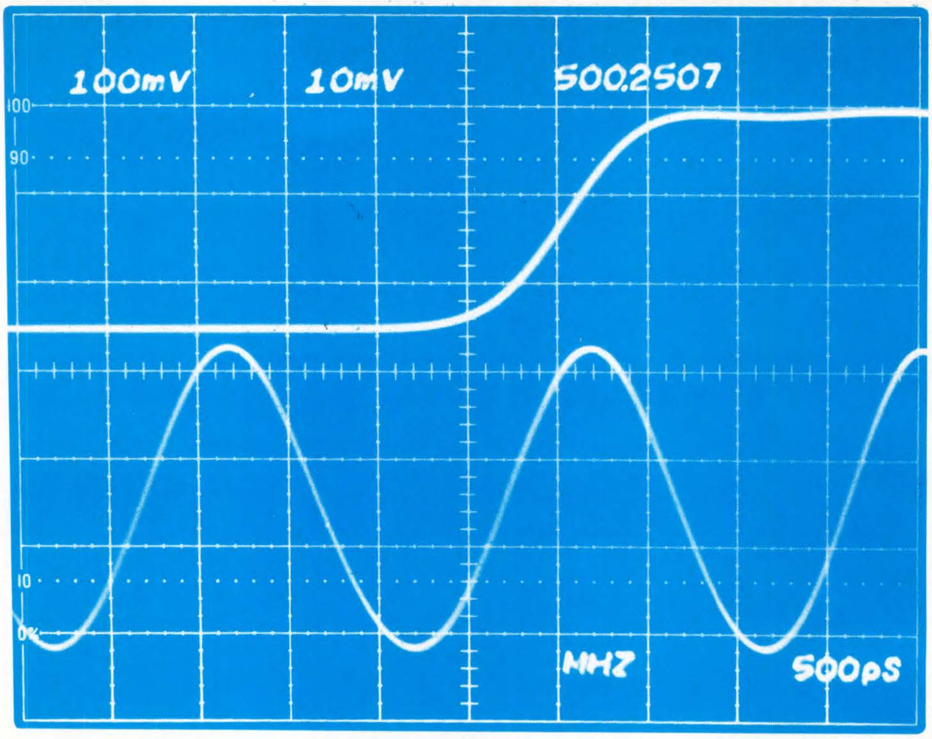
PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

International Business Press Associates
DESIGN ELECTRONICS
ELECTRONICS WEEKLY
EDN/EEE
ELEKTRONIK
ELEKTRONIK-ZEITUNG
INTER ELECTRONIQUE

 Norman L. Cahners, Chairman of the Board; Saul Goldweitz, President; H. V. Drumm, Executive Vice President/Magazines; Ned Johnson, Senior Vice President/Magazines. EDN/EEE (formerly Electrical Design News) is published semi-monthly. Editorial, Advertising offices, 221 Columbus Ave., Boston, Mass. 02116 (617) 536-7780. Subscription offices, 270 St. Paul St., Denver, Colo. 80206 (303) 388-4511. Printed at 85 W. Harrison St., Chicago, Ill. 60605. Controlled circulation postage paid at Chicago, Ill. Send form 3579 to Subscription office. EDN/EEE is circulated to electronic design engineers and engineering managers in electronic OEM industries. Plants having more than twenty employees and manufacturing electronically operated or controlled equipment of their own design are considered part of this industry. Engineers in such plants responsible for specification of components, materials and test equipment for electronic application may receive EDN/EEE without charge. Completed qualification form and company letterhead required. Subscriptions to others in continental United States, $2 per copy. $20 per year. Send requests for qualification forms and changes of address to subscription office in Denver, Colo.



CRT READOUT

CHAR. SET ABCDEFGHIJKLMNPQRSTUVWXYZ0123456789mμnpd↓</.>Δ+-Ω
Actual Size

TEKTRONIX 7000-Series Oscilloscope Systems

CRT READOUT, unique to the *TEKTRONIX 7000-Series Oscilloscope Systems,* provides a combined display of waveforms, measurement parameters and symbols on the CRT for direct reading.

Wrong answers because of overlooked control settings are now passé. CRT READOUT tells you the full story. Speed, perception and convenience are available because the scale data is printed right on the display. These values are automatically corrected for both probe attenuation and sweep magnification. There are also special symbols for identifying trace position (IDENTIFY), amplifier polarity (↓) and uncalibration (>).

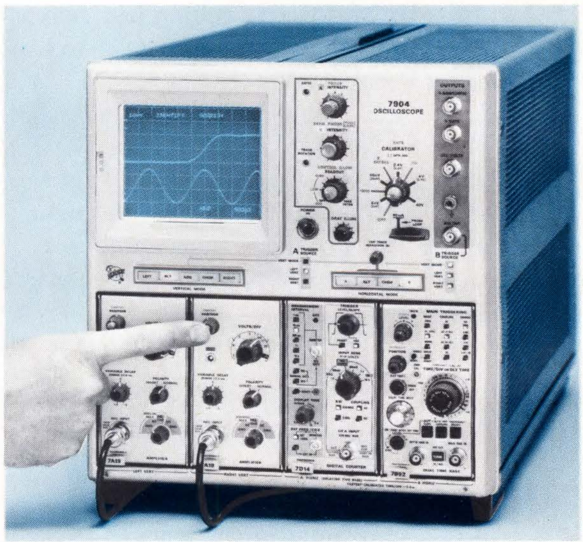
Correct answers are always on your photographs with CRT READOUT. The photos will show the waveforms along with their parameters and symbols — A REAL TIME SAVER.

CRT READOUT is available for 7000-Series plug-ins working in *frequency, time, voltage, current, resistance* and *temperature* domains - - - AND there are MORE coming.

CRT READOUT functions in all 7000-Series mainframes and plug-ins except those having a suffix N (7403N, 7B53N, etc.).

Tektronix, Inc. lease and rental plans are available in the U.S.A. For information, call your local TEKTRONIX Field Engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

CIRCLE NO. 7



CRT READOUT responding to various functional instructions and generating up to 50 symbols is shown using the 500-MHz 7904, a four-plug-in Oscilloscope with a pair of 500-MHz, 10-mV 7A19 Amplifiers, a 525-MHz 7D14 Digital Counter and a 500-ps/cm 7B92 Dual Time Base.

TEKTRONIX®

committed to technical excellence

A few words for the new year

As 1972 begins, we at EDN/EEE would like to wish each and every one of our readers a happy and prosperous new year.

We could go on and make predictions or encourage resolutions, but we're sure that most people have probably had their fill of this sort of thing by now. So we'll just offer three suggestions for the new year. Following them won't necessarily make the year a more prosperous one, but may make it more enjoyable and rewarding.

Our first suggestion is to enter our Design Contest, the details of which are given on p. 106-107. The contest will provide an opportunity for you to test your creativity, and have some fun—and perhaps become $1000 richer to boot. What better way to start a new year? In a subsequent issue we'll print not only the winning entries, but any others we think you may enjoy hearing about.

Our second suggestion is that you take up some new interest this year—one that is totally unrelated to your work. This interest might be learning to play bridge, studying a foreign language, or even becoming a Boy Scout leader or assistant.

Such an interest shouldn't be difficult to decide on. We've all thought at one time or another about taking up some hobby or pursuing some subject but didn't do anything about it because we were too busy. To start, therefore, it's necessary to be arbitrary and just take the time, whether or not it seems to be at the expense of something else.

There are obvious advantages in developing new interests, particularly for engineers, who tend to be work-oriented. The mind needs challenge to realize its full capability; but it also needs diversion. And we're afraid that many engineers are too wrapped up in their work and things related to it, almost to the exclusion of anything else that provides intellectual challenge and enjoyment. One new interest, of course, isn't the complete answer—but it's a start.

The third suggestion is to set one or more goals for yourself now, at the beginning of the year, so that in December you'll have a frame of reference against which to judge how well you did for the year. It's amazing how many people look back every December and feel that they should have done better but aren't exactly sure how or why.

To avoid this uncertainty set yourself goals, whether they relate to money, position, or just being recognized as the best engineer in your department or group.

Frank Egan
Editor

STAFF

Publisher
E. Patrick Wiesner

Editorial Staff
Frank Egan, *Editor*
Steve Erenburg, *Managing Editor*
Harry Howard, *Senior Editor*
Earle Dilatush, *Western Field Editor*
Bob Cushman, *New York Editor*
Roy Forsberg, *Boston Editor*
Roger Allan, *Associate Editor*
Bill Furlow, *Associate Editor*
Thelma Main, *Editorial Assistant*

Art Staff
Ray Lewis, *Director*
Edgar Good, *Assistant Director*
Mike Beard, *Illustrator*
Bill Caulfield, *Illustrator*

Production Manager
Wayne Hulitzky

Assistant Production Manager
Constance J. Martin

Circulation Manager
Ron Kinnes

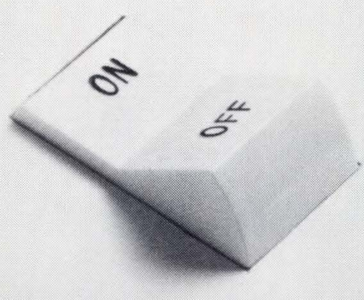
Editorial Consultant
John Peter

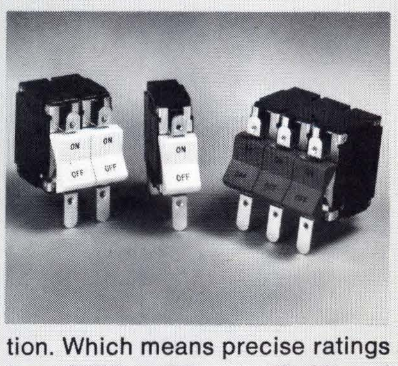
Editorial Office Addresses
Executive *(617) 536-7780*
221 Columbus Ave.
Boston, Mass. 02116

New York (212) 689-3250
205 E. 42nd St.
New York, N.Y. 10017

Denver (303) 388-4511
270 St. Paul St.
Denver, Colo. 80206

And it doesn't look like a circuit breaker.





Therein lies its beauty.

When you use the JC rocker-handle circuit breaker as a front-panel on-off switch you get overload protection, too. Without the expense of using a switch and a breaker.

Behind that handsome rocker handle is the engineering and construction you know Heinemann for. Hydraulic-magnetic protection. Which means precise ratings from 0.020 to 30 amp. 32, 50, and 65V DC; 125 and 250V at 60 Hz and 400 Hz. Job-matched time delays or non-time-delay response. Temperature-stable trip points. Optional special-function internal circuits. One, two, or three-pole models. And a five-year warranty.

Oh, yes. The rocker handle comes in white or gray.

A pretty attractive package. All around.

Write us for Bulletin 3381. Heinemann Electric Company, 2626 Brunswick Pike, Trenton, N.J. 08602. Or Heinemann Electric (Europe) GmbH, 4 Düsseldorf, Jägerhofstrasse 29, Germany.

HEiNEMANN

4933

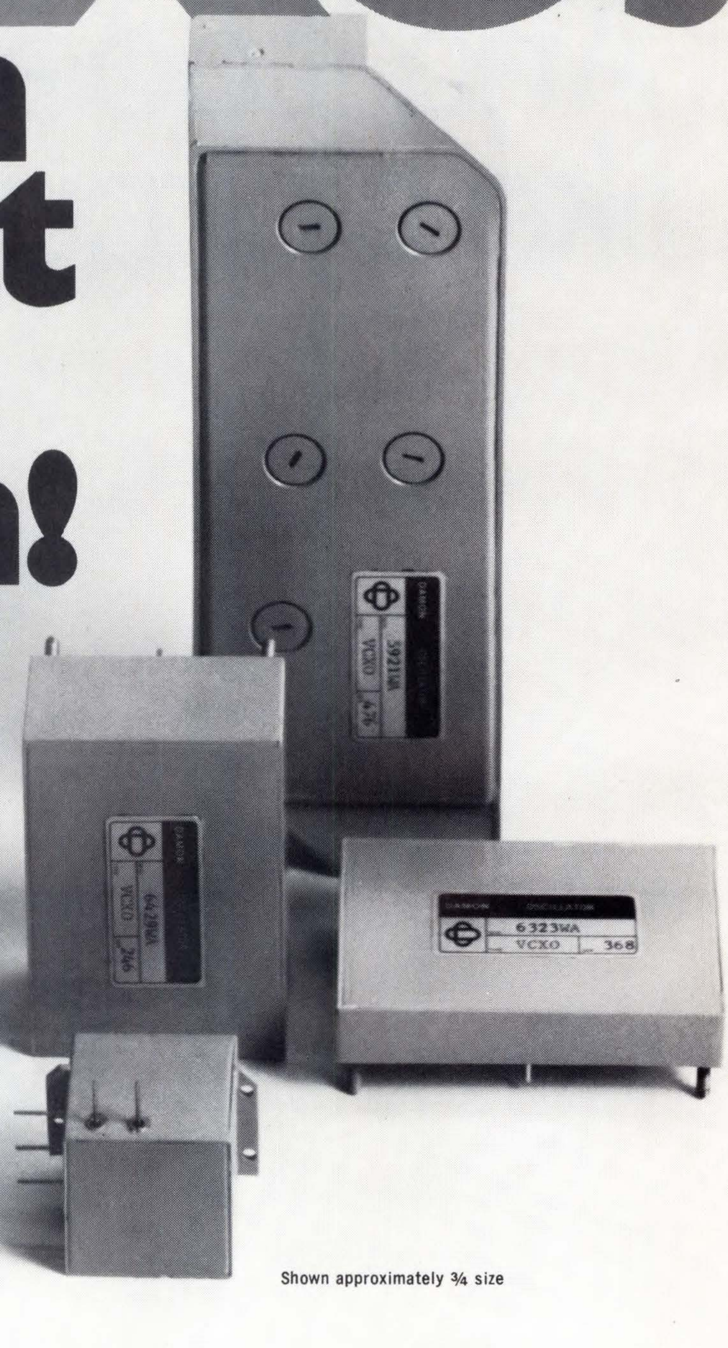
CIRCLE NO. 9

VCXOs

Get 'em straight from Damon!

Whether you're in a sweat on a VCXO prototype for a tough application – or need a production run in a hurry, you can get 'em straight from Damon. Speedy proficiency in design and production of VCXOs allows Damon to deliver all-silicon solid state devices with linearity to within 1% of best straight line and frequency deviation to ±0.25%.

Just glance at the specification guide below for more good news on available characteristics. Computer-assisted designs are available, too. Ask Damon today for a quote on VCXOs tailored to your specifications – and deadlines. Call or write: Damon/Electronics Division, 115 Fourth Ave., Needham, Mass. 02194. Phone: (617) 449-0800.



Shown approximately ¾ size

SPECIFICATION GUIDE*

Parameter	Basic and Multiplier VCXOs	Mixer and Mixer-Multiplier VCXOs
Center Frequency	1 KHz to 300 MHz	100 Hz to 300 MHz
Frequency Deviation	±0.01% to ±0.25% of C.F.	±10 Hz to ±1 MHz
Frequency Stability 24 hr. @ 25°C	±1 to ±10 ppm	±0.5% of peak deviation
0 to 65°C (no oven)	±10 to ±50 ppm	±2% of peak deviation
Linearity	to within 1% of best straight line	to within 1% of best straight line
Minimum Deviation Rate	0 (dc)	0 (dc)
Maximum Deviation Rate	0.2% of C.F. (100 KHz max.)	10 KHz to 100 KHz
Mod. Voltage (Typical)	±5 V peak	±5 V peak
Mod. Input Impedance	>50 K ohms	>50 K ohms
Output Power Available	0.5 mw to 20 mw	0.5 mw to 20 mw
Load Impedance	50 ohms to 10 K ohms	50 ohms to 10 K ohms
Power Requirements (Typical)	−25 V ±1 V @ 30 ma	−25 V ±1 V @ 40-50 ma
C.F. Manual Adjustment Range	±0.01%	±5% of peak deviation

* Obviously, the limits are not absolute. The interrelationship of parameters for VCXOs are of such a nature as to permit optimization of any one or more characteristics to satisfy customer requirements.

DAMON

CIRCLE NO. 10

DIGITAL MEASUREMENT AND DISPLAY

Best buys Better specs Bigger digits

More than 50 standard models of **api** digital measurement/display devices get your measurements up front with excellent readability, clean styling and the stable, reliable performance of MOS/LSI circuitry. DTL/TTL compatible BCD outputs . . . autopolarity . . . display hold, print command, polarity and overrange outputs . . . programmable decimal points . . . 0.1% accuracy . . . 100 db common mode rejection . . . 1000 meg. input impedance — are features common to most models.

For premium performance in a small size at low cost, the new 2½- and 3½-digit **api** 4350 Series offers remarkable brilliance and clarity in ½″ planar 7-segment digits. Rugged, low voltage electrofluorescent tubes rated for 100,000 hours produce intense blue, green or turquoise display. Only 2.1″ high x 4″ wide.

For readability from 40 feet, the **api** 4300 Series units have ⅞″ high, 7-segment planar displays of four digits. Panel space only 3″ x 4.5″; separable power supplies save depth behind panel. DPM std. ranges to 19.99 mv and 1000 V, 19.99 ua and 199.9 ma. The **api** 4320 *Digital Temperature Indicator* also features isolated BCD output, 0.15% accuracy, 1°F. resolution. The **api** 4310 *Comparator* algebraically compares BCD input to a preset limit, for indication and on-off control. For complete specs and application help, write LFE, Process Control Division, 1601 Trapelo Road, Waltham, Mass. 02154. Tel. (617) 890-2000.

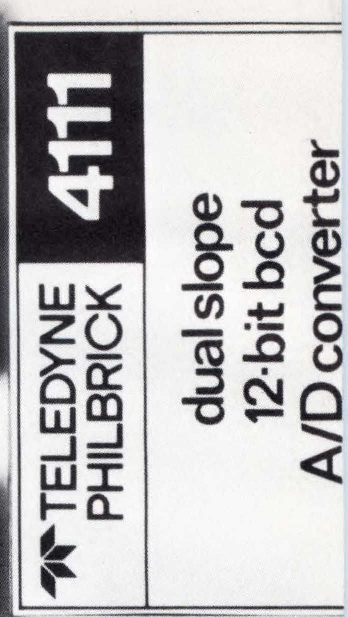
LFE CORPORATION

Process Control Division

CIRCLE NO. 11

NO. 122

NO. 123



NO. 127

NO. 124

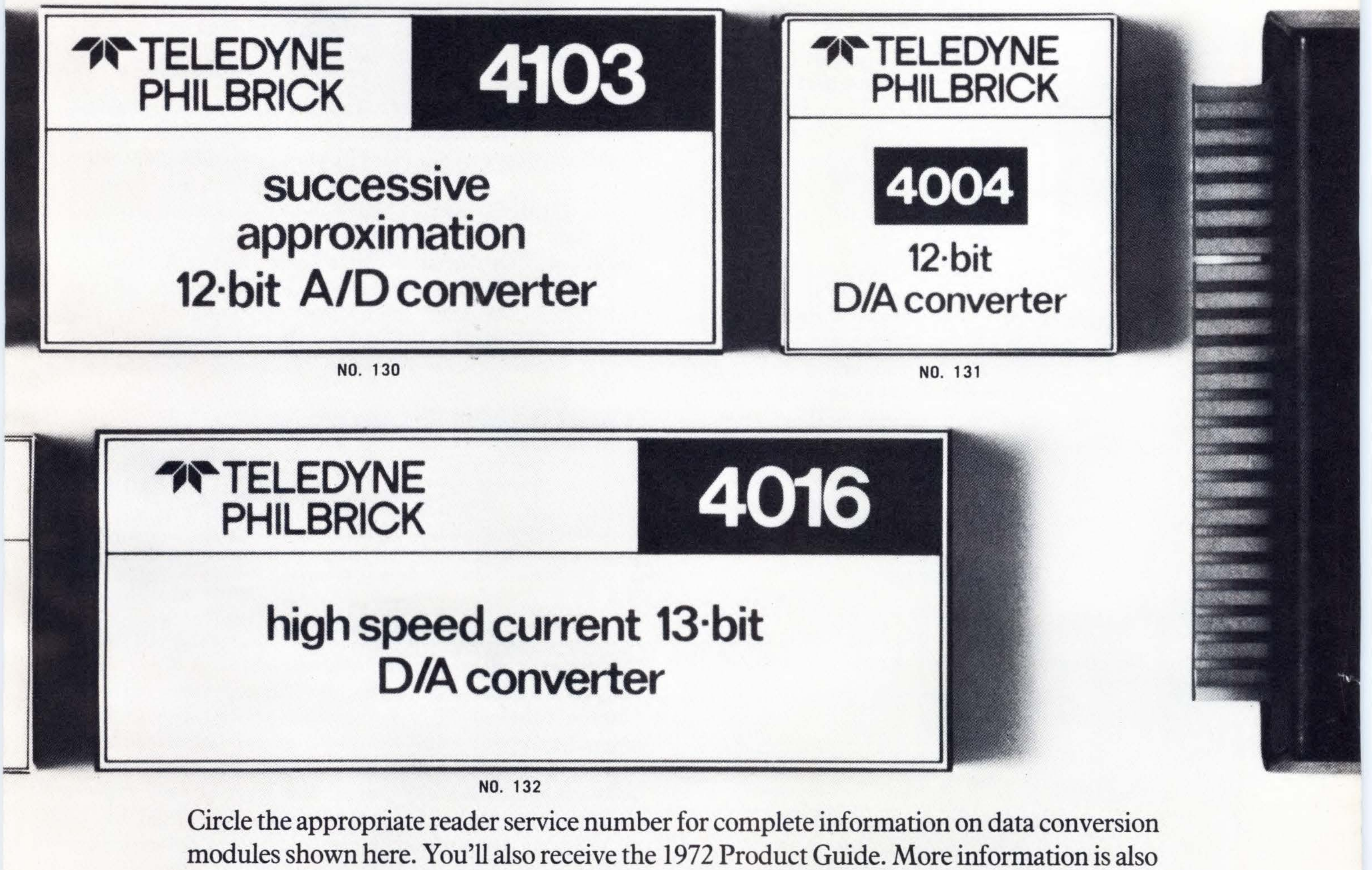
NO. 125

NO. 128

NO. 126

NO. 129

To show them all would take another 15 pages.

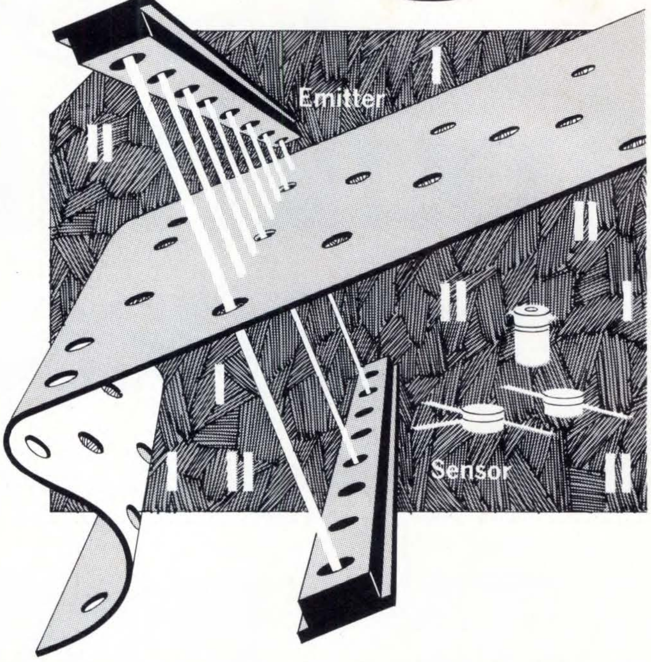


NO. 132

Circle the appropriate reader service number for complete information on data conversion modules shown here. You'll also receive the 1972 Product Guide. More information is also available from your local Philbrick representative or Teledyne Philbrick, Allied Drive at Route 128, Dedham, Mass. 02026. For toll-free data (800) 225-7883. In Mass. (617) 329-1600.

Philbrick Data Converters. A bit ahead of the rest.

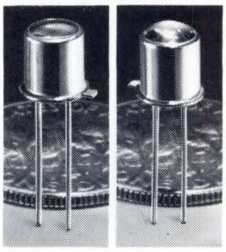
Read Light Right



Read Light Closely!

Light emitted from concentrated, multiple, high density light sources calls for light sensors of comparable mechanical mounting capability. Motorola plastic Micro-T* and hermetic "pill" detectors can be mounted close as 85 mils in discrete applications using manual soldering and 100 mils with flow soldering. Perfect emitter-detector matching is ensured through use of identical array packaging. For extremely high resolution requirements, Motorola standard monolithic, 39-element diode/transistor arrays are on 0.005″ center-to-center spacing. The active area is 0.005″ x 0.0045″ with 0.0005″ space between elements. Use both in OCR, mark sensor and card/tape reading designs.

Read Light Quickly!

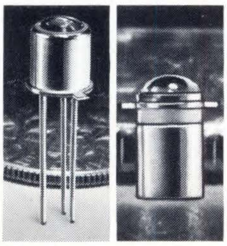


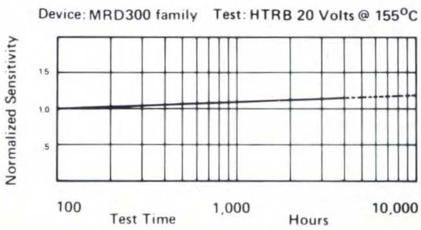
RELATIVE RESPONSE TIME

Light Sensor	Time
Motorola Pin Photodiode	1 ns
Photomultiplier Tube	4 ns
2N2369 Switching Transistor	6 ns
Motorola Phototransistor	4 μs
Motorola Photodarlington	300 μs
Cadmium Selenide Cell	0.5 ms
Cadmium Sulfide Cell	1 ms
Human Eye	16 ms

Ultra-fast recognition of red or IR wavelengths in laser detection, light demodulation, shaft/position encoders, switching and logic circuits in the nanosecond range demands ultra-fast devices. MRD500/510 PIN diodes typically respond in 1 ns; conventional, bulk-effect detectors need longer response times. Both units feature high sensitivity and are available with convex or flat glass lenses in standard, TO-18 cases. Exclusive Annular* passivation ensures long-term reliability and stability.

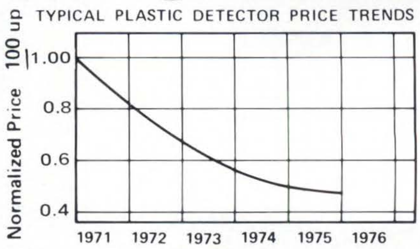
Read Light Reliably!

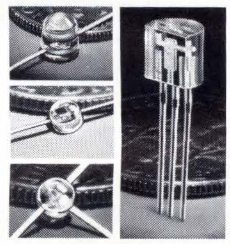




Critical to any application requiring stable characteristics over very-long-term operating life expectancy is detector sensitivity which must remain constant so system biasing is not thrown off spec. Similar to beta measurement in a conventional transistor, phototransistor sensitivity = output current ÷ light input. Curve shows the sensitivity for a standard hermetic, MRD300 detector family having little or no change in documented or projected sensitivity beyond 4,000 hours of testing. Indications from this and other ongoing tests show Motorola's family of Annular passivated light detectors to have identical reliability as standard metal-can transistors which have shrugged off millions of hours of rugged, mil-type life testing without significant failures.

Read Light Economically!





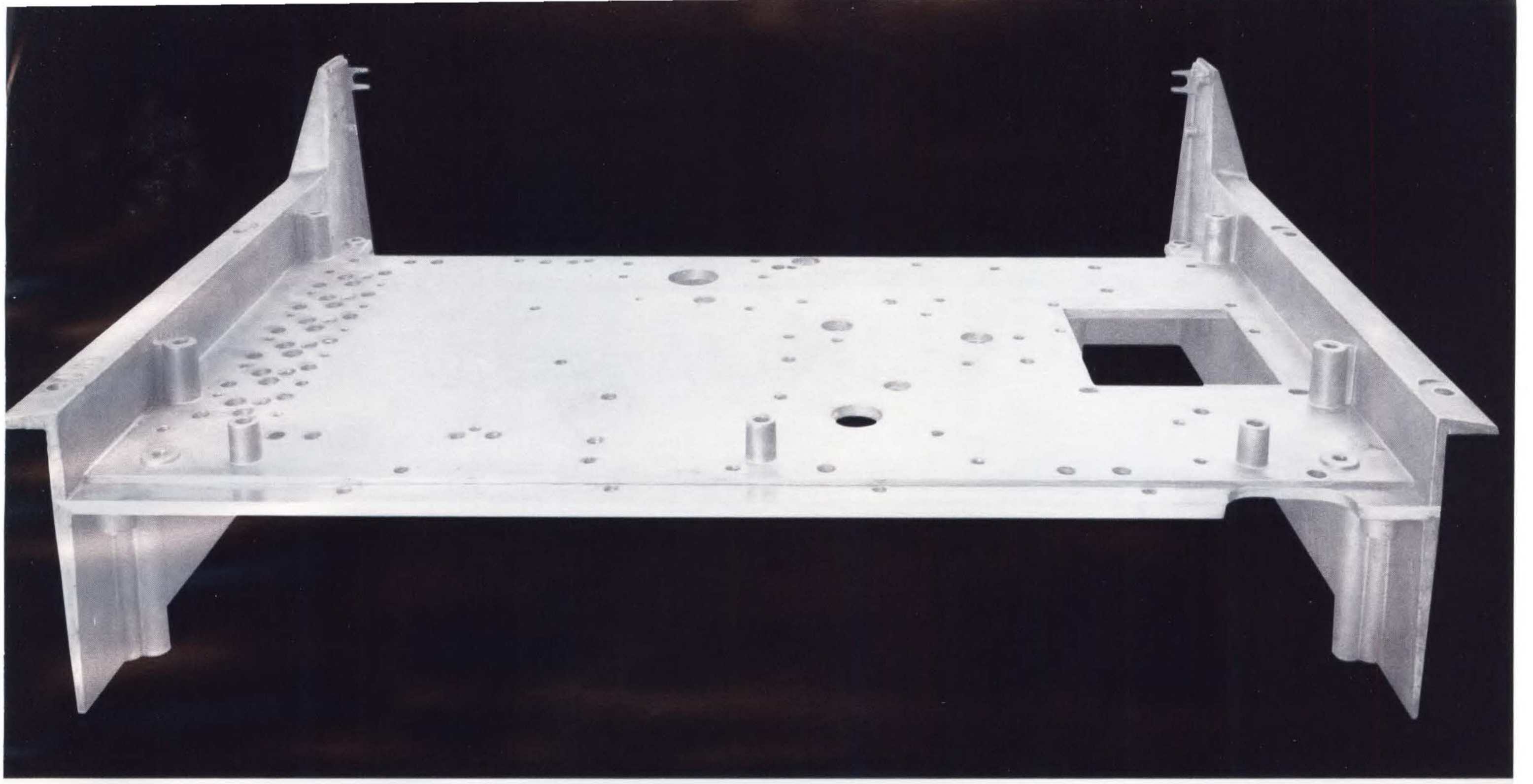
The trend in silicon photodetector pricing is *down!* And you can control light-generated current flow with 24 different Motorola PIN photodiodes, phototransistors and photo Darlingtons for optimized optical performance in dc to high frequency designs. For example, 100-up prices on the *metal,* MRD3050 series now start at only 80¢ — a level comparable to plastic! Select the right light detector for your design from the broadest light detector line available — Motorola's! Write Box 20912, Phoenix, AZ 85036 for complete detector data.

MOTOROLA OPTO
Let There Be Light

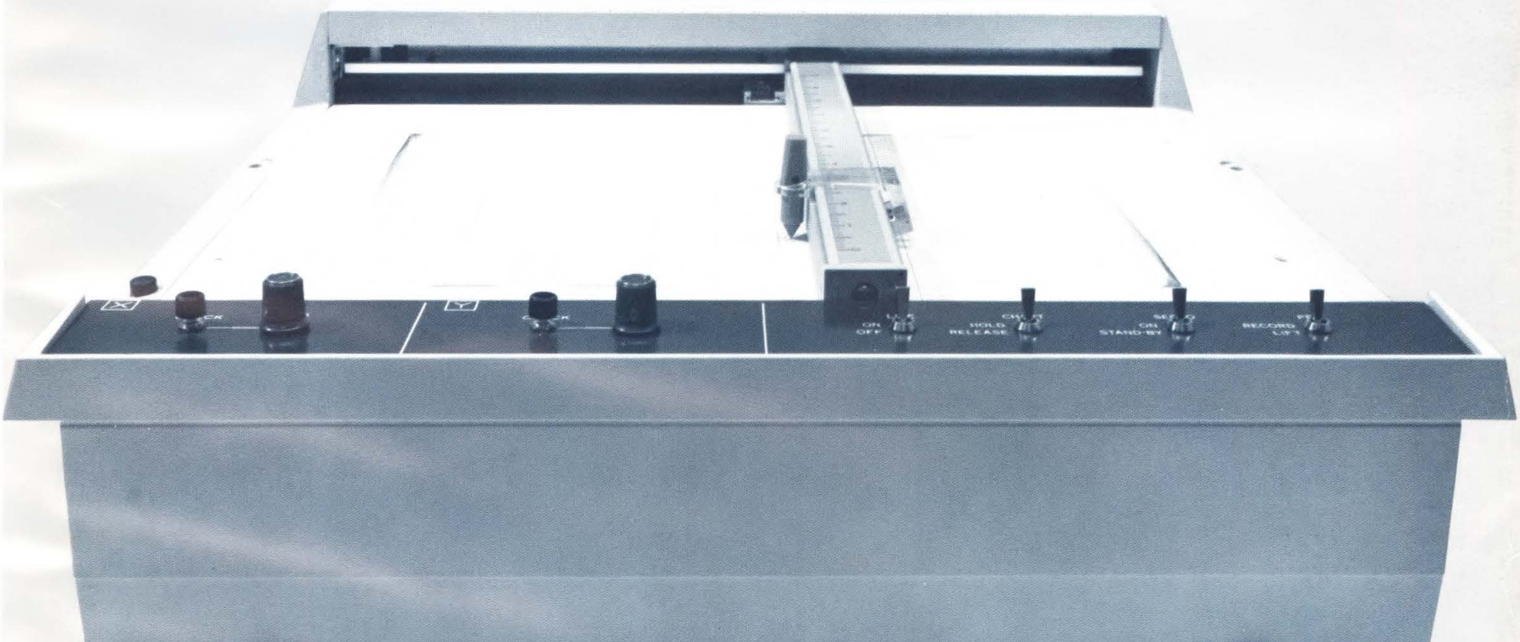
*TRADEMARK MOTOROLA INC.

CIRCLE NO. 13

CIRCLE NO. 14 ▸



Only one OEM xy recorder is cast for the role.



Ever try to find an xy recorder designed to adapt to your OEM system? We've built a totally new cast aluminum recorder because you've been buying modified laboratory machines for OEM applications. And paying for them in more ways than one.

HP's 7040 won't force you into buying anything you can't use. An OEM machine from the ground up, it's designed around a one-piece, die-cast aluminum mainframe... a rugged platform for the modular features you select. But *only* the features you select.

A complete cast of options lets you specify exactly what you need to do the job. Everything from a control panel (shown above) to rear connector. Nearly 40 independent options in all.

You get standard features that make sense in any OEM application. Things like Autogrip electrostatic holddown, IC circuitry, a long-life hybrid potentiometer, disposable pens and more. All the things we learned while pioneering the development of xy recorders for two decades.

A rugged die-cast mainframe. A complete cast of options. HP's new 7040 is the only OEM xy recorder cast for the role. Get specifications and discount data from Hewlett-Packard, 16399 West Bernardo Dr., San Diego, California 92127; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

GRAPHIC RECORDERS

111-04

The Digital Multiplier.

It can multiply two 8-bit signed numbers in 135 nanoseconds. But that's just the beginning. Look:

We have a super-fast, super-flexible, monolithic digital multiplier. It is the only one in the world.

It's the Am2505. It multiplies a 4-bit number by a 2-bit number and adds the 6-bit product to another 4-bit number. S = XY + K.

An array of 2505s multiplies two signed numbers in 2's complement representation, adds a third number in 2's complement representation, and gives you a double-length signed result also in 2's complement form.

You can make any size multiplier you need. (For longer word lengths, build a bigger array. If you add a few of our high-speed ALUs, the Am9340s, you can go even faster.)

The Am2505 can multiply numbers in active HIGH level (positive logic) or active LOW level (negative logic).

The Am2505 is ideal in digital filters, Fast Fourier Transform Processors and minicomputers.

But the most important feature of the Am2505 is that it's here, in quantity, all you need.

If you're doing digital signal processing or even thinking about doing it, call us or Hamilton/Avnet.

Delays and Package Count

Array Size	Number of Am2505s for 2n bit product	Number of Additional Am9340s	Typical Delay Times ns. at 25°C — Level of Adders Am9340: 0	1	2
8x8	8	0	135		
12x12	18	0	205		
	18	5		155	
16x16	32	0	275		
	32	7		185	
	32	16			180
20x20	50	0	345		
	50	9		220	
24x24	72	0	415		
	72	11		255	
	72	24			215
28x28	98	0	485		
	98	13		290	
32x32	128	0	555		
	128	15		325	
	128	32			250

Advanced Micro Devices, Inc.

Telephone 800-538-7904 toll free, and ask for Shel Schumaker, or in California 408-732-2400. In Los Angeles, Steve Zelencik at 213-360-2102. In Mid-America, Chuck Keough at 312-297-4115. In the eastern United States, Steve Marks at 212-343-2220, or in Boston, Vince Sabella at 617-861-1550. 901 Thompson Place, Sunnyvale, California 94086/TWX 910-339-9280/TLX 346306.

CIRCLE NO. 15

Hand is scanned for positive identification

Positive identification—a problem encountered by companies in access control, employee verification and computer access--has received a boost by a device from Identimation Corp., Northvale, N.J. By measuring the virtually unique geometry of a person's hand, reducing the measurement to a digital code and storing that code on the person's ID card and/or in a computer memory bank, the company claims to have achieved a new level of security.

Hand geometry, according to a study by the Stanford Research Institute, is a distinct human, measurable characteristic that can be related to individuals. Tolerances can be established to reduce the probability of cross identification to less than one in a thousand.

The basic unit can evaluate an infinite number of users at a cycle time of about 3 seconds; the time required to step up to the unit, insert a card, place the hand on the lighted surface of the unit for optical scanning, and then remove the hand and card.

It is designed to be used as a free-standing unmanned machine or in conjunction with computers or other devices and is reportedly able to be wed to existing systems with minor changes.

According to company reports, units are under test at a major Strategic Air Command Base for security control. One will soon be used to verify the identity of patients at a Methadone agency to reduce the quantity of Methadone presently reaching the black market. Contracts have also been received for delivery of a modified unit to serve as a collusion-proof time-clock terminal to provide verified information for payroll purposes. This system reportedly eliminates the need for time cards and key-punch operators because the data goes directly to magnetic tape and then into the computer.

Controlled access to restricted areas is provided by the Identimat 2000.

Persons seeking access insert an identity card in the slot.

Placing their hand on the machine initiates an optical scan which is used for comparison with infomation coded on the card. Acceptance or rejection is indicated by panel lights.

"Bucket brigade" IC forms heart of speech compression system

The first successful development of a practical "bucket brigade" integrated circuit is claimed by Amperex Electronics Corp., a division of North American Philips Corp., New York, N.Y. According to Mr. Selig Gertzis, Director of Operations of the Amperex Integrated Circuits Div. in Cranston, R.I., "bucket brigade" ICs have been the object of considerable interest in the electronics industry for many years, with proposals for such a device dating from 1952. Until now, however, technical and manufacturing problems have prevented a practical "bucket brigade" IC from reaching the market.

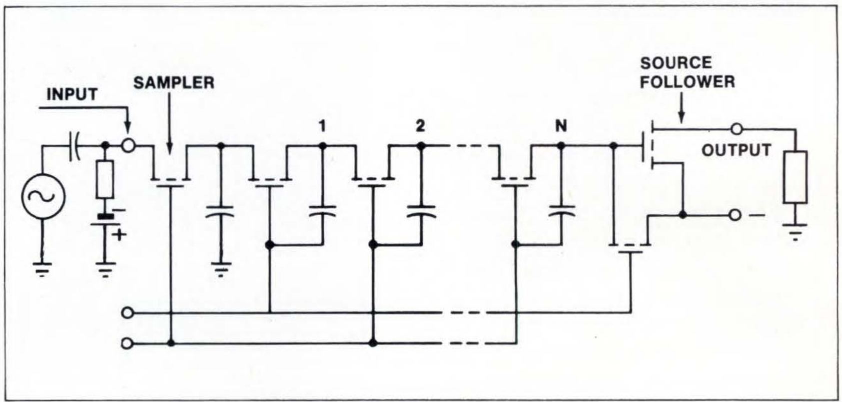
The term "bucket brigade" describes the way in which the device, an analog shift register, transfers information from stage to stage in response to timing signals. The new device, designated M31, is a p-channel MOS IC containing 32 analog shift stages—or "buckets"—plus an input sampling circuit and an output follower. Applications include variable length delay lines, scanning circuits and time-axis conversion. Because the M31 operates directly on the analog input signal, no analog-to-digital or digital-to-analog signal conversions are necessary.

In the first commercial application of the device by Cambridge Research and Development Group of Westport, Conn., the M31 is used as a variable-length audio-frequency delay line. Here it permits recorded speech to be compressed or expanded (speeded up or slowed down) by any amount up to ±400% of the originally recorded speed, and played back without distortion or appreciable loss of intelligibility. Cambridge Research and Development Group foresees wide application for its Variable Speech Control system in education, work with the blind and other handicapped groups, and in business and the professions. While speech compression without pitch distortion has previously been accomplished under laboratory conditions, the Cambridge system is said to be the first commercially-practical variable speech control system ever developed for OEMs and the general public.

The "bucket brigade" IC consists of a chain of storage capacitors and charge-transfer circuits, acting as an analog shift register with an externally controlled shift rate. Information is stored in the array of capacitors—not directly as charge level but, instead, as charge deficit. The use of charge deficit instead of charge level permits the manufacturer to use a single transistor per storage capacitor and results in a less complex circuit than previously proposed analog shift registers.

As realized in the M31, the "bucket brigade" is a p-channel MOS IC in a 10-lead TO-5 can; however, bipolar circuits of analogous design have been developed and tested. The M31 contains 32 stages of charge storage plus sampling and output-follower stages. Because of the absence of dc gate currents, attenuation in the M31 is negligible, according to Amperex, and even after hundreds of stages no amplifiers are necessary. Twenty M31s have been strung together to provide 640 stages of variable delay line. Since delay and signal bandwidth are inversely proportional, one may be traded off for the other to provide a wide range of delays and bandwidths. The analog capability of the 640-element delay line is indicated by its 58 dB dynamic range with harmonic distortion of less than 1%. Clock rates for the M31 can be as high as 100 kHz.

More information on this device may be obtained from Amperex Electronic Corp., Integrated Circuits Div., Cranston, RI 02920.



"Bucket Brigade" IC stores information in capacitors as charge deficit.

$6 billion security market foreseen by '76—an electronics boon

An in-depth analysis and forecast of the industrial, commercial and residential security market has produced some startling figures. Done by the New York-based research firm of Frost & Sullivan, Inc., the study forecasts a major growth in intrusion-detection devices and systems, spurred on by the rising crime.

The market for intrusion-detection equipment, in the industrial sector alone, will grow from $40 to $67 million annually, according to the study.

This estimate does not include physical protection equipment such as locks and special doors. The industrial fire-equipment and alarm market is pegged around $410 million and will grow to $950 million by 1976. It is estimated that only 15% of U.S. industrial plants have substantial electronic surveillance and intrusion-alarm systems.

The "sleeping giant" of the security industry, says the report, is its residential segment. This residential security segment alone will be in excess of $400 million by 1976, pushed on by skyrocketing home burglaries that have increased by 286% since 1960, according to FBI statistics.

The engineers who designed this electronic tube anode could have given the production men a hard time. It was to be die-drawn from a single piece of copper in three reverse draw planes to a total draw-depth of 12 inches. But conventional, easily drawn copper alloys were out. Conductivity requirements, both electrical and thermal, ruled out most of them. The water cooled anode had to maintain maximum electrical efficiency while dissipating 22.5 kW. Outgassing specifications were even more critical: the anode would operate in a high vacuum and no impurities could be tolerated.

By specifying OFHC copper both the design and manufacturing problems were solved.

Uniform purity was the primary reason. OFHC copper is 99.99+% pure. That meant that production men could accurately predict the performance of the copper and design a drawing process to suit. And, purity eliminated outgassing. In addition AMAX certified conductivity of OFHC at 101% IACS. Good physical strength and good glass-to-metal sealability completed the picture.

OFHC copper may be the solution to your electrical and mechanical problems, too. We have all the data. Draw on it any time.

Specifying ductile copper without sacrificing conductivity and outgassing requirements is easy as OFHC.®

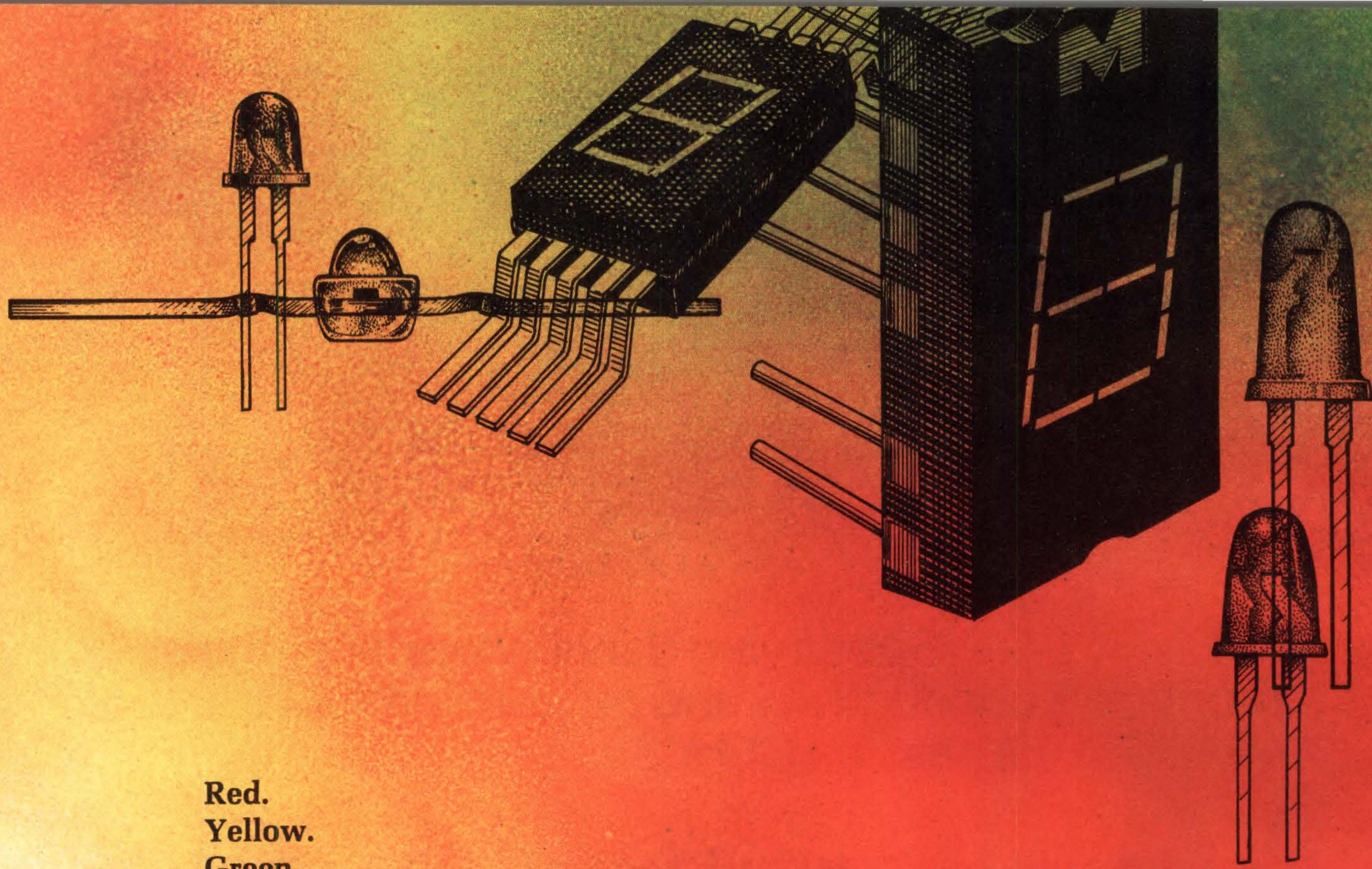
It's a story you can draw on. Send for it.

AMAX COPPER, INC.

A SUBSIDIARY OF AMERICAN METAL CLIMAX, INC.
1270 AVENUE OF THE AMERICAS, NEW YORK, N.Y. 10020

3T

CIRCLE NO. 16



Glass sphere floats in laser beam

If the rotating vane radiometer didn't convince you that radiation exerts pressure on a object, an experiment conducted at the Bell Telephone Laboratories should.

Using a beam of laser light, Bell Labs scientists have raised small transparent glass spheres off of a glass surface and held them aloft for hours in a stable position. In their experiment, Arthur Ashkin and Joseph Dziedzic focused a laser beam upward on a glass sphere about 20 μm in diameter. Radiation pressure from the light raises the sphere and traps it in the beam preventing it from slipping sideways.

Initially, radiation pressure is not sufficient to overcome Van der Waals force which is about ten-thousand times the force of gravity for a 20-μm sphere. Therefore, a transducer is attached to the glass plate to free the sphere by vibration. Once freed, the sphere rises in the beam and comes to rest where equilibrium is established between the upward force of the beam and the pull of gravity. By changing position of the focus, the particle can be moved up and down or sideways very precisely.

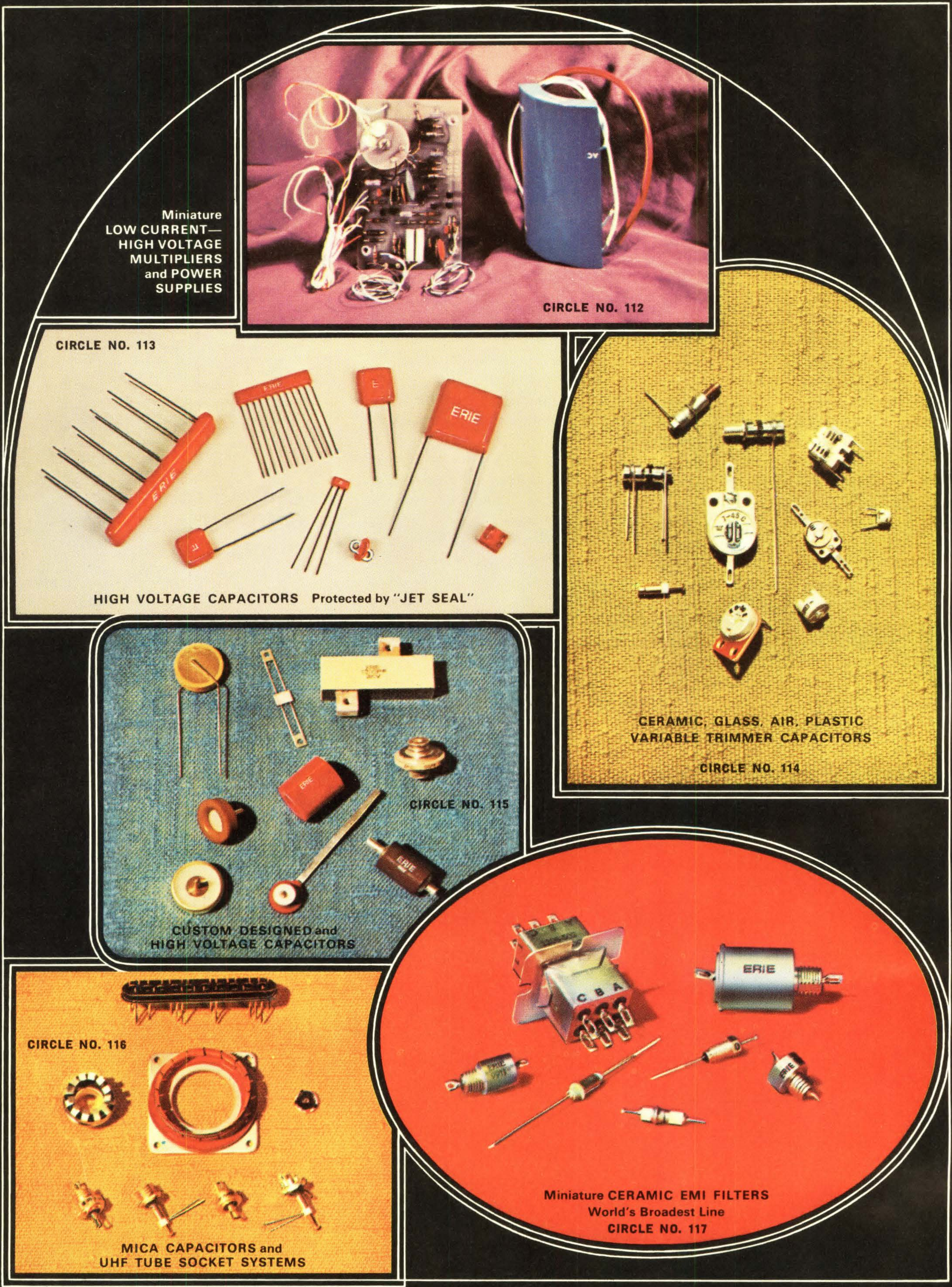
In the experiment a second laser was used to study the trapping forces by focusing its beam on the sphere from the side. As the power of the second laser was increased, the particle was displaced until it was driven out and fell.

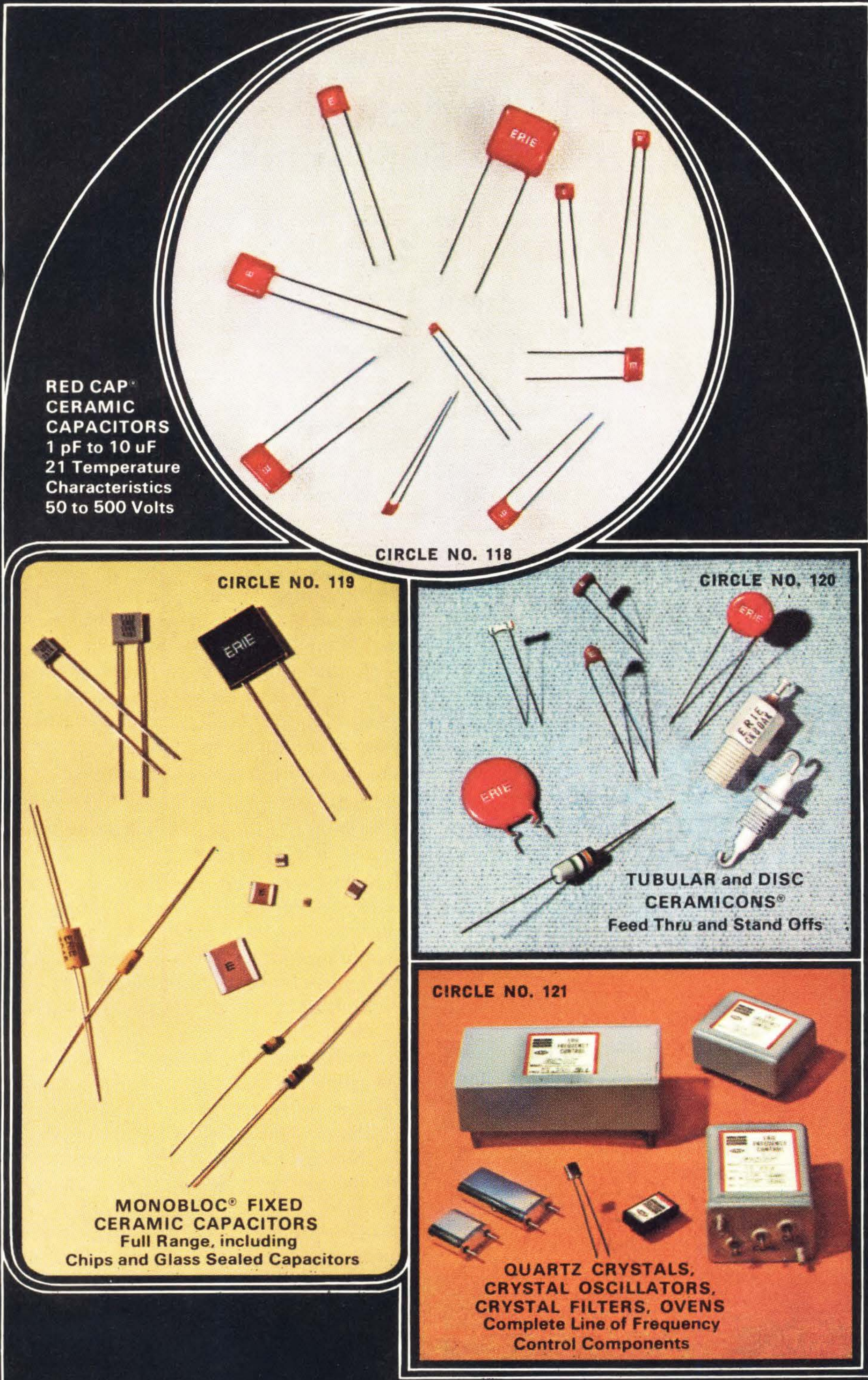
Dr. Ashkin pointed out that any laser will produce the levitation effect. The sphere should be transparent, because a particle that absorbs light would probably melt. By remaining cool, the transparent sphere allows radiation pressure to be studied without any disturbing thermal effects.

Several applications have been proposed for the technique. It can be used to provide simple, precise methods for manipulating small particles without mechanical support. In communications research, it could be useful in measuring scattering loss caused by particles, either in the atmosphere or in other transmission media. Laser levitation may also be a valuable research technique for suspending particles in optically induced thermonuclear fusion experiments.

Power required to perform the levitation ("optical trapping") is surprisingly small. A quarter-watt unit was used for this experiment.

The tiny star-like particle, a 20 μm-diameter glass sphere, is being held aloft in air by laser light.


Miniature
LOW CURRENT—
HIGH VOLTAGE
MULTIPLIERS
and POWER
SUPPLIES
CIRCLE NO. 112
CIRCLE NO. 113
ERIE
HIGH VOLTAGE CAPACITORS Protected by "JET SEAL"
CERAMIC, GLASS, AIR, PLASTIC
VARIABLE TRIMMER CAPACITORS
CIRCLE NO. 114
CIRCLE NO. 115
CUSTOM DESIGNED and
HIGH VOLTAGE CAPACITORS
CIRCLE NO. 116
MICA CAPACITORS and
UHF TUBE SOCKET SYSTEMS
C B A
ERIE
Miniature CERAMIC EMI FILTERS
World's Broadest Line
CIRCLE NO. 117



Designing with Quality ERIE Electronic Components makes life just a little simpler. . .

Try to beat this winning combination. A full line of electronic components produced to quality and performance standards that are right on target with *your* design and equipment needs.

ERIE has long been known as the quality name in electronic components. And today we're the IN place to go for top-of-the-line components. ERIE plays a vital role in military, industrial, commercial, home entertainment and communications systems. You name it . . . ERIE's there. Why don't you join the swing to ERIE?

Write TODAY for literature describing any component family illustrated. And if you would like to see your ERIE man, just jot a note. We'll do the rest. Who knows, ERIE components may even make your life just a little simpler.

ERIE

ERIE TECHNOLOGICAL PRODUCTS, INC. Erie, Pennsylvania 16512

Linears and memories highlighted at EDN/EEE seminars

Thirty-one speakers from more than two dozen semi-conductor manufacturers will address a pair of 2-day seminars at the Proud Bird Restaurant in Los Angeles during the second week in January. The seminars are sponsored by EDN/EEE Magazine.

Kicking off the seminar series will be "Linear ICs—Applications and Innovations" on Jan. 11-12; Jan. 13-14 features "Semiconductor Memories—Nano-second Bits For Microbucks". Noted speakers in each seminar will mix application ideas with solid design information, highlighting new devices and techniques. Not forgotten is the real chemistry of meetings: There will be plenty of time for questions—and answers—during the program, at coffee breaks, and at lunch.

Advance registration for each seminar is $75.00. Use the coupon on page 60 or write EDN/EEE Seminars, Box 156, Palos Verdes Estates, CA 90274.

Linear ICs—applications and innovations

Tuesday, January 11, 1972
8:00 a.m. to 9:00 a.m.—Registration
9:00 a.m. to 5:00 p.m.

Impact of LICs on D/A & A/D Converters; Marvin Rudin; President; Precision Monolithics.

Applying Digital/Analog Interface Circuits; Don Jones; Applications Engineer; Harris Semiconductor.

Interface Circuits For Computer Systems; Dale Pippenger; Prod. Engineer; Texas Instruments Incorporated.

Applications of LIC With High Noise Immunity DTL: Dave Guzeman; Prod. Market Manager; Teledyne Semi-conductor.

Applications for Hybrid Data Converters; George Smith III; R&D Manager; Beckman Instruments.

Care and Feeding of Analog Switches; Jim Sherwin; Chief Applications Engineer; Siliconix.

Designing With Ultra Low-Drift Operational Amplifiers; Walt Borlase; Microcircuit Appl. Manager; Nova Devices, Subs. of Analog Devices.

5:00 p.m.—No-host cocktail party—Attitude Adjustment Time. Meet the speakers and discuss *your* applications.

Wednesday, Jan. 12, 1972
9:00 a.m. to 5:00 p.m.

Common Problems & Solutions in Using Linear ICs; Karl Huehne; Applications Manager, Motorola.

New Directions in Op Amps and Power Distribution; Joel Scheinberg; Product Manager; National Semiconductor.

Applications for Micropower Amplifiers; Wayne Folleta; Design Engineer; Qualidyne.

Designing With Micropower Operational Amplifiers; Jim Bohorquez; Linear Products Manager; Solitron Devices.

IC Voltage Regulators; Bob Mammano; V.P. Engineering; Silicon General.

Design & Application of a High-Speed Comparator; Colin Barry; Manager Linear Product Design; Signetics.

Significant Advances in Analog Switches and Gates; Jack Gifford; Intersil.

Applications of New Linear/Interface Circuits; Orlando Gallegos, Product Marketing Manager; Raytheon Semiconductor.

Semiconductor memories—nanosecond bits for microbucks

Thursday, Jan. 13, 1972
8:00 a.m. to 9:00 a.m.—Registration.
9:00 a.m. to 5:00 p.m.

Timing In Semiconductor Memory Devices and Systems; John Springer; Advanced Micro Devices.

Implications of a Memory Component at the Systems Level; Gene Carter; Microcircuit Prod. Manager; National Semiconductor.

Semiconductor Minicomputer Mainframe Memory; Jerry Prioste; Memories App. Engineer; Motorola.

Design Considerations in Building High-Speed Bi-polar RAMs; Bob McConnell; Bipolar Design; Computer Microtechnology.

Bipolar Memory Applications; Mel Snyder; Dir. Bipolar Memory Mktg.; Intersil Corp.,

Re-Entrant Programming & Read Only Memories—Optimizing Hardware and Software; Bob Hartman; Senior Design Engr; Electronic Arrays.

Bipolar & MOS Memory System Design; Jerry Markus; Manager Bipolar Memory Marketing; Signetics.

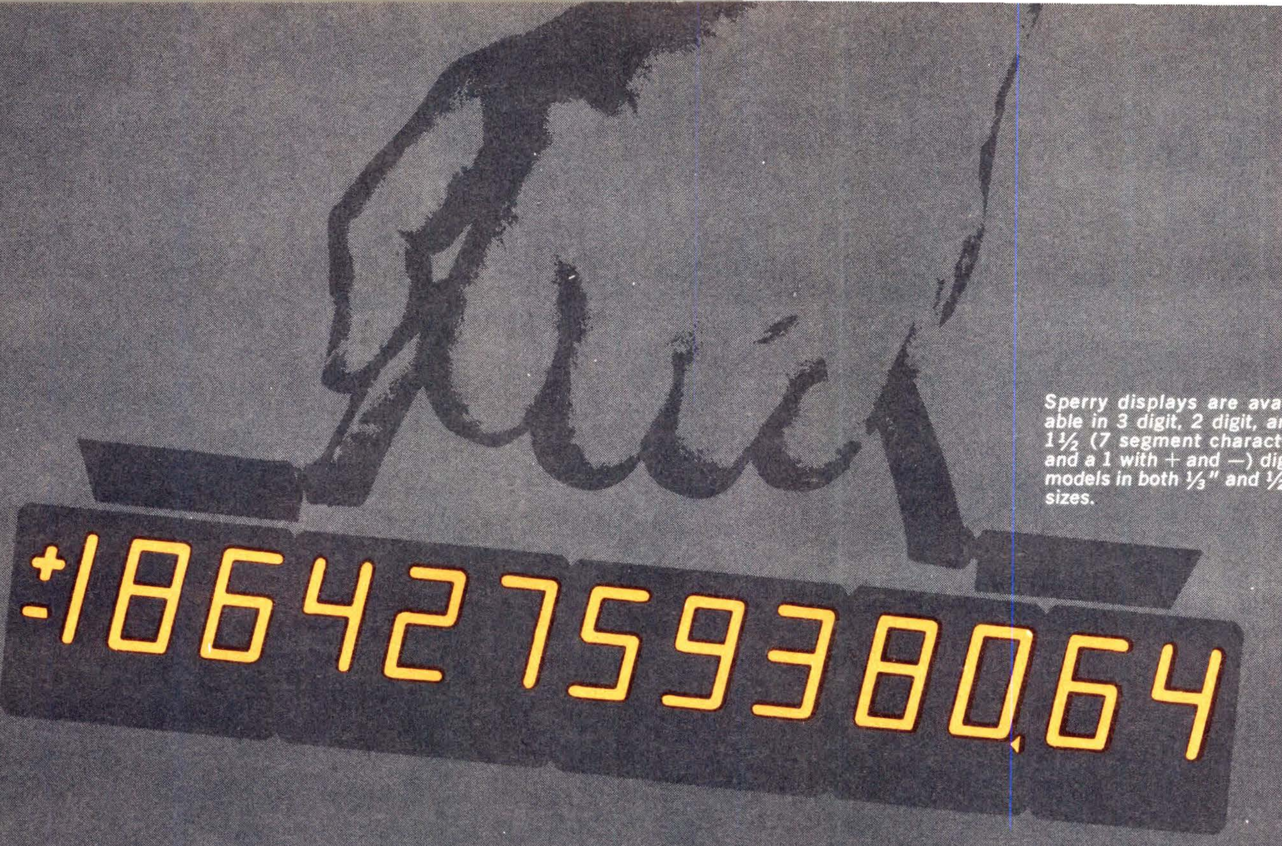
5:00 p.m.—No-host cocktail party—Attitude Adjustment Time. Meet the speakers and discuss *your* applications.

Friday, Jan. 14, 1972
9:00 a.m. to 5:00 p.m.

Comparisons of Standard vs Custom MOS Circuits; Steve Jasper; Applications Engineer; American Micro Systems.

Designing High-Speed Memory System With MOS Read-Write Memories; Ron Livingston; Program Manager; Advanced

(Continued on page 28)



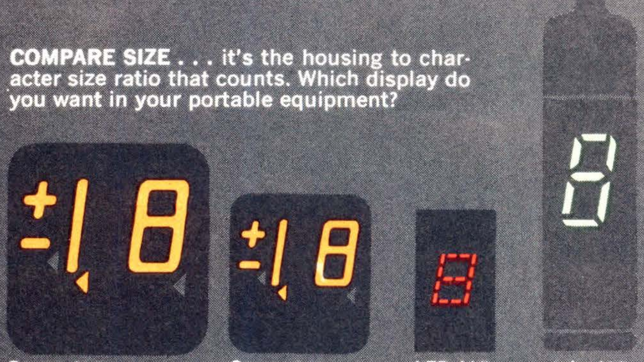
Sperry displays are available in 3 digit, 2 digit, and 1½ (7 segment character and a 1 with + and —) digit models in both ⅓" and ½" sizes.

Compare portable displays

If you think that LED's or phosphor/fluorescent displays are the only one's you can logically use in your portable equipment, you better take a close comparison look at Sperry. The facts speak for themselves:

COMPARE READABILITY . . . a must requirement. Sperry displays† can be read in direct sunlight. Try the others.

COMPARE SIZE . . . it's the housing to character size ratio that counts. Which display do you want in your portable equipment?



Sperry ½" Sperry ⅓" LED ¼" tube ½"

85mW 100mW 500mW

COMPARE POWER . . . a very important factor. ¼ inch LED's normally require over 500mW. ½" phosphor/fluorescent devices normally require over 100mW. Because Sperry displays are so bright to begin with, they can go all the way down to 85mW without affecting readability. What about voltage? A simple, inexpensive DC/DC converter takes the battery voltage up to the 170 volts required to operate Sperry displays.

COMPARE RELIABILITY . . . simplicity is the key. Sperry displays have no wirebonds or filaments. They are so ruggedly built and reliable that they are used aboard the Boeing 747. Need we say more.

Add these Sperry advantages to continuous unbroken figures and a low cost of $2.30* per digit for either the ½" and ⅓" device and you can end the comparison and specify Sperry — the right displays for your portable equipment or any gear. Get the whole story on Sperry displays by requesting complete technical information using this publication's reader service card or phone or write: Sperry Information Displays Division, Post Office Box 3579, Scottsdale, Arizona 85257, Telephone (602) 947-8371

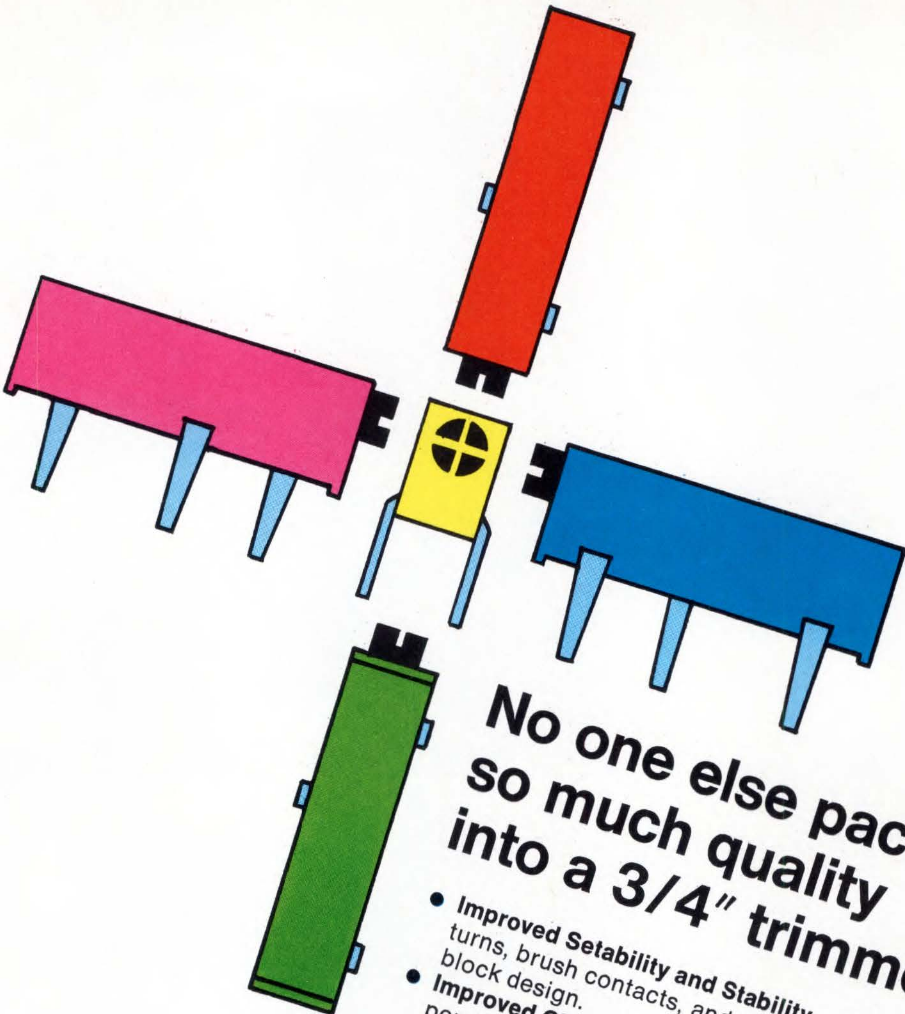
SPERRY
INFORMATION DISPLAYS

It's a whole new ball game in display devices!

†Patent Pending *Based on 5,000 digit quantity.

CIRCLE NO. 21

SPERRY RAND



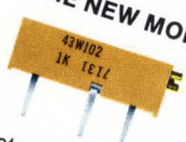
No one else packs so much quality into a 3/4″ trimmer –

- **Improved Setability and Stability** – Twenty turns, brush contacts, and unique "T" slider block design.
- **Improved CRV and RT Tolerance** – Three percent or three ohms CRV and ±10% RT tolerance.
- **Double Slotted Metal Shaft** – Accommodates standard or phillips-head screwdriver.
- **Sealed Case** – Permits cleaning in common solvents.
- **Choice of 3 Pin Configurations** – All 3 pin configurations available.
- **Low Profile** – Stands only ¼ inch above the board.
- **Resistance to Shock and Vibration** – Meets pertinent MIL-R-22097 requirements.

and sells it for less!

For a data sheet, just use the reader service card.

THE NEW MODEL 43



actual size

Spectrol

SPECTROL ELECTRONICS CORPORATION
A Subsidiary of Carrier Corporation
17070 EAST GALE AVENUE
CITY OF INDUSTRY, CALIFORNIA 91745
TELEPHONE: (213) 964-6565
TWX (910) 584-1314

CIRCLE NO. 22

The CIP/2200 is a new, more powerful, minicomputer that offers new flexibility and does its task well. Things like:

Decimal Arithmetic
Variable Length Operations
Control Stack Facility for automatic state switching
Bi-directional String Moves
Bit Manipulation Instructions
User Instructions Capability
Expanded Software including RPG compiler

The CIP/2200 uses microinstructions allowing implementation of more powerful instructions and greatly expanding applications and functions accommodated by the minicomputer. Microprogrammed features are: the Serial I/O Controller, a bootstrap loader and front panel memory access routine. Custom microprogrammed extensions are provided for, also. Microprogramming relieves the programmer of many inherent details when initiating programs.

Decimal arithmetic is now accomplished easily on the new, more powerful CIP/2200. Decimal numbers appear as byte strings in memory up to 16 digits. There is no packing, and conversion time is short. You get the same decimal capability as the big computers with all the advantages of the mini.

Variable length operations mean more efficient use of memory and permit a wide range of instruction types.

The control stack mechanism saves machine state when entering subroutines or interrupt service routines. It saves Program Counter (P), machine status byte (S), and B, A, and X registers, thus giving programs never before available on minis.

Bi-directional string moves allow up to 256 bytes in large string moves. In memory-to-memory operations, the registers are not altered.

Bit manipulation instructions can be used to save programming time, more efficiently utilize registers, and compare data with simple instructions instead of using subroutines.

Direct memory channel allows microprogram controlled, high speed data transfer to occur concurrently with program execution. 50 K bytes per second maximum transfer rate (910,000 bytes/sec available).

The CIP/2200 I/O structure consists of a microprogrammed serial I/O interface, a byte I/O facility, firmware support for direct memory channel concurrent transfers, and the capability of attaching up to two independent direct memory access (DMA) processors.

All these advantages and many more are available now from Cincinnati Milacron with the new, more powerful CIP/2200 minicomputer. Write or call, (513) 494-5444 now, for complete details to: MINICOMPUTERS, Process Controls Division, Cincinnati Milacron, Lebanon, Ohio 45036.

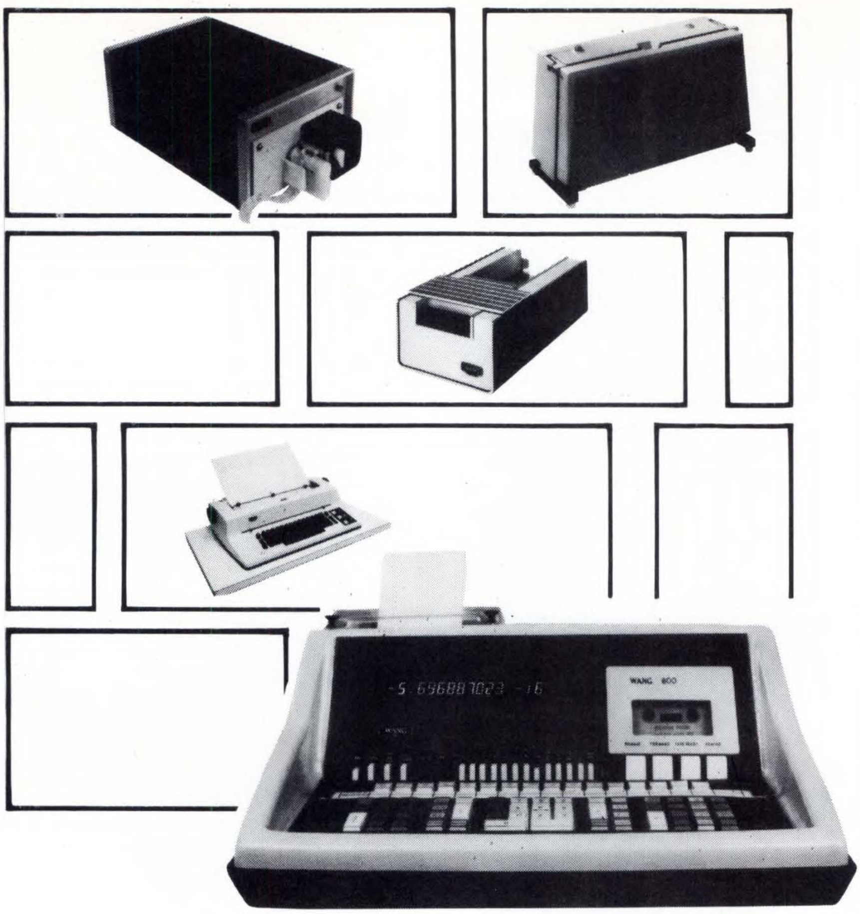
this year, there's something really new in minicomputers ...Cincinnati Milacron's CIP/2200

CIP/2200 is brand new. It performs functions that heretofore could be done only by larger computers. See copy above.

minicomputers

CINCINNATI MILACRON

Machine Tools
Process Controls
Chemicals
Plastics
Plastics Processing Machinery
Abrasives



Memory Systems.

Using Dynamic Refresh MOS RAMs In Large Memory Systems; M.E. Hoff; Manager Application Research; Intel.

Logic Design With Programmable Arrays; Al Tuszynski; Consultant; Solitron Devices.

Application of Reconfigurable Semiconductor Memory Systems; H. William Slaymaker; Manager Applications; SEMI.

256-Bit ECL RAM Application; Jake Stinehelfer; Applications Engineer; Fairchild Semiconductor.

New V-ATE High-Speed, High-Density Memory Process; Francis Azariah; Product M/M Memories; Raytheon Semiconductor.

Cost Comparisons of Core vs Semiconductor Memories in Today's and Tomorrow's Technology; Joseph McGrath; Senior Engr; Technology Marketing Inc.

Green and yellow LED readouts join red

Monsanto recently introduced the MAN 5 and MAN 8 readouts, the first LED numeric displays in colors other than red. Both are pin-for-pin compatible with the red MAN 1, but require about 50% more current. The MAN 5 is a green GaP device emitting light at 565 nm (peak and the MAN 8 is a yellow $GaAs_{.15}P_{.85}$ display which radiates light at 589 nm (peak).

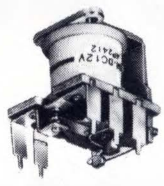
The chips used in the new devices are transparent, and therefore radiate light in all directions. A reflector is mounted behind each chip in the MAN 5 and 8 readouts to direct side and back radiation toward the front, and to spread it into a bar segment. This technique results in a fairly uniform bar, but a "hot spot" is visible at the chip location. This is more apparent from off-axis, but doesn't detract from the readability of the devices.

Also newly introduced are discrete LEDs in green (MV5222) and yellow (MV5322). They are mechanically identical to the MV5020 series red LED's. These discrete devices are encapsulated in green or yellow epoxy, which enhances color purity but decreases brightness. The MAN 5 and 8 readouts are encapsulated in clear epoxy.

For further information contact Monsanto Electronic Special Products Group 10131 Bubb Rd. Cupertino, Calif. 95014

GENERAL PURPOSE

BABCOCK RELAYS... A Broad Line for PC Board or Chassis, Dry Circuit to 20 Amps.

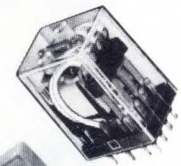


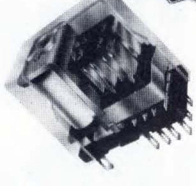
PC Board Subminiature Relays

Ultra low profile with a new flat magnetic system, high sensitivity and a life span to 300,000,000 operations make the Series NF relay unique in application potential. Rated at 2 amps, these DPDT and 4PDT units will switch 6, 12, 24, 48 and 60 VDC, with a (DPDT) pull-in of only 150 MW.

Series HT and HM miniature, open frame, SPDT relays are offered with 2 to 5 amp. ratings. These units feature high sensitivity and long life, and will switch 3, 6, 9, 12, 18, 24, 35, 42 and 60 VDC.

For more information, circle No. 57.

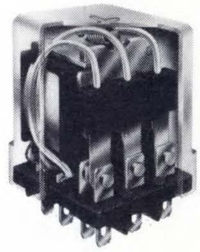




Miniature Relays

A novel "lift-off" card-operated contact system on the Series K relay results in higher speed, with minimal bounce or chatter. UL Recognized, the unit is rated at 2, 3 and 5 amps, in 2, 4 and 6-pole versions, for switching 3, 6, 12, 24, 36, 48, 60 and 115 VDC, and 6 to 220 VAC. Other miniature industrial models, also interchangeable with comparable types, are available in 1, 2 and 4-pole configurations, with ratings of 3, 5 and 7 amps, and voltages of 6 to 110 VDC and 6 to 240 VAC.

For more information, circle No. 58.

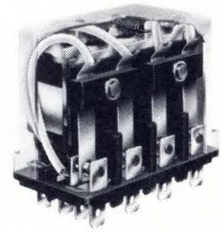


AC/DC Power Relays

New Babcock Series HP 10 amp. relays are offered in 2, 3 and 4-pole configurations for use in ac and dc control systems. These units are UL Recognized and are interchangeable with comparable types. They will switch 6, 12, 24, 48 and 110 VDC, and 6, 12, 24, 48, 115, 220 and 240 VAC.

For more information, circle No. 59.

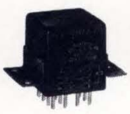
Detail technical data on the complete line of Babcock relays is available by writing or calling Babcock Control Products, Babcock Electronics Corp., Subs. of Esterline Corp., 3501 No. Harbor Blvd., Costa Mesa, Calif. 92626; Tel: (714) 540-1234.



AC Power Relays

Large capacity, compact size and long life are features of UL Recognized Series HG relays. Units are available with ratings to 20 amps (250 VAC) and 1.5KW 3-phase (220 VAC), for switching 6, 12, 24, 48, 115, 220 and 240 VAC, in 2, 3 and 4-pole configurations. These relays are interchangeable with comparable relays.

For more information, circle No. 60.



MIL-R-6106

MIL-R-5757

Timers/Sensors

Mercury Wetted

2A Industrial

20A Industrial

ESTERLINE

For instance.

Here's an op amp that's price competitive with the 101A, the 709, 740 and the 741. In its TO-5 can it's pin compatible with them all—and not a bit bigger.

But in performance it stands tall among the large complex modules.

It's the perfect answer for when 100kΩ to 500kΩ source impedances make amplifier input currents marginal, but price constraints force you to use a low cost bipolar op amp.

Surprise!

It's a FET-input op amp, the Intersil 8007. It costs only $5.00 in 100-piece quantities, and has a typical input bias of 2pA. (Model 8007A is available with I_B down to 1pA max.) It has a 6V/μsec slew rate (@ $A_{CL}=+1$) and internal frequency compensation.

Get one free.

Try it. Ask your Intersil distributor for a sample 8007 op amp. Discover the superb performance and design freedom it gives you compared to a marginal bipolar. Or use it instead of a big expensive module and save both dollars and real estate.

What you need in analog.

Remember the company that put it all together in analog technology. Intersil. 10900 N.Tantau Ave., Cupertino, CA 95014.

Get it here.

Intersil stocking distributors. Schweber Electronics; Century Electronics; Semiconductor Specialists; DeMambro Electronics; R. V. Weatherford Co.

Intersil area sales offices. Los Angeles (213) 370-5766; Metropolitan New York (201) 567-5585; Minneapolis (612) 925-1844; San Francisco Bay Area (408) 257-5450.

Overseas representatives. Clichy, France: Tranchant Electronique. Amsterdam, Holland: Klaasing Electronics. Tokyo, Japan: Internix. Zurich, Switzerland: Laser & Electronic Equipment. London, U. K.: Tranchant Electronique. Munich, West Germany: Spezial Electronics.

U. S. representatives in all major cities.

Intersil

CIRCLE NO. 26

Termination eliminates Curie shift point

A new wire and cable termination for high-temperature thermometric use has no Curie shift point, according to its developer, General Laboratory Associates, Norwich, N.Y.

This ceramic-to-metal seal termination exhibits a smooth curve of resistivity vs temperature, thus offers a precalibrated change in resistance for instruments operating up to 1200° F.

Neon implantation boosts IC resistor values

Using neon implantation, engineers at Mullard Research Laboratories, Redhill, England have been able to raise sheet resistance and improve IC resistor linearity.

Radiation damage introduced by the neon reduces the mobility, thus raising the sheet resistance for a given linearity and number of carriers. Resistivity of a semiconductor is a function of both charge-carrier concentration and mobility.

Reductions in mobility by a factor of five have been observed. Resistors made by this technique appear to be stable and to have acceptable leakage currents. Application of the technique to both MOS and bipolar circuits is being investigated.

GE MiniMod technology purchased by TI

Although GE has joined the ranks of several other large companies in their decision to discontinue production of ICs, the MiniMod packaging concept that they developed will live on. Texas Instruments has announced a technology exchange agreement with GE for the MiniMod package and Multi-Bond

Microwave Associates 50 Ohm PIN Diodes (continued):

Electrical Characteristics (@ 25° C)

Model Number	Min. Breakdown Voltage V	Typical Ther. Resist. °C/W	Meas. Freq. GHz	Max. IL@ −20V dB	Max. VSWR @ −20V	Min. Isolation @25 mA dB	Typical Lifetime μs	Switching Time RF on ns	Switching Time RF off ns	Switching Conditions f = 1 GHz	Case Style
MA-47200	500	10	1.0	0.25	1.5	30	2.0	200	60	100 mA, 100V	114 (stud)
MA-47202	500	15	6.0	0.5	1.5	25	1.5	150	30	100 mA, 100V	114 (stud)
MA-47204	500	20	10.0	0.6	1.5	20	1.5	100	30	100 mA, 100V	114 (stud)
MA-47206	100	30	10.0	0.5[1]	1.5[1]	20[2]	75 ns	5	5	10 mA, 10V	114 (stud)
MA-47201	500	10	1.0	0.25	1.5	30	2.0	200	60	100 mA, 100V	115
MA-47203	500	15	6.0	0.5	1.5	25	1.5	150	30	100 mA, 100V	115
MA-47205	500	20	10.0	0.6	1.5	20	1.5	100	30	100 mA, 100V	115
MA-47207	100	30	10.0	0.5[1]	1.5[1]	20[2]	75 ns	5	5	10 mA, 10V	115

NOTES:

1. MA-47206 and MA-47207 measured @ −10V
2. MA-47206 and MA-47207 measured @ 10 mA

First class
Permit No. 310
Burlington, Mass.

Business Reply Mail/No Postage Stamp necessary if mailed in the United States

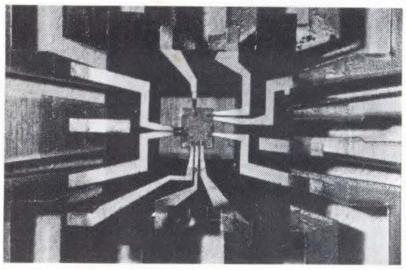
Postage Will Be Paid By

MICROWAVE ASSOCIATES, INC.
Burlington, Massachusetts 01803

Att: Advertising Dept.

automatic bonding process. In addition, the agreement includes technology relating to specific thin-film hybrid tape circuits.

GE developed the processes to in-



MultiBond process makes it possible to bond up to 72 IC leads in one stroke.

crease reliability through improved bonding and automatic handling techniques (see EDN, Jan. 15, 1971, p. 12).

To provide rapid buildup, TI has purchased certain production equipment from GE.

Morris Chang, TI vice president, said the MiniMod package will probably find first application in linear, consumer and computer circuits.

Engineer's lobby formed

A Political Action Committee for Engineers and Scientists (PACES) has been formed to promote and support legislation that will benefit those working in the scientific community.

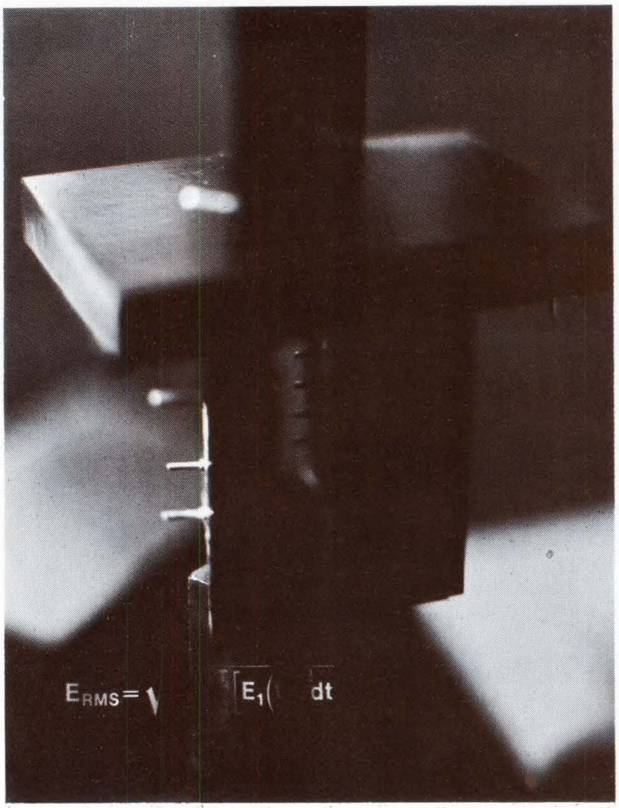
This new organization, which is a department of the Council of Engineers and Scientists Organization, is open to engineers, scientists, technicians, managers of technical programs and others with occupations requiring technical training. The minimum contribution for membership is $10 per year for employed persons and $2 for those unemployed or retired.

Some of PACES' goals include: utilization of unemployed engineers, scientists and other technically trained personnel; patent law reform; establishment of portable benefits and national standards for technical competence and ethics.

For additional information write to PACES Eastern Office, 318 Cooper St., Camden, N J 08102; Western Office, Suite 305, 1620 Centinela Ave., Inglewood, CA 90300 or Washington Office, Suite 809, 1140 Connecticut Ave., N.W., Washington, D C 20036.

Make true rms measurements with your own modules

Why spend more than you have to for a true rms meter when you can build your own at a reasonable cost with ready-made modules?



Traditionally, rms measurements have been made by one of two methods: the average reading instrument, or the "true rms" reading instrument using the thermal method. The first method simply rectifies and filters a waveform and uses a scale-factor conversion. While this method can be implemented at reasonable cost, the scale-factor conversion applies only to sinusoids. The method is therefore accurate only for pure sine waveforms.

The second method is accurate for all types of waveforms because the thermal, or "heating equivalent," technique compares the heating value of the waveform with that of a dc voltage. The disadvantage here is the high cost of such a unit -- for example a true rms DVM option costs upwards of $1000.

A new alternative in making rms measurements is now available to designers in the form of compact, solid-state function modules which compute rms values by the "operational" method. By this we mean that the module performs the mathematical operations which define rms:

$$RMS = \sqrt{\overline{e(t)^2}} \qquad (1)$$

The line under the square root sign indicates the "average of". The rms operation therefore consists of squaring, averaging and square rooting. These new modules of the type shown in **Fig. 1,** are made by various manufacturers, and have the advantages of low cost, good accuracy, and ease of calibration and use. Some examples of how to make these measurements will be shown later.

Common methods of rms measurement

The most commonly used method of rms measurement has been the average reading method, since it gives reasonably accurate measurements at moderate cost. It is the method used in VTVM's and most DVM's; however it is based on the ratio of rms value to average value for a pure sinusoid, which is 1.11.

The average reading method is implemented by a precision half-wave rectifier circuit with capacitive coupling, as shown in **Fig. 3.** The output of the amplifier goes to a simple RC-type filter with sufficient time constant to average the lowest frequencies measured. Accuracy of this precision rectifier circuit is dependent on the magnitude of loop gain at the frequency of the waveform being measured: as the loop gain begins to fall off at higher frequencies, so does the output accuracy.

Measurements on most average-reading instruments can only be made up to about 200 kHz for a 1% error, because of frequency response limitations. This method is satisfactory where only moderate accuracy is required and where relatively pure sine waves are measured. In cases where precision measurements must be made and where distortion is present in the sinusoid, it is not satisfactory.

For example, 1% of third harmonic distortion in a sinusoid is not noticeable visually (on an oscilloscope screen), but an average reading measurement of such a signal could be in error by up to 0.33%, depending on the phase relationship of the harmonic. Odd harmonics contribute maximum errors to average reading measurements at 0° and 180° phase angles with respect to the fundamental. It can therefore readily be appreciated that up to the point where distortion becomes visible to the eye (3-5%), one cannot be sure just how accurate his measurement really is. When distortion *is* visible, one can be sure that his measurement is *not* very accurate; and when a non-sinusoidal waveform is measured the reading is all but useless.

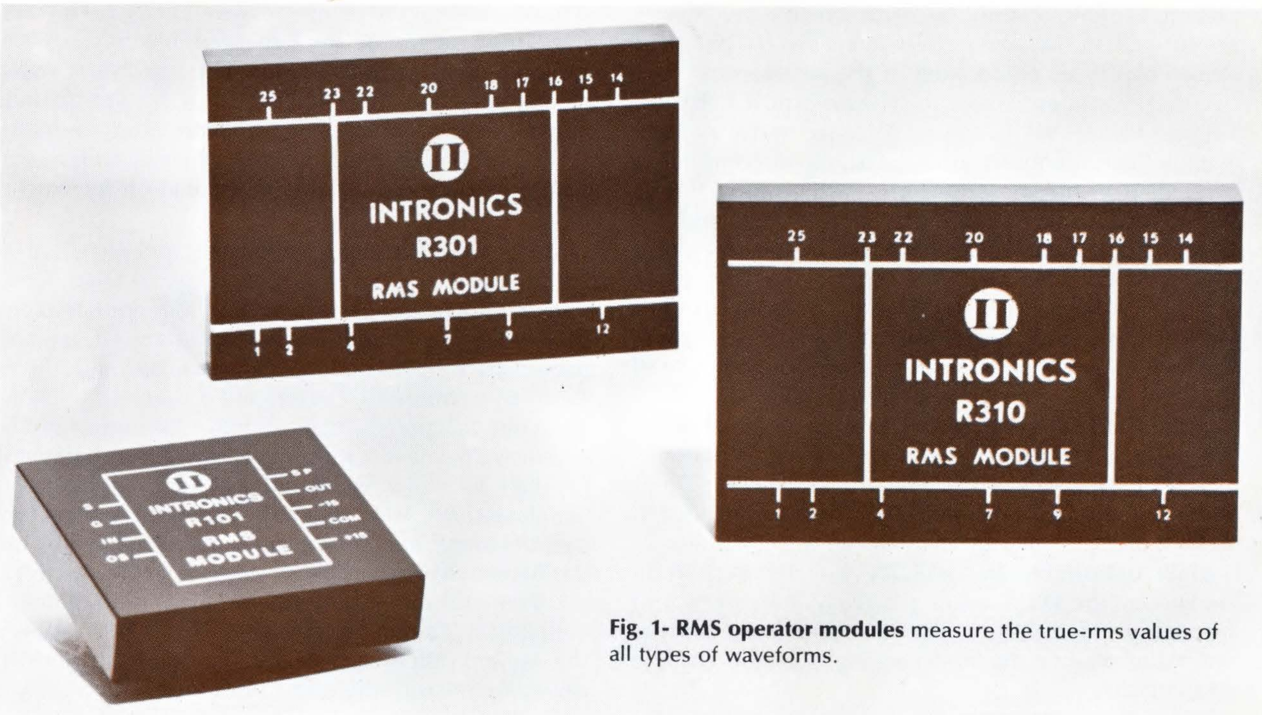


Fig. 1- RMS operator modules measure the true-rms values of all types of waveforms.

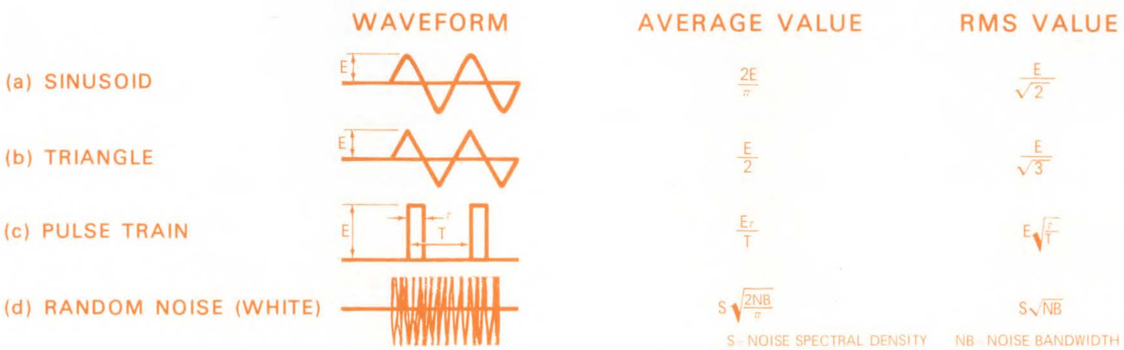


Fig. 2 - RMS characteristics are shown by these common signals which may be measured for average value and rms value. As one progresses from pure sinusoids to distorted sinusoids to triangular waveforms and then to pulses, it is easy to see that rms measurements based on average-value readings become increasingly inaccurate. In fact, a pulse train with small duty cycle becomes difficult to measure even with true rms techniques because of its large crest factor.(Crest factor is defined as the ratio of peak value to rms value of a waveform, and characterizes the waveform in terms of the dynamic range required to make the measurement). In general, accuracy of the measurement will decrease with increasing crest factor. The crest factor of a sine wave is 1.414, while that of pulses such as those shown might be as high as 10.

An important and interesting property of rms values can be demonstrated by calculating the rms value of an arbitrary waveform expressed in the form of a Fourier series:

$$E(\omega t) = a_0 + a_1 \sin \omega t + a_2 \sin 2\omega t + a_3 \sin 3\omega t + \cdots \quad (2)$$

When this function is squared and then averaged, the cross-product terms go to zero, and the final result is:

$$E_{RMS} = \sqrt{a_0 + \frac{a_1^2 + a_2^2 + a_3^2}{2}} \quad (3)$$

which shows that the dc term and all harmonic terms add as the square root of the sum of the squares. This result is termed "rms addition" and is significant because it says that each harmonic term contributes independently to the total rms value. For a given signal, which is the sum of a dc component and an ac component, the resultant rms value is:

$$E_{RMS} = \sqrt{E_{DC}^2 + E_{AC}^2} \quad (4)$$

where, in some cases, the two terms would have to be measured separately.

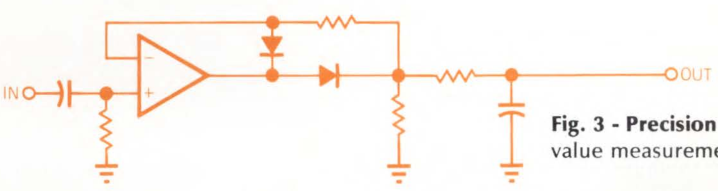


Fig. 3 - Precision rectifier and filter circuit are used in average value measurements.

There is another source of error which is sometimes overlooked in rms measurements. This is an error caused by any dc component of the waveform.

A dc component exists in a waveform if it has an average value that is nonzero. Since most average reading instruments are ac coupled, the dc component is rejected in the measurement. Furthermore, the dc component in many cases can be very small and not visually noticeable. This means that an rms measurement generally requires two separate steps if an ac coupled instrument is used. First the ac component of the waveform must be measured, then the dc value. The RMS value of the waveform is then found by use of Eq. (4), which is given in the caption of **Fig. 2.**

In addition to the above, one must also be careful that neither the low-frequency nor the high-frequency roll-off of the instrument is affecting the ac component of the waveform being measured. The real danger in making an rms measurement using a DVM average-reading option lies in assuming that the resolution implied by the DVM reading is really the accuracy of the measurement. Any of the above-mentioned errors can make all but the first few digits of the reading meaningless.

The second common method of rms measurement is the "true rms" method using thermal, or heating equivalent, techniques. The very fact that the term "true rms" had to be coined to distinguish from measurements that are *not* "true rms" indicates that true rms measurements are probably rare. And indeed they are, due to the high cost of either a true rms voltmeter or a true rms DVM option.

The thermal method used in these instruments is implemented in the manner shown in **Fig. 4.** This same basic method can be implemented in other ways, for example by using matched junction transistors instead of the matched thermopiles. Also, by use of more complex circuitry employing low frequency chopping, it is possible to implement this technique with a single heater-resistor and thermopile instead of the matched pairs.

This method, though expensive, has excellent accuracy (to 0.05%) over a wide range of frequencies, limited only by the performance of the input amplifier. It is expensive though, for two reasons: First, matched heater-thermopiles, which can now be made in the form of a thin-film circuit, are expensive. Second, stringent design requirements make the input amplifier expensive because it must have a large gain-bandwidth product to make wideband RMS measurements. It simultaneously must also be capable of handling large output voltage and currents in order to sufficiently heat the heater- resistance, which may be as low as 50Ω.

Due to dc drift problems in such an amplifier, ac coupling has almost always been used. This results in the same problem as with average-reading intruments regarding measurement of a waveform with a dc component.

Thermal methods suffer one other drawback: namely, their very slow response time, which is the same for any type waveform since it is dependent only on the thermal time constant of the heater-resistor thermopile combination. This response time is the time required to make a measurement to the accuracy of the instrument and is in the range of 1 to 10 sec for presently available commercial units. Because of it, there is also a low-

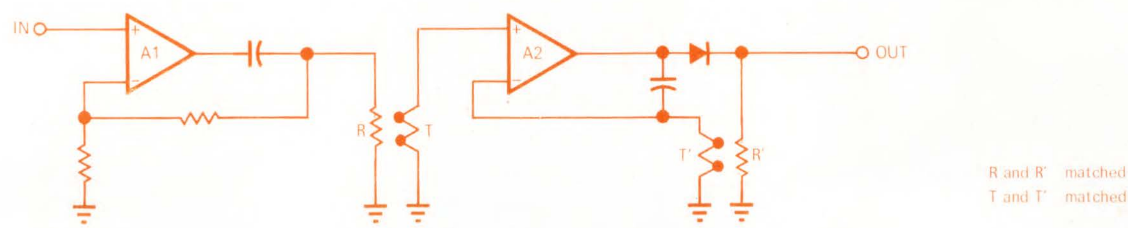


Fig. 4 - One circuit for thermal method of rms measurement is shown here. Input amplifier A_1 buffers and amplifies the input signal and drives heater-resistor R. Heat produced by R develops an output from thermopile T (series connected thermocouples). This output is amplified by A_2,producing a dc output voltage across heater-resistor R' which is matched to R. Thermopile T' is also matched to T so that a balance condition exists when temperatures of the two heater-resistors are equal. Under this condition the dc voltage across R' is equal to the rms value of the voltage across R. A proper scaling factor is used on the output reading in accordance with the closed-loop gain of A_1.

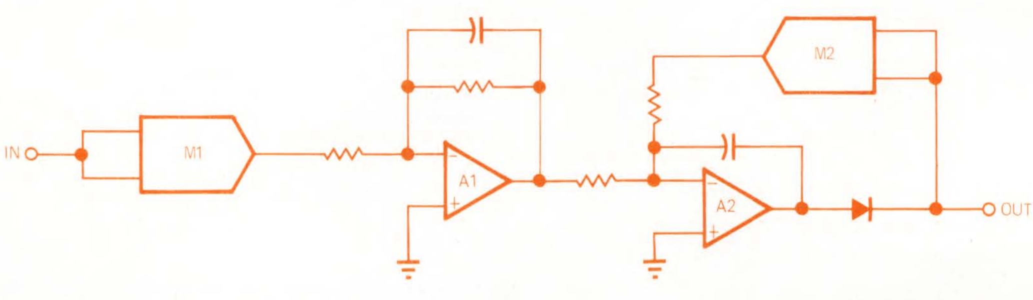


Fig. 5 - RMS circuit based on analog multiplier techniques for squaring and square-rooting waveforms uses analog multipliers and op amps to produce a dc output voltage proportional to the rms value of the input waveform.

frequency limitation on these units, since the period of the waveform being measured must be small compared to the thermal time constant. Low-frequency cut off of the input amplifier is therefore designed to take care of this limitation.

If a very low-frequency waveform were to be measured, the heater resistance would heat up and cool down with the waveform variation, and the output of the rms converter would follow this, giving an average reading rather than an rms reading.

How rms operator modules work

The new rms modules are based on analog multiplier techniques for squaring and square-rooting waveforms. As illustrated in **Fig. 5,** in a typical module the input waveform is squared by an analog multiplier, then averaged by a single-pole active filter, and square-rooted by a multiplier-amplifier combination. As with other rms methods, this technique produces a dc output voltage equal to the rms value of the input waveform.

In this operational method the output is really a processed version of the input waveform, whereas in the thermal technique it is a separately generated dc voltage which is made equal to the RMS value of the input by comparison. The operational technique can readily be made accurate from dc to 1 MHz using a wideband multiplier for M_1. By contract, M_2 can be a slow multiplier, since it operates only on a filtered waveform.

The circuit shown in **Fig. 5** can be made accurate to 0.5% at a moderate total cost by using individual commercially available analog multiplier modules with offset adjustments, and op amps. The RMS operator modules, though, with certain simplifications and special circuit techniques, actually achieve better performance in accuracy, temperature stability and bandwidth in a single compact package than is possible using analog multipliers.

These modules offer a number of significant advantages when compared to the two previously discussed methods of rms measurement. The first, and most obvious advantage, is in price. Compared to about $475 for an average-reading DVM option or $1250 for a typical true rms reading option, rms operator modules sell for $85 to $145, depending on specifications. This means that engineers can apply them to problems involving a number of data measurement channels, like in multipoint vibration monitoring, and not worry about prohibitive costs.

A second advantage is that they have a fast response time compared to thermal techniques. Compared to a time constant of about 1 sec for thermal units, the modules have internal time constants set at 2 msec to 10 msec, depending on the model. These faster time constants can be used when measuring waveforms of moderate frequencies, say 5 kHz and higher. It means that you make a reading to 0.1% accuracy in 14 msec, if the internal time constant is 2 msec. Actually the time constant can be tailored to the required measurement by adding an external capacitor to achieve a larger time constant. This is necessary for low-frequency waveforms since the time constant of the filter must be made large compared to the fundamental period of the waveform being measured. It should be noted, however, that this time constant does not have any effect on

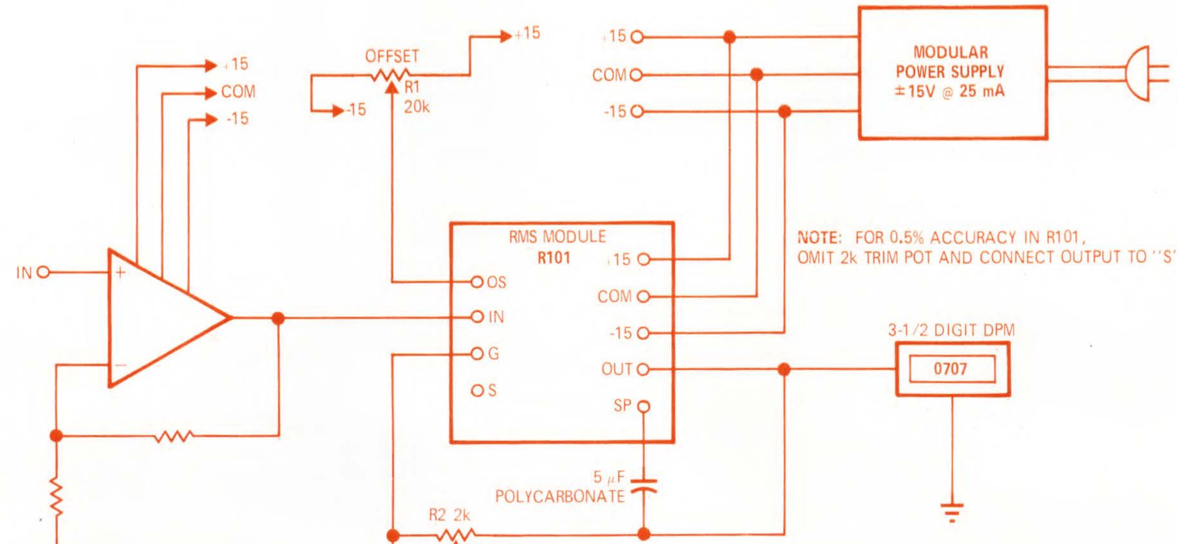


Fig. 6 - Low-cost lab-type rms meter is easily made from rms modules. The operational amplifier preceding the rms module (R101) is used in the non-inverting configuration to buffer and amplify the input signal. Amplification allows the input of the R101 to be driven near full scale to give best total accuracy. If the bandwidth requirement is not too great, a low cost IC op amp can be used for A_1. For best accuracy the R101 must be zeroed and adjusted for scale factor, which is done by means of trim pots R_1 and R_2. When measuring full-scale waveforms down to 50 Hz, the averaging time constant of the R101 is increased to 0.1 sec by means of an external 5μF polycarbonate capacitor, C. A low cost ±15V, 25 mA modular power supply is used to power the rms operator module and operational amplifier.

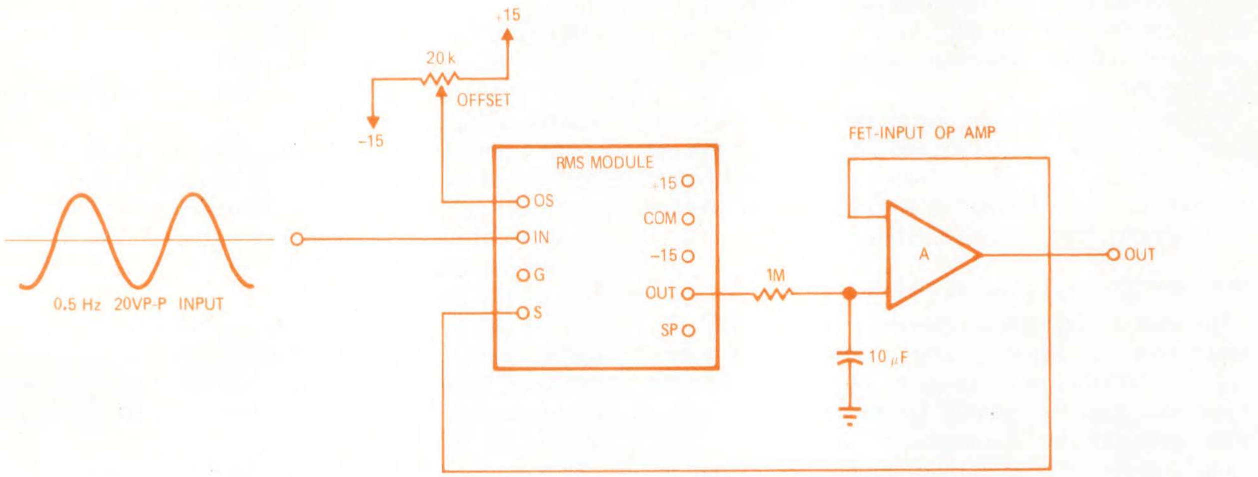


Fig. 7 - RMS circuit for measuring slow waveforms develops the required long time constant with an RC filter and op amp.

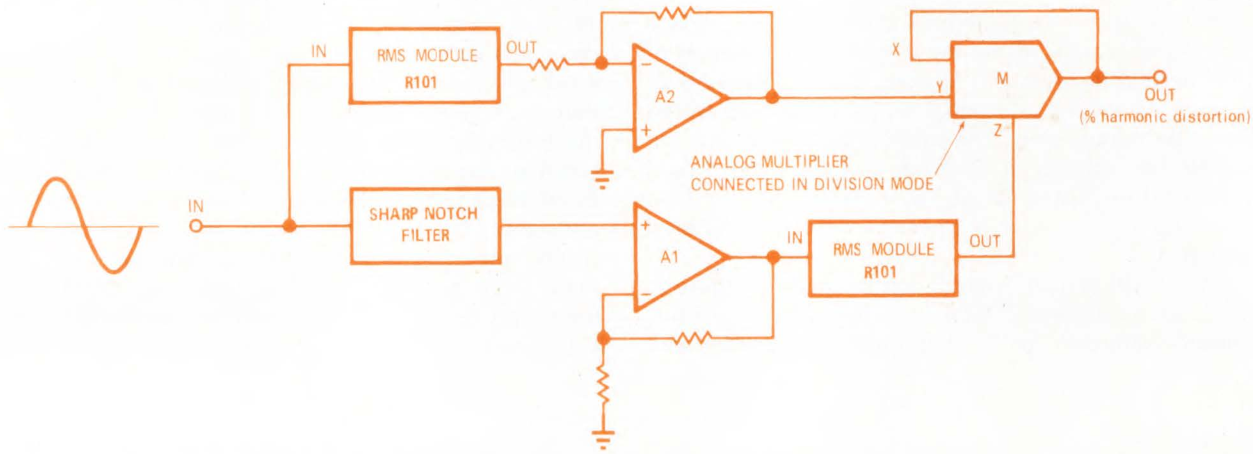


Fig. 8 - In audio distortion measurements, a near sinusoidal signal is applied to a sharp notch filter that virtually eliminates the fundamental component. Output of the notch filter, which contains all of the harmonic terms, is amplified and applied to an rms module whose output is the rms value of the sum of all the harmonic terms. If this dc value is divided by the rms value of the original input signal the result is a dc output proportional to the total harmonic distortion of the input signal.

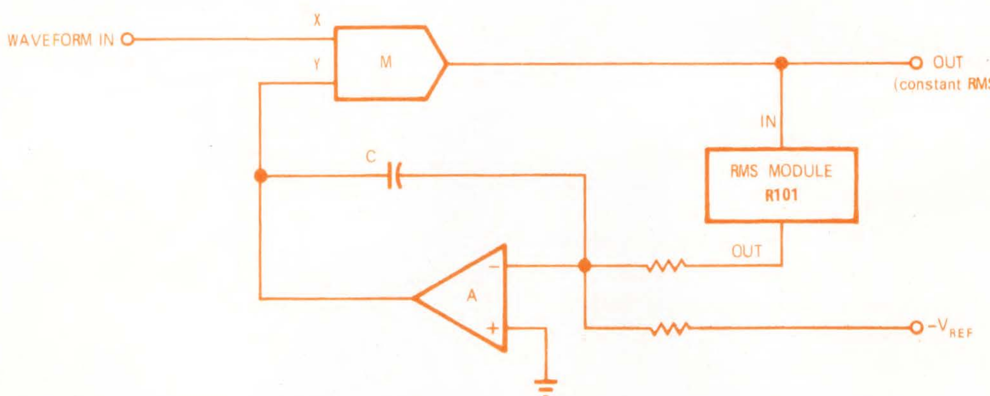


Fig. 9 - In an rms regulator circuit, the true rms module converts the output signal to a dc voltage equal to the rms value of the output. This dc level is compared to a dc reference and the difference is amplified and used to control one of the inputs to an analog multiplier which is used as a variable gain control.

the bandwidth of the module with regard to higher frequency measurements because the time constant is simply the time for the filter to charge up to the squared waveform average value.

A third advantage is the fact that these RMS operator modules are dc coupled devices, whereas the other two methods almost always are ac coupled. Dc coupling is important for two reasons: Waveforms with a dc component can be measured in one step instead of two separate measurements, as described previously. A sufficient time constant must still be provided by an external capacitor to sufficiently filter the lowest frequency ac component, but, since pure dc requires no filtering, it is processed directly in the rms operation.

The other reason why dc coupling is important is that the RMS module is easily calibrated using a dc source. The modules require offset and scale factor adjustments for optimum accuracy. This is done simply by shorting the input to ground and zeroing the output. The scale factor is then adjusted while applying an accurate ±10V dc source and setting the full scale output to +10V. Other types of rms converters which are ac coupled require either a precision ac reference for calibration, or another rms converter to calibrate against after measuring the same waveform. This additional equipment can sometimes be hard to come by in the laboratory, whereas a stable dc power source is almost always at hand.

How to use rms operator modules

The following applications of rms operator modules use the low-cost Intronics R101 for purposes of illustration. The most general application for these modules is shown in **Fig. 6,** which illustrates construction of a low-cost laboratory-type digital rms meter. A 3-1/2 digit DPM is used to read the output voltage of the R101. Typical accuracy for this rms meter is 0.1% of reading +0.05% of scale (10V) and cost is about $330. For a lower-cost unit, the DPM can be replaced by a common d'Arsonval meter movement, and the price can be reduced to about $150.

A second application is shown in **Fig. 7,** where it is desired to measure the rms value of a slow, 0.5Hz, 20V peak-to-peak waveform. This requires a time constant of about 10 sec, which would in turn require a prohibitively large external capacitance value. To get around this problem, a 10-second time constant is developed externally by means of an RC filter and an FET-input op amp connected to have a gain of +1. The result of the required large time constant, however, is that about a minute is required to make an accurate reading.

A third application of rms measurements is in audio distortion measurement as shown in **Fig. 8.**

A fourth application is in true rms regulation **(Fig. 9).** Here, by using an rms operator module, an analog multiplier, and an operational amplifier, an arbitrary input waveform with amplitude variations can be regulated to give a constant rms output value.

Databank

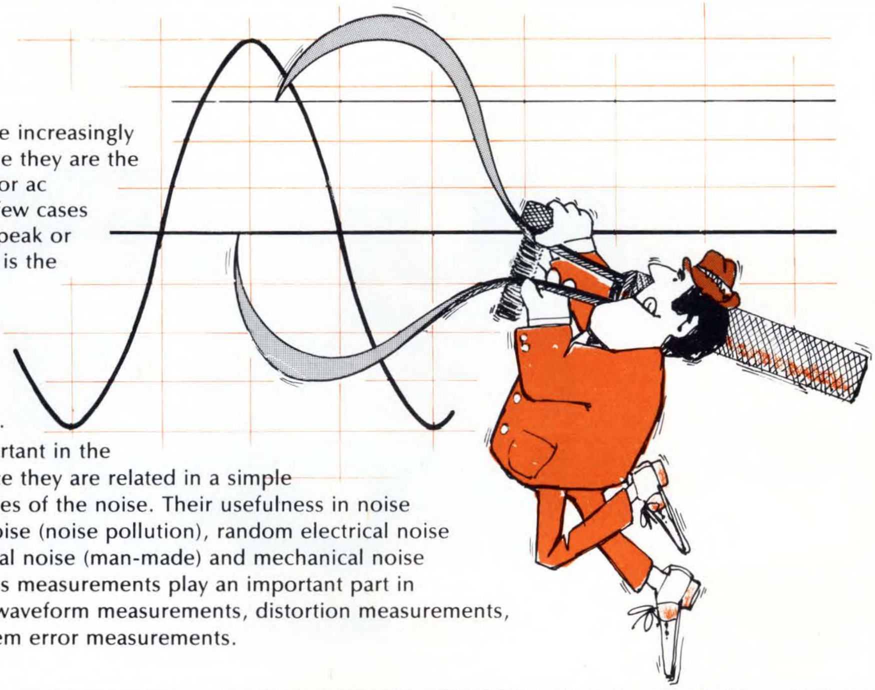
1. E. Uiga, *"The Significance of RMS, Average and Peak Responses", EEE, April 1964.*

2. *"Bill Smith of HP Speaks Out on What's Wrong with DVM AC Measurements", EEE, March 1971.*

Author's biography

Eugene L. Zuch has been with Intronics Inc. for 4½ years and is currently manager of applications engineering, customer product applications and technical marketing. Prior to this he worked at MIT Instrumentation Lab. Gene has had a number of articles published and has had one patent granted to him. He received his B.S.E.E., M.S.E.E. and M.S. in Management at MIT and is a member of IEEE.

Why RMS?



RMS measurements have become increasingly important in recent years because they are the most meaningful measurement for ac waveforms **(Fig. 2)**. Except for a few cases where it could be argued that a peak or average value is just as useful, it is the energy content of a waveform that we are interested in.

RMS measurement is so widely accepted that when engineers speak of ac voltages it is always assumed that rms value is meant.

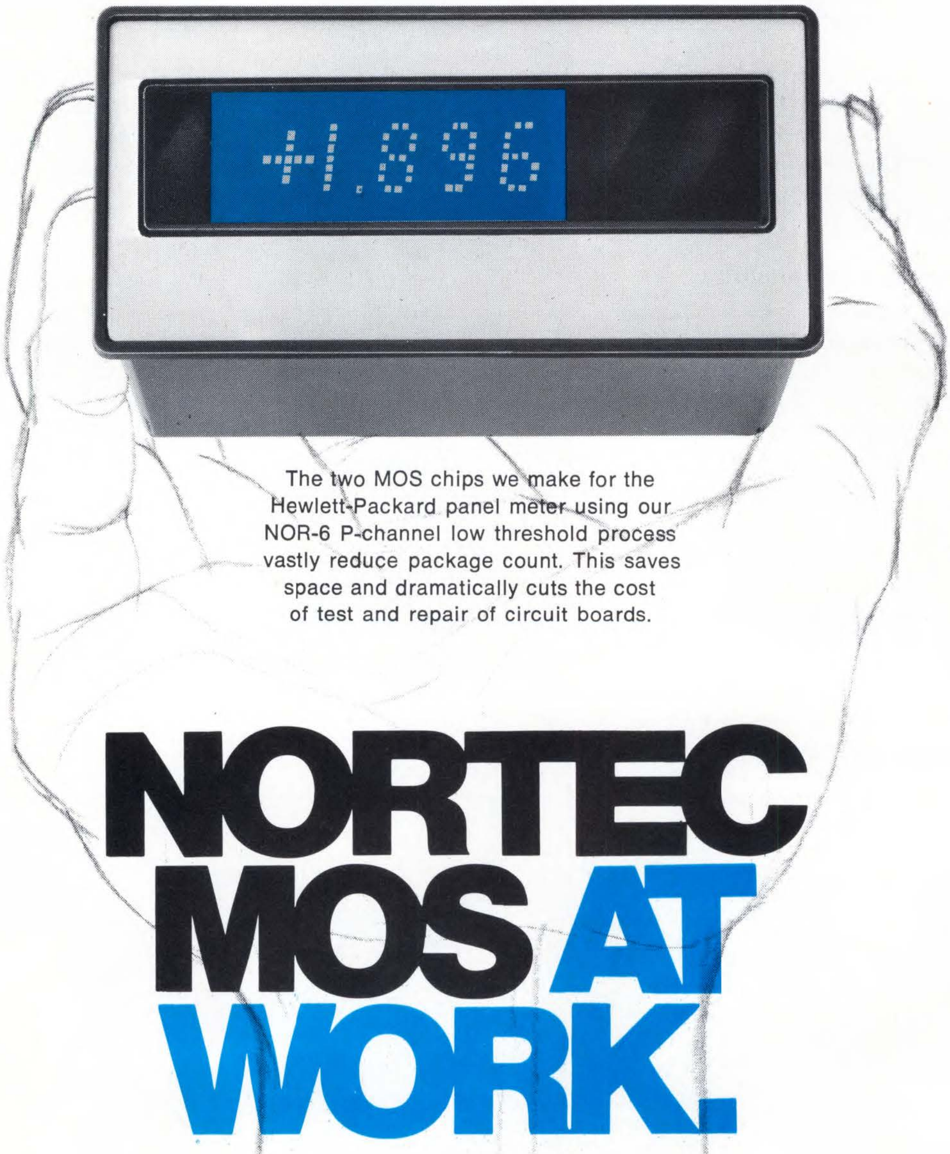
RMS values are particularly important in the case of noise measurements since they are related in a simple manner to the statistical properties of the noise. Their usefulness in noise measurements includes audio noise (noise pollution), random electrical noise (thermal noise), periodic electrical noise (man-made) and mechanical noise (vibration noise). In addition, rms measurements play an important part in power measurements, complex waveform measurements, distortion measurements, rms regulation, and control system error measurements.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE L61**

No need for klugey panel meters, once you replace the guts with MOS. We designed the parts, NORTEC helps produce the quantities we'll be needing. Result: our new 3½ digit panel meter that's on a sales rampage.

Larry Lopp, HEWLETT-PACKARD

NORTEC Electronics is in business to make winners of our customers. We're designing and building parts for bill changers, computers, entertainment consoles, panel meters, and communications blackboxes. The only way we'll make it big in MOS/LSI is by helping our customers make it big. Try us for design, prototypes, or production.



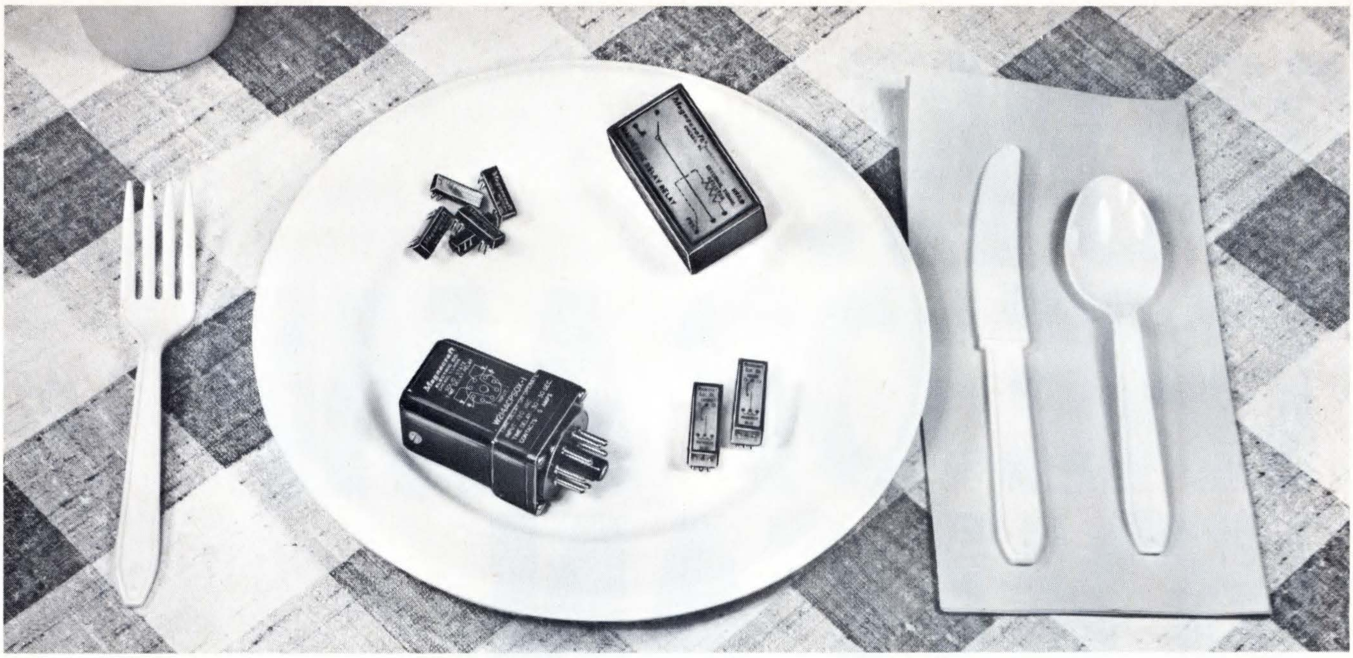
The two MOS chips we make for the Hewlett-Packard panel meter using our NOR-6 P-channel low threshold process vastly reduce package count. This saves space and dramatically cuts the cost of test and repair of circuit boards.

NORTEC MOS AT WORK.

NORTEC
ELECTRONICS CORPORATION

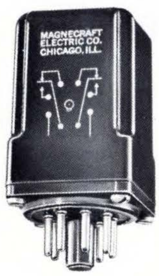
3697 Tahoe Way, Santa Clara, Ca. 95051 • Tel. (408) 732-2204 • Telex 348-359

CIRCLE NO. 31



designers will have a **PICNIC** with these new relays

NON-POSITION SENSITIVE MINIATURE MERCURY WETTED REED RELAY CLASS 137MPC—This amazing new relay represents a significant state-of-the-art advancement in relay technology. The low-profile miniature PC-mounting mercury wetted reed relay offers bounce-free operation in any position. Now circuit designers will have new freedom of design. Further, the relay is only 1.12 x .40 x .375 inches, requiring minimal area on printed circuit boards. This relay features stable contact resistance of 100 milliohms over its long life of over 20 million bounce-free operations with diode suppressed coil.



SOLID STATE (HYBRID) TIME DELAY RELAY CLASS 214CP—Magnecraft takes great pride in announcing this new time delay relay. Proven hinge-pin reliability designed into the output relay driven by a solid state circuit used in thousands of our timers, gives you the best low cost small size timing relay on the market. Operate delay timing ranges are offered between 3 hundred milliseconds and 4 minutes with ±5% repeatability and input supply of 115VAC.

We are sure you will share our enthusiasm in this new product when you apply the small size and cost savings to your circuit designs. The body of the timer is only 1.4 x 1.4 x 2.1 inches, the size of our 88 general purpose relay case. The adusting potentiometer gives full range timing control and the very popular octal socket pins extend just a bit beyond the body of the time delay relay to an overall height of 2.3 inches.

DUAL-INLINE-PACKAGED REED RELAYS CLASS 107DIP, 108DIP, 117DIP AND 118-DIP—Magnecraft is proud to announce its new DIP (dual-inline-package) line of 8-pin reed relays. These new relays are designed not only to be compatible with the standard packaging developed for integrated circuits, but to offer Magnecraft quality at a lost cost. This unique design gives further savings by offering the user the optimum in automated insertion and other economical installation techniques associated with printed circuit applications.

These fantastic new epoxy molded reed relays are ideal for use in circuits where high density packaging is essential. The 5VDC IC compatible versions of these relays will operate directly from TTL or DTL circuits.

Other standard coil voltages are available from stock in 6, 12, and 24 VDC as well as contact configurations in 1 form A, 2 form A, 1 form B, and 1 form C. Most versions are also offered with a choice of an internal clamping diode. The size of this device is a tiny .750 x .300 x .210 inches.

SOLID STATE (HYBRID) PRINTED CIRCUIT TIME DELAY RELAYS CLASS 502PCSR AND CLASS 503PCSR—These new time delay relays make use of hybrid circuitry combining a monolithic silicon structure in the control function with a dry reed relay performing isolated circuit switching. Two fully adjustable timing ranges are afforded by using a remote pot or fixed resistor giving 0.2 to 100 seconds or 1 to 300 seconds each with ± 2% repeatability. Standard coil voltages are available from stock in 12 and 24VDC as well as contact configurations in 1 form A rated at 1 amp and 1 form C at 0.5 amp. The size of this time delay relay is a mere 2.25" x 1.25" x .75".

Magnecraft® ELECTRIC COMPANY

5575 NORTH LYNCH AVENUE • CHICAGO, ILLINOIS 60630 • 312 • 282-5500 • TWX-910-221-5221

See you at I.S.A. Booth 658

CIRCLE NO. 32

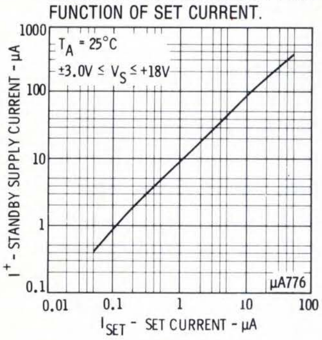
NOW: THE OP AMP YOU CAN PROGRAM

Our new μA776: Closest thing to a universal op amp yet devised.

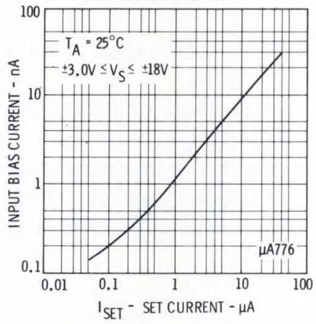
We call the μA776 our "do-everything" op amp. It probably is the next industry standard: one high quality device that, with the addition of a simple external resistor, can be tailored for optimum performance over an enormous span of applications. From the world's linear leader.

μA776 Typical Performance

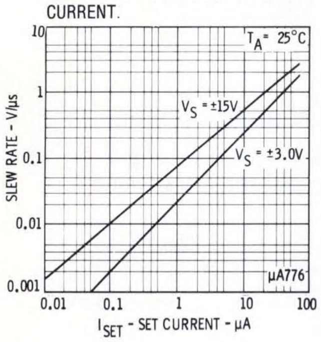
QUIESCENT SUPPLY CURRENT AS A FUNCTION OF SET CURRENT.



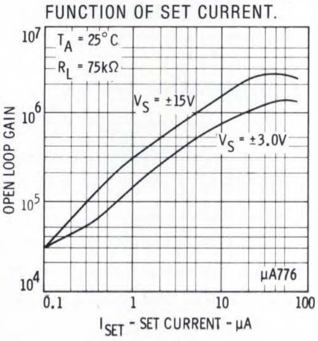
INPUT BIAS CURRENT AS A FUNCTION OF SET CURRENT.



SLEW RATE AS A FUNCTION OF SET CURRENT.



OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SET CURRENT.



The wide range of available characteristics makes it extremely versatile. And useful. It is adjustable for either standard or micropower application. It can be biased to have any of a number of fixed characteristics; or biased so that the characteristics of the amplifier can be varied in response to an input signal. And it can be turned on or off externally.

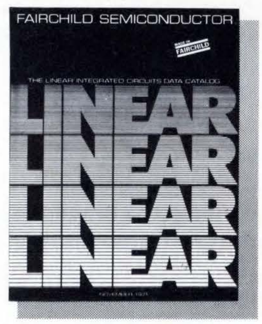
The μA776 offers superior operation at levels similar to standard general purpose op amps. In fact, when biased with a 15μA set current, it has approximately the same gain, slew rate and bandwidth as a μA741. But with an *order of magnitude improvement* in input bias current, input offset current, noise current and power dissipation.

Or you can operate it from a supply voltage of only ± 1.2V. This means the device can be run off of two battery cells and with the proper set resistor the total power drain of the op amp will be lower than the battery leakage.

The broad versatility of the μA776 means it is ideal for micropower applications, battery powered systems, medical electronics, long-time integrators, high-accuracy sample and hold, frequency processors and active filters. For many uses, it becomes the only op amp you need specify on your standard parts list.

Available with complete data package, from your friendly Fairchild distributor.

New LIC Data Book



The μA776 is the newest of 17 general and specific purpose op amps.
All fully described in our new LIC Data Book: 320 pages covering 84 quality LIC devices.
Available now by writing to the address below.

MADE IN FAIRCHILD

FAIRCHILD SEMICONDUCTOR, A Division of Fairchild Camera & Instrument Corp., 464 Ellis St., Mountain View, Ca. 94040. (415) 962-5011. TWX: 910-379-6435

CIRCLE NO. 33

Incandescent lamps mate well with silicon photosensors

If you omit the incandescent-filament lamp when you compare devices for irradiating silicon photosensors, you may short-change your design.

Incandescent lamps, in addition to being a good source of illumination, are also efficient energy sources for irradiating photosensors--especially those of the silicon type. Basically three types of energy sources are in current use for this purpose: incandescent lamps, solid-state emitters and cathode glow tubes. Let's take a look at the advantages and limitations of incandescent lamps in comparison with the other sources of illumination.

Realistic performance of incandescent lamps is depicted by the nomograph of **Fig. 1.** Notice that both filament temperature and the transmission efficiency of the glass envelope through which photons must pass are considered. Notice too, that filaments are most efficient in the same wavelength region where the glass envelope allows maximum transmission (90 to 92% over the range of 0.4 to 2.7 μm.)

This "window of emission" is shown as percent transmission in the upper portion of **Fig. 1**. Where the outline of the emission window intersects a given wavelength generated by the incandescent filament, the indicated percentage of filament-released photons will pass through the glass envelope.

The "emission window" concept used in **Fig. 1** refers to the relative ability of the glass envelope of subminiature type Chicago Miniature lamps to pass discrete wavelength units (hλ), unchanged in wavelength (λ) and direction of propagation.

Use of this nomograph is demonstrated with a few examples to illustrate the comparatively large number of photons obtained from miniature incandescent lamps.

Case I: How many photons of wavelength 4.0 μm pass through the glass envelope when the tungsten filament has a temperature of 2100°K and a radiant surface area of 0.010 cm^2?

Tracing the 4.0 μm vertical line up to where it intersects the 2100°K curved line, we find that 1.6×10^{17} photons of that wavelength are produced at the filament per cm^2 surface area per second. Correcting for actual area of this filament (0.010 cm^2) and the 41% transmission factor through the glass envelope we have:

$$0.010 \times 0.41 \times 1.6 \times 10^{17} \text{ equals } 6.56 \times 10^{14} \text{ photons/sec.}$$

Case II: How many photons of wavelength 1.0 μm will pass through the glass envelope from this same lamp with 2100°K filament temperature?

The 1.0 μm vertical line intersects the 2100°K curved line at 2.0×10^{17} photons. Transmission factor through the glass envelope for this wavelength equals 90%. Therefore:

$$0.010 \times 0.90 \times 2.0 \times 10^{17} \text{ equals } 1.8 \times 10^{15} \text{ photons/sec.}$$

Referring to Case I and Case II, it is evident that the miniature incandescent filament lamp does emit a tremendous number of useful photons in the electromagnetic spectrum range outlined by the emission window.

This contrasts with the very small number of useful photons emitted by cathode-glow tubes and light-emitting diodes, which emit photons only in narrow, isolated discrete wavelengths (line spectrum) instead of a solid band.

Comparative testing

To demonstrate the magnitude of difference between incandescent filament lamps, LEDs and cathode-glow tubes for supplying photons, a comparative test was made.

Measured values of a No. 683 T-1 lamp, 1/8-inch diam, 1/4-inch long, operated at 11 different voltages and with the photosensor located at two different spacings from the broadside of the filament are listed in **Table I.** The broadside emission area of the filament facing the photosensor surface was only about 0.002 cm^3.

Following these 11 voltage measurements with the incandescent filament lamp, two types of solid-state emitters (LED) were placed in position opposite the photosensor, with direct contact of emitter and sensor in both tests.

LED No. 1 had a rating of 3.5V at 0.025A, and gave a photosensor response of 0.10 μA. When the voltage was raised to 3.9V at 0.050A, the response increased to 0.15 μA.

LED No. 2 had a rating of 1.65V at 0.050A, and gave a response of about 0.15 μA. When pushed to 1.88V, 0.075A, it produced a response of 0.20 μA.

Another comparison was made by substituting for the No. 683 T-1 lamp a NE2H high-brightness lamp operating on 118V, 60Hz, with a 22,000Ω series resistor. The glass envelope of the NE2H was in contact with the photosensor glass envelope. With both electrodes glowing and facing the photosensor, the sensor output equaled 15 μA. With the glow lamp moved to a spacing of 1/4 inch, the reading fell to 2 μA. Cathode-glow lamp area facing the sensor equaled 0.09 cm^2. The ratings of this NE2H are 1/4W and 5000 hrs life.

Next, a normal-brightness cathode-glow lamp (N-E2E) was substituted for the NE2H. Series resistor value

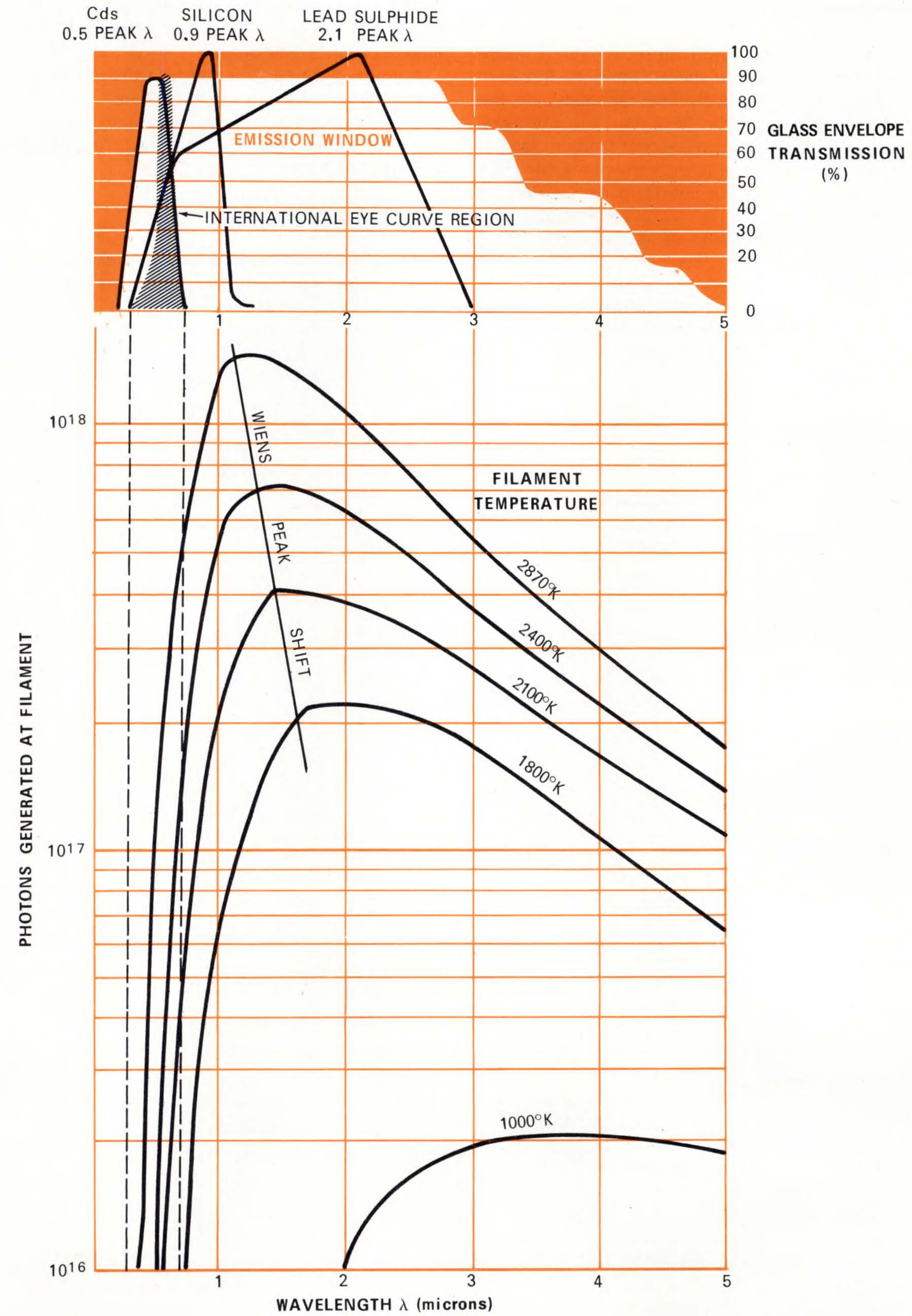


Fig. 1—Highest filament efficiency and maximum transmission through the glass envelope occur in the same region.

was 62,000Ω. With glass envelopes in contact as before, the reading was 2 μA. This lamp also had a cathode area of 0.09 cm^2.

Compare these results with those in **Table I.** More tests could be made on line-spectra emitters, but all of them would have a relatively low capability, on the order of 2 to 3 magnitudes less than the photocell response made by small incandescent filament lamps.

If the 683 lamp with parameters shown in **Table I** was to be operated at 3V, life performance would be measured in years; and at its 3V filament temperature of 1760°K, it would be able to withstand considerable shock and vibration.

Relative Merits. Values listed in **Table II** are derived from column 6 of **Table I.** These values for photocell response show the relative merits of the different photon emitters on a "watt-input versus output-of-sensor" basis.

The column headed Watts per Microampere indicates the input energy in watts required for the emitter to produce 1 μA into a 1 kΩ load connected across the silicon photosensor output.

A unit factor of 1.00 is used for the 683 lamp operating at 5V, as shown in the last column. The figures for the other emitters indicate how many times as much power is required for them to produce a photosensor response of 1 μA.

Dynamic characteristics

So far we have touched only on steady-state characteristics for these emitters, so a brief survey of the dynamic characteristics is indicated.

LEDs. Switching speeds for LEDs and cathode-glow tubes are much faster than for incandescent-filament lamps. Some LEDs can be switched on and off in 10-20

1	2	3	4	5	6	7
VOLTS	AMPERES	MEAN SPHERICAL CANDLE-POWER	MAXIMUM FILAMENT TEMPERATURE (K°)	INPUT (W)	PHOTO-SENSOR OUTPUT, (μA) NOTE 1	PHOTO-SENSOR OUTPUT, (μA) NOTE 2
6.0	0.0693	0.110	2130	0.41	150	52
5.5	0.0661	0.075	2060	0.36	138	39
5.0	0.0629	0.050	1980	0.31	125	30
4.5	0.0593	0.031	1900	0.27	103	20
4.0	0.0560	0.020	1840	0.22	80	14
3.5	0.0520	0.0098	1760	0.18	51	8.5
3.0	0.0480	0.0044	1670	0.14	30	5.0
2.5	0.0440	0.0018	1560	0.11	15	2.4
2.0	0.0391	0.00061	1460	0.08	7	1.0
1.5	0.0340	0.00021		0.051	2	0.4
0.68 NOTE 3	0.0276	0.0001		0.024	0.4	

NOTES:

1: PHOTOVOLTAIC SILICON SENSING AREA = .04cm^2 SPACING OF SENSING AREA FROM BROADSIDE OF FILAMENT = 1/8 INCH.

2: SPACING CHANGED TO 3/8 INCH.

3: THRESHOLD OF VISIBILITY.

Table I—Photosensor output varies with filament voltage and distance between source and sensor.

TYPE OF EMITTER	WATT INPUT/ μA OUTPUT	WATTS/μA	RELATIVE POWER REQUIRED
CM–683 at 5 .OV	0.31/125	0.0025	1.00
CM–683 at 3 .OV	0.14/30	0.0047	1.88
NE2H–High Brightness rating 0.25W	0.25/15	0.0167	6.7
NE2E–Normal Brightness rating 0.10W	0.10/2	0.05	20
No. 1 "LED" solid–state emitter 3.5V, 0.025A	0.0875/0.1	0.875	350
No. 1 "LED" solid–state emitter 3.9V, 0.050A	0.195/0.15	1.3	520
No. 2 "LED" solid–state emitter 1.65V, 0.050A.	0.0825/0.15	0.55	220
No. 2 "LED" solid–state emitter 1.68V, 0.075A.	0.126/0.20	0.63	252

Table II--Highest efficiency, in a comparison of the three types of energy sources, is obtained with incandescent lamps.

nsec, while others require up to 200 µsec. However, the relative output of LEDs is low. Also, LEDs are expensive compared to neon glow tubes and incandescent lamps, but they do have long life and are extremely resistant to shock and vibration.

Cathode-Glow Tubes. Small neon cathode-glow tubes also have faster switching time than incandescent-filament lamps. They are especially suited for oscillation circuitry from 1 to 20,000 Hz, because of their unique bistable characteristics. The more refined types today also make excellent voltage regulators. Their photosensor response is generally higher than that from LEDs, but considerably lower than that from incandescent-filament lamps. This stems from their line emission being comprised of discrete-wavelength energies, usually measured in microwatts output. The actual area of emission from cathode-glow tubes must be small for them to be coupled efficiently to a small photosensor. Like LEDs, cathode-glow tubes are highly resistant to shock and vibration.

Because LEDs and cathode-glow tubes have limited radiation output and geometry of emission, they do not lend themselves to applications using reflecting surfaces.

Plastic lenses used on LEDs can help collimate the radiant energy from the actual surface of emission and some gain can be obtained. The large emission area of neon glow lamps practically prohibits the use of reflectors or lenses.

Incandescent Lamps. With miniature incandescent filament lamps, the filament is quite small in size. When it is positioned away from its own support into free space, either a reflector or lens will greatly intensify the beam of radiant energy in a forward direction--from 75% to 500%.

A gold-plated reflector, encasing a long, straight-line filament lamp, will increase the forward output of effective energy, in the near infrared spectrum, about 80% over the effective radiant energy of the same lamp without reflector.

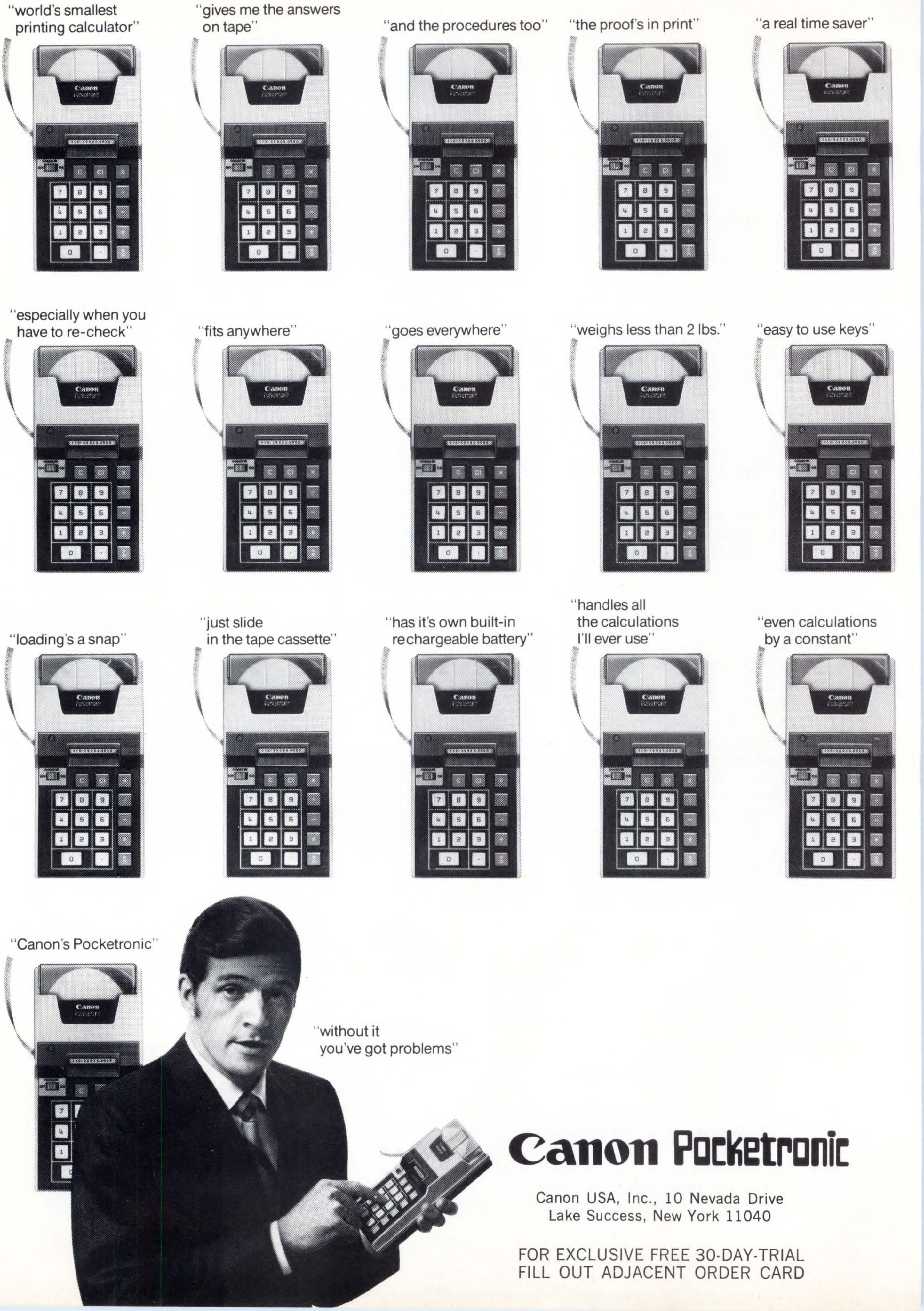
Switching time of miniature lamps for about 90% modulation of luminous energy is limited to about 10 Hz because of thermal lag. The frequency of switching can be greatly increased, if a relatively small change in filament temperature can be used to trigger a desired, differential-microampere response in the photosensor coupled to it. This method takes advantage of the thermal ripple of filament temperature caused by the alternating current, used at different frequencies, to bring it up to incandescent temperatures.

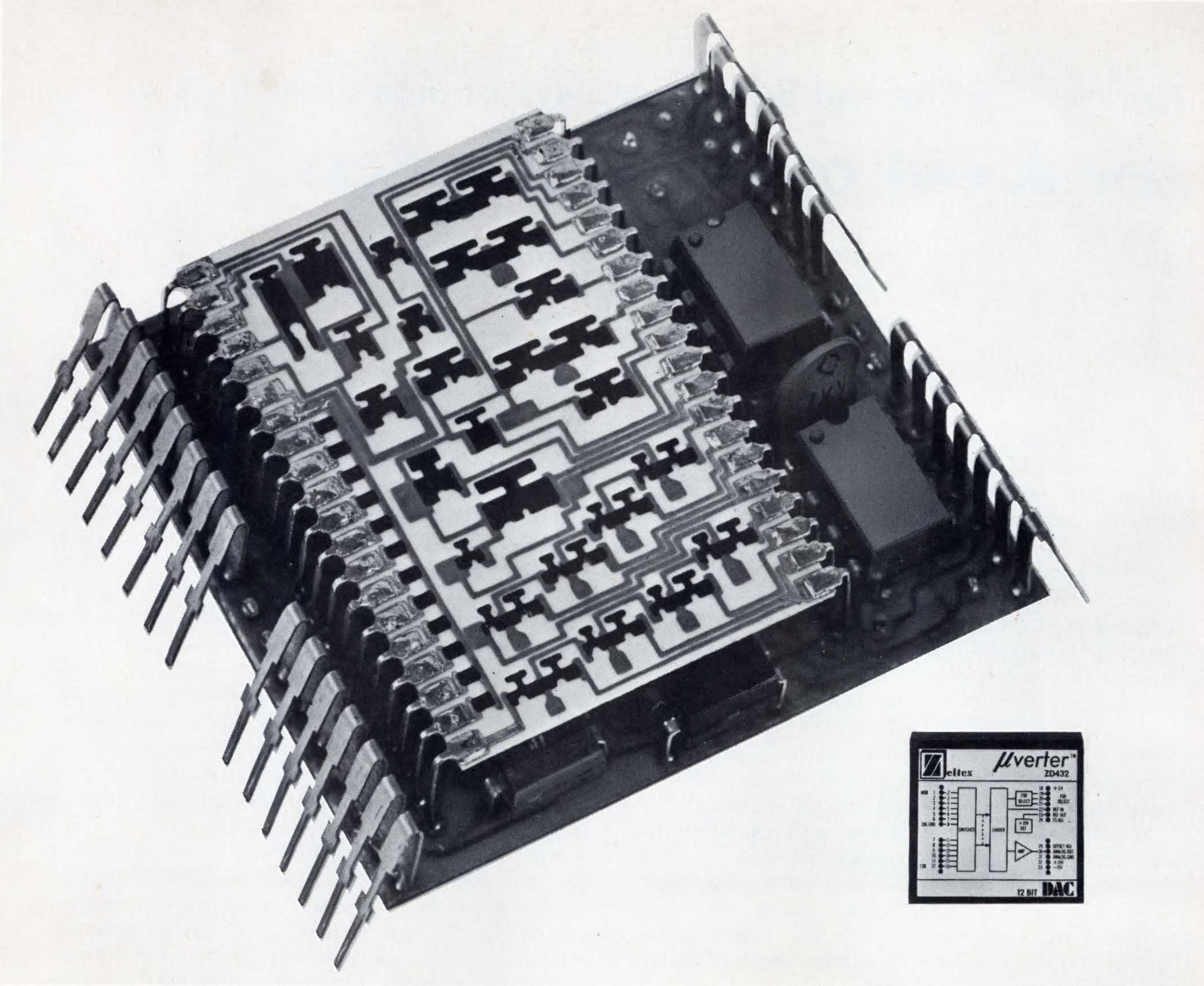
Thermal ripple for the 683 lamp with specifications shown in **Table II,** energized by 60 Hz ac would cause a differential change in response of about 7 to 8 µA for 5.0V rms applied. This would correspond to 120 pulses per second. Using 400 Hz ac the differential would be about 1 to 2 µA with 800 pulses per second.

With 3.0V applied at 60 Hz the photosensor response would be about 3 µA differential. Other finer tungsten-wire lamps could be used to increase the switching or pulsing speed to still higher values, but the photosensor, microampere-response differential would not be sufficient because of the lower radiated power output of these low-current lamps.

Author's biography

Otto J. Forsberg is Chief Design Engineer for the Chicago Miniature Lamp Works, Chicago, Ill. He was a pioneer in the development of subminiature lamp devices and is credited with the design and development of a number of firsts in this field over a period of more than 40 years. Mr. Forsberg is currently in his 52nd year at the Chicago company.


"world's smallest printing calculator"
"gives me the answers on tape"
"and the procedures too"
"the proof's in print"
"a real time saver"
"especially when you have to re-check"
"fits anywhere"
"goes everywhere"
"weighs less than 2 lbs."
"easy to use keys"
"loading's a snap"
"just slide in the tape cassette"
"has it's own built-in rechargeable battery"
"handles all the calculations I'll ever use"
"even calculations by a constant"
"Canon's Pocketronic"
"without it you've got problems"
Canon Pocketronic
Canon USA, Inc., 10 Nevada Drive
Lake Success, New York 11040
FOR EXCLUSIVE FREE 30-DAY-TRIAL
FILL OUT ADJACENT ORDER CARD



You designed our conversion products!

We believe in designing products *for* design engineers! That's why tens of thousands of ZELTEX conversion products are now in the field and hundreds being presently "designed in." Employing our complete in-house thick-film facility we build our converters from the substrate on up!

Our thick-film resistor networks are actively trimmed to 0.01% and feature 0.05% FSR/10,000 hr. long term stability.

This capability plus new circuit design techniques have drastically reduced our engineering and production costs, and allowed us to produce the best price/performance conversion products on the present market.

Our conversion products are burned in for 16 hours at 85°C; that's why our infant mortality rate is virtually zero!

As a design engineer you'll appreciate our inter-model compatibility, especially for OEM system designing: pin layout has been standardized between like models allowing direct interchangeability when higher or lower resolutions are required; external selection of input/output voltage ranges are made by convenient lead strapping; and location of power and ground leads are designed to fit standard DIP socket matrices—*that's total design!*

Our products are designed to simplify your design problems! Send for data sheets and applications covering our complete line of conversion products. Just circle the reader service number or give us a call today!

DAC'S	ZD429	ZD433	ZD430	ZD440	ZD431	ZD441	ZD432
Resolution	2-digit	3-digit	8-Bit	8-Bit	10-Bit	10-Bit	12-Bit
Settling Time (to ½ LSB)	20 µs	20 µs	20 µs	2 µs	20 µs	5 µs	20 µs
Linearity (% of FSR), max.	±0.2%	±0.05%	±0.2%	±0.2%	±0.05%	±0.05%	±0.01%
Input Coding (TTL/DTL)	Binary Coded Decimal		Two's Complement, Straight Binary (Parallel data entry)				
Analog Outputs (FSR)	0V to +10V		Unipolar: 0 to +10V; Bipolar: ±10V, ±5V				
Output Drive	5 mA (short circuit proof)						
Long Term Stability	±0.05% FSR/10,000 Hr.						
Price (1-99)	$19	$39	$19	$29	$29	$39	$49

ADC'S	ZD470	ZD460	ZD461	ZD471	ZD462
Resolution	8-Bit	8-Bit	10-Bit	10-Bit	12-Bit
Conversion Period, max.	15 µs	50 µs	100 µs	30 µs	100 µs
Linearity (% of FSR), max.	±0.2%	±0.2%	±0.05%	±0.05%	±0.01%
Long Term Stability	±0.05% FSR/10,000 Hr.				
Input Impedance	10K Ohms shunted by 10 pF				
Analog Inputs (FSR)	Unipolar: 0V to +10V; Bipolar: ±10V, ±5V				
Digital Outputs (TTL/DTL)	NRZ Serial and Parallel Binary; Two's Complement and Straight Binary				
Price (1-99)	$79	$49	$69	$99	$99

All Models in STOCK

Conversion Products Specialists

1000 Chalomar Road
Concord, CA 94520
Phone: 415-686-6660
TWX: 910-481-9477

Zeltex INC.

A SUBSIDIARY OF REDCOR CORP.

CIRCLE NO. 34

Gerry Williams and Bill Shoemaker of Signetics

speak out on op amp testers

The user of a bench-top linear IC tester better know not only what parameters are being tested, but how. Otherwise, he may find that his tests are meaningless.

It amazes us that the majority of bench-top linear IC testers presently on the market simply do not perform meaningful tests on many of the most important parameters that they purport to test. This is especially true in the case of op amps.

Conveniences such as the ability to change programs or select the type of readout used, are relevant considerations in selecting an op amp tester. However, these features should not be permitted to divert the buyer's attention from this fact: the single most important consideration in evaluating and selecting a linear IC tester is whether or not the equipment performs meaningful tests on the devices being tested. Obvious as that may sound, the majority of bench-top testers presently on the market do not do so.

In some cases, only partial tests are being performed on important op amp parameters. In others, the tests that *are* being performed are practically meaningless with respect to the specification against which the devices should be tested. A close look at some of the test techniques employed in various linear IC testers will make this readily apparent.

Generally, most testers in the under $10,000 class measure ("test") gain, common-mode rejection, input offset voltage, input current, power-supply rejection, power consumption, slew rate, and a few other parameters.

The most glaring proof that the designers of a number of currently available testers did not fully understand the operational characteristics of a typical op amp is illustrated by the presence of separate tests for such device characteristics as gain, positive output voltage swing and negative output voltage swing on their testers.

Gain can be common-mode or differential-mode. it can be at any frequency. It can be small-signal at any output level, or large-signal between any output limits. Fortunately, op amp gain is usually understood to be differential-mode dc gain.

The fact that all major monolithic op amp manufacturers have adopted large-signal dc gain with respect to a specified output-voltage swing for purposes of specification has apparently had little effect on designers of op amp testers.

The typical instrument gives a single full-load test result for gain at some reduced output voltage swing. It then provides subsequent independent tests for positive and negative output voltage swing, where the inputs are driven, successively, to produce positive output saturation, then negative output saturation.

This approach to testing the gain of an op amp against either the manufacturer's spec or the user's own internal spec is totally inadequate for two reasons: First, the output voltage of an op amp is often a very nonlinear function of differential input voltage (notwithstanding the inclusion of the op amp into a broad category of devices commonly referred to as "linear" ICs). Gain variations of 200% or more are common from the positive to negative output voltage quadrants. Second, an arbitrary measurement of output saturation levels does not define large-signal gain so is virtually useless.

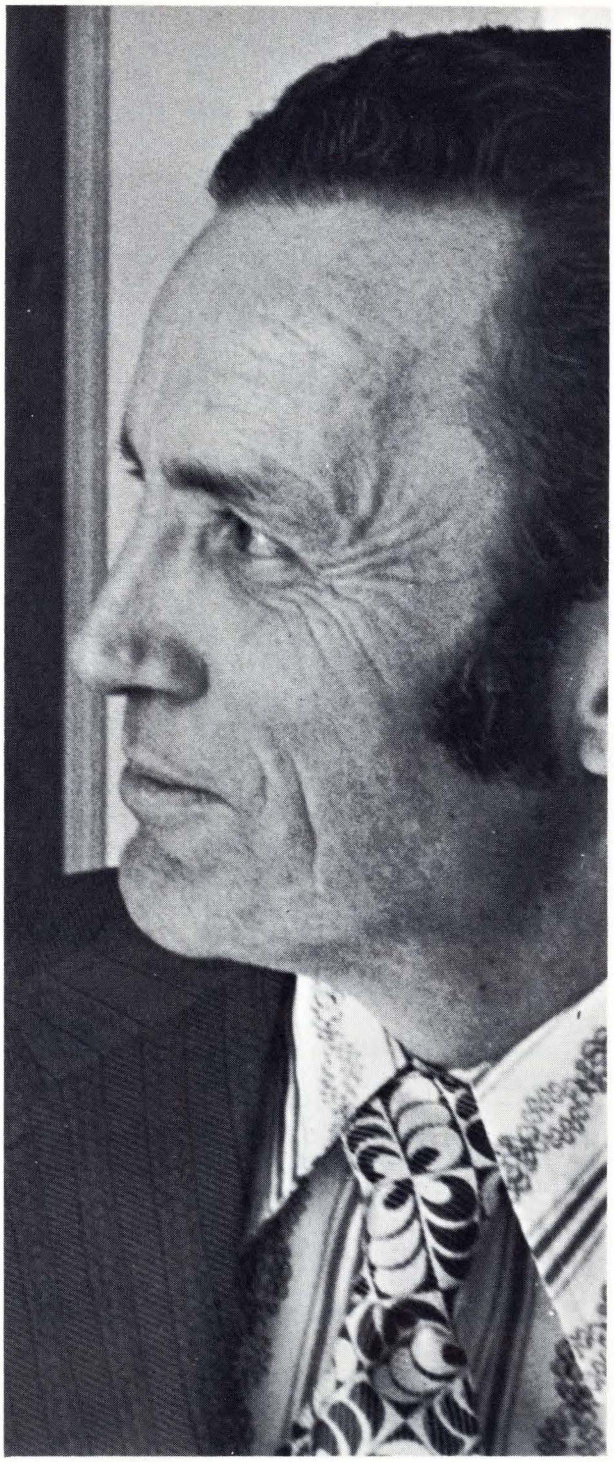
With respect to the first reason, the gain of a typical op amp can vary substantially at different output-voltage levels as a consequence of nonlinearities resulting from thermal feedback on the chip. Because of this fact, it is inadequate to test gain at some reduced output voltage swing, assuming gain linearity, and then to make subsequent independent tests of positive and negative output voltage swing. In spite of this, the majority of today's testers perform their gain "test" in this manner. The results of such a test can be substantially different from the actual gain of the device at its specified output voltage limit (200 to 300% variations should not be considered unique).

There is only one correct method of testing the gain of an op amp against the manufacturer's and/or typical user's specifications. That method requires that two separate and distinct gain tests be made on the device, and that the maximum guaranteed output voltage swing of the device be imposed as a test condition.

During the first gain test, output voltage of the op amp must be forced to the guaranteed positive voltage limit (from zero volts). The dc gain of the device is then measured and compared against the guaranteed minimum gain spec. In the second gain test, the procedure is repeated to the guaranteed negative output limit.

These two tests accurately compare the device gain and its guaranteed value, because every major manufacturer of operational amplifiers specs its devices on a "large-signal gain" basis. That means that they guarantee that their device will have some minimum gain—say 50,000 volts per volt--when that device is at full output loading, and when the output voltage is equal to (not "less than or equal to", but "equal to") some positive and negative voltage, typically plus and minus 10 volts.

Gerry Williams



Bill Shoemaker

They further define what they mean by "large-signal voltage gain" by stating in their specification that it is "the ratio of the maximum output-voltage swing with load to the change in input voltage required to drive the output *from zero to this voltage.*" This is a direct quote from the spec sheets of four of the largest U.S. manufacturers of op amps. It clearly defines the requirement to perform the gain tests on their devices in the previously-described manner because of potential gain nonlinearity over the device operating range, and lack of gain symmetry from positive to negative output-voltage quadrants.

The unfamiliarity with real-world op-amp characteristics is again exhibited by some manufacturers of bench-top linear IC testers when they provide a common-mode rejection (CMR) test and positive and negative common-mode voltage (CMV) limit tests.

Here again, they are measuring device CMR at some reduced CMV swing. They assume that the CMR characteristic is linear over the device's full operating range; and then make subsequent independent tests of plus and minus CMV limit. Unfortunately, the fact that the device might have a CMR within specification at the reduced CMV swing over which it is tested does not assure the user that it is within spec over the full guaranteed CMV swing. Again, this is due to circuit nonlinearities.

Gain and CMR are extremely important op amp parameters, for both can directly affect the overall system specifications of the equipment in which they are employed. Both parameters can contribute to the overall scaling error of the system. Large-signal CMR is especially important in the unity-gain buffer circuit, where the applied signal is also the device CMV.

It is not sufficient, however, to simply perform the gain and CMR tests on a "large-signal" basis and let it go at that, particularly a high degree of confidence is needed that the devices are within specification at every point along their gain and CMR characteristic curves. Nonlinearities can result in a device that is "in-spec" at specified output voltage and CMV limits, yet "out-of-spec" at reduced output and CMV voltages (as well as vice-versa). This is why it is necessary to supplement the large-signal test results with a statistical sampling of the devices to be tested to determine their degree of nonlinearity.

When done, this permits the user to develop a "degree-of-confidence" that devices which pass the large-signal gain and CMR tests are, in fact, good devices over the full operating range. This test capability would most logically be provided through an accessory to the basic large-signal tester that would permit fast and accurate generation of a device's gain and common-mode rejection characteristic curves over the full operating range. This would let the user rapidly check production samples of op amps for linearity. Interestingly enough, we know of only one bench-top linear IC tester on the market that has this capability.

The fact that an instrument designer might not be cognizant of such op amp phenomena as parameter nonlinearities resulting from thermal feedback and negative gain should not be too surprising, for the vast majority of engineers who use op amps in their design work are not aware of these facts.

This does not alter the harsh truth, however, that a tester designed by such an engineer is inadequate to perform its required function.

A more devastating indictment of the op amp testers on the market (on the basis of "the designer should have known better") is that a majority of them have only one "offset voltage" test in their automatic test sequence.

This is especially strange, because an op amp can be outside of its offset-voltage spec under two separate and distinct sets of conditions. One of them is where the balanced source resistance (R_S) approaches zero ohms; and the second is with the balanced source resistance at some maximum specified value, such as 10 kΩ. To really check an op amp's offset voltage against its spec, tests must be made under both these conditions. Again, we are aware of only one linear bench-top tester that includes two offset-voltage tests in its automatic test sequence.

It is understandable that there is a learning curve involved whenever a new area of knowledge is entered, and the design of bench-top test equipment for linear ICs is certainly such an area. However, it is unfortunate for those who purchase inadequate equipment that the bulk of the manufacturers who have marketed these instruments have not spent the necessary time, money and effort during the investigative stage of development. Such expenditures would have given an understanding of the real-world characteristics of op amps, and would have resulted in tester designs that could provide true value to the end user in return for his investment. ▭

Who are Gerald Williams and Bill Shoemaker?

Gerald Williams is General Manager of Signetics Measurement/Data Operation.

After receiving his B.S.E.E., cum laude, from the University of Portland in 1961, he joined General Electric. For the next 6 years he served there in various functions, ranging from design engineer of process industry control systems to marketing engineer for drive systems.

Gerry joined Signetics in 1969 as Marketing Manager for the Instrumentation Operation after taking 2 years off from industry to earn an M.B.A. from the University of Pennsylvania's Wharton School of Finance and Commerce.

Gerry lives in Mt. View, Calif. with his wife, Dianne, and their 4-month old son.

Bill Shoemaker is Staff Engineer at Signetics Measurement/Data. For the past 3 years, he has specialized in the development of integrated-circuit test systems. Previously, he was a senior member of the Technical Staff at Beckman Instruments of Fullerton, Calif.

After obtaining a B.S.E.E. Degree from UC Berkeley in 1951, he joined California Research and Development Corp. (a subsidiary of Standard Oil of California) and spent 8 years developing instrumentation for linear accelerators and geophysical research. Bill is a member of both Tau Beta Pi and Eta Kappa Nu. He holds eight patents, has presented two ISA papers and was awarded an M.S.E.E. Degree by Stanford University in 1971.

Bill lives in Los Altos, Calif. with his wife, Mary, and their two teenage sons. Scouting, tennis, science and music are part of the family activities.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE L63**

NEW! 1024 PRØM™/ROM.

For greater flexibility in obtaining economical bipolar read-only memory devices from design through volume production.

We invented the PRØM concept, established its reliability, and delivered in volume. Now we're adding to the most complete line offered in the industry and have used the knowledge obtained over a year's experience to bring you an even more dependable product. The application flexibility of our new PRØM/ROM is achieved because both are electrically identical and pin-for-pin interchangeable with each other and other 1024 bit devices. The PRØM is available with two outputs—open collector or tri-state. The ROM is mask programmable and available in standard ASCII to EBCDIC code converter patterns. Custom programming is also available. The reliability of both PRØM devices is documented by 260,000,000 fuse hours of life test data. For further details see your Harris representative or distributor.

Features:

256 words/ 4 bits per word

Fully decoded

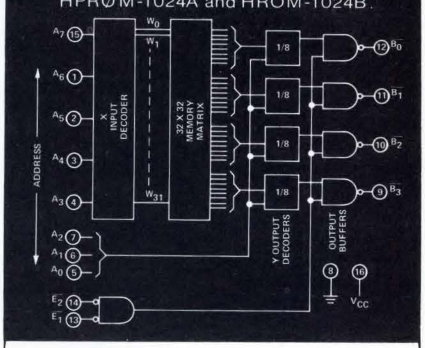
DTL/TTL compatible

50 ns access time

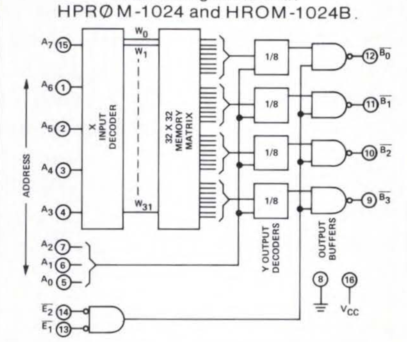
Expandable—"Wired-OR" outputs with chip select input

Available in military and commercial temperature ranges

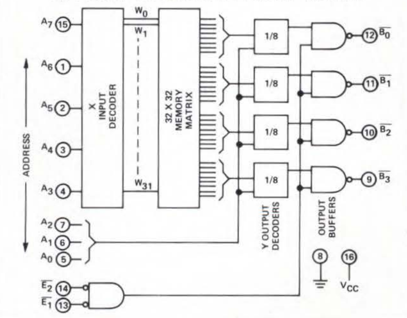
HPRØM-1024 Block Diagram
Interchangeable with HPRØM-1024A and HROM-1024B.



HPRØM-1024A Block Diagram
Interchangeable with HPRØM-1024 and HROM-1024B.



HROM-1024B Block Diagram
Interchangeable with HPRØM-1024 and HPRØM-1024A.



1024's are also available in the innovative Diacon package.

New too!
HROM-2561M Character Generator
One of the highest speed devices of its kind, with guaranteed A.C. performance over the full military temperature range.

Features:

1.5 MHz over full military temperature range

512 x 5 organization

ASCII to 5 x 7 dot matrix, p-MOS

	100-999 units 0°C to +75°C	−55°C to +125°C
HPRØM-8256 Bipolar 32 x 8 T_A = 40ns	$12.00	$24.50
HPRØM-1256 Bipolar 256 x 1 T_A = 35ns	$14.75	$24.50
HPRØM-0512 Bipolar 64 x 8 T_A = 55ns	$27.50	$43.00
†HPRØM-1024 Bipolar 256 x 4 T_A = 60ns	$55.00	$71.50
†HPRØM-1024A Bipolar 256 x 4 T_A = 60ns	$55.00	$71.50
†HROM-1024B Bipolar 256 x 4 T_A = 60ns	$15.00*	$18.75*
†HROM-2561M p-MOS 512 x 5 f_ϕ = 1.5MHz	$19.25	$28.60

† New * 500-999 units

HARRIS SEMICONDUCTOR
A DIVISION OF HARRIS-INTERTYPE CORPORATION
P.O. Box 883, Melbourne, Florida 32901
(305) 727-5430

DISTRIBUTORS: Schweber Electronics: Westbury, New York (516) 334-7474; Rockville, Maryland (301) 881-2970; Hollywood, Florida (305) 927-0511 / **Harvey/R & D Electronics:** Lexington, Massachusetts (617) 861-9200 / **Semiconductor Specialists, Inc.:** Chicago (312) 279-1000; Detroit (313) 255-0300; Minneapolis (612) 884-8132; Kansas City (816) 452-3900; St. Louis (314) 428-6100; Dallas (214) 358-5211; Indianapolis (317) 243-8271; Pittsburgh (412) 781-8120; Dayton (513) 278-9455 / **R.V. Weatherford Co.:** Albuquerque (505) 265-5671; Anaheim (714) 547-0891; Austin (512) Enterprise 1443; Dallas (214) 231-6051; Denver (303) 427-3736; Glendale (213) 849-3451; Houston (713) Enterprise 1443; Palo Alto (415) 321-5373; Phoenix (602) 272-7144; Pomona (714) 623-1261; San Diego (714) 278-7400; Seattle (206) 762-4200. **HARRIS SALES OFFICES:** Wellesley, Massachusetts (617) 237-5430; Wayne, Pennsylvania (215) 687-6680; Palos Heights, Illinois (312) 597-7510; Melbourne, Florida (305) 727-5430; Palo Alto, California (415) 321-2280; Norwalk, Connecticut (203) 853-3646; Washington, D.C. (202) 337-4914; Dallas, Texas (214) 231-9031; Scottsdale, Arizona (602) 946-3556; Long Beach, California (213) 426-7687.

CIRCLE NO. 35

Don't let LED output measurements throw you

Here's how to determine, compare and analyze LED light output, whether you're evaluating specifications or making your own measurements.

Luminance, in footlamberts, has been widely used to describe the light output of LEDs, but when used alone it is not sufficiently descriptive to be of much value. The first point to remember is that luminance describes the "brightness" of an emitter *per unit of area*. Typically, footlambert measurements are made on a very small spot on the surface of the emitter. Thus, unless you know the total area of the source, footlambert figures don't mean much. Measurements in millicandelas describe the luminous intensity of light radiated by the *entire* source. This luminous intensity is typically measured on-axis within a small cone extending from the sensor to the source; and of the two measurements mentioned, millicandelas provide the better comparison tool.

On-axis measurements in footlamberts and millicandelas do not completely describe an LED. They, along with apparent source size, are merely the first three measurements that you will need in order to make valid LED comparisons.

Detectors fall into two categories

Devices used to detect and measure light generally fall into two categories:

Thermal detectors—those devices such as thermopiles, thermocouples and thermistor bolometers. In all cases they operate on heat rise caused by incident radiation. Their response usually covers a wide portion of the EM spectrum. Because of this they are better suited for radiometric than for photometric measurements, although filters can be used to make their response approximate the CIE photopic (standard eye) curve.

Photon detectors—These devices react directly to photon radiation incident on their surfaces and are usually supplied by the manufacturer with curves specifying a certain analog output calibrated in photons/sec. Photon detectors respond to the light wavelengths as shown in **Fig. 1** and since their response is generally wider than the photopic curve, it can be filtered to closely approximate the response of the eye.

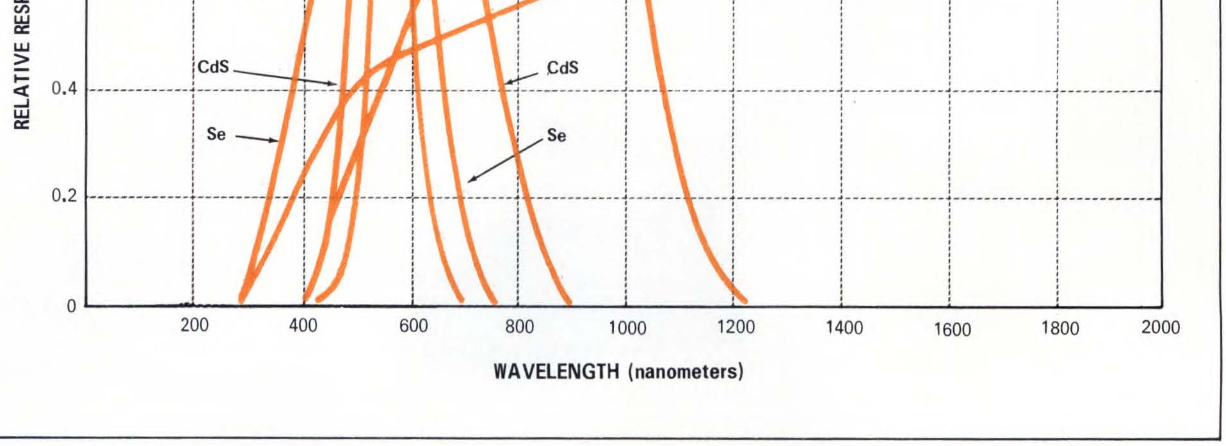


Fig. 1—**Relative response vs wavelength** for several photon detectors. The dashed line represents human eye response. Because the detectors shown have curves similar to the eye but of wider range, they can be filtered for photometric measurements.

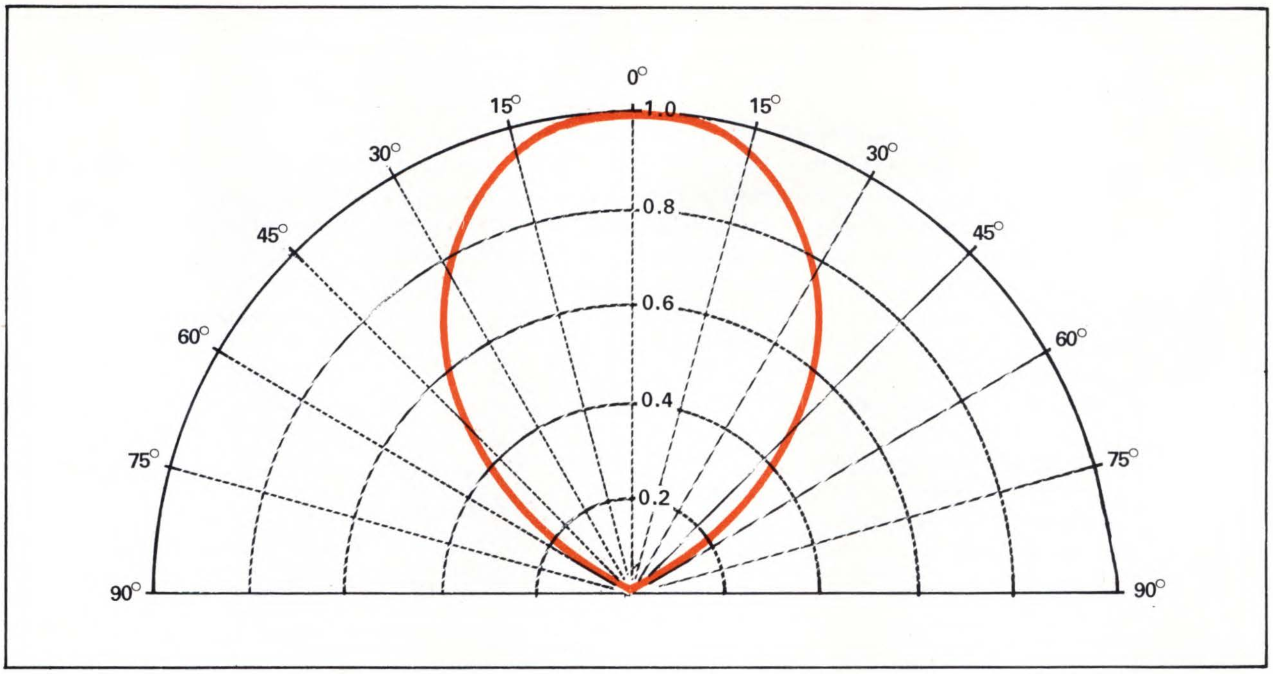


Fig. 2—**Goniometric plot of LED output** is valuable because it shows light output in all directions relative to the on-axis output. This on-axis measurement is usually given by the manufacturer in footlamberts or millicandelas.

This greatly facilitates the conversion of readings into photometric terms.

Radiometric and Photometric Units

In the Dec. 15, 1971 issue of EDN/EEE, George Smith's article, "LEDS & Photometry," presented photometric terms and definitions along with an explanation of their usages. The terms we have listed next are only partial and are presented to help you correlate photometric with radiometric units. The corresponding basic units of each system are:

Luminous energy (talbot)	—Radiant energy (joule)
Luminous flux (lumen)	—Radiant flux (watts)
Luminous intensity (candela) candela = lumens/steradian	—Radiant intensity (watts/steradian)
Luminance (footlambert) footlambert = candela/πft^2 = lumens/steradian/πft^2	—Radiance (watts/steradian/ cm^2)

What do you need to know?

To make intelligent selections of LEDs (or for that matter, any light source) you must have—as a minimum—measurements of the on-axis luminous intensity and a relative plot of the off-axis luminous intensity. This plot, shown in **Fig. 2**, is called a goniometric or goniophotometric plot, and describes the luminous intensity in all directions. The area within the curve when related to on-axis intensity represents the total luminous flux output of the device. These on-axis and goniometric measurements may be given in footlamberts by some manufacturers, and if so you will need to know the apparent size of the light source to derive millicandela figures. Since one footlambert is $\frac{1}{\pi}$ candela per ft^2, then candela = (π) (footlamberts) (ft^2), where (ft^2) represents the apparent size of the light source in square feet. Obviously, with small sources such as LEDs, the area of the

Fig. 3—**Luminance measurements** in footlamberts are made with a spot meter over a small portion of the emitting surface. Apparent size of the light source must be known if luminance readings are used to compare different light sources.

source must be calculated precisely to retain accuracy in this correlation.

Measurement procedures

Luminance is usually measured, as in **Fig. 3**, with a spot meter that measures a very small area of the radiating surface. While this spot size varies with the manufacturer and model, it is typically 0.002 inch in diameter. Again, to be meaningful, both luminance and the apparent size of the emitting surface must be listed.

Total lumen output is measured with a test block shown in **Fig. 4**, that contains a conical cavity. The interior surface wall of this cone is polished and coated to reflect all light emitted from the source onto the sensor. One very important assumption made in this test is that all light emitted is radiated into the forward hemisphere. While this is valid for most LED devices on the market, it obviously does not hold for all other types of light sources. Calculation of radiated power is computed as a function of peak wavelength. Energy/photon is found by $\frac{hc}{\lambda}$ where: h (plancks constant) equals 6.63×10^{-34} joule sec, c is the speed of light (3.0×10^{8} meters/sec) and λ is peak wavelength in meters. Then total radiated power = energy/photon × photons/sec, with photons per sec being determined by the analog output of the detector and curves supplied by the detector manufacturer. These calculations will provide radiometric data (watts) unless the sensor is filtered and the manufacturer's data are corrected for photometric units (lumens). If the sensor is not corrected to the photopic curve, then lumens/radiant watt can be calculated from the standard luminosity function at the LED's peak radiation wavelength.

Ideally, luminous intensity in millicandelas should be measured within an infinitesimal cone projected to a point source. Unfortunately, this would require an infinitesimal detector, which could not collect enough luminous flux to

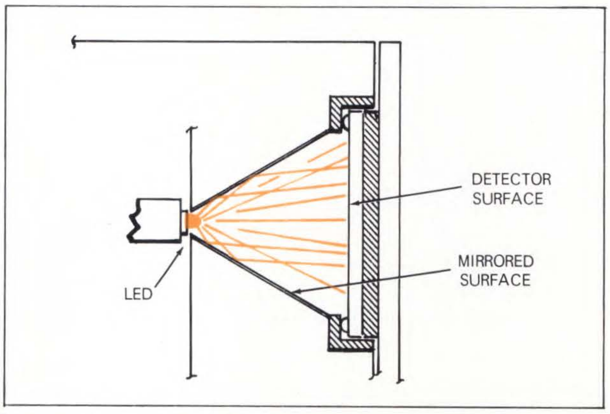


Fig. 4—**Total lumen output** can be measured in this test fixture. This is the only direct measurement technique that provides a comparison of overall efficiency. By monitoring power input to the device, luminous efficiency can be calculated in lumens out per electrical watt input.

Fig. 5—**The microcandela meter** is adaptable for photometric and radiometric measurements of intensity and output.

give any reading. Therefore, finite detectors are used and intensity calculated from I = df/dω to give a theoretical infinitesimal cone. *It is essential for correlation that dF/dω be calculated, or that the angle of the cone measured (in steradians or "degrees half cone") be included with the millicandela ratings.*

To standardize these readings, at least within your own company, it is advisable to use a test fixture like the one described in **Fig. 6** so that the conic angle will be fixed and repeatable. Distance L must be greater than $20d_1$, distance P should be minimized and angle θ should be no greater than 5°. At $\theta = 5°$ the cone measured will be 0.0240 steradians. It is important that θ be measured or calculated and recorded with all data obtained from measurements made with this device. Calculations are made exactly as previously described under total lumen output. As in that test, the results will be in radiometric units (in this case watts/steradian) unless filtering and calibration of the detector permit direct reading in photometric units. The readings usually quoted are those made on-axis, but by mounting the device under test on an indexing table, goniometric measurements can be plotted for off-axis angles.

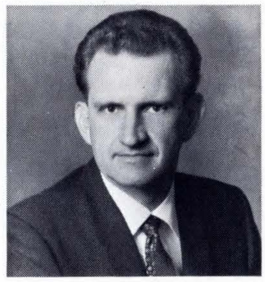
The table in **Fig. 7** gives photometric and radiometric formulae and defines the symbols and units used. Using these formulae you can correlate performance from data sheets or your own measurements. To compare LEDs from different manufacturers, you should have these five measurements on each device:

1. Apparent source size.
2. Footlamberts (on-axis).
3. Millicandelas (on-axis).
4. Spatial distribution (goniometric) plot.
5. Total lumen output.

Each tells you something specific about the operation of the LED. In a pinch you can derive some of these measurements from others—for example, source size and footlamberts tell you what you need to determine millicandelas. Likewise, millicandelas (on-axis) and the goniometric plot will allow you to calculate total lumen output. But if you make all the measurements, you will be able to make several cross checks, and will have introduced a much higher confidence factor into your tabulations, decisions and designs. □

By Bill Furlow, associate editor, EDN/EEE and James K. Branch.

Author's Biography



James K. Branch has been President of Photo Research Div. of Kollmorgen Corp., Burbank, Calif. for 20 years. He has 25 years of experience in the photometric and photographic sciences and is an active member of OSA, SMPTE, SPIE and SPSE.

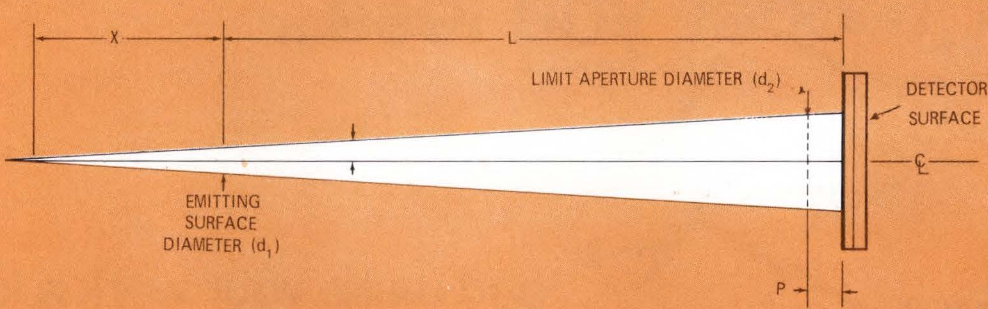
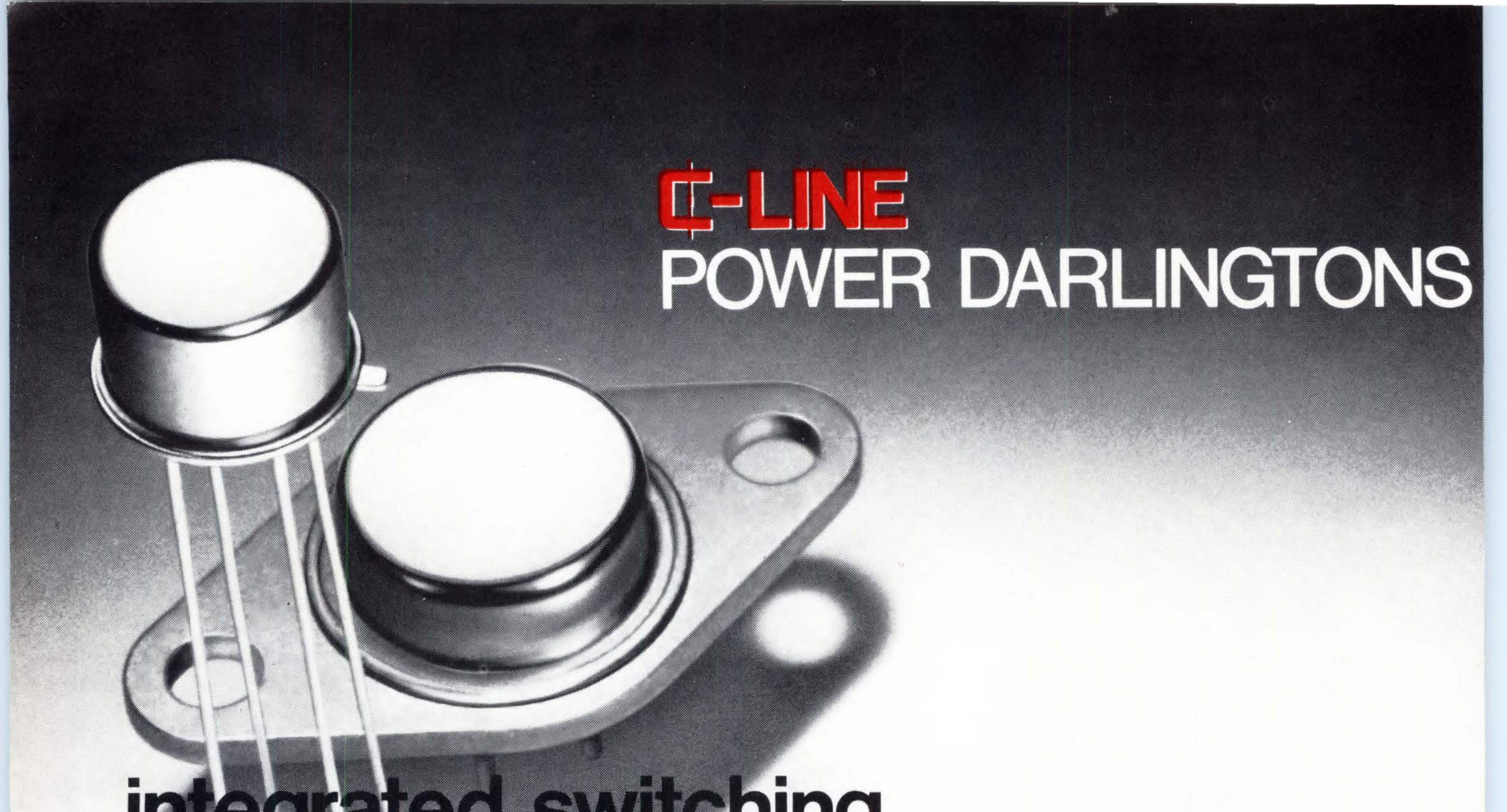


Fig. 6—**Measurement of luminous intensity** in millicandelas should be made on a test fixture similar to that shown here. One-half cone angle, θ, should be less than 5°, and must be specified in all references to the data obtained.

PARAMETER	LUMINOUS FORMULAS	RADIOMETRIC FORMULAS	SYMBOLS AND UNITS
Luminous/Radiant Intensity (using any probe)	$I = \frac{EA}{\omega}$	$J = \frac{HA}{\omega}$	I = Luminous intensity, in candelas. J = Radiant intensity, in microwatts/cm²/steradian. E = Illuminance, in footcandles (lumens/ft²). H = Irradiance, in microwatts/cm². A = Area of receiver in ft² for luminous formulas, in cm² for radiometric formulas. ω = Solid angle, in steradians. r = Source-to-receiver distance in feet for luminous formulas, in cm for radiometric formulas. F = Light flux, in lumens. P = Radiant flux, in microwatts. K_λ Conversion factor for converting from an illuminance reading to irradiance for an LED whose peak wavelength is λ. B = Luminance, in foot-Lamberts. a_s = Area of source (effective light-emitting area of LED), in ft².
Luminous/Radiant Intensity (using small angle probe)	$I = Er^2$	$J = Hr^2$	
Total Flux Output (using any probe)	$F = EA$	$P = HA$	
Irradiance (conversion from Illuminance reading)		$H = K_\lambda E$	
Luminance (conversion from Luminous Intensity)	$B = \frac{\pi I}{a_s}$		

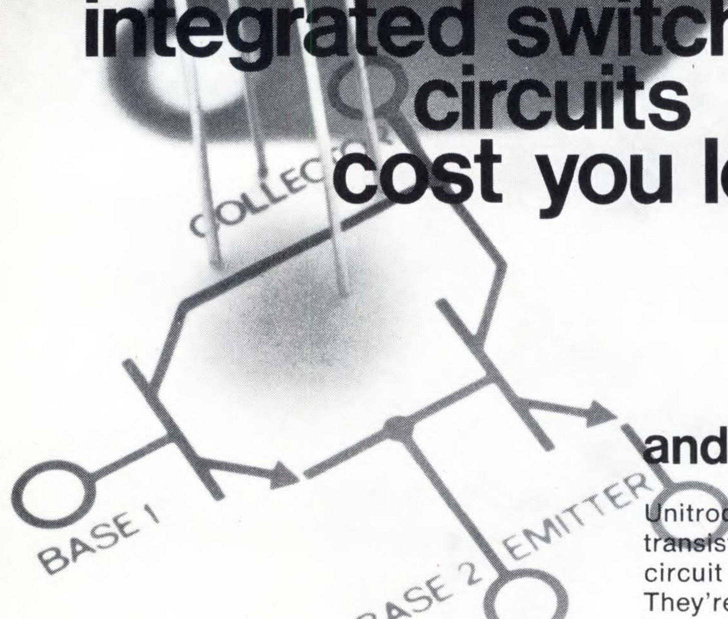
Fig. 7—**Formulae and units required** for light source measurements in both luminous and radiant terms.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE L64**



₵-LINE POWER DARLINGTONS

integrated switching circuits cost you less...



and make your work a lot easier.

Unitrode's new industrial 10 Amp silicon planar NPN Darlington transistors offer you the advantages of a monolithic two transistor circuit for less than the price of comparable discrete devices. They're ideal for high gain switching applications such as print hammer drivers, solenoid, servo and lamp drivers and for amplifying applications such as motor controls and linear amplifiers. They're available in two hermetically sealed metal packages — a lead-mounted TO-33 (U2T101) and a chassis-mounted TO-66 (U2T201). Both utilize overlay (multiple emitter) techniques on driver and output transistors. Saturation voltage is 1.5V max. @ 5A and current gain is 2000 min @ 5A. Collector-Emitter voltage ratings are available up to 150 volts. U2T201 has a power dissipation rating of 25W @ a case temperature of 100°C. For whatever Darlington application you have, Unitrode ₵-Line Darlingtons are more efficient and less expensive than any other method of performing the function. Why not make us prove it? (U2T101 is $2.75 ea. in lots of 100.)

For fast action, call sales engineering collect at (617) 926-0404
Unitrode Corporation,
Dept. 1AA, 580 Pleasant St., Watertown, Mass. 02172

Free samples on request.

UNITRODE quality takes the worry out of paying less.

CIRCLE NO. 75

Have a 50V swing on a 30V supply

If this sounds like something for nothing, read on. The key is differential output op amps and your point of reference, which must not be ground.

Electromechanical devices, such as solenoids and indicators, frequently require a greater voltage swing than is available from most op amps that use common supply voltages. At best, a 25V, pk-pk swing can be obtained from most general-purpose op amps on ±15V dc power supplies. In such a case, 5V of the 30V total supply voltage is used for biasing. For higher output voltage swings it is common to resort to more specialized, high-voltage op amps and power supplies. The cost of circuitry utilizing these special purpose amplifiers and power supplies is several times that of similar lower voltage op amp circuits.

Frequently, this approach can be avoided by making further use of the differential nature of op amps. In particular by using a differential output op amp, as shown in **Fig. 1**. Voltage swings far greater than the total supply voltage can thus be achieved. As shown, a 50V, pk-pk swing can be obtained with a differential output amplifier on the 30V available from ±15V dc supplies. This is a result of opposite polarity outputs. The outputs provide opposing 25V, pk-pk swings resulting in a net swing between the two outputs of 50V, pk-pk. This output can be applied to any floating load not requiring ground reference.

To further reduce cost, the differential output performance can be approximated using two single-ended-output IC op amps (**Fig. 2**). In this case a second, inverting, amplifier provides the opposite polarity output. This added output, however, has additional phase shift introduced by the second amplifier. Bandwidth of this circuit is limited more by phase-shift error than by amplitude error.

A second differential output amplifier formed by two single-ended output op amps is shown in **Fig. 3**. In this circuit the phase shifts at the two outputs are the same and a greater gain-accuracy bandwidth is attained than in the circuit of **Fig. 2**. Input impedance is also higher because the signal drives an op-amp input instead of a summing resistor. The only limitation of this circuit, as shown by the gain expression, is that the minimum attainable gain is unity.

To develop a differential output, this circuit uses a common feedback current. This current is equal to e_1/R_1 because the differential input voltages of both op amps are

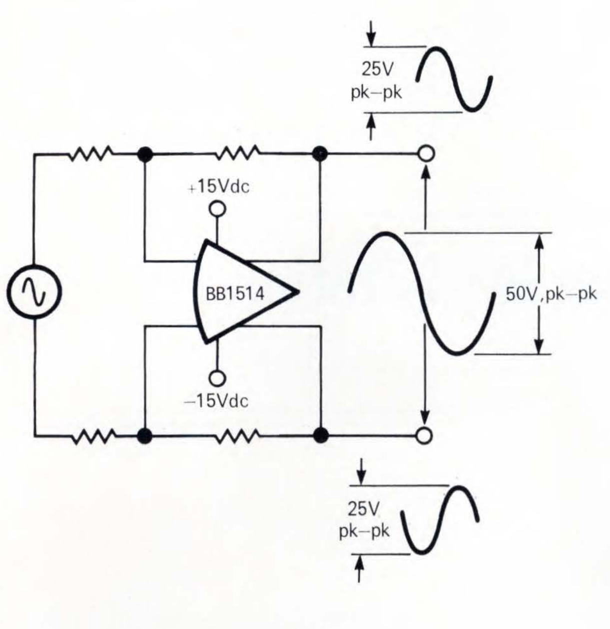


Fig. 1—**Differential output op amp** provides 25V p-p outputs of opposite polarity resulting in 50V pk-pk differential output.

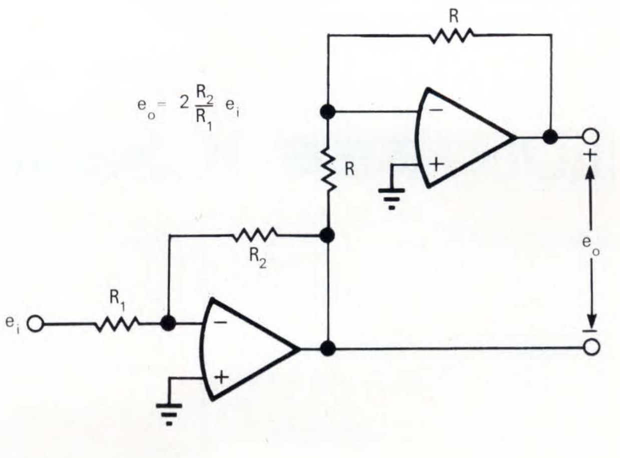


Fig. 2—**Two inverting op amps** provide a 50V swing at low cost, but phase shift limits bandwidth.

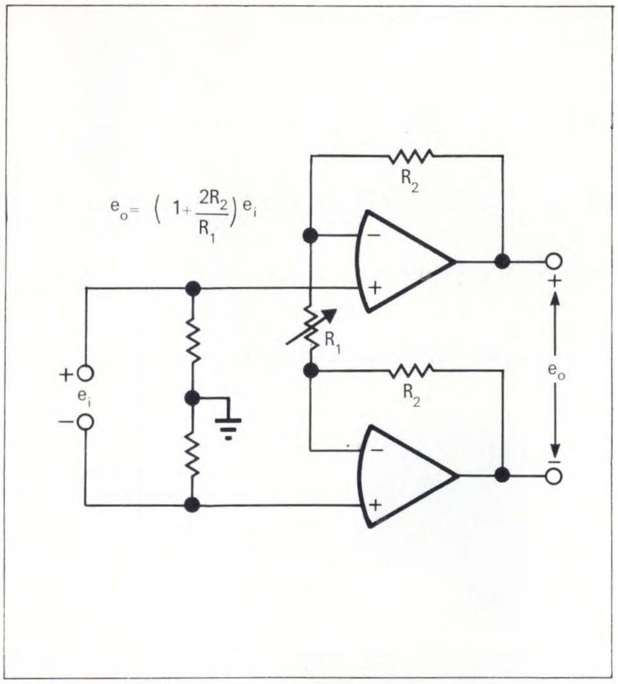


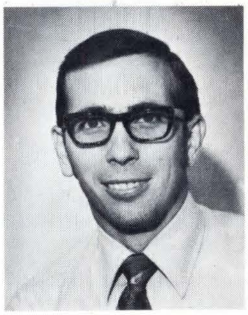
Fig. 3—**High input impedance** adjustable-gain differential output amplifier is achieved using a common feedback current and two single-ended output op amps.

nearly zero. Feedback current flows out of the feedback resistor of one op amp, thru R_1 and into the feedback resistor of the second op amp. Due to the opposite direction of feedback current in the two amplifier circuits, the outputs are of opposite polarity. □

Databank

"Operational Amplifiers: Design and Application," G. Tobey, J. Graeme, L. Huelsman McGraw-Hill, New York, 1971.

Author's biography



Jerald Graeme is Manager of Monolithic Engineering for Burr-Brown Research Corp., Tucson, Ariz. Jerald is a co-author/editor of the Burr-Brown/McGraw Hill book "Operational Amplifiers: Design and Application". He is a member of IEEE, Tau Beta Pi and holds a B.S.E.E. from the Univ. of Ariz. and a M.S.E.E. from Stanford Univ.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE L65**

CAHNERS BOOK DIVISION

offers you a 10 day free trial and satisfaction guaranteed on these books selected to help you in your work – in your leisure activities

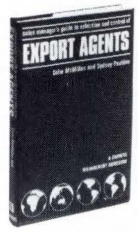
101. **COMPLETE GUIDE TO PROJECT MANAGEMENT** by Dennis L. Locke. Systems and techniques which can be used with profit in large or small plants, on projects worth $200 or $2 million. Costing, controlling, evaluating an industrial project so that it is completed on time, according to specs, within budget. Over 60 how-to-do-it examples, control charts, forms. illus. 224 pp. $10.95

POLLUTION — A Cahners Critical Issues Report

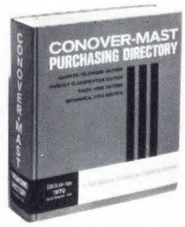
110. **Vol. 1.** What Management Needs to Know about Pollution Control. $5.00

111. **Vol. 2.** Environmental Management — Pollution Control Legislation. $5.00

102. **INVENTORY CONTROL IN PRODUCTION AND MANUFACTURING** by Adin B. Thomas. How to achieve big cost reductions and larger return on capital by efficient inventory management. A successful blend of theories by an expert who knows them all. illus. 224 pp. $11.95



103. **SALES MANAGER'S GUIDE TO SELECTION AND CONTROL OF EXPORT AGENTS** by Colin McMillan and Sydney Paulden. Specific, up-to-date information on every aspect of locating, selecting, controlling export agents. Twenty-seven types of agencies. How to pinpoint the agent by defining the market illus. 232 pp. $11.95



104. **CONOVER-MAST PURCHASING DIRECTORY.** For over half a century the indispensable one-volume annual for purchasing, production, engineering. Finds the right industrial product or service in seconds. Complete, including phone numbers of over 33,000 suppliers. Over 2250 pp. $30.00

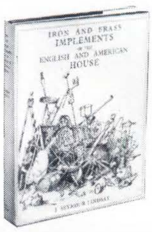
105. **IRON AND BRASS IMPLEMENTS OF THE ENGLISH AND AMERICAN HOUSE** by J. Seymour Lindsay (D.C.M., F.S.A.). Revised and enlarged edition includes new illustrations and new material from American museum and private collections. Covers hearth hardware and furnishings, early lighting, cooking utensils, tobacco smoking equipment etc. From medieval to early 19th century. illus. index, intro. by Ralph Edwards, C.B.E., F.S.A. $12.50

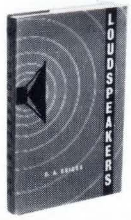
106. **LOUDSPEAKERS** by G. A. Briggs. 5th edition. All aspects of the design and performance of loudspeakers and enclosures are dealt with in non-technical terms. Separate chapters are devoted to Electrostatic Speakers and Stereo. A classic by a world-renowned, witty writer and audio expert. 336 pp. 230 illus. index. $6.95

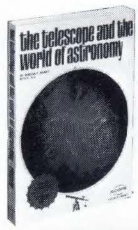
107. **THE TELESCOPE AND THE WORLD OF ASTRONOMY** by Marvin F. Riemer. 3rd edition, revised and enlarged. Deals with equipment, planets, universe, constellations, nebulae, galaxies, double stars, clusters, variable stars, visitors to our skies, photography, satellite tracking. Author a member of N.Y. school system. Illus. 2 appendices. 2 bibliogs. glossary. index. (pullout 18x24-inch chart of the Northern sky.) 212 pp. $3.95

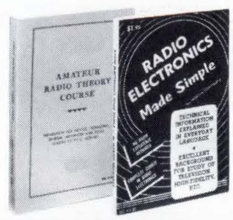
108. **AMATEUR RADIO THEORY COURSE** by Martin Schwartz. Revised. Complete, simplified home study course covering requirements for Novice, Technician, Conditional and General Classes of Ham licenses. 260 pp. illus. $3.95

109. **RADIO-ELECTRONICS MADE SIMPLE** by Martin Schwartz. Complete coverage from basics through transmitters and receivers. 190 pp. illus., preface. index. appendices. $1.95









SATISFACTION GUARANTEED OR MONEY BACK — ORDER TODAY — USE THIS HANDY COUPON

ALL BOOKS AVAILABLE ON 10-DAY FREE TRIAL — SEND CHECK AND WE PAY SHIPPING COSTS

Quantity	No.	Price	Total
	101	10.95	
	102	11.95	
	103	11.95	
	104	30.00	
	105	12.50	
	106	6.95	

Quantity	No.	Price	Total
	107	3.95	
	108	3.95	
	109	1.95	
	110	5.00	
	111	5.00	

Cahners Book Division, EDN/EEE
89 Franklin St., Boston, Ma. 02110

Check Enclosed ☐ Bill Me ☐ Bill My Company ☐

Name____________________

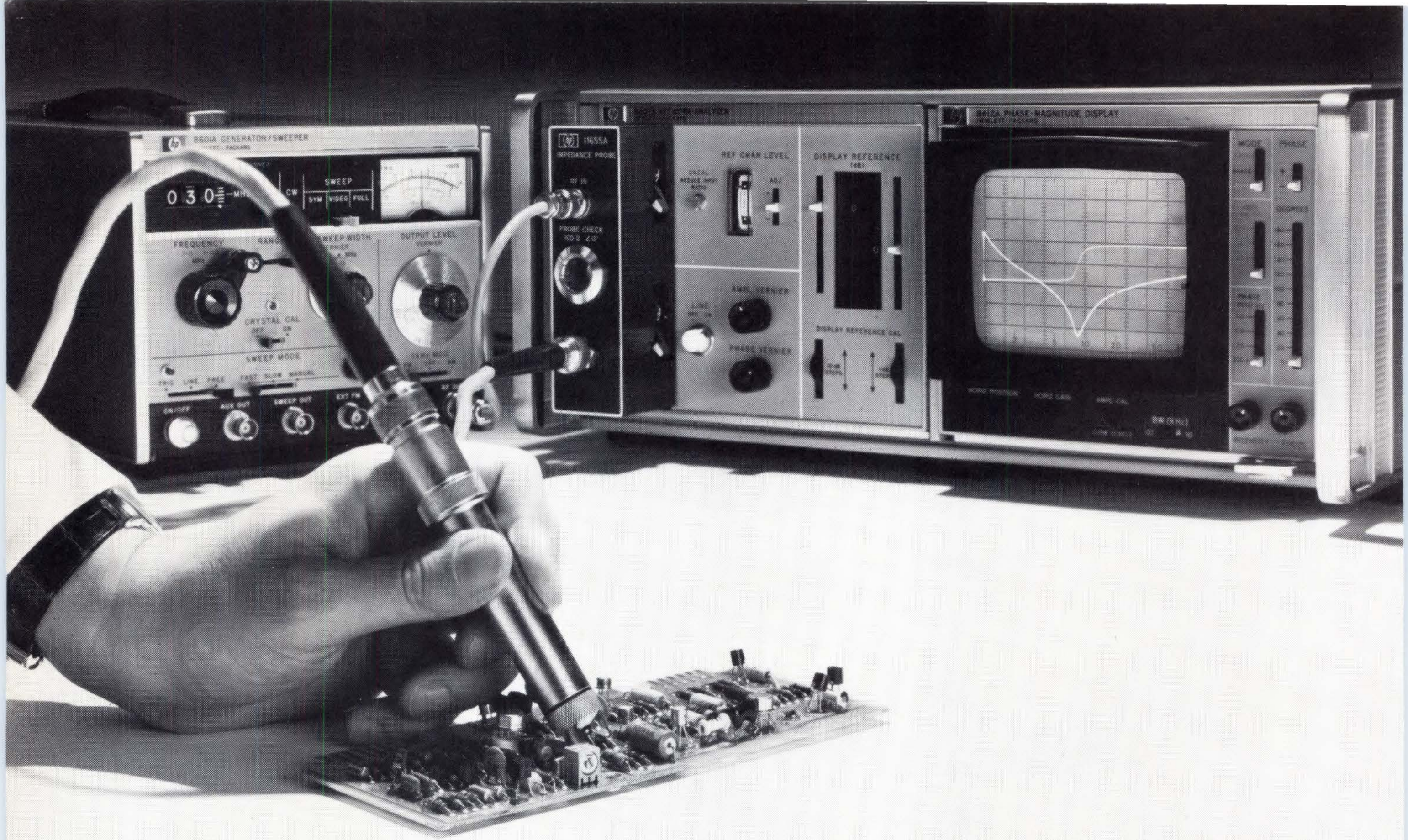
Title____________________

Company____________________

Address____________________

____

__________Zip__________



Introducing "touch & see" swept impedance measurement. Now the "do-everything" RF test system does even more.

Just add our new impedance probe to the HP 8407A Network Analyzer, and you can measure complex impedance of circuits, coax systems, discrete components. View impedance excursions over the wide range from 0.1Ω to 10KΩ as you sweep between 500 kHz and 110 MHz.

The HP 8407A Network Analyzer itself makes comprehensive swept RF measurements quickly, and with high accuracy. You see important characteristics like gain/loss, phase shift, voltage and current transfer functions, group delay, impedance, return loss and S-parameters. Dynamic range is greater than 100 dB, yet you can resolve 0.05 dB. It has 360° phase range with 0.2° resolution.

The 8407A Network Analyzer with the 8412A Phase-Magnitude Display costs $4525. The new impedance probe (Model 11655A) costs $750. Other accessory kits for circuit probing and for general measurements in coaxial systems are also available, priced from $325 to $500.

To learn more about how our "do-everything" network analyzer can help you in design and production test applications, call your field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

04112

HEWLETT hp PACKARD

NETWORK ANALYZERS

CIRCLE NO. 79

Single-amplifier active filters give stable Q

Using positive fixed-gain amplifiers and simple formulas, it is easy to design stable bandpass active filters. Their Q is adjustable by varying amplifier gain.

If your design needs call for a bandpass filter with variable Q, consider the two circuits discussed in this article. Each uses a single, fixed-gain amplifier and a few carefully-chosen passive components. And, both have highly stable Q and resonant frequency.

To evaluate the performance and sensitivity of these circuits, both a mathematical derivation and test results of circuits that were built using these design principles, are presented.

Mathematics

For a second-order bandpass filter, the general form of the voltage transfer function is:

$$H(s) = \frac{e_o(s)}{e_i(s)} = \frac{K_o\ (\omega_o/Q)\ s}{s^2 + (\omega_o/Q)\ s + \omega_o^2}$$

where K_o = voltage gain at resonance
ω_o = resonant frequency in radians/sec.
Q = ratio of resonant frequency to the −3 db bandwidth (ω_o/BW).

The two circuits of **Figs. 1** and **2** have the above constants listed as functions of R, C, and amplifier gain, K. Note that amplifier gain is determined by the feedback resistors R1 and R2; i.e., R2 = (K−1)R1. Because gain depends on the value of Q, it may be necessary to place a small potentiometer (R3) in the R1 branch to control gain and hence circuit Q.

Sensitivity of Q. To determine the percentage change of a function based on the percentage change of an independent variable, evaluate the differential sensitivity of that function with respect to the variable.

To evaluate Q sensitivity for the circuit in **Fig. 1**, use the equation:

$$\frac{\Delta Q}{Q} = (2\sqrt{2}\,Q - 1)\left[\frac{\Delta R2}{R2} - \frac{\Delta R1}{R1}\right]$$

And for **Fig. 2**:

$$\frac{\Delta Q}{Q} = (2Q - 1)\left[\frac{\Delta R2}{R2} - \frac{\Delta R1}{R1}\right]$$

From these equations, it can be seen that if tight-tolerance feedback resistors with matched temperature coefficient are used to set amplifier gain, the circuit Q will remain very stable. This is an important advantage of the Q-dependent type of circuit.

Sensitivity of ω_o. The same procedure is also used to find the change in resonant frequency, ω_o. Because ω_o for both

Fig. 1

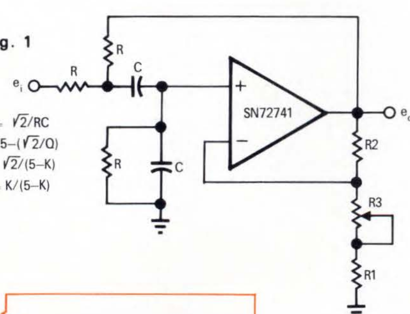
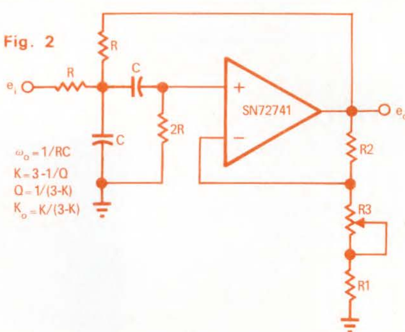


Fig. 2



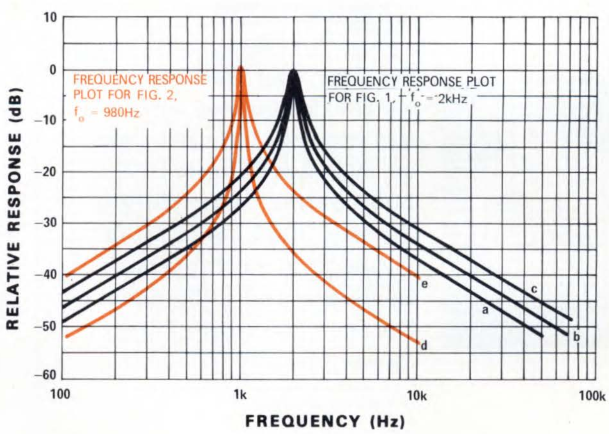


Fig. 3

Figs. 1 and 2—**Circuit Q** of both filters remains very stable with feedback resistors that have equal temperature coefficients.

Fig. 3—**Frequency response plots** of both circuits show the effect of changes in amplifier gain.

designs is a function of 1/RC, the percentage change in ω_o for **Fig. 1** becomes:

$$\frac{\Delta\omega_o}{\omega_o} = -\sqrt{2}\left[\frac{\Delta R}{R} + \frac{\Delta C}{C}\right]$$

And for **Fig. 2**:

$$\frac{\Delta\omega_o}{\omega_o} = -\left[\frac{\Delta R}{R} + \frac{\Delta C}{C}\right]$$

These equations show that ω_o will be very stable if low-TC, tight tolerance R and C components are used in either design.

Circuit Performance

To test these designs, both circuits were built. Frequency response measurements are shown plotted in **Fig. 3**. For each curve the value of gain at resonance was made the 0 dB reference point. Actual values of resonant-frequency gain are given in **Table I**, which lists the pertinent data collected for each circuit.

From this table, notice that as amplifier gain is changed, both Q and the resonant-frequency gain change. This agrees closely with the equations listed in **Figs. 1** and **2**.

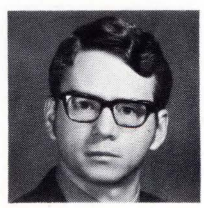
Conclusion. By simplifying design procedures for two bandpass-filter circuits, a highly-stable active filter can be built with only a few components. In both, circuit Q is dependent on the closed-loop gain of the amplifier. By stabilizing gain with feedback resistors that have equal temperature coefficients, the Q can be made very stable.

Resonant frequency can be stabilized with low-tolerance components for R and C—the frequency determining elements. To insure even tighter stability for ω_o, use components with equal but opposite temperature coefficients to make the $\Delta\omega_o/\omega_o$ equation equal zero. ▭

TABLE I

Plot	Q(Meas)	K	K_o	K_o(dB)	Circuit
a	15.20	4.90	51.5	34.20	Fig. 1 R = 24k, 1% C = 0.0047μF, 5% R_1 30k, 1% R_2 = 120k, 1% R_3 = 1k Trimpot
b	10.40	4.86	36.2	31.18	
c	7.35	4.81	25.6	28.16	
d	47.7	2.97	143.5	30.50	Fig. 2 R = 27k, 1% C = 0.006μF, 5% R_1 = 15k, 1% R_2 = 30k, 1% R_3 = 1k Trimpot
e	11.2	2.91	33.5	43.14	

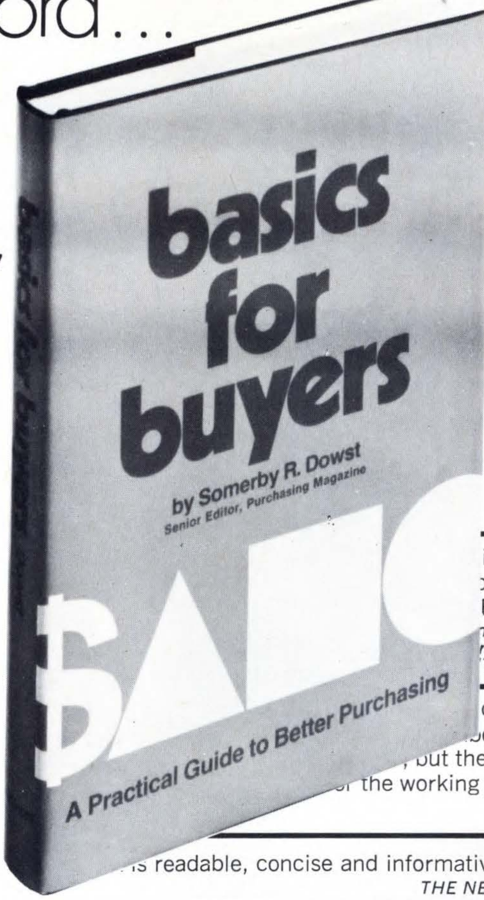
Author's biography



Howard T. Russell is presently a teaching assistant at the University of Santa Clara, Santa Clara, Calif. Prior to that he was with Texas Instruments Incorporated. Russell is a graduate of Texas A&M with a B.S.E.E. and M.S.E.E.

Don't just take our word . . .

Read what independent, authoritative sources say.



"It's a practical handbook written for the working pros — not the bosses, but the people who get the job done. We don't usually plug competitors. But good is good and BASICS FOR BUYERS is."

John F. O'Connor
Managing Editor
PURCHASING WEEK

" . . . an eminently practical handbook of purchasing fundamentals. Dowst is an experienced purchasing agent as well as a first rate journalist."

Paul Farrell
Editor/Publisher
HEALTH INSTITUTION PURCHASING

" . . . it seems like a fresh approach to a subject that has become somewhat stereotyped as far as textbooks are concerned."

G. W. Howard Ahl
Executive Vice President
National Assoc. of Purch. Mgmt.

" . . . the first book on the subject designed primarily for junior and middle level members of purchasing departments."

THE JOURNAL OF COMMERCE

" . . . a sound handbook for industrial buyers . . ."

THE WALL STREET TRANSCRIPT

is good
ɔmpetitors.
BUYERS."
ıley
resident
TION COMPANY

designed
book written
but the people
the working pros."

. . . is readable, concise and informative to all . . ."

THE NEW YORK TIMES

"I will be recommending it to new employees . . . It should be read by every new buyer."

James M. Hill, Jr.
Director of Procurement
RAYTHEON COMPANY

"The real place BASICS FOR BUYERS earns, however, is on the desk of every buyer throughout industry."

Arnold D. Finley
Contract Administrator
Sanders Associates

Table of Contents:

15-day FREE trial examination. Satisfaction Guaranteed. Price $10.95

Please send me _____ copies of BASICS FOR BUYERS @ $10.95 each. I understand that I may examine the book FREE for 15 days and if not satisfied, I can return it. Otherwise, I'll send you my check.

☐ Bill Me ☐ Bill Company ☐ Check Enclosed (We pay Postage)

Name ____________________

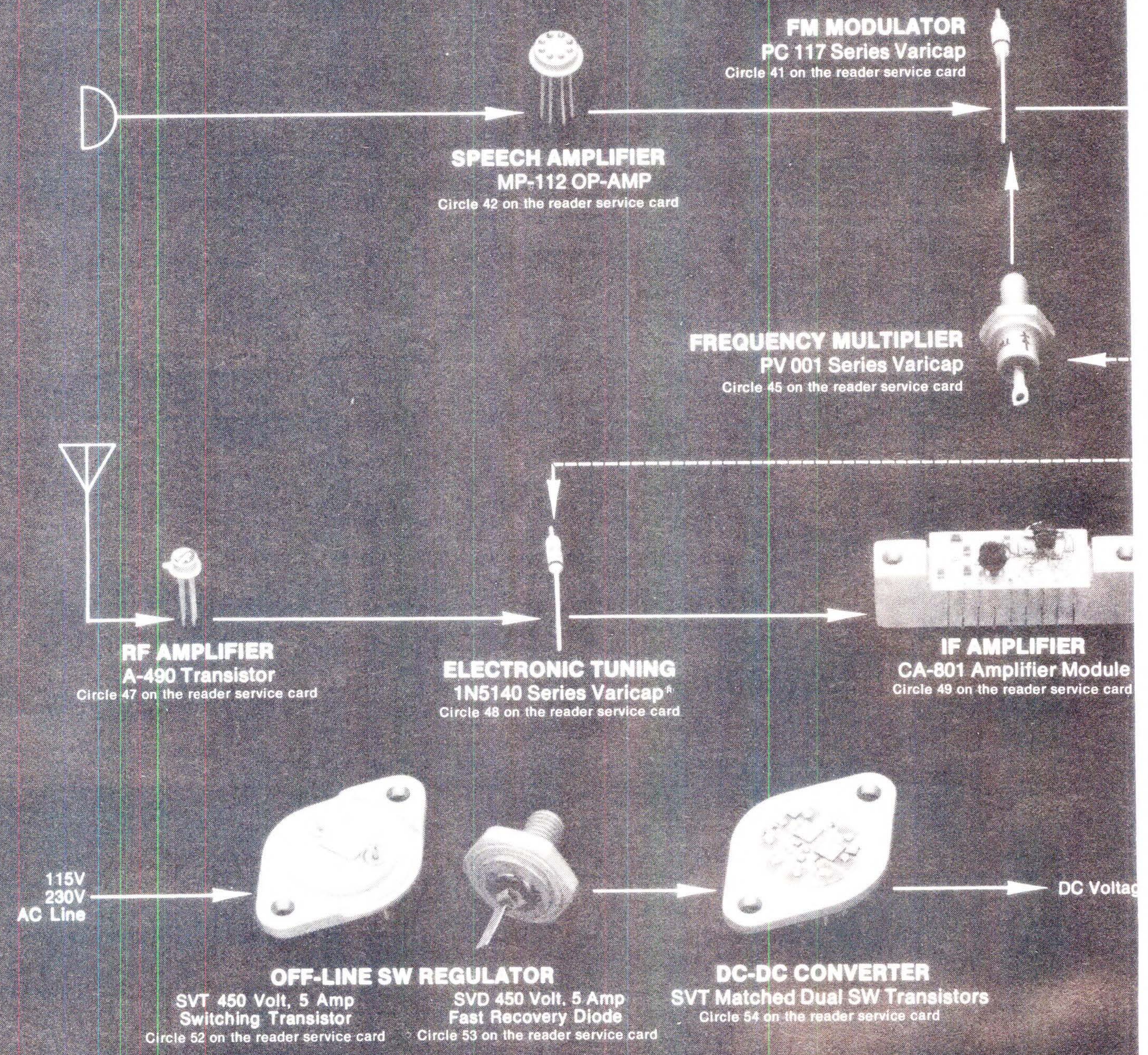
Company ____________________

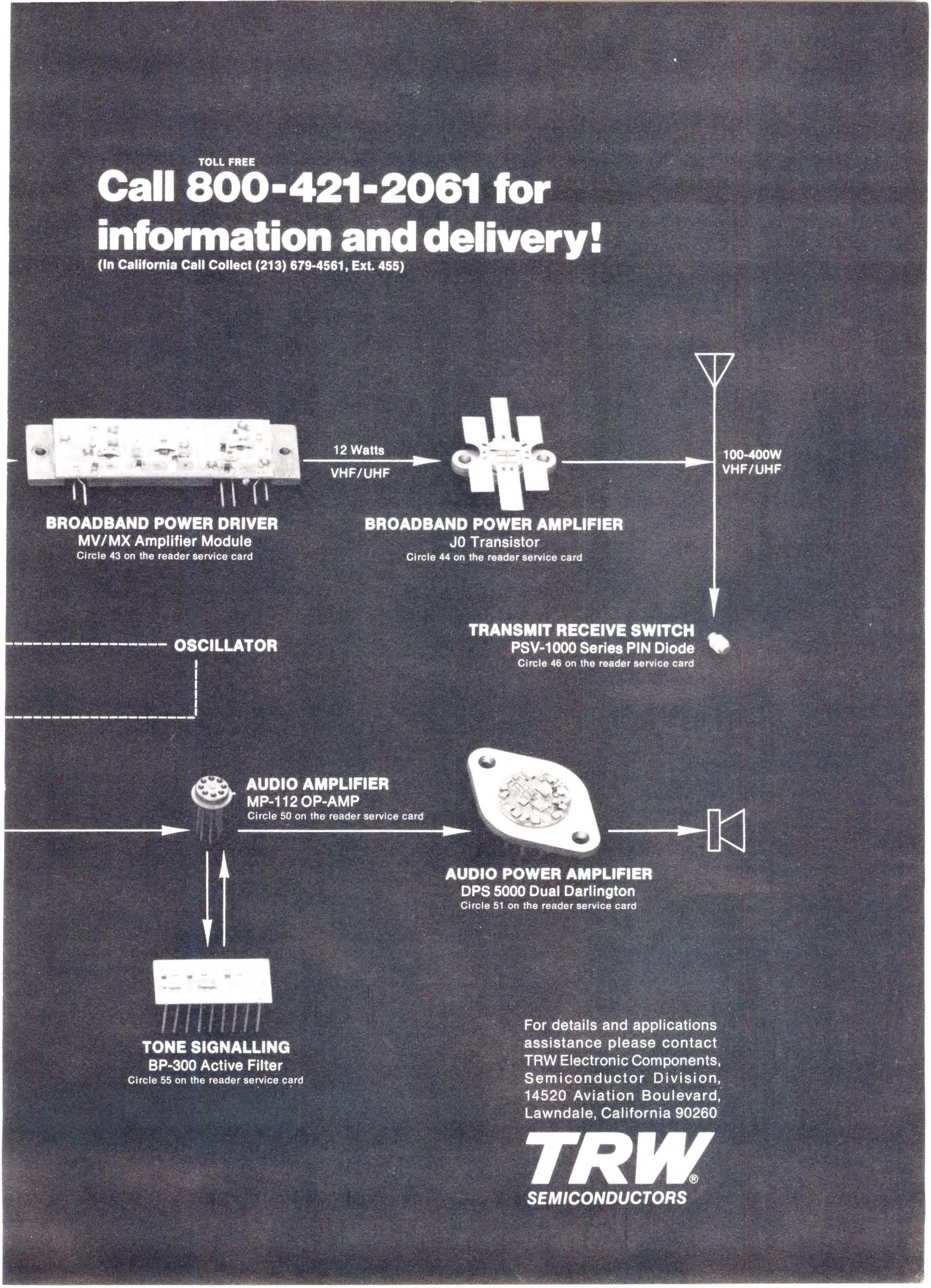
Address ____________________

City/State/Zip ____________________

(Add any applicable State Tax)

Build your next transceiver with TRW solid state technology –




TOLL FREE
Call 800-421-2061 for information and delivery!
(In California Call Collect (213) 679-4561, Ext. 455)
12 Watts
VHF/UHF
100-400W
VHF/UHF
BROADBAND POWER DRIVER
MV/MX Amplifier Module
Circle 43 on the reader service card
BROADBAND POWER AMPLIFIER
J0 Transistor
Circle 44 on the reader service card
TRANSMIT RECEIVE SWITCH
PSV-1000 Series PIN Diode
Circle 46 on the reader service card
OSCILLATOR
AUDIO AMPLIFIER
MP-112 OP-AMP
Circle 50 on the reader service card
AUDIO POWER AMPLIFIER
DPS 5000 Dual Darlington
Circle 51 on the reader service card
TONE SIGNALLING
BP-300 Active Filter
Circle 55 on the reader service card
For details and applications assistance please contact TRW Electronic Components, Semiconductor Division, 14520 Aviation Boulevard, Lawndale, California 90260
TRW®
SEMICONDUCTORS

Memory System Kits

Now Intel produces all interfacing ICs necessary to build complete TTL-compatible memory systems using Intel 1103's, the 1024-bit dynamic MOS RAM that's become an industry standard.

You can get a ready-to-plug-in system from us, or you can build your own system with Intel components and design assistance that begins with a 28-page handbook of instructions for designing with 1103 RAMs.

Any system you buy or build will accept standard TTL inputs and generate standard TTL outputs. All clock drivers, decoders, level shifters, and other TTL interfaces can be on the same board with 1103's.

For example, the board pictured here, Intel Memory System in-16, is a complete functional memory storing 4K 9-bit words per board. To expand the word length or number of words you simply add boards. Maximum cycle time is 950 ns. Price when built by us is about 1¢ per bit in OEM quantities.

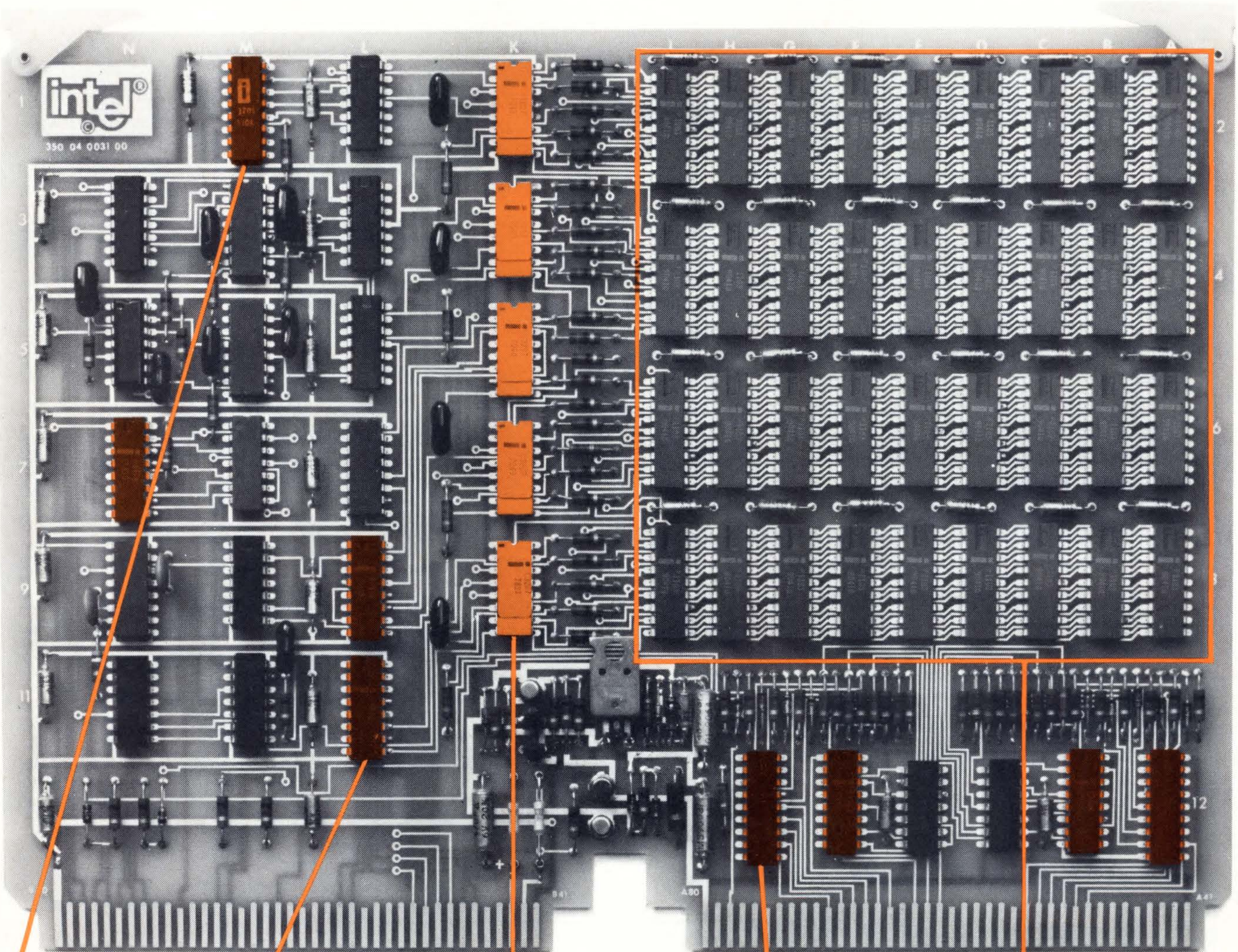
Also available off-the-shelf are faster memories like System in-10, an 1103 memory with a maximum system cycle time of 450 ns, smaller, compact memories like System in-20, which uses Intel's 256-bit static MOS RAM to store 1K 12-bit words per 6" x 8" board, and bipolar memories like system in-50, a 100-ns system that stores 512 8-bit words.

All system components called out on the page opposite are now in stock. For immediate delivery phone your local Intel distributor: Cramer Electronics, Hamilton Electro Sales, Industrial Components, or Electronic Marketing.

For further information on memory systems, phone Intel or our nearest sales office: Tustin, Calif. (714) 838-1126, Florham Park, N.J. (201) 822-0044, Lexington, Mass. (617) 861-1136 or Bloomington, Minn. (612) 925-3144. In Europe contact Intel at Avenue Louise 216,B 1050 Bruxelles, Belgium. Phone 492003. In Japan, contact Intel Japan, Han-ei 2nd Bldg., No. 1-1, Shinjuku, Shinjuku-ku, Tokyo 160. Phone 03-354-8251.

Intel Corporation is headquartered at 3065 Bowers Avenue, Santa Clara, Calif. 95051. Phone (408) 246-7501.

New interface ICs simplify 1103 systems. Easy to build. Easy to buy.



Chip-select decoder. Intel 3205 converts the chip-select signal from a binary code to a voltage on 1 of 8 terminals. Maximum delay is 18 ns.

Latch. Intel 3404, a 6-bit latch with 12 ns maximum delay, stores write data and addresses momentarily for input to 1103's.

Driver. Intel 3207 accepts standard TTL input and creates correct voltage levels for both clock and address inputs of 1103 RAMs.

Sense amp. Intel 3208 converts output current of 1103 to proper voltage levels for TTL circuits.

1103 RAMS. There are 36 here, storing 36,000 bits of data.

intel® delivers

CIRCLE NO. 56

Single-voltage circuit generates "power-on" reset pulse

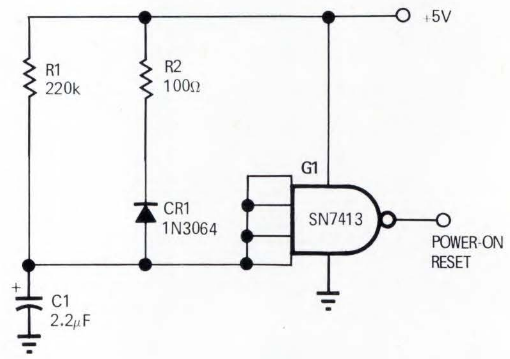
Entry by Robert C. Snyder
GDI Inc., Melbourne, Fla.

A simple IC operating from the common +5V logic supply can be used to provide a "power-on reset" to the rest of the logic system. The output reset time is easily set with a single capacitor, C1. Fast Recovery is provided by the addition of two components (R2 and CR1).

Upon initial power supply turn-on, capacitor C1 is charged at a rate determined primarily by the input current from the SN 7413 Schmitt Trigger, and to a small degree by R1. CR1 prevents R2 from contributing to the charge current.

During the charge time, the output of gate G1 will be high and will not sink any current. When C1 is charged to 1.5V, G1's output will go low and terminate the power-on reset. R1 continues to charge C1 until it reaches the supply voltage, thus keeping G1 out of the active region and reducing its noise susceptibility.

When the power supply is turned off, CR1 forward biases and allows C1 to be discharged through R2 at virtually the same rate as the power supply.



One Schmitt trigger and three discrete components insure the correct initial state of logic circuits when power is applied. The output reset time is set with capacitor C1.

To vote for this circuit
Circle 150

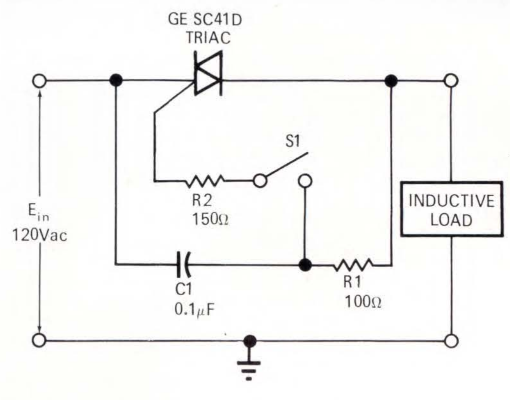
Triac gating circuit

Entry by Charles A. Farel and David M. Fickle
IBM Corp., Boulder, Colo.

Triacs have become increasingly popular for controlling ac power to resistive and inductive loads such as motors, solenoids and heating elements. Compared with competing devices such as relays, triacs offer important advantages in the area of cost, reliability, packaging and electromagnetic interface.

This simplified triac gating circuit switches ac power from the supply to the load. The circuit's chief innovation lies in the combination of the basic switching network with suitable dV/dt commutation suppression.

The circuit applies power to the load when the low-power switch (or relay) S1 is closed. Current through resistor R1 turns on the triac in the conventional manner.



Triac circuit switches ac power to inductive loads. Components R1 and C1 provide suitable dV/dt suppression.

When the switch is opened, the circuit automatically turns off the power. Resistor R1 and capacitor C1 suppress the dV/dt commutation pulse to ensure safe and effective turnoff. This suppression is essential when switching power to inductive loads.

The circuit shown can be extended easily to polyphase applications.

To Vote For This Circuit
Circle 151

Anti-coincidence circuit prevents loss of data

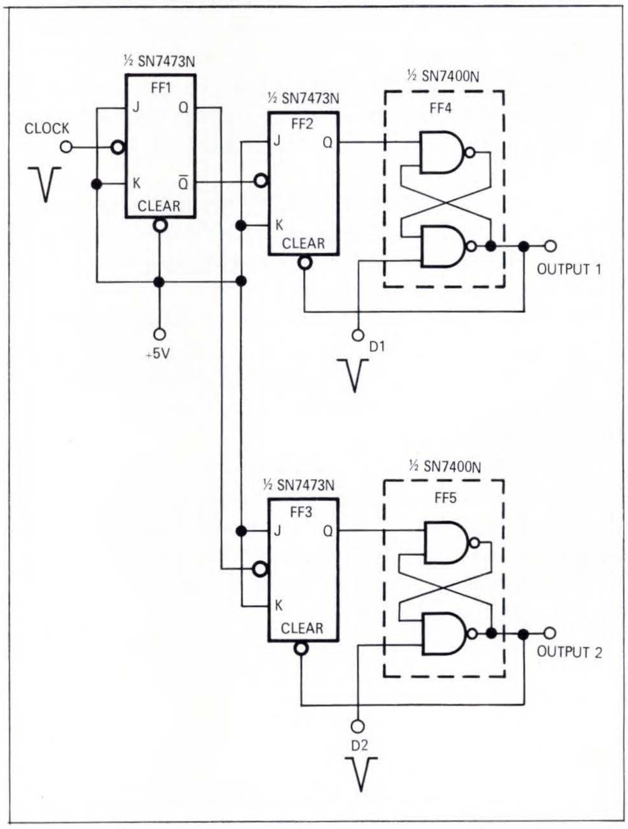
Entry by J. H. Burkhardt, Jr.
Union Carbide Corp., Oak Ridge, Tenn.

One hazard in the use of bidirectional counter circuits, in which up and down data occur randomly and independently, is that an up pulse may occur simultaneously with a down pulse. If the maximum frequency of the separate data pulses is known, this "Anti-coincidence Circuit" can be used to separate these random up/down pulses and assure that no information is lost.

Each falling edge of the clock toggles flip-flop FF1. The outputs of FF1 are square waves with a frequency of one-half that of the clock. These complementary square waves are used as clocks for FF2 and FF3. The reset inputs of RS flip-flops FF4 and FF5 are held high by the normally disabled FF2 and FF3. Data pulse D1 will set FF4, and D2 will set FF5, enabling FF2 and FF3. Recall that the clocks of FF2 and FF3 are complements, so that these flip-flops will toggle 180 degrees apart.

If FF2 toggles first, FF4 will be reset and FF2 will be disabled until another D1 pulse sets FF4. Then FF3 will toggle and reset FF5, which disables FF3 until another D2 pulse is received. The high-to-low transition of outputs 1 and 2 will always be separated by at least one clock period regardless of the relationship of D1 and D2, provided their maximum frequencies are always less than half that of the clock.

In general, any type of 2-input positive NAND gate may be used to form FF4 and FF5, and any type J-K master-slave flip-flop may be used for FF1, FF2 and FF3. The selection of logic type is made on the basis of circuit requirements, cost and availability.



Outputs 1 and 2 will always be separated by at least one clock period, even if inputs D1 and D2 occur simultaneously. This assures no loss of information in bidirectional counters.

To Vote For This Circuit
Circle 152

Thirty-second timer uses IC one-shot

Entry by Frederick R. Shirley
Sanders Associates, Nashua, N.H.

Commercially available one-shot ICs are usually limited to applications requiring relatively short delay periods of a few microseconds or less. However, by adding just four external components, the 9602 improved dual one-shot IC can be used to generate timing periods of up to one minute. The major advantages of the circuit shown **(Fig. 1)** are as follows:

- Long time-constant
- Only five components
- Small size
- Low cost
- Standard TTL levels
- Full military temperature range
- Optional non-retriggerable operation
- High reliability.

With the component values shown in the schematic, the circuit has a delay period of 30 sec. The period can be extended to 1 minute by increasing the value of R from 270 kΩ to 560 kΩ. Or the period can be reduced to as little as 10 msec by decreasing R to 30 kΩ and decreasing C to 1 μF.

The circuit shown is non-retriggerable (i.e. it will ignore input pulses during the timing period). It can be made retriggerable by deleting the feedback connection between pins 7 and 5 of the IC. In this mode, the one-shot will be reinitiated by input triggers during the timing period.

The timing cycle is initiated by applying a positive-going trigger pulse at the input. Current from the 5V supply then charges capacitor C via resistor R. This yields a timing period proportional to the RC product.

When the voltage across C reaches the threshold voltage (approximately 1V) the capacitor discharges through Q1. The transistor has two functions. It serves as a current amplifier to permit values of greater than 50 kΩ for resistor R, and it provides level shifting to protect the electrolytic capacitor from the negative standby voltage (-0.7V) between pins 1 and 2 of the IC.

Resistor R1 does not affect timing, but must be included to provide the correct standby current for the IC. During standby, the IC saturates Q1 and holds the capacitor voltage at the discharge level until the arrival of another trigger input.

Maximum length of the timing period is limited by three main factors: the product of capacitance and leakage resistance for the capacitor, the β gain and the I_{CBO} leakage of the transistor.

The 330 μF tantalum capacitor used in this circuit has a maximum leakage of 5 μA at the maximum circuit voltage (1V) and with the maximum ambient temperature. This means that the value of R can be no greater than 600 kΩ (i.e. 3V/5 μA).

The 2N2484 transistor has a minimum β of 20 (at I_C = 10 μA) for the worst-case temperature of −55°C. So, at the steady current of 200 μA, the worst-case β will be about 37. To meet the requirements of the IC, this means the maximum value of R is 560 kΩ (i.e. 0.7 x 37 x 22 kΩ). The maximum transistor leakage is approximately 2 μA at 125°C. This allows a maximum value for R of 1.5 MΩ (i.e. 3V/2 μA). Thus, taking the three constraints into account, the maximum permissible value for the charging resistor is 560 kΩ, when using a CSR13 capacitor with a value of 330 μF.

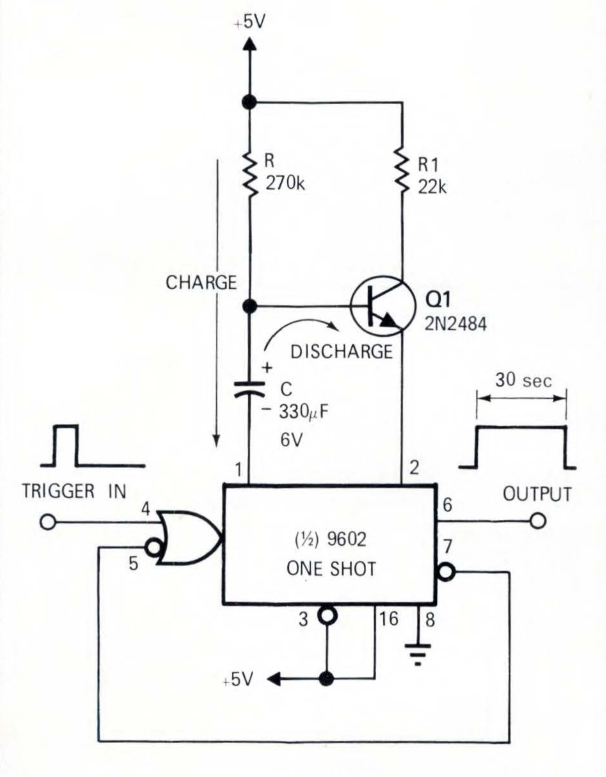


Fig. 1—**Long-delay timer** uses an IC one-shot plus four external components to generate delays of up to one minute.

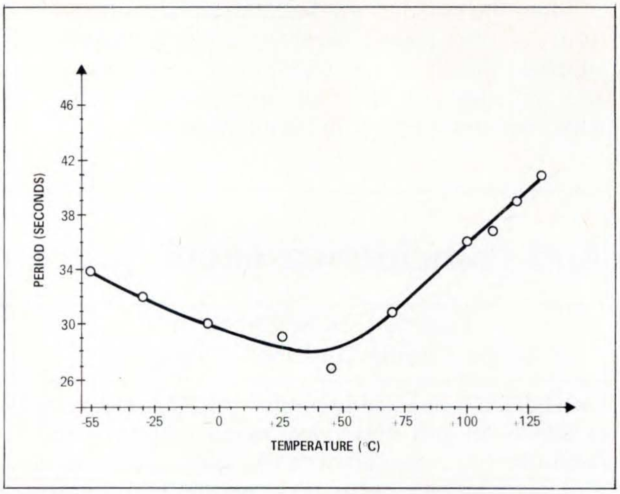


Fig. 2—**Graph of period versus temperature** shows that the circuit of **Fig. 1** is useable over the full military temperature range. At low temperatures, performance is limited by the reduction in transistor gain. At high temperatures, leakages in the capacitor and transistor are the limiting factors.

Delay period for the timer can be calculated from the following equation:

$$T = RC/3$$

where T is the period in seconds, R is in kilohms and C is in farads.

The graph **(Fig. 2)** shows period plotted against ambient temperature for the 30-sec version of the circuit. This curve shows that the circuit operates satisfactorily from −55°C (where β is the limiting performance factor) to +125°C (where I_{CBO} and capacitor leakage are limiting factors). As can be seen, period varies from 28 to 41 sec over the temperature range.

To Vote For This Circuit
Circle 153

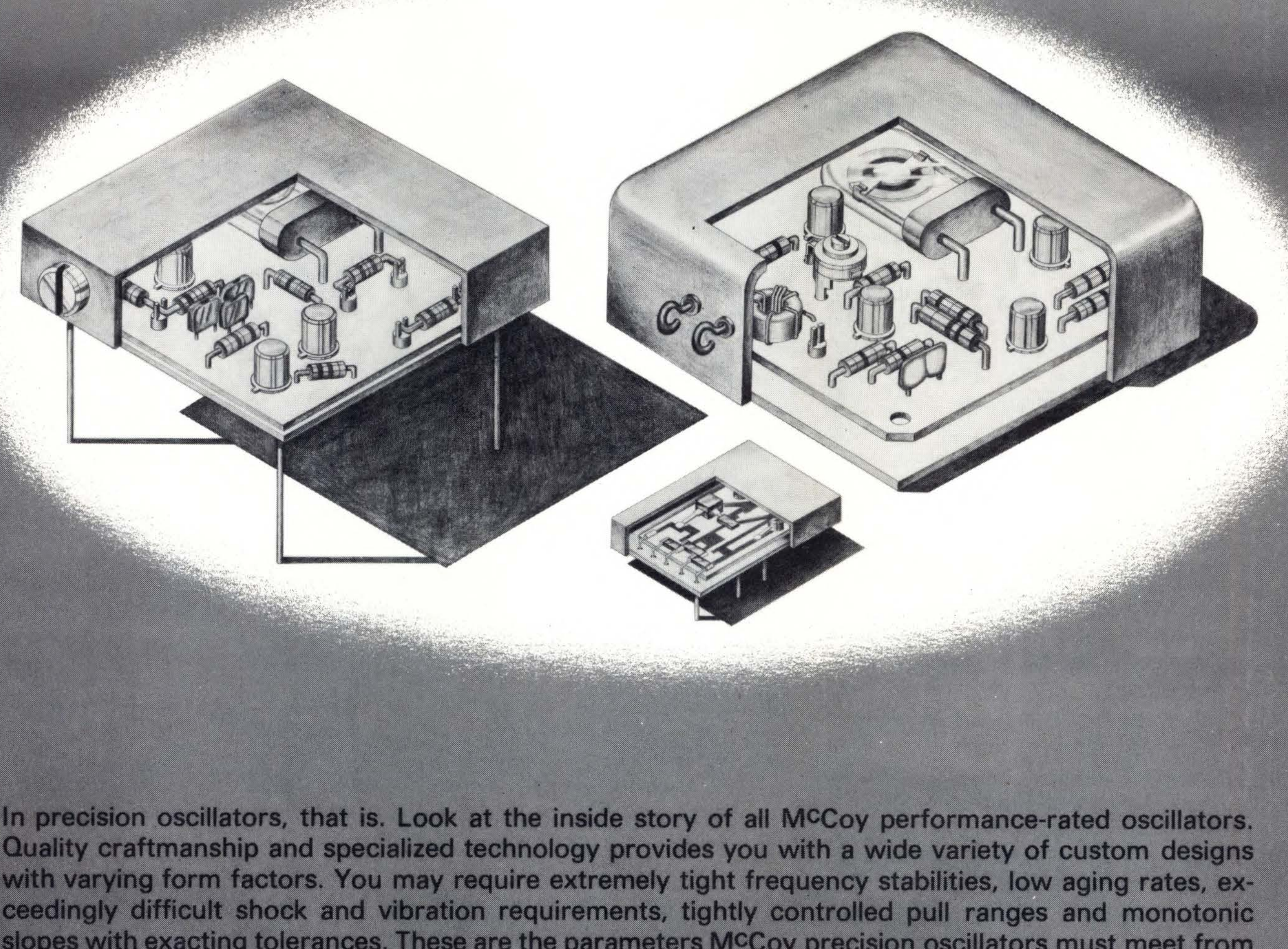
Your vote determines this issue's winner. All circuits published win a $25 U.S. Savings Bond. All issue winners receive an additional $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Savings Bond Grand Prize.

Vote now, by circling the appropriate number on the reader inquiry card.

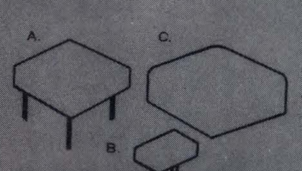
Submit your own circuit, too. Mail entries to Circuit Design Program Editor, EDN/EEE, 221 Columbus Ave., Boston, MA 02116.

Readers have voted Robert L. Wilbur winner of the September 15 Savings Bond Award. His winning circuit was called "Proportional oven-temperature controller". Mr. Wilbur is with the Southwest Research Institute.

Let's make it crystal clear.



In precision oscillators, that is. Look at the inside story of all McCoy performance-rated oscillators. Quality craftmanship and specialized technology provides you with a wide variety of custom designs with varying form factors. You may require extremely tight frequency stabilities, low aging rates, exceedingly difficult shock and vibration requirements, tightly controlled pull ranges and monotonic slopes with exacting tolerances. These are the parameters McCoy precision oscillators must meet from custom design stage through quality controlled manufacturing processes. Check our inside story with these specifications, then check your requirements and call your McCoy Representative or write to: McCoy Electronics Company, Mt. Holly Springs, Pa., 17065.



A.

MODEL MC163X2 Temperature Compensated Crystal Oscillator

Frequency Range: 8.0 KHz to 28.0 MHz

Frequency Tolerance	Temperature Range
±0.5 PPM	−30° to + 60°C
±1.0 PPM	−40° to + 70°C
±5.0 PPM	−55° to + 105°C

Input Voltage: + 12 VDC±2% and + 5 DVC±5%

Output: Square Wave Compatible with TTL or DTL Logic

Outside Trim: Available on Request

Package Size: 2" X 2" X .525" High

Mounting: 5 ea., .030" Dia. Wire Leads for PC Board Mounting

Seal: Hermetic

B.

MODEL MC1000A1 Standard Crystal Oscillator

Frequency Range: 188 KHz to 50 MHz

Frequency Tolerance	Temperature Range
±50 PPM over	−55° to + 105°C
±50 PPM over	−40° to + 85°C
±50 PPM over	0° to + 75°C

Input Voltage: + 5VDC ± 5%

Output: Square Wave Compatible with TTL or DTL Logic

Package Volume: .196 Cubic Inches

Package Size: 1.190" X .715" X .230" High Max.

Mounting: Printed Circuit Board or Direct Plug in to a Dual In-Line Socket

Seal: Hermetic

C.

MODEL MC133X7 Temperature Compensated Voltage Controlled Crystal Oscillator

Frequency Range: 5 KHz to 75 MHz

Total Deviation: Up to 0.1% (1000PPM)

Temp. Stability: To ± 10 PPM over −40 to +70°C

or

Total Deviation: Up to 60 PPM

Temp. Stability: ±1 PPM over 0 to +80°C

Input Voltage: +15VDC ± 1% at typically 25 MA

Output: 1 MW Min.

Deviation Linearity: Better than 5%

Deviation Rate : Up to 20 KHz

McCoy ELECTRONICS COMPANY

a subsidiary of OAK ELECTRO/NETICS CORPORATION

MT. HOLLY SPRINGS, PENNSYLVANIA 17065 • TELEPHONE: 717-486-3411 • TWX: 510-650-3548

"ADVANCING CRYSTAL TECHNOLOGY FOR TWO DECADES"

CIRCLE NO. 25

Portable scopes approach pocket size

PROGRESS IN OSCILLOSCOPES

Two new portable oscilloscopes in the $500 to $600 price range give the user a chance to select the instrument that is best suited to his needs. One boasts an extremely compact design and rugged construction. The other emphasizes performance specifications and two convenient package sizes. Both are fully portable and offer laboratory-quality performance.

Miniscope fits in a coat pocket

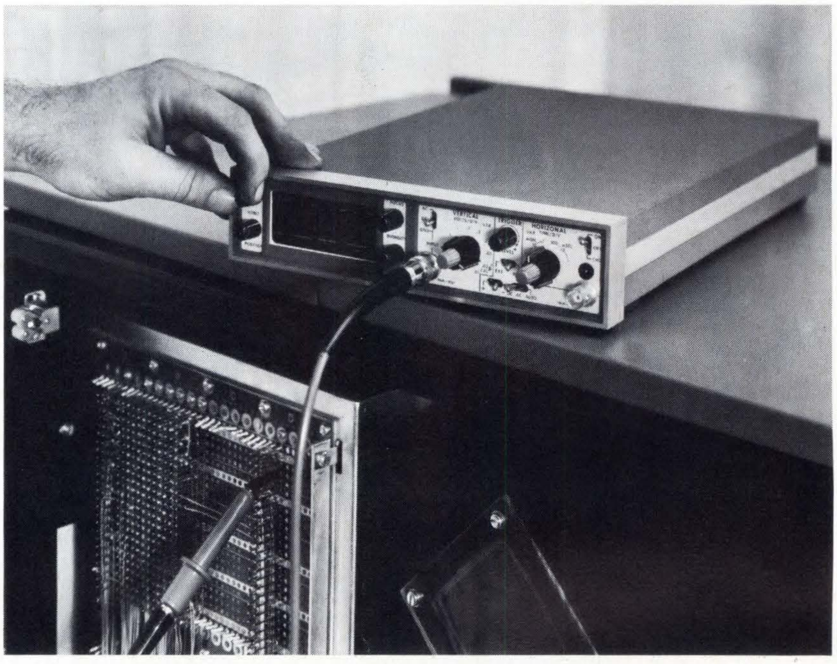
Tektronix has taken the lead in reducing size and weight with the Model 211. This portable will actually fit in a large coat pocket. Its overall dimensions are 3 by 5-1/4 by 9 inches, and its weight with batteries is 3 lbs. This is about half the size and weight of other Tektronix portable scopes and, at $545, is about half their price, too.

As you might expect, there are some limitations in performance compared to their other portables. Bandwidth of the 211 is dc to 500 kHz at sensitivities of 50 mV/div to 50V/div, and 100 kHz at 1 mV/div. Calibrated sweep rates range from 5 μsec/div to 200 msec/div. A variable magnifier extends the maximum rate to at least 1 μsec/div. Both vertical and horizontal calibrations are reported to be accurate within 5%.

DC power is provided from 10 "AA" NiCd cells that give up to 5 hours of operation on a full charge. The batteries must be recharged with the scope off, and a full charge requires about 16 hours. A protection circuit automatically interrupts power when battery voltage drops to 10V to prevent deep discharge.

Double insulation allows the unit to be floated 700V above ground when operating on battery power, and 250V rms above ground when operating on an ac line. Permanently-attached input and power cords stow by wrapping

Tektronix Model 211 has taken the lead in reducing size and weight. This $545 unit weighs 3 lbs and has a 5-MHz bandwidth.



Vu-Data Series PS900 offers a dc-to-20 MHz bandwidth at a $595 price tag. Weight for this portable scope is approximately 7 lbs.

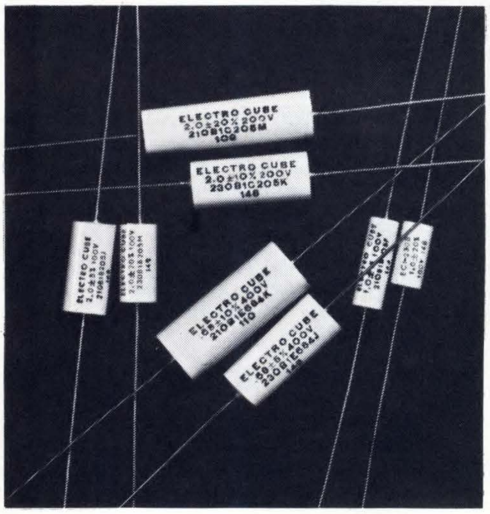
Electrocube capacitors have added a lot to the market. Now we're adding a little to the contest.

Smaller metallized Mylar capacitors

— up to 61% less volume. Like .25 x .34 x .78 instead of .33 x .49 x .95 for a 2.0 mfd 100 VDC unit. Look at the before and after comparisons below. And they're smaller without changing performance or price.

Capacitance values are from .0010 to 50.0 mfd. Voltage ratings are 100, 200, 400 and 600 VDC. Round or oval wrap and fill cases are available in this new 230 series. (If you just need regular sizes, we have more than 840 case sizes and six case styles, including epoxy and hermetically sealed metal cases, in our 210 series metallized Mylar.)

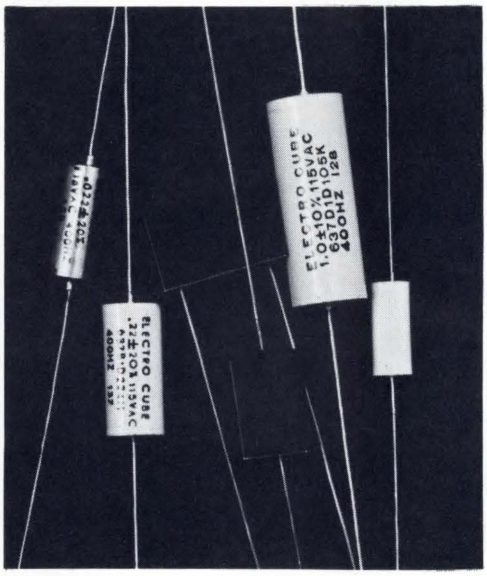
We're ready to ship 230 series capacitors from stock in small quantities, and in 4-5 weeks for production. We hope these help you with EDN/EEE's contest, but think they'll help your company's products even more.



AC rated metallized polycarbonate capacitors

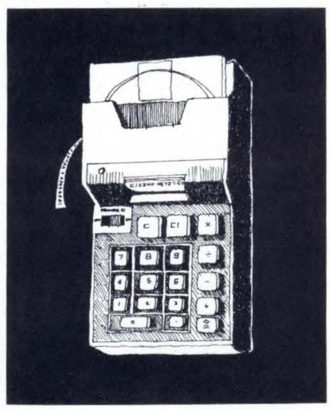
241 different units. Values from .0010 to 2.0 mfd, for 115 VAC, 400 Hz. But the real plus is full AC rating. Every unit is manufactured, tested and screened for AC operation. These aren't derated DC units.

Six case styles are available, including wrap and fill, rectangular epoxy, and hermetically sealed metal cases. Besides sending you full specs, we'll also add a bulletin on problems in using DC capacitors for AC applications.



Bonus calculator

If you win 1st prize in EDN/EEE's design contest, and if your winning design *and* one of your company's current products incorporate any Electrocube capacitor, we'll give you an electronic calculator just like the second place winners in the contest will get. You'll come out ahead with Electrocube capacitors even if you don't win a contest, so use lots of them. But good luck with the contest. We'd like to give you the calculator.



We'll send literature airmail the same day we get your inquiry. Call (213) 283-0511 if you're in a hurry. Or write to 1710 South Del Mar Avenue, San Gabriel, Calif. 91776.

electrocube

capacitors, EMI filters, RC networks, transformers, ballasts

CIRCLE NO. 61

Progress in Products

on a mandrel at the rear of the instrument. All controls are recessed on the instrument's side, with sensitivity and sweep control settings visible from the front. The CRT face has a 6-by-10 grid with spacings of approximately 0.2 inches.

Vu-Data Offers DC-to-20-MHz Bandwidth

Vu-Data, a San Diego based company with experience in monitor instrumentation, enters the general-purpose oscilloscope market with the Series PS900 portables. Outstanding features of these units are a dc-to-20 MHz bandwidth, versatile power supply and a $595 price tag (without batteries).

Several nice features of the supply are worth noting. Eight standard "C" cells provide dc power. Any "C" cell can be used for portable operation including carbon-zinc types, thus battery failure in remote areas need not be a problem if eight spares are available. When rechargeable batteries are used they can be recharged either with or without the scope in operation. Units operate for approximately 5 hours with fully-charged NiCd batteries. Protection against deep discharge is provided.

Vertical sensitivity ranges from 10 mV/div to 20 V/div in calibrated steps. A vernier extends the range to approximately 50 V/div. Sweep rate is calibrated from 1 μsec/div to 100 msec/div, and a vernier extends the maximum to approximately 100 nsec/div. Rise time is less than 18 nsec. Calibration is said to be accurate within 3%. Circuits employ standard "off-the-shelf" ICs and discrete components. The CRT display has a 4-by-10 division matrix with 1/4-inch spacing.

Two packaging options are available as standard units. The Model PS910 measures 1-3/4 by 8-1/2 by 12 inches and the PS920 measures 3-1/2 by 4-1/2 by 12 inches. Weight of either unit is approximately 7 lbs including batteries.

Tektronix, Inc., Box 500, Beaverton, OR 97005. **315**

Vu-Data Corp., 7595 Convoy Ct., San Diego, CA. 92111. **316**

Low-cost calculator on a single chip

PROGRESS IN MICROELECTRONICS

Engineers at Texas Instruments have designed an MOS/LSI circuit that contains all the logic and memory circuits for a complete electronic calculator. Using the new type TMS1802 IC, it is possible to build a compact calculator having three registers and eight-digit resolution. Circuitry provided on the chip allows full-precision add, subtract, multiply and divide operations plus many important special features.

TI is employing PLA (programmable logic array) technology which allows fabrication of many versions from a single basic chip merely by using a modified final mask for each special configuration.

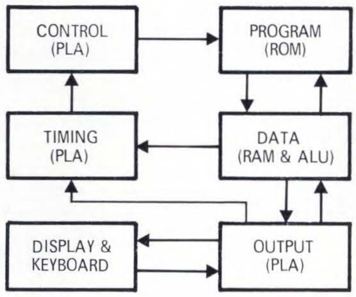
Inexpensive Calculators

Because TI doesn't have to produce a different chip and an entirely different set of masks for each customer, the company can achieve lowered set-up and manufacturing costs and, hence, offer a competitive selling price. In large quantities, the initial version of the circuit, type TMS1802NC, sells for under $20. The lowered costs offered by the single-chip approach should soon make it possible to manufacture calculators priced for a mass market.

Special Features

The TMS1802 can perform floating-point or fixed-point arithmetic. It is suitable for constant or chain operations. Circuitry on the chip allows many other useful calculator features such as automatic roundoff, leading-zero suppression and most-significant-digit protection under overflow conditions.

Though TI calls the TMS1802 "a calculator on a chip," some external circuitry is required in most practical calculator configurations. For example, though the display outputs are fully decoded on the chip, some sort of external buffers will be needed to drive most numerical displays. With suitable drivers, the circuit will work with just about any seven or eight-segment display including LED types. According to Daniel Baudovin, TI's program manager for MOS standard products, it should be possible to drive liquid-crystal readouts directly from the chip, without the need for external driver transistors.



All the functions for a complete calculator are included on the TI TMS1802 chip except for the keyboard, display, clock oscillator and display drive circuitry.

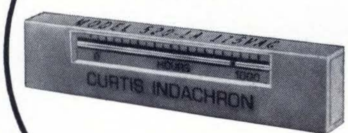
Additional external circuitry is needed to provide a clock signal for the calculator chip, but because the TMS1802 uses a single-phase clock, the external circuitry can be quite simple.

"Host" Chip

Because of the use of PLA technology, every function on the calculator chip is programmable—not just the ROM. Thus the timing section, control section and input/output decoders can all be modified to achieve different computing characteristics. In fact, the TMS1802 can be used in other computing applications—such as special terminals—and is not restricted to portable calculator designs. For these reasons, TI often refers to the TMS1802 as a "host" chip to indicate its vast range of possible applications.

The unit is packaged in a 28-pin plastic DIP. The current eight-digit version, TMS1802NC, costs $150 (1-24), $125 (24-99) or $95 (100-249). Prices on extremely large quantities are negotiated and are believed to drop well below $20. The unit is available from stock in small quantities. Delivery time for production quantities is six weeks. Texas Instruments Incorporated, Box 5012, MS/308, Dallas, TX 75222.

317



Introducing the little counter that can.

It can become four different systems.
It can go anywhere you do.
It can protect you against obsolescence.
It can make buying and maintaining a counter less expensive than ever before.

Meet the Hewlett-Packard 5300, the snap-together counter that's not much bigger than the palm of your hand. It has six digit accuracy, solid state display and autoranging. It'll make period, frequency, time interval and ratio measurements, operate on its optional snap-on battery pack and drive a printer. Rugged dust-proof aluminum case resists almost any bumps it might get in the field. Prices start at only $520 for one of the most amazing counters you've ever owned.

Start with the basic mainframe ($395). Then snap on any of the following modules (more on the way) to make just the counter you need, and avoid obsolescence, too:

10 MHz frequency module. Model 5301A, $125.

50 MHz all-purpose module includes period, time interval. Model 5302A, $250.

500 MHz module with both 50Ω and 1 MΩ inputs. Model 5303A, $750.

100 ns time interval module with: unique "time holdoff" feature, dc coupling, slope and trigger level controls, and period and frequency measurements to 10 MHz. All the functions you'd pay $1200 for in a universal counter. Model 5304A, $300.

Rechargeable battery pack module works with any of the other modules for cord-free operation. Model 5310A, $175.

The 5300 is one system you have to use to appreciate. If you've ever needed to accurately measure frequency or time interval, you owe it to yourself to call your nearby HP field engineer for further information. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

Counters that promise a lot and deliver it all.

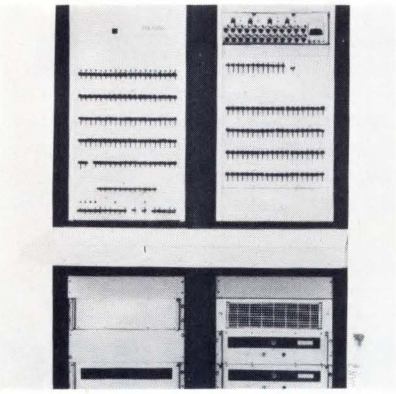
02109

HEWLETT hp PACKARD

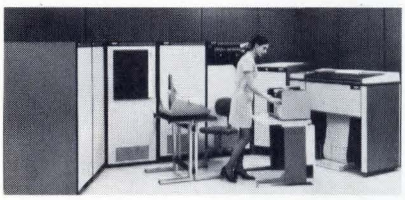
ELECTRONIC COUNTERS

CIRCLE NO. 65

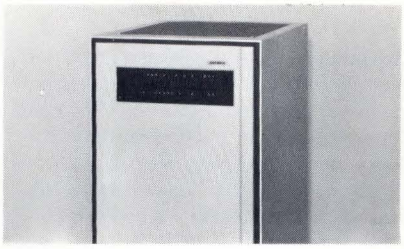
Desktop calculator, Model 1212, offers round off or drop off at the flick of a switch, full memory, automatic constant for division and multiplication, complete chain operation, zero suppression, 7-segment display, credit balance indication and a floating decimal input system. The unit has a built-in handle for interoffice transportation. Price for the 12-digit calculator is $495. Dictaphone Corp., 120 Old Post Rd., Rye, NY 10580. **188**



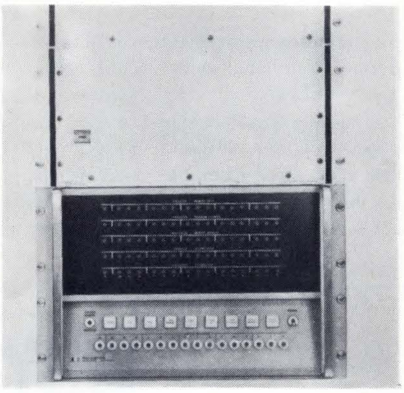
Test system FTS 1000 evaluates plug-to-plug, add-on memories that are IBM-compatible, whether they are core, plated wire or semiconductor peripheral memories. The system is configured to test memories of up to 223 words by 90 bits. Read and write times up to 5 MHz are provided in an up or down address sequence mode. Prices range from $15,000 to $50,000, with 60 day delivery time. Semiconductor Test Systems, Inc., 3 Computer Dr., Cherry Hill, N J 08034. **189**



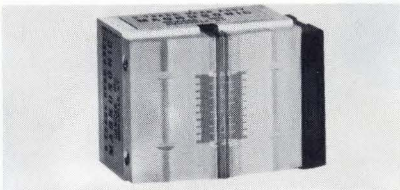
Computer system 6145 uses a 16-bit word plus parity for maximum efficiency in real-time application. Memory configurations begin at 32k words and are expandable in 16k increments up to 128k in a single processor configuration. Memory cycle time is 650 nsec. Price for basic processor with 32k memory and two DMA channels is $135,-000. EMR Computer, 8001 Bloomington Freeway, Minneapolis, MN 55420. **190**



Add-on memory ARM-50 enables users to triple the mainframe capacity of their IBM 360/50 economically. Units come in modular capacities ranging from 131,072 to 1,048,576 bytes. The 131,072 byte module measures 30 by 60 by 30 inches. All IBM cabinet colors are available. A 131,072-byte module rents for $2550 and is available 60 days after receipt of order. Ampex Corp., 13031 W. Jefferson Blvd., Marina del Rey, CA 90291. **191**



Disc memory system Model 1709 is a high-capacity fast-access peripheral for HP 2114/2115/2116 computers without DMA. Memory capacity comes in five levels from 32k to 524k words. Average access time is 16.7 msec and transfer rate is 15k words/sec. System hardware consists of the disc, power supply and single-card interface controller that plugs into the I/O slot of the computer. Price is $5500. Data Disc, Inc., 686 W. Maude Ave,. Sunnyvale, CA 94086. **192**



Nine-track, dual-gap write/read head, Model 221-9, is designed for tape speeds to 200 ips. Packing density is 3200/1600 frpi phase encoded and 800 bpi maximum NRZ. Write current for 95% saturation is 40 mA ± 20% (3200 frpi). Another feature is a long-life ferrite erase head. Heads are available with or without controlled tape floating. Magnusonic Devices, Inc., 124 Duffy Ave., Hicksville, NY 11801. **193**

Digital data system, the Model 950 Novalogger, makes use of plug-in modules to achieve system compatibility with a variety of recording devices. Other features include multirange programming, format programming and engineering-unit conversion. Price for a 10-channel mainframe is $2475. Novatronics Co., Inc., Digital Printer and Data Acquisition Systems, Box 516, Stump Rd., Montgomeryville, Industrial Park, Montgomeryville, PA 18936. **194**

Digital cassette recorder 240 incorporates a mechanism that extracts a 2-inch loop of tape from the cassette's center opening and automatically loads the tape on an external capstan and precision guide assembly. Either single- or double-track models are available. Standard operating speeds are 2 and 20 ips, with an additional search speed of 50 ips. Bell and Howell, Electronics and Instruments Group, 360 Sierra Madre Villa, Pasadena, CA 91109. **195**

Key-to-disc system Model 2400, is a modular intelligent peripheral processing system that uses from one to twenty keystations. The display is tutorial, guiding and instructing the operator. Modular configurations range from a dedicated cluster system for volume entry to a large, multi-purpose peripheral system including data communication. Mohawk Data Sciences Corp., Palisade St., Herkimer, NY 13350. **196**

Computer output printing system Model 1670 is a stand-alone system that accepts input from either disc or tape. The output is recorded on either microfilm (1603 microfilm printer) or an optional 110-line-a-minute impact printer. Memorex Corp., San Tomas at Central Expressway, Santa Clara, CA 95052. **294**

Magnetic tape transport MT-120 features a high-capacity dual vacuum buffering system that permits bidirectional tape speeds up to 120 ips without program restrictions. With packing densities up to 800 bpi, data transfer up to 96 kHz is readily available—rates up to 240 kHz can be obtained. Peripheral Support Inc., 22519 S. Normandie Ave., Torrance, CA 90501. **295**

Magnetic-card I/O device, called Data Director, is a desk top unit for small computers and certain keyboard applications. The system packing density is 556 bpi/track on an eight-track format for a 3.25 by 7.375-inch card. Price for the unit is $1880. B Industries, Inc., 2202 W. McDowell Rd., Phoenix, AZ 85009. **296**

Two printers, Models 2420 and 2440, have been added to the Series 2000 family. Printing speeds are 250 to 1100 lpm (2420) and 700 to 1800 lpm (2440). Print format for both printers is 132 characters, with 120- or 136-character formats optional. Data Products, 6219 DeSoto Ave., Woodland Hills, CA 91364. **297**

Disc-storage system, Model 3670, is plug-compatible with the IBM 3330 and features 27 msec average access time. All control electronics is contained in the operator/diagnostics console located above the pack enclosure of each drive. Each module has two independent drives. Memorex Corp., San Tomas at Central Expressway, Santa Clara, CA 95052. **298**

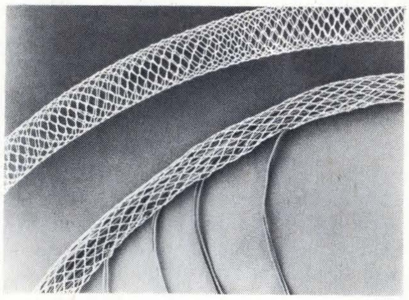
Minicomputer business system SIMPLEX-70 offers multi-terminal remote access and extreme operator simplicity. System includes console, TTY and high-speed printer. Basic system sells for $50,000 ($1200/month leasing). Custom Computer Systems, Inc., 40 S. Mall, Plainview, NY 11803. **299**

Magnetic core memory DC-38 is a 3-wire, 3D coincident current unit with 650 nsec full-cycle time and 250 nsec maximum access time. Basic 4k configuration consists of two plug-ins—a digital stack board and a timing and control board. Datacraft, Box 23550, Ft. Lauderdale, FL 33307. **300**

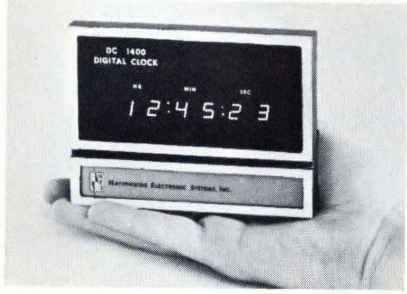
Series of plug-to-plug expansion core memories, called Smart Systems, are for the IBM 360/30, /40 and /50. Through module concept, the memory system is expandable (16k increments) to 128k bytes for the Mod 30, 512k for the Mod 40 and up to 1-million for the Mod 50. Standard Memories, Inc., 2401 S. Broadway, Santa Ana, CA 92707. **301**

Silicon video memory M-10 provides storage for a full 525-line standard TV picture. Writing and reading is either slow-scan or standard 525 line video. Standard features include a single frame time erase, and frame "snatch" or frame "freeze". Optel Corp., Box 2215, Princeton, N J 08540. **302**

Digital panel meter, Model AN2544, displays readings up to ±3.999 with automatic polarity symbol. The 4-3/4-digit meter provides accuracy of (±0.01% of reading ±0.0025% F.S. ±1 count) with 6 PPM stability. The meter features a floating, guarded differential input. BCD and sign outputs are available at the rear connector. Price is $350 in small quantities. Analogic, Audubon Rd., Wakefield, MA 01880. **212**

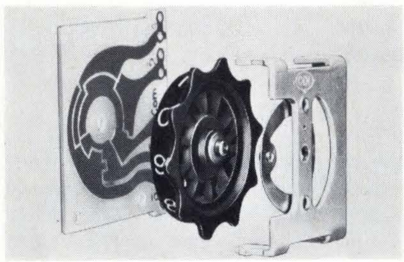


Heat-shrinkable PVC mesh tubing called "Shrink-Net" offers flexible electrical connector bundling. When exposed to 200°F heat, it shrinks up to 50% in seconds. The diamond mesh permits easy formation of multiple break-outs. Shrink-Net is available in white, but other colors are available on special request. Templock, Div. of Zippertubing Co., 13000 S. Broadway, Los Angeles, CA 90061. **215**



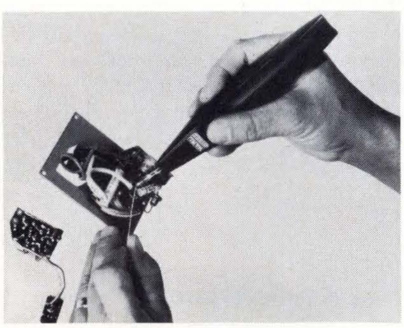
LED readout digital clock, Model DC1400, mounts directly on panel face, so requires no back-of-panel space. Readout time is based on the 60 Hz line frequency. BCD outputs are available for use with computers or instrumentation, and a complete selection of time ranges (11:59:59, 23.999 etc.) is available. Price is $250. Nationwide Electronic Systems, Inc., 7N662 Route 53, Itasca, IL 60143. **218**

Screen-printable conductors, Platinum-Gold 180 and 181, provide maximum adhesion on beryllia and alumina substrates. Platinum-Gold 180 provides the highest solder leach resistance available, and 181 offers fast wetting when used with solder pastes. Both will print 5-mil lines and spaces with standard wire screens. Electro Materials Corp. of America, 605 Center Ave., Mamaroneck, NY 10543. **213**

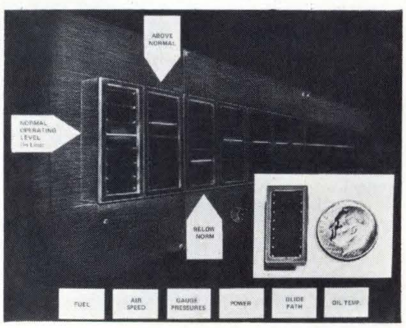


Ten-position thumbwheel switch is available in decimal, binary or binary-complement coding. The switch mounts on 1/2 inch centers and requires only 1-1/2 inches of space behind the panel. Contact resistance to 0.05Ω max., while current switching capability is 125 mA at 115V ac. Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago, IL 60614. **216**

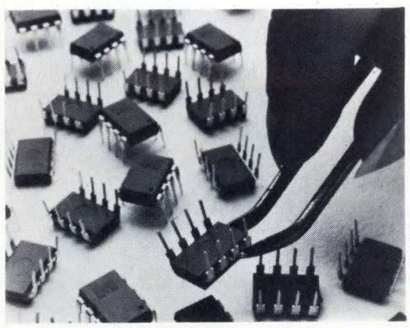
Optically-clear epoxy, Epo-Tek 310, bonds to glass, ceramic or metal. The two-part adhesive can withstand temperature cycling between −50 and +75°C with no adverse effects. It cures in 2 hrs at 65°C, has a pot life of 8 hrs and develops a lap-shear strength of 570 psi. Half-pound evaluation kits are available for $10 fob factory. Epoxy Technology, Inc., 65 Grove St., Watertown, MA 02172. **219**



Portable soldering iron uses rechargeable nickel-cadmium batteries. Peformance is equivalent to 50W and one charge provides up to 60 soldering operations. The "ISO-TIP" (patent applied for) eliminates the need for grounding and allows portable field repairs where ac line current is not conveniently available. The price is $19.95 complete with charger. Wahl Clipper Corp., 2902 Locust St., Sterling, IL 61081. **214**



Miniature light-bar indicator, Type 5-3, contains eight incandescent light-bars packaged in a 16-pin DIP. The light-bars are mounted on 0.10 inch centers and the package measures 0.88 by 0.46 by 0.24 inches. Power requirement is 8 mA at 5V or 10 mA at 4V. Life is rated at 250,000 hrs at 8 mA or 100,000 hrs at 10 mA. Price is $2.70 each in quantities of 1000. Readouts, Inc., Box 149, Del Mar, CA 92014. **217**



Dual-channel optoisolator, Type MCT2D, is packaged in 8-pin DIP, allowing four channels of optical isolation to be plugged into a single 16-pin DIP socket. Each channel consists of an infrared LED and a silicon phototransistor. Isolation resistance is typically $10^{11}\Omega$ per channel, and coupling capacitance is 0.5 pF. Price is $9.80 each in quantities of 1-9. Monsanto Commercial Products Co., 10131 Bubb Rd., Cupertino, CA 95014. **220**

COMPONENTS/MATERIALS

Minature connectors and cable are available in 2-, 4-, 7- and 12-contact or coaxial versions. Assembly of the coaxial connectors requires only cutting the cable and screwing it directly into the plug. In the multicontact connectors, the lead wires are soldered to the pins or sockets on a completely exposed insert, which is then pressed into a snap-lock ring in the plug body. Microtech, Inc., 777 Henderson Blvd., Folcroft, PA 19032. **284**

Digital switch modules have contact closure of one msec (nominal) duration. Release time has no effect on the one-shot pulse output, assuring that data is transmitted in correct order. Contacts are 24 carat gold-plated and magnetically actuated, with maximum ratings of 20V and 10 mA. Price is $0.45 to $0.94 each in large quantities. Magsat Corp., 7 Sisson Ave., Hartford, CT 06106. **285**

Infrared process heaters feature a full area radiation emitter surface which operates at 1250°F with a 30W/in^2 rating. This design eliminates the need for a reflector, and results in panels weighing approximately 5-1/2 pounds per square ft. Heaters are made in many standard sizes up to 24 by 35 inches and in standard voltages of 120, 240 and 480V. Watlow Electric Mfg. Co., 12001 Lackland Rd., St. Louis, MO 63141. **286**

LED panel lamps are graded for consistent luminous intensity. The QT/D-200 miniature LED indicators are packaged with a microgrooved lens that provides a wide viewing angle and does not attenuate the light. The units are available with a red lamp in a round cap, and install in a standard 9/32-inch panel cutout. Marco-Oak Industries, 207 S. Helena St., Anaheim, CA 92803. **287**

Miniature relays mount directly on PC boards with 0.1 inch grid spaced terminals. Series 1360 relays measure slightly over 1 cubic inch and have contact ratings from 5 to 50A. Standard coil voltages are 6 to 48V dc or 6 to 120V ac. Switching configurations available are SPST-NO, SPST-NC, SPDT, DPST-NO, DPST-NC and DPDT. Guardian Electric Mfg. Co., 1550 W. Carrol Ave., Chicago, IL 60607. **288**

Conductive plastic bags prevent build-up of static charges and protect electronic components and subassemblies during shipping and storage. "Conducto-Bags" are made of polyethylene fused to a conductive material and are available in 3-, 4-, 6-, 8- or 12-mil thicknesses. Flat widths of the bags are from 6 to 20 inches and they can be heat sealed. W. A. Plummer Mfg. Co., 13000 S. Broadway, Los Angeles, CA 90061. **289**

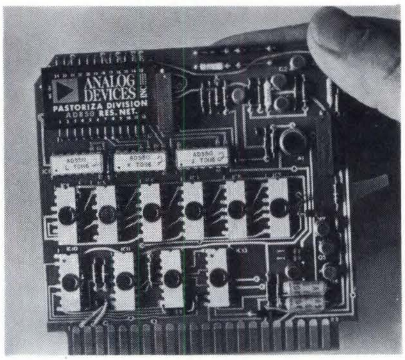
MOS chip capacitor kit containing 20 capacitors in each of 10 values, offers the hybrid designer capacitance values from 0.5 to 220 pF for circuit evaluation. The chips are 20, 30, 35 and 45 mils square and 6.0 (±) mils thick. They are gold-backed for eutectic bonding. Kits are $100 each in quantities of 1 to 10, and $90 each for more than 10. Dionics Inc., 65 Rushmore St., Westbury, NY 11590. **290**

All-plastic connectors cut costs and meet requirements of MIL-C-26482 and 38999. Available in 7-, 12-, 20- or 24-contact versions, these connectors feature a straight-push engaging system using locking tabs that snap into an undercut in the receptacle. To release the plug, the receptacle barrel is squeezed until the locking tabs release. Viking Industries, Inc., 21001 Nordhoff St., Chatsworth, CA 91311. **291**

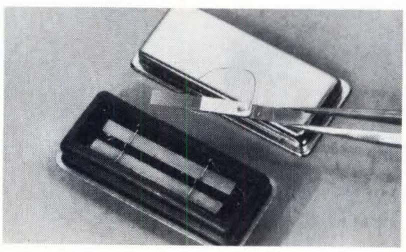
Cermet trimmer resistors are available in single, dual, triple or quad packages. The "Centrim" uses a cermet track bonded to a hi-alumina substrate. It is a linear taper device with resistances from 100Ω to 1 MΩ. Rotational life is rated at 500 cycles and cost is $0.20 each in production quantities. Centralab, 5757 N. Green Bay Ave., Milwaukee, WI 53201. **292**

Gunn diode packages feature ceramic to metal sealing and OFHC copper heat sinks. "Minipaks" are available with pedestal diameters of 0.012 to 0.040 inch and ceramic IDs of 0.015 to 0.050 inch. Packages are plated with a minimum of 100 microinches of pure gold. Pedestal flatness is held to three light-bands. Electro Ceramic Industries, 75 Kennedy St., Hackensack, N J 07601. **293**

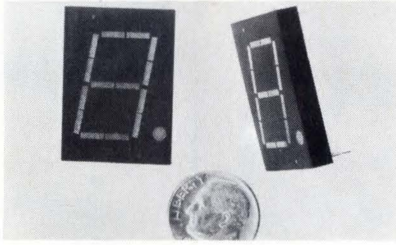
Semiconductor inductor TFF-L plugs directly into a standard DIP socket and provides lumped inductance without external magnetic fields, magnetic materials or windings. Available inductances range from 10 mH to 10 H. The 0.78- by 0.56- by 0.49-inch unit weighs <10 g and operates from ±12 to ±20V. Price is $18 each. The Five Friends, Box 7541, Stanford, CA 94305. **170**



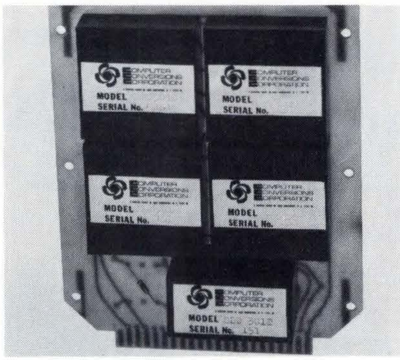
Twelve-bit A/D converter, Model ADC-12QL, draws only 600 μW quiescent power. Converter is immune to battery-voltage variations, holding output error below ±1 bit for battery voltage drop from 15 to 12V. Temperature coefficients offered are 20 ppm/°C (Model ADC 12QL/K) and 50 ppm/°C (Model ADC-12QLJ). Price is $675 each or $485 in 100-lots for ADC-12QL/J, and $950 each or $575 in 100-lots for ADC-12QL/K. Analog Devices, Inc., Rte. 1 Industrial Park, Box 280, Norwood, MA 02062. **171**



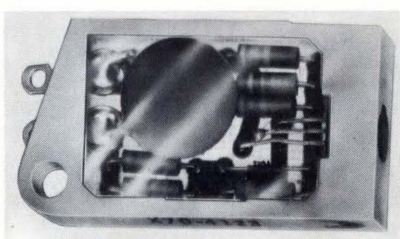
Three-to-30 kHz mechanical filter flatpacks are designed for bandwidths in the 0.2 to 2.0% band-width/center-frequency range. The filters employ flexure-mode resonators made of iron-nickel bars and piezoelectric-ceramic transducers. Available configurations are 1-, 2-, and 4-resonator. Package size is < 1/3 cubic inch. Collins Radio Co., Component Marketing Dept. 600, Newport Beach, CA 92663. **172**



Numeric display, Type SLA-3, generates a single-plane character 0.8-inch high and completely compatible with standard 74-Series decoder/driver ICs. Package thickness is only 0.165 inch. Electrical characteristics for this seven-segment display are 4.4V, 20 mA (typical) and 4.7V at 30 mA. Display may be operated in time-shared mode. Opcoa Inc., 330 Talmadge Rd., Edison, N J 08817. **173**



Synchro-to-linear angle converter converts three-phase synchro or two-phase resolver input into a dc voltage linearly proportional to the rotor shaft angle. Accuracy is ±30 minutes of arc. Available outputs are −10 to 10V (−180 to 180° or −90 to 90°) and 0 to 10V (0 to 360°). Circuit is mounted on a 4.5- by 6.5- by 1-inch PC board. Price in production quantities is <$300. Computer Conversions Corp., 6 Dunton Ct., East Northport, NY 11731. **174**



Solid-state sensing switch, a self-contained unit, consists of a single-transistor LC oscillator using a high-Q resonant circuit. Actuation inhibits the oscillation. Turn-on time, independent of the actuation rate, is approximately 200 μsec. Unactuated current drain is 2.6 mA and actuated current is 8 mA. Licon, Div. of Illinois Tool Works, 6615 W. Irving Park Rd., Chicago, IL 60634. **175**

Modular instrumentation amplifiers come in two versions—Model 310J and 310K. Model 310J has maximum input voltage drift of ±3 μV/°C, while drift for the 310K is ±1 μV/°C. Maximum input offsets are ±300 μV (310J) and ±150 μV (310K). In 1 to 24 quantity, prices are $29 (310J) and $59 (310K) with OEM discounts. Function Modules, Inc., 2441 Campus Dr., Irvine, CA 92664. **176**

Analog-to-digital converters, 51 Series, offer a choice of thirty models ranging from a 2-digit BCD unit at $59 to a 0.01% accuracy 12-bit binary unit at $86. All models are available with unshielded or shielded enclosures. Input voltage ranges are 0.1, 1.0 and 10V, uni- or bipolar. The units are housed in rectangular blocks with pin type connectors for PC board mounting. Gralex Industries Div. General Microwave Corp., 155 Marine St., Farmingdale, NY 11735. **177**

Tuning-fork type audio tone encoder/decoder Model EFM-U spans the 150 to 1700 Hz frequency range including all standard EIA frequencies from 151.4 to 1600 Hz. Frequency tolerance is ±0.1% while temperature coefficient of frequency is 3.5 × 10^{-5}/°C. Entire active device is potted in an epoxy compound. Murata Corp. of America, 2 Westchester Plaza, Elmsford, NY 10523. **178**

Digital-to-synchro converter on a PC board translates up to a 12-bit binary word into 3- or 4-wire, 400 Hz synchro or resolver information. Depending on the input reference voltage, available outputs are 11.8, 26 or 90V at 3 VA maximum. Accuracy is ±1 bit. Northern Precision Laboratories, Inc., 202 Fairfield Rd., Fairfield, N J 07006. **179**

Portable solid-state timers are battery operated units that automatically signal at the end of a pre-set time. The Port-A-Timer with a timing interval of 1 to 20 sec is the first of the series. Other models will offer intervals of 1 to 100 sec and 1 to 1000 sec. Lafayette Instrument Co., Box 1279, Lafayette, IN 47902. **180**

Position measuring and display systems are designed for specific machine needs. Basic systems are: Minicoder (absolute, with ±0.0015" total accuracy), Koder II (incremental, with ±0.005"/20" accuracy) and Kodel Series 300 (absolute, with digital readout, floating zero and ±0.0005"/33" accuracy). Ideal Aerosmith, Inc., 1505 E. Fox Farm Rd., Cheyenne, WY 82001. **181**

Plug-in single-phase bridge rectifiers, BRPI.500 and BRP300 Series, have ratings of 1.5 and 3A respectively at 50 to 800 V, along with a maximum single-cycle surge rating of 50A peak. Both devices have standard JEDEC 8-pin octal bases. Price range for 1-99 quantity is from $1 to $4.30. Rectifier Components Corp., 124 Albany Ave., Freeport, NY 11520. **182**

Power supply Model Z10 converts low frequency ac (47 to 440 Hz) to 50W of regulated dc power within a 4-by 6-by 2.25-inch package. The supply delivers 10A with dc outputs between 2.7 and 5.3V dc. Price is $219 each for 1 to 4 pieces. Abbott Transistor Laboratories, Inc., 5200 W. Jefferson Blvd., Los Angeles, CA 90016. **183**

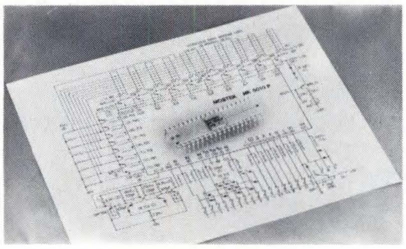
Multi-control, band-reject filter Model MN-4070-8 is an eight-section unit that features eight knobs for continuous tuning, along with lockable counters for memory. The unit is tunable over the 40 to 70 MHz range and its dimensions are 24 by 2 by 8 inches. Applied Research Inc., 76 S. Bayles Ave., Port Washington, NY 11050. **184**

A/D converters, Model 250 Series, are 8-, 10- and 12-bit plus sign converters that use successive approximation technique. Conversion time is 500 nsec/bit. Prices are $295 for 8 bits (Model 251A), $325 for 10 bits (Model 252A) and $395 for 12 bits (Model 253A). Dynamic Measurements Corp., 6 Lowell Ave., Winchester, MA 01890. **185**

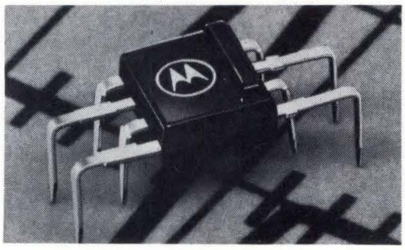
Solid-state timers, TR4 and TR7, provide from 0.1 to 300 sec ON delay (TR4) and 0.1 to 300 interval delay (TR7). The OFF delay for both units is 0.5 to 300 sec. Circuits are enclosed in a black phenolic housing and each has screwdriver adjustment. Durakool, Inc., 1010 N. Main St., Elkhart, IN 46514. **186**

Solid-state relay SLS-2000 is a DPDT unit in a DIP configuration with direct TTL-compatible drive voltage of 2.4V dc/1.6 mA maximum. Drive may be subjected to continuous 32V dc without damage. Unit is priced at $21.75 each. Logic Systems, Div., Sterer Engineering and Manufacturing Co., 4690 Colorado Blvd., Los Angeles, CA 90039. **187**

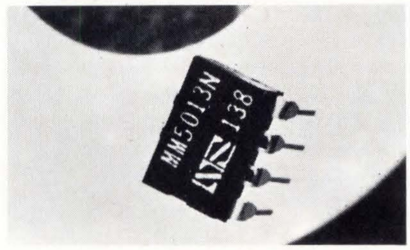
NEW SC's



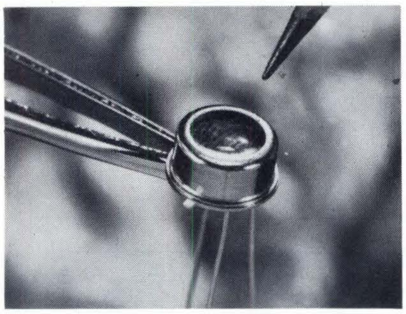
"Calculator on a chip" MOS/LSI Type MK501OP, a 10-digit version, contains the equivalent of 2100 transistors on a 180 × 180 mil chip. All math functions are performed on the chip, requiring only interfacing components, power supply, display and keyboard to make a complete calculator. Price varies from $75 each in small quantities to $15 in very large quantities. MOSTEK Corp., 1400 Upfield Dr., Carrollton, TX 75006. **197**



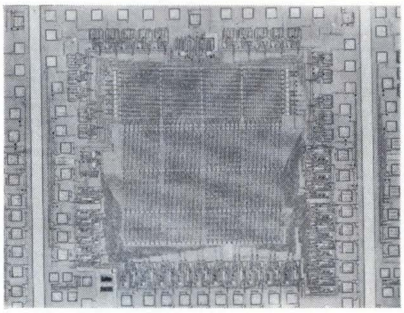
Zero-crossing switch, Model MFC8070, operates directly from ac line. Output pulse is generated 70 μsec before the controlled ac voltage passes through zero and is typically 140 μsec long. A differential input allows two external sensors to be compared to a reference voltage to generate the output gate. Price is $2.00 each in quantities of 100. Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, AZ 85036. **200**



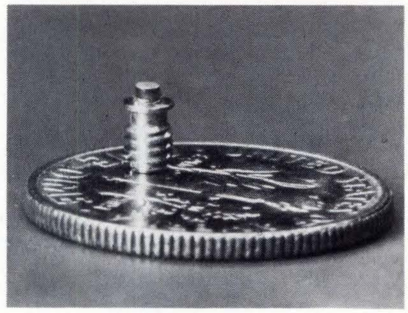
1024-bit MOS shift register/accumulator is packaged in 8-pin miniDIP or TO-100 can. The MM4013/5013 fully-controlled dynamic storage device achieves 8-pin packaging by merging the chip-select control function with the read/write controls. Frequency range is 400 Hz to 2.5 MHz. Price is $10.60 to $16.00 each in 100-up quantities. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **203**



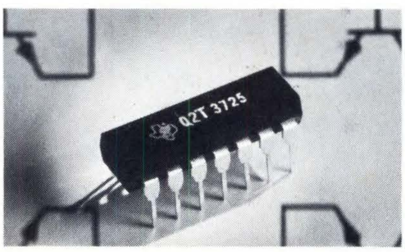
High-speed silicon photodiode, Type TIXL80, operates in reverse current mode to provide rise and fall times of 15 nsec. Responsivity is typically 0.55 amp/watt at 900 nm, dark current is 10 nA at V_R = 100V and continuous power dissipation is 100 mW. Price is $23.50 each in 100-piece quantities. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, MS/308, Dallas TX 75222. **198**



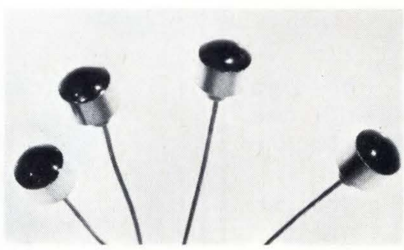
MOS LSI programmable logic array (PLA) provides various programs from one standard device by modification of one photomask. The CRC3506/7 TTL-compatible PLA consists of 64 20-bit words. Operation is low threshold dynamic (1.0 MHz) with static outputs. Price is $26.20 each (100's) plus mask charge of $750. Collins Radio Co., MOS Marketing Dept. 600, Newport Beach, CA 92663. **201**



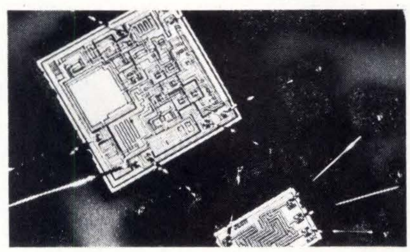
V-band IMPATT diodes provide up to 25 mW power output at 50 to 60 GHz. Type A5501S-H has 10 mW minimum power output, 0.5% efficiency and is priced at $200. Type A5502S-H has 25 mW minimum output power at 1.0% efficiency and costs $500. Both are housed in "Minidisc" packages on threaded studs. Hughes Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, CA 90509. **204**



Quad transistor memory driver, Type Q2T3725, replaces four discrete 2N3725 transistors. Beta is guaranteed to be a minimum of 30 at 500 mA. Produced as a second-source product to the MPQ3725 and SH6500, the new device features maximum collector-emitter saturation voltage of 0.26V at 100 mA and 0.52V at 500 mA. Available from stock at $3.65 each in 100 piece orders. Texas Instruments Incorporated, Box 5012, Dallas TX 75222. **199**



Gallium phosphide LED, the Solid-Lite OSL-4, offers large apparent source size of 0.175 inch by use of a "headlight" type reflector mounted behind the emitter. Total power output is 225 μW, equivalent to 4.5 millilumens. Luminous intensity is 2.7 millicandelas at 15 mA drive current. Typical forward voltage at 15 mA is 2.1V, and reverse current is 1.0 μA at 4.0V. OPCOA Inc., 330 Talmadge Rd., Edison, N J 08817. **202**



FET input op amp family features input offset adjustable to zero with a single 10k pot. The LH0042/LH0042C general-purpose op amps are pin compatible with standard TO-5 IC op amps. Offset voltage drift is 10 μV/°C and slew rate is 3V/μsec. Zero adjustment does not degrade drift or CMRR. They are available in standard TO-5 metal cans, flat packs or 14-lead DIPs. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **205**

Programmable ROM with 64 eight-bit word organization has an additional bit/word for factory and customer testing. Access time is <75 nsec. In addition to six address bits, two chip-enable inputs are provided for memory expansion. The MCM5003AL has open collector outputs, the MCM5004AL has 2-kΩ collector pullup resistors. Price, in quantities of 100, is $27.50. Motorola Semiconductor Products Div., Technical Information Center, Box 20912, Phoenix, AZ 85036. **206**

Infrared emitters offer high power efficiency and spectral compatibility with silicon sensors. TIL31 features hermetic TO-18 metal case and 6-mW radiant power output at 100 mA forward current. Type TIL32 is offered in a clear epoxy package and is rated at 1.2 mW output at 20 mA input. TIL31 is priced at $1.60 each and TIL32 $0.86 each in 1000 piece lots. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, MS/308, Dallas, TX 75222. **208**

Emitter coupled logic IC Series is expanded. Fifteen new devices, including 4 MSI units, bring the total number of ECL functions now available in the 9500 Series to 22. The latest additions include 95L Series low-power, high-speed gates (20 mW power, 2 nsec delay). MSI functions added to the line include a 2-bit adder/subtracter, quad 2-input multiplexer, quad exclusive-OR gate/4-bit comparator and quad latch. Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94040. **210**

Monolithic audio amplifier, the EEP LM352, delivers 2.1W output power. The usable range of power supply voltage is from 6 to 15V. Quiescent current drain is 1.2 mA. Open-loop gain is 70 dB at 12V. Input is direct coupled and bias is self-centering. Packaged in a 14-pin plastic DIP with a copper-bar heat dissipator, they cost $3.15 each (1-24). European Electronic Products Corp., 10150 W. Jefferson Blvd., Culver City, CA 90230. **207**

High-speed voltage comparator ICs, the "527" and "529," feature Schottky clamped outputs. The 529 has a single differential-pair input, while Type 527 uses a Darlington input. Delay time, from input to gate output, is typically 10 nsec for the 529 and 15 nsec for the 527. The 529 has a Z_{in} of 5 kΩ and bias current is 5 μA. The 527's Z_{in} is 50 kΩ and its bias current is typically 700 nA. Prices vary from $6.50 to $17 each in lots of 100. Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **209**

4-bit shift registers, Type 93H00 and 93H72, are the first high-speed MSI functions in the 9300 TTL Series. Typical shift frequencies are 55 to 60 MHz, minimum is 45 MHz. 93H00 is a pin-for-pin replacement for the 9300. 93H72 is similar except that J and K inputs are replaced by a single D-type input and a clock enable input. This permits synchronous shift, parallel load and hold modes. Prices for both devices are $4.85 to $9.70 each in 100 quantities. Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94040. **211**

NEW SCs

Silicon avalanche photodetector is designed for 900 to 1060 nm operation. The unit measures 2 inches in diam and is 1.3 inches long. It contains a photo-diode, temperature-sensing voltage reference diode, amplifier and regulated avalanche-gain bias circuit. Price is $165 each on 100 piece orders; delivery is 4 weeks ARO. Texas Instruments Incorporated, Box 5012, Dallas TX 75222. **221**

Dual element photocell uses a 2-element electrode in bifilar configuration. The VT 800/2 photocell is designed to provide isolated control of two circuits from a single light source. The plastic-encapsulated device costs $0.50 each in 1000-piece quantities. Vactec, Inc., 2423 Northline Industrial Blvd., Maryland Heights, MO 63043. **222**

Monolithic integrated-circuit dividers offer ultra-high-speed operation. The SP630 is a 600-MHz decade divider and the SP620 is a 400-MHz divide-by-five circuit. Both units are packaged in 8-lead TO-5 cans. In the "B" version (commercial temperature range), the SP630 sells for $150 each and the 620 for $65 each in single quantities. Plessey Electronics Corp., 170 Finn Ct., Farmingdale, NY 11735. **223**

Quad silicon-on-sapphire transistor is a P-channel enhancement-mode device offering total dielectric isolation and elimination of capacitances normally associated with bulk-silicon devices. The L01 transistor quad chip measures 40 × 40 mils and is packaged in a 14-pin DIP with build-in protective devices. Price is $19.50 each in quantities of 1 to 9. Inselek, 743 Alexander Rd., Princeton, N J 08540. **224**

Monolithic filter innovation provides four-pole design in a TO-5 package. A typical specification includes center frequency of 20 MHz, with 3 dB bandwidth of 16 kHz (min) and 50 dB bandwidth of 64 kHz (max). Insertion loss is 3-1/2 dB max. McCoy Electronics Co., Mount Holly Springs, PA 17065. **225**

96 character ROMs, Models F8-1 and F11-1, provide upper and lower case for matrix printers. Model F8-1 produces 5 by 7 dot matrix characters from ASCII input, and is designed for use with Matrix 300 and 600 line/min printers. Cost is $425. The F11-1 generates 7 by 9 dot matrix characters for use with the Matrix 1300 printer and costs $550. Versatec, Inc., 10100 Bubb Rd., Cupertino, CA 95014. **226**

Why buy the Star of India? When you really need a little gem.

Overbuying can be princely fun. If you're the Aga Khan.

But now, with the current budget squeeze, common sense has entered the picture. So has Raytheon's CDU-150 scope.

A top quality, general-purpose oscilloscope with price/performance second to none. DC to 35MHz at 5 mV/cm. Dual channel. Big, bright 8x10 cm display. Stable triggering over the full bandwidth. Time-base delay.

Plus light weight for honest portability. Ruggedness that can easily take hundreds of miles in the trunk of your car without a flutter. At a price of only $1495.

Think about it. The uncompromising quality of the CDU-150. And the money you save by not buying more than you need. Send us the coupon. Or contact the nearest sales reps on the opposite page.

Raytheon Company
Instruments Operation
175 Middlesex Turnpike
Bedford, Mass. 01730

Gentlemen: Send information on the CDU-150.

Name__________

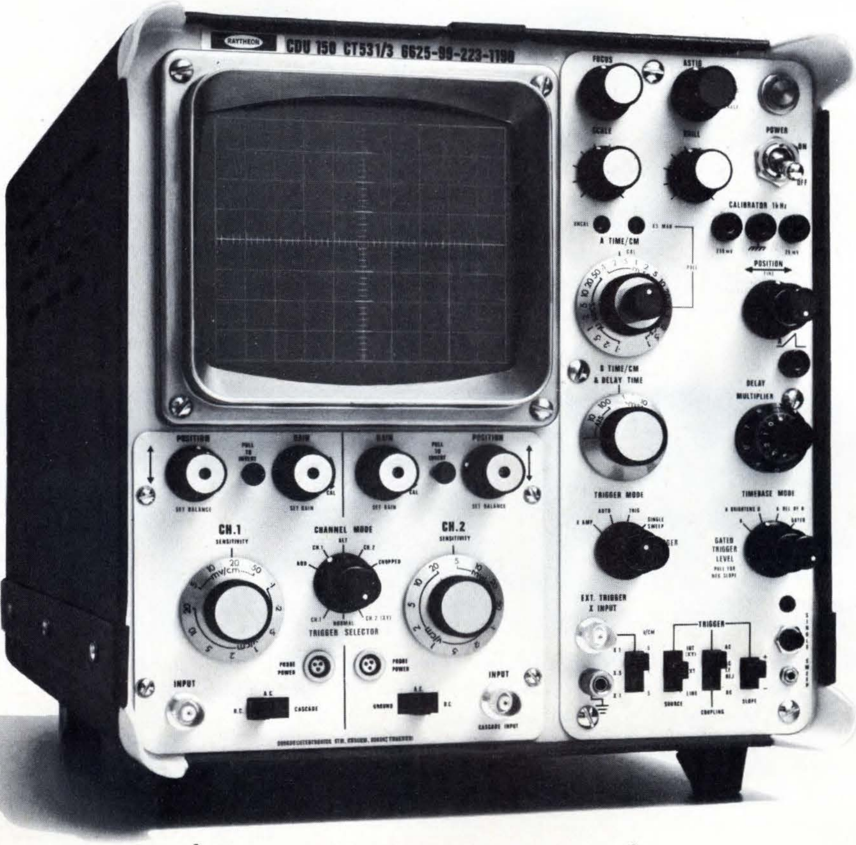
Company__________

Address__________

City__________

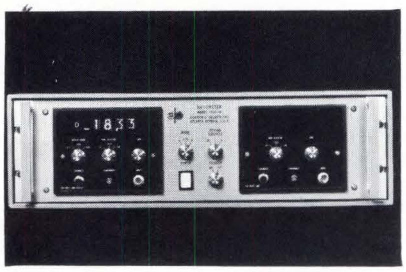
State__________ Zip__________

RAYTHEON

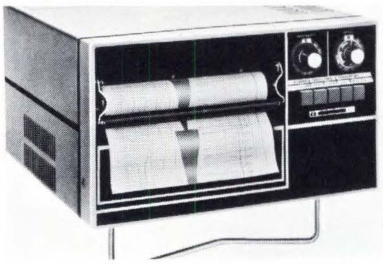


(Our little jewel.)

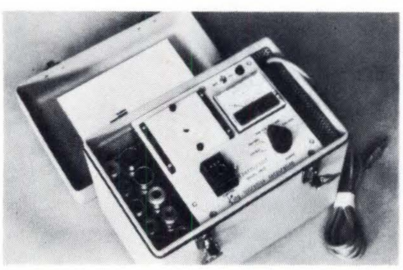
CIRCLE NO. 84



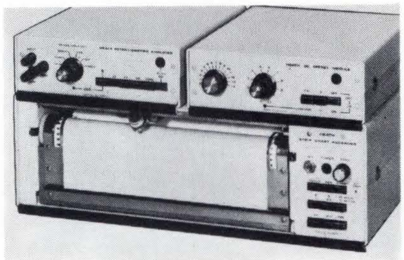
Ratiometer, Series 1833, accepts the output from two receivers, bolometers or crystal detectors and displays the ratio between the signals in dB. Both single and dual display models are available. Features include 0.01 dB resolution and ±70 dB dynamic range. BCD output is optional. Price is $2900 with delivery 90 days ARO. Scientific-Atlanta, Inc., Box 13654, Atlanta, GA 30340. **227**



Oscillographic light-beam recorder, Model TR-180LB, records up to 18 channels of data on a 7-inch-wide chart. Servo-controlled chart speeds range from 0.1 to 100 ips. Writing is on direct-print chart paper via high-intensity mercury vapor light source. Frequency response is up to 5 kHz. Gulton/Techni-Rite, Inc., Rte 2, East Greenwich, RI 02818. **228**

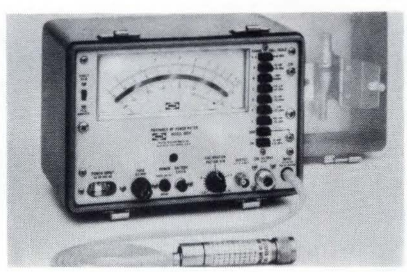


Temperature calibration system, the portable Model 3603, incorporates a dry-well heat source, a digital potentiometer control, a direct readout and adapter chucks for testing temperature instruments in the range of 100 to 600°F. Stabilized temperature is reached in less than 20 min from a cold start and is accurate within ±0.15% of set point. King Nutronics Corp., 13826 Saticoy St., Van Nuys, CA 91402. **229**

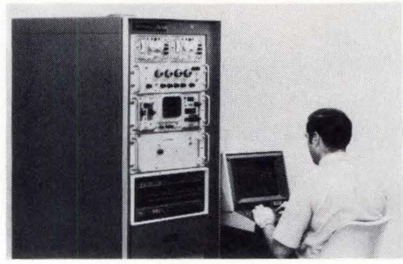


Strip-chart recorder offers pushbutton selection of 23 chart speeds from 30 ipm to 0.2 iph. Switch-selectable calibrated spans range from 1 mV to 500V full scale in a 1-2-5 sequence. Input is potentiometric on ranges to 500 mV, with 10 MΩ input impedance on other ranges. Price of the Model EU-205B is $675. Heath/Schlumberger Scientific Instruments, Benton Harbor, MI 49022. **230**

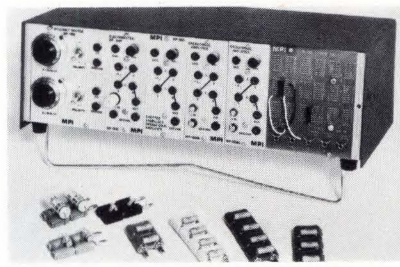
Digital pressure calibration system, comprised of a solid-state pressure transducer and a 4-1/2-digit voltmeter, is accurate to 0.1%. By transducer choice, full scale pressure ranges from 30 inches of mercury to 5000 psi can be provided. Buffered BCD output is standard at no extra cost. Tyco Instrument Div., 150 Coolidge Ave., Watertown, MA 02172. **231**



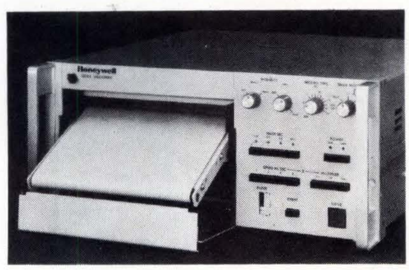
Microwave power meter for 50 and 75Ω systems measures from a few nW to 100 mW at frequencies from 1 MHz to 14 GHz. A single-sweep range covers the meter's 50 dB dynamic range. Basic accuracy is 1% of full scale or 1.5% of reading. Price for the 10 nW to 10 mW Model 1034 or the 100 nW to 100 mW Model 1035 is $645 each. Detectors are priced at $250 and $270 respectively. Pacific Measurements, Inc., 940 Industrial Ave., Palo Alto, CA 94303. **232**



Waveform digitizing system, the computer-operated Model S-3003, is intended for those who collect enormous amounts of oscilloscope data. The system offers the versatility of a computer-controlled programmable oscilloscope capable of acquiring signals from dc to 14 GHz. Price is between $25,000 and $70,000 with 16 week availability. Tektronix, Inc., Box 500, Beaverton, OR 97005 **233**



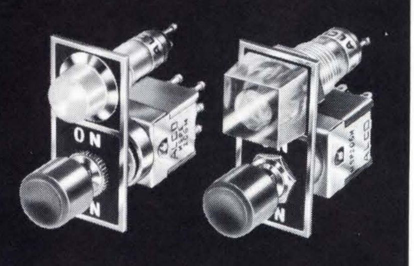
Operational manifold includes a dual mV source, electrometer op amp, chopper-stabilized op amp, two differential op amps and an IC patch panel that will hold up to nine ICs. Price of the Model MP-1502 is $325 for mainframe and power supply. Thirteen plug-in modules are priced from $59 to $190. McKee-Pedersen Instruments, Box 322, Danville, CA 94526. **234**



Direct-writing oscillographic recorder, the Model 1508B Visicorder, is available in either 12 or 24 channels and features servo paper drive, grid system, timing system, built-in paper take-up, automatic record-length control, record/event numbering and trace identification. The range of paper speeds is from 0.1 to 120 inches/sec in 40 steps. Honeywell Inc., Test Instruments Div., Box 5227, Denver, CO 80217. **235**

LOW COST LIGHTED PUSH BUTTON

We have available a variety of lens styles, colors, and switching configurations used with attractive etched plates to make your own low cost lighted Push Button switches. Send for descriptive literature.



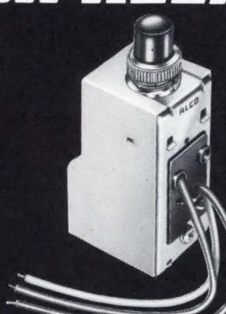
ALCOSWITCH®

DIV. OF ALCO ELECTRONIC PRODUCTS, INC. NORTH ANDOVER, MASS. 01845

CIRCLE NO. 85

PUSH BUTTON SWITCH-RELAY

Another Alco First... By combining a push on/off switch and a relay, we've created a very unusual safety switch. If power is accidently interrupted it automatically cuts off the load. Specify, 115VAC, 6 or 14VDC. Rating 5A.

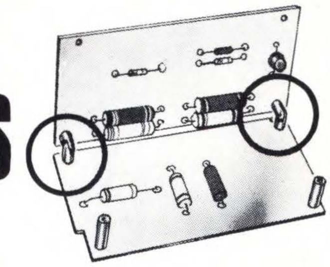


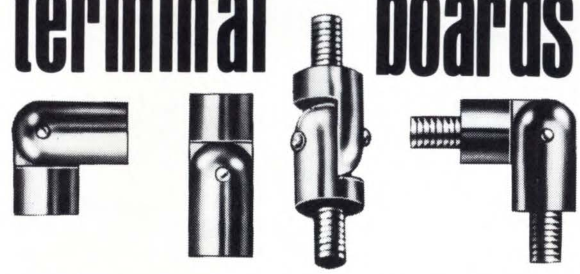
ALCOSWITCH®

DIV. OF ALCO ELECTRONIC PRODUCTS, INC. NORTH ANDOVER, MASS. 01845

CIRCLE NO. 86

hinged standoffs for terminal boards





A TYPE FOR EVERY APPLICATION

- Faster Maintenance
- Interconnects Circuits
- Wiring Exposed for Testing
- Space Saver

Manufacturers of Standardized Hardware for Electronics

NEW FREE CATALOG ON REQUEST

DESIGNERS · MANUFACTURERS

KEYSTONE

ELECTRONICS CORP.

49 Bleecker Street • New York, N.Y. 10012

CIRCLE NO. 87

GREAT MOMENTS

• • • • • in electrical history

. . . the day each budding electronics buff bumps into Mueller Clips and forms a lifelong friendship. "Mueller Clips are to men what safety pins are to women," wrote A. E. Rose of Canadian Westinghouse Company Limited, in a recent fan letter we treasure most in our 60-year collection. Think you can find the 1001st use for our supergadgets for quick, temporary electrical connections?

At Jobbers everywhere.

Write factory for FREE sample clips and catalog.

Mueller Electric Co.

1576G East 31st Street • Cleveland, Ohio 44114

CIRCLE NO. 71

NEW GRC GEAR KIT demonstrates BIG STOCK AND CUSTOM SERVICES IN . . . TINY GEARS

(Die-cast Zinc Alloy or Molded Plastic)

- Gear Clusters
- Gears with Hubs,
- Spacers
- Gears with Shafts
- Gears with Cams
- Spur Gears
- Bevel Gears
- Crown Gears
- Miter Gears
- Rack Gears
- Worm Gears
- Helical Gears
- Spiral Gears
- Ring Gears

Write today for GRC Gear Kit, Stock List and Designers' Aids on Your Letterhead

Division of Coats & Clark Inc.

136 Beechwood Ave., New Rochelle, N. Y. 10802 • (914) 633-8600

Plants in: New Rochelle, N. Y.; Warren, R. I.; Toccoa, Ga.

In Canada: Gries Div., Dynacast Ltd. Lachine, Que.

Gries Reproducer Co.

CIRCLE NO. 88

EQUIPMENT

Electrical thermometer, Model 290, has measurement span of −60 to 130° C using a multiple scale taut-band meter that provides accuracy of ±1-1/2°C over the entire range. Power is from a 9V transistor battery. Price is $120, with probes $20 to $30 each additional. RFL Industries, Inc., Boonton, N J 07005. **303**

Dropout detector-counter for evaluating the quality of new or used analog magnetic tape (available in 7- or 14-channel versions) permits certification of wideband instrumentation tape to user specifications. Test signal is variable from 50 kHz to 2 MHz. Features include self-testing and display of tape footage. General Electric Co., Space Div., Box 58408, Houston, TX 77058. **304**

Broadband EMI detector weighs less than 3 lbs, operates from built-in rechargeable nickel-cadmium batteries and has sensitivity to broadband EMI in the order of 0 dB/μV/MHz. Model BD-3637A finds application as an electronic fault detector, interference locator, transient detector or as an RF monitor. Andy Hish Associates, 14657 Aetna St., Van Nuys, CA 91401. **305**

Instrumentation recorder handles 10-1/2-inch reels of 1/4-inch tape and offers four channels. The Model 300 features a dc-powered six-speed electrically-switched drive system with tape speeds of 15/16 through 30 ips. Direct frequency response is 200 Hz to 12 kHz at 15/16 ips and 200 Hz to 187 kHz at 15 ips. Prices range from $4850 to $5830 depending on channels and direct or FM record required. Pemtek, Inc., 942 Commercial St., Palo Alto, CA 94306. **236**

Digital comparator, Model 1500, accepts up to a 6-digit BCD input (TTL logic level) and compares it to a front panel thumbwheel setting or to a remote BCD input (limit setpoint). Programmed and Remote Systems Corp., 899 W. Highway 96, St. Paul, MN 55112. **237**

Universal DMM, Model 8120A, features 25 ranges and modes (ac and dc ranges from 100 mV to 1000V, current ranges from 100 μA to 1A and resistance ranges from 1000Ω to 10 MΩ). Overranging on all ranges is 20% and all specifications are guaranteed. Price is $795. John Fluke Mfg. Co., Inc., Box 7428, Seattle, WA 98133. **238**

EQUIPMENT

Scanning electron microscope produces higher electron beam currents at lower accelerating voltages than conventional SEMs. The CWIKSCAN/100 field emission instrument uses a low voltage mode to prevent electron pile-up. Coates & Welter Instrument Corp., 777 N. Pastoria Ave., Sunnyvale, CA 94086. **239**

Console card reader family includes Models M 1000C and M 600C with reading speed of 1000 and 600 cpm respectively. Both are designed for remote batch terminal and computer center requirements and are available with an IBM or UNIVAC multiplexer channel interface controller. Price is $4695 and delivery is 60 days ARO. Documation Inc., 841 E. New Haven Ave., Melbourne, FL 32901. **240**

Programmed temperature controller, Model PTC-1, provides digital control of temperature rate of change, with slope control on both heating and cooling cycles. All controlled parameters may be remotely preset with digital (BCD) information. Price is $2450, and delivery will be after Jan. 1. Milliken Electronics, Box 489, Greer, SC 29651. **241**

Microwave amplifier for the 5.925 to 6.425 GHz band, Model SSD-54109, provides 300W CW power with minimum gain of 75 dB. The amplifiers meet mandatory requirements of ICSC, operate from 110/120V 1 phase 50/60 Hz and are small enough to be installed in the elevated equipment bay. Warranty is 15,000 hrs or 2 years and price is less than $20,000. Availability is 45 days ARO. Sperry Rand, Electronic Tube Div., Department 9002, Waldo Rd., Gainesville, FL 32601. **242**

Automatic data logger features 10-channel scanning, a wide choice of digitizers and fully programmable data control for any recording formats and codes. Model 7200 has base price of $2650. Monitor Labs Inc., 10451 Roselle St., San Diego, CA 92121. **243**

Coil and core magnetic analyzer that operates on a go/no-go basis will detect open coils, short to case, circuit sensitivity, shorted turns and bucking fields. Model CT-100 operates at 1 MHz and has a built-in calibrate circuit for self test. Price is $375. Keonics, Inc., 1600 Victory Blvd., Glendale, CA 91201. **244**

EQUIPMENT

Pyrometer that weighs 1 lb operates from a single "C" battery and uses an electrical cold-junction circuit. Model 320 G/P instruments are available in four temperature ranges (−150 to +200°F, 0 to 500°F, 0 to 750°F and 0 to 1000°F). Accuracy is better than ±3% of full scale. Price each, including 5-ft probe and instruction book, is $62. Triplett Corp., Bluffton, OH 45817. **306**

Digital capacitance meter that operates at 1 MHz incorporates built-in dc bias supply and features signal level of 15 mV rms. Model 861 is suitable for three-terminal and differential measurements of semiconductors. Both dc analog and BCD outputs are provided. Price is $995 and delivery is 3 weeks ARO. MSI Electronics Inc., 34-32 57th St., Woodside, NY 11377. **307**

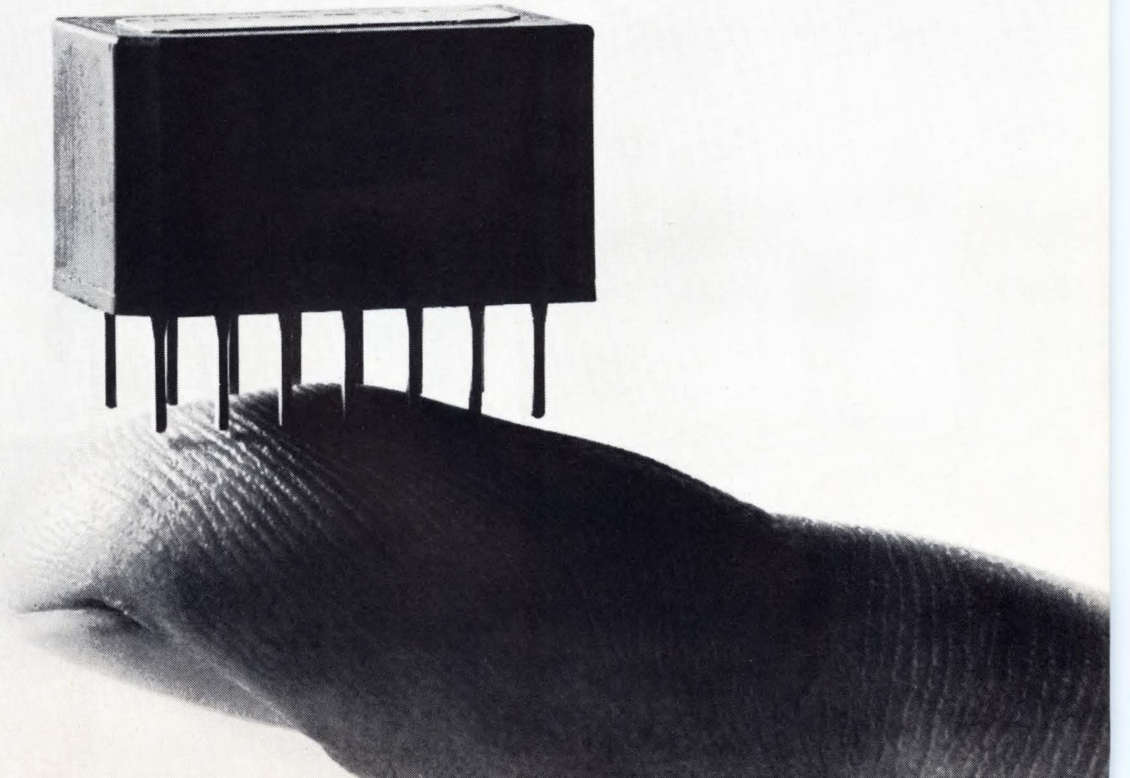
Instrumentation tape recorder/reproducer handles up to seven channels on 1/2-inch—or 14 channels on 1-inch—tape, and accepts reels up to 10-1/2 inches in diam. Model CPR-4010 has seven speeds ranging from 15/16 to 60 ips. Direct system bandwidth is 300 kHz at 60 ips. The magnetic record and reproduce heads have a warranty of 1000 hrs of non-prorated use. Bell & Howell, 360 Sierra Madre Villa, Pasadena, CA 91109. **308**

Probing analyzer, consisting of high resolution microscope, four high-ratio micropositioners and a fixed-focus camera, makes probing of individual transistors in LSI and MSI arrays easy and practical. The selling price of $4800 includes a 1-day training program. Delivery is stock to 4 weeks. Comaltest, Inc., Commerce Dr., Danbury, CT 06810. **309**

Digital tele-thermometer for monitoring patient temperature provides temperature range from 80 to 109.9°F with ±0.1°F accuracy. Model 48 features a LED readout, is battery operated and uses inexpensive, interchangeable probes that require no special recalibration. Price is $395 plus $15 for the battery charger. Probe prices begin at $15. Yellow Springs Instrument Co., Box 279, Yellow Springs, OH 45387. **310**

Calculating counters of the Model 1600R Series measure low-frequency signals by period measuring techniques followed by electronic calculation. Sensitivity is 10 mV rms, and up to two measurements/sec can be made with 6- or 8-digit resolution at 5 Hz input. Anadex Instruments Inc., 7833 Haskell Ave., Van Nuys, CA 91406. **311**

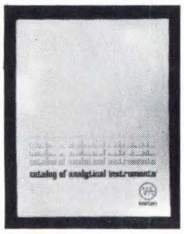
If you've been looking for a miniature crystal-controlled clock oscillator in a 14 pin DIP package to fit standard PC board sockets, stop looking and start writing for the K1091A spec. sheet from Motorola Component Products Dept. 4545 W. Augusta Blvd. Chicago, Ill. 60651. MOTOROLA



Specifications: 4 to 20 MHz range; 0.01% stability; prototype quantities available for immediate delivery in 4.9152 MHz, or 5.0, 10.0 or 20.0 MHz.

CIRCLE NO. 94

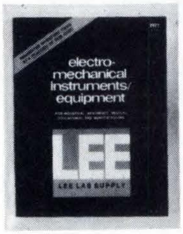
LITERATURE



Analytical instruments including those for NMR and electron paramagnetic resonance as well as laboratory electromagnets, induced electron emission spectrometers and analytical data processing systems are the subject of an eight-page catalog that references specification sheets for each item. Varian, Analytical Instrument Div., 611 Hansen Way, Palo Alto, CA 94303. **264**

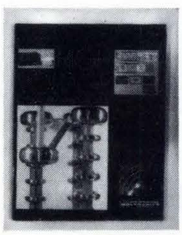
LED readout assembly with character height of 0.125 or 0.205 inch is described in a two-page bulletin R05021. The readout is a six-by-eight dot matrix connected for seven-segment driving. Readouts are offered as a complete package including decoder/driver and bezel assembly. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. **265**

Lock-in amplifier theory and operation are the subjects of an eight-page application note (IAN-21). The note divides the lock-in amplifier into functional blocks, and provides discussion of each of them as well as their interrelationship. Topics include phase-sensitive detector, filtering by lock-in and signal-to-noise improvement. Ithaco Inc., 735 W. Clinton St., Ithaco, NY 14850. **266**

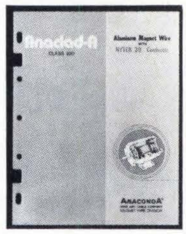


Bargain buys in instruments, transducers, recorders and other items fill this 120-page catalog that contains over 600 illustrations. All items are guaranteed to meet manufacturer's specifications. Gyros, synchros, transducers, oscillographs, amplifiers, voltmeters and others are available off-the-shelf. Lee Lab Supply Div. of Datacraft, Inc., 13714 S. Normandie Ave., Gardena, CA 90249. **267**

Solid-state timers are the subject of a 17-page catalog. It illustrates and describes six standard models of solid-state timers that feature constant linear timing accuracy. Also included is a convenient table of timer terminology (terms and definitions). General Time Corp., Industrial Controls Div., 135 S. Main St., Thomaston, CT 06787. **268**



High-voltage power supplies, both standard and custom, with ratings from 1 kV to 2 MV dc and power ratings to 250 kW are fully specified and described in a 40-page catalog. Models suitable for powering lasers, electron microscopes, CRTs, electrostatic paint systems, X-ray source systems and accelerators are included. Universal Voltronics Corp., 27 Radio Circle Dr., Mount Kisco, NY 10549. **269**



Aluminum magnet wire with "Hytek 20" conductor is the subject of a four-page bulletin. The Class 220 magnet wire is intended for extended service life at operating temperatures up to 220°C. Bulletin WC-7125 also includes data on thermal life and connection methods for round wire in sizes from 11 to 30 AWG. Anaconda Wire and Cable Co., Dept EFL, 605 Third Ave., New York, NY 10016. **270**

Diodes – silicon planar, zener, four-layer and stabistors – comprise the approximately 300 listings included in an eight-page short-form catalog. Power ratings range from 250 mW to 3W, and all important electrical and mechanical characteristics are given for both JEDEC and house numbered types. American Power Devices, Inc., 7 Andover St., Andover, MA 01810. **271**

Machines for hot-stamp marking to identify wire and sleeve are the subject of information sheets on Model KTE-6 (hand operated) and Model KWE-7 (air operated) with capacity of approximately 11,000 markings per hour. Both machines are available for wire marking only, sleeve marking only or a combination of the two. Kingsley Wire-Marking Machines, 850 Cahuenga Blvd., Hollywood, CA 90038. **272**

Digivider/Digidecade...the great idea by Kelvin, Varley, Poggendorff and Porter.

Hank Porter (front), used some of the principles set forth by his distinguished friends to come up with two new products.

Digivider is a thumbwheel switch that has been converted into a voltage divider. It's like a 10-turn potentiometer. When you dial the voltage you want, that's precisely what you get. The large digits, however, give you simplicity and greater accuracy. No fine, hairline settings are necessary. Digivider accuracies range from 0.1 to 0.01% full scale voltage ratio. All are available with resolutions to 0.0001% and input impedances from 100 to 100,000 ohms.

Other available features: Overrange. 12 and 16 position voltage division in the most significant digit. Plus, high resolution trimming in the least significant digit.

Digidecade is a thumbwheel switch converted into a resistance decade. Actually, one version of the Digivider can be used, only instead of dialing the voltage, you dial the resistance you want. Again, accurate and with visual ease.

The Digidecade also comes as a resistance decade utilizing a weighted code of 1-2-2-2-2, using five resistors to achieve nine discrete steps of resistance from (0-9) or multiples thereof. It is a linear progression that yields the desired total resistance.

Digidecades are available with accuracies from 1% to 0.1% of setting, resistance ranges from 10 ohms to 1 megohm and step sizes of 1 to 100,000 ohms.

As with all DIGITRAN products, you can count on stability and quality. You won't get more than a 5 milliohm change in contact resistance through 100,000 accurate switching operations.

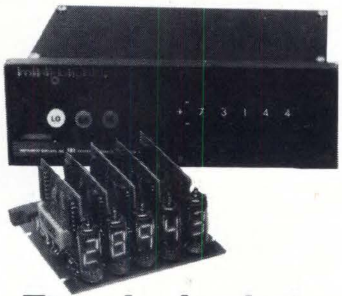
So, write for our new catalog on DIGIVIDERS and DIGIDECADES, or even better, give us a call. That's a great idea too.

THE DIGITRAN COMPANY

A Division of Becton, Dickinson and Co. B-D

855 S. Arroyo Parkway, Pasadena, Calif. 91105
(213) 449-3110 • TWX 910-588-3794

CIRCLE NO. 95



Literature

Electrical coating material, "Aquadag E", is the subject of a data sheet that describes the spray, dip, brush and sponge methods of applying this fast-drying liquid to make conductive coatings and impregnants with controlled resistance from 10 to 1000 Ω/square. Acheson Colloids Co., Box 288, Port Huron, MI 48060. **245**

Glass-ceramic chip capacitors with capacitance-to-volume ratios of up to 90 μF/in^3, values from 10 to 330,000 pF and four standard sizes are described in Data Sheet CAD-CCC. Corning Glass Works, Corning, NY 14830. **246**

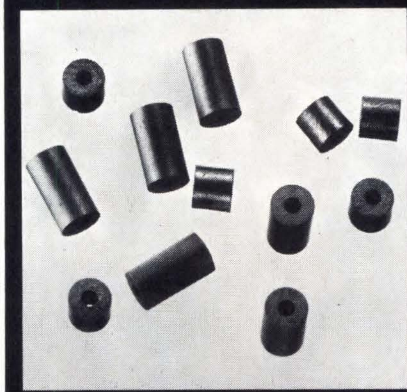
Microwave radio for the 10.7 to 13.2 GHz band is described in a six-page brochure that gives performance ratings and specifications for video, FDM message and PCM. Applications information for common carrier, business radio, educational, municipal, medical, CATV and broadcast is included. Microwave Associates, Inc., Communication Equipment Div., South Ave., Burlington, MA 01803. **247**

High voltage power supplies for use with photo-multiplier, CRT, image intensifier and night vision gating systems are described in a 30-page catalog. Background data and a capabilities index are provided for reference. Venus Scientific Inc., 399 Smith St., Farmingdale, NY 11735. **248**

Tuneable active filters of the 730 Series are four-pole low pass filters with externally tuneable cutoff frequencies. They are described in a two-page data sheet that discusses applications in test equipment, data transmission and frequency analysis apparatus. Analog Devices, Inc., Rte. 1 Industrial Park, Box 280, Norwood, MA 02062. **249**

Digital VOM with 2¾ digit readout is described in a data sheet that provides complete specifications, prices and accessory information. Triplett Corp., Bluffton, OH 45817. **250**

Rectifier fuses with ratings from 1 to 800A are described in a four-page catalog. The fuses are designed for applications in variable-speed drive systems, motor controls, lift trucks and other electronic and control devices. Federal Pacific Electric Co., 150 Avenue L, Newark, NJ 07101. **251**



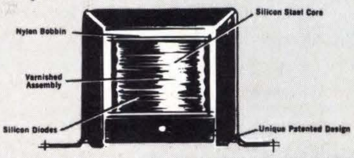
WALL PLUG-IN LOW VOLTAGE

CONVERTERS/INVERTERS/CHARGERS

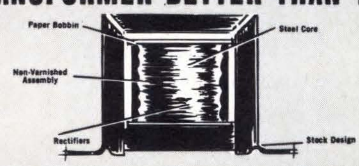
To insure high quality and top performance in our plug-in power supplies and chargers, we make our own low voltage

TRANSFORMERS

using superior materials in a smaller sized unit. The years of successfully satisfying the unique needs of the industry with specialty transformers is "at your service".



WHY IS THIS LOW COST DYNAMIC TRANSFORMER BETTER THAN THIS



STOCK TRANSFORMER COSTING MORE.

In addition to those advantages already pointed out, DYNAMIC TRANSFORMERS can be made to your SPECIFICATIONS in days and in most cases with NO COST for prototypes.

TRANSFORMERS FOR ALL REASONS

- ☐ Patented, U/L listed
- ☐ Internal or External
- ☐ Wall-mounted
- ☐ Fast-charging
- ☐ Power conversion
- ☐ Conversion/ charging
- ☐ Printed circuit
- ☐ Sub-miniature
- ☐ Ferro-resonant
- ☐ Multi-input
- ☐ Multi-output

THE TRANSFORMATION OF POWER

A unique brochure explaining the many advantages and application possibilities of Dynamic's patented U/L listed transformers, converters, chargers and power supplies, technical data sheets and bulletins, are available on specific products. A request on your letterhead or phone our Sales Engineering Department WPX-1.

Designed to be listed under the U/L • CSA SPECIFICATIONS

Illustrated at right is the Model 3-1743 presently in production for use with a keyboard logic circuit. Suitable for minicomputers, calculators, remote CRT terminals, etc.

Dynamic Instrument Corp. has designed, developed and patented a complete range of low-voltage, filtered, transistor-regulated power supplies and chargers designed to supply the necessary power to a vast variety of Electronic equipment.

Utilizing a wall plug-in type unit eliminates or greatly reduces the problems involved with UL listing your product. They also remove the major heat source, reduce size and weight, and also greatly increase your design flexibility. The latest design applications of the Dynamic wall plug-in supplies are in conjunction with such sophisticated equipment as mini-computers, calculators, keyboard logic circuits, and remote CRT Terminals.

Just call or write: Dept. WPX-1.

Dynamic's product range and capabilities also cover:

POWER CONVERSION

AC-AC for products requiring low-level AC voltage. AC-DC for small electric motor driven products that do not use batteries.

SECONDARY BATTERY CHARGING

Dynamic Chargers for charging Nickel-Cadmium; Lead-Acid and Manganese-Alkaline Batteries.

AC-DC CONVERSION/CHARGING

Dynamic Converter-Chargers providing rechargeability or instant use of battery operated products.

FAST CHARGING SYSTEMS

Dynamic design and production capability relative to Fast Charging Systems.

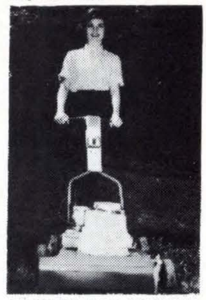
TRANSFORMERS

Internal, External and Wall-Mounted Dynamic Transformers.

SPECIALTY TRANSFORMERS

Dynamic Plug-In, Printed Circuit Transformers; Sub-Miniature Transformers; Ferro-resonant Transformers; Multi-Input Voltage and Multi-Output Voltage Transformers.

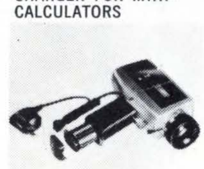
CONVERTER/CHARGER FOR PORTABLE MEDICAL-ELECTRONIC EQUIPMENT



CHARGER FOR BATTERY ELECTRIC-STARTER SYSTEMS

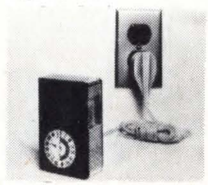
CHARGER FOR BATTERY OPERATED TOYS

CONVERTER/"FAST" CHARGER FOR MINI-CALCULATORS



CONVERTER/CHARGER FOR MOTER DRIVEN CAMERAS

AC CONVERTER FOR PORTABLE ELECTRONIC EQUIPMENT



"FAST" CHARGER FOR ELECTRONIC FLASH

DYNAMIC INSTRUMENT CORP.

115 E. Bethpage Rd.,
Plainview, N. Y. 11803
516 - 694-6000

TWX 510-224-6482 CABLE ADDRESS "DYNINST" PLAINVIEW, N. Y.

CIRCLE NO. 98

LITERATURE

Helium-Neon lasers are covered in two data sheets that describe the Model 50 and Model 104 units. Performance, specifications and suggested applications are included in each two-page bulletin. Optics Technology Inc., 901 California Ave., Palo Alto, CA 94304. **278**

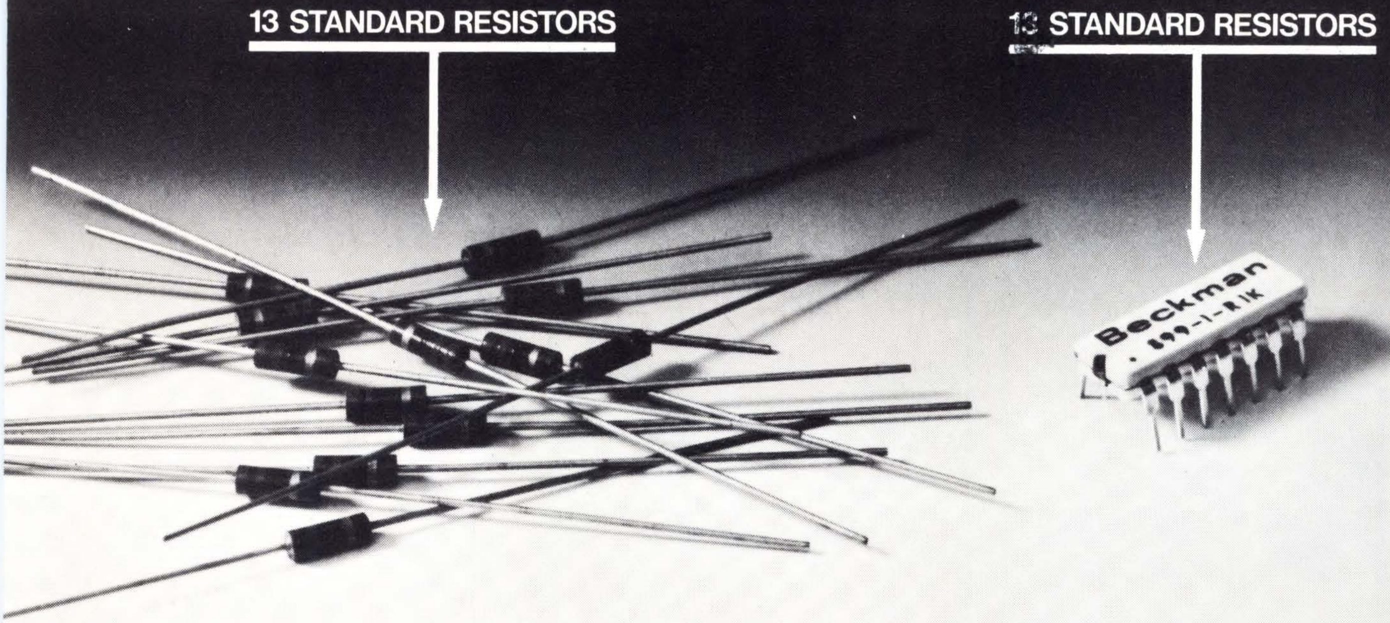
Instrumentation and converters are the subjects of a general catalog that provides photos and descriptions of 28 different products. Included are A/D and D/A converters, special-purpose converters, test instrumentation and process control instrumentation. Don Alt & Associates, Inc., 99 Hicksville Station Plaza, Hicksville, NY 11801. **279**

Inertial reference systems used for conducting dynamic vehicle performance tests are illustrated in a four-page brochure. Performance charts, specifications and application information are provided for these compact, self-contained units. Humphrey, Inc., 2805 Canon St., San Diego, CA 92106. **280**

Modular dc power supplies with outputs ranging from 3.7 to 150V are described in a 16-page catalog along with information on racks, panels, meter combinations, overvoltage crowbar and other optional accessories. North Electric Co., Portland Way North, Galion, OH 44833. **281**

Dial Pulse generators are described in Bulletin 4006 which gives details of two models. The manual dial pulse version has a selector knob for determining the number of pulses generated. The remote programmable version is designed for external pulse programming. G-V Controls, Div. of Sola Basic Industries, 101 Okner Parkway, Livingston, N J 07039. **282**

Free sample. Magnetic shielding is the subject of a catalog that gives detailed drawings of various shields and describes shield test chambers and wrap-around and foil shielding. A test sample of Hipernom wraparound shielding is included. Amuneal Manufacturing Corp., 2900 E. Tioga St., Philadelphia, PA 19134. **283**



Helipot's one-piece money saver saves time and space, too.

To keep working with discrete standard resistors just isn't logical. Not when there are ceramic DIPs available that do the same jobs in less space—quicker, easier and cheaper. Whether inserted automatically or by hand.

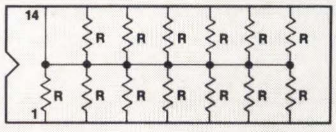
Stocked locally for immediate delivery, too. At "on the board" cost-saving prices, in small or large quantities.

(Check the specs.) No wasted time while they're "made to order," unless you want custom modifications, which we can do fast.

And remember, ceramic. Ceramic reliability at plastic prices.

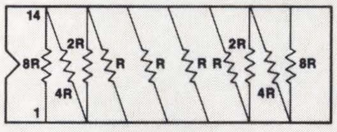
Why wait? Call your local Helipot Representative now for applications assistance or more information.

Beckman®
INSTRUMENTS, INC.
HELIPOT DIVISION
Fullerton, California



MODEL SERIES 899-1
Resistance Values (ohms): 100, 150, 220, 330, 470, 680, 1K, 1.5K, 2K, 2.2K, 3.3K, 4.7K, 6K, 6.8K, 10K, 15K, 22K.
Common Applications: Digital pulse squaring; MOS/ROM pull-up/ pull-down; "wired OR" pull-up; power driver pull-up; open collector pull-up; TTL input pull-down; TTL unused gate pull-up; high-speed parallel pull-up.
Standard Tolerance: ± 2.0%

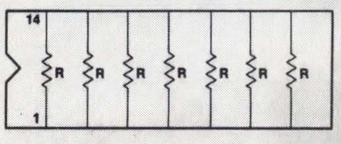
Pricing:		
	1-99	$1.45
	100-499	1.12
	500-999	0.97



MODEL SERIES 899-2
Resistance Value (ohms): 10K
Common Applications: Inverting operational gain; potentiometric gain; differential gain; noninverting gain; gain adjustment.
Standard Tolerance: ± 2%

Pricing:		
	1-99	$2.75
	100-499	2.15
	500-999	1.86

CIRCLE NO. 101



MODEL SERIES 899-3
Resistance Values (ohms): 68, 100, 110, 150, 220, 330, 470, 680, 1K, 1.5K 2.2K, 3.3K, 4.7K, 6.8K, 10K, 15K, 22K.
Common Applications: Line termination; long-line impedance balancing; power gate pull-up; ECL output pull-down resistors; LED current limiting; power driver pull-up; "wired OR" pull-up; TTL input pull-down.
Standard Tolerance: ± 2%

Pricing:		
	1-99	$1.25
	100-499	0.99
	500-999	0.86

Literature

Incremental shaft-angle encoders designed for English/Metric measuring systems are featured in Bulletin 818. The unit may be considered as two dual-channel encoders in one page. One English/Metric system gives 100 and 254 pulses/revolution, the other 500 and 1270. Trump-Ross Industrial Controls, Inc., 265 Boston Rd., North Billerica, MA 01862. **252**

Dual trimming potentiometer, Type FD, with ½-inch diam for trimmer, rheostat, potentiometer or attenuator applications is described in four-page Bulletin 5231. Charts, tables, dimensional drawings and part-number explanations are included. Allen-Bradley Co., 1201 S. Second St., Milwaukee, WI 53204. **253**

IC circuit handler, Model IC-2500A, is described in a brochure that explains the operation and capabilities of the unit, which is designed for automatic feeding, contacting and sorting of dual-in-line packaged devices. Integrated Mechanical Systems, Inc., 8424 Sunset Rd., N.E., Minneapolis, MN 55432. **254**

Controls catalog contains over 400 electronic and electromechanical controls including thermostats, air-flow sensors and controls, voltage and frequency sensors, flashers and time delays. Line drawings, specifications, photographs and descriptions are included. G-V Controls, Div. of Sola Basic Industries, 101 Okner Parkway, Livingston, NJ 07039. **255**

A/D converters are described in Bulletin 51 which covers thirty models in a low-cost high-accuracy line ranging from two-digit BCD to 12-bit binary. Accuracy is ±½ LSB and input voltage ranges of 0.1, 1, and 10V are offered. Gralex Industries Div., General Microwave Corp., 155 Marine St., Farmingdale, NY 11735. **256**

"The Twenty Eight Most-Asked Questions About Doctor 32. And the Answers." is an eight-page brochure that gives information on a computer-controlled digital test system that performs functional, parametric and dynamic testing in real time at speeds up to eight MHz. Adar Associates, Inc., 85 Bolton St., Cambridge, MA 02140. **257**

Ferrite components catalog covers a complete line of ferrite isolators and circulators. A coaxial section describes octave-band devices and 10%, 20% and common-band units. A waveguide section covers three-port circulators and miniature isolators for C-, X-, Ku-, and K-band. Micromega Div., Bunker Ramo Corp., 12575 Beatrice St., Los Angeles, CA 90066. **258**

Relay sockets and barrier terminal strips are featured in an eight-page catalog that gives ratings, application guides, dimensions and ordering information for the "Snaptrack" line of sockets and captive-wire style barrier terminal strips. Reed Devices, Inc., 21W183 Hill Ave., Glen Ellyn, IL 60137. **259**

"How to Buy a Minicomputer" is a 32-page pamphlet that answers the 17 most commonly-asked questions about what to look for in minicomputers. It discusses such topics as architecture, the importance of new memory techniques, types of instruction sets and software, and peripheral equipment. Data General Corp., Southboro, MA 01772. **260**

"Electronic Instrumentation Digest" is an 18-page catalog that provides information on the company's line of test instrumentation. Included are: digital printers; frequency meters; IC testers; function generators; pulse generators; digital clocks; digital comparators and others. Prices are included. Beckman Instruments, Inc., 3900 N. River Rd., Schiller Park, IL 60176. **261**

Hermetically sealed connectors are featured in three four-page catalogs that describe over 120 standard models. The catalogs provide complete specifications, insert configurations, shell designs, dimensions and information on special versions. Gulton Industries, Inc., 822 Production Pl., Newport Beach, CA 92660. **262**

Plastic platform headers used in the manufacture of transistors, LEDs, incandescent lamps, photocells, capacitors and miniature switches are described in Product Data Sheet 6300-a. Included in the six-page bulletin are typical applications of standard, removable and nonremovable plastic headers and bipin bases. General Electric Co., Lamp Parts & Equipment Sales Operation, 21800 Tungsten Rd., Cleveland, OH 44117 **263**

here it is
the 1st annual EDN/EEE creative design contest

How to enter

Any reader of EDN/EEE may enter this contest. All you need do is study The January 1, 1972 issue of EDN/EEE very carefully...then set your imagination at work on designing a new device or circuit using the products advertised. Send schematics, drawings, diagrams, etc. to:

EDN/EEE
Design Contest
221 Columbus Avenue
Boston, Mass. 02116

Your entry must be sent by March 1st, 1972.

How your entry will be judged

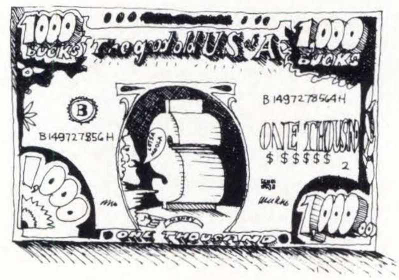
All entries will be judged by the Publisher and editors of EDN/EEE on the basis of 3 criteria:

1. Technical competence and utility
Is the design real . . . will it work?

2. Creative imagination
How unique and original is your idea? Does it perform a much needed function? Is it a source of fun! Will other designers get a real charge out of it?

3. Number of different advertised products used
Have you really studied the January 1st, 1972 issue of EDN/EEE. Have you imaginatively used components throughout the design? The more advertised products your design uses, the greater is your chance of winning.

Here are the prizes



1st prize:
$1,000 cash money

10 2nd prizes:
Portable electronic calculators worth $400 each.

Contest details

Any reader of EDN/EEE may enter. Contest is not open to employees of Cahners Publishing Co. or their families. All entries become the property of EDN/EEE. YOUR ENTRY MUST BE POSTMARKED NO LATER THAN MIDNIGHT, MARCH 1, 1972. Results will be announced and winning entries described in a later issue of EDN/EEE.

EDN/EEE

Cahners Publishing Company, Inc.
221 Columbus Avenue, Boston, Mass. 02116

here's your entry blank

Fill it in, attach it to your schematics or diagrams, and mail to:
EDN/EEE Contest, 221 Columbus Avenue, Boston, Mass. 02116

name ______________________ company ______________________

address ______________________ address ______________________

city __________ state __________ zip ______ city __________ state __________ zip ______

tel. no. ______________________ title ______________________

name and function of your entry ______________________

Parts used in your design

Products Advertised in this issue
(page number only, unless multiple products are advertised on same page)

Other Products
(product, manufacturer, and where appropriate, model number)

'Super-stable' circuit super-simplified

Gentlemen:

Mr. Accardi's "Super-Stable Reference-Voltage Source" (Circuit Design #151, EDN/EEE, 10/1/71, p. 41) can be super-simplified to the circuits of **Figs. 1a** and **1b**. The six auxilliary components he used for starting (CR3, CR2, Q1, R4, R5 and R6) can be reduced to two (dual polarity) or to zero (unipolar operation). For the basic zener bridge op amp circuit to turn on properly, it is necessary only to prevent output voltage reversal (CR4-**Fig. 1a**) and then to supply a small bridge unbalance voltage in the proper direction (R6). A few millivolts will do. Using the 741 as in **Fig. 1b**, the output can neither reverse nor slew to ground, so that the circuit is inherently proper-side self starting. For higher currents, break X-Y and add Q2. A large capacitor can be added across CR1 for noise reduction.

Although Mr. Accardi did not indicate why he selected $V_1 = V_z/10$, this

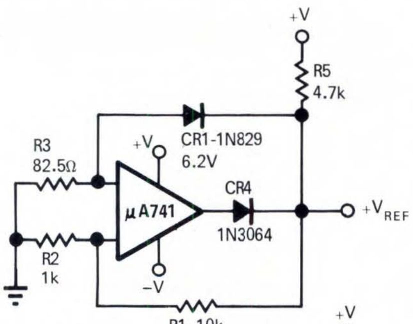


Fig. 1a

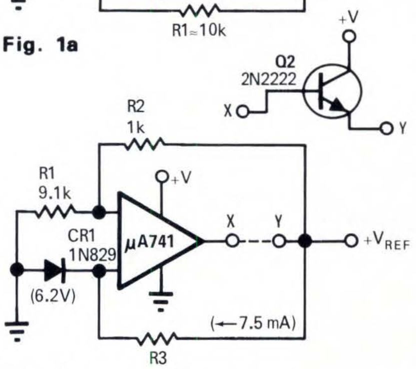


Fig. 1b

value turns out to be remarkably close to optimum. Analysis yields a unique value for $R_3 = \sqrt{R_{AC}R_{DC}}$, which maximizes the feedback gain-product AB. Here, $R_{AC} = R_z$, and $R_{DC} = V_z/I_z$. A and B are the op amp and zener bridge gain (loss) factors. To prove this for **Fig. 1b**, let: $K_1 = R_1/(R_1 + R_2) = V_z/V_o$, $R_3 = nR_z$, $K_2 = R_z/(R_3 + R_z) = 1/(n + 1)$, where V_z, R_z = zener voltage and ac impedance at I_z. At balance, $V_o = V_z + nI_zR_z$, and $B = (K_1 - K_2)$. Substituting for K_1, K_2 and V_o and solving for B; $B = (a - 1)n/[n^2 + n(1 + a) + a]$, $a = V_z/I_zR_z$. Letting $dB/dn = 0$, solving for n and substituting back results in:

$R_3 = R_z \cdot \sqrt{V_z/R_zI_z} = \sqrt{V_zR_z/I_z} = \sqrt{R_{AC}R_{DC}}$.

Thus R_3 should be the geometric mean of the ac and dc impedances of the zener, a remarkably unexpected result. For the published circuit, I_z = 7.5 mA and $R_z = 10\Omega$, so that $R_3 = \sqrt{(6.2)/(10)(0.0075)} = 91.5\Omega$. This compares favorably with Mr. Accardi's 82.5Ω. K_1 is adjusted for I_z = 7.5 mA. The calculated value of R_3 also minimizes output Z_o.

Yours truly,
Allan G. Lloyd
Holobeam Inc.

"All we can figure is that they broke in and programmed the computer to transfer all our assets to a numbered account in Switzerland."

Additional sabotage suggested

Gentlemen:

I enjoyed E.U. Thomas's "Switching Sabotage" article in Nov. 1 EDN/EEE.

Here's another cutie I learned about (the hard way) a number of years ago.

Reversing Connections to Load

Non-simultaneous operation of poles in **Fig. 1** ("make" on top pole before

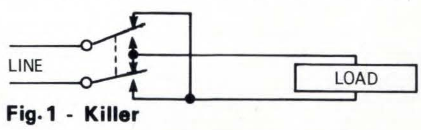
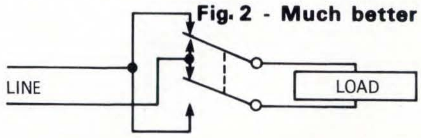


Fig. 1 - Killer

Fig. 2 - Much better



"break" on bottom pole) makes a dead short across the line, through the relay.

Non-simultaneous operation of poles in **Fig. 2** merely opens the load temporarily.

Yours truly,
R. W. Frank

Better definitions offered

Dear Sir:

In your Progress in Products article on universal asynchronous receiver-transmitters in your November 1 issue, p. 53, we find technical deficiencies that should be brought to the attention of your readers. The most serious of these are the definitions of baud and asynchronous transmission.

Baud should be defined as the reciprocal of the shortest signal element, usually one data-bit interval. The variable stop length in asynchronous transmission is what makes the baud rate differ from the bit rate. In synchronous transmission each element is one bit length so that baud rate equals bit rate. Specific examples and further definitions are explained in the Application Note on our TR1402A programmable asynchronous receiver/transmitter. (For a free copy of this App. Note, Circle No. 313)

Two other key specifications, namely gross distortion error and minimum character interval, are not mentioned in the article and should be. Their definitions are also explained in our Application Note.

A. B. Dall
Vice President, Marketing
Western Digital Corp.
Newport Beach, Calif. 92663

SALES OFFICES

E. Patrick Wiesner
Publisher
221 Columbus Ave.
Boston, Mass. 02116
(617) 536-7780

Hugh R. Roome
National Sales Director
205 E. 42nd St.
New York City, New York 10017
(212) 689-3250

NEW YORK CITY 10017
Gerry Hoberman, District Manager
Richard Millar, District Manager
205 E. 42nd St.
(212) 689-3250

BOSTON 02110
Richard Parker, District Manager
Hal Short, District Manager
89 Franklin St.
(617) 482-6786.

PHILADELPHIA 19103
Steve Farkas, District Manager
Penn Towers
1819 John F. Kennedy Blvd.
(215) 569-2424

CHICAGO
John Huff, Regional Manager
Terry McDermott, District Manager
15 Spinning Wheel Rd.
Hinsdale, Illinois 60521
(312) 654-2390

DENVER 80206
John Huff, Regional Manager
270 St. Paul St.
(303) 388-4511

SAN FRANCISCO 94103
William J. Healey, District Manager
1111 Hearst Building
(415) 362-8547

LOS ANGELES 90036
Ed Schrader, Regional Manager
Harry Fisher, District Manager
5670 Wilshire Blvd.
(213) 933-9525

ADVERTISER'S INDEX

Index to Ads, Products and Literature

Application Notes

COS/MOS decade counters are the subject of Application Note ICAN-6733, "Battery-Powered Digital-Display Clock/Timer and Metering Applications Utilizing The RCA CD4026A and CD4033A Decade Counters – 7-Segment Output Types." Containing 16 pages and with 66 illustrations, the note describes interfacing with various 7-segment display units commercially available. RCA Commercial Engineering, Harrison, N J 07029. **273**

IF/FM amplifier detector IC that eliminates the three-coil detector transformer is the subject of application bulletin LM361. Included in its six pages are sections on FM detection, the LM 361 circuit diagram, operating characteristics and applications. Numerous schematics and waveform drawings illustrate each section. European Electronic Products Corp., 10180 W. Jefferson Blvd., Culver City, CA 90230. **275**

"MECL System Design Handbook" is a 211-page book that presents current and complete information for the easy design of high-speed digital systems using Motorola MECL logic. Emphasizing design with high performance MECL, it has nearly 200 illustrations to complement the text. Price is $2.00 each and copies may be obtained by sending check or money order payable to Motorola Inc., Box 20912, Phoenix, AZ 85036. **277**

Ten-Resistor DIP network, consisting of two identical groupings of five thick-film resistors, each having values of R, R, 2R, and 4R and 8R is featured in a four-page catalog sheet. Model 899-2 has each resistor group precisely matched for resistance ratio and temperature tracking. Complete specifications, photographs and application information are provided. Helipot Div., Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, CA 92634. **274**

Corrosion control in electronic equipment is the subject of a ten-page report that deals primarily with corrosion problems in computer systems. The booklet reports removal efficiencies of a dry-pellet oxidant for acid-gas fumes. Methods for determining contamination level and system life are provided, along with design data and performance characteristics of the Purafil system. H. E. Burroughs & Associates, Box 80434, Chamblee, GA 30341. **276**

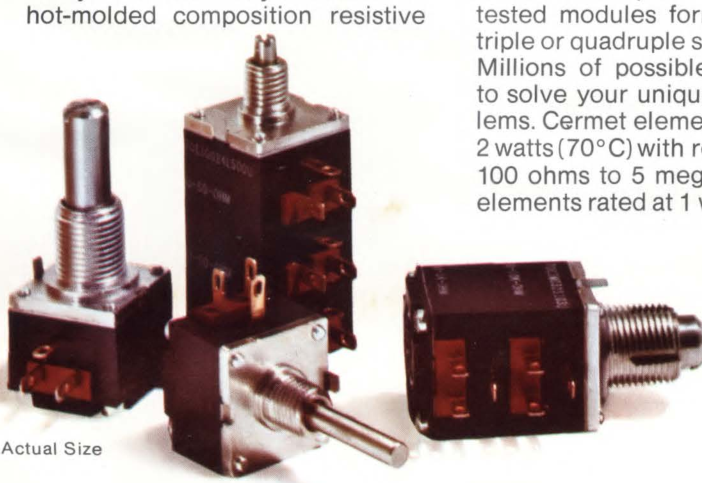
Standard time and frequency broadcasting format from NBS radio stations WWV and WWVH is the subject of a six-page brochure. The information reflects changes made in the format as of July 1, 1971. Included is information on circuit card accessories to adapt existing Specific Products' receivers to the new services carried by the stations. Specific Products, Div. of The Dr. Henry L. Richter Corp., 1237 S. Shamrock, Monrovia, CA 91016. **312**

Reference copies **of the following articles are available without charge:**

R.S. NO.	TITLE	PAGE NO.
L61	Make true rms measurements with your own modules	34
L62	Incandescent lamps mate well with silicon photosensors	44
L63	Speakout	50
L64	Don't let LED output measurements throw you	54
L65	Have a 50V swing on a 30V supply	59

MOD POT™ versatility is unmatched. Hundreds of standard modules give you millions of options.

MOD POT is the most versatile ⅝″ square potentiometer available today. A whole family of cermet or hot-molded composition resistive modules, switch options and vernier drives with single or concentric shafts. These pre-engineered, pre-tested modules form single, dual, triple or quadruple section controls. Millions of possible combinations to solve your unique control problems. Cermet elements are rated at 2 watts (70°C) with resistances from 100 ohms to 5 megs. Composition elements rated at 1 watt (70°C) with resistances from 50 ohms to 10 megohms, five standard tapers. And if you need something truly special we're equipped to handle that too. Call your appointed A-B distributor for details, or write: Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, WI 53204. Export: Bloomfield, N. J. 07003. Canada: Galt, Ontario. United Kingdom: Bletchley, Bucks.



Actual Size

NEW DIMENSION ELECTRONICS
ALLEN-BRADLEY

CIRCLE NO. 110