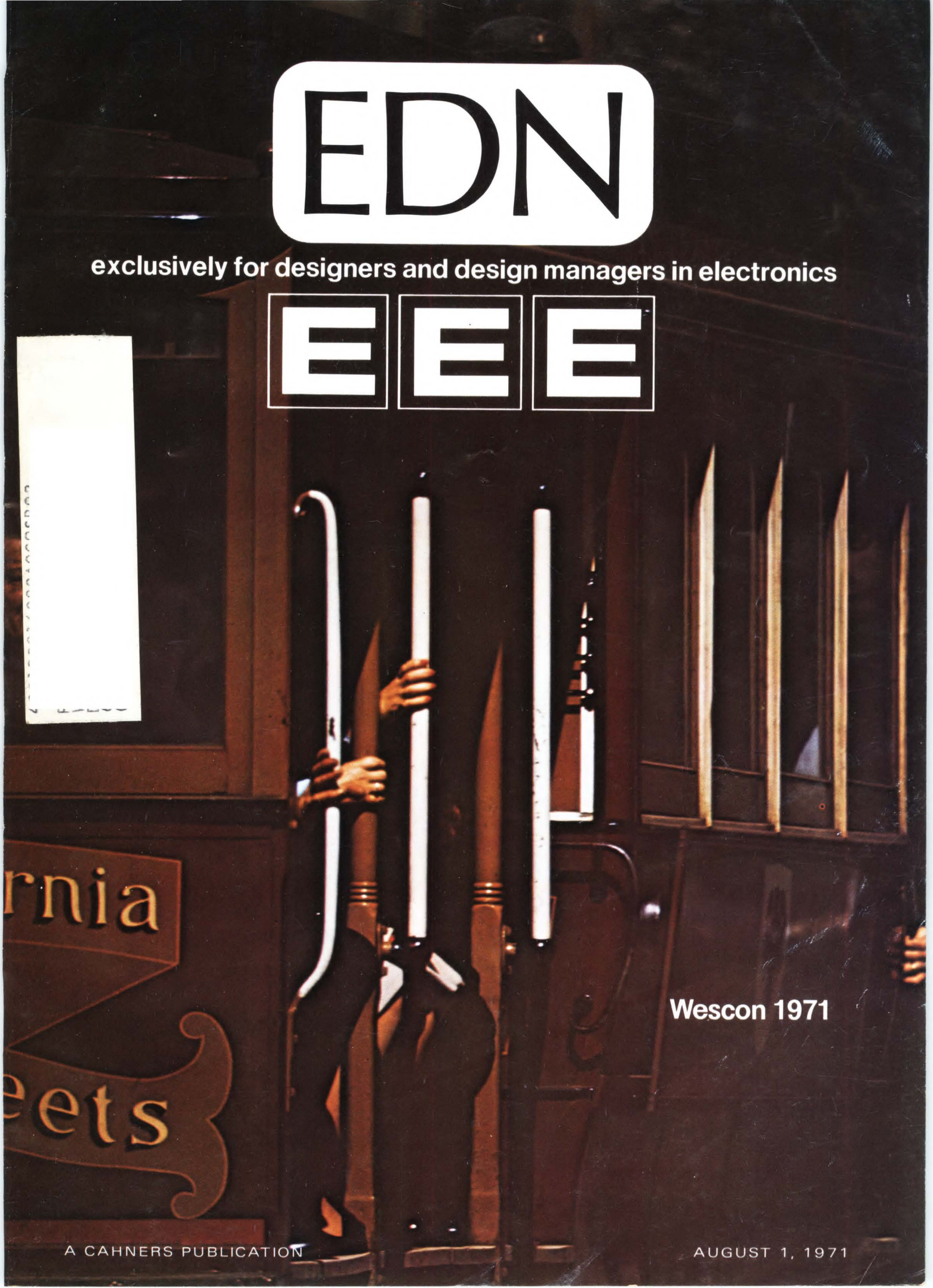
EDN

exclusively for designers and design managers in electronics

EEE



Wescon 1971

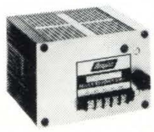
A CAHNERS PUBLICATION

AUGUST 1, 1971

Introducing the best DC power supply catalog in the world.

Forty-two informative pages. Specifications. Drawings. Photos. Prices. Three-day shipping guarantee. Organized for quick selection of the best model for your application. Included are:

Mini-modules with regulated single or dual outputs. Save space and improve reliability by mounting them directly on printed circuit boards. $30 up.



Standard modules with ratings to 32 amps. Choose from single and dual output regulated models and single output unregulated. $60 up.

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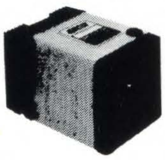

Plug-ins with single or dual outputs, for commercial or MIL-Spec. use, regulated or unregulated, high isolation, fixed or adjustable. $45 up.

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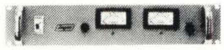
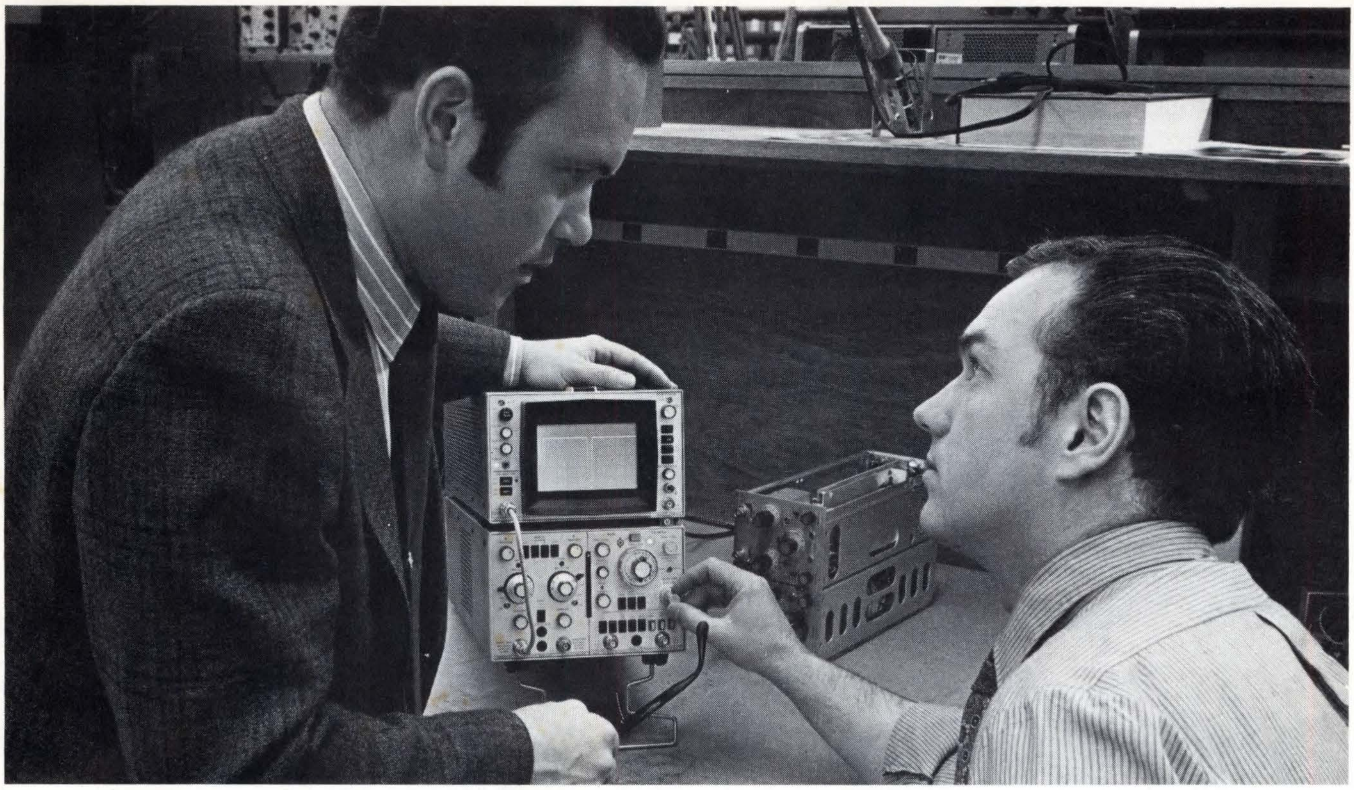


For your copy of the world's best power module catalog, write or call Acopian Corp., Easton, Pa. 18042. Phone: (215) 258-5441. The power modules you order from it will be shipped with (you'll happily agree) the world's best tag . . .

CIRCLE NO. 1



HP's 250 MHz 183: Still The Performance Champ! Ask For A Demo.

If you want to look at waveforms in high-speed logic circuits, or to photograph ultra-fast transients—there's still only one general purpose, lab oscilloscope that gives you a real-time window from DC to VHF. It is HP's 183, the 250 MHz 10 mV/div scope (to 600 MHz with direct access plug-in)—**now available for demos on your bench.**

HP pioneered in the development of the first useful, usable high-frequency scope to give you these features: 10 mV sensitivity, 1.5 ns rise time, 4 cm/ns writing speed, negligible distortion from input capacitance. **Balancing price and performance the 183A system is a bargain**—with delayed sweep, $3900; without delayed sweep, $3400 (available in either cabinet or 5¼″ rack-height versions).

HP's technical leadership, covering a wide area of disciplines, made it all possible. An in-house IC capability produced monolithic transistor arrays for the vertical amplifier—key factor in achieving good transient response with 250 MHz bandwidth and high-fidelity reproduction of waveforms.

HP's step-ahead CRT technology produced a unique CRT to display fast signals. The CRT uses two transmission lines for the vertical deflection system, to provide distributed deflection of the electron beam and to give the CRT **a cutoff frequency well beyond present IC technology.**

Since the 183A mainframe is not limited by hard-wired, internal amplifiers, you have freedom to take advantage of any existing HP 180 Series plug-ins, plus any HP high frequency innovations, as they become available—and higher bandwidth amplifiers are now in HP development labs.

Meanwhile, the HP 183 250 MHz Scope is a deliverable system, **capable of making your measurements, now.** And it's backed by almost two years of successful, in-the-field performance on customer workbenches.

The same step-ahead thinking exemplified in the HP 250 MHz scope also exists in all HP scopes. To find out all about the most exciting new developments in the rapidly changing world of oscilloscopes, ask your HP field engineer to show you the whole HP 180 scope family, including sampling and storage. Or write, Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

CIRCLE NO. 2

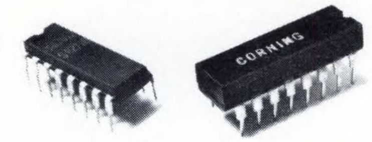
Scopes are changing.
Are you?

081/13A

HEWLETT hp PACKARD

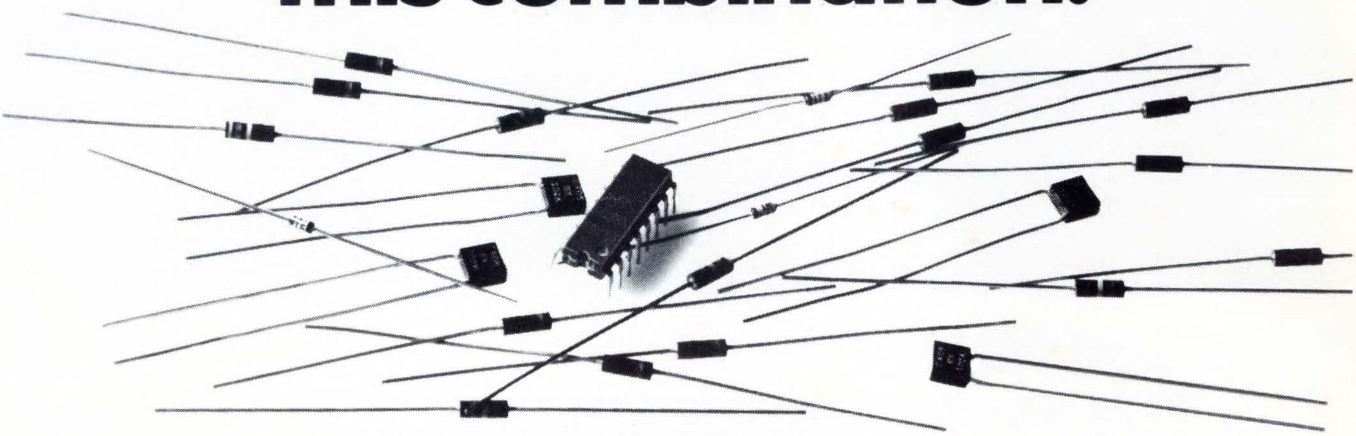
This Combination

Integrated circuit



CORDIP™ Component Network

replaces this combination.



Integrated circuit plus 23 discrete resistors, capacitors, and diodes

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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.

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SPECIFICATIONS

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

CORDIP™ COMPONENT NETWORKS
From

CORNING
ELECTRONICS

CIRCLE NO. 3

AUGUST 1, 1971
VOLUME 16, NUMBER 15

EDN/EEE

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Cover

Art Director, Ray Lewis, couldn't resist photographer Ron McCallister's interpretation of San Francisco. The cover is from a roll of pictures taken for EDN's well-received WESCON '69 cover. WESCON '71 coverage starts on p. 10.

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DESIGN ELECTRONICS
ELECTRONICS WEEKLY
EDN/EEE
ELEKTRONIK
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INTER ELECTRONIQUE

We make components for guys who can't stand failures.

By the time they find the problem, the entire factory will be buried in ping pong balls. And there'll be a few thousand more applicants for advanced membership in the can't-stand-electronic-failures club.

If only we had been there in time. You see, we make resistors and capacitors for guys who can't stand failures. Guys like your most important customers, guys like you.

We build an extra measure of reliability into all our components to help you build extra reliability into all your systems—to head off problems like this.

To be specific, we make tin oxide resistors—now including both miniature RLR05's and flame proofs—and glass and Glass-K™ capacitors. They're the best you can get, though they'll cost you no more.

Take our tin oxide resistors—no other resistors can deliver the same stability and reliability over life. They offer guaranteed moisture resistance across all ohmic values, for reliability that can't be matched by metal film, wirewounds, carbon comps or metal glaze resistors.

This kind of extra performance comes in miniature size, too. Our new RLR05 (commercial style C3), developed for dense packaging applications, competes costwise with carbon comps.

And we lead the field with flame proof resistors. Ours will withstand overloads in excess of 100 times rated power without any trace of flame. And because they open rather than short under severe overload, they provide protection for the rest of the system—a vital consideration in critical and expensive EDP, telecommunications, and instrumentation gear.

Or take our glass capacitors. The Air Force has confirmed they have much better stability and much higher insulation resistance than the ceramic, mica, and other capacitor types tested. That's why our glass capacitors have been designed into so many major aerospace and missile projects. And why industry has designed them into the most important EDP and instrument applications.

Or our Glass-K™ capacitors—we developed them to give you the volumetric efficiency and economy of monolithic ceramic capacitors, but with the much improved stability and reliability that only a glass dielectric can add. Our Glass-K™ capacitors are now being used in pacemaker heart units and in several major EDP systems. And these Glass-K™ capacitors can now be used in BX characteristic applications.

As you might expect, both our resistors and capacitors meet Established and High Reliability standards, such as MIL-R-39017, MIL-R-55182, and Minuteman.

At Corning we make components for guys who can't stand failures. Guys like your most important customers. Guys like you.

And even though you might expect to pay a lot more for these features, you don't. Because as the largest manufacturer of these type components, our production volume affords us economies that enable us to be competitive in price.

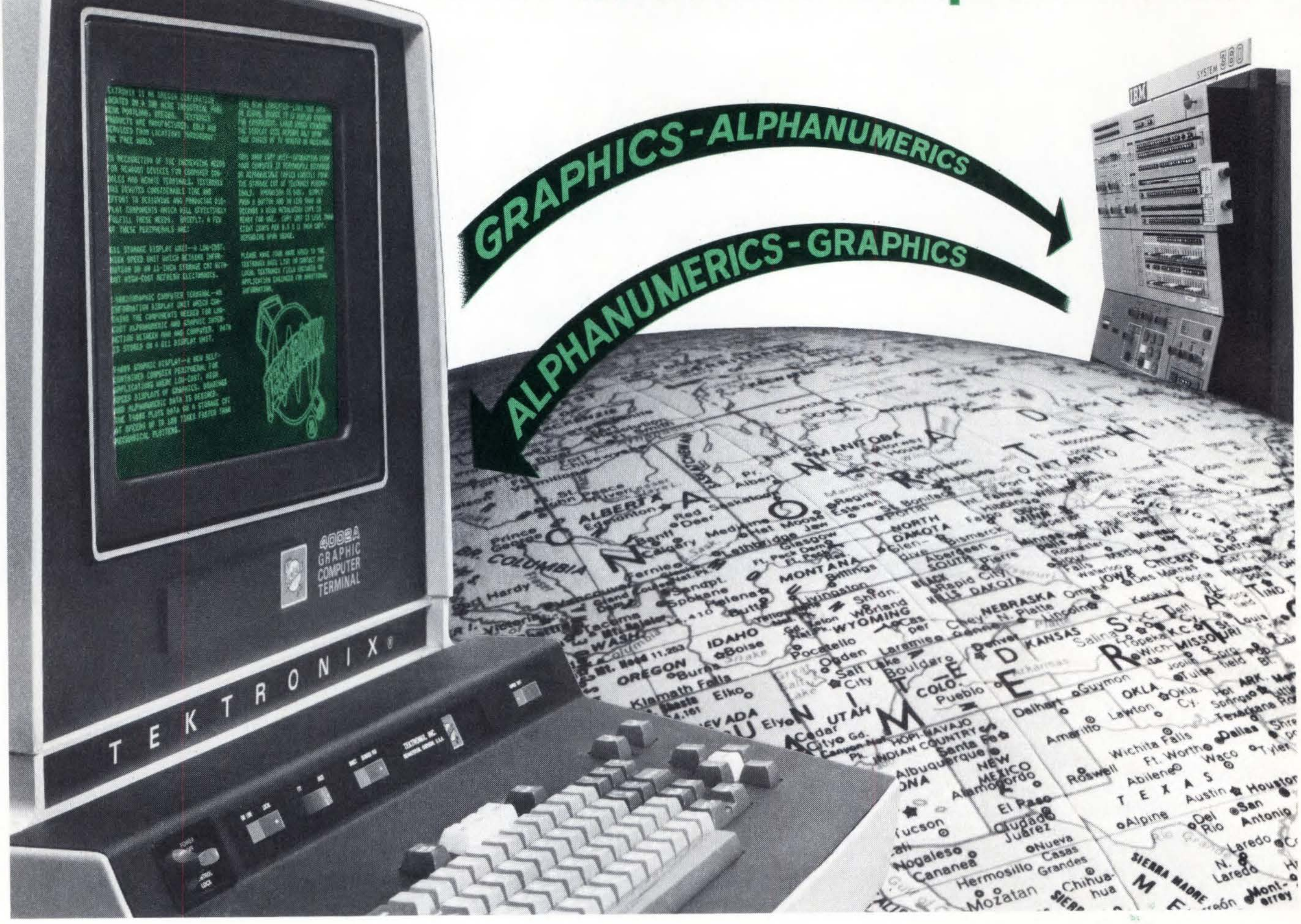
So the next time you're designing a system, design-in an extra measure of performance. Reach for your CORNING® resistor and capacitor catalogs or look us up in EEM. Or for in-depth technical information write us at: Corning Glass Works, Electronic Products Division, Corning, New York 14830.

Then call your local CORNING authorized distributor for fast off-the-shelf delivery. He not only stocks components for guys who are demanding, but he offers service to match, too.

CORNING
ELECTRONICS

CIRCLE NO. 4

NEW Interactive Computer Terminal



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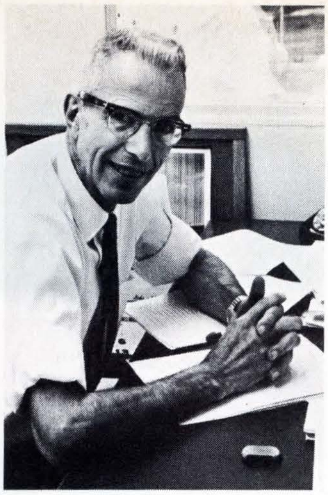
CIRCLE NO. 5



Editorial

Were They the "Good Old Days"?

A recent excursion trip on one of the endangered species known as a steam train brought back many memories for the participants. We shared a nostalgic look backward in time—a look complete with its fondly remembered sounds and smells. We also shared almost-forgotten memories of the misery a cinder in the eye can cause, and the exquisite torture of inhaling soft coal smoke when inside the unrelieved blackness of a rock tunnel.

Just such a fond "good old days" atmosphere has sometimes pervaded the thinking of electronic engineers. We tend to rhapsodize over such remembered things as the "well built" test equipment of yesteryear, or the thrills of hearing shortwave broadcasts from around the world. Like the railroad buffs, we have stars in our eyes. We forget that today's dirt-cheap ICs were not even imagined in those days of glass-envelope vacuum tubes. We also forget such truths of those times as the fact that a signal generator with flat output across its tuning range was known only in well-heeled laboratories. Back then, the circuits needed to flatten its output were both complex and very expensive. Even plain ordinary circuit gain could only be had by a liberal expenditure of dollars, components and power consumption.

By contrast with those fondly remembered times, gain is cheap today. It requires little power, almost no real estate, and the cost is nominal. Even computational capability costs little to add to instrumentation—so little that it can be applied in a multitude of ways to improve electronic gear. Devices can be made more automatic, more stable, more versatile; in fact, more in almost any desired direction.

We are just beginning to realize what we've got a hold on. The "good old days" of electronics don't stand a candle to what's ahead. I'm sure that in a few years even the miracles of today will take their place as the "way it was".

Earle Dilatush

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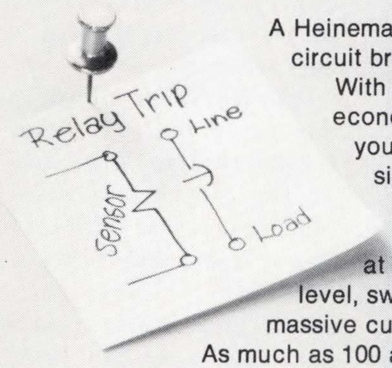
Low-cost limit control for OEM's.

With a circuit breaker.

With a circuit breaker?



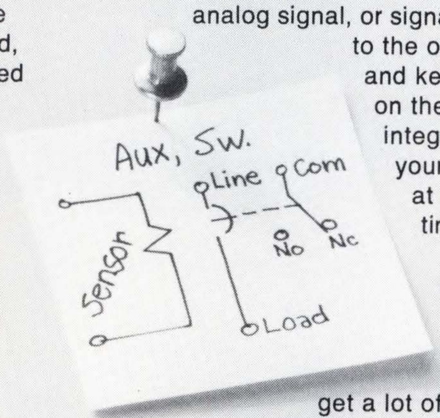
A Heinemann relay-trip circuit breaker.

With this one economical device, you can take a signal from any low-voltage sensor and, at a preselected level, switch off a massive current load. As much as 100 amp, to be precise.

There is no end to the uses you can find for this simple little control device. It will work with pressure sensors, voltmeters, ammeters, tachometers, pH sensors, what have you.

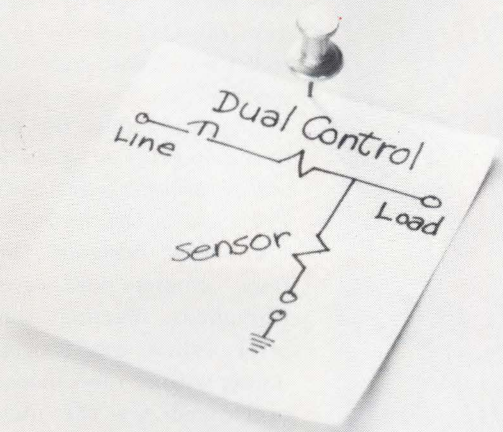
For alarm or other purposes, we can include auxiliary switch contacts right inside the breaker. When the circuit changes state, you can turn on a light, ring a bell, or start another operation.

If you want the security of precision fault protection, as well as the relay-trip action, get our Dual-Control breaker (JA or AM Series). It monitors the critical analog signal, or signals, basic to the operation, and keeps tabs on the electrical integrity of your equipment at the same time.



Whichever design you choose, you can get a lot of functional value for the price of a circuit breaker.

Like to find out more? Send for our Engineering Guide, and we'll include a copy of Bulletin 3352 on Dual-Control breakers. Free, of course. Heinemann Electric Company, 2626 Brunswick Pike, Trenton, N.J. 08602. Or Heinemann Electric (Europe) GmbH, 4 Düsseldorf, Jägerhofstrasse 29, Germany.



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CIRCLE NO. 7

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SAN FRANCISCO, CALIF.—Though it won't be as big as last year's electronic bazaar, WESCON '71 (Aug. 24-27) promises to be the most pleasant one ever staged—both for exhibitors and employees.

Past WESCONs always left something to be desired in terms of convenient location. When held in Los Angeles, attendees found themselves running back and forth between the Sports Arena and Hollywood Park. And past San Francisco stagings offered little improvement with the show held in the Cow Palace, miles from downtown San Francisco where most hotels and restaurants are located. Until about 3 months ago, it looked like the Cow Palace again.

In an unprecedented action for a major convention, however, WESCON's directors announced, just 90 days before the show's opening, that this year's show would be moved from the Cow Palace to the Brooks Hall/Civic Auditorium locale, at the heart of San Francisco's civic center.

Unquestionably, the Brooks Hall/Civic Auditorium site offers numerous advantages over the Cow Palace. For starters, the newly selected location was designed for conventions, complete with air-conditioning throughout. Further, there's multilevel parking next door and freeway access within a few blocks. Not to be overlooked are the numerous San Francisco hotels and restaurants within walking or quick cab-trip distance.

Compared to last year's attendance of 36,758, this year's extravaganza hopes to attract at least 30,000. Un-

(San Francisco Visitors Bureau)

doubtedly, WESCON's attendance attrition stems from the unemployment blight that continues to plague the electronics industry. Despite the expected lower attendance, WESCON '71 officials hope to have 600 exhibitors (300 companies), including contingents from Europe, Canada and Japan. Last year's show attracted 604.

Under the chairmanship of Stanford Research Institute's R. L. Leadabrand, the WESCON '71 program committee has planned thirty-two 2-1/2-hour sessions. Six major categories will be covered: Computer Equipment & Engineering Software (8 sessions); Components and Circuitry (7 sessions); Manufacturing (6 sessions); Management and Marketing (5 sessions); Communications (4 sessions); and Medical Electronics (2 sessions).

The 32 sessions were selected from a slate of 56 by WESCON's 10-man program committee. One of the selected sessions, "Computer Aided Manufacturing," was organized by EDN/EEE's Tom Rigoli.

In discussing his session, Editor Rigoli points out, "As electronic companies scramble to turn their technology into profit, computer-aided design (CAD) is being increasingly eclipsed by computer-aided manufacturing (CAM)."

Already, several companies have emerged to provide a CAD/CAM service. Typically, their service includes converting a logic diagram into an optimum circuit layout—and then developing a software package to control automated equipment such as a N/C "Wire-Wrap" machine. Aimed at bringing the CAM field into proper perspective, Rigoli's session will include:

—"How Not to Approach CAM" by C. E. Coffee, Consultant.

—"CAM Software: Inputs Required and Outputs Produced" by P. R. LaBahn, Standard Logic, Inc.

—"Economic Advantages of Integrating Standard DIP Hardware with Flexible Software" by D. Miller, Scanbe Mfg. Corp.

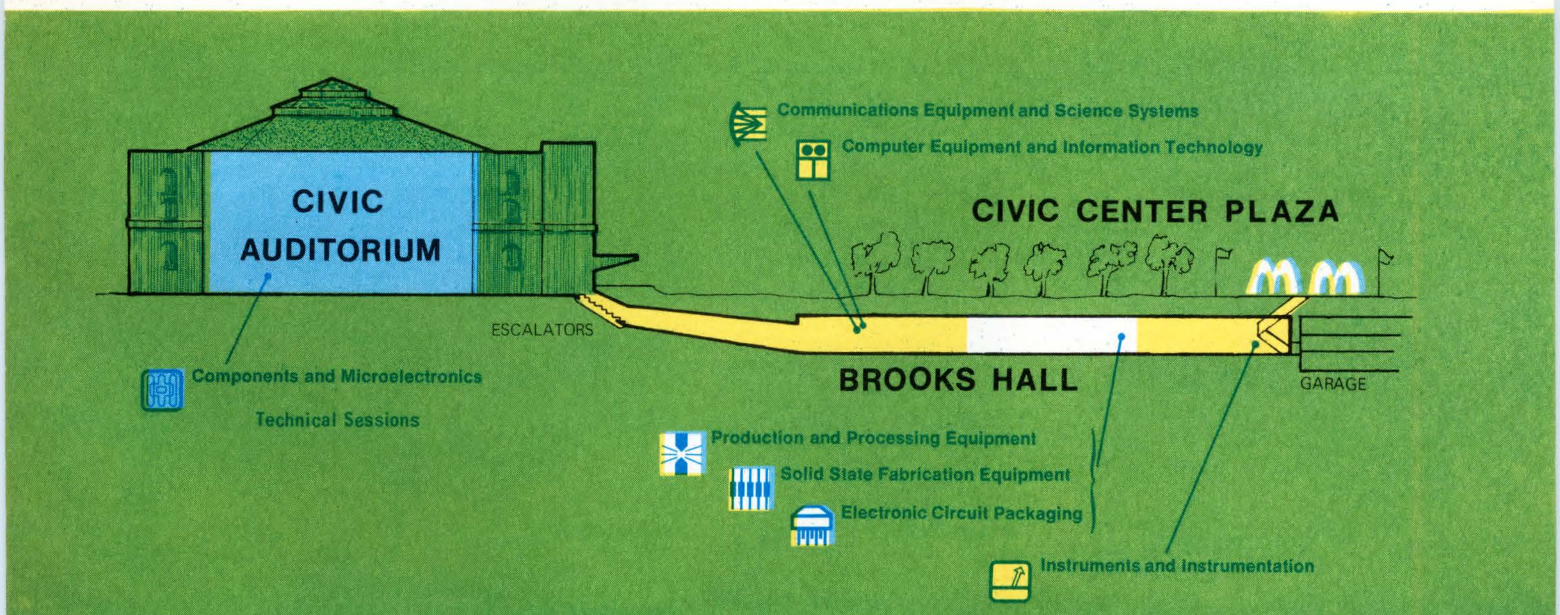
—"New Vistas for CAM" by W. C. Fordiani, EECO.

Another session is entitled "The Way It Was and the Way It's Going to Be: An Overview of the New Dynamics for Career Engineers". There will be a panel discussion on this topic, with the following members participating: Dr. James Mulligan, IEEE President; Dr. Hubert Heffner, Deputy Director of U.S. Science and Technology; Dr. R. C. Mercure, WEMA President; and Mr. Paul Robbins, Executive Secretary for NSPE.

There are several other technical sessions that are sure to tweak a designer's interest. Among those worth noting: Micropower Microelectronics; Ion Implantation for Microelectronics; Hybrid Manufacturing; CAD for High Frequency Circuits; Optoelectronics; Microwave Solid-State Devices; and Exploitation of Available Computer Programs in Electronic Circuit Design.

You may recall that last year EDN organized a session on programmable calculators. Dr. Rudy Panholzer, who gave one of the papers for last year's session, is the organizer of this year's session, "Tomorrow's Programmable Calculators."

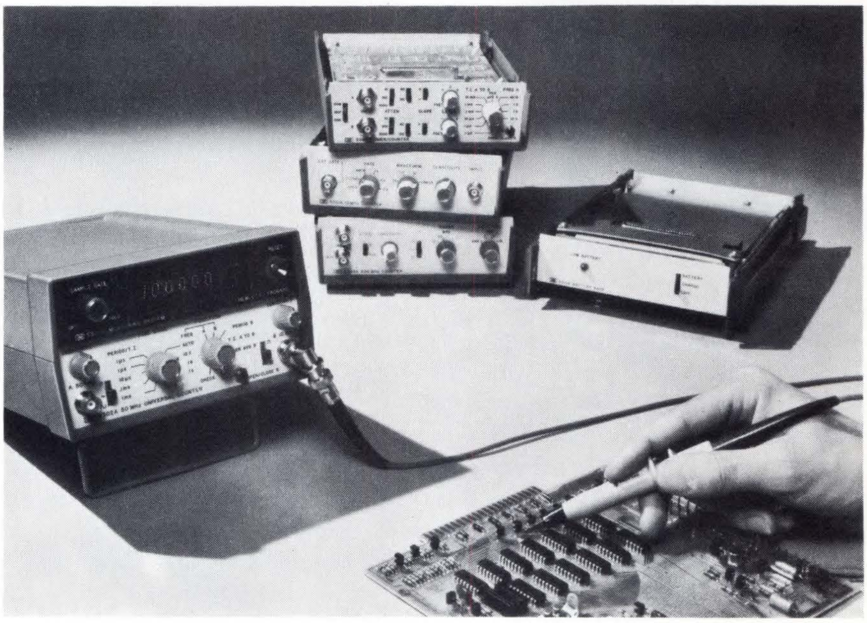
It's also interesting to note that Hal Tenney, President of Kinetic Technology, Inc., will be giving a paper titled "What It Took to Come Out of Chapter XI." Tenney's presentation, an appropriate sequel to an earlier EDN article ("KTI is Alive and Well and Operating Under Chapter 11", Dec. 1, 1970), is part of the session "Turnaround '71, Strategy for the '70s", organized by Frank Burge of Precision Monolithics, Inc.



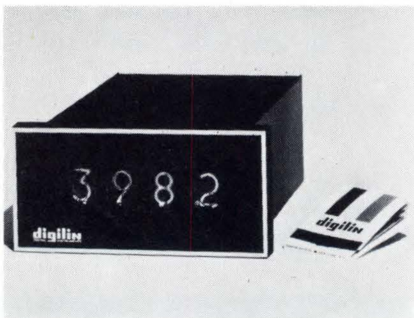
Three Instruments Offer Low-Cost Accuracy

A modular MOS/LSI counter, a general-purpose digital multimeter, Model 3469A with LED display, and a small 3-1/2-digit DVM, Model 3403A that reads volts and with an option decibels, will be displayed at WESCON by Hewlett-Packard. The cost of the counter's main frame is $400 with a choice of four functional snap-on modules, including a 500-MHz counter and a battery pack. The complete system is designated Model 5300A. The Model 3469A, selling for $595, performs average ac measurements from 1 mV to 500V (20 Hz to 10 MHz), resistance measurements of 1Ω to 10 MΩ and dc measurements of 100 mV to 1000V and 1 μA to 100 mA. Model 3403A measures dc and ac, and exhibits the results on a 3-digit LED display. Dimensions for this unit are 4.5 by 7.75 by 9.5 inches. Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304.

Booths 1015-17, 1114-17, 1139-41 and 1237-40. 160



Panel Meter Fills 3-1/2—4-1/2 Digit Interval



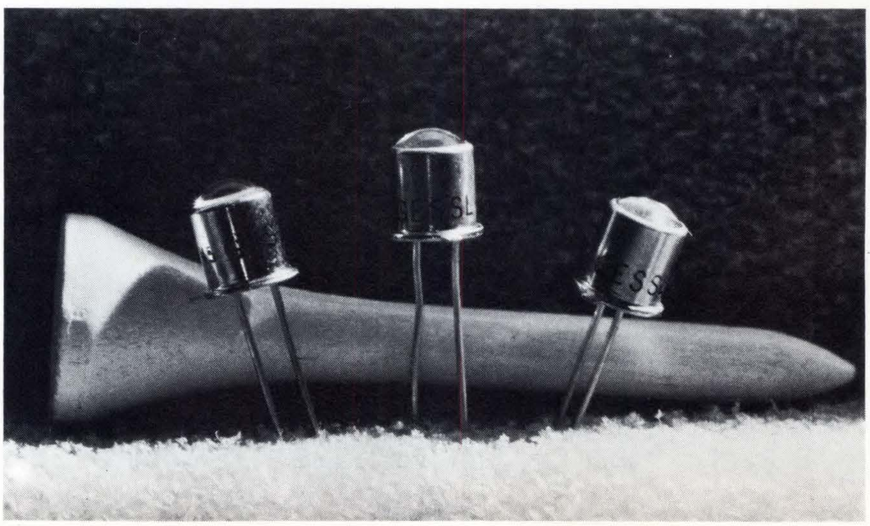
An extended range which provides a full-scale indication of 3999, is designed to fill the gap between 3-1/2- and 4-1/2-digit meters. The Type 2430 meter has an extruded aluminum housing 3.70 inches wide, 2.05 inches high and 5.75 inches long. Mounting and calibration adjustments are made from the front panel by removing the snap-out plastic window. Re-zeroing is done automatically after every measurement cycle. Full scale input is 2V dc, and accuracy is ±0.05% of indication ±1 digit. Full, 4-digit storage provides a steady non-blinking display. An out-of-range condition is indicated by a flashing display of four nines. Standard TTL-compatible 1-2-4-8 BCD output is provided for all digits. Both the display and BCD output may be held constant for an indefinite period by contact closure of the hold terminal. The price is $199 in single quantity. Digilin, Inc., 1007 Air Way, Glendale, CA 91201.

Booth 1121. 162

Solid-State Lamps Make Debut

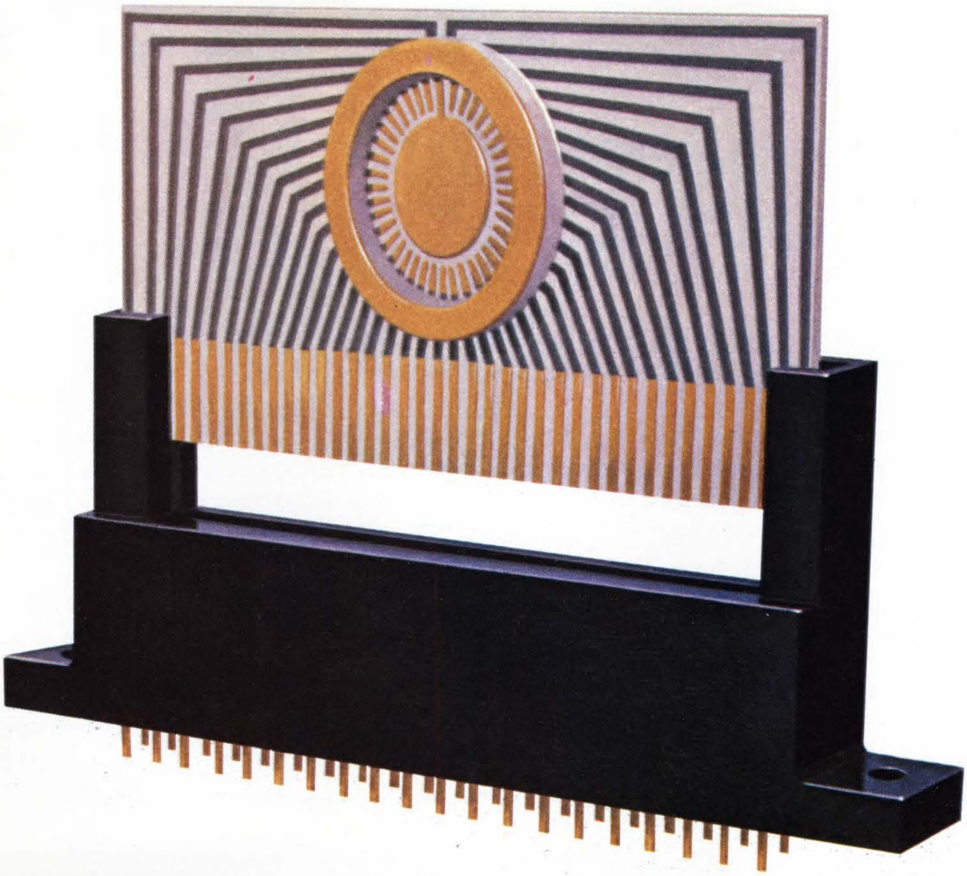
Three infrared solid-state lamps—two at a very low cost/mW output—will be introduced by General Electric's Miniature Lamp Dept. These lamps are designated SSL-54 (1 mW), SSL-55B (5.2 mW) and SSL-55C (6.7 mW). The narrow beam of these gallium-arsenide units contains approximately 50% of the total IR energy produced. Samples (1-9) will be available at $3.14, $5.82 and $6.51, with 1000-lot quantities priced at $1.21, $2.25 and $2.52, respectively. All-glass, wedge base lamps that are 0.24 inch (diam) by 0.8 inch (length) will also be on display. These lamps offer new application potential where space is at a premium. General Electric Co., Nela Park, Cleveland, OH 44112.

Booth 2308 161



ampeconomation
COST SAVINGS BY DESIGN WORLDWIDE

Everything about this MOS/LSI packaging concept is economical, including our connector. And you can rely on that.



Our edgemount connector is specifically designed to help you take advantage of the economy and flexibility in leadless IC substrate packaging.

You get *all* the substrate advantages: low initial cost, greater packaging density, easy insertion/extraction, quick replaceability. And the low per line cost of our connector matches the package's economy. Now, that's cost savings all the way.

Can you depend on it? Yes. Because our connector is designed to give reliable, uniform contact with every pad across the substrate. In addition, posts are rigidly molded in the block on .050″ staggered centers, with no exposed bent metal.

For specs and information on this connector and new substrate packaging concepts, write:
AMP Incorporated, Industrial Division, Harrisburg, Pa. 17105

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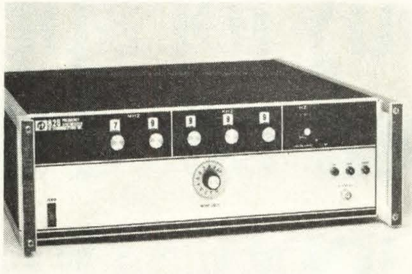
Manufacturing and Direct Sales Facilities in: Australia, Canada, France, Great Britain, Holland, Italy, Japan, Mexico, Puerto Rico, Spain, Sweden, United States and West Germany.

CIRCLE NO. 8

Low-Cost Frequency Synthesizer Grants High Performance



R F Communications, a subsidiary of Harris-Intertype, will be showing their Model RF-828 at WESCON. Priced at $2676 for the basic unit, this 1 kHz to 80 MHz synthesizer offers 5 digit control in one kHz steps with a stability of 1 PPM per month. Options include a vernier for 1-Hz resolution, and a higher stability of 5 parts in 10^9 per day. Both options are priced at $300 each. Output is variable from 10 mV to 1V and is programmable, as is the optional vernier. The unit's synthesis scheme uses phase-locked loops and an error-cancelling mixing scheme. The output frequency of 1 kHz to 80 MHz is obtained by mixing two VHF oscillator outputs. One of these is free running and is added to the outputs from HF oscillators in mixers and a phase-locked loop to obtain the other VHF frequency. Since the mixer circuits and the phase-locked loop are relatively wideband, the short term as well as the long term instabilities of the free-running VHF oscillator are cancelled out so that only the HF oscillators determine the long and short term stability of the output. The HF oscillators are phase locked to a frequency standard, and when added to the VHF oscillator produce the 80-MHz frequency range. R F Communications Inc., 1680 University Ave., Rochester, NY 14610.

Booth 1046 163

Instruments Create Effective Combination

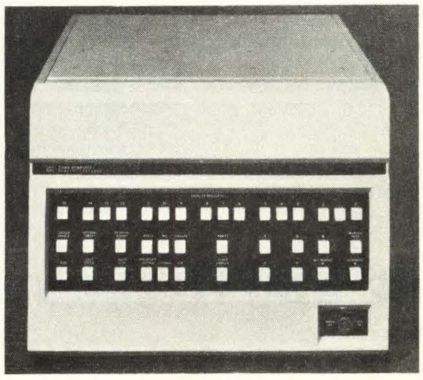
Solid-state sweep generator, Model 610C with a broad range of plug-ins covering from 100 kHz to 18 GHz, will highlight the Wiltron Company display. The unit features a new detector and marker option with a combination cabinet-rack package only 7 inches high and weighing <12 lb. Mainframe price is $1390. Also to be shown is a logarithmic level meter, Model 501, that provides a linear dB measurement range of -40 to 20 dBm with an accuracy of ± 0.5 dB using any general-purpose RF detector. Unit price is $895. The Model 610C and 501 combination forms a transmission and VSWR measuring system that has 60-dB gain or loss measurements with approximately ± 0.3 dB accuracy over the 50 kHz to 12.4 GHz range. System price is $3240. Wiltron Co., 930 E. Meadow Dr., Palo Alto, CA 94303.

Booths 1323-1324 164

Minicomputer Features Expandable Memory

Modular building-block design of the 2100A minicomputer enables a user to start with an economical version, and simply plug in more memory boards as his needs increase. The 2100A has 16-bit words and can hold from 4096 to 32,768 words of core memory within a 12-inch high mainframe. Unit is completely hardware and software compatible with the existing series of HP 2114/2115/2116 computers. Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304.

Booths 1015-17, 1114-17, 1139-41 and 1237-40 165



Our new OEM series is the best power supply you can buy for applications that don't need the best power supply you can buy.

Most OEM applications don't need all the special features we build into our best line of power supplies. And most OEM power supply users just won't pay for features they don't need. That's why we've introduced a new power supply designed especially for the OEM user.

We call it our OEM Series power supply.

There are now 89 models in this new series from 4 to 32 volts and in current ranges from 0.9 to 36 amps. There are also ±12 and ±15 volt dual output models, with current ranges up to 2.7 amps. The OEM series offers 0.1% regulation instead of our usual 0.01% and comes with open frame construction instead of our usual closed black box. Aside from that, you might never notice any other difference. The OEM series features the same excellent stability, same dependable overload protection, same versatile mounting capability, same "guaranteed forever" performance and same off-the-shelf delivery. The only conspicuous difference is in the price.

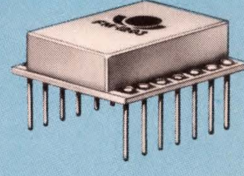
So now, when you don't need the best power supply that we sell, we can sell you the best power supply that you need.

acdc electronics inc.

Oceanside Industrial Center, Oceanside, California 92054, (714) 757-1880

CIRCLE NO. 10

Centralab offers immediate delivery on functional modules



Centralab, the industry leader in thick film microcircuitry, now has combined its recent advances in packaging and chip hybrid technology to bring you five new functional modules available for immediate delivery from stock. These modules are sealed in ceramic packages with 14 swaged terminal pins universally spaced .600″ row-to-row and .100″ apart to facilitate printed circuit board mounting.

Module	Function	Rating	Suggested Applications
FM-1110	Power driver	1 amp @ 60v steady state	Interfacing with relay/solenoid coils, magnetic cores, lamps, etc. in computers, control consoles, test equipment, digital systems, etc.
FM-1203	Dual driver	300 ma @ 28v steady state	
FM-1403	Quad driver	300 ma @ 28v steady state	
FM-2100	MOS clock driver	200 ma with up to 30v shifts	To drive all popular MOS circuitry in calculators, computers and other digital systems.
FM-3100	Programmable multivibrator	Output pulse widths 200 ns to 12 μs	Delay, timing and pulse shaping in computers, control circuits, test equipment and other digital systems.
*FM-4100	RC clock oscillator	500 kHz to 6 mHz	Time base, square wave generators and tone signalling controls for computers, test equipment, etc.
*FM-5100	Overvoltage crowbar	Trip voltage 4.5 to 12.5v, < 1 μ sec response	To protect voltage sensitive devices such as IC's, MOS devices, etc.
*FM-5111	Overvoltage crowbar	Trip voltage 12.5 to 20.5v, < 1 μ sec response	
*FM-5120	Electronic fuse	Trip current 1 amp @ 40v, < 1 μ sec response	DC electronic equipment and systems where precise, fast current disconnect is required.
*FM-6110	Power operational amplifier	250 ma peak output current with supply voltages ± 15 vdc	Servo systems, test equipment, power supplies, etc.

DESCRIPTION

FM-1110, 1203, 1403: Single, dual and quad drivers
Designed to accept standard DTL and TTL logic levels and to drive loads which require high power. Consist of single or multiple NAND/NOR gates and high gain amplifiers.

FM-2100: MOS clock driver
Designed to accept standard DTL and TTL logic levels and universally drive MOS circuitry. Consists of a three input AND function followed by a power inverter.

FM-3110: Programmable monostable multivibrator
A flip-flop which, when triggered by an input pulse, generates an output pulse of prescribed width, with control through interconnection of appropriate package pins.

***FM-4110: RC clock oscillator**
An RC astable multivibrator and an output buffer stage capable of providing a square wave output at a predetermined fixed frequency. It can operate down to 5 Hz with the addition of external capacitors.

***FM-5110, 5111: Overvoltage crowbar**
A high speed electronic voltage sensing element and switch designed to protect voltage sensitive electronic devices by shunting out the supply voltage when high transients or other overvoltage conditions are experienced on the supply line.

***FM-5120: Electronic fuse**
The electronic equivalent of a fuse which features accurate threshold levels, high speed and reset capabilities. Available in a variety of current threshold levels.

***FM-6110: Power operational amplifier**
An operational amplifier designed to provide output capabilities far beyond those obtainable with equivalent monolithic IC's.

***These modules are scheduled for introduction in 1971.**

We welcome inquiries on any variation of the above modules and can provide rapid turnaround on samples and production quantities of custom modules. For design assistance or other information, write Sales Manager, Microcircuits, Centralab. Standard modules are also available through Centralab Distributors.

CENTRALAB
Electronics Division
GLOBE-UNION INC.
5757 NORTH GREEN BAY AVENUE
MILWAUKEE, WISCONSIN 53201

M-7115

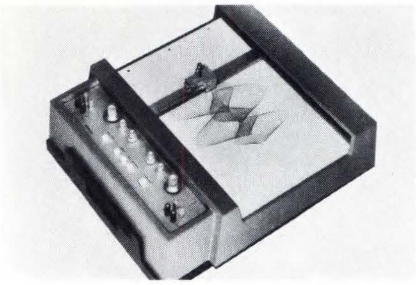
CIRCLE NO. 11

Plotter Creates Accurate Artwork

Digital plotter, Model 738, may be seen in operation at WESCON. In combination with the Model 900 controller, either IC masks can be produced on strippable film or artwork can be recorded directly on photographic film. The Model 738 has a 48- by 72-inch plotting area and operates in either incremental or ZIP mode. Speeds up to 571 inches/min are possible. Static positional accuracy is ±0.004 inch with repeatability of ±0.002 inch. The system is also capable of multicolor and multiple line width pen-and-ink drafting. Other systems to be demonstrated include the 900/1136 graphic output system (offered with up to 32k bytes of programmable memory) and a leadscrew-driven flatbed plotter, Model 745. California Computer Products, Inc., 2411 W. La Palma Ave., Anaheim, CA 92801.

Booths 1715-1716 and 1836-1837 166

Analog Recorder Generates Sharp Traces



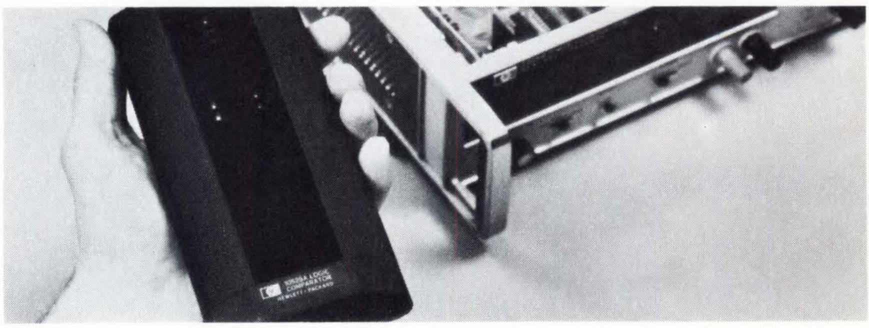
Pressurized ink-writing system and "Metrisite" feedback system are key features of the Brush 500 X-Y recorder to be shown at WESCON. A disposable plastic cartridge contains about a year's supply of ink and is pressurized to give crisp, clear, uniform traces. The "Metrisite" noncontact feedback element provides 99.85% linearity full scale and eliminates problems associated with potentiometric type feedback controls. Additional features include 100 μV/div to 1.0V/div sensitivity adjustable in 13 steps; 40 ips slewing speeds; 10- by 15-inch writing area with electrostatic paper hold down; and balanced, floating and guarded inputs. Gould Inc., Brush Div., 3631 Perkins Ave., Cleveland, OH 44114.

Booths 1207-1208 167

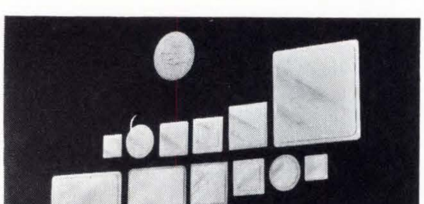
Handy Aid Simplifies Fault Location

Logic comparator, Model 10529A, compares IC devices with a reference IC mounted on an interchangeable board inside the comparator unit. An LED display indicates any logic level mismatch between corresponding pins. Comparator unit is only $295, and a complete trouble shooting kit, Model 5010A, sells for $495. Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304.

Booths 1015-17, 1114-17, 1139-41 and 1237-40 168



Lids Withstand High Pressures



"UNiLiDS" comprise a line of lids for final hermetic sealing of microelectronic packages. These lids are self-locating and are suitable for all methods of final hermetic sealing, including parallel-seam welding and brazing. Since mechanical stresses are not induced into the lid by the manufacturing process, the lids are flat and will withstand pressures of up to 100 psi without oil-canning. They are available to match any circular, rectangular or square microelectronic package without tooling charge. Solid State Equipment Corp., 4343 E. River Dr., Philadelphia, PA 19129.

Booths 1423-1424 169

And now, from the ROM capital of the world...

...4096 and 3072 bits.

With seven ROMs, we were already on top in the read-only-memory market.

Our two newest ROMs will keep us on top for a long time to come.

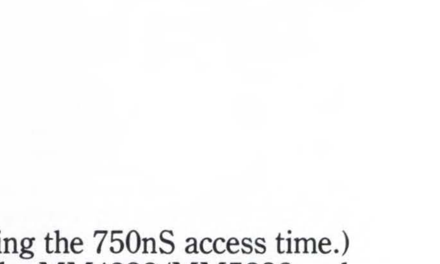
Each is worthy of special note.

The MM4232/MM5232 is a 4096 bit static ROM organized in either a 512 word x 8 bit or 1024 word x 4 bit configuration controlled by a mode control input. With an access time of 1 microsecond. It features two mask programmable chip enable lines (CE_1 and CE_2), a clever innovation which provides logic control up to 16K bits *without external logic.*

Our other new ROM is the MM4241/MM5241 Vertical Scan Character Generator. A 3072 bit static read-only-memory organized in a 64 x 6 x 8 format with an access time of 750nS. The MM4241AAN/MM5241AAN is a standard 5 x 7 font available off-the-shelf.

Both of our newest ROMs use standard supplies (+5, −12V) and are bipolar compatible at the inputs and outputs. In addition, both have been designed with Tri-State™ logic outputs. (Another innovation, and one which gives you wire OR'd capability without loading common data lines or reducing the 750nS access time.)

Finally, both the MM4232/MM5232 and MM4241/MM5241 are mask programmable. Thereby allowing you to submit your own programs for processing in a paper tape or punched card format.



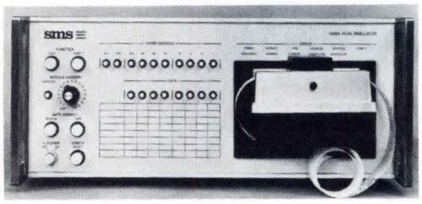
That's a look at our two newest ROMs. For more details on them, our other seven read-only-memories, our line of standard code converters and look-up tables, or a handsome picture postcard of the ROM capital of the world, contact us today.

National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051. Phone (408) 732-5000. TWX: (910) 339-9240. Cable: NATSEMICON.

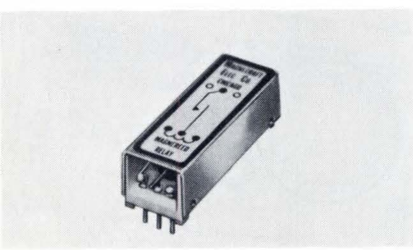
Note: MM42xx refers to −55°C to +125°C temperature range devices; MM52xx to −25°C to +70°C

National

CIRCLE NO. 12

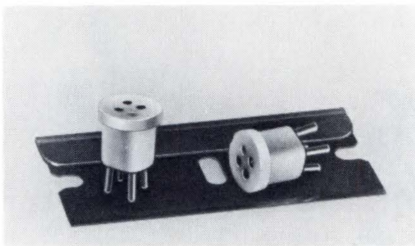


With the 1000A simulator, the design engineer is able to lay out his PC boards as he would in his final design, simulate the ROMs he intends to use and verify those designs before he is committed to a mask. He can assure himself of an error-free ROM program and uncover and correct timing problems in days, thus reducing design time and cost. The paper tapes may be used by SMS to manufacture 1024 x 4 or 512 x 8 ROMs to his specifications. The unit can be configured to simulate up to 16 4096-bit ROMs or a total of 65,536 bits. It interfaces with customer equipment via the 16 or 24 DIP connectors of the buffered simulation cable. Access time at the connector of the 5 ft long simulation cable is 120 nsec. Loading is performed manually or with paper tape. Other features include manual data editing, verification and protection of the contents of the memory module and self-test capability of the complete system. The simulator, to be introduced at WESCON, is available for purchase, lease or rental. The basic unit, with two 4096-bit simulation modules and cables, is priced at $4350. Additional simulation modules and cables are priced at $795 each. Signetics Memory Systems, 740 Kifer Rd., Sunnyvale, CA 94086.
Booth 1712 **170**



Nonposition sensitive mercury-wetted reed relays are available in either a low-profile, PC-mounting package (Class W137MPC) or an in-line, axial lead model (Class 137M). SPST-NO contacts are rated 1 VA at 0.1A or 10V dc max, resistive. Contact resistance of the Class 137M is stable at 100 mΩ over a life of 20 million operations when equipped with diode suppressed coil. Units are available for standard operating voltages of 6, 12 and 24V dc. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, IL 60630.
Booth 2230 **171**

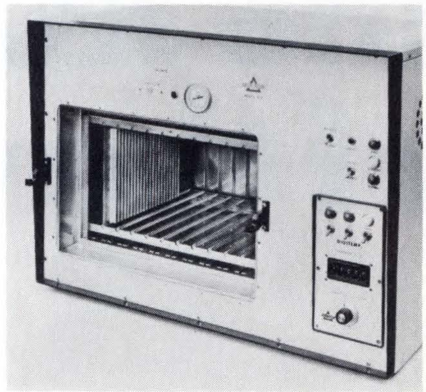
Fused-quartz products, including a transparent fused-quartz OHF stabilized tubing rod, furnace assemblies, spring wafer carrier and cleaning boats, will be shown at WESCON. Amersil will discuss a redesigned clear fused-quartz distillation apparatus and five new compact models for ultralow-conductivity water. Amersil, Inc., 685 Ramsey Ave., Hillside, N J 07205.
Booth 2215. **172**



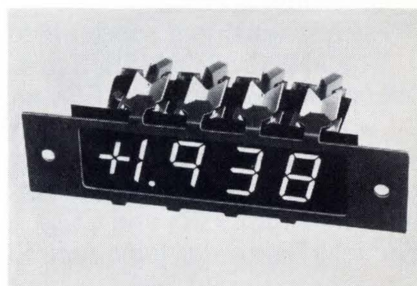
Transistor and IC sockets designed to accept TO-5 and TO-18 packages feature high-speed, low-cost positive mounting, without the need for chamfering the chassis hole. Sealectro 1/4-turn sockets mount simply in a D-flat hole by merely dropping the socket through the mounting hole and turning 90° with a manual or an automatic tool. Precision contact design provides low contact resistance, high vibration and shock resistance and retention of better than 50 grams/lead. Sealectro Corp., Circuit Components Div., 225 Hoyt St., Mamaroneck, NY 10543.
Booth 1609 **173**

Sweep/signal generator, Model 1003, tunes from 350 to 650 MHz with sweep width adjustable from 200 kHz to 300 MHz. Calibrated output from +13 to −77 dBm is standard, and remote control of all functions is possible. Sweep times from 100 to 0.01 sec with line lock, triggered, and manual modes are included. Crystal-controlled harmonic and single frequency markers are available with front panel ON/OFF, size, width, and tilt control. Price is $995. Wavetek, 9045 Balboa Ave., San Diego, CA 92123.
Booths 1124-1126 **174**

EMI filters including suppression devices ranging from 0.10 inch in diam to heavy-duty units capable of 100A continuous operation, and the company's newest series of economically priced line-to-line filters intended to meet UL applications, will be on display at WESCON. The Potter Co., 500 W. Florence Ave., Inglewood, CA 90301.
Booth 2316 **175**



Digital DIP burn-in system, to be shown at WESCON, is available with chambers ranging in size from 1.2 to 4.33 cubic ft and holding 10 to 40 boards. Temperature and gradient requirements meet MIL-STD-883. Circuit board connectors are kept outside the temperature environment by flexible seals. The basic system includes the chamber, solid-state controller, door, rack for boards, flexible seals in rear of chamber, and printed circuit connector for each board position. Options available with the unit include "Digitemp" controller, preset temperature points, temperature monitor recorders, CO_2 and LN_2 cooling, back-to-back doors, base assembly, power distribution, automatic shut-off, matrix, connector wiring and mounting space for power supplies and instruments. Price starts at $1875. Delta Design Inc., Box 1118, La Mesa, CA 92041.
Booths 1549 & 1550 **176**



Miniature 7-bar segment display features bright 1/2-inch display presentations in a single plane configuration. Installation time is reduced with the Series 1040 "complete package" concept and plug-in capability. Standard based lamps (A58) are replaced from front or rear of the panel. Five different screen colors are available. Hybrid driver/decoders for high and low current lamps can be purchased separately or PC board mounted. Price per digit/decoder is $11.31 in quantity. IEE, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405.
Booth 1039 **177**

Tubeless, Tireless

HP's new 3431A panel meter has no tubes to burn out; its shaped-character LED display will perform tirelessly, almost forever. To further increase its reliability, Hewlett-Packard has "designed out" many components, replacing them with proprietary LSI and MSI circuits. And the 3431A's solid-state power supply helps reduce power requirements to only 5 watts. As a result, electrical and thermal stress is minimized, for longer life. Battery operation is optional, allowing portable applications.

Size, too, is minimized by the 3431A's advanced circuitry. It measures only 1.7" high by 3.5" wide by 2.9" deep—including power supply. All others are 25% to 650% larger in volume.

The 3431A is also the best-looking DPM available. Its display is brighter and easier to read than tube or bar-type displays — and cannot give erroneous readouts. Its pop-out front panel covers all mounting fixtures and adjustment controls, and can be painted or silk-screened with any color or nomenclature.

The 3431A is the new performance leader. Accuracy is ±0.1% rdg, ±1 digit, with 1 mV sensitivity. The operating temperature range is 0° C to 60° C. Exclusive HP features include full scale and 10% FS autoranging signals, 55 ms zero-to-FS response time, sample rate display, and remote digital control of sample rates.

Any way you look at it, the 3431A is your only choice in DPM's, if you're looking for instrument quality. Yet it costs only $225, in quantities of 100. For full details, contact your local HP field engineer, or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

CIRCLE NO. 13

091/11

HEWLETT hp PACKARD

COMPONENTS

Computer-Aided Circuit Design Using Network Topology

A circuit designer often has to analyze a single network many times with different sets of component values before the final network realization is obtained. Conventional analysis techniques which require the evaluation of high-order determinants are undesirable even with a digital computer due to frequent redundancy in the determinant-expansion process. The extra calculations in determinant expansion and simplification (cancellation of terms) are lengthy and costly.

The three topological methods for computation of z and y parameters of a passive two-port discussed here eliminate completely the cancellation of terms and fit digital computation. All the terms in the formulas can be computed using a single "tree-finding" program. The application of topological formulas in computer-aided circuit analysis can thus save a lot of time and expense, especially when many repetitions of the analysis procedure are required.

Some useful definitions

Network topology may be described as a study of (electrical) networks in connection with their non-metric geometrical (namely, topological) properties, through the investigation of their graphs. A detailed introduction is outside the scope of this article,[1] but some definitions are introduced with an example.

Consider the network N in Fig. 1a. In this network there are four nodes (A, B, C, D) and six branches (R_1, R_2, L_3, C_4, L_5, R_6). If each of the six branches is replaced by an arc or a line segment, with the four nodes remaining unchanged, we obtain a *graph* G of N (Fig. 1b). Each of the six line segments is called an *edge* of G, corresponding to a branch in the network. The four nodes are called the *vertices* of G.

If edge *2* is removed from G, a graph G_1 results (Fig. 2). G_1 is a portion of G and is called a *subgraph* of G. Edges *1, 3* and *4* in G (or G_1) form a closed path or a loop in G (or G_1) called a *circuit*

Author: Dr. Chan is Professor of Electrical Engineering and Chairman of the E.E. Department, University of Santa Clara, California. He is also the author of "Introductory Topological Analysis of Electrical Networks," recently published by Holt, Rinehart and Winston.

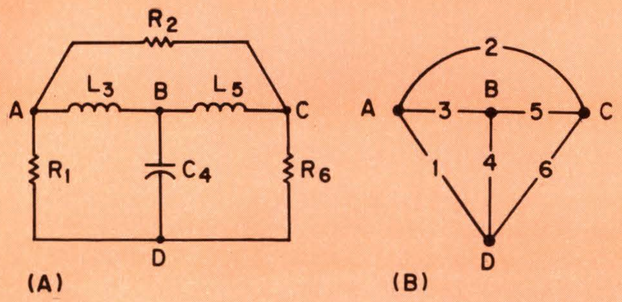


Fig. 1.(a) Network N. (b) Graph G of N.

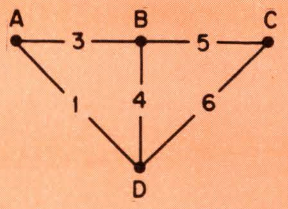


Fig. 2. G_1, a subgraph of G, formed by removing edge 2 from G.

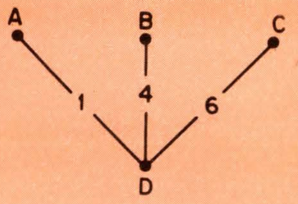


Fig. 3. G_2, a subgraph and a tree of G, has all four vertices of G and 3 (4-1) edges.

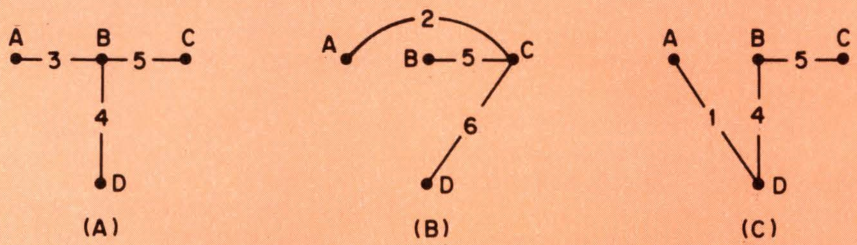


Fig. 4. Three trees of G: (a) $T^{(1)}$, (b) $T^{(2)}$, (c) $T^{(3)}$.

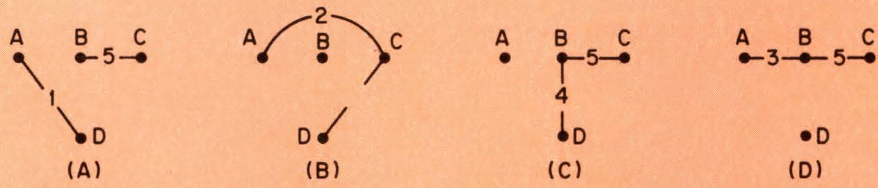


Fig. 5. Four 2-trees of G: (a) $T_2^{(1)}$, (b) $T_2^{(2)}$, (c) $T_2^{(3)}$, (d) $T_2^{(4)}$.

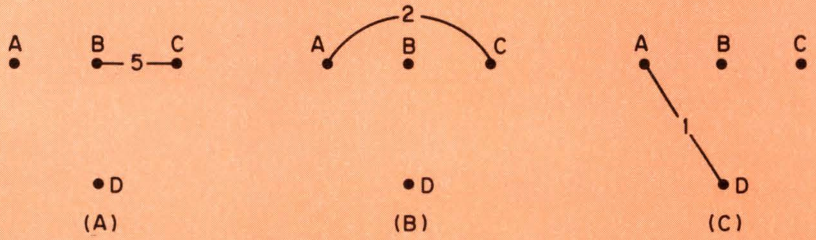


Fig. 6. Three 3-trees of G: (a) $T_3^{(1)}$, (b) $T_3^{(2)}$, (c) $T_3^{(3)}$.

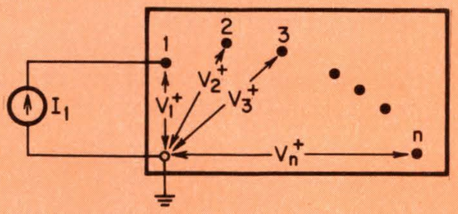


Fig. 7. Passive RLC one-port driven by a current source I_1.

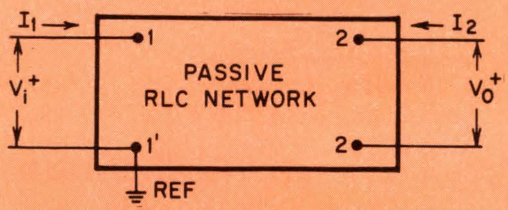


Fig. 8. Passive RLC 2-port.

or a *loop*. Three other circuits in G are, for example, $(1, 3, 5, 6)$, $(2, 3, 5)$ and $(4, 5, 6)$.

If edges 2, 3 and 5 are removed from G, a subgraph G_2 is formed by the remaining edges 1, 4 and 6 (Fig. 3). G_2, which contains only three edges but connects all the four vertices A, B, C and D of the original graph G in one piece, is called a *tree* of G, the edges of the tree being called *branches*. Three other trees of G (Fig. 4) are $T^{(1)}$ $(3, 4, 5)$, $T^{(2)}$ $(2, 5, 6)$ and $T^{(3)}$ $(1, 4, 5)$.

All four trees of Figs. 3 and 4 have five common properties that characterize a tree of a given graph:

(a) They contain the same number of edges (3 in this example);

(b) they contain all the vertices (4) of the original graph G;

(c) they are "one-piece" graphs;

(d) none of them contain any circuits;

(e) they have exactly v-1 branches, v being the number of vertices in the original graph G.

A "one-piece" graph, like those in Figs. 3 and 4, is called a *connected graph*. It can be shown[1] that a connected subgraph containing all the v vertices and no circuits is a tree of the graph.

If any one of the branches is removed from a tree, a "two-piece" circuitless subgraph called a *2-tree* (of the original graph G) is obtained. A 2-tree has the following properties:

(a) It has two components (parts, pieces), being a two-piece subgraph of G;

(b) both components together contain all the v vertices of G;

(c) one of the two components (or both, in a trival case) may be an isolated vertex;

(d) it contains exactly v-2 branches (one less than the number of branches in a tree).

Four of the 2-trees of G are illustrated in Fig. 5. Note that symbols T and T_2 denote trees and 2-trees, respectively. Superscripts mean an arbitrary order of counting. For example, $T^{(3)}$ and $T_2^{(4)}$ mean "the third tree" and "the fourth 2-tree," respectively.

A 3-tree T_3 or, more generally, a k-tree T_k, can be similarly defined. Some of the properties of a k-tree (k being a positive integer) of a graph G of v vertices are:

(1) It is a circuitless subgraph of G;

(2) it has k components (some of which may be isolated vertices);

(3) it contains exactly v-k branches.

In Fig. 6 each of the 3-trees (of G) has one branch as expected ($v-k = 4-3 = 1$), and there are two isolated vertices in each 3-tree. Obviously, the only 4-tree of G is the subgraph containing four isolated vertices but no branches since $v-k = 4-4 = 0$.

Ys and Zs in terms of "trees"

Consider the passive *RLC* one-port (one-terminal-pair network) with n independent nodes and zero initial conditions (Fig. 7), driven by a single current source I between terminals 1 and $1'$. Node $1'$ is taken as a reference (datum) node. The voltages V_1 $V_2 \ldots,$ V_n are the Laplace transforms of the node-pair voltages $v_1, v_2, \ldots, v_n$, that is, the voltages between the n nodes and node $1'$, respectively, with the plus polarity mark at the n nodes. The n independent node equations in matrix form are

$$\begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & & \\ y_{n1} & y_{n2} & \cdots & y_{nn} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ \vdots \\ V_n \end{bmatrix} = \begin{bmatrix} I \\ O \\ \vdots \\ O \end{bmatrix} \qquad (1)$$

or, in matrix notation,

$$\mathbf{Y}_n \mathbf{V}_n = \mathbf{I}_n \qquad (2)$$

where $\mathbf{Y}_n$ is the $n \times n$ node-admittance matrix, V_n the $n \times 1$ column matrix of the node-voltage transforms and I_n the $n \times 1$ column matrix of the transforms of the known current sources.

Solving for V_1 using Cramer's rule, we find

$$V_1 = \frac{\Delta_{11}}{\Delta} I_1 \qquad (3)$$

where Δ is the determinant of $\mathbf{Y}_n$ and Δ_{11} is the $(1, 1)$ cofactor of Δ. Thus, the driving-point impedance $Z_d(s)$ of the one-port is

$$Z_d(s) = \frac{V_1}{I_1} = \frac{\Delta_{11}}{\Delta} \qquad (4)$$

Similarly, for a reciprocal (passive *RLC*) two-port (two-terminal-pair network) (Fig. 8), the open-circuit impedances ($z_{11}, z_{12} = z_{21}, z_{22}$) and the short-circuit admittances are given by

$$z_{11} = \frac{\Delta_{11}}{\Delta} \qquad (5a)$$

$$z_{12} = z_{21} = \frac{\Delta_{12} - \Delta_{12'}}{\Delta} \qquad (5b)$$

$$z_{22} = \frac{\Delta_{22} + \Delta_{2'2'} - 2\Delta_{22'}}{\Delta} \qquad (5c)$$

and

$$y_{11} = \frac{\Delta_{22} + \Delta_{2'2'} - 2\Delta_{22'}}{\Delta_{1122} + \Delta_{112'2'} - 2\Delta_{1122'}} \qquad (6a)$$

$$y_{12} = y_{21} = \frac{\Delta_{12'} - \Delta_{12}}{\Delta_{1122} + \Delta_{112'2'} - 2\Delta_{1122'}} \qquad (6b)$$

$$y_{22} = \frac{\Delta_{11}}{\Delta_{1122} + \Delta_{112'2'} - 2\Delta_{1122'}} \qquad (6c)$$

respectively, where Δ_{ij} is the (i, j)-cofactor of Δ, and Δ_{ijmn} is the cofactor of Δ obtained by deleting rows i and m and columns j and n from Δ. The sign of the cofactor is given by $(-1)^{i+j+m+n}$.

The determinant Δ of the node-admittance matrix and its cofactors can be expressed topologically as follows:[1]

$$\Delta = \sum_k T^{(k)}(y)$$

= sum of all tree-admittance products of G (7)

$$\Delta_{ii} = \sum_k T_{2\,i,1'}^{(k)}(y)$$

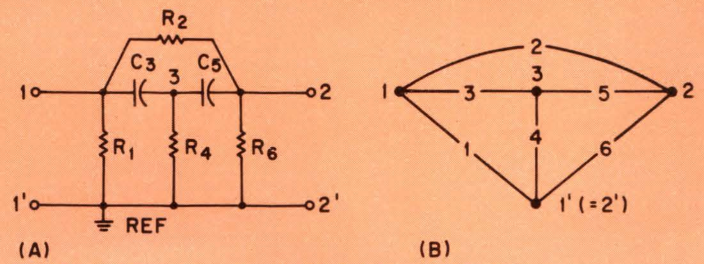


Fig. 9. (a) 2-port network N. (b) Graph G of N.

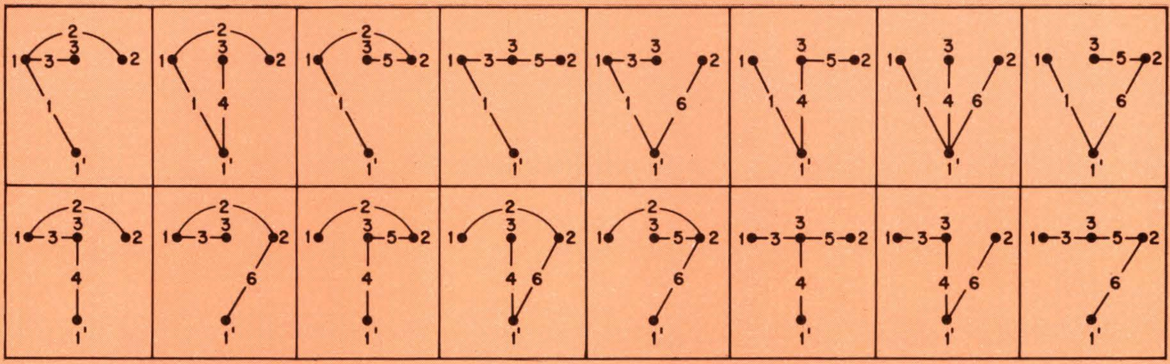


Fig. 10. The set of all 16 trees of G of Fig. 9b.

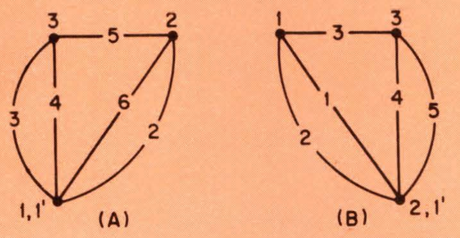


Fig. 11. (a) Graph G(1) for computing Δ_{11}. (b) Graph G(2) for computing Δ_{22}.

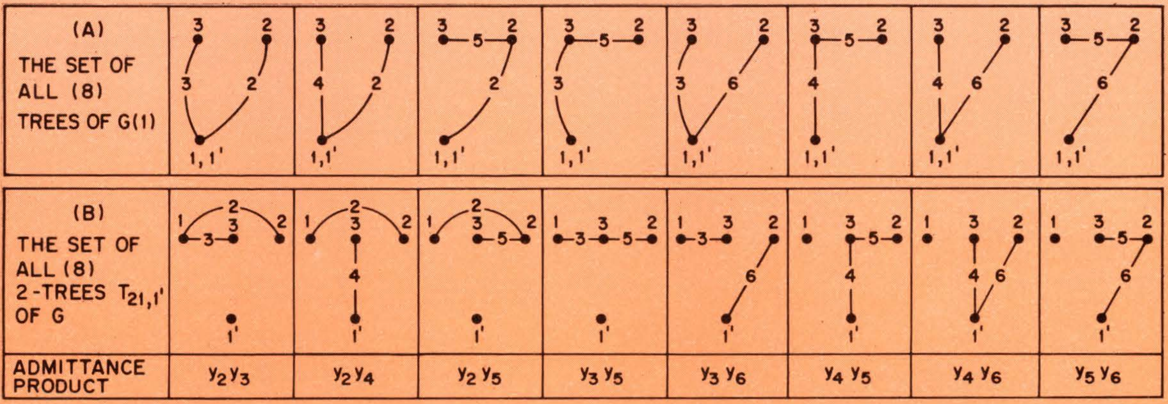


Fig. 12. Two sets of eight trees, corresponding to each other: (a) All trees of G(1). (b) All 2-trees $T_{2_{1,1}}'$ of G (with vertices 1 and 1′ in different components in each such 2-tree).

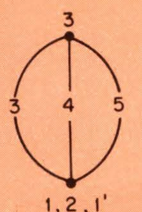


Fig. 13. Graph G(12) for computing Δ_{1122}.

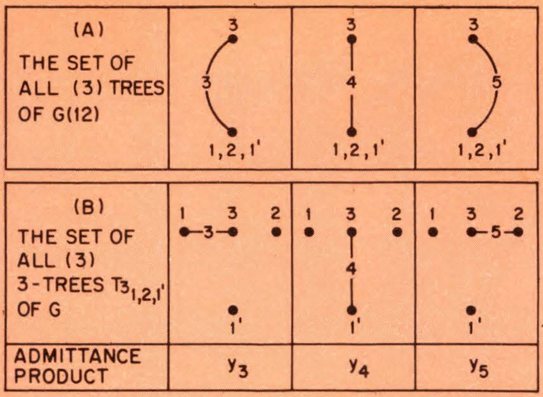


Fig. 14. Two sets of trees, three in each, corresponding to each other. (a) All trees of G(12). (b) All 3-trees $T_{3_{1,2,1}}'$ of G (with vertices 1, 2, and 1′ in three different components of each such 3-tree).

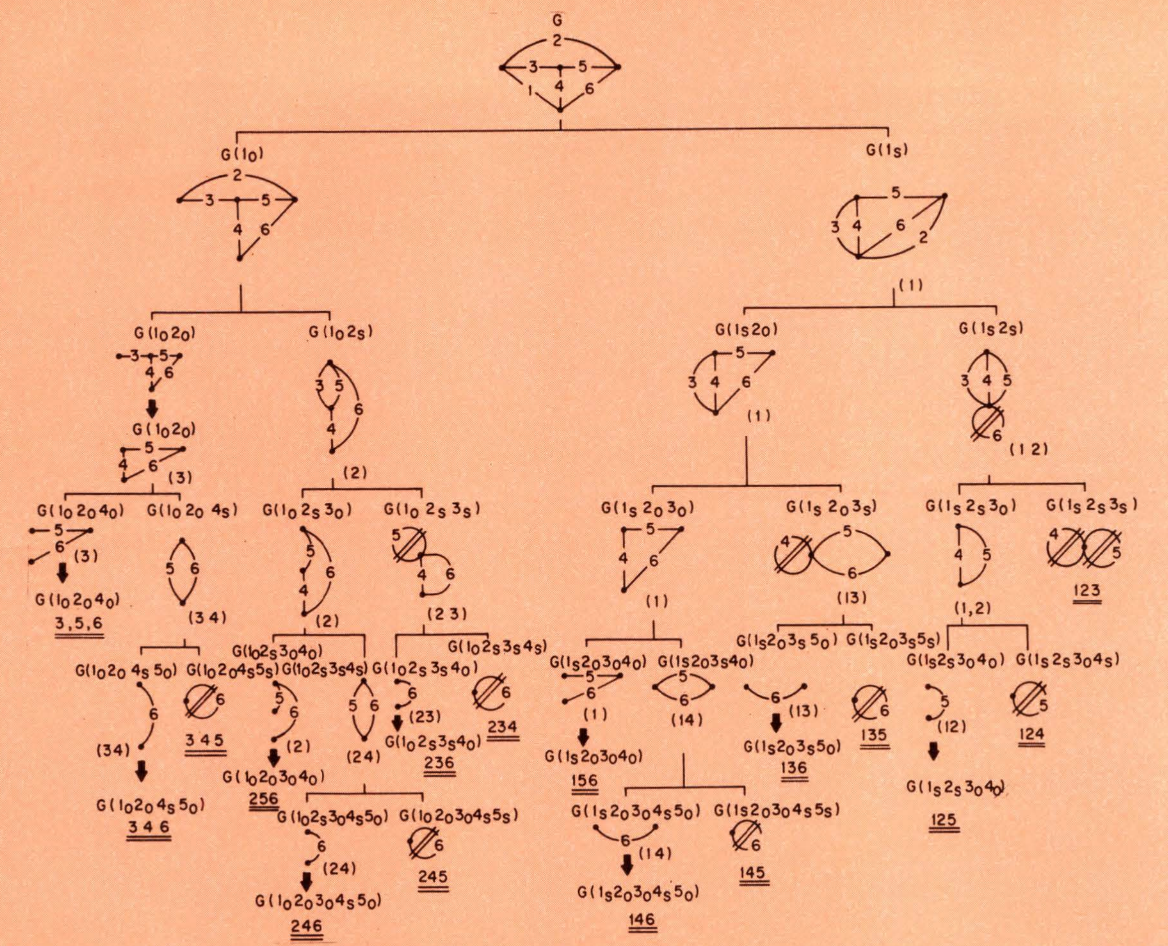


Fig. 15. Method 2 for finding all trees of G (Ex. 4).

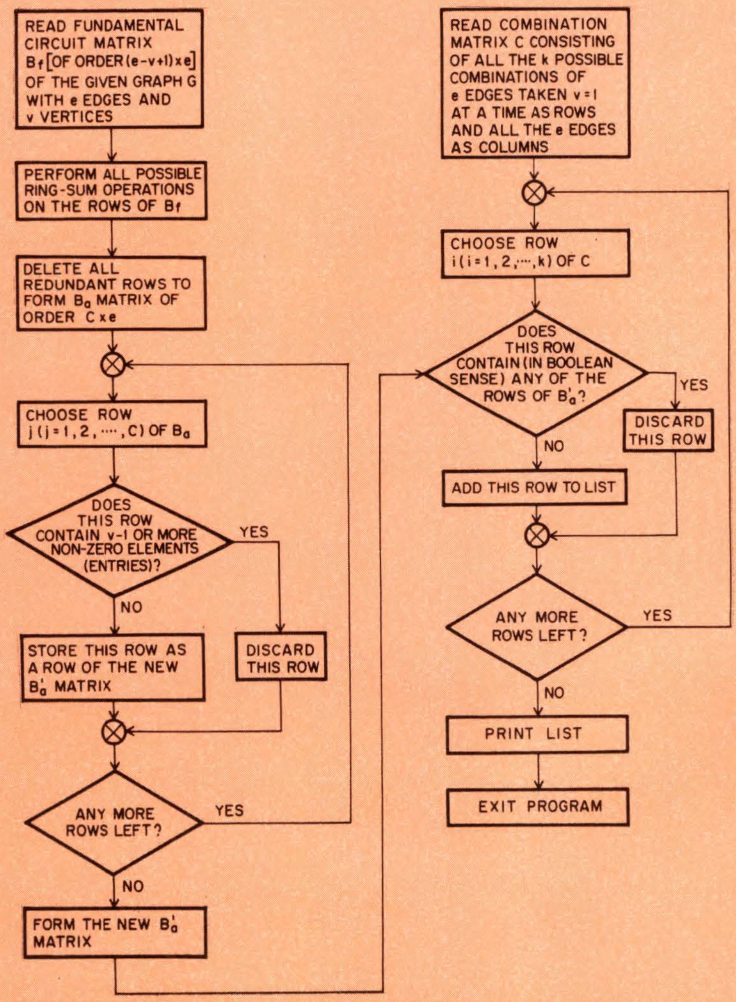


Fig. 16. Simplified flow chart for tree-finding method 1. (See Appendix for definitions of fundamental circuit matrix, ring sum, complete circuit matrix, redundant row, $B_a{}^1$ matrix, combination matrix, incidence matrix.)

= sum of all 2-tree admittance products with vertices i and $1'$ in different components of each such 2-tree. (8)

$$\Delta_{ij} = \sum_k T_{2_{ij,1'}}(y)$$

= sum of all 2-tree admittance products with vertices i,j in one component and node $1'$ in the other component of each such 2-tree. (9)

$$\Delta_{iijj} = \sum_k T_{3_{i,j,1'}}(y)$$

= sum of all 3-tree admittance products with vertices i, j, and $1'$ in 3 different components of each such 3-tree. (10)

$$\Delta_{ijmn} = \sum_k T_{3_{ij,mn,1'}}(y)$$

= sum of all 3-tree admittance products with vertices i and j in one component, vertices m and n in another, and vertex $1'$ in the third component of each such 3-tree. (11)

In each of these a *k-tree admittance product* is defined as the product of the admittances of all the branches of the k-tree.

As examples, the tree admittance product of the tree (3, 4, 5) of Fig. 4a is $y_3y_4y_5$; the 2-tree admittance product of the 2-tree (1, 5) of Fig. 5a is y_1y_5; and the 3-tree admittance of the 3-tree (5) of Fig. 6a is y_5. The 4-tree admittance product of the 4-tree containing only four isolated vertices but no branches is 1 with the definition that the "admittance" of an isolated vertex is 1 for completeness.

With expressions (7) through (11) all the network functions in Eq. (4), (5), and (6) may be evaluated topologically in terms of the trees, 2-trees, and 3-trees. However, it is interesting to note that all the cofactors of the type Δ_{ij} may be evaluated in terms of the trees (not 2-trees) of the modified graph $G(i)$ obtained from G by short circuiting vertices i and $1'$. That is

Δ_{ii} = sum of all tree admittance products of $G(i)$ obtained by short-circuiting vertex i to the reference vertex $1'$. (12)

Similarly,

Δ_{iijj} = sum of all tree admittance products of $G(ij)$ obtained by short-circuiting vertices i and j to the reference vertex $1'$. (13)

Cofactors of the type Δ_{ij} may be evaluated by summing the tree admittance products of those trees common to both $G(i)$ and $G(j)$. That is

Δ_{ij} = sum of all tree admittance products of trees which are common to graphs $G(i)$ and $G(j)$. (14)

Finally,

$\Delta_{1122'}$ = sum of all 3-tree admittance products of those 3-trees that are common to both graphs $G(12)$ and $(12')$. (15)

Using trees in computations

Example 1. Computation of the open-circuit impedances z_{11}, z_{12} and z_{22} of the passive 2-port network N in Fig. 9a with graph G in Fig. 9b.

For convenience, let

$$y_1 = \frac{1}{R_1} = G_1 \qquad (16a)$$

$$y_2 = \frac{1}{R_2} = G_2 \qquad (16b)$$

$$y_3 = sc_3 \qquad (16c)$$

$$y_4 = \frac{1}{R_4} = G_4 \qquad (16d)$$

$$y_5 = sc_5 \qquad (16e)$$

$$y_6 = \frac{1}{R_6} = G_6 \qquad (16f)$$

In Figs. 10 and 11a we have the set of all trees of G corresponding to the terms of Δ_{11} and the graph $G(1)$, with trees corresponding to Δ_{11}. The graph $G(2)$, with trees corresponding to Δ_{22} is in Fig. 11b. The set of all (8) trees of $G(1)$ (Fig. 12a) corresponds to the set of 2-tree ($T_{2_{1,1'}}$) of G (with vertices 1 and $1'$ in different components in each such 2-tree) (Fig. 12b).

Using (7) and Fig. 10 we get

$$\Delta = y_1y_2y_3+y_1y_2y_4+y_1y_2y_5+y_1y_3y_5+y_1y_3y_6+ y_1y_4y_5+y_1y_4y_6+y_1y_5y_6+y_2y_3y_4+y_2y_3y_6+y_2y_4y_5+ y_2y_4y_6+y_2y_5y_6+y_3y_4y_5+y_3y_4y_6+y_3y_5y_6 \qquad (17)$$

Using (8) and Fig. 12b or (12) and Figs. 11a, 12a we get

$$\Delta_{11} = y_2y_3 + y_2y_4 + y_2y_5 + y_3y_5 + y_3y_6 + y_4y_5 + y_4y_6 + y_5y_6 \qquad (18)$$

Using (8) and Fig. 10 or (12) and Fig. 11b we get

$$\Delta_{22} = y_1y_3 + y_1y_4 + y_1y_5 + y_2y_3 + y_2y_4 + y_2y_5 + y_3y_4 + y_3y_5 \qquad (19)$$

Using (8) or (12) we get

$\Delta_{2'2'} = 0$ (because nodes $1'$ and $2'$ are the same node) (20)

Similarly, using (9) or (14) and (20)

$$\Delta_{12'} = 0 \qquad (21)$$

and $\Delta_{22'} = 0$ (22)

Using (9) and Fig. 10 or (14) we get

$$\Delta_{12} = y_2y_3 + y_2y_4 + y_2y_5 + y_3y_5 \qquad (23)$$

Substituting (16) through (23) in (5a, b, c) the open-circuit impedances z_{11}, z_{12} and z_{22} are determined.

Example 2. Computation of the short-circuit admittances y_{11}, y_{12} and y_{22} of the passive 2-port of Fig. 9a.

Using (10) and Fig. 14b or (13) and Fig. 14a we get

$$\Delta_{1122} = y_3 + y_4 + y_5 \qquad (24)$$

$\Delta_{1122} = 0$ (since vertices $1'$ and $2'$ are identical) (25)

Thus, using (15)

$$\Delta_{1122'} = 0 \qquad (26)$$

Substituting (24), (25) and (26) into (6a, b, c), and noting the fact that the numerators for the short-circuit admittances y_{11}, y_{12}, y_{22} can be obtained from the numerators of the open-circuit impedances z_{11}, z_{12}, z_{22}, we can determine the admittances y_{11}, y_{12}, and y_{22}. It can also be shown that

$$\mathbf{Y}_{sc} = \mathbf{Z}_{oc}^{-1} \quad (27)$$

where

$$\mathbf{Y}_{sc} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \quad (28) \text{ and } \mathbf{Z}_{c} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \quad (29)$$

Thus, the short-circuit admittance matrix $\mathbf{Y}_{sc}$ may be obtained indirectly by computing the inverse of $\mathbf{Z}_{ov}$.

It is evident from the two examples above that the most important part of the topological approach is the determination of trees (of G and its modified graphs). Here are three of the tree-finding methods.

Method 1. Observe that if we have a graph G of v vertices and e edges, a tree of G contains v-1 edges. Thus, to find all the trees of G, we can first obtain the set $C(e,v\text{-}1)$ of all combinations of e edges taken v-1 at a time, and eliminate from the set those combinations of edges that contain circuits. The remaining combinations must be trees. Thus: Total number of trees of $G = C(e, v\text{-}1)$ – [those combinations that contain circuits]
where

$$C(e, v-1) = \frac{e(e-1)(e-2)\ \dots\ (e-v+2)}{(v-1)(v-2)\ \dots\ 3{\cdot}2{\cdot}1} \quad (30)$$

Example 3. Let G be the graph of Fig. 9b. Here the number of edges is $e = 6$, and the number of vertices is $v = 4$. Thus

$$C(e, v-1) = C(6, 3) = \frac{6{\cdot}5{\cdot}4}{3{\cdot}2{\cdot}1} = 20$$

The edge combinations are, listed in proper sequence:

123	(134)	145	156	234
124	135	146		(235)
125	136			236
(126)				
245	256	345	356	(456)
246		346		

By inspection, we note that the combinations in parentheses contain circuits. Eliminating these four combinations from the total of 20 combinations, we obtain the set of all (16) trees of G as verified by (17) in Ex. 1.

Method 2 (Minty).[2]

1. Draw the given graph G with all its edges numbered. Delete all self loops (i.e., loops containing only one edge) if any.

2. Delete the non-circuit edges (those not contained in any circuits of the graph) and call the resultant graph $\bar{G}$. Record the non-circuit edges by their numbers under $\bar{G}$.

3. Pick an edge, say j, and obtain two graphs with respect to j—$G(j_o)$ and $G(j_s)$, where $G(j_o)$ is obtained from $\bar{G}$ by removing edge j (edge-opening operation); and $G(j_s)$ is obtained by short-circuiting edge j by coalescing its two vertices in $\bar{G}$ (edge-shorting operation). Draw $G(j_o)$ and $G(j_s)$ below $\bar{G}$ and transfer the non-circuit edge numbers of $\bar{G}$ under the two new graphs. Also record edge number j under $G(j_s)$ along with the transferred non-circuit edge numbers. Delete self loops in $G(j_o)$ and (Gj_s), if any, resulting from 3. Repeat 2 to obtain $\bar{G}(j_o)$ and $\bar{G}(j_s)$.

4. In $\bar{G}(j_o)$, pick an edge, say m, and repeat 3. to obtain $\bar{G}(j_om_o)$ *and* $\bar{G}(j_om_s)$; also, in $\bar{G}(j_s)$ pick an edge, say n, and repeat 3. to obtain $\bar{G}(j_sn_o)$ and $\bar{G}(j_sn_s)$. Now repeat 2. to obtain the $\bar{G}$ graphs.

5. Repeat step 4 in each resultant graph until all edges are exhausted. The numbers recorded under the final graph correspond to the branches of a unique tree of the original graph.

Example 4. Let G be the graph of Fig. 9b again. The steps involved in obtaining the set of all trees of G using Method 2 are illustrated in Fig. 15. The 16 trees obtained by this method are identical with those obtained in Ex. 3 using Method 1.

Method 3 (the Wang algebra)[3].

1. Choose as the reference any one of the vertices with the highest number of edges connected to it.

2. For each of the other vertices, write a term $(e_1 + e_2 + \dots + e_k)$ where $e_1, e_2, \dots, e_k$ are the numbers of the k edges connected to that vertex.

3. Form the product of all v-1 terms obtained in (2) where v is the total number of vertices in the given graph G.

4. Expand the product using the following rules
   (a) $e_ie_j = e_ie_j$
   (b) $e_ie_i = e_i^2 = 0$
   (c) the sum of two identical terms is zero

5. Each term in the expanded sum in step 4 after simplification by the three rules corresponds uniquely to a tree of G so that all the terms together constitute the set of all trees of G.

Example 5. Once again, let G be the graph of Fig. 9b.

Step 1. Since each of the four vertices has exactly three edges connected to it, we arbitrarily choose vertex *1'* as the reference vertex.

Step 2. The three terms corresponding to vertices *1*, *2*, and *3*, are respectively $(1 + 2 + 3)$, $(2 + 5 + 6)$, and $(3 + 4 + 5)$.

Step 3. The set $\{T\}$ of all trees of G is given by

$$\begin{aligned}\{T\} &= (1+2+3)(2+5+6)(3+4+5) \\ &= (12+15+16+\underline{2^2}+25+26+23+35+36)(3+4+5) \\ &= 123+135+136+\underline{\underline{235}}+236+\underline{23^2}+\underline{3^25}+\underline{3^26} \\ &= +124+145+146+245+246+234+345 \\ &\quad +346+125+\underline{15^2}+156+\underline{25^2}+256+\underline{\underline{235}} \\ &\quad \underline{+35^2}+356\end{aligned}$$

Step 4. After simplification using the three rules and rearranging the terms in the ascending order we have

$$\begin{aligned}\{T\} = &\ 123+124+125+135+136+145+146+156 \\ &+234+236+245+246+256+345+346+356\end{aligned}$$

which gives all 16 trees of G obtained in Ex. 3 and 4.

Tree-finding computer programs

From *Ex. 3, 4* and *5* it is obvious that any of the

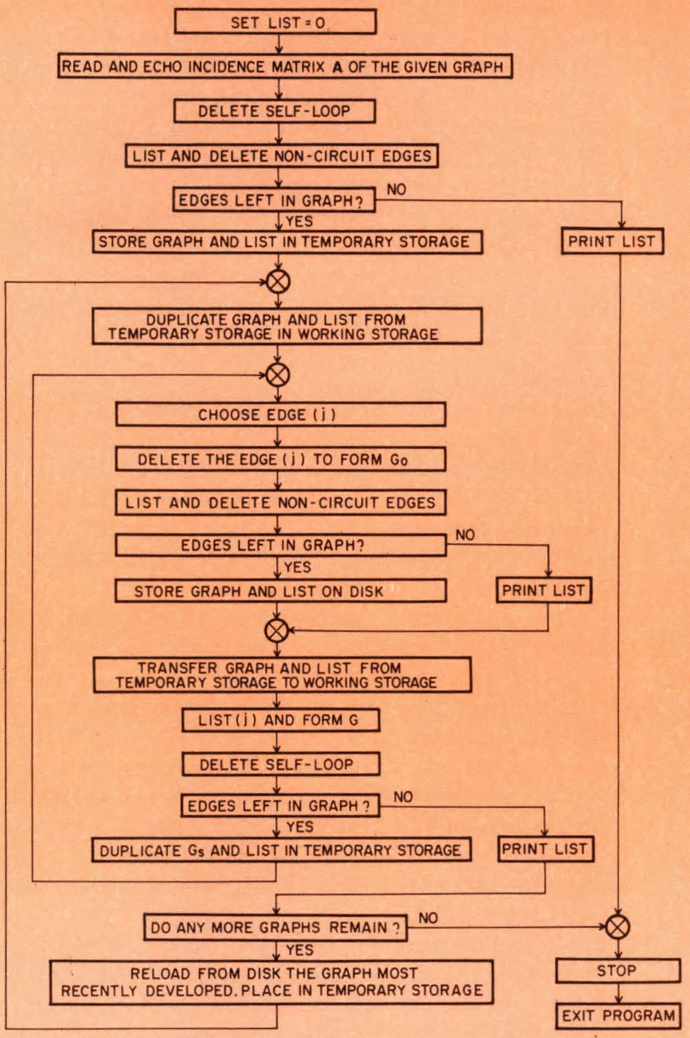


Fig. 17. Simplified flow chart for tree-finding method 2. (See Appendix for definition of incidence matrix.)

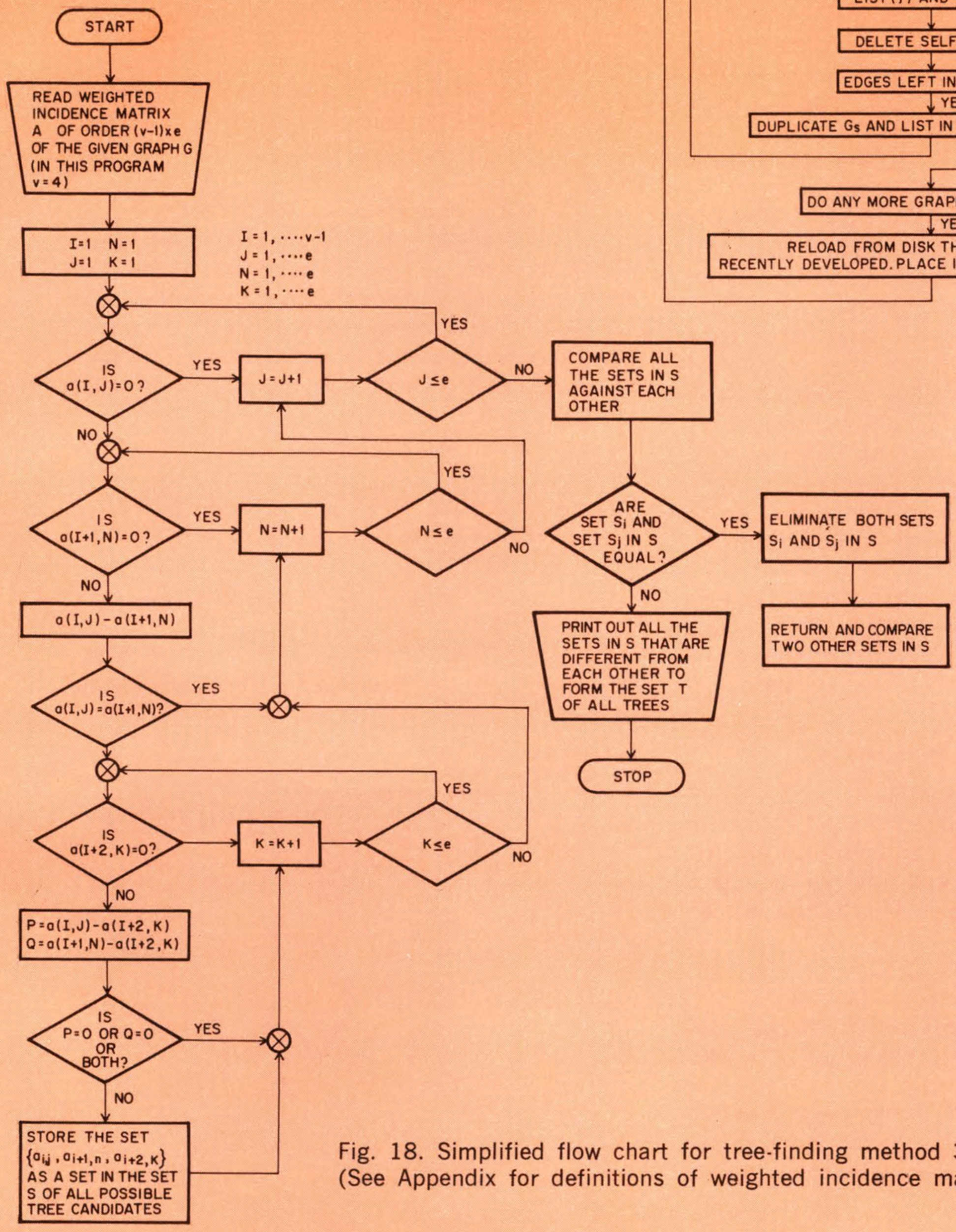


Fig. 18. Simplified flow chart for tree-finding method 3 for 4-vertex, e-edge graph. (See Appendix for definitions of weighted incidence matrix and tree candidates.)

three methods can be used to develop a tree-finding computer program. In the flow chart for the program based on *Method 1* (Fig. 16), all the combinations of e edges, taken v-1 at a time, $C(e, v\text{-}1)$, are computed. (We recall that e and v are total numbers of edges and vertices, respectively, for the given graph G.) Then all the circuits are eliminated from the $C(e, v\text{-}1)$ combinations, and the remaining constitute the set of all trees of G.

Flow charts for Minty's program *(Method 2)* and for the Wang-algebra tree-finding program *(Method 3)* are in Figs. 17 and 18, respectively.

A critique

Once a tree-finding program is formulated, all the 2-trees and 3-trees, as well as the trees, can be obtained by the same program. Thus a considerable amount of time and effort can be saved. The topological formulas (7) through (11) may be expanded and further modified to give still simpler expression.[4]

The tree-finding analysis can be extended to nonreciprocal networks by modifying the corresponding topological expressions.[1]

It is interesting to note that while the first tree-finding algorithm is the simplest in theory, there are cancellations in the process (underlined terms, *Ex. 3*). *Method 3* (Wang algebra) is the easiest for manual computation, but it has redundancies of "squared" terms and duplications (rules *b* and *c*, respectively and *Ex. 5*). On the other hand, in Minty's method there are no cancellations or duplications but it may be cumbersome to form the "tree chart" when applied manually (Fig. 15). Here is where the computer program can play an important role in the design process.

Needless to say, there are many other tree-finding algorithms,[5,6,7] and the three presented here are among the simpler ones. A wide adoption of topological techniques in network design not only depends very much upon an efficient tree-finding algorithm, but also on ingenuity in programming the whole design procedure so as to cut the time and cost below that required by conventional methods.

Finally, it should be emphasized that for networks which contain large numbers of trees, one should use either non-topological techniques[5] or topological formulas with a higher degree of sophistication.[8]

Appendix: Definitions for Figs. 16, 17, and 18.

1. *Fundamental circuit matrix* B_f *with respect to a tree T* is a matrix of order $(e - v + 1) \times e$ with each row identified by a fundamental circuit (formed by a unique link and possibly some tree branches) and each column is identified by an edge such that

$$\mathbf{B}_f = [b_{ij}]_{(e-v=1)\times e}$$

where $b_{ij} = 1$ if edge j is contained in circuit i
$= 0$ if edge j is not contained in circuit i
(e = total number of edges in the graph; v = total number of vertices in the graph)

2. *The ring-sum* $(S_1 \oplus S_2)$ of two sets S_1 and S_2 is the set consisting of all the elements which are either in S_1 or in S_2 but not those common to both sets. (Thus, the ring-sum is the same as the logical difference in set theory.)

3. The *(complete) circuit matrix* $\mathbf{B}_a$ is a matrix of order $c \times e$ (where c is the total number of circuits and e is the total number of edges in the graph) with each row identified by a circuit and each column by an edge such that

$$\mathbf{B}_a = [b_{ij}]_{c\times e}$$

where

$b_{ij} = 1$ if edge j is in circuit i
$= 0$ if edge j is not in circuit i

4. A *redundant row* in a matrix is a row which contains (in the Boolean sense) some other row in the matrix.

5. The $\mathbf{B}'_a$ *matrix* is obtained from $\mathbf{B}_a$ by eliminating all those rows of $\mathbf{B}_a$ which contain $v - 1$ or more non-zero entries. (Thus, each row of $\mathbf{B}'_a$ represents a circuit containing $v - 1$ or less edges.)

6. The *combination matrix* **C** is the matrix of order $k \times e$, where $k = \mathbf{C}\ (e,v-1)$ is the total number of all possible combinations of e objects (edges, in this case) taken $v - 1$ at a time; e is the total number of edges of the graph; and v is the total number of vertices of the graph. Each row of **C** represents a combination of the e edges taken $v - 1$ at a time; and each column of **C** represents an edge of the graph.

7. The *incidence matrix* **A** of a graph of e edges and v vertices is the matrix of order $(v - 1) \times e$:

$$\mathbf{A} = [a_{ij}]_{(v-1)\times e}$$

where

$a_{ij} = 1$ if edge j is connected to vertex i
$= 0$ if edge j is not connected to vertex i

(Thus, each row of **A** is identified by a vertex and each column by an edge; the reference vertex is not included in **A**; this is why **A** has $v - 1$ rows.)

8. The *weighted incidence matrix* $\mathbf{A}_w$ of a graph of e edges and v vertices is the matrix of order $(v-1) \times e$:

$$\mathbf{A}_w = [a_{ij}]_{(v-1)\times e}$$

where

$a_{ij} = e_j$ (the "weight" or symbol which identifies edge j), if edge j is connected to vertex i;
$= 0$, if edge j is *not* connected to vertex i

9. A *tree candidate* is a set of $v - 1$ elements $a_{1i_1}\ a_{2i_2}, \ldots\ a_{v-1,i_{v-1}}$ such that all of the a_{ij} s are different in value (weight).

References:

1. S. P. Chan, *Introductory Topological Analysis of Electrical Networks*, Holt, Rinehart and Winston, N.Y. 1969.
2. G. J. Minty, "A Simple Algorithm for Listing All the Trees of a Graph," *IEEE Transactions on Circuit Theory* (correspondence), pg. 120, March 1965.
3. K. T. Wang, "On a New Method for the Analysis of Networks," *National Research Institute of Engineering, Academia Sinica, Memoir No. 2*, pgs. 1-11, 1934.
4. S. P. Chan and S. G. Chan, "Topological Formulas for Digital Computation," *Proceedings, First Annual Princeton Conference on Information Science and Systems*, Princeton University, March 30-31, 1967.
5. F. F. Kuo, "Network Analysis by Digital Computer," *Proceedings of the IEEE* Vol. 54, No. 6, pgs. 820-829, June 1966.
6. D. A. Calahan, "Linear Network Analysis and Realization of Digital Computer Programs: An Instruction Manual," *Univ. of Illinois Bulletin*, Vol. 62, No. 58, February 1965.
7. W. Mayeda and S. Seshu, "Generation of Trees Without Duplications," *IEEE Transactions on Circuit Theory*, Vol. CT-12, No. 2, June 1965.
8. W. R. Dunn Jr., and S. P. Chan, "Topological Formulation of Network Functions without Generation of k-trees," *Conference Record, Sixth Annual Allerton Conference on Circuit and System Theory*, Univ of Illinois, October 1968.


It's a disease that can hit solder reflow assembly operations hard. You put your chips perfectly in place, but lo and behold at the end of the line the circuits won't play.
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CIRCLE NO. 15

FACTORS IN DESIGNING TWT POWER SUPPLIES

Plot the six key factors involved in TWT power supply design and you'll have a set of comparative data from which final design selection can easily be made. Learn how by following the examples given here.

STEVE SMITH, Quatt Wunkery

After surveying the most conventional approaches to the design of TWT power supplies in our July 15 issue, we now focus on the seven factors a systems engineer must consider for his final design. These seven basic factors are: size, weight, reliability, efficiency, engineering cost, manufacturing cost, and time. Accompanying graphs that illustrate eight design approaches to TWT power supply designs show how to display these different factors for easy comparison.

To the extent that the system end-use often constrains size and weight to be within certain limits, these two factors are self-explanatory. To compare one design approach with another, and measure what is within the state of the art, we need a method of evaluating various approaches. The usual methods used for comparison are watts per cubic inch and watts per pound. However, since one may always sacrifice a percent of efficiency or spend 10% more and reduce size or weight another few percent, the ranges of numbers to assign are those that good design practice and a healthy respect for the competition lead to.

The packaging expertise that is brought to bear on any system can have a great deal to do with the final size and weight of the system. For example, the use of a magnesium baseplate and magnesium structural and mounting elements internally can save a great deal of weight, and proper use of fluoro-chemicals for insulation and cooling can often reduce the size considerably.

It is not unusual to see five prototypes of a transformer, made by five companies to the same electrical specifications, vary in volume and weight over a 3:1 range. Neither is it unusual to find that the reliability of such a collection of prototypes does not correlate with either size, weight or cost; for the reliability of magnetic components is a function of proper design and good workmanship, and as such will correlate only with the particular vendor. The only way for a user to be assured of getting dependable performance and reliability is to find a transformer supplier that he can relate to and work well with.

Reliability

System reliability is a measure of the care and quality of materials that went into designing the system. Reliability is also a measure of how likely the system is to perform when needed. Overall component count is also involved. But rather than get involved in MTBF calculations, assign to each design approach a relative factor, such that the larger this figure of merit is, the greater the intrinsic reliability of this approach (provided it is properly designed).[1] These figures of merit are purely arbitrary and are based on personal experience of the author as well as that of other engineers the author has dealt with. They may be adjusted at the discretion of the reader, based on his own personal experience in the subjects involved.

The stress level at which components are operated has a great deal to do with reliability, in that a 1W resistor derated 50% at sea level needs further derating at 70,000 ft, and the 50% factor may become 80% or 10% depending on the thermal conductivity of the encapsulant used.

Heat dissipated by tantalum capacitors, especially the larger ones, may require additional voltage derating or special heat-sinking considerations. Encapsulation of such components in a high-thermal-conductivity potting compound can keep them cool, but the shrinkage of many potting compounds during curing can put strain on the leads sufficient to insure an early failure unless special precautions are taken.

Improper choice of encapsulants or processing temperatures can cause strain-sensitive transformer cores to fail. A heat sink mounted so that it flexes with temperature can cause its transistor to fail.

Just as much effort must be put into packaging as into design in order to end up with a dependable high performance system. Most insulation, cable, and con-

1. To determine the weighting factor for the intrinsic reliability of a design going into production, check to see whether the design engineer's time on the bench was spent finding out what he had overlooked or finding out what he didn't know. If the former, no correction is necessary. If the latter, multiply by 0.3. If the engineer designed it and his red-hot tech made it work, multiply by 0.1. If the design was signed off and the preproduction models are misbehaving in a way that the prototype didn't, multiply by 0.05.

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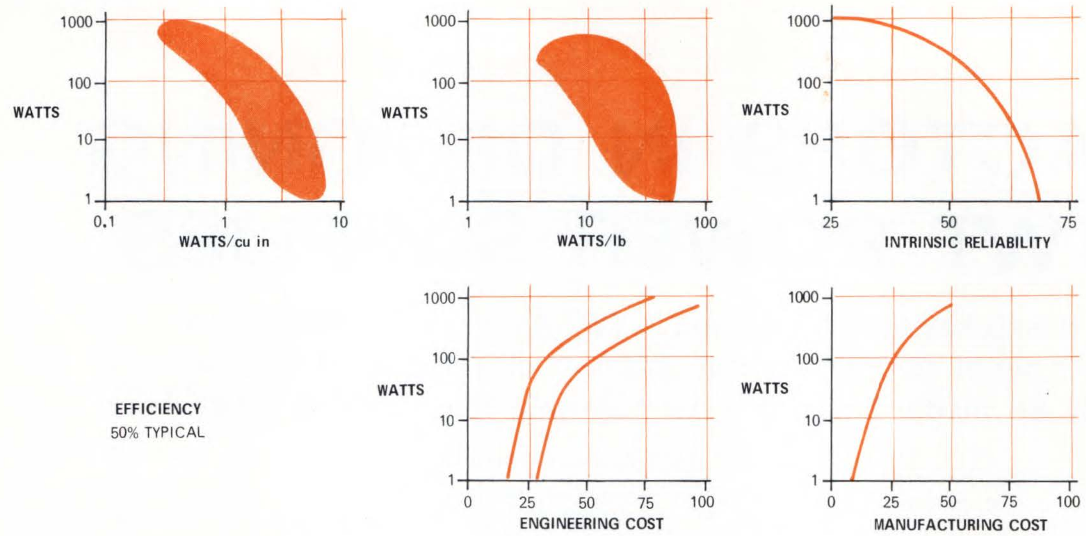
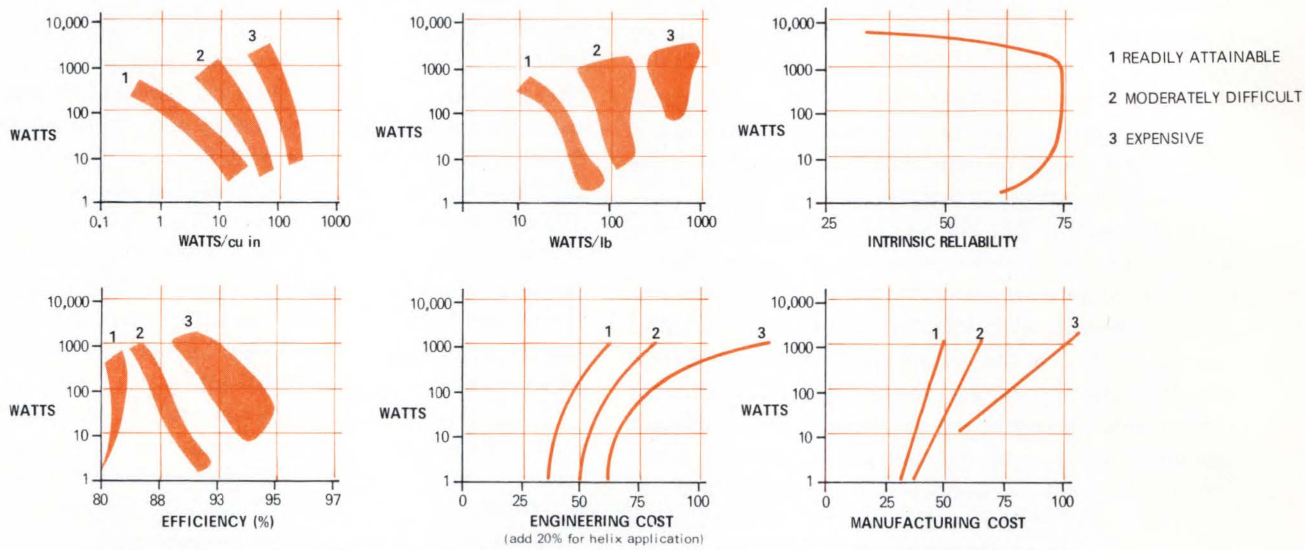
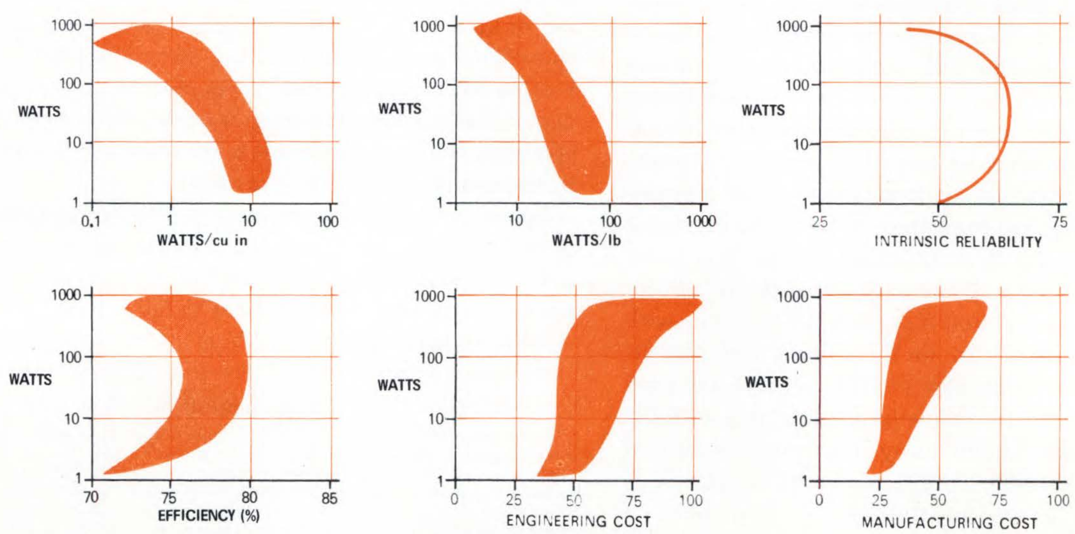
Comparative Plots of Key Factors for 8 TWT Supplies



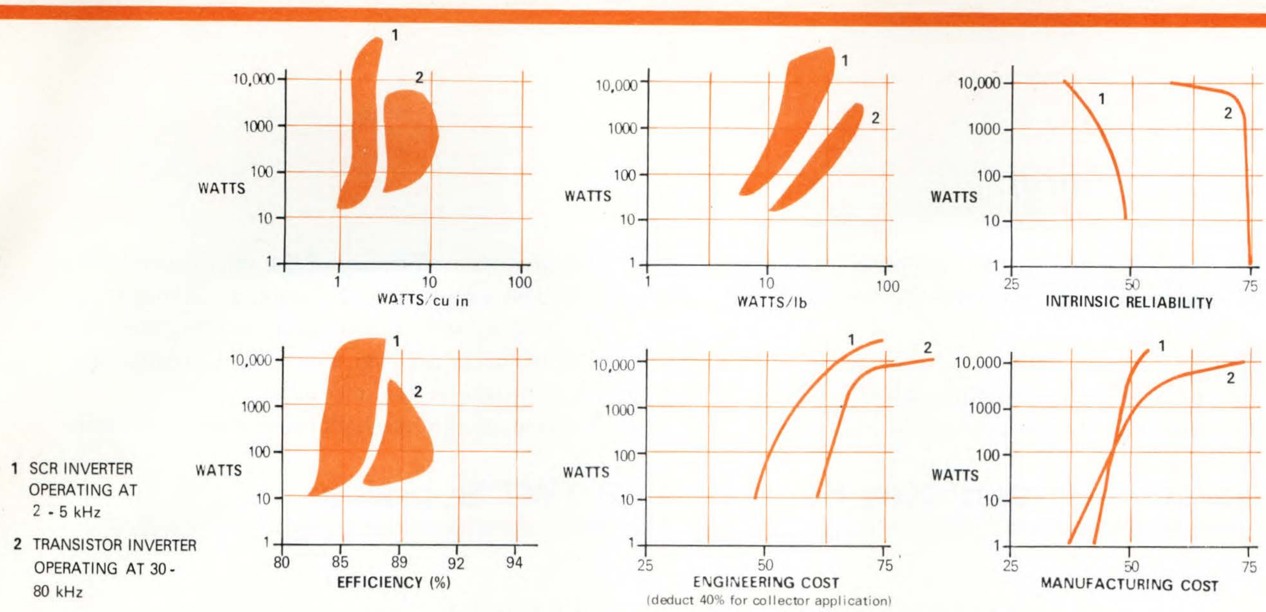
Case 1: 28V dc input, linear regulator, dc-ac inverter, step-up transformer. (Helix or Collector).



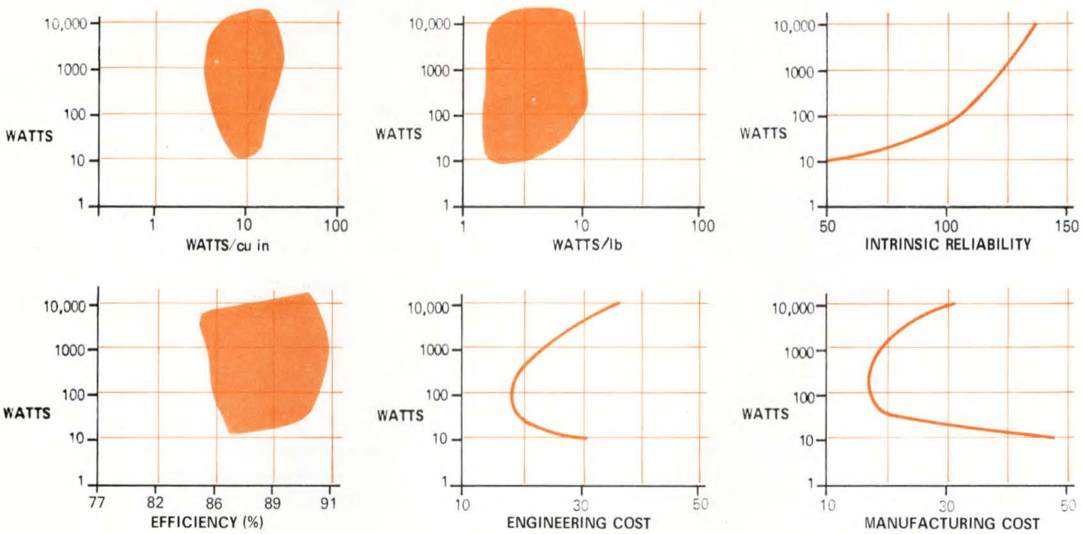
Case 2: 28V dc input, switching regulator, dc-ac inverter, step-up transformer. (Helix or Collector)



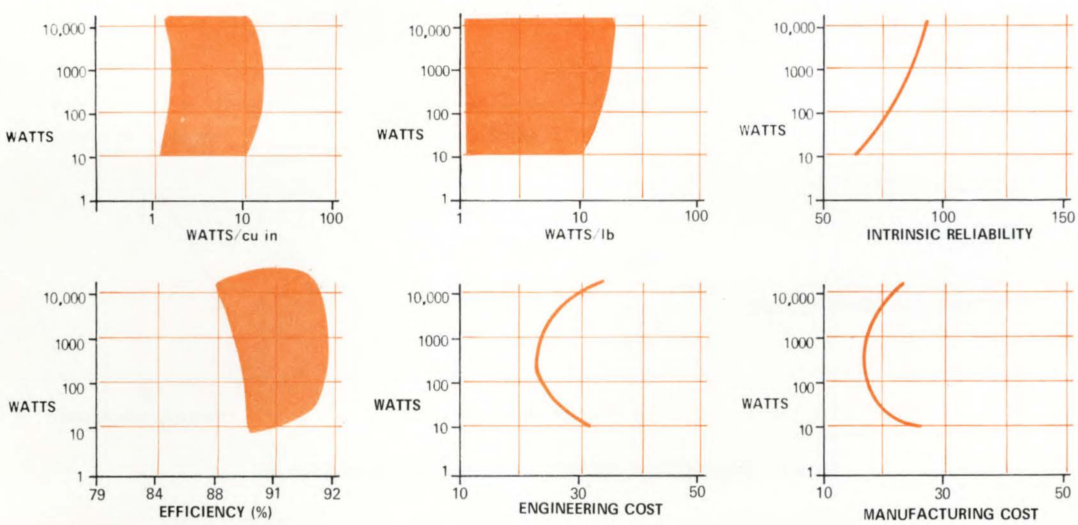
Case 3: 28V dc input, switching preregulator, linear regulator, dc-ac inverter, step-up transformer. (Helix only).



Case 4: 115V/3ϕ/400-Hz input, isolation transformer, switching regulator, dc-ac inverter, step-up transformer. (Helix or Collector).



Case 5: 115V/3ϕ/400-Hz input, magnetic amplifier, step-up transformer.



Case 6: 115V/3ϕ/400-Hz input, SCR/triac control elements, step-up transformer.

(Continued)

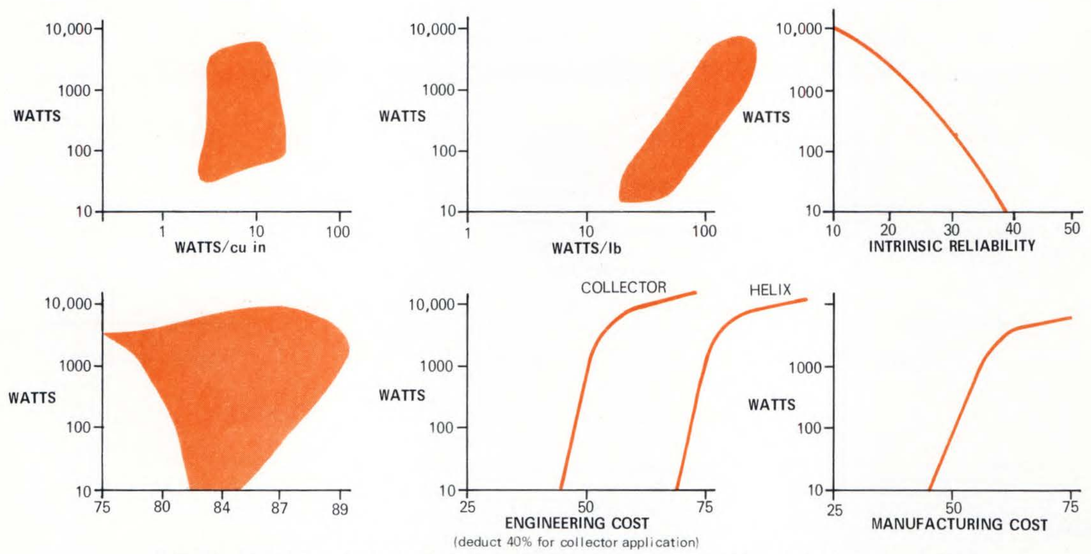
nector suppliers have applications engineers who are conversant with packaging problems. Work with them.

Efficiency

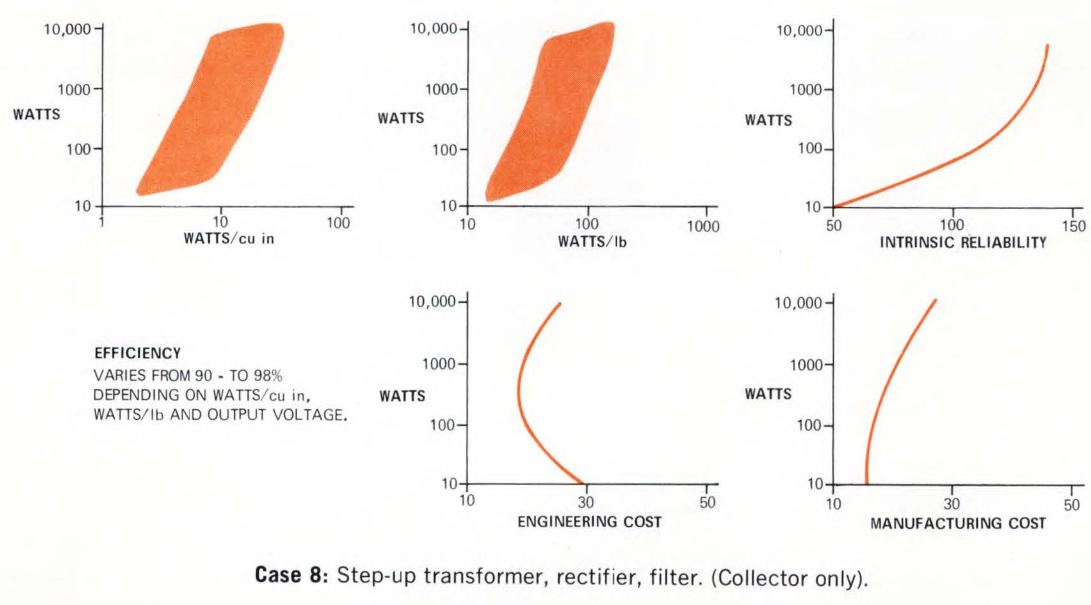
Efficiency of a power conversion system is defined here to mean the ratio of output energy to input energy. DC-to-RF conversion efficiency of the microwave tube powered by the supply is not included, although in some cases it is possible to use the heat dissipated by the tube collector to perform useful work within the system, thus raising system efficiency.

For efficiency, assign numbers directly as conversion

Comparative Plots of Key Factors for 8 TWT Supplies



Case 7: Full-wave bridge directly on the ac line, no isolation transformer, switching regulator, transistor dc-ac inverter, step-up transformer. (Helix or Collector).



Case 8: Step-up transformer, rectifier, filter. (Collector only).

efficiency percentages, and in most cases indicate a range of values, the higher being more difficult to attain. In many cases the highest value is not the absolute limit, as these numbers are not necessarily exact, nor do they embody all knowledge. For choosing and evaluating a design, a range of attainable conversion efficiencies should be plotted against average dc input power to the TWT.

Engineering/Manufacturing Cost

Engineering and manufacturing cost parameters are also relative numbers, since each company figures costs differently. Once the designer or buyer determines the cost of a particular approach, he will be able to determine the cost of other approaches with at least a ball park accuracy from the relative cost curves presented. Be aware that cost parameters assume some average efficiency, and for a particular approach, at some constant power density and volumetric efficiency the cost will increase as efficiency increases. Further, some engineers believe that the cost of developing a circuit or system is 3.1416 times greater if done for a specific job rather than company-sponsored research with no specific customer deadlines or performance levels imposed. The author's experience indicates that a factor of three to four is about right, so "pi" is probably a good choice. Bear this in mind when estimating project costs or procuring for R&D work.

Time

Time is a factor, because someone always wants to know how long it will take to complete the job. While a large company could spend $30,000 on a project in one day, and a small company could take a year to spend the same amount, both are unworkable extremes. A project costing $30k could not be done in one day because the people would not have enough time to communicate with each other. The same project, if done by one man, would be taking too long, because he would have to do everything from bench work to potting to drafting to writing weekly reports. On projects of the type discussed here an optimum group size for design and development work and for producing engineering quantities ranges from four to seven people.

Estimate the time required by determining how long it would take the number of people involved to spend the money allocated for the job. For example, if experience showed that a four-man group took 6 months to spend $60k, and optimum size of the new group turned out to be five men, one could expect that the five-man group could have done the job for $60k in about 5 months. However, be aware that if 10 people were assigned to a five-man job, efficiency will be less than optimum and the project could easily take twice as long or cost twice as much or both.

CW or Pulse

A key factor that has been almost completely ignored in the past is whether the system is CW or pulse. In the case of a pulse system, a modulator of some sort will be needed, and cathode and collector energy storage must be provided. It is important that lead lengths between these capacitors and the TWT be minimum to insure good pulse fidelity. It is also important that these energy storage capacitors be noninductive. The modulator, whatever else its requirements, must generate a pulse at the grid that is on the order of a few hundred volts positive, and is nominally floating at the cathode potential. If an anode-gated TWT is used, the modulator will have the more difficult task of switching the anode from a few hundred volts more negative than cathode potential to fairly close to ground. Grid modulators are fairly conventional, and while the attainment of high duty cycles or fast rise times often requires some expertise, their specification follows readily from the I/O requirements and environmental factors. Anode modulators are generally more difficult, expensive, bulky, and time-consuming and should be avoided.

The primary perturbation that pulse systems impose on power supplies, aside from the foregoing, is the loop frequency response criteria. For fixed PRF it is usually necessary that loop gain roll off to unity at the PRF. It is possible to maintain a stable, moderate gain beyond the PRF, but this is more difficult and places unusual limitations on the energy storage capacitors and the step-up transformer.

Sales Potential

The choice of which design approach to use should also be based on future sales potential. In many cases the systems designer has an option to spend funds over and above that allocated for the project. This may be desirable if future sales are likely. However, money is now very tight and the best current sales potentials for airborne TWT systems are those that can be satisfied with systems costing as little as possible. In 4 to 6 years the sophisticated market will probably be booming again, and experimental or developmental work will be more freely supported.

At present, probably the safest route to take is that which minimizes engineering time since it not only keeps costs down but the program is less likely to be crippled if future layoffs take place. ▭

Untuned Frequency Doubler Has Low Distortion

Most doublers must be tuned to change operating frequency, but not this one. Its circuitry combines a differential amplifier and biased diodes, making it easy to set up as well as reliable in operation.

ERWIN WINZ, IBM Corporation

Because no tuned circuits or filters are employed in its circuits, the frequency doubler shown in **Fig. 1a** permits frequency changes at will. The upper frequency it can handle is limited only by the particular diodes used and the stray capacitance of the circuit. For example the test model performed over a range of 50 Hz-500 kHz.

There are several other advantages to this doubler method. The circuit is less expensive, and uses less space, than the conventional type containing filters. Adjustment is simple. Also the output is of high quality, for it has total harmonic distortion of only −40 dB with sinusoidal input.

This type of circuit is suitable for almost any application that requires frequency multiplication, such as in the frequency multiplier stages of a PM or FM transmitter. By modifying it, squaring is possible, although amplifier gain and dc offset voltage become more critical and ac coupling is no longer possible.

The circuit shown in **Fig. 1a** was built and tested, using a differential amplifier of conventional design. A gain of 10 was chosen. Capacitors C1, C2 and C3 serve only for ac coupling. Resistors R1, R2, R13 and R12 provide adjustable bias for diodes D1 and D2. The circuit is driven by a voltage source, V_{in}, and the output is taken from the collector of Q2. (An inverted signal is available at the collector of Q1.)

Fig. 1b gives an equivalent circuit, and **Fig. 1c** the diode characteristics and the effects of $\pm V_{bias}$ for both diodes. As shown by the curves, the bias voltages shift the diode characteristics such that D1 conducts on a smaller or larger positive amplitude of the input signal, depending on the negative V_{bias} setting. Diode D2 is similarly affected, except for negative amplitudes of the input signal. The resulting current waveforms at points A and B in **Fig. 1b** are shown in **Fig. 1c**.

In **Fig. 2** these waveforms are

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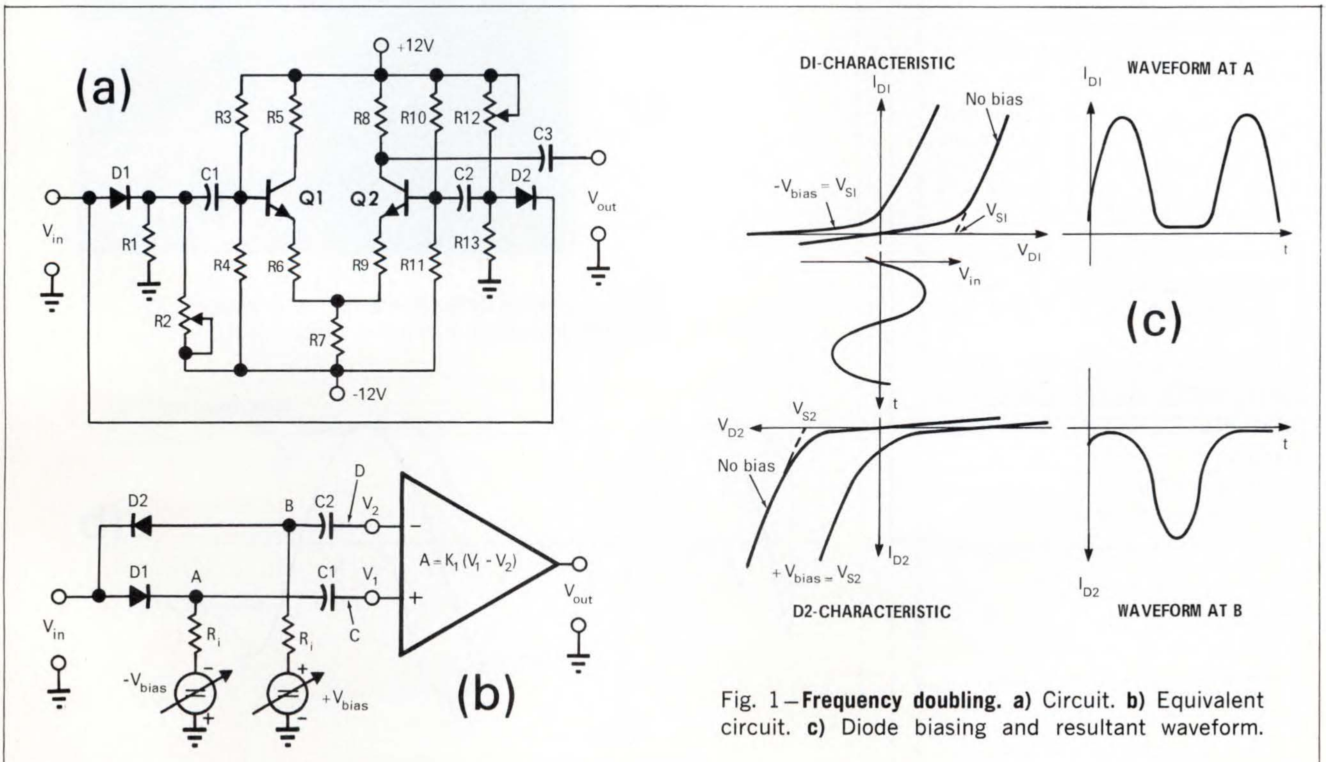


Fig. 1—**Frequency doubling. a)** Circuit. **b)** Equivalent circuit. **c)** Diode biasing and resultant waveform.

(Continued)

Doubler (Cont'd)

shown superimposed, with their dc components removed by capacitors C2 and C1. The difference between the voltages at D and C has the same form as the output voltage, except for the effect of the scale factor K1 (amplifier gain).

Although the waveforms show the basic performance of the circuit, a mathematical analysis proved that the output voltage V_{out} is, indeed, sinusoidal and that it is at twice the frequency of the input signal. It also showed that only even-order terms are present, that higher-order terms decrease rapidly and that each higher-order term contributes to the first term—a fact that is highly desirable because it reduces the total harmonic distortion of the output waveform.

Some Considerations. Diodes for use in this circuit do not have to be matched, for any mismatch can be taken care of by adjustment of the bias voltage. There is an upper limit to the input voltage. When it is exceeded, distortion occurs. However, as long as the current through the diodes is not more than approximately 1 mA (peak), distortion is negligible. Variations in the input signal level can be accommodated by adjusting the bias voltages.

For the test circuit, the required bias was approximately 250 mV for germanium diodes or 500 mV for silicon diodes. Temperature effects on the diodes cause a shift of operating point, but if a slight increase in harmonic distortion can be tolerated no bias readjustment is usually needed. ☐

Erwin Winz is a senior associate engineer in product development at IBM's Research Triangle Park facility in North Carolina. Mr. Winz graduated from Technische Hochschule, Stuttgart, with the degree of Diplom-Ingenieur.

a)

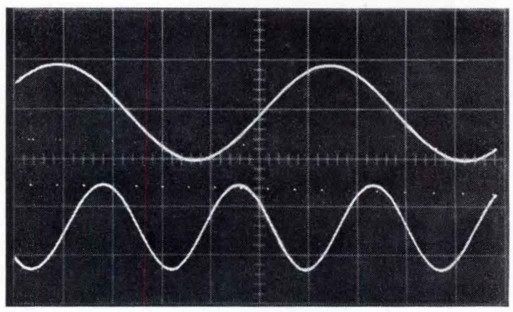
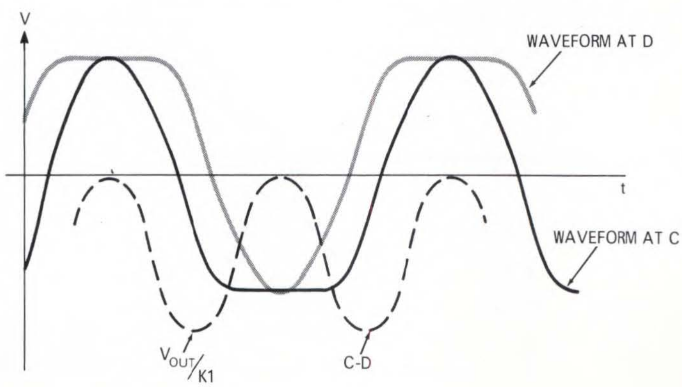


Fig. 2—**a) Scope photo** of waveforms. **b) Waveform plot** showing the doubling mechanism.



(b

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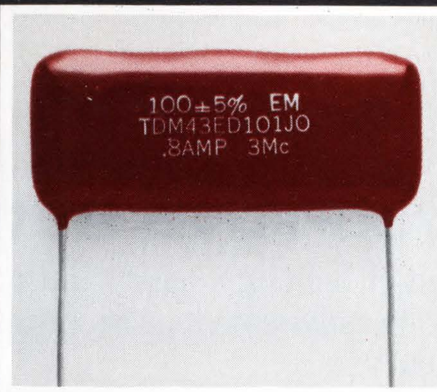

Typical TDM43 Capacitor, actual size

NEW in the industry—El-Menco TDM43 Transmitting Dipped Mica Capacitors are unequalled in small size and low cost for their ratings. Compared to conventional types with similar characteristics, they require only one-sixth as much space... save you 83% of the volume previously required. The superior coating transmits heat more efficiently, so you can use a smaller size for a given rating.

Specify these high-quality TDM43 Capacitors wherever better performance and long, reliable life are critically important... and where space and weight are at a premium. For medium power, moderate-to-high voltage service, TDM43's can be used in tuned amplifier tank circuits, for DC blocking in high frequency amplifiers, in high frequency filter networks needing high Q and RF current capabilities, and in timing circuits requiring a high degree of stability.

Check the table below for representative values among the many standard TDM43 units available... or call or write Electro Motive if you have a special application or one in which pulse conditions are present. Technical literature available on request.

Ideal for high frequency circuits, in military, communication, and industrial portable and airborne equipment... equivalent to RTM 63 in EIA spec. TR-109.

Typical Values Available—TDM43 Transmitting Dipped Mica Capacitors

Capacitance Value in pF	60 Hz Peak W.V.	Characteristic	Rated Current in amps. at Freq. of 3.0 MHz	1.0 MHz	0.3 MHz	0.1 MHz	Max. Dimens. in Inches L	W	T
47	1500	C	0.50	0.10	0.07	0.03	2.010	.850	.220
1200		F	4.90	3.80	1.20	0.42	2.010	.850	.230
2700		F	5.90	5.80	2.20	0.90	2.010	.850	.230
3300	1000	F	6.10	6.20	2.60	1.10	2.010	.850	.230
5600		F	6.50	7.30	4.10	1.80	2.010	.850	.240
9100		F	6.80	8.10	5.50	2.40	2.020	.860	.260
10,000	750	F	6.90	8.40	6.40	2.70	2.020	.860	.260
15,000		F	7.00	8.90	7.80	3.30	2.030	.870	.280
20,000		F	7.10	9.20	8.30	3.50	2.040	.880	.310
22,000	500	F	7.20	9.40	8.80	3.70	2.030	.870	.300
30,000		F	7.20	9.60	9.30	3.90	2.040	.880	.320
36,000		F	7.30	9.80	9.70	4.10	2.040	.890	.340
39,000	250	F	7.30	9.90	10.0	4.20	2.050	.890	.350
68,000		F	7.40	10.3	10.9	4.50	2.050	.900	.370
100,000		F	7.40	10.5	11.5	4.70	2.070	.910	.440

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CIRCLE NO. 17

Two Prove Better Than One

Instead of fighting a costly battle to get a single capacitor that would satisfy reliability requirements, this component engineer paralleled smaller ones as a solution.

ARTHUR F. BISSELL, Ball Bros. Research Corp.

Larger-value metallized-film capacitors (10 μF for example) are frequently used in resonant circuits for producing video deflection currents. However, trouble with heating often occurs and is difficult and expensive to eliminate.

Metallized polycarbonate capacitors are frequently chosen for such applications because of their desirable properties of excellent stability, low df and small size. One drawback to their use at these frequencies concerns their df, which may be low when measured at the usual 120 Hz, but quite different at video frequencies. Another results from the edge-foil termination used to keep down the physical size. Such a termination does not provide good heat dissipation, which aggravates the heating problem already present from the capacitor's df.

Assuming that the better qualities of metallized polycarbonate capacitors dictate their use, it is up to the designer to somehow solve the heating problems. One approach is, of course, to specify a low df at the use frequency, but this gets costly and still doesn't relieve the other weak link of the chain—the poor heat transfer by the edge-foil termination. A better answer is to simply parallel two 5 μF units. This, while seldom done, has many advantages. It divides the current approximately equally between the two capacitors, and at the same time doubles the number of lead wires that are available to conduct heat away. Also the increased capacitor surface area provides improved heat radiation. A major gain comes from the heat reduction that results from paralleling the capacitor's equivalent series resistance.

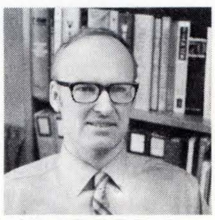
Other gains are also possible in the areas of both packaging and purchasing. The two 5 μF units have only slightly greater volume than a single 10 μF, but are shorter, and this may permit better space utilization. Also it may be cheaper to purchase twice as many 5 μF units than to buy the usual quantity of 10 μF ones.

Summed up, in this application paralleling:

—greatly reduces heating problems.

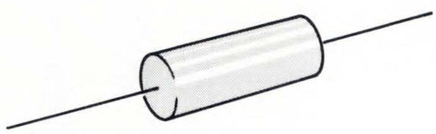
—adds flexibility as far as mounting is concerned.

—offers possibilities for reducing cost. □



Arthur F. Bissell is a group engineer at Ball Brothers Research Corp. where he is concerned with component selection, specification and testing. Mr. Bissell holds a B.S.E.E. from the University of Colorado.

VIDEO FREQUENCY TANK CAPACITOR CONSIDERATIONS

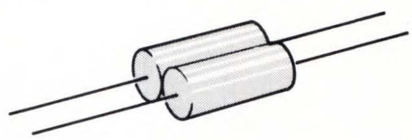


Single 10 μF metallized polycarbonate capacitor.

Notes:

(1) Dissipation factor, df, normally tested at 120 Hz, may be appreciably higher at video frequencies.

(2) Heat dissipation capability is restricted by the limited area of the internal contact, by thermal resistance of the lead wires and by the area of external dissipating surface.



Paralleled 5 μF units of the same type.

Notes:

(1) Dissipation factor is reduced to less than half that for the single 10 μF capacitor, greatly reducing heating.

(2) Heat dissipation is improved by the doubled number of internal contacts and lead wires, and by the increased external surface area.

Dual Mode Stepping Motor Drive

This circuit combines high-speed slewing and incremental positioning of stepping motor drives. Advantages are an uncomplicated closed-loop circuit, with the transition to step-by-step control executed easily and smoothly.

JACOB N. KLUGER, Xerox Corp.

In this design, a two-pole, two-phase, bifilar-wound motor[1] is used. Shaft angle and electrical angle are therefore the same, with four 90-degree steps in each cycle. An optical commutator disc and photocell array provide shaft-angle information; the large step angle makes it easy to install and adjust the device.

The commutating and control circuit is diagrammed in **Fig. 1**. Slewing is commanded by setting the $\overline{\text{STEP}}$ input to a high level and the $\overline{\text{SLEW}}$ input low. Each photocell "sees" the shaded sector of the disc as it passes, and their signals act to directly set the ring counter stages. The sector is 60 degrees wide, and adjusted so that the boundary leads the shaft angle by 45 degrees. Consequently, only one photocell signal is generated at a time and the sequence of motor winding excitation satisfies **Table 1**. Motor torque and speed are optimized by relating winding excitations to the shaft angle as shown in **Table 1**.

1. The motor is an IMC 015-815, with a load at the shaft of 0.7 oz-inch friction and 0.005 oz-inch² inertia. Slew speeds of 450 steps/sec are reached, followed by open-loop positioning at 120 steps/sec.

TABLE 1

COMMUTATION SEQUENCE FOR THE HIGH-SPEED SLEWING OF A STEPPING MOTOR

Shaft Position Range	Energized Windings	Position Toward Which Motor is Driven
315° - 45°	A1 & B2	90°
45° - 135°	A2 & B2	180°
135° - 225°	A2 & B1	270°
225° - 315°	A1 & B1	0°

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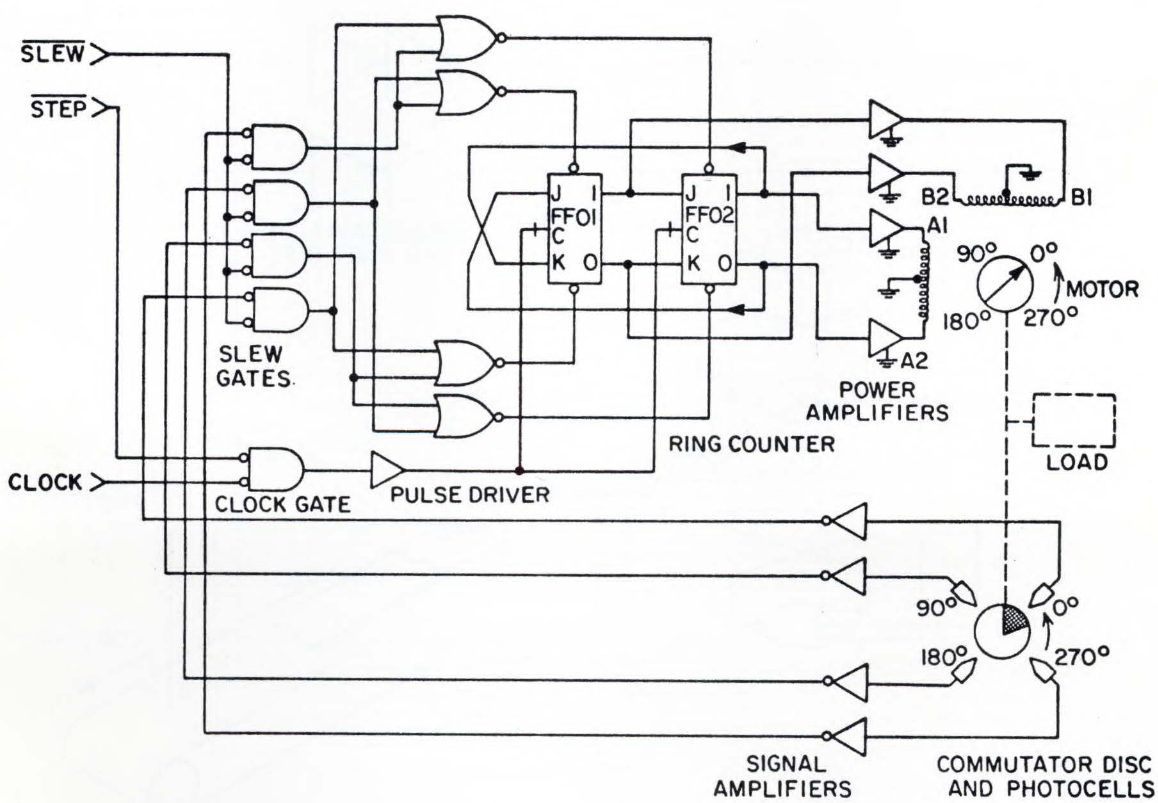

Fig. 1—**Motor winding** connections and commutator disc arrangement to provide slewing or stepping in the direction shown.

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Drive *(Cont'd)*

Suppose that the motor is to be slewed from the position shown in **Fig. 1**. The 0-degree photocell signal is high and the others low, setting counter stage FF01 low and FF02 high. Windings A1 and B2 are therefore energized, causing the motor to seek a new equilibrium at 90 degrees. Prior to reaching that position, however, the 90-degree photocell will see the leading edge of the commutating sector. The sensor at 0 degrees will, in the meanwhile, have been deactivated as the trailing edge of the sector passes well beyond it. The switching action will then be repeated as the motor advances through the next quadrant.

Clocked pulse operation is obtained by setting the $\overline{\text{SLEW}}$ input high and the $\overline{\text{STEP}}$ input low. The clock rate is within the relatively low range where the motor responds without error. The counter drives the motor in conventional open-loop fashion since the slew gates now inhibit all photocell signals. Stepping proceeds from the last state in which the counter was placed by the slewing connections, and a smooth transition is obtained as the motor slows down to the clocked rate. The motor and load are stopped by holding both $\overline{\text{STEP}}$ and $\overline{\text{SLEW}}$ signals at their high levels.

This drive is used to operate a conveyor (**Fig. 2**). The object is to move the piece being conveyed to a position determined by photocell PC02 and then stop the conveyor. A GO pulse enables (and latches) gate A02 and disables gate A01 to start the slewing mode. When the piece is detected by PC01, the resulting pulse disables A02 and enables A01 to place the system in the stepping mode. Detection of the leading edge of the piece by PC02 enables both A01 and A02, and the conveyor immediately stops. ▭

Jacob N. Kluger has been with the Xerox Corp. in Rochester, N.Y. for 7 years. He now is a senior engineer with responsibilities for advanced development and design engineering. Kluger holds a B.M.E. from Cooper Union and an M.S. from the Univ. of Rochester. He has two patents applied for and is a member of NYSPE and ASME.

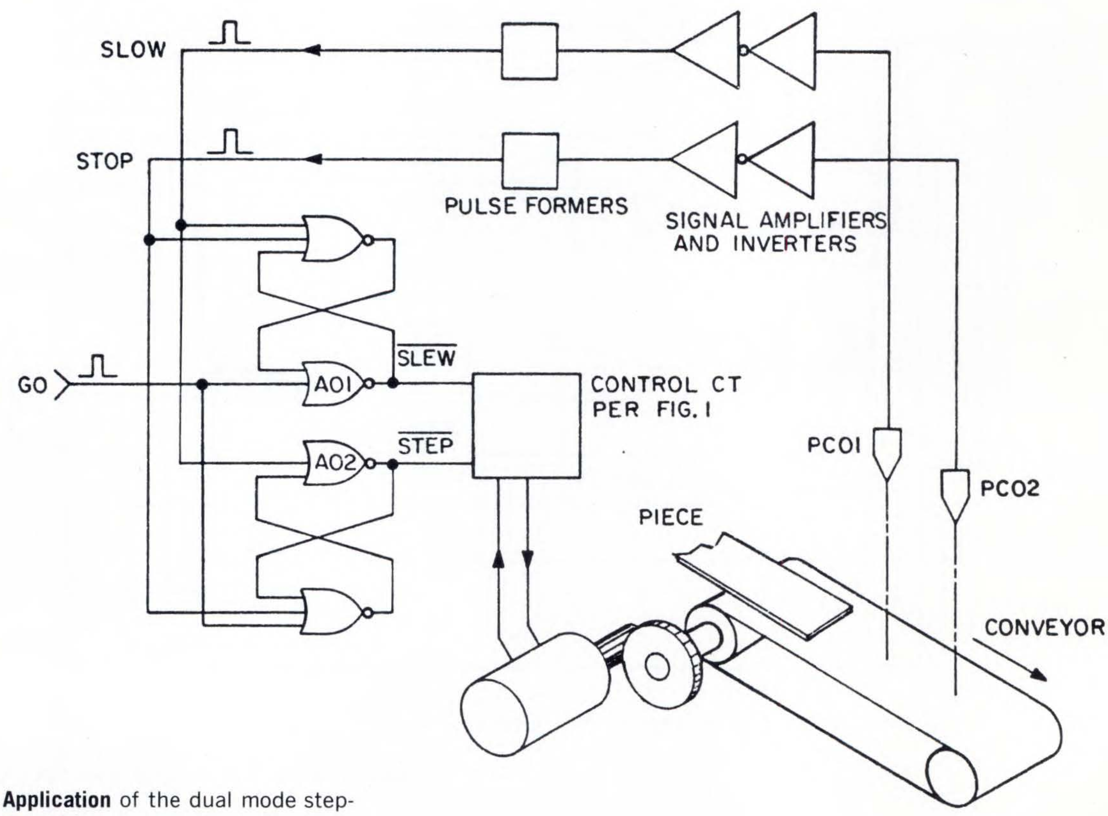

Fig. 2—**Application** of the dual mode stepping motor drive to operate a conveyor.

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Voltage-controlled current source

To Vote For This Circuit Circle 151

by Peter T. Skelly
University of Washington
Seattle, Wash.

As shown in **Fig. 1**, a voltage-controlled current source can be constructed using complementary transistors in the feedback loop of an operational amplifier. This type of circuit is superior to the more usual op-amp current-source configuration (**Fig. 2**) because the improved circuit always has near-zero common-mode voltage at the input to the op amp. With the conventional circuit of **Fig. 2**, the common-mode input voltage is approximately equal to the voltage drop across the load.

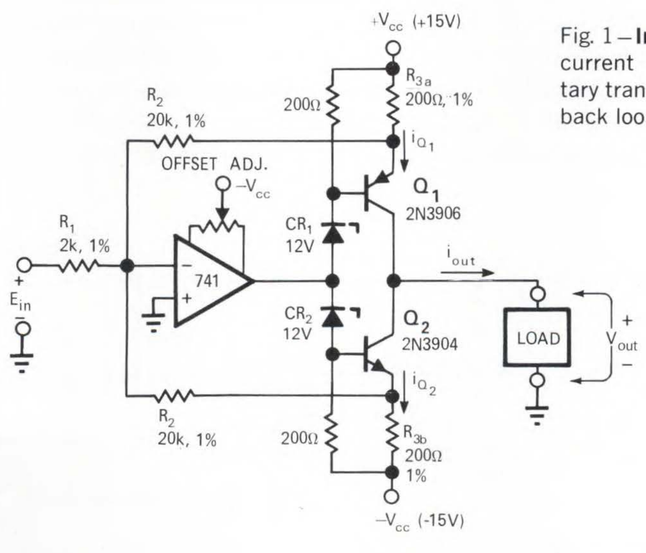
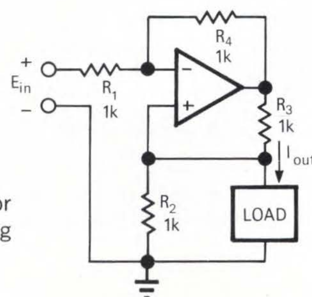


Fig. 1 — **Improved** voltage-controlled current source with complementary transistors in the op-amp feedback loop.



$$I_{out} = \frac{-E_{in}}{R_1} = -1\ \mathrm{V/mA}$$

$$\frac{R_1}{R_2} = \frac{R_4}{R_3}$$

Fig. 2 — **Conventional** configuration for voltage-controlled current source using an op amp.

The circuit of **Fig. 1** was designed for use in an integrator with a ground-referenced integrating capacitor. With the component values indicated, it produces 1 mA/V. The general transfer equation is:

$$i_{out} = \frac{2V_{in} R_2}{R_1 R_3}$$

Resistors R_{3a} and R_{3b} sense the current through Q_1 and Q_2 so that a voltage proportional to the difference ($i_{Q1} - i_{Q2}$) is fed back to the input of the op amp for comparison with the input voltage. The output current I_{out} also equals this current difference ($i_{Q1} - i_{Q2}$) if we neglect the base currents of Q_1 and Q_2.

The zener-diode voltages determine the quiescent-current level. Operation at very low quiescent currents is possible without crossover distortion because of the current-sensing feedback.

Lowest output-offset currents can be achieved by using transistors with large matched betas and by nulling the offset voltage of the op amp. The op amp should be compensated for operation at a gain of R_2/R_1. Frequency response of this type of circuit is limited by op-amp bandwidth and slew rate and by the frequency response of the transistors. For the circuit shown, frequency response is limited to 1 MHz by the performance of the specified op amp. ▭

Staircase generator uses current-regulating diode

To Vote For This Circuit Circle 152

by Robert G. Warsinski
Ford Motor Co.
Detroit, Mich.

The output of a pulse-generating position transducer must sometimes produce an analog input for the horizontal axis of an X-Y recorder or storage scope. Unfortunately, many pulse-to-analog converters depend on the repetition frequency of the pulses (transducer velocity) as well as on the actual number of pulses (transducer position).

A well-designed staircase generator can produce an analog output which is proportional to the number of input pulses, regardless of repetition frequency. The key to the transducer-interface circuit described here is the use of a current-regulating diode (CRD) as a constant-current source in a staircase generator circuit. The rest of the circuitry is fairly conventional.

Basically, the staircase generator operates as a charge-exchange integrator. Each input pulse causes ceramic capacitor C_5 to become charged to approximately 7 mV. Between pulses these charges drain off, resulting in current flow through diode CR_6, and thus causing the LH201 op amp to charge low-loss capacitor C_6 by an equal amount. This transferred charge is held by the integrator capacitor, and is added to all subsequent charges received by charge exchange from C_5. The integrator's output voltage continues to increase up to the saturation level of the op amp in a series of 7-mV staircase steps.

To insure that the same amount of charge goes to C_5 with every pulse, regardless of pulse rate, a monostable multivibrator is employed to switch on Q_3 and the CRD for a constant time duration with every pulse.

Relay AR automatically resets the integrator to zero when the output voltage reaches almost 8.7V. This prevents data from being lost if the op amp should saturate before the data run is completed. ▭

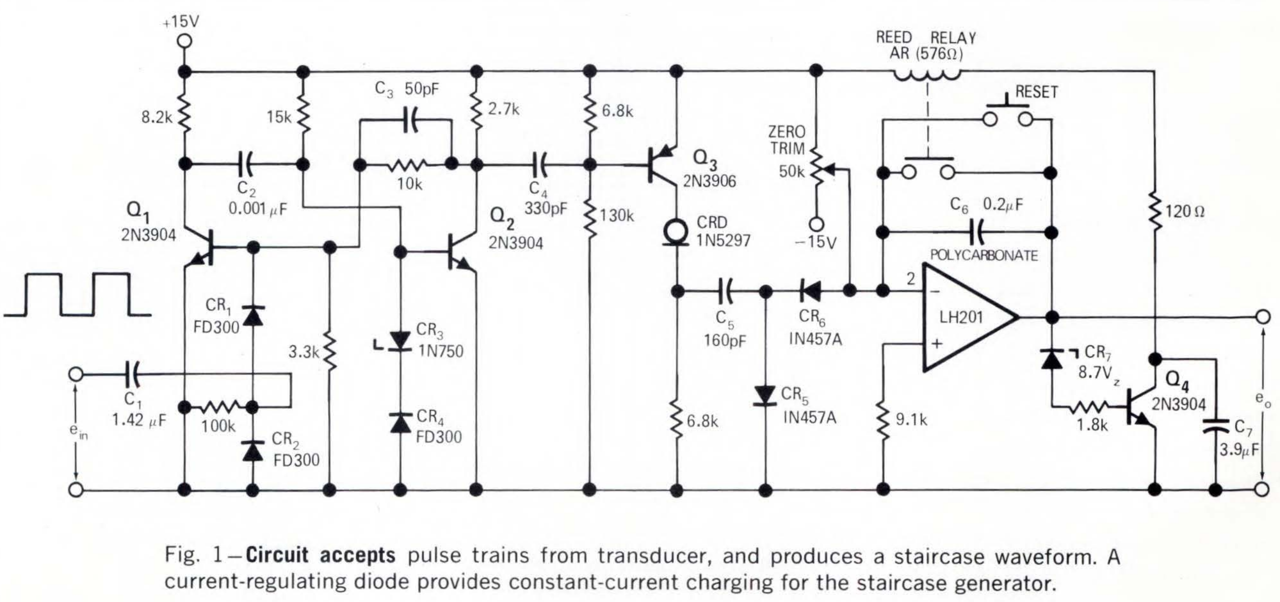


Fig. 1—**Circuit accepts** pulse trains from transducer, and produces a staircase waveform. A current-regulating diode provides constant-current charging for the staircase generator.

Multiplexing without FETs

To Vote For This Circuit Circle 153

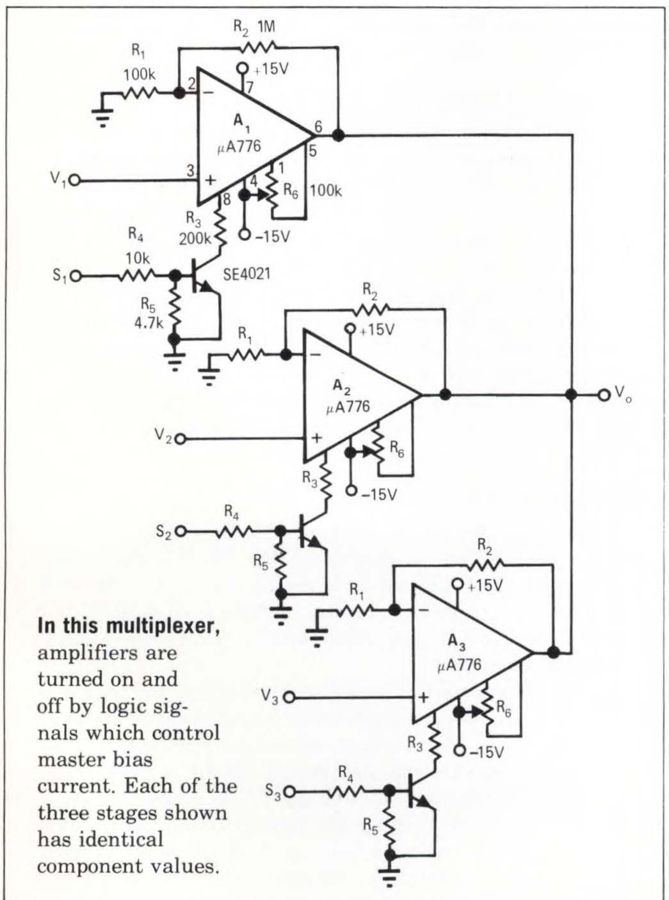
by **Marvin K. Vander Kooi**
Fairchild Semiconductor
Mountain View, Calif.

A circuit for time-division multiplexing and signal conditioning usually requires FET switches and buffer amplifiers. If FET switches are used, the system will require additional positive and negative supply voltages that are sufficiently larger than the peak signal amplitude to ensure that the FETs turn on and off completely.

The circuit shown here, however, completely eliminates the need for FET switches. This circuit uses the new μA776 op amp, which has an external bias-current-setting feature.

The amplifiers operate from conventional ±15V supplies, and the multiplex inputs (S_1 through S_3) can be driven directly from TTL or DTL devices. Each amplifier is controlled by either supplying or denying its 70 μA master-bias input, thus turning the amplifier ON or OFF, respectively.

For the circuit shown, the isolation between an ON amplifier and a signal fed to the input of another OFF amplifier is 80 dB at 50 kHz. Switching time of the output, from one multiplex to the next, is limited only by the 1 μV/sec slew rate of the amplifier. The SE4021 transistor, indicated in the schematic, has a leakage (I_{cbo}) of only 2nA, which ensures complete amplifier turn-off.



In this multiplexer, amplifiers are turned on and off by logic signals which control master bias current. Each of the three stages shown has identical component values.

New Company's Conversion Modules Break Price/Performance Barriers

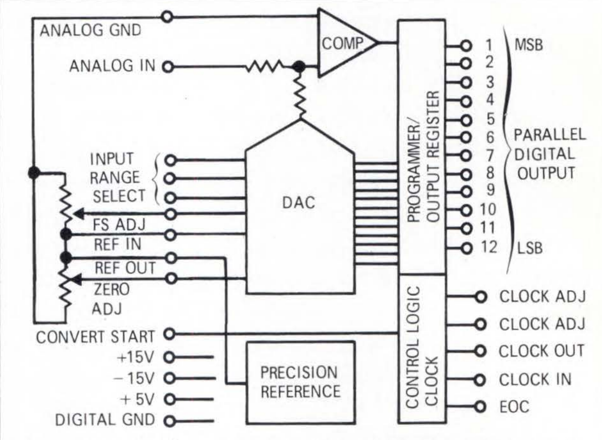
PROGRESS IN PACKAGED CIRCUITS

Cycon, Inc., a new company in Sunnyvale, Calif., has introduced its initial product line—an impressive family of 36 digital-to-analog converters and 18 analog-to-digital converters. One of the new modules, Model CY3235, is said to be the first high-performance, 12-bit ADC to break the $100 price barrier. Using the successive-approximation technique, it provides analog-to-digital conversion to an accuracy of 0.01% in less than 50 μsec. According to L. Wayne Peacock, Cycon's VP of Marketing, the CY3235 with a unit-quantity price tag of only $99 is "comparable in speed, linearity and temperature stability to units costing over three times as much."

The company's new DACs achieve similar price breakthroughs. One 8-bit external-reference DAC with a settling time of 20 μsec sells for $16 (1-24) and $13.50 (25-99). This beats Zeltex's price of $19 (1-99) for a comparable unit. (However, the Zeltex unit has a built-in reference element and can be strapped to provide three different output ranges, whereas the Cycon unit provides a full-scale output of ±10V only). Other Cycon DACs provide accuracies as good as 0.01% (less than ±1/2 LSB for a 12-bit unit) over the entire operating-temperature range. High-speed units have settling times as low as 2.5 μsec.

Cycon's conversion modules are available with resolutions from 8 to 12 bits (binary) and from 2 to 4 digits (BCD). Standard output ranges of 0 to 10V, ±5V and ±10V are offered for the DACs, and the ADCs have similar input ranges. With most of the modules, ranges can be selected and the user can choose between an internal or external reference, merely by strapping pins. If required, the internal reference of one unit can drive up to five additional units, thus insuring common temperature tracking.

Cycon's type CY3235 A/D converter has 12-bit resolution and sells for $99 in single quantity.



Functional block diagram of the CY3235 which uses a successive-approximation conversion technique.

Industrial Temperature Range

All conversion modules are specified for operation over the temperature range of 0 to 70°C. Satisfactory operation is also possible from −25 to 85°C. Depending on the particular model chosen, temperature stability ranges from 5 to 100 PPM/°C. Settling times of DACs range from 1 to 5 μsec, while conversion times of ADCs range from 10 to 100 μsec.

The DACs are housed in compact encapsulated modules (2 by 2 by 0.4 inch) with DIP IC pin spacing and layout compatibility. ADC modules (2 by 4 by 0.4 inch) are exactly twice the size of the DACs. The pin layout is consistent for all models, thus allowing convenient interchangeability of units when different resultions or other optional features are required.

Optional Features

All the ADCs include an internal adjustable clock, but they can also be run from an external system clock. Optional features include input-impedance buffering (to over 100 MΩ) and serial output. Cycon expects, also, to offer variations on the DACs: for example, making them suitable for two-wire digital-to-current conversion.

According to Jerry Collings, Cycon president, the company intends to introduce comprehensive lines of modular building blocks in three basic areas: conversion products, signal-conditioning devices and nonlinear-function modules. The company's founders are all well qualified in these areas of technology. Peacock, Collings and Dean C. Bailey (Cycon's VP of Operations) all recently held top management positions with Precision Monolithics. Collings was also one of the original founders of Zeltex. Cycon, Inc., 1080 E. Duane Ave., Sunnyvale, CA 94086. **287**

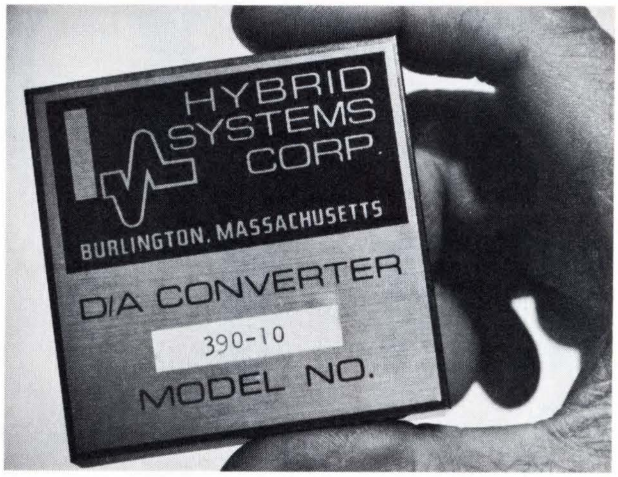
High-Speed Multiplying DAC Simplifies CRT Displays

PROGRESS IN PACKAGED CIRCUITS

A new digital-to-analog converter from Hybrid Systems is said to be as fast as the fastest fixed-reference types available, yet it can perform at these speeds in the multiplying mode (varying reference voltage) as well as in the fixed-reference mode. The 10-bit multiplying DAC, Model 390-10, has an output settling time of 50 nsec (to within 0.05 percent) for a full-scale digital input change, and 5 μsec for a full-scale reference voltage change. The reference voltage range is 0 to 6.2V.

Display-Terminal Application

One important application for multiplying DACs occurs in CRT display terminals. Using DAC modules, displayed characters or symbols can be synthesized from a series of straight lines, and the computer only has to generate sufficient data to define the initial position, slope and length of each line. By contrast, in conventional display systems the computer must generate sufficient data to define symbols point-by-point. Thus DACs can greatly simplify display systems and relieve the digital computer of much of its heavy burden. Hybrid's 390-10 is especially suitable for this type of application because of its fast settling and because its current (rather than voltage) output allows the output of two DACs to be summed through a single resistor. The full-scale current output of the 390-10 is 5 mA.



Hybrid Systems' new 10-bit multiplying DAC has a settling time of only 50 nsec, which makes it especially useful in display applications.

A typical system block diagram, for a display terminal using DACs, is shown in **Fig. 1**. Digital inputs applied to the fixed-reference DACs locate the initial position of the CRT beam, while the variable-reference converters move the beam along a line from that initial position. The slope and length of the line are determined by the digital inputs applied to the multiplying DACs. In this way the beam can be moved in a series of straight-line segments, and under computer control, any shape or pattern may be displayed.

Suppose, for example, that one wished to produce the letter "A" which requires three line segments. Then the beam would be moved through two 45-degree motions and one horizontal motion. The digital computer needs to generate only 12 numbers (4 for each line) to completely form the letter. If the computer generated the letter point-by-point, it would be required to compute up to 150 numbers. Of course, more complex shapes (especially those involving curved lines) require more line segments, but the DAC approach continues to provide greater simplicity than point-by-point generation. In fact, with the conventional approach, the computations required for rapid generation of complex shapes could quickly tie up or even overload the computer.

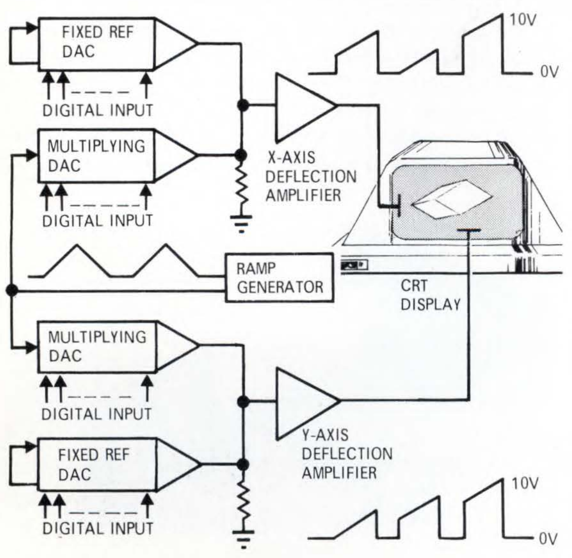
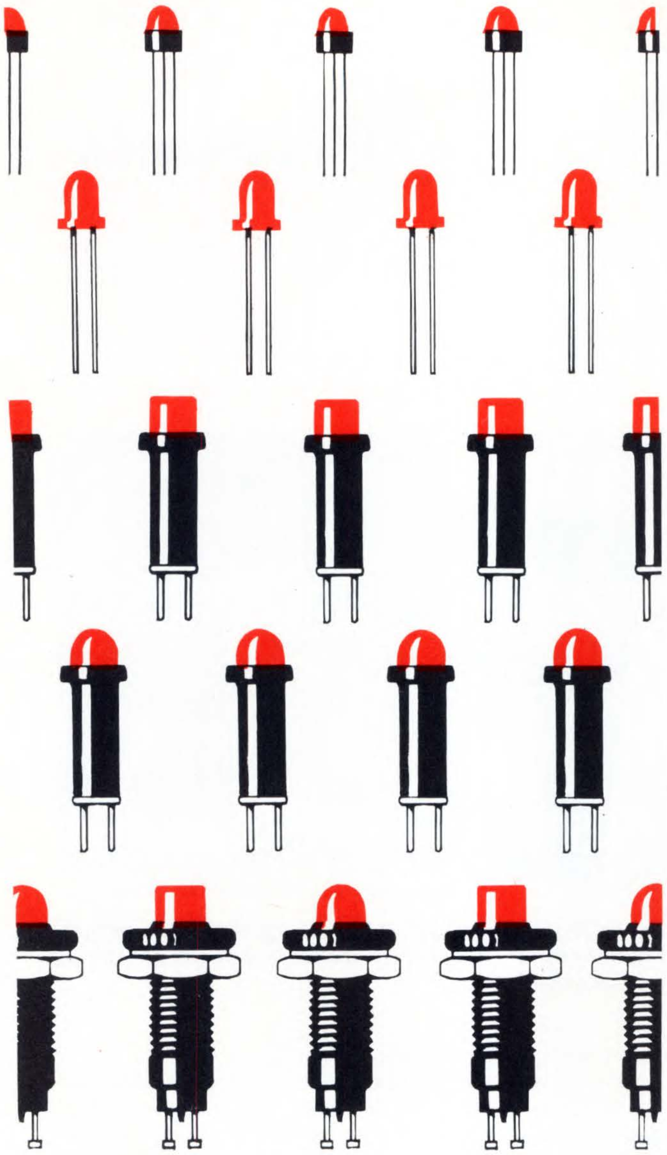


Fig. 1—Schematic diagram shows how digital-to-analog converter can simplify design of a display terminal. Fixed-reference DACs determine the starting points of straight-line segments, while multiplying DACs determine the length and direction of each line (by attenuating the triangular-waveform reference signals).

Fixed or Variable Reference

Hybrid's 390-10 has a built-in reference and can be easily strapped for fixed-reference operation, if required. It accepts TTL or DTL digital inputs, and operates from ±15V power supplies. Housed in a compact module (2.3 by 2.3 by 0.525 inch), it weighs under 3 oz. The temperature coefficient is only 30 PPM/°C over the operating range of 0 to 70°C. In quantities of 1 to 9, it costs $150. Delivery is stock to 2 weeks. Hybrid Systems Corp., 95 Terrace Hall Ave., Burlington, MA 01803. **288**

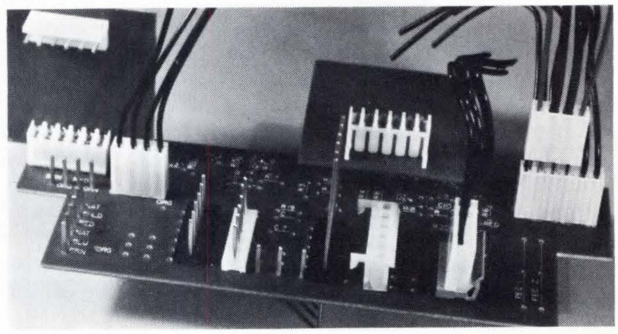


Design Versatility Touted in New Packaging Systems

PROGRESS IN PACKAGING

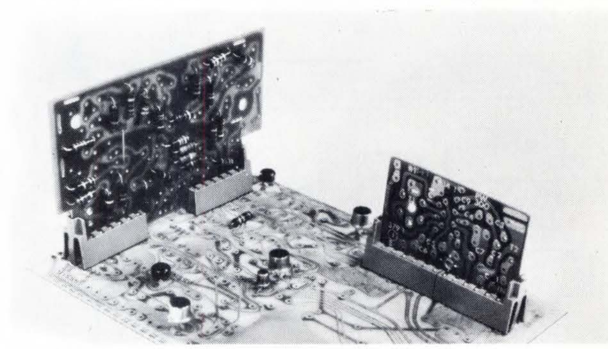
Two packaging systems that add another degree of versatility to PC board design are the "Conectcon" system from Molex Inc. and the "BergCon" interconnection system from Berg Electronics.

In the "Conectcon" system (based on a modular building-block concept), a male terminal, mounted on a PC board, connects with a female terminal preassembled in the required housing. Male terminals can be staked directly or placed (already assembled in a nylon wafer) onto a PC board. Three female assemblies complete connections for: cable-to-board, board-to-board parallel, board-to-board perpendicular and board-to-chassis. All housings are made of molded nylon. Terminals used in these housings are crimped to wires and snap-lock into place. They can be removed easily with an ejector tool. Housings can handle from 3 to 24 wires in sizes from 18 to 26 gauge. Photo below shows many aspects of



"Conectcon" packaging flexibility.

"BergCon" consists of crimp-to-wire disconnects, wire-wrapping posts and multiple contact housings for 0.1-, 0.215- and 0.15-inch spacing. Pins designed for high-speed, close-tolerance staking on 1/16-inch PC boards can be used in a variety of ways including a low-cost interconnection method featuring free access to IC legs for soldered and wrapped-wire

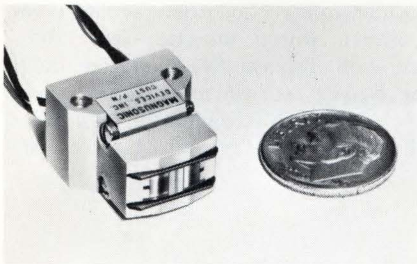


terminations.

Multiple contact housings include rapid connect and disconnect snap-housings, a mini-housing allowing simultaneous termination of up to 72 terminated conductors, and a variety of PC card connectors. The photo shows a typical mounting configuration where connector blocks are shown mounted together and separated to accommodate larger boards.

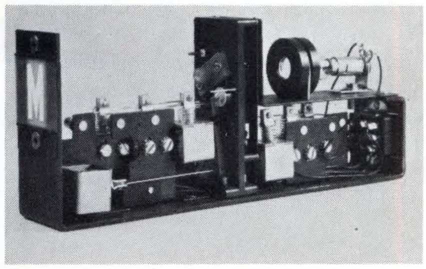
"Conectcon", Molex Inc., Downers Grove, IL 60515.

"BergCon", Berg Electronics Inc., New Cumberland, PA 17070. **290**



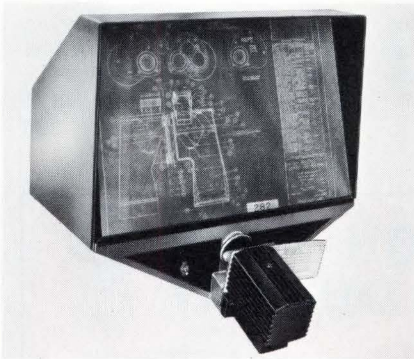
Cassette read-after-write head, Model 216, comes in single and 2-channel configurations and is obtainable in up to 4 tracks. A unique trough guide (patented) accurately guides the tape over the complete head. The head can be used at densities up to 3200 flux changes/inch and at speeds from 1 to 7 ips. Track formats such as ANSI, ECMA and ISO are proposed standards. Magnusonic Devices, Inc., 124 Duffy Ave., Hicksville, NY 11801. **291**

Calculator Model EC 1117 features many of the capabilities of larger machines. Nixie display has a 12-digit capacity plus sign, decimal point and underflow—when the calculator can handle no more numbers, it eliminates digits from the right. A 3-position switch permits selection of "Round-off", "Round-up" or "Truncate" operating positions. Price is $545. Friden Div., The Singer Co., San Leandro, CA 94577. **294**

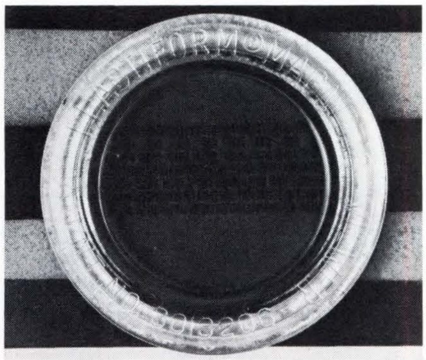


Self-decoding visual readout device, MAJOR-64, is ideal for computer peripherals and digital displays. The unit randomly selects any one of 64 images from a single high stability film. Time is <70 msec from application of an input signal to back projection of the image onto a 7.5- by 10-inch screen. Unit dimensions are 1.6 by 3.5 by 8.75 inches. Major Data Corp., 891 W. 18th St., Costa Mesa, CA 92627. **297**

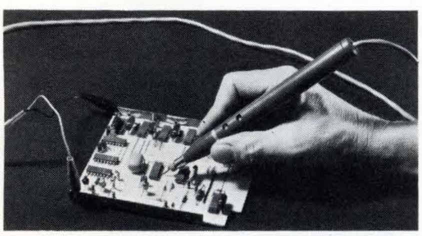
Alterable read-only memory system permits microprogram testing and debugging in a real-time environment. Execution time is 220 nsec/instruction. Basic capacity of 1k × 16 is expandable to 2k × 16 at additional cost. Supporting software and a 400-page microprogramming handbook are included with each purchase. Microdata Corp., 644 E. Young St., Santa Ana, CA 92705. **292**



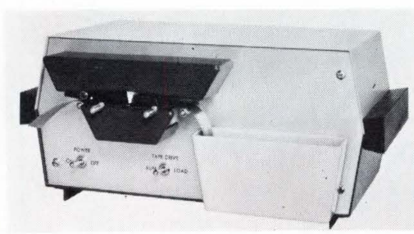
Micro-film and aperture card reader, HP-12, provides the user with a complete image, no scanning required. It has a built-in manual focusing and renders clear images of 12× magnification on a 14- by 20-inch ground glass screen. Lenses for greater magnification are available. Price for the 19- by 20- by 14-inch unit is $295. Warren Machine Co., 117 Urban Ave., Westbury, NY 11590. **295**



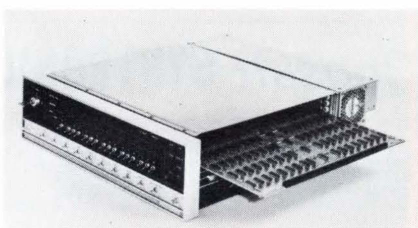
Magnetic tape viewer has a sharp resolution at a density of 800 bpi and gross flaw detection possible up to 3200 fci. Measuring 1-3/4 inches in diameter, the disc-shaped unit consists of finely divided magnetic material suspended in a solution. When the viewer is placed on the tape, the magnetic field pattern forms a clear image. 3M Co., Box 3686, St. Paul, MN 55101. **298**



Pocket-size test probe, Model L-2000, determines the logic state of RTL, DTL and TTL circuits. Measuring 8 inches in length, including tip, by 5/8-inch in diameter, the unit is powered by system under test. Light-emitting devices permit visual observation of pulsed operations up to 120 Hz. Price is $35. Aqua Survey & Instrument Co., Inc., 7041 Vine St., Cincinnati, OH 45216. **293**



Punched-tape reader, RR-3400RB6, reads both 8- and 6-level feedhole advanced tapes interchangeably. Additional features include speeds up to 400 cps, magnetic rocker/jam roller combination, self-adjusting magnetic brakes and fiber optic distribution system. Price is $930 for 1-9 quantities. REMEX, A Unit of Ex-Cell-O Corp., 1733 Alton St., Santa Ana, CA 92705. **296**



Memory configuration for the Supernova SC combines core and semiconductor memories containing 4096 × 16 bits of core and 1024 × 16 bits of bipolar memory. The bipolar memory features an "overlay" capability that will permit a user to assign semiconductor memory to selectively replace core memory locations in the system. Data General Corp., Southboro, MA 01772. **299**

Multi-speed data set, Model 911, offers synchronous data rates of 2400, 4800 and 9600 bps and a fourth switch position to accommodate any asynchronous rates up to 1800 bps. Computer Transmission Corp., 1508 Cotner Ave., Los Angeles, CA 90025. **300**

"KeyProcessing System" CMC 5 consists of one to 12 "Keystations" tied to a general-purpose computer. In a remote location, the CMC 5 can send or receive data at up to 2000 bps. Computer Machinery Corp., 2231 Barrington Ave., Los Angeles, CA 90064. **301**

Keyboard terminal stand, available in both 23- and 36-inch widths, has a cantilevered, nonglare plastic laminate work surface and a shelf for storage. Wright Line, A Div. of Barry Wright Corp., 160 Gold Star Blvd., Worcester, MA 01606. **302**

Retentive memory SL contains five independent circuits. Each circuit is a latch reed relay that holds information during power loss. All modules are plug-in and are protected by a thermoplastic enclosure. Square D Co., Dept. SA, Milwaukee, WI 53201. **303**

CRT terminals, Models 40 and 44, are IBM compatible and produce hard copy of display. These units combine keyboard entry, 2400-baud operation and produce a 4.5- by 5-inch copy by keyboard command. Photophysics, Inc., 1601 Stierlin Rd., Mountain View, CA 94040. **304**

Digital tape recorder PI-1217/19 offers a wide variety of IBM-compatible configurations (7 or 9 channels). Packing densities range from 200 to 1600 bpi at speeds of 45 to 100 ips. Precision Instrument Co., 3170 Porter Dr., Palo Alto, CA 94304. **305**

CRT terminals, Models I, II and III, have modular construction that permits field alteration within minutes. Basic configuration displays 800 characters and has 53-key teleprinter keyboard. Beehive Medical Electronics Inc., 1473 S. 6th W., Salt Lake City, UT 84104. **306**

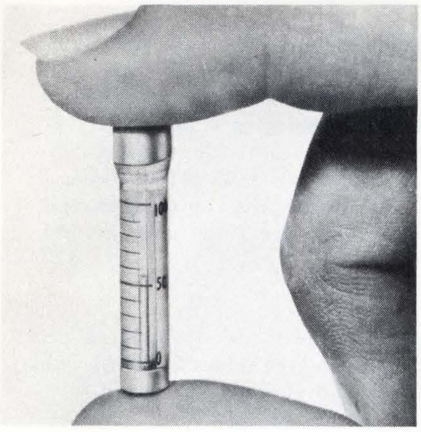
Modem M-48, a 4800-bps unit, operates on unconditioned leased or dial-up lines. It is primarily intended for point-to-point application using 4-wire dedicated lines as the primary service, dial-up as back-up. Paradyne Corp., 2040 Calumet St., Clearwater, FL 33515. **307**

Automatic tape winder, Model TW-420, winds or rewinds 1/2-, 1- or 2-inch magnetic tape from a 10.5-inch standard NAB or IBM reel to any special reel, flanged or flangeless. MPH Electronics, 9654 Alpaca St., South El Monte, CA 91733. **308**

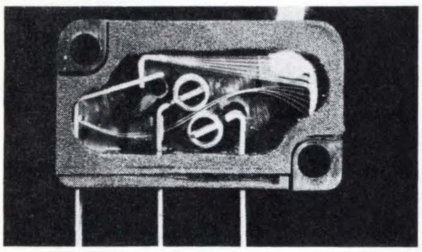
Keyboard terminal, UCC/Datel 31, features an incremental recorder-reader that uses a 4- by 4-inch cassette containing 1/8-inch tape with storage capacity of 90,000 characters. Data format is compatible with IBM 2741. University Computing Co., 1500 UCC Tower, Box 6228, Dallas TX 75222. **309**

Five electronic calculators, Series 1800, display answers on a single-plane display. From a simplex four-function model to a 2-memory, automatic square root machine, all have 14-column capacity. Prices range from $395 to $645. Victor Comptometer Corp., 3900 N. Rockwell St., Chicago, IL 60618. **310**

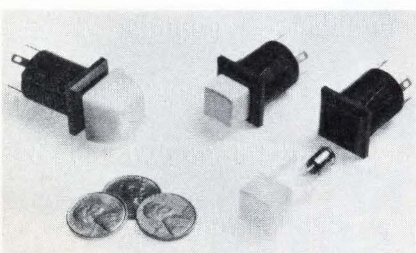
Counting keyboard, Electro/Set 460, stores six fonts, each containing widths for 128 different characters. The keyboard provides justified 6-, 7-, or 8-level tape for all unit or non-unit type faces from 4 - 96 Points. Graphic Equipment Div., Fairchild Camera & Instrument Corp., 221 Fairchild Ave., Plainview, NY 11803. **311**



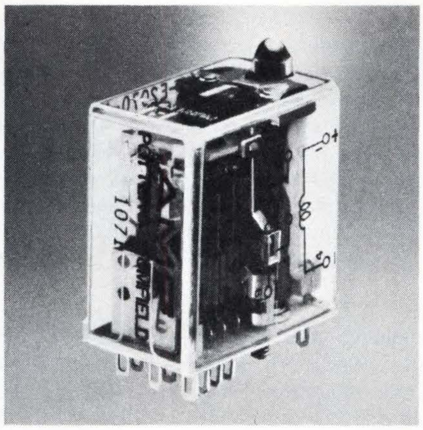
Miniature elapsed-time indicator provides a permanent record of total elapsed operating hours of equipment and instruments. Units are 1.256 inches high and operate over a temperature range of −35 to 150°F. models are available with calibrated time scales for 1000, 2000, 5000 and 10,000 hours. The Fredericks Co., Huntingdon Valley, PA 19006. **312**



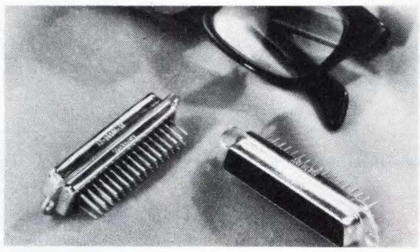
Miniature switches of the 1SV "Rolling Wave" line feature an S-shaped beryllium copper snap-action spring and resilient, multi-point stationary gold contacts. Switches operate at 25g maximum force and interface with solid-state logic circuits with little or no buffering. Micro Switch, Div. of Honeywell Inc., 11 W. Spring St., Freeport, IL 61032. **313**



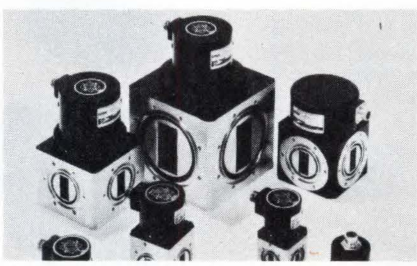
Momentary SPST illuminated pushbutton switch accepts either standard 1/2-inch² pushbuttons or truncated keyboard buttons. Rated from dry circuit to 1/2A resistive at 30V dc, the QT switch has travel of 0.01 inch total, actuation force of 6 oz and life rating of 2 million operations. Price in 1000 lots is $0.84 each. Marco-Oak, Subsidiary of Oak Electro/Netics Corp., 207 S. Helena St., Anaheim, CA 92803. **314**



A light-emitting diode, used as an indicator light, is now available on R10 Series relays. An LED placed across the relay's coil emits a highly visible red light that indicates power on the coil. LEDs are presently available on R10L relays operating from input voltages up to 48V dc. Potter & Brumfield, Princeton, IN 47670. **315**

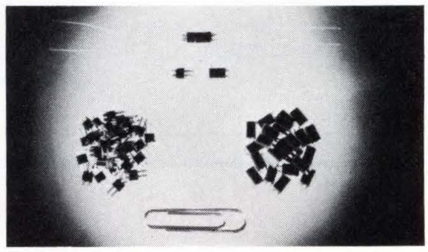


Miniature pin-and-socket connectors feature fixed pin wire-wrappable contacts set in a two-piece, glass-filled nylon dielectric. This addition to the "MinRac" 17 Series is available in standard 9-, 15-, 25-, 37- and 50-contact configurations. Amphenol Industrial Div., Bunker-Ramo Corp., 1830 S. 54th Ave., Chicago, IL 60650. **316**

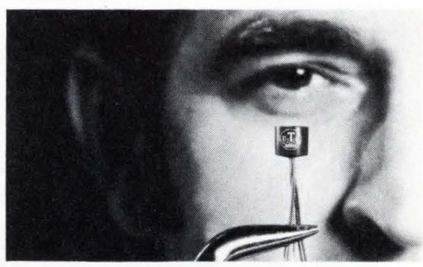


Waveguide switches utilize the unique "Transactor" actuator. The actuator rotor and switch RF rotor are combined in a single integrated assembly, eliminating all mechanical linkage. These actuators are smaller and more reliable than older designs using motor/gears or solenoids, require only about one-third the current and are designed for extreme environments. Transco Products, Inc., 4241 Glencoe Ave., Venice, CA 90291. **317**

Optical bi-directional incremental encoders feature integral electronics and operation from single +5V dc power. The 5V70 Series is available with up to 4096 counts per each revolution; the 5V270 with up to 20,000 counts/revolution. Prices start at $149 for the 5V70 Series. Baldwin Electronics, Inc., 1101 McAlmont St., Little Rock, AR 72203. **318**



Subminiature two-contact connectors of the G-Series are suited for medical instruments, hearing aids, transducers, high density IC packages, and numerous micro-miniature custom applications. Price is $1.25 each in single quantities ($0.65 each in quantities of 1000). Microtech, Inc., 777 Henderson Blvd., Folcroft, PA 19032. **319**



A new family of industrial quality transformers incorporates the electrical performance characteristics of comparable MIL-spec units at a substantial reduction in price. Applications of the I-DO-T and I-DI-T transformers include isolation, matching, and push pull driving. Typical quantity price is in the $2.50 to $3.00 range. United Transformer Co., Div. of TRW, Inc., 150 Varick St. New York, NY 10013. **320**

Thick-film resistors of the HR series are nonhydrogen sensitive and extend MIL-R-10509 performance to 1000 MΩ and 15 kV. A noble-metal thick-film element with glass seals permits operation from −55 to +225°C. Price is as low as $0.94 each in production quantities. EMC Technology, Inc., 1300 Arch St., Philadelphia, PA 19107. **321**

IC socket assemblies on PC boards permit any complement of 14-, 16-, 24-, 36-, or 40-pin IC sockets. Either 0.062- or 0.125-inch thick glass boards are available. Interdyne, 2217 Purdue Ave., Los Angeles, CA 90064. **322**

AC power receptacle meets International Electrotechnical Commission (IEC) standards for European equipment and has been approved for listing by UL and Canadian Standards Assn. (CSA). The 3-pin EAC-301 has a center pin that mates first and disconnects last. It mounts easily in a rectangular chassis cut-out. Switchcraft, Inc., 5555 N. Elston Ave., Chicago, IL 60630. **323**

Multiple conductor transmission line is constructed with "Teflon"-coated silver-plated conductors that are woven into a flat ribbon with a binder of nylon. Transmission line in this series is available in conductor sizes from 20 to 34 AWG, with impedances from 50Ω to 150Ω. Connecta Data, Inc., Box 355, Eatontown, N J 07724. **324**

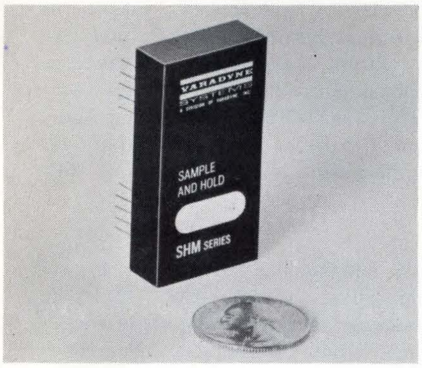
Edge-mount connector for leadless substrates accepts 0.04-inch thick single-sided ceramic substrates. They are available in 40-position single-sided configuration with contacts on 0.05-inch centers. AMP Inc., Harrisburg, PA 17105. **325**

Isolation transformers and power supplies for medical electronics, Series H, help prevent "microshocks". They offer typical leakage currents of $< 2\ \mu A$ with 2000V minimum breakdown voltage. Interwinding capacitance approaches 0.0001 pF and primary-to-secondary shorts are virtually impossible. Elcor Products by Welex Electronics, 2431 Linden Lane, Silver Spring, MD 20910. **326**

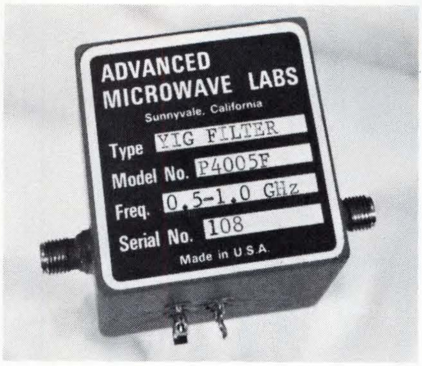
Miniature slide switches of the MSS Series are available with either direct or right-angle mounting terminals for PC-board use. Switch rating is 0.3A at 125V ac and rating is 15,000 cycles at rated load. Prices start as low as $0.60 each in single lots. Alcoswitch Div., Alco Electronic Products, Inc., Box 1348, Lawrence, MA 01842. **327**

Rectangular relay socket for 14-contact 4PDT plug-in type relays is offered with both solder eyelet and PC contact tails. Rating is 7.5A at 600V ac. Amphenol Industrial Div., The Bunker-Ramo Corp., 1830 S. 54th Ave., Chicago, IL 60650. **328**

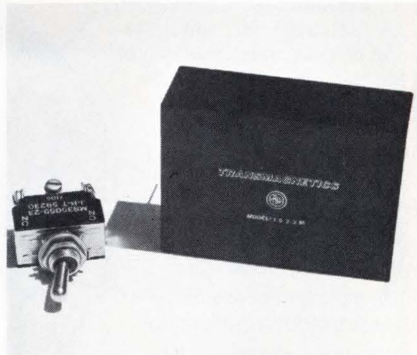
Miniature pushbutton switches with 15/32 diameter bushing are available with standard, watertight and round base—and with momentary or alternate action. Standard and watertight versions are rated at 5A, 125V ac or 28V dc, resistive load. Prices range from $0.57 to $5.95 each, depending on quantity. Specialty Products Div., Cutler-Hammer, Inc., 4201 N. 27th St., Milwaukee, WI 53216. **329**



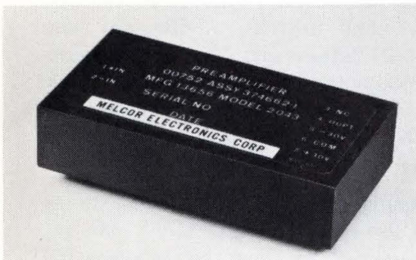
Sample and hold module, Model SHM-2, features 100-nsec acquisition time, 10-nsec aperture time and 30V/microsecond slew rate. Frequency response is from dc to 500 kHz. Long-term stability is ±0.01%/6 months. Price each is $149. Varadyne Systems, 1020 Turnpike St., Canton, MA 02021. **330**



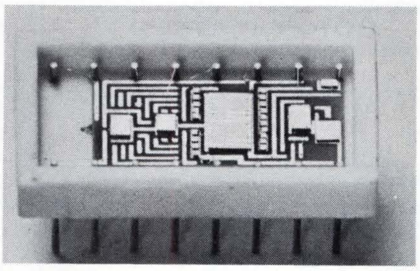
YIG filter will tune from 500 MHz to 1 GHz in only 80 μsec. The four-stage Model P4005F provides 3-dB bandwidth of 20 to 35 MHz, 4 dB insertion loss and off-resonance isolation > 80 dB. Package size is 1.7 inches² by 2 inches. Advanced Microwave Labs, 825 Stewart Dr., Sunnyvale, CA 94086. **333**



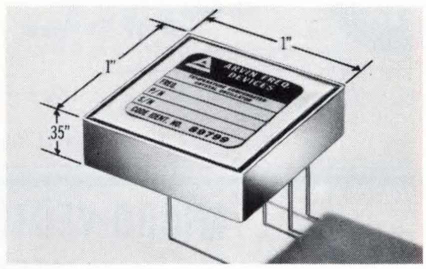
Synchro-to-digital converter measures 3.5 by 2.5 by 1.25 inches. It accepts input from a 26V or 115V synchro and provides 12-bit binary or 4-decade BCD output ±6 arc min accurate. Maximum conversion rate is 400/sec. Price is $350 for either version. Transmagnetics Inc., 210 Adams Blvd., Farmingdale, NY 11735. **336**



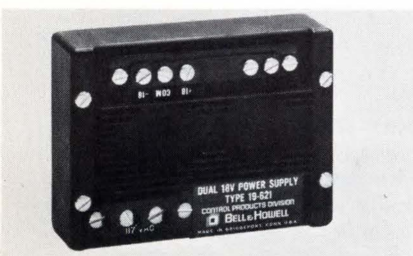
Operational amplifiers, Models 2043 A/B/C, have an open-loop voltage gain of 25,000 at frequencies up to 5 MHz. Other features include 20 MΩ common mode impedance, 5 mV offset voltage, 1 μA offset current and common-mode voltage rejection of 1000. Melcor Electronics Corp., 1750 New Highway, Farmingdale, Long Island, NY 11735. **331**



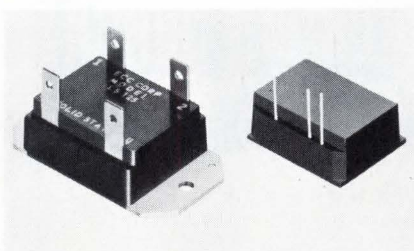
High-speed 10-bit converter, Model MN325, comes in a 16-pin DIP. Unit includes monolithic switching networks, precision thin-film resistor network and internal reference. Power consumption is only 500 mW. Logic input is DTL/TTL compatible. Prices are $69 (1-24) and $49 (100 quantity). Micro Networks Corp., 5 Barbara Lane, Worcester, MA 01604. **334**



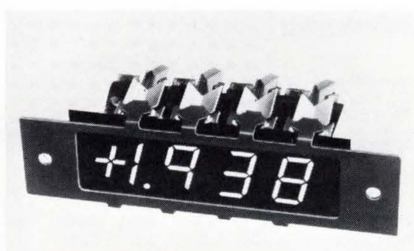
Crystal oscillators, Arvos II in a 1- by 1- by 0.35-inch case, generate any frequency between 7 and 25 MHz. The stability is ±20 PPM or better over the temperature range of −40 to 75°C. Maximum input power requirement is 300 mW. Input requirement is 12V dc ±1%, and the output is TTL compatible. Arvin Industries, Inc., Columbus, IN 47201. **337**



Dual regulated dc power supplies, 19-621 and -622, have a working voltage range of 105 to 125V in a frequency range of 50 to 60 Hz. Maximum power drain is 10 VA. Output voltages are ±18V, ±0.5% (19-621) and ±15V, ±0.5% (19-622). Mechanical dimensions are 4.7 by 3.5 by 1.8 inches. Price is $75. Bell & Howell Co., Control Products Div., 706 Bostwick Ave., Bridgeport, CT 06605. **332**



Two series of solid-state relays, LS (line-activated switch) and HR (hybrid relay), are available in 4 to 40A current range and 200 to 400V rating. Both units contain triacs and act as single-pole normally-open contactors. The LS Series offers units of up to 1200V. Reed coil voltages of 6 to 24V ac are available for the hybrid devices. ECC Corp., Box 669, 1011 Pamela Dr., Euless, TX 76039. **335**



Miniature 7-bar segment display, Series 1040, illuminates 0.46-inch high characters in a single plane configuration and is readable from 12 ft. Lamp replacement is accomplished from front or rear of the panel. Total price for the complete unit (display and associated circuits) is $11.31. Industrial Electronic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405. **338**

Circuits

RF power amplifier, Model PA-1000, is a linear class A unit that provides up to 60W output between 100 kHz and 140 MHz. Output is electrically equivalent to an open-circuit voltage of 110V rms maximum in series with 50Ω. Electronic Navigation Industries Inc., 1337 Main St. East, Rochester, NY 14609. **345**

Signal conditioning card allows use of piezoresistive accelerometers to make measurements across very broad ranges of acceleration and frequency. Frequency response is ±2% from 0.2 Hz to 2000 Hz. Endevco Dynamic Instrument Div., 801 S. Arroyo Pkwy., Pasadena, CA 91109. **346**

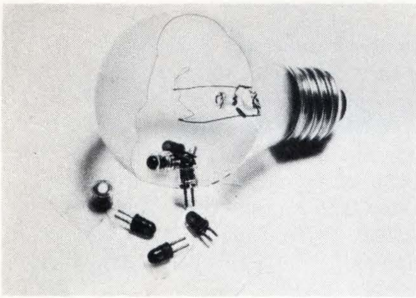
L- and S-band telemetry amplifiers meet the latest IRIG and DOD requirements. Model AM-1542N for the 1435- to 1540-MHz bands provides 20-dB gain with ±0.3-dB flatness and 4.5-dB noise figure. Model AM-2302N for the 2200- to 2300-MHz band provides 23-dB gain with ±0.3-dB flatness and 5.5-dB noise figure. Approximate price is $900 each. Avantek, Inc., 2981 Copper Rd., Santa Clara, CA 95051. **347**

YIG-tuned Gunn effect diode oscillators tune the 8- to 12.4-GHz range with low frequency drift without the use of heaters. Model FS-56 is self-shielding, and operates from a ±15V dc supply. Frequency Sources Inc., Box 159, North Chelmsford, MA 01863. **348**

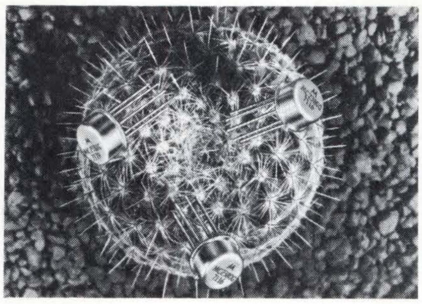
Wideband amplifier, Model 725, has 27-dB gain from 50 kHz to 500 MHz with nominal impedance of 50Ω. Size is 7-3/4 by 4-3/4 by 2-1/4 inches, weight is 2 lbs and price is $150 each. Measurement Specialties Laboratory, Inc., Box 3654, Santa Monica, CA 90403. **349**

Antenna selector switch that operates with any type of pulse transponder with a video output pulse, Model 735, automatically selects whichever of two antennas provides the best coverage. Vega Precision Labs., Inc., 239 Maple Ave., Vienna, VA 22180. **350**

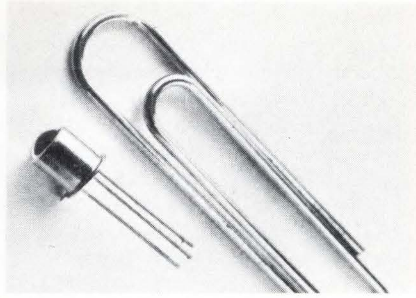
FET amplifier priced at $9.75, Model ZA801M1, features 25 pA maximum input current, 10,000:1 CMRR, 10^{11}Ω input impedance and 50 μV/°C maximum drift. Package size is 1 by 1 by 0.4 inch. Zeltex, Inc., 1000 Chalomar Rd., Concord, CA 94520. **351**



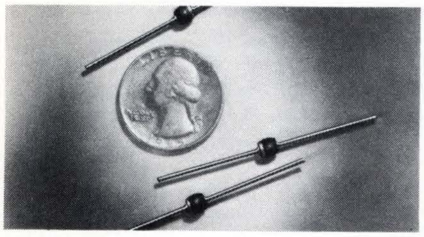
Solid-state lamps, using LEDs, 5082-4440 and -4444, are priced at $0.65 each in quantities of 10,000. The 4440 is for panel mounting and 4444 for printed-circuit board mounting. These gallium-arsenide-phosphide lamps have a red diffused plastic lens with high visibility over a wide viewing angle and a high OFF/ON contrast ratio. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94340. **352**



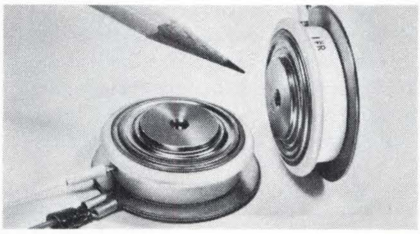
Dual 100-bit dynamic shift registers, MC 2380G and 2381G, drive TTL circuits directly at 3 MHz minimum. The MC2380G has open-drain output devices. A variant, the MC2381G, has an internal pulldown resistor on the output to provide direct MOS interface. Prices range from $5.95 (1-24) to $3.95 (100-999). Motorola Semiconductor Products Inc., Box 20924, Phoenix, AZ 85036. **355**



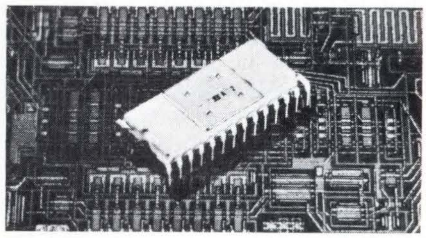
Two series of Darlington phototransistors, CLR 2000 and 2100, provide high light currents at low irradiance levels. For the CLR 2000 the flat window is characterized at 0.2 mW/cm^2, and for the CLR 2100 lensed unit at 0.02 mW/cm^2. Prices range from $1.53 to $1.68 (quantities of 500) for the CLR 2000, $1.63 to $1.79 for the CLR 2100. Clairex Corp., 560 S. 3rd Ave., Mount Vernon, NY 10550. **358**



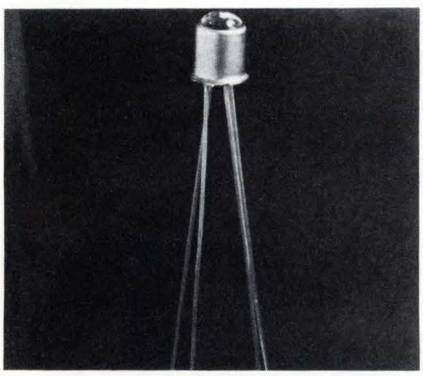
Low forward voltage, fast recovery 3- and 6A Metoxilite rectifiers have monolithic non-cavity construction, fused metal oxide hermetic seal, low thermal impedance and low reverse leakage. The 3A rating at 55°C requires no heat sink, special mounting or forced air cooling. The 6A device meets MIL Std. 750. Semtech Corp., 652 Mitchell Rd., Newbury Park, CA 91320. **353**



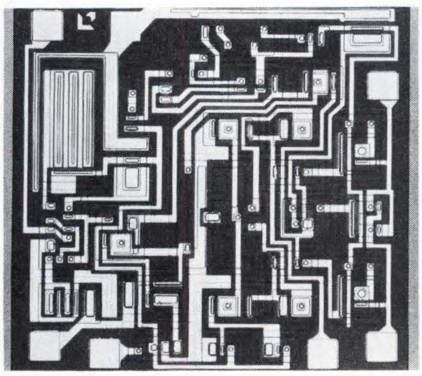
A line of silicon control rectifiers, 300PA, handles 300-A average current. Rated voltage is 500 to 1600V. For firing, maximum peak gate power is 10W, maximum average gate power is 2W and maximum peak positive gate voltage is 20V. Typical gate current for triggering is 50 mA. Semiconductor Div., International Rectifier Corp., 220 Kansas St., El Segundo, CA 90245. **356**



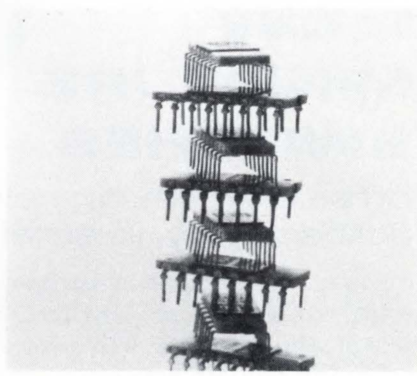
Monolithic 16-channel multiplexer DM110 features a special buffer circuit that permits the output to "float" in an inhibit condition. Power consumption is 100 mW (ON state) and 10 mW (inhibit state). This device is MOS/CMOS compatible and capable of driving two TTL inputs. Price is $19.90 in 100-unit quantities. Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. **359**



Light-sensitive FETs, FF-102 and -108, feature dark current of 0.05 nA, response time of 30 nsec typical and broad spectral response (near infrared through visible blue). Both are packaged in a TO-72—the FF-102 has a lens and the FF-108 has flat glass for use with external optics. Prices range from $6 (1-99) to $4 (100-999). Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. **354**



Operational amplifier Am1660 is designed to fill the performance and price gap between the 301A and the 308. It offers 22-mW power dissipation with typical offset current of 800 pA, and is priced at $5 in quantities over 100. Other electrical parameters include 5-nA input bias current and 12-MΩ input resistance. Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, CA 94086. **357**



Bipolar ROM MM6280/MM5280 is an 8192-bit unit organized as 1024 words by 8 bits. It has an access time of 100 nsec and power dissipation of 60 μW/bit. Because of the capacity, one device is capable of providing 128 standard ASCII encoded alphanumeric characters with codes for upper and lower control. Monolithic Memories, Inc., 1165 E. Arques Ave., Sunnyvale, CA 94086. **360**

Deoxidizing gas-sensing semiconductor TGS is composed of oxidized metals such as tin oxide, zinc oxide and ferric sesquioxide, and decreases in electrical resistance when it encounters deoxidizing gases such as hydrogen, carbon monoxide, methane, propane, alcohol, volatile oil and acetylene. Japan Industrial Trade Service Press, C.P.O. Box 1095, Osaka, Japan. **361**

Field programmable ROM, MM6305/5305, is a 2048-bit bipolar unit that is the largest bipolar ROM presently on the market. In lots of 100 to 249 prices start at $100 each for a 0 to 70°C unit. Monolithic Memories, Inc., 1165 E. Arques Ave., Sunnyvale, CA 94086. **362**

Three 1024-bit multiplexed dynamic shift registers operate at a data rate of 10 MHz typical and are designated 2502 – a quad 256-bit unit, 2503 – a dual 512-bit unit and 2504 – a single 1024-bit register. In lots of 100 to 999, prices start at $11.05 each. Signetics Crop., 811 E. Arques Ave., Sunnyvale, CA 94086. **363**

IC op amp, LM216 Series, offers input offset currents that range from 50 pA down to <15 pA. Input bias current range from 150 pA down to 50 pA and all amplifiers draw <200 nA at maximum supply voltage of ±20V. In lots of 100 items, prices range from $9.95 to $40 each. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **364**

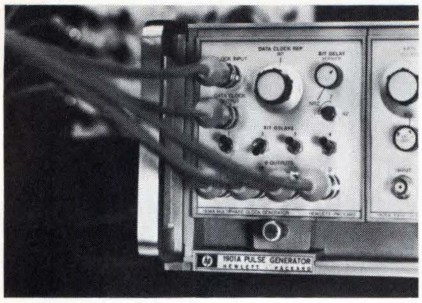
Monolithic phase-locked loop LM565 contains a linear VCO, doubly-balanced phase detector and amplifier and a low-pass filter. The 0-to-70°C unit is $6.70 each, in 100-up quantities. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **365**

Silicon controlled rectifiers include 16 devices that span the range from 100 to 1400V at 110A. Prices in lots of 10 to 44 range from $14.75 to $150.50. Technical Information Center, Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, AZ 85036. **366**

White noise generator diodes cover the frequency spectrum through the UHF range. Operating in the avalanche mode, they produce Gaussian random noise with an optimized constant amplitude as a function of temperature and frequency. In lots of 1 to 9, prices range from $15.60 to $21.60. CODI Semiconductor, Div. of Computer Diode Corp., Pollitt Dr., Fair Lawn, N J 07410. **367**

NPN silicon power transistor series SDT 401-431 and SDT 1050-1164 are 125W units that are the first high voltage devices specified lower than 100 μA I_{CBO}. Gain selections are up to 5A, and price is <$10 each in lots of 1 to 99. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, FL 33404. **368**

Logarithmic diode family, LD-3029, provides a 7-decade operating range at +25°C, −55°C and 5-decade operating range at 85°C. Price is $4.50 each. CODI Semiconductor, Div. of Computer Diode Corp., Pollitt Drive South, Fair Lawn, N J 07410. **369**

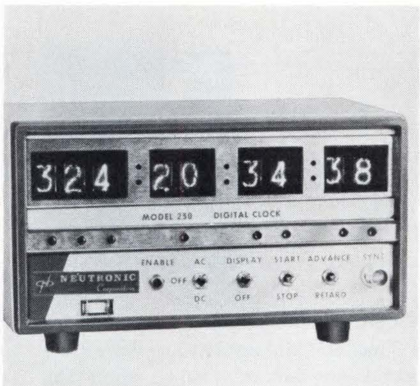


Multiphase pulse generator for testing MOS integrated circuits supplies 2- or 4-ϕ clock patterns required for testing at rates to 12.5 MHz (4ϕ) or 25 MHz (2ϕ). Model 1934A, which is programmable, is a plug-in module for the 1900 Series pulse generators. Output pulses can be RZ, NRZ, or DNRZ. The price is $775. Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **370**

Frequency counter, Model 1250, covers from 5 Hz to 32 MHz, has solid-state LED readouts and automatic decimal positioning. Storage circuitry gives non-blinking readout on all four ranges. Price is $395. Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, N J 07114. **371**

16-bit, 20-MHz data generator, Model 220, is priced at $495. Features include readily expandable 16-bit cycle lengths, clock rates from 0 to 20 MHz and TTL/DTL-compatible inputs and outputs. Datapulse Div., Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, CA 90230. **372**

AC volt-amp recorder has full-scale current ranges of 25, 100 and 300A (60 Hz) at 4% accuracy. Voltage ranges are 150, 300 and 600V (60 Hz) with accuracy of 3% of full scale. A clamp-on transducer handles conductors up to 1 inch in diameter. Standard writing speed is 1 inch/hr. Price is $159. Rustrak Instrument Div., Gulton Industries, Inc., Municipal Airport, Manchester, N H 03103. **373**



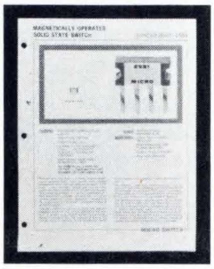
Digital clock allows precision measurement of real or elapsed time and displays seconds, minutes, hours, and (optional) days. There is provision for synchronizing with WWV. Model 250 is priced at $1150. Neutronic Corp., Box 625, Bridgeton, MO 63044. **374**

X-Y Recorder, Model 400, weighs less than 10 lb and fits into an attache case. Chart size is 8-1/2 by 11 inches, operation is from D-cell batteries and the maximum slewing speed is better than 15 inches per second. Price is $495. Gamma Scientific, Inc., 3777 Ruffin Rd., San Diego, CA 92123. **375**

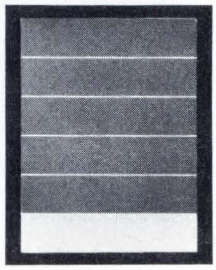
PCM bit synchronizer provides tunable bit rates from 1 bps to 5 Mbps, a special input filter, and an override control that permits switching from the computer program mode to manual control and back without destroying the original setup. The model number of this fourth-generation product is 720. EMR-Telemetry Div., Weston Instruments, Inc., Box 3041, Sarasota, FL 33578. **376**

Voltmeter/counter combines an autoranging ac and dc digital voltmeter with digital dB presentation, and a fully automatic counter. Counter frequency range is from 10 Hz to 1.5 MHz with 0.1-Hz resolution. Northeast Electronics Corp., Airport Rd., Concord, NH 03301. **377**

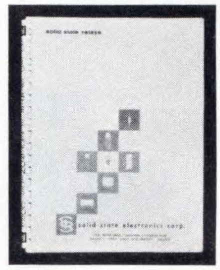
VCF waveform generator covers the very wide range from 0.0001 Hz to 11 MHz. Frequency response of the Model 7030 is extremely flat. Waveforms include sine, square, triangle, ramp, pulse and sync. Output is 15V pk-pk into 50Ω. Price is $595 each. Exact Electronics, Inc., Box 160, Hillsboro, OR 97123. **378**



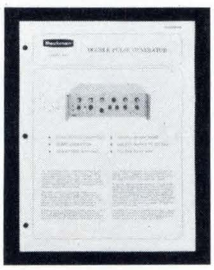
Solid-state switch is described in four-page product sheet 2SS1. Typical applications and specifications are given for this subminiature addition to Micro Switch's magnetically-operated solid-state switch line. Micro Switch, Div. of Honeywell Inc., 11 W. Spring St., Freeport, IL 61032. **200**



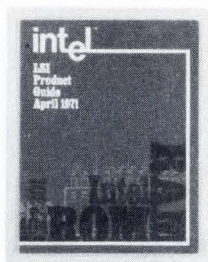
Low-power logic applications and schematic diagrams that show how to mix 54L TTL with ultra-low-power logic for best solution to the speed/power trade-off problem are discussed in a brochure available from Teledyne Semiconductor, 1300 Terra Bella, Mountain View, CA 94040. **203**



"Solid-State Relays" is the title of a 48-page catalog describing the company's line of relays and coils, including opto-electronic, latching, microreed, binary, time delay, frequency sensitive and other types of relays. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **206**

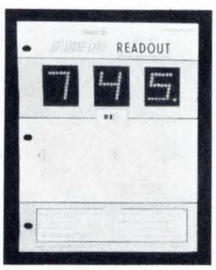


Double pulse generator with repetition rates from 10 Hz to 15 MHz and square waves from 1 Hz to 100 kHz is covered in Bulletin 2456 which outlines such features as adjustable rise and fall times from 10 nsec to 10 msec. Technical Information Section, Electronic Instruments Div., Beckman Instruments, Inc., 3900 N. River Rd., Schiller Park, IL 60176. **201**

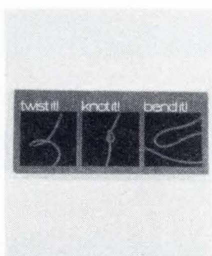


Advanced semiconductor memories are the subject of a 20-page catalog describing semiconductor memory devices employing silicon-gate MOS and Schottky bipolar technologies. Major specifications, block diagrams, pin configurations, timing diagrams and characteristic curves are included. Intel Corp., 3065 Bower Ave., Santa Clara, CA 95051. **204**

"MOS/LSI In Plastic Packages" is the title of an 8-page bulletin (CB-132) that describes assembly steps, package dimensions, environmental results and life-test results of the company's plastic dual in-line packages for MOS/LSI ICs. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, M/S 308, Dallas, TX 75222. **207**



Solid-state readout the new Series 745 single-digit module designed particularly for use in hand-operated portable or desk-top instruments, is described in a new bulletin from Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. **202**



Foamed dielectric cable "Micro-Cell F110" is described in a new folder containing a sample of the foamed FEP "Teflon" cable. Microdot Inc., Cable Div., 220 Pasadena Ave., South Pasadena, CA 91030. **205**

Subminiature toggle switches are described in a 12-page catalog with photographs, engineering drawings, specifications, prices and distributor listings. C&K Components, Inc., 103 Morse St., Watertown, MA 02172. **208**

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Literature

Monolithic ceramic capacitors are covered in a 12-page catalog from Electro Materials Div., Illinois Tool Works Inc., 11620 Sorrento Valley Rd., San Diego, CA 92121. **209**

Modular remote batch terminals are the subject of a 12-page catalog from M&M Computer Industries, Inc., 770 N. Main St., Orange, CA 92668. **210**

"Control Knob Selector" wall chart measures 25 by 38-1/2 inches and covers 300 plastic and aluminum stock knobs. Electronic Hardware Corp., Control Knobs Div., 180-08 Liberty Ave., Jamaica, NY 11433. **211**

Dual in-line and standard pulse transformers are the subject of data sheets from Vanguard Electronics, 930 W. Hyde Park, Inglewood, CA 90302. **212**

Power supplies designed especially for packaged digital displays are the subject of this four-page catalog from Instrument Displays, Inc., Granite St., Haverville MA 10830. **213**

Trimming resistor networks packaged in a 14-lead dual in-line container are detailed in a brochure entitled "Space, Time and Temperature". Amphenol Controls Div., The Bunker-Ramo Corp., 120 S. Main St., Janesville, WI 53545. **214**

Relay sockets with 8, 10, 14 and 20 fixed or removable contacts are covered in Form 1458-371 from Continental Connector Corp., 34-63 56th St., Woodside, NY 11377. **215**

Capacitors, coaxial cable and connectors, fuseholders, lamps, readouts, pots, resistors and semiconductors are among the items featured in 56-page Bulletin 132 from Reliance Merchandizing Co., 2223 Arch St., Philadelphia, PA 19103. **216**

Terminal boards are the subject of a newly revised, 20-page publication from General Electric Co., General Purpose Control Dept., Box 913, Bloomington, IL 61701. **217**

High-speed, wide-band op amps are covered in this four-page sheet from Melcor Electronics Corp., 1750 New Highway, Farmingdale, Long Island, NY 11735. **218**

Hybrid amplifier specifying guide covers small signal amplifiers, medium power linear amplifiers, CATV amplifiers and high power RF amplifiers. Marketing Services Dept., Fairchild MOD, 3500 Deer Creek Rd., Palo Alto, CA 94304. **219**

Connectors and headers for OEM electronic packaging applications are outlined in literature from 3M Co., Dept. EL1-23, Box 3686, St. Paul, MN 55101. **220**

Ferrite products including toroids, beads, tubes, baluns, antenna rods and pot cores are covered in 16-page Catalog No. 107 from Indiana General, Electronic Products, Keasbey, N J 08832. **221**

Magnetic pickup Catalog 8506 is reported to be the most comprehensive piece of literature available on these devices. The 16-page catalog is available from Controls Div., Airpax Electronics, Box 8488, Fort Lauderdale, FL 33310 **222**

Rack and panel connectors in the 213 Series are the subject of a four-page catalog from Amphenol Connector Div., The Bunker-Ramo Corp., 2801 South 25th Ave., Broadview, IL 60153. **223**

Field effect transistors including both N- and P- junction types are featured in a 16-page brochure with a cross referencing index from Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. **224**

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Bold-face type denotes advertisers in this current issue.

Application Notes

"Choice of Protection", third edition of the Airpax technical journal designed to aid in the selection of circuit protection devices, has been expanded to 20 pages. It is primarily a treatise on magnetic circuit breakers. Airpax Electronics, Box 8488, Fort Lauderdale, FL 33310. **240**

Silicon solar cells are the subject of a four-page bulletin that presents a general description of cell construction, electrical characteristics, an equivalent circuit diagram and spectral response of cells compared with the radiation of various light sources. M7, Inc., 210 Campus Dr., Arlington Heights, IL 60004. **243**

Power supplies fpr GaAs injection lasers are described in a 12-page application note. AN-4469 shows schematic diagrams and discusses the operation of supplies for pulsing single-diode lasers, laser stacks, and laser arrays. Eleven different circuits are described. RCA Commercial Engineering, Harrison, N J 07029. **245**

"Using Small Computers in Data Communications Networks" is the title of a five-page reprinted article that describes techniques, characteristics and performance. It is available from Interdata, Inc., 2 Crescent Pl., Oceanport, N J 07757. **241**

"Laser Pulses" is the title of a periodic series of technical notes on the design, use and properties of laser glass and glass lasers. To receive the series, write on company letterhead to Laser Products Dept., American Optical Corp., 14 Mechanic St., Southbridge, MA 01550.

"MOS Interface" is an application note with illustrations describing an inexpensive method of interfacing the MOS portion of a system with conventional bipolar logic or systems output device. Astro Space Labs., Inc., Research Park, Huntsville, AL 35806. **246**

Data collection system for pollution control using a computer interface system for collection and control of data is described in Application Note T-267. Included are systems that can accept data from a variety of analog and digital sources, communicate with off-site processing equipment over telephone lines and respond to control signals received over the same lines. Princeton Applied Research Corp., Box 565, Princeton, N J 08540. **242**

"Analog Dialogue" provides technical information ranging from applications for a new monolithic IC voltage switch to the use of analog multipliers for measurement of sine wave amplitudes without averaging. Included are op amps as electrometers, results of long-term drift measurements on a variety of op amps, and applications of low-bias FET-input IC op amps. Analog Devices, Inc., Rte. 1 Industrial Park, Norwood, MA 02062. **244**

"Vector Voltmeter Measurement Techniques" is a fully-illustrated booklet describing a wide variety of measurements that can be made over the 1.5 MHz to 2.4 GHz frequency range with accuracy and convenience previously unobtainable. Detailed setup diagrams are provided. For Application Note 22, write on company letterhead to the Public Relations Dept., PRD Electronics, Inc., 1200 Prospect Ave., Westbury, NY 11590.

Reprints Available

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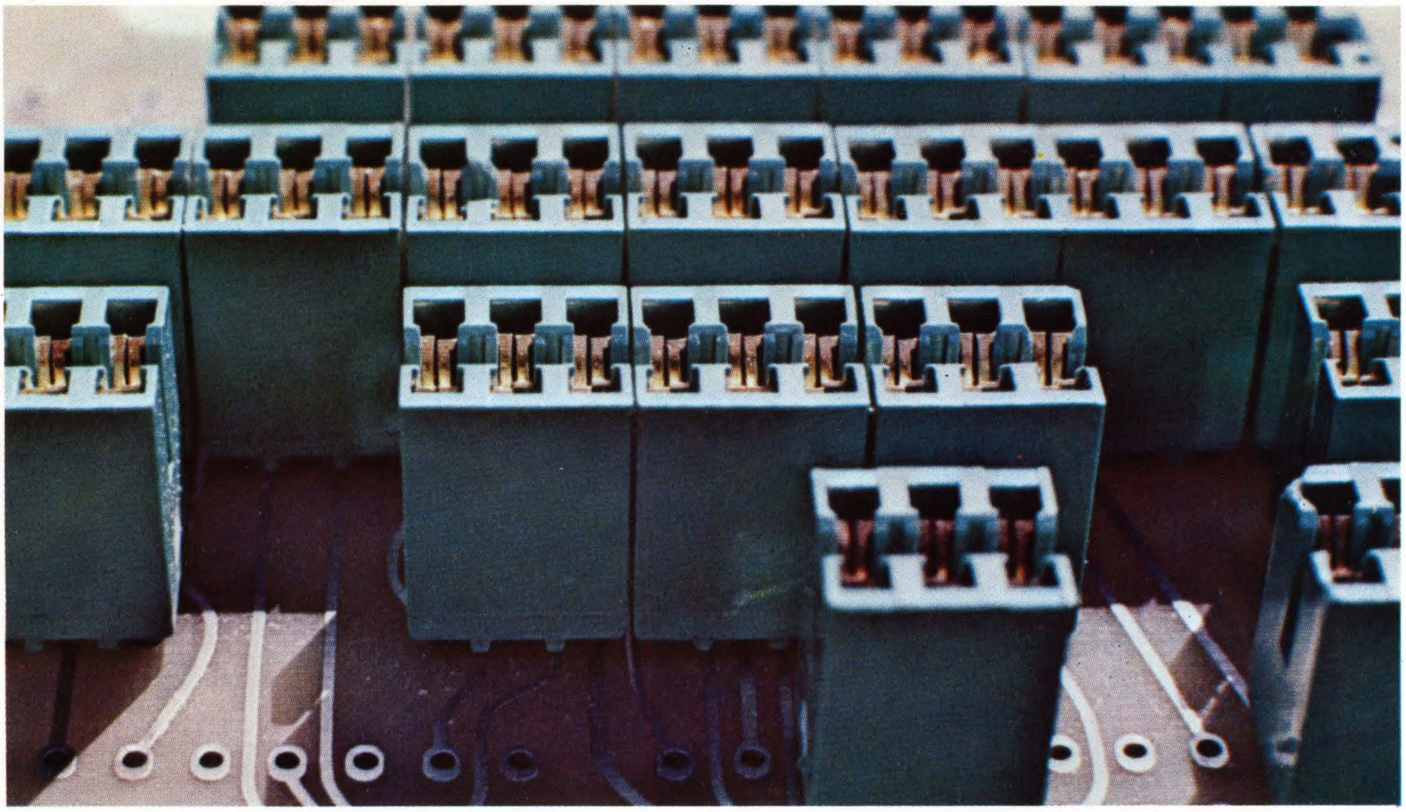

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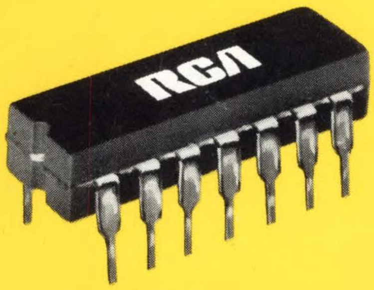

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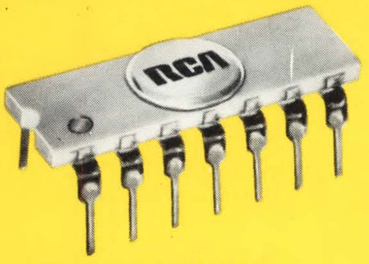

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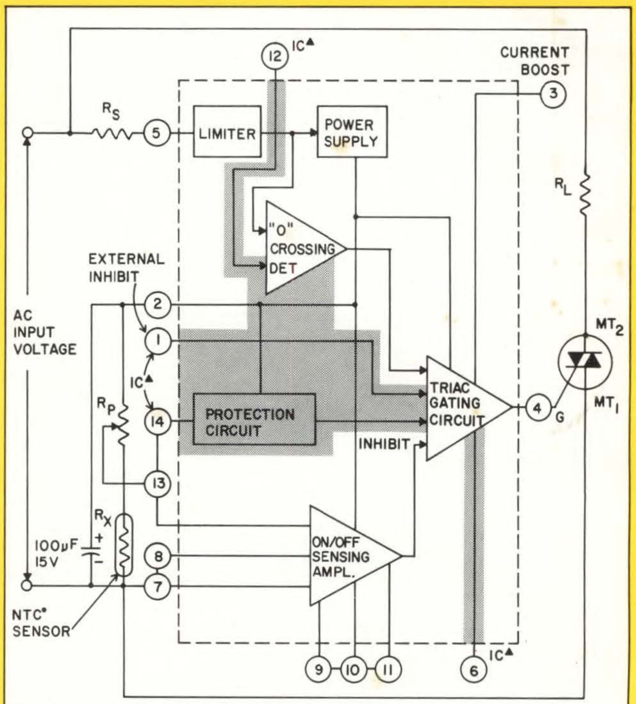

*NEGATIVE TEMPERATURE COEFFICIENT
▲IC=INTERNAL CONNECTION ON CA3079

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• 24V, 120V, 208/230V, 277V at 50 60, or 400 Hz operation	√	√	√
• Differential Input	√	√	√
• Low Balance Input Current (max.)-μA	1	1	2
• Built-in Protection Circuit (Fail-Safe) for opened or shorted sensor (Term. 14)	√	√	
• Sensor Range (R_X)-kΩ	2 to 100	2 to 100	2 to 50
• DC Mode (Term. 12)	√	√	
• External trigger & inhibit (Terms. 6 & 1)	√	√	
• DC Supply Volts (max.)	14	14	10

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