EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

EDN

Transient recorder boasts four-channel capability

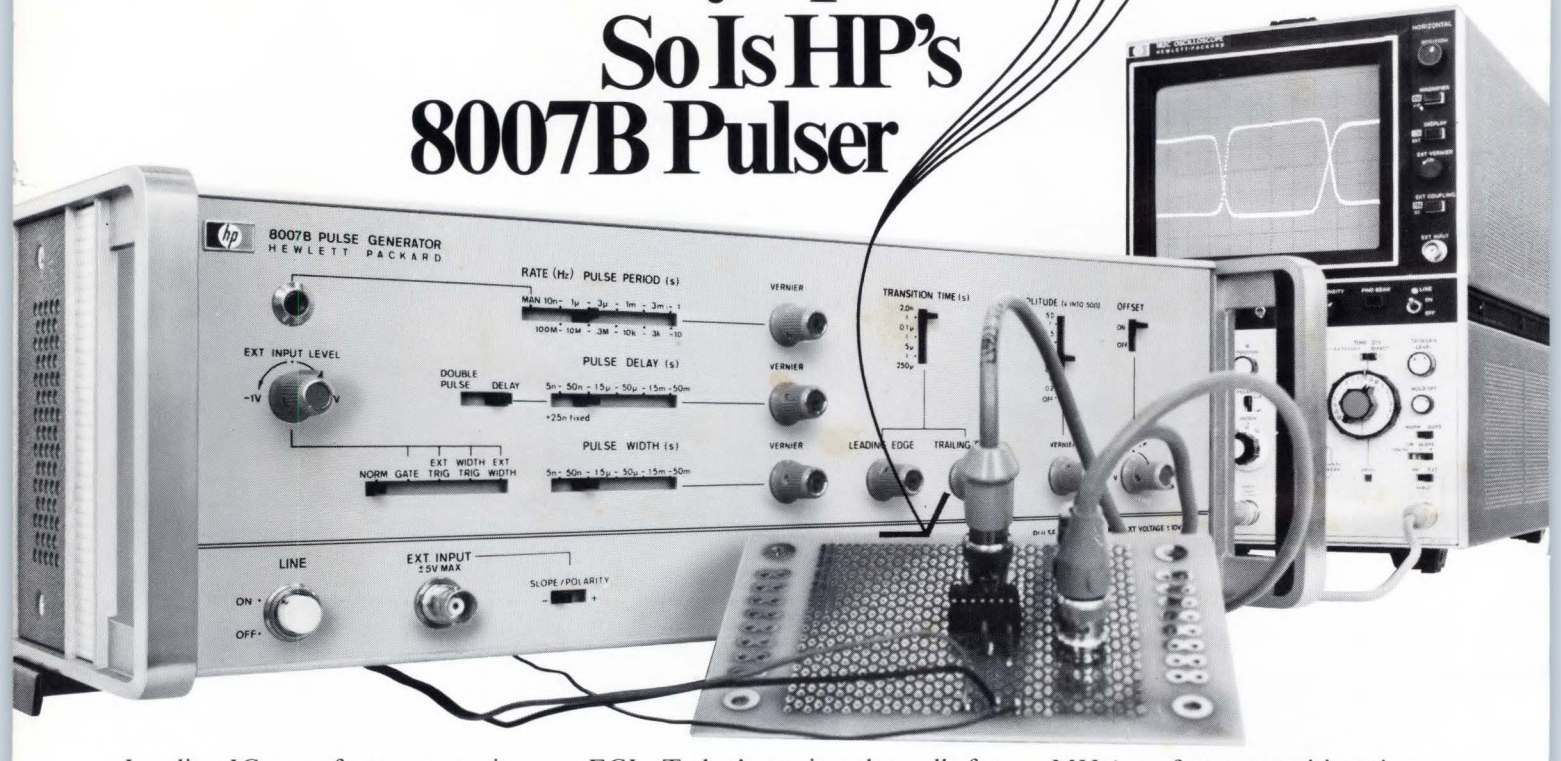
Helpful tips on using fast-recovery diodes

A CAHNERS PUBLICATION

APRIL 20, 1973

ecl

Testing Is Very Special- So Is HP's 8007B Pulser



Leading IC manufacturers use it – and they can't afford to take chances in testing. They know that the 8007B delivers the pulses they need. And they know that the $1,750 price is below competitive models.

Look at the specs of this fast pulse generator: rep rates from 10Hz to 100MHz, variable transition times from 2.0ns to 250μs, ±5V amplitude and ±4V dc offset. It's this kind of capability that you'll need for testing ECL II, ECL 10,000, and other comparable families.

Also note the generator's 50 ohm source impedance – mighty important for minimizing reflections when you're working with fast ECL. Today's testing also calls for a wide span of linear transition times, like the 2.0ns to 250μs of the 8007B. You can really use this when you're measuring propagation delay to a manufacturer's specs (even test linear devices).

In addition to ECL, the 8007B equips you to test most other IC families. You can, for example, measure the sensitivity of a flip-flop; or determine the noise immunity of TTL circuits by adding pulses onto as much as a 4V dc level. These types of tests are made possible because of the continuously variable ±4V offset.

If your test needs call for even higher repetition rates (to 200 MHz) or faster transition time (to 1.2ns), you may also want to look into its companion generator, the 8008A.

For more information on either the 8007B or the 8008A fast pulse generators, contact your HP field engineer.

For standards in pulse generators, think Hewlett-Packard.

083/3

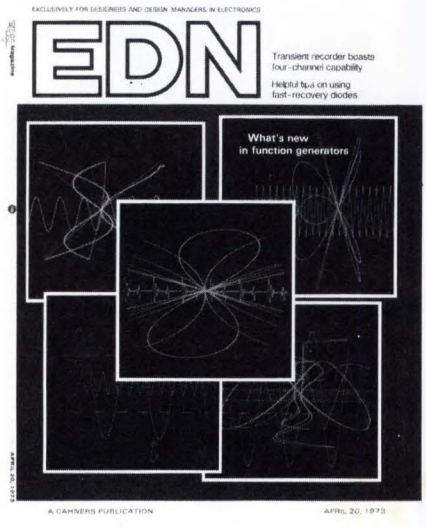
HEWLETT hp PACKARD

Sales, Service and support in 172 centers in 65 countries.
Palo Alto, California 94303. Offices in principal cities throughout the U.S.

CHECK NO. 2

APRIL 20, 1973
VOLUME 18, NUMBER 8

EDN with EEE
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



COVER

Todays function generator is a highly versatile instrument capable of producing not only the three basic waveforms of sine, square and triangle, but also a host of other signals such as tonebursts, FM and AM, phase modulated and synchronized signals, as shown courtesy of Wavetek Corp., San Diego, CA. For more details see pg. 36.

DESIGN NEWS

DESIGN FEATURES

PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

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

BPA
ABP

The industry's first LED-for-a-dime.

MLED500
19¢ 100-up
17¢ 1000-up

MLED640
2 mcd at 20 mils
90° viewing angle
Clear diffusing lens

MLED650
1.4 mcd at 50 mils
140° viewing angle
Red diffusing lens

MLED655
2 mcd at 20 mils
90° viewing angle
Red diffusing lens

MLED660†
1 mcd at 20 mils
90° viewing angle
Dark red diffusing lens

MLED665†
3 mcd at 10 mils
30° viewing angle
Red diffusing lens

†available shortly.

The 10¢ LED. Here. There. Everywhere.

1. Panel Indicators
2. Channel Indicators
3. Battery Indicators
4. Fault Indicators
5. Cameras
6. Stereo Indicators
7. Instrumentation
8. Calculators

We're geared up. We're ready to go. And with a price of 10¢, how can you afford *not* to design lots of LEDs into your new equipment designs!

These new devices come off the same high-volume, low-cost production lines that made our transfer-molded, Unibloc* plastic transistor outstanding the world over for economical, low-cost versatility. The result – the MLED500 series – now sets its own standard of leadership where price is the #1 parameter.

- High luminous intensity – 0.3 mcd typically at 20 mils
- Diffusing red lens – 110° field of view
- IC compatibility – low power consumption

You've tried LEDs produced by light guys, bright guys and innovators. *Now* try LEDs produced by a producer. Motorola Optoelectronics.

MAKE ME AN OFFER I CAN'T REFUSE!

Quote me a price on these LEDs in the quantities I've filled in:

MLED500 _____ MLED655 _____
MLED640 _____ MLED660 _____
MLED650 _____ MLED665 _____

Application: ☐ Immediate ☐ Long-Term

Name _____

Title _____

Company _____

Address _____

City _____ State _____ Zip _____

Motorola Optoelectronics
Box 20912, Mail Drop TB209
Phoenix, AZ 85036

*Trademark of Motorola, Inc.

Semiconductor

From Motorola, the LED producer.

Circle No. 3

★SIMPLIFY PROCUREMENT★

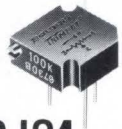
BOURNS NOW OFFERS 16 MIL SPEC POTENTIOMETERS/VARIABLE RESISTORS

Save paperwork, money and time by ordering all your Mil Spec potentiometers from Bourns, the most complete single source in the industry. It's sound logistics — one purchase order, one approved source. At the same time you're protected by Bourns tradition of excellence. Each Bourns potentiometer is designed and manufactured to consistently exceed Mil Spec requirements.

★ NON-WIREWOUND – **MIL-R-22097**

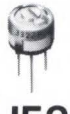
*RJ12 C-F

*RJ22 C-F



*RJ24 C-F

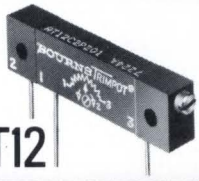
*RJ26 C-F



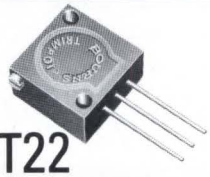
*RJ50 C-F

★ WIREWOUND – **MIL-R-27208**

RT10



*RT12



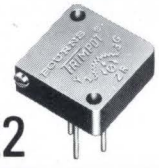
*RT22

*RT24

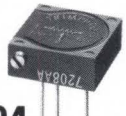
*RT26

★ ESTABLISHED RELIABILITY – **MIL-R-39015** ★ **MIL-R-39035**

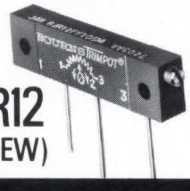
RTR12



RTR22

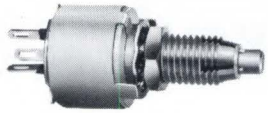


RTR24 (NEW)



RJR12
C-F (NEW)

★ **MIL-R-94**



*RV6

BOURNS HAS MORE POTENTIOMETERS ON QPL THAN ANY OTHER MANUFACTURER!

BOURNS INC

★ **MIL-R-23285**

RVC6 (NEW)

BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507

* AVAILABLE FROM STOCK AT YOUR LOCAL BOURNS DISTRIBUTOR

Circle No. 4

Circle No. 21

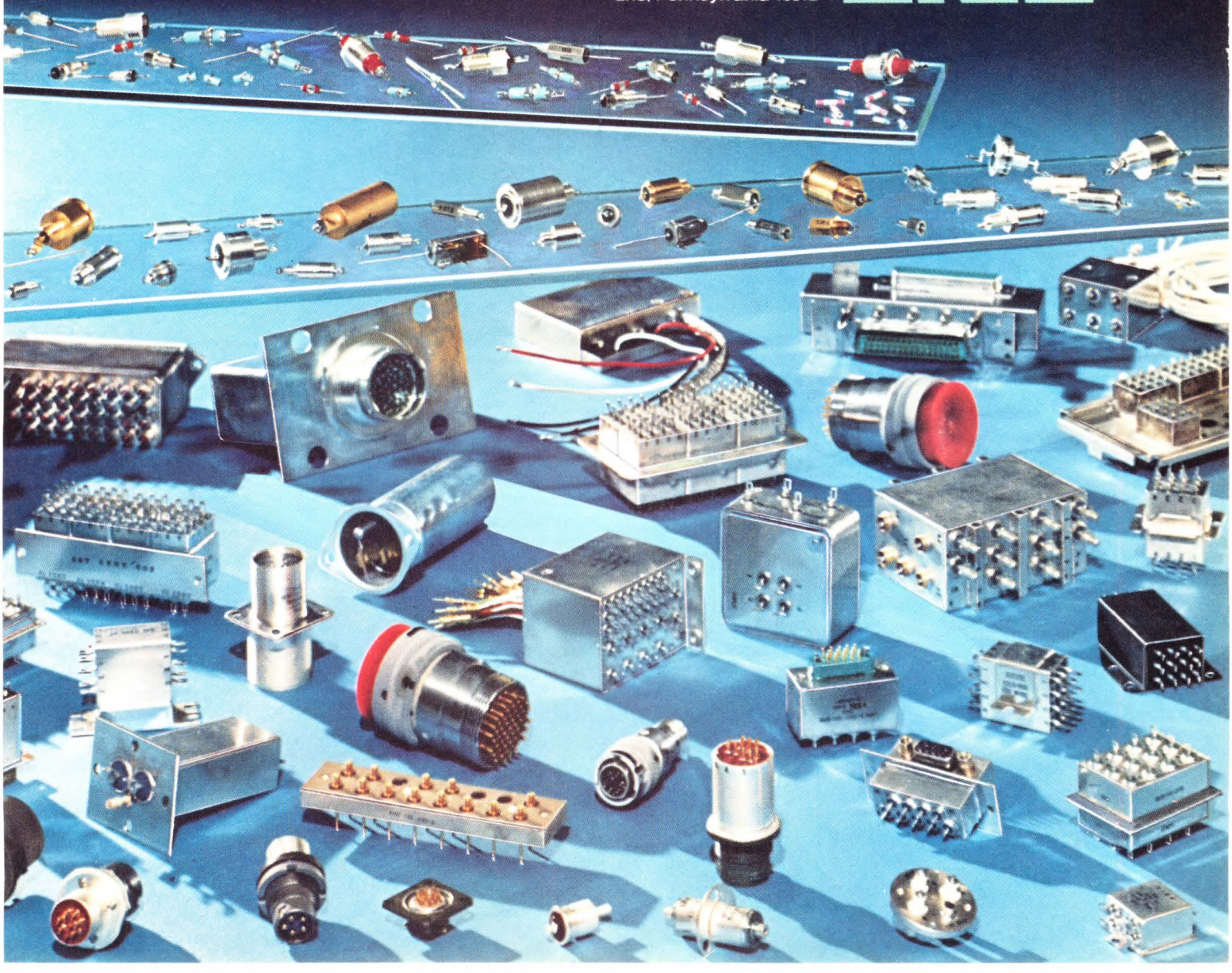
EMI FILTER
CAPITAL OF THE WORLD

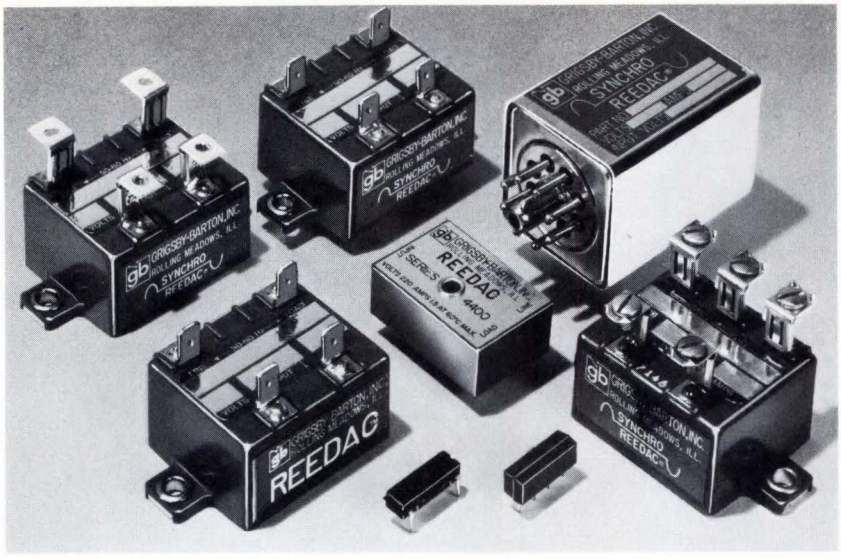
FROM CERAMIC POWDER TO MIL-APPROVED TEST LAB...
ERIE HAS IT ALL, UNDER ONE ROOF

Only one company can deliver your total EMI Ceramic Filter needs . . . ERIE. We've been applying sophisticated ceramic and related technologies to developing superior filters for 35 years. Today ERIE has, by far, the broadest line of subminiature EMI Filters in the world. From tiny high frequency filters to broad band filters to custom filter assemblies, ERIE offers the ultimate in quality. And you get single-source responsibility too, for we build the complete filter in a plant devoted exclusively to the design and manufacture of EMI Filters. So come to ERIE for your filter needs. We'll put a team to work on your particular application. Aerospace. Communications. Avionics. Industrial Equipment. Whatever the market, we can help eliminate electromagnetic "noise" and emissions. In the meantime, write for our complete catalog . . . EMI Filters or call 613/392-2581.

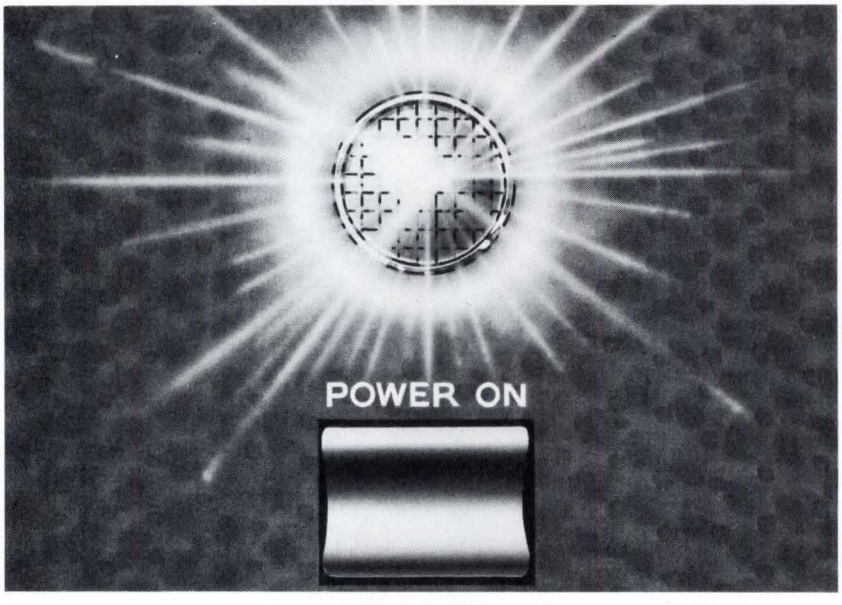
ERIE TECHNOLOGICAL PRODUCTS, INC.
Erie, Pennsylvania 16512

ERIE





REEDACS® LIVE.



AND LET LIVE.

If you use triac switching circuits, you've probably had premature switching failures. But you won't with Reedacs. Because we found the "bug" was an unknown electrical characteristic of the triac. And we developed exclusive circuitry to keep Reedacs immune from the "bug."

Reedacs are offered in a wide selection of sizes and types. Octal plug-in to DIP. Hybrid or Photo-coupled input. Synchronous or random turn-on output. Switch to 240 VAC and 40 amps.

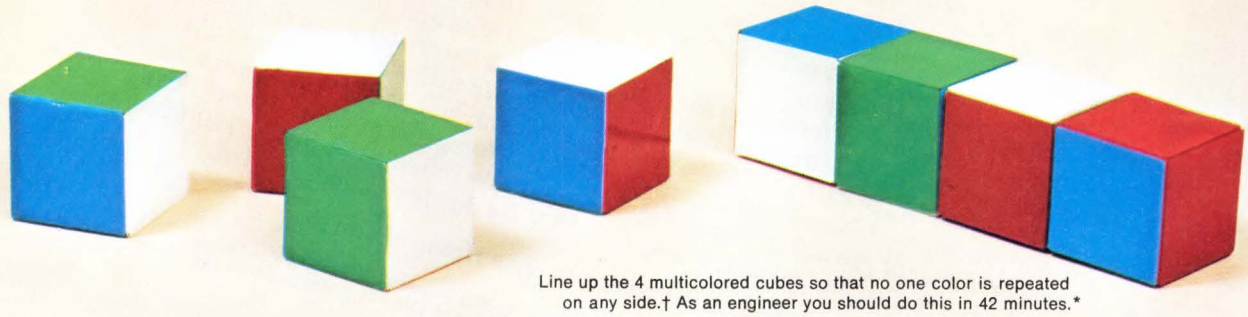
Now, get the facts on how to increase your equipments' life. Send for our free report on the "bug" causing premature failure and for all technical specifications for Grigsby-Barton Reedacs.

GRIGSBY-BARTON INC.

3800 Industrial Dr., Rolling Meadows, Ill. 60008
Phone (312) 392-5900 TWX 910-687-3789

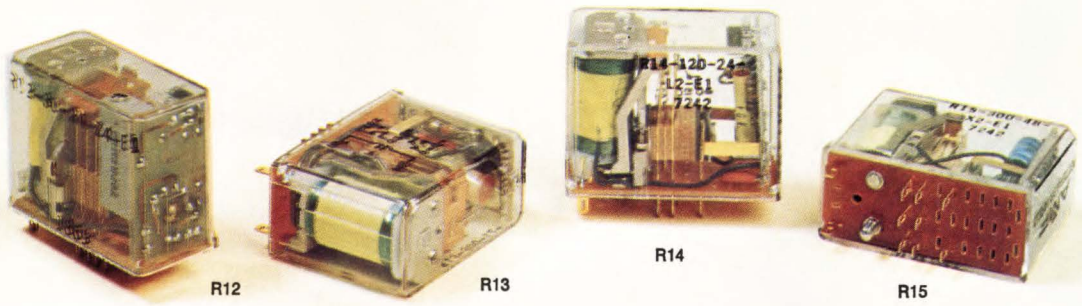
Circle No. 7

This problem should take you about 42 minutes to solve.



Line up the 4 multicolored cubes so that no one color is repeated on any side.† As an engineer you should do this in 42 minutes.*

With P&B's four new time delay relays you solve cost, accuracy and size problems. Immediately.



These new solid state time delays—each designed to solve different design problems—are built around our compact, widely accepted R10 relay. Each is available in 2 or 4 Form C contact arrangements and may be mounted directly to a chassis, printed circuit board, special mounting strip or in sockets having solder or printed circuit terminals.

R12 Series. A high resolution, 15-turn potentiometer provides delay on operate timing variations within ranges of 0.1 to 2.0, 1.0 to 30 and 5.0 to 120 seconds. Coils are for 12, 24 or 48V DC. Six contact styles cover a load range from dry circuit to 10 amperes.

R13 Series. These fixed, delay on operate time delays are available in 10 timing ranges from 1 to 300 seconds. They require less than 240 milliwatts of DC to operate. Operating voltages are 12, 24 and 48V DC. Contact ratings: dry circuit to 5 amperes.

R14 Series. Seven timing ranges provide delay on operate (R14) or interval timing (R14A) from .025 to 600 seconds. Available fixed or externally adjustable with coil voltages of 6, 12, 24 and 48V DC. Contacts may be specified from dry circuit to 10 amperes.

R15 Series. AC operated from 12, 24, 48 and 115V power sources, these compact time delays may be ordered fixed or externally adjustable in seven timing ranges from .025 to 300 seconds. Delay on operate (R15) or interval timer (R15A) modes are available.

Get complete specifications from your local P&B representative or call Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. 812-385-5251.

**Think you can readily solve the puzzle shown above? Ask your P&B representative for one.*

Solving switching problems is what we're all about.

AMF
Potter & Brumfield

Circle No. 6

†"Instant Insanity". Copyright Parker Brothers

OUR 40 YEARS OF RESEARCH HAVE PRODUCED MANY SMALL REWARDS...

As you can see by comparing some of our circa 1933 carbon resistors with today's super-sophisticated resistive devices. Frankly, it has taken millions in research to satisfy designers' demands for more performance in smaller packages — and at low cost.

We're still big in carbon comps, the time-proven work horse and now in carbon films for critical performance needs. We're also big in some of the really exotic micro-technologies — thin and thick films, miniscule chip resistors and package networks in a super-abundance of formats.

Engineers and buyers of components are often surprised when they see the price/size ratios of our components. So if you haven't called Airco Speer lately, may we suggest you do so now? Just dial 716-285-9381 or TWX 710-524-1653. You're due for a small reward.

Airco Speer Electronics — The Home of the Ω

RF Chokes • Shielded Coils • Molded Capacitors • Flat Power Film Resistors • Fixed Composition Resistors • Fixed Carbon Film Resistors • Thick and Thin Film Chips and Networks

AIRCO Speer Electronics – the Innovators

Circle No. 8

There'll be some changes made

Point 1: The "average American consumer" has been described as a middle-aged male, dressed in a Hong Kong suit and Italian shoes, who sits in his Canadian easy chair, nibbles on Swiss cheese with a bottle of Dutch beer at his elbow, watches a Japanese TV set on which a Volkswagen commercial is being telecast at an American football game and between halves complains to his wife about imports.

Point 2: Many labor leaders in the United States feel that large, U.S. based multinational companies have reached beyond the national jurisdictions of the unions and as a result are able to negate the effects of strikes. They want legislation forcing the multinational companies to limit their activities to the United States.

Point 3: The United States represents 6% of the world's population, leaving 94% of the total world market for goods and services outside of the U.S.

Point 4: The United States imports all or most of its natural rubber, tin, nickel and chrome and has a shortage of crude oil, iron ore and copper. The so-called "American automobile" contains basic materials or semi-manufactured goods from 32 countries, while the ordinary telephone has ingredients from 18 countries.

Point 5: Current tariffs, quotas and other import restrictions imposed by the U.S. are estimated to cost American consumers between 10 and 15 billion dollars a year in higher prices.

Point 6: Despite two devaluations, the American dollar is still beset by problems in the world money markets, thanks to our still unfavorable balance of payments.

Point 7: Meat and other food prices continue to soar, in spite of actions such as last year's relaxation of beef import quotas.

What do all these divergent and contradictory points mean?

As a minimum, they show that world trade is the kind of issue that can set brother against brother and family against family—with one's viewpoint being strongly colored by economic position, industry affiliation and even specific job function.

More importantly, the above points typify the kinds of things that both Congress and the Administration are now wrestling with in their attempts to come up with a foreign economic and trade posture that is best for the country. Most people agree that our present policies need revising. But how?

Is the rather radical Hartke-Burke Bill, which is described as "necessary" by its backers and "isolationist suicide" by its opponents, the way to go? Or should we try for international agreements, wherein each partner voluntarily limits its exports. Another possibility is outright subsidies for hard-hit companies or industries.

Decisions can't be put off too much longer, and when they come the electronics industry is going to be affected as much as any other industry and more than most. Those who don't fully understand the issues and their ramifications may be surprised, and even unhappy, with the results. But doesn't someone who deliberately remains uninformed forfeit the right to complain?

Frank Egan

Editor

STAFF

Publisher
Hugh R. Roome

Editorial Staff
Frank Egan, *Editor*
Roy Forsberg, *Managing Editor*
Bob Cushman, *Special Features Editor*
Roger Allan, *Associate Editor*
John Bond, *Associate Editor*
Earle Dilatush, *Associate Editor*
Bill Furlow, *Associate Editor*
Art Stapp, *West Coast Editor*

Art Staff
Dan Kicilinski, *Director*
Patricia Rawlins, *Illustrator*
Elizabeth Garrenton, *Illustrator*
Richard Pierro, *Illustrator*

Production Staff
Wayne Hulitzky, *Director*
William Tomaselli, *Manager*
Susan Kennedy, *Assistant*

Circulation
Ron Kinnes, *Manager*

Marketing Services
Ira Siegel, *Manager*

Editorial Consultant
John Peter

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

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

West Coast (415) 383-4220
23 Bayview Terrace
Mill Valley, CA. 94941

West Coast (213) 933-9525
5670 Wilshire Blvd.
Los Angeles, CA. 90036

Honeywell announces the end.

Our new Honeywell Model Ninety-Six isn't just another high-performance magnetic tape recording system. As far as state-of-the-art will reach...it's **the end**—the ultimate—an instrumentation system that incorporates every feature you have been asking for in a laboratory system.

For example, like previous Honeywell recorders, our Model Ninety-Six has a vacuum-buffered, low-tension tape drive for gentle tape handling, minimum head and tape wear. But unlike all other tape recorders, it will handle 16" reels, through nine tape speeds from 15/16 to 240 ips, and incorporates six other important improvements that together spell **the end** in tape recording:

The end of head wear worries. All of the new Honeywell solid ferrite heads are warranted for 3,000 hours. This alone should help solve one of your biggest headaches.

The end of spectral pollution. Two Honeywell features, FM flutter compensation, and an all new wideband phase lock servo system combine to give you the cleanest reproduce spectrum in tape recording. You'll be happy to know, too, that this servo system offers flutter attenuation at a band-width we believe you simply cannot buy anywhere else.

The end of configuration problems. Tired of trying to match your available electronics to a new task? The 28-channel Model Ninety-Six has omniband electronics. This means you can configure the recorder—at minimum expense—to match your needs as your needs change. Which also means...

The end of support concerns. Omniband signal electronics require only six basic plug-in assemblies to accommodate **all** record and reproduce functions, including bias oscillator, head drivers and preamps.

The end of maintenance hang-ups. Our new Model Ninety-Six is probably the most thoroughly tested tape system ever offered. We've spent thousands of hours wringing the bugs out...to make sure you don't have to. What's more, the testing, front panel access and built-in transport calibration system all were designed to be simple and reliable...to minimize service requirements.

For full details on the new Honeywell Model Ninety-Six, call or write: Charles O. Miller, MS211, Honeywell, Inc., Test Instruments Division, P.O. Box 5227, Denver, Colorado 80217, (303) 771-4700.

Honeywell
The Automation Company

Circle No. 25

RCA introduces its one-transistor Darlington.

No we haven't changed the Darlington circuit. We've just turned it into the Darlington transistor. By putting the whole circuit on a single monolithic chip.

In the RCA Darlington transistor design, optimum use of the silicon real estate and single level metallization provide improved performance characteristics. You get greater control over parameters and increased peak current handling capacity . . . up to 15 amps.

It's all spelled out in black and white. $I_{S/B}$ $E_{S/B}$ and Thermal Cycle ratings are all specified . . . even the output diode is characterized.

And they don't come any more rugged. All steel (TO-3) package, controlled solder chip mounting and heavy duty clip connections make the RCA Darlington transistor a dependable workhorse in your system.

So if you're working with discretes, you can now get higher packaging densities, lower your overall system cost and, at the same time, increase system reliability by reducing the number of external connections.

Why not give your system the advantage of all these benefits by switching from the Darlington circuit to the RCA Darlington transistor. It's at your distributor, waiting for you right now in the following configurations:

TO-3 pkg.	T_D@25°C	VERSAWATT plastic pkg.	T_D@25°C	$V_{CEO(sus)}$ $V_{CER(sus)}$
2N6385	100W	2N6388	40W	80V
2N6384	100W	2N6387	40W	60V
2N6383	100W	2N6386	40W	40V

Want more data? Write RCA Solid State, Section 50D15/UTL37, Box 3200, Somerville, N.J. 08876. Phone (201) 722-3200.

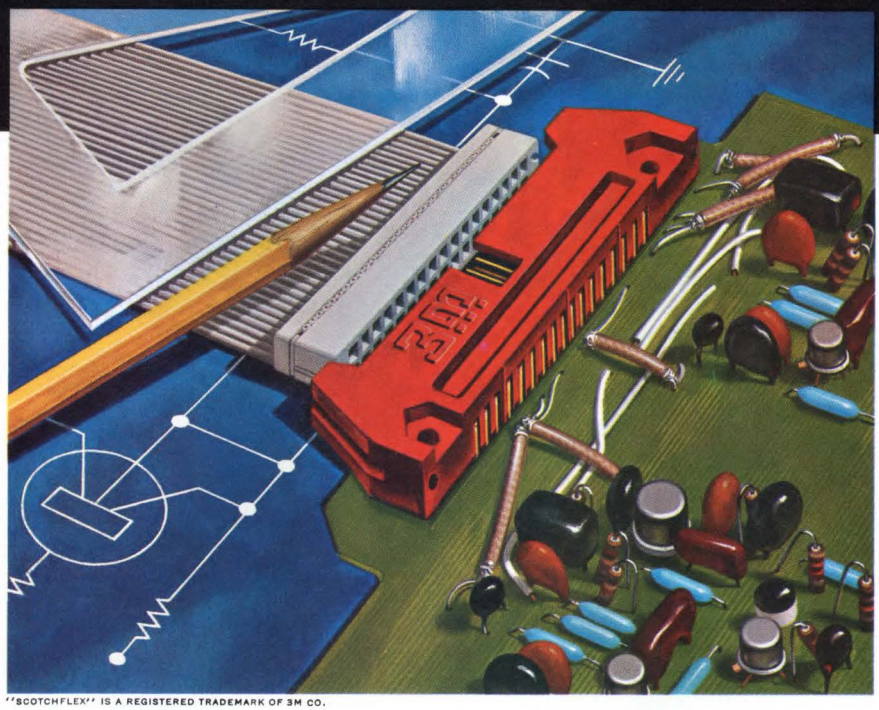
RCA Solid State

products that make products pay off

International: RCA, Sunbury-on-Thames, U.K., or Fuji Building, 7-4 Kasumigaseki, 3-Chome, Chiyoda-Ku, Tokyo, Japan. In Canada: RCA Limited, Ste-Anne de Bellevue 810, Canada.

Circle No. 62

For built-in reliability, design with "Scotchflex" Flat Cable/Connector Systems.



"SCOTCHFLEX" IS A REGISTERED TRADEMARK OF 3M CO.

"Scotchflex" Flat Cable and Connectors can offer you trouble-free packaging for your next generation equipment.

There's built-in reliability for your circuit inter-connects. Our flat, flexible PVC Cable has up to 50 precisely spaced conductors. The gold plated U-contacts are set into a plastic body to provide positive alignment. They strip through the insulation, capture the conductor, and provide a gas-tight pressure connection.

Assembly cost reductions are built-in, too. "Scotchflex" Connectors make up to 50 simultaneous connections without stripping or soldering. No special training or costly assembly equipment is needed.

Off-the-shelf stock offers you flat cable in a choice of lengths and number of conductors from 14 to 50. Connector models interface with standard DIP sockets, wrap posts on .100 x .100 in. grid, or printed circuit boards. Headers are available to provide a de-pluggable inter-connection between cable jumpers and printed circuit boards (as shown). Custom assemblies are also available on request.

For full information on the "Scotchflex" systems approach to circuitry, write to Dept. EAH-1, 3M Center, St. Paul, Minn. 55101.

3M COMPANY

Circle No. 12

AVX

believes there is a tomorrow

Today, our capability is the industry's best. We're making it better. AVX is doing something today about tomorrow. We're building a new addition at Myrtle Beach — substantially increasing our two million a day capacity. We're beefing up our capability to help fill the ever-increasing demand for multi-layer ceramic capacitors.

AVX is refining what is already a proven production process. Computerized control speeds product off the end of the line. Every conceivable means, including proprietary mechanization and in-line testing, is used to deliver customer orders to spec and on time.

AVX believes there is a tomorrow and that's why we're doing so much today. If you need help with multi-layer ceramic capacitors, ceramic discs, tubular feed-thrus, chips or ceramic filters, write AVX Ceramics Corporation, P.O. Box 867, Myrtle Beach, S.C. 29577 or telephone (803) 448-3191. We'll help you.

AVX

THE Ceramic Capacitor Manufacturer

Braintree, MA.

Circle No. 13

Two new digital multimeters with price and performance you can't refuse.

8350A

5½ digits, autoranging
0.005% accuracy
5 ranges dc volts
5 ranges of ohms
4 ranges ac volts
$1495, complete DMM

8375A

5½ digits, autoranging
0.003% accuracy
Functional self-test
5 ranges dc volts
7 ranges of ohms
4 ranges **true RMS** ac volts
Powerful systems options
$1995, complete DMM

Both instruments use Fluke's patented recirculating remainder a-to-d converter for low parts count, low power consumption and boast a calculated MTBF of at least 10,000 hours. ● Either instrument gives you more multimeter for your money. **Now isn't that an offer you can't refuse?**

FLUKE®

For details call your local Fluke sales engineer. In the continental U.S., dial our toll free number, 800-426-0361 for his name and address. Abroad and in Canada, call or write the office nearest you listed below. Fluke, P.O. Box 7428, Seattle, Washington 98133. Phone (206) 774-2211. TWX: 910-449-2850. In Europe, address Fluke Nederland (N.V.), P.O. Box 5053, Tilburg, Holland. Phone 13-670130. Telex: 884-55237. In the U.K. address Fluke International Corp., Garnett Close, Watford, WD2, 4TT. Phone, Watford, 33066. Telex: 934583. In Canada, address ACA, Ltd. 6427 Northam Drive, Missisauga, Ontario. Phone 416-678-1500.

Circle No. 14

Channel display uses MOS/LSI

The impact of MOS/LSI technology is just beginning to be felt in the commercial-television market. One of the first uses of P-channel MOS in a commercial set is in a circuit to display the channel number on the TV screen for about one second after a channel has been selected (**Fig. 1**).

Designed for OEM use by Hycom, Inc., Santa Ana, CA, the circuit consists of a gated oscillator, display-time generator, read-only memory, shift registers and associated logic as shown in (**Fig. 2**).

Numbers of the 12-VHF channels and of 8 preset UHF channels—designated as U-1 through U-8—are stored in the ROM. Inputs from the channel selector are decoded to select the appropriate number which is then read out of the ROM using the horizontal- and vertical-sweep frequencies for timing.

Fig. 1—Channel number is displayed for 1.2 sec after a channel is selected.

The output modulates the CRT beam at a clock frequency of about 400 kHz which gives a minimum vertical line width of about 1 in. on a 19-in. screen.

Channel-number display just begins to scratch the surface of the potential applications for this type of device. For several years some commercial TV stations have been transmitting time and frequency signals on some of the unused horizontal lines of the TV raster in cooperation with the National Bureau of Standards. (See EDN, Sept. 1, 1971, p. 15). Because of the cost of the equipment needed to decode the transmitted signals and display the information on the TV screen, there has been no attempt to offer this capability on consumer sets so far.

As low-cost LSI circuits with higher practical speed become available, this basic technique can be used to decode, store and display a variety of information that could be transmitted on the unused horizontal lines. And it could do it at a cost that would be practical for consumer use.

Clock frequencies achievable with N-channel MOS would provide minimum vertical line widths of about 1/4 in. allowing the technique to reach its full potential for alphanumeric display applications.

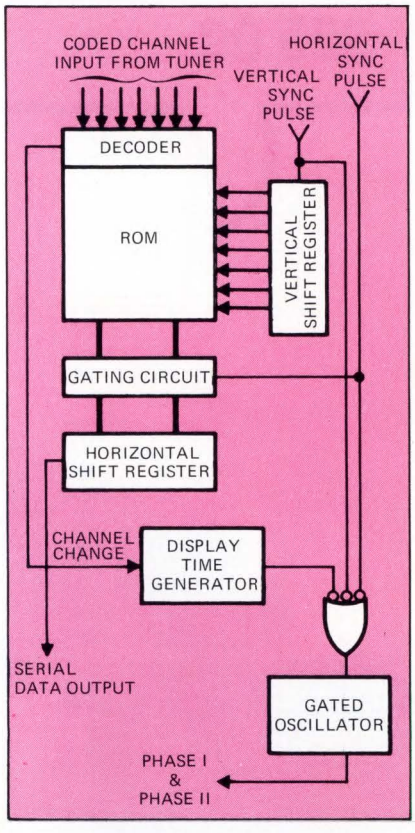


Fig. 2 — Information stored in the ROM is used to modulate the CRT beam at a clock frequency of about 400 kHz.

Although TV sets using this circuit have only recently been offered to American consumers, they have been available in Japan since August 1972 when they were introduced by Sharp Corp. — *AS* ▭

Meet the editors—and learn how to write for publication

If you want to write for publication, but don't really know the ins and outs of getting into print, here's your chance to find out what the editors want and how they can assist you. In two one-day seminars, scheduled for May 25 and October 19, you'll have a chance to meet with the editors of the 14 national technical publications headquartered in Boston.

They will explain what they're looking for and how you can get your stories into the news and feature sections of their publications. You'll have lunch with one editor and dinner with another, both of your choice. In addition, the editors will be available after dinner for private consultations about your specific publishing problems. You'll learn:

- How to determine which publications may be interested in your article
- How to deal with the editors
- How to get all kinds of help and guidance from them
- How to become a newsmaker
- How to get different versions of your story printed in a variety of publications as "in-field exclusives."

Your time won't be wasted with textbook discussions of grammar, sentence structure and style. Rather, the seminar will provide you with practical, hard-core details on how to get into print. You'll meet with the editors of 14 publications, including EDN.

The seminar, HOW TO WRITE FOR PUBLICATION, will be held at Boston University's George Sherman Student Union. The registration fee of $75 includes lunch, dinner, cocktail hour and all materials. Make checks payable to Boston University—SPC, and mail them to Mrs. Shirley Coyne, BU-SPC, 640 Commonwealth Ave., Boston, MA 02215. Phone(617)353-3488. The seminar is sponsored by BU's Science Communication Div. of the Graduate School of Journalism. — *RF* □

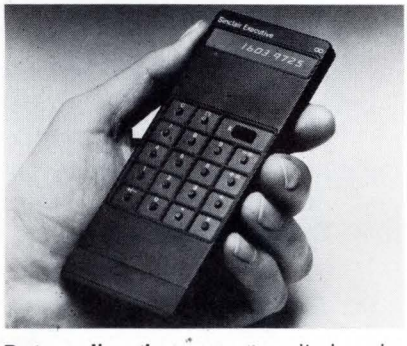
Power-supply modification turns standard calculator chip into unique product

How does a calculator designer give his company a sales advantage despite the fact he's forced to use the same LSI chip that all his competitors are using? One answer to this modern-day dilemma comes from Sinclair Radionics Ltd, a small British firm. Sinclair powers one of the standard chips (a General Instrument 500 series) with a short ON duty cycle followed by a longer OFF cycle. This allows the Sinclair designers to reduce their battery size and thus scale down their calculator's overall size and weight, to the point that it has an obvious "difference" to the buying public.

Clive Sinclair, head of the company and the main circuit designer, told EDN that the power-supply oscillator runs at about 100 kHz, and when no key has been depressed, applies power to the chip at a 1:20 or so duty cycle. This keeps the chip's memory alive and reduces the power consumed from the usual 300-mW level to about 20 mW. When the user depresses a key, the supply steps up to a 1:3 duty cycle for the length of the time needed to make the calculation.

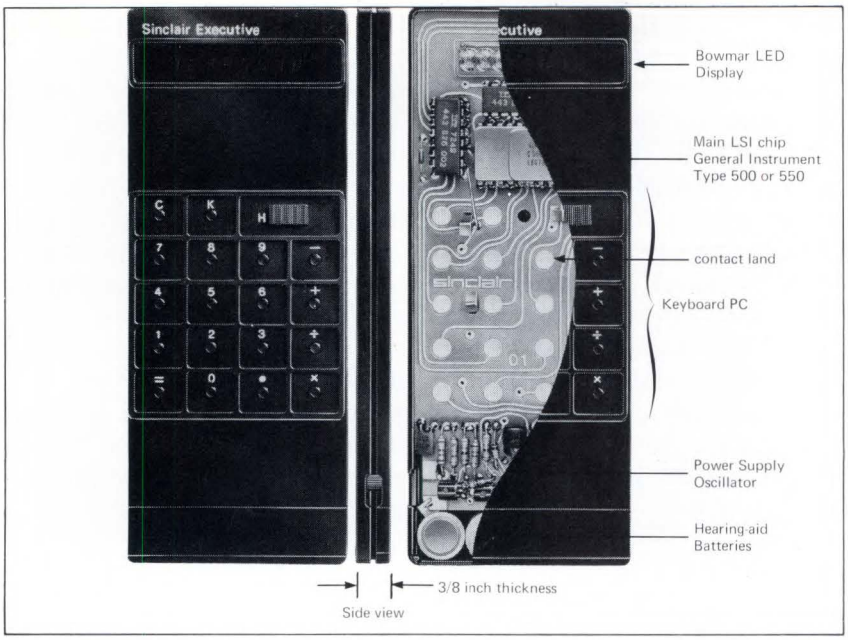
Sinclair says he has applied for a patent on the principle and expects his product will retain its uniqueness on the marketplace for awhile. Probably, some of the new micropower CMOS calculators that the Japanese say they are about to introduce will be the first challengers to Sinclair. Yet, it is interesting to note that the prototype of the CMOS calculator that Ragen announced 1-1/2 years ago—and has yet to be delivered—was several times thicker than Sinclair's 3/8-in. thick package. This may be due to Ragen's trying to obtain a full year's operating life on a battery, while Sinclair is only claiming 3 months average battery life. Incidentally, Ragen's present excuse for its delay is that it is having difficulties obtaining useful yields on CMOS chips that will meet its original one-year battery-life specification. Perhaps they, too, ought to duty cycle their power supply.

As can be seen from the cut-a-way view of the Sinclair calculator, the big reduction in thickness comes from the use of small hearing-aid batteries which is permitted by the duty cycling. To take advantage of this, Sinclair also had to have a low-profile readout and keyboard. The display problem was solved with a Bowmar LED assembly, but it was not so easy to find a standard keyboard that was thin enough. Sinclair ended up developing its own.



Duty-cycling the power supplied to the LSI/MOS chip allows this calculator to be very light (2-1/2 oz) and slim (3/8-in. thick).

The bottom half of the Sinclair keyboard, which can be seen in the cut-a-way view, is formed by conductor-land patterns etched on a pc board. The top halves are formed by small spring-metal tines that are pressed against the lands underneath by the buttons that protrude through the calculator case. This home-brew approach seems to us less reliable than some of the newer U.S. keyboards that also have low profiles (we've been



Cut-a-way view of Sinclair calculator shows the discrete-component oscillator that supplies the intermittent power to the General Instrument calculator chip above. The bottom half of the keyboard is formed by the printed circuit. The display is a Bowmar LED unit.

impressed with a sample of T.I.'s "metal-bubble" type, for example.). One cannot help wondering if Sinclair with its bold 5-year guarantee won't live to regret their keyboard's open contacts.

The oscillator circuitry that does the duty cycling must be an expensive addition for a calculator, for it is made up of discrete components and must be assembled by hand labor. Nevertheless, Sinclair believes it has made an overall gain. The marketing strategy has been to dub the thin calculator "The Executive" and then to convince buyers at high priced department stores like Saks Fifth Avenue, Abercrombie & Fitch and Nieman Marcus in the U.S. and similar high-ticket stores in Europe to carry it as a luxury item. In these fashionable environments, the higher price that Sinclair must charge ($195 as compared to the $100-$130 prices for other calculators using the same chip) does not phase the customers so much, if they become attracted to the slim form factor. The initial interest and sales have been quite good, we've been told, and Sinclair is predicting sales of 40k units/year in the U.S.

The lesson here for circuit designers ought to be obvious. There is still a place for circuit-level ingenuity, even in these days of identical LSI "guts."—*RC* □

Automated-graphics system takes the drudgery out of drafting

A computer and a paper "keyboard" form a novel system for converting freehand sketches into fully proportioned drawings. The experimental system is designed to speed the creation, filing and updating of large volumes of graphic material such as maps and engineering drawings. It is the result of collaboration between IBM's Research Div. and Advanced Systems Development Div.

Placed at random on a special electronic tablet, a rough sketch and the paper keyboard are simply touched with an electronic pen to enter graphic or alphanumeric data and to initiate computer program functions.

In addition to the tablet and pen, the graphics system includes control units and special programs for the IBM 1800 Data Acquisition and Control System to which the equipment is attached. A conventional television monitor and hardcopy plotter serve as output devices.

A user wishing to create a drawing places his rough sketch and the paper keyboard anywhere on the tablet to suit his work methods. He enters the sketch into the computer by quickly outlining it with the pen, merely pointing the pen at the keyboard to specify such details as broken or dotted lines, arrows or circles. To create a circle, for example, he would touch the keyboard's circle-drawing function with the pen and then, on the sketch, indicate the center of the circle and any single point on its circumference.

The user can also add dimensions and labels by selecting the appropriate characters from the keyboard and pointing out where they should be placed on the sketch.

To check his work, the user can at any time have the sketch displayed on the television screen. He does this by pointing the pen to the "display" function on the keyboard. Similarly, he can cause the sketch to be produced in hardcopy form by the plotter or stored by the computer for later work.

To convert the sketch into a finished drawing proportioned according to the entered dimen-

sions, the user merely touches the "finished drawing" function box on the paper keyboard. He is alerted automatically if dimensions conflict or are incomplete.

Finished drawings and maps can be altered with these same techniques, which are estimated to help a draftsman complete a job in as little as one-fifth of the time for manual methods.

The electronic tablet contains a grid that produces a range of unique voltages across its face. The pen senses the voltage at a given point and the control unit generates the coordinates of the point. These coordinates are used by the computer to determine the shape of the sketch as it is entered, the position of the paper keyboard and the characters and functions selected by the user.

The computer program contains a description of the paper keyboard and a library of routines relating to the keyboard functions. New descriptions and routines can be inserted into the program to fit a variety of applications. —*FE* □

Magnetic storage system for full color video display developed for maps and other avionic readouts

A new color display system study has just been completed by Hughes Aircraft and Ampex Corporation. The joint effort involves the use of a modified 8-channel video disc recorder developed by Ampex and a high resolution 4-beam color display developed by Hughes Aircraft.

Intended as a navigational aid for jet aircraft, the color map will be displayed on a 5 in. CRT with 7 mil resolution, readable under 10,000 lamberts of ambient light.

A vidicon camera scans off sixteen fields of 56 lines each for each of the three primary colors used, red, blue and green, to generate color for the display. These fields are stored on a magnetic disc and then played back to produce a 8-to-1 interlace color picture. The playback video is processed so that it is comprised of four simultaneous video signals, each with a 2-to-1 interlace (**Fig. 2**).

The four signals are sent to each of the four beam guns in the display CRT. Each beam scans one fourth of the CRT as shown in **Fig. 2**, and all beams

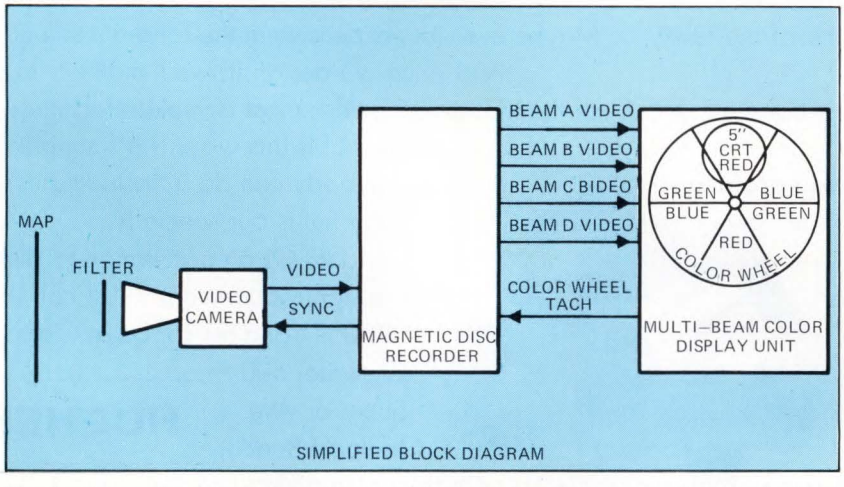


Fig. 1—A complex interlacing scheme of four electron beams, synchronized with a rotating color wheel produces a high-brightness, high-resolution display. The screen is scanned vertically with 896 lines.

TM – Contour Cable is a trademark of Hughes Aircraft Company.

We specialize in flat cable and flexible circuit problems nobody else can crack.

A lot of people make flat cable. A lot of people make flexible circuits. We're one of the few who make both.

But the big difference isn't only what we can manufacture, it's what we can design.

Hughes CONTOUR™ Cable solved problems for the Viking Mars probe. We worked out solutions for the Minuteman missiles. We cracked tough packaging problems for shipboard and airborne systems, radar, sonar, high-speed computers.

And we can crack your tough ones, too.

Not wild-eyed, super-expensive, forever-and-a-day solutions. Practical solutions. Maybe even less-expensive-in-the-long-run solutions.

And once we design it, we'll make it. In one of the industry's newest, most complete facilities.

Think of it this way. If it's simple and easy, anybody can do it, including us. But the tough nut is our specialty.

A tour? Or a consultation to discuss your design requirements? Just call (714) 548-0671 and ask for Dave Cianciulli. Or write: 500 Superior Ave., Newport Beach, California 92663.

HUGHES
HUGHES AIRCRAFT COMPANY
CONNECTING DEVICES

Cables, circuits, connectors . . . only Hughes puts it all together.

Circle No. 16

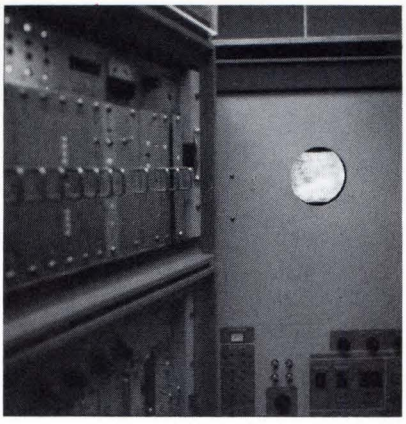


Fig. 2 —The prototype color map system at Ampex Corp. runs from memory stored on an 8-track disc.

scan simultaneously. At the same time the CRT is being scanned, a color wheel rotates in front of the CRT. The disc recorder is synchronized to the color wheel, which gives the video color.

The use of four beams allows the CRT to scan at 1/4 speed and with 1/4 the bandwidth for each beam. Reducing the scan speed of each beam preserves the beam geometry allowing for a higher resolution than having the beam scan four times as fast. In addition, to achieve the brightness with high resolution, the four beams each need to contribute 1/4 of the total energy applied to the screen. Feasibility studies at Hughes proved the four beams to be necessary.

The display unit located in the cockpit would show a color reproduction of a map while automatically locating the position of the aircraft in the middle of the display. The aircraft's navigational computer addresses the system causing the video tape recorder to load a video disc recorder with the appropriate sections of the map.

The unit employs an electronic video window movement that will allow continuous data flow to and from the disc. When a map perimeter is reached, the disc automatically reloads a new section of the tape stored map.

The system, originally developed in conjunction with NAVAIR (the Navy Air Development Program), will also allow for the display of other video data, such as radar, ballistics or infra-red, which can be superimposed upon the map.

Currently, only breadboard hardware has been developed. With its present configuration, the system might easily be adapted to other digital readouts for avionic purposes. As of this writing, EDN learned that both Hughes and Ampex were continuing the project on their own. It is not likely that the final CRT would use a color wheel, but rather a liquid crystal or piezoelectric color filter.—*JM* □

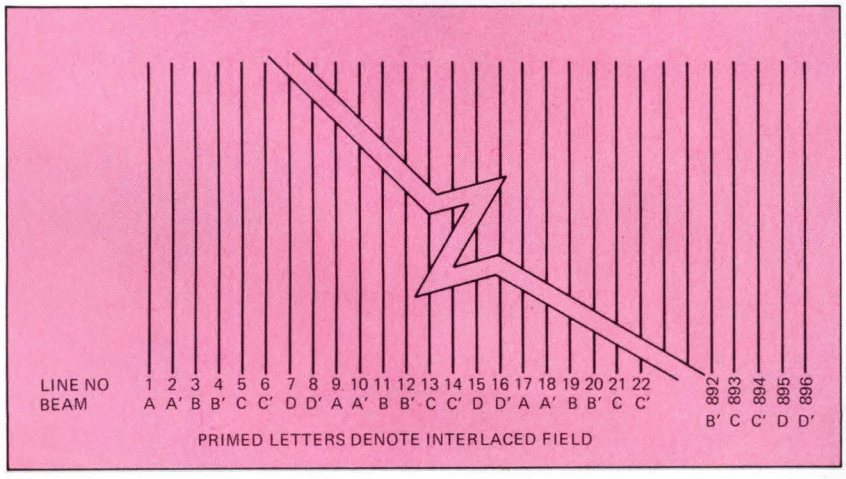


Fig. 3—Four beams, labeled A, B, C, and D are interlaced in the above scheme. The prime numbers denote the interlace sequence across the screen. Four beam guns are necessary to produce both the required resolution, and the display brilliance needed for viewing in high ambient light environments.

Think Twice:

When is a portable really portable?

HP's 1700 Series Portable Scopes Always Are...

They're tough go-anywhere scopes: weatherproof, dustproof, completely self-contained. Not the kind of "portable" that's gently moved from bench to bench, trailing a power cord. With a 1700 Series scope you don't worry about the rain. Or the rough ride. Or whether, when you get there, you'll find ac or dc power—or no line power.

An HP portable gives you features you'd expect only in a big lab scope. Like a large, bright CRT that lets you see even difficult signals in high ambient lighting, ECL trigger circuits and a trigger hold-off control, and sweep linearity over the full 10 divisions of horizontal display—ideal for maximum resolution in making those critical timing measurements.

But that's just the beginning. Then the 1700 Series allows you to pick the specific features you need for your field service application: conventional or variable-persistence storage CRT; bandwidths of 35, 75, or 150 MHz; sweep speeds as fast as 2 ns/div; delayed or non-delayed sweep; selectable input impedance; bright-scan viewing mode; and a built-in rechargeable battery pack for complete measurement independence.

And we're just as proud of the things you don't get with a 1700 Series portable. No heat sinks. No fans. No ventilation holes to let in dust and moisture. That's because our circuits are designed for very low power consumption—and for long, trouble-free operation. And there's no challenge in servicing our portables. In fact, you can completely recalibrate some models in an hour or less, even if all the internal adjustments are misaligned. It's not very sporting, but this ease of servicing quickly adds up to impressive savings.

So before you choose a scope, check your requirements. Then think twice about costs and benefits. Remember, Hewlett-Packard portables let you make any measurement you need—and they cost from $100 to $250 less than comparable scopes. These 1700 Series portables are priced from $1475 to $2300 for non-storage models and from $2375 to $2725 for models with variable-persistence storage. For help in choosing the HP portable that's best for you, send for a free copy of our "No-Nonsense Guide to Oscilloscope Selection." Or contact your local HP field engineer. Hewlett-Packard, Palo Alto, California 94304. In Japan: Yokogawa—Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokoyo 151, Japan. In Europe: HPSA, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland.

Scopes Are Changing; Think Twice.

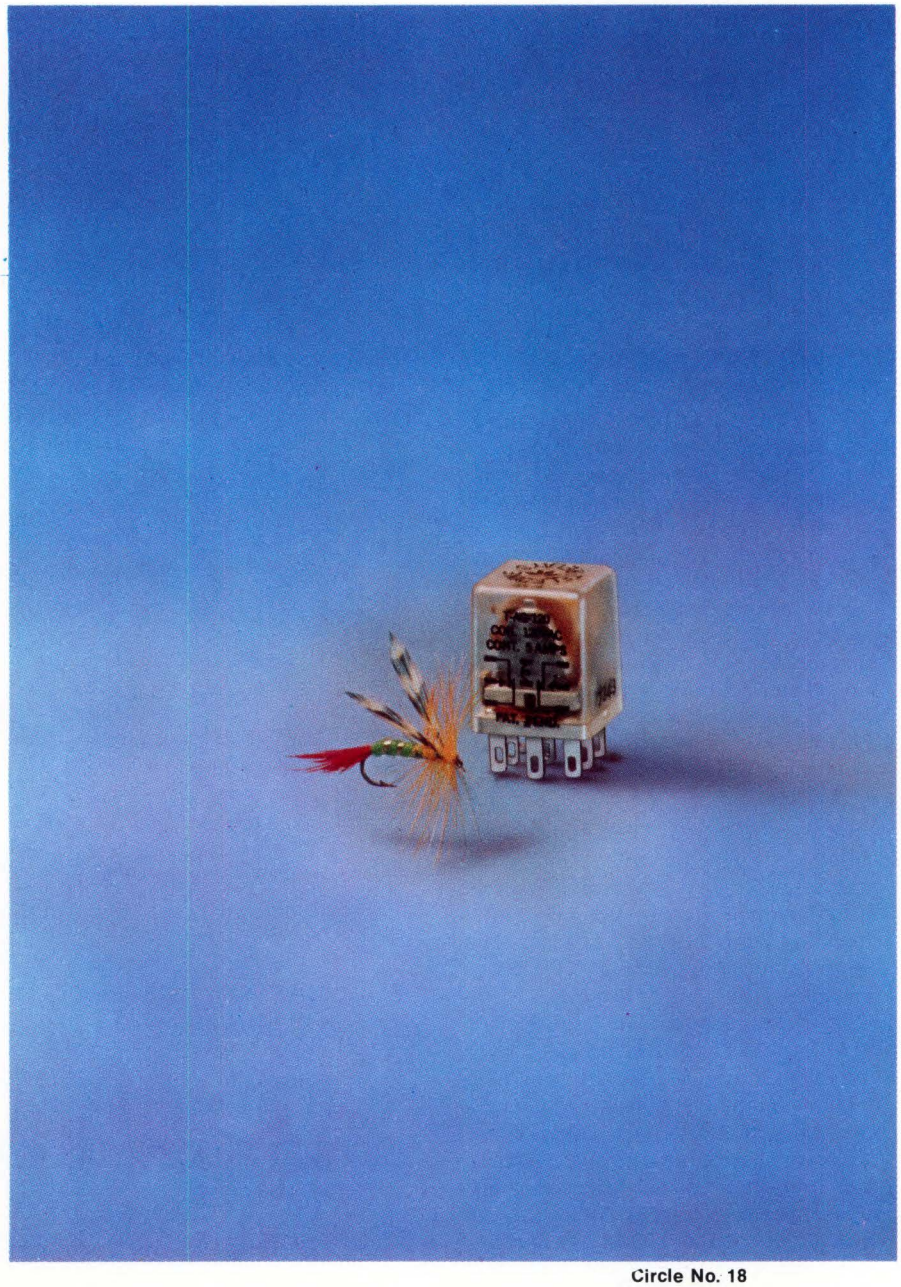
083/1

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

Circle No. 17

THE SMALLEST 5 AMP GENERAL PURPOSE RELAY



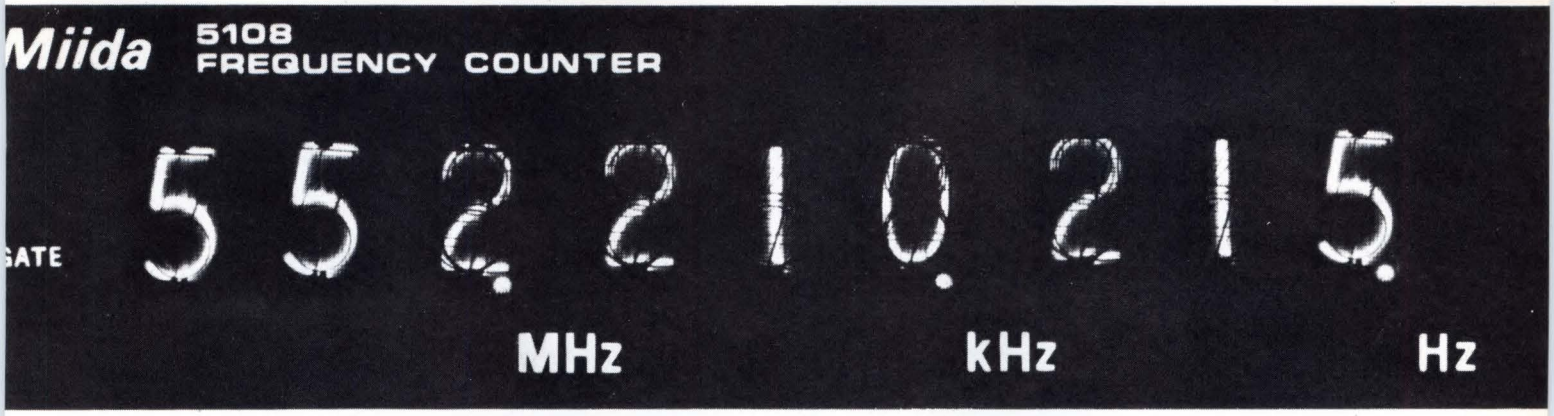
Available now, Teledyne's new Mini-T.

This industrial, heavy-duty 120 volt 5 amp relay features a life expectancy of over 10 million dependable operations. The space-saving 2PDT Mini-T with transparent dust cover has a full line of complementary sockets and hold down clips for P.C. board or chassis mounting. This Teledyne relay employs an unusual shaded pole design that permits direct AC operation without the need for rectifying diodes. Available with either AC or DC coils and demonstrating cost effectiveness that's hard to beat, the United States-manufactured Mini-T is truly worth its one-half ounce weight. The Mini-T . . . another finely-crafted relay from Teledyne. Call our nearest distributor today.

3155 West El Segundo Boulevard
Hawthorne, California 90250
Telephone (213) 679-2205

TELEDYNE RELAYS

Circle No. 18



550MHZ 10mV

UHF bandwidth with extreme sensitivity—this is what you need to calibrate both a transmitter and receiver. Only the 5108 provides you at this price with 10mVrms sensitivity from 100Hz to 550MHz (100mVrms from 10Hz to 100Hz).

The 9-digit display is a gratifying necessity, when you use the 5108's full resolution of 1Hz on a 16-second gate time. Your controls provide 4 decades of resolution, down to a 160-millisecond gate time for 0.1kHz resolution.

Time base aging rate is slower than a movie star's: 5×10^{-8} for the temperature-compensated crystal oscillator.

More: 35dB auto-attenuation with automatic noise suppressor; 20dB additional with manually switched attenuator.

Service and parts—Never a problem; **HONEYWELL** provides both. Throughout the USA. Quickly and efficiently.

There are 19 essential specifications on the 5108 data sheet, most of them superior to those of any competing counter. You've just read 5 of the 19. This is the best counter you can procure in this price range, and you can get all the details, plus the name of your local representative by writing or calling Tom Williams at Miida.

$950

Miida Electronics

2 Hammarskjold Plaza • New York, N. Y. 10017 • (212) 973-7152

Circle No. 19

Xtal Filters.

Damon shapes up fast!

Whether your signal shaping need is a sharp rejection notch, a band-pass or a single side-band filter – call Damon. Choose from dozens of computer-assisted standard designs including Butterworth, Chebyshev, Gaussian or Bessel. Or let Damon create a custom filter to your specs. Either way, you're sure of the exact crystal filter you need. A production run or a prototype, Damon meets your schedule. Try us. Damon/Electronics Division, 80 Wilson Way, Westwood, MA 02090. Tel: (617) 449-0800.

Band-Pass Filters

PARAMETER	RANGE
Center Frequency	10 Khz-75 Mhz
Bandwidth	.01%-3% of C.F.
Phase Linearity	<±5%
Transient Overshoot	>40 db
Shape Factor	<1.25:1
Differential Phase Shift	<±2°
Group Delay Uniformity	<±5%

Band-Reject Filters

PARAMETER	RANGE
Center Frequency	10 Khz-35 Mhz
Reject Bandwidth	.01% to .5% of C.F.
Pass Bandwidth	Up to 100% of C.F.
Shape Factor	<1.8:1
Notch Rejection	>80 db
Insertion Loss	<0.5 db
Ripple	<0.25 db

Single Side-Band Filters

PARAMETER	RANGE
Center Frequency	10 Khz-35 Mhz
Pass Bandwidth	.01% to 2% of C.F.
Carrier Rejection	>40 db
Shape Factor Carrier Side	<1.15:1
Shape Factor Side-Band Side	<1.25:1
Insertion Loss	<3 db
Ripple	<1 db

Circle No. 20

DAMON

Raytheon Semiconductor announces two super products that just made us No.1 in voltage regulators.

No gimmicks. Just proof.

Here they are. Adjustable and fixed dual-tracking voltage regulators that are so simple to design into your system you can forget about your slide rule and calculator. They require fewer external components so they take up less space. Compared to other voltage regulators, they provide more than twice as much current. Which means you can supply a lot more systems for a lot less money in the long run. And they are the first voltage regulators to provide thermal shutdown protection for both outputs at a junction temperature of +175°C.

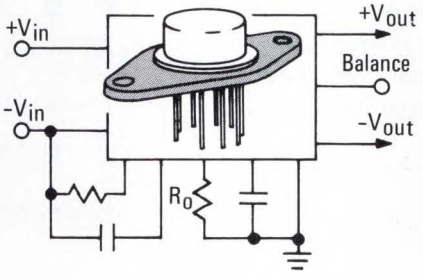
Adjustable 4194

With the 4194 you get both positive and negative outputs from 50mV to 42V — the widest range available today. All it takes is one external resistor (R_O) to ground for setting the desired output voltage. And to find out the value of R_O you just use this simple formula: $2.5 \times V_O = R_O\ (K\Omega)$.

Or if you want to program the outputs simultaneously, use one pot calibrated for 2500 ohms/volt.

Depending on the application, you'll only need from 4 to 6 external components — compared to 8 to 12 for other regulators.

The 4194 provides 200mA at both outputs simultaneously, with



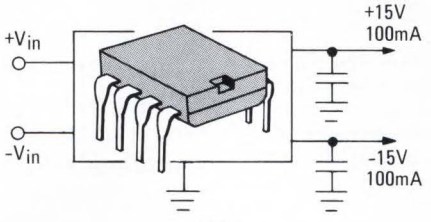
4194

0.2% load regulation over the entire voltage range. You need just one resistor to provide asymmetrical tracking voltages for the popular 710, 711, 702, 106 or the like. And with external pass transistors the 4194 can supply output currents to 10A.

Fixed 4195

Check these features against competition. The 4195 provides positive and negative 15V outputs at 100mA each. And it does it with only two bypass capacitors, compared to competition's six external components. That means you can power a lot more op amps for a lot less money.

The 4195 can be used as a single supply with an output of up to +50 volts. It comes in 3W and 900mW packages or — and this is another first — an 8-pin plastic mini-DIP!



4195

RAYTHEON

Raytheon Semiconductor
350 Ellis Street
Mountain View
California 94040
Phone (415) 968-9211.

Send me information right away on the voltage regulators checked below.

- ☐ LM104/204/304
- ☐ LM105/205/305
- ☐ LM109/209/309
- ☐ 723
- ☐ 4194
- ☐ 4195

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

CITY/STATE/ZIP _____

The function generator: more flexibility at lower prices

While there haven't been many basic design changes, frequency has been increasing; prices are dropping; and flexibility is on the upswing.

Roger Allan, Associate Editor

When the recent 1969-1970 recession hit, engineering budgets were cut drastically, and designers found precious little money to spend, particularly on new laboratory instruments. These had to be more tailored for the job and had to offer a lot more value for the same money. One such instrument that has done just that is the function generator. Despite improvements in flexibility, it is selling for even less money than it did one year ago, thanks, in part, to keen competition from the dozen or so manufacturers in the field.

Function generators offering moderately accurate sine, square, triangle, pulse and ramp outputs over a few microHertz to 10 and 20 MHz are selling in the $300-to-$500 range, down from the $400-to-$600 range of about a year ago. And they are quite flexible. They offer frequency sweep, single-shot, burst, gating, modulation and voltage-control features in many different combinations to suit different general-purpose requirements. Some are available for as low as $245.

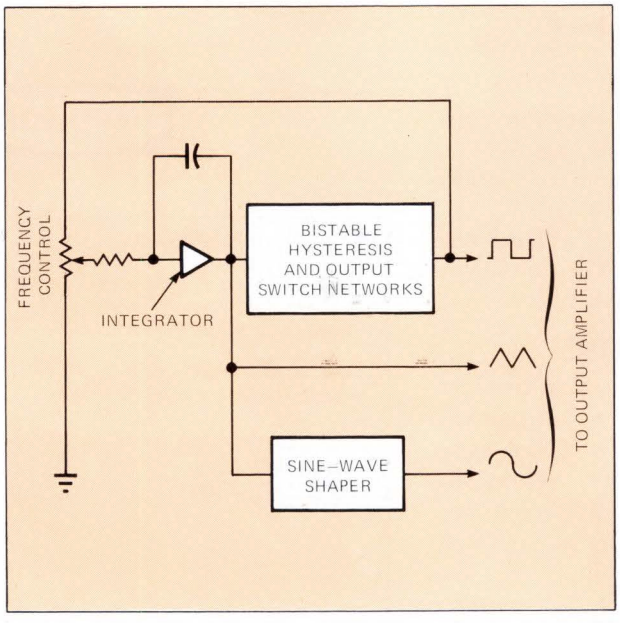


Fig. 1—A fundamental function-generator circuit. The triangular wave is developed in the integrator which incorporates a capacitor that charges and discharges from a constant-current source. This is fed into a bistable hysteresis network in a closed-loop to form the square wave. The sine wave is shaped from the triangle after the latter is fed into a diode-array-shaper network. Ramp and pulse waveforms are made by combinations of offset voltages and time-symmetry changes.

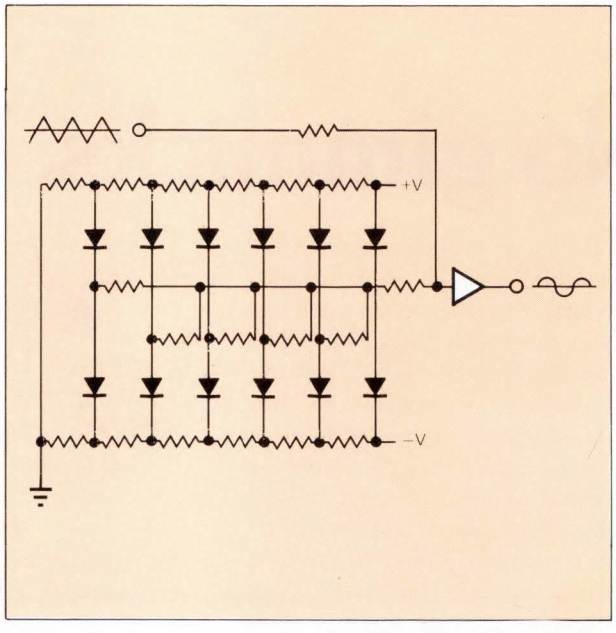


Fig. 2—Shaping a sine wave from a triangle is often done using diode networks such as this one. The triangle is broken up into segments whose slopes are controlled to conform to those of the sine wave. Networks of this type and similar ones using transistors can provide sine-wave distortion of 0.1% at best, with 0.5% being more common. Sine-wave shaping by diode or transistor breakpoints is still the most practical method for function generators.

Some people would have us believe that the emergence of low-cost monolithic chips and

This function generator has a lot to offer. It can provide sine, square, triangle, pulse, ramp and sync waveforms over a frequency range of 0.005 Hz to 5 MHz. It also includes trigger, gate, variable dc, variable offset and VCF features for $395. (*Ailtech*)

hybrid potted modules, that can produce the same functions as instruments, have been the cause of declining instrument prices. This is not quite true. Hybrid and monolithic generators are aimed mostly at dedicated systems applications. They are aimed at the designer who has a need for a specific generator to do a specific job and who had to build it himself only a few years ago. And in their own right, these devices are filling an important need.

They are not, however, quite as flexible as instruments. They require a dc voltage for power, cannot provide high output power thereby necessitating the use of output power amplifiers, do not have external frequency dials for control, have no display and require external capacitors and resistors in order to work. Add to that the cost of an external metal housing, and one can see that no great savings can be had using modules or IC chips over instruments. Moreover, many IC chips can only offer about 5% sine-wave distortion, a far cry from the 0.5% spec of instruments.

Where the function generator instrument has tended to shine has been in its multi-purpose usefulness which threatens to oust many other types of specific laboratory instruments, such as the pulse generator, the sine-wave oscillator and the sweep generator, to name a few. For everyday general-purpose laboratory or field use, the function generator simply can't be beat in value. Only in specific applications where, for example, sine-wave purity is very important (about 0.01% or better) or a very fast (less than 10 nsec) rise and fall time is required from a pulse, would specific instruments, such as synthesizers (for frequency purity and stability) and pulse generators (for fast rise-time pulses), be better.

The basic circuit

If we were to look at modern function-generator circuitry, we could find that nearly all have the same fundamental configuration (**Fig. 1**), despite some minor approaches here and there. This starts with the development of a triangular wave in an integrator by charging and discharging a capacitor from a constant-current source (a rise-time circuit is sometimes used). The square wave is formed from the triangular wave in a closed loop after the latter is fed into a bistable hysteresis network such as a Schmitt trigger. A wave-shaping circuit (**Fig. 2**), usually made up of diodes or transistors, converts the triangle into a sine wave by piece-wise linear approximation. Ramp and pulse waveforms are generally generated by combinations of offset voltages and time-symmetry changes.

The most important part of a function generator's circuitry is the sine-shaping network, and this has hardly changed over the last decade. Some manufacturers use computer programs to calculate sine wave distortion, by using the V/I characteristics of the diodes in the shaping circuit as the variables. This is said to improve distortion specs down to 0.1% under certain conditions up to 100 kHz. However, most generators provide only about 0.5% sine-wave distortion at best under real-world laboratory and field conditions. And this is basically a limitation of the shaping network.

This is not to say that better distortion specs cannot be met. But for the price range that function generators compete in, current methods of sine-wave shaping by diode breakpoints are the most economical.

Of course, there are some problems, but they are not that bad. The wave-shaping circuit introduces a discontinuity in the sine-wave slope when the triangular wave used to generate it

A digital readout for both frequency and amplitude is featured in Model 147. Covering a frequency range of 0.0005 Hz to 10 MHz, the 3-1/2-digit display instrument costing $1295 produces sine, square, triangle, positive and negative pulse, sawtooth, ramp and sync outputs. (*Wavetek*)

Low-cost function generators like this one offer a high performance/price ratio. The Model 5700 costs only $295 but offers sine, square and triangle waveforms over 0.002 Hz to 2 MHz, a 1000:1 tuning-dial ratio, auxiliary square waves, an output attenuator, dc offset control and two outputs—a 600Ω balanced output with 30V p-p into an open circuit and a 50Ω single ended output with 15V p-p into an open circuit. (*Krohn-Hite*)

reaches its peak. At that point the triangle changes its slope and the shaper circuit has nonzero gain. This discontinuity is only a problem in applications where the sine wave is fed into a differentiator circuit to produce a different sine wave out of phase with the original one.

Some generators produce a small amount of high-frequency noise on the sine-wave peaks, which can be more noticeable at low-level outputs. This switching noise emanating from the basic triangular-square-wave loop network is generally about 100 mV for a 10V rms sine wave. However, in some cases, as much as 1V out of the 10V is noise, a parameter rarely specified in any data sheet.

There is one function generator, Exact Electronics' Model 335, which does not make use of the standard basic integrator network. Instead, it digitally synthesizes its triangles from a 2000-bit staircase with a combination of an up/down counter, a shift register and a D/A converter. Because the TCs of the RC network and op amps limit integration methods in long-term stabilities, the synthesized method, which can be as stable as the basic clock, offers much better long-term stability. Exceptional stability doesn't come cheap in a function generator, however. The Model 335, which spans 10 μHz to 50 kHz, has a $1250 price.

Differences in methods used to produce pulses lead to different advantages and drawbacks for the user. Two of these methods include a skewed waveform technique (**Fig. 3**), which involves a time symmetry control at the integrator's input to bias the VCG (voltage controlled generator) amplifier and a threshold detector (**Fig. 4**).

The former method allows pulses to be generated only up to 1/10th of the function generator's highest frequency, because they are limited by the basic triangle-square-wave loop. With the latter method, up to 1/2 the maximum generator frequency can be reached, as the limiting factor becomes the detector and output amplifier.

The threshold-detector method is free of any pulse-width/frequency interaction, something the skewed method suffers from. Few data sheets ever specify this type of problem.

But there is one important advantage of the skewed technique that the threshold circuit cannot offer, and that is the adjustable duty cycle ramp and sine wave. In both skewed and detector cases, the duty cycle is constant with varying frequency.

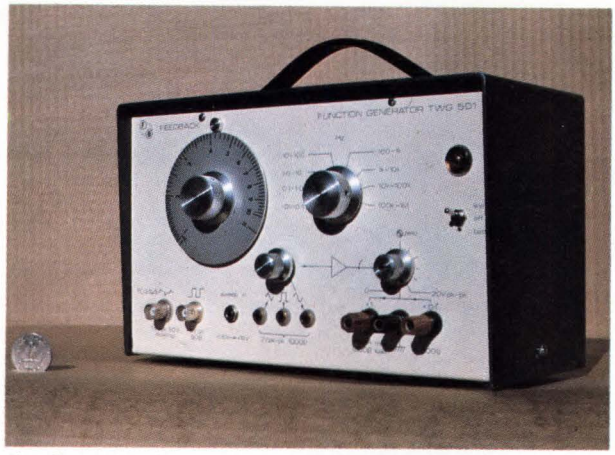
The 20-MHz plateau

Ever since function generators were introduced, one mark of progress manufacturers preoccupied themselves with was how high a frequency could they produce. While most generators stop at 10 MHz, three have reached the 20-MHz plateau (from Exact, Systron-Donner and Ailtech) and have stopped there only because of limitations in component state-of-the-art.

At 20 MHz, a function generator would require an amplifier with a bandwidth of approximately 5 to 100 MHz to provide the fundamental frequency and its fifth harmonic. Considering the price range function generators are in, such amplifiers can become a large part of the cost.

For all the flagwaving and fanfare about 20-MHz

Model 129 is really two generators in one. The main generator offers VCF and has sine, square, triangle, ±square, ±pulse, +sine and sync waveforms over 0.1 Hz to 5 MHz. The AM/FM generator produces sine, square and triangle waveforms over 1 Hz to 1 MHz, has simultaneous AM and FM and can also be used to gate and trigger the main generator for toneburst and pulse operation. Total cost is $895. (*Exact*)



Simultaneous sine, square and triangle outputs are available from Model TWG501. The $395 generator covers 0.009 Hz to 1.1 MHz and offers VCF, a 20V p-p output at 20 mA, fast 15-nsec rise time, square waves and a trigger-pulse output. (*Feedback*)

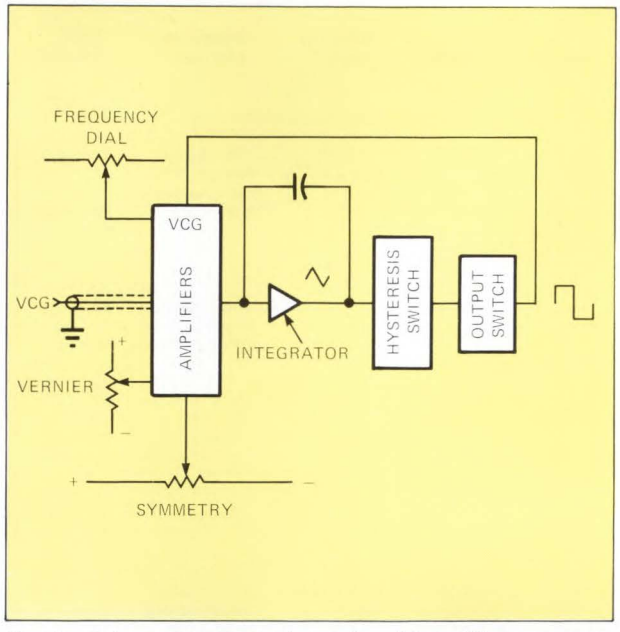


Fig. 3—Pulses are commonly produced by adding symmetry control to the basic sine, square and triangle circuit. This time-symmetry control works by adding dc bias to the VCG (voltage controlled generator) amplifiers which results in skewed waveforms. By adjusting the symmetry potentiometer, numerous other waveshapes can be obtained. (block diagram courtesy of Wavetek)

capabilities, is the user getting that much more in benefits for what he has to shell out in money? As one industry spokesman sees it, the high-frequency race is largely cosmetic. He points out that the large majority of applications, perhaps as much as 90%, are in the 5-MHz range. Furthermore, the quality of signals at 20 MHz degrades rapidly as the instrument approaches its operating limits.

At 20 MHz, signals get attenuated and a square wave looks more like a sine wave, while sine waves increase in distortion. Most generator triangles look awful at that point, containing much nonlinearity. Data sheets usually specify the best signal purities within a lower frequency range, usually to 10 MHz, while at 20 MHz, the specs get worse. A 20-MHz square wave has a half period of 25 nsec. With a 15- to 20-nsec rise and falltime, one could see that a total transition time of 30 to 40 nsec would be greater than the square wave half period, resulting in high square-wave aberrations.

Other industry leaders voice optimism on the importance of the high-frequency push. As some of them point out, instruments have historically been the leaders of progress, and one important benchmark of that progress has always been measured by their highest frequency. With future improvements in IC components, better waveforms at high frequencies are sure to come. Some familiar applications like testing the frequency response of amplifiers are important ones for high-frequency generators.

There is also another frequency trend, one going the other way to lower frequencies. Frequencies down to 1 μHz (that's a waveform with a period of more than one week!) are available from Exact's Model 335, with several other manufacturers offering 0.002-Hz frequencies or lower. This has been spurred on by new applications in geophysical and medical fields such as earthquake, earth-period, human-voice, human-nervous system and soil-erosion simulations. Low-frequency waveforms are being applied to mechanical test systems such as shaker tables and vibration testing and in ASW (anti-submarine warfare) applications.

One pitfall a user should be aware of is the generator's dial calibration when it comes to low frequencies. Many generators have a large dynamic frequency range below 1 Hz crammed onto the lower end of the dial, which usually does not contain many numbers. So the user is forced to assume that the generator is more or less linear below 1 Hz, and that is not always true.

A few words about specs

While specsmanship is the name of the game with most electronic products, it becomes less of an important consideration for function generators as they become lower and lower in cost. Function generators are not ultra high-precision instruments, after all, but general-purpose laboratory and field tools. Nevertheless, the prospective purchaser should watch out for a few important specs such as output voltage and impedance, dial frequency accuracy and stability.

Most generators provide 20V p-p output into an

Company	Model	Frequency range	Waveforms generated	Output amplitude	Frequency stability	Unit cost	Other features
Ailtech Div. of Cutler-Hammer Co., Farmingdale, NY and City of Industry, CA	F230B	0.005 Hz to 3 MHz	sine, square, triangle, ramp, pulse, sawtooth, sync.	32.5V p-p into O.C. — 16.25V p-p into 50Ω	±0.05% of setting for 10 minutes — ±0.25% of setting for 24 hours	$ 695	Sweep, trigger, gate, fixed and variable dc offset, VCF, toneburst
	F231A	"	"	"	"	$ 795	sweep, trigger, gate, fixed and variable dc offset, VCF, toneburst, VCA
	F240A	"	sine, square, triangle, ramp, offset sine, sync	32.5V p-p into O.C. from 50Ω or 600Ω — 30V p-p into 600Ω and 16.25V p-p into 50Ω from $Z_S = 50\Omega$ — 16.25V p-p into 600Ω and 2.5V p-p into 50Ω from $Z_S = 600\Omega$	" "	$ 795	trigger, gate, VCF, phaselock, variable dc offset
	501	0.005 Hz to 5 MHz	sine, square, triangle, pulse, ramp, sync	25V p-p into O.C. 12.5V p-p into 50Ω	"	$ 395	trigger, gate, variable dc, variable offset, VCF
	510	0.01 Hz to 10 MHz	"	"	"	$ 495	variable dc, variable offset, VCF
	511	"	"	"	"	$ 595	trigger, gate, variable dc, variable offset, VCF
	520	0.02 Hz to 20 MHz	sine, square, triangle, pulse, ramp, sync	25V p-p into O.C. — 12.5V p-p into 50Ω	±0.05% of setting for 10 minutes — ±0.25% of setting for 24 hours	$ 695	variable dc, variable offset, VCF
	521	"	"	"	"	$ 795	trigger, gate, variable dc, variable offset, VCF
Clarke-Hess Communication Research Corp., New York, NY	743	0.001 Hz to 4 MHz	sine, square, triangle	20V p-p into O.C. — 10V p-p into 50Ω	±0.05% of setting for 10 minutes — ±0.2% of setting for 24 hours	$ 365	VCF, toneburst, synchronization, gate, variable dc offset, switched zero output.
	745	0.01 Hz to 1.099 MHz (digitally set)	"	"	"	$ 475	"
	748	0.001 Hz to 4 MHz	"	"	"	$ 515	VCF, VCA, toneburst, synchronization, gate, variable dc offset, switched zero output
Esterline Angus	F-1000	0.01 Hz to 100 kHz	sine, square, triangle, sync	100mV p-p and 10V p-p into 600Ω from $Z_S = 50\Omega$	±0.05% for 10 minutes — ±0.25% for 24 hours	$ 310	
Exact Electronics, Inc., Hillsboro, OR	120	0.1 Hz to 3 MHz	sine, square, triangle, sync	20V p-p into O.C. — 10V p-p into 50Ω	0.04% of setting for 10 minutes — 0.2% of setting for 24 hours	$ 295	variable dc offset
	122	"	"	"	"	$ 395	VCF, selectable 50Ω or balanced 600Ω outputs, variable dc offset
	123	"	"	"	"	$ 345	VCF, variable dc offset
	124	0.1 Hz to 5 MHz	sine, square, triangle, pulse, sync	"	0.05% of setting for 10 minutes — 0.25% of setting for 24 hours	$ 595	trigger, gate, VCF, internal sweep, toneburst, dual-output amplifiers, variable dc offset
	125	"	"	"	"	$ 795	trigger, gate, VCF, internal linear sweep, internal/external logarithmic sweep, toneburst, variable dc offset, dual-output amplifiers
	126	0.1 Hz to 3 MHz	sine, square triangle, ramp, pulse, sync	"	"	$ 495	trigger, gate, toneburst, sweep, VCF, variable dc offset, dual-output amplifiers
	127	"	"	"	"	$ 595	trigger, gate, toneburst, sweep, VCF, variable dc offset, dual-output amplifiers, digital-dial frequency adjustment
	128	"	"	"	"	$ 695	trigger, gate, toneburst, sweep, VCF, variable dc offset, dual-output amplifiers, logarithmic sweep, ramp hold, V:f
	335	10 μHz to 50 kHz	sine, square, triangle, ramp, pulse, sync, haversine, haver-triangle	20V p-p into O.C. — 10V p-p into 50Ω	0.05% of setting for 10 minutes — 0.25% of setting for 24 hours	$1250	variable dc offset, trigger, gate, hold, peak hold, digital synthesis, VCF

LEGEND

1. O.C.-open circuit
2. VCF-voltage controlled frequency
3. VCA-voltage controlled amplitude
4. V:f-voltage proportional to frequency
5. Stability specs are given with respect to time only.
6. Specifications shown are as they appear in the various manufacturers' literature.

Company	Model	Frequency range	Waveforms generated	Output amplitude	Frequency stability	Unit cost	Other features
	605	0.001 Hz to 1.66 MHz	sine, square triangle, ramp, pulse, sync	15.99V p-p into 50Ω	0.04% of setting for 10 minutes — 0.2% of setting for 24 hours	$1450	gate, trigger, fully programmable, fi dc offset, local and remote control, VCF
	606	"	"	"	"	$1250	gate, trigger, fully programmable, fixed offset, remote control, VCF
	7030	0.0001 Hz to 11 MHz	sine, square, triangle, sync, ramp, pulse	30V p-p into O.C. — 15V p-p into 50Ω	0.05% of setting for 10 minutes — 0.25% of setting for 24 hours	$ 595	VCF, variable symmetry, variable dc offset
	7050	"	"	"	"	$ 745	VCF, variable symmetry, gate, trigger, variable dc offset
	7056	"	"	"	"	$ 995	VCF, variable symmetry, gate, trigger, AM, phase-lock
	7060	"	"	"	"	$ 845	VCF, gate, trigger, toneburst, sweep, variable dc offset, dual generators
	7071	"	"	"	"	$1095	VCF, trigger, gate, sweep, toneburst, linear/logarithmic/gated sweep, ramp hold, variable dc offset
	7230	0.001 Hz to 20 MHz	sine, square, triangle, pulse, ramp, sync	30V p-p into O.C. — 15V p-p into 50Ω	0.05% of setting for 10 minutes — 0.25% of setting for 24 hours	$ 795	VCF, variable dc offset, variable symmetry
	129	0.1 Hz to 5 MHz	sine, square, triangle, pulse sync	20V p-p into O.C. — 10V p-p into 50Ω	0.05% of setting for 10 minutes — 0.25% of setting for 24 hours	$ 795	AM, FM, toneburst, gate, trigger, variable dc offset, manual sweep, VCF
Feedback, Inc., Berkeley Heights, NJ	TWG300	0.001 Hz to 1 kHz	sine, square triangle	40V p-p at 20mA $Z_S = 10\Omega$	0.1% of setting for 1 hour	$ 950	clipped triangle with variable slopes, monitor square and triangle waveforms
	TWG500	0.01 Hz to 100 kHz	"	40V p-p at 100 mA $Z_S = 10\Omega$	"	$1695	variable-phase sine waves over 360°, reference and quadrature, VCF, sweep, gate, trigger, dc offset
	TWG501	0.009 Hz to 1.1 MHz	"	20V p-p at 20 mA $Z_S = 25\Omega$	±0.05% for 10 minutes ±0.1% for 6 hours	$ 395	up to seven simultaneous outputs, VCF, dc offset, trigger-pulse output
Heath/ Schlumberger Scientific Instruments, Benton Harbor, MN	EU-81A	0.1 Hz to 1 MHz	"	20V p-p into O.C. — 10V p-p into 50Ω	±0.05% for 10 minutes — ±0.3% for 24 hours	$ 245	adjustable dc offset, VCF
Hewlett-Packard Co., Loveland Instrument Div., Loveland, CO	3300A	0.01 Hz to 100 kHz	sine, square, triangle, sync	35V p-p into O.C. — 15V p-p into 600Ω — 2V p-p into 50Ω	±0.05% of setting for 10 minutes — ±0.25% of setting for 24 hours	$ 725	simultaneous dual outputs, VCF, dc offset, accepts four plug-ins
	3301A	auxiliary plug-in for 3300A mainframe unit				$ 30	provides internal connections to mainframe
	3302A	"				$ 255	trigger, phaselock
	3304A	"				$ 295	sweep, dc offset, sawtooth
	3305A	"				$1015	manual and automatic triggered sweep, VCF, logarithmic sweep, programming, sweep output
	3310A	0.0005 Hz to 5 MHz	sine, square, triangle, pulse, ramp, sync	30V p-p into O.C. — 15V p-p into 50Ω		$ 595	dc offset, VCF
	3310B	"	"	"		$ 735	dc offset, VCF, single- and multiple-cycle output, start-stop phase
	3311A	0.1 Hz to 1 MHz	sine, square, triangle	20V p-p into O.C. — 10V p-p into 600Ω		$ 249	VCF, dc offset
Interstate Electronics Corp., Anaheim, CA	F31	0.03 Hz to 3 MHz	sine, square, triangle, sync	20V p-p into O.C. — 10V p-p into 50Ω	0.05% for 10 minutes — 0.25% for 24 hours	$ 295	adjustable dc level
	F32	"	"	"	"	$ 345	VCF, adjustable dc level, output-limit indicator
	F33	"	"	"	"	$ 395	VCF, adjustable dc level, variable-width pulse, trigger, gate, external sync, VCF, output-limit indicator, adjustable dc level

LEGEND

1. O.C.-open circuit
2. VCF-voltage controlled frequency
3. VCA-voltage controlled amplitude
4. V:f-voltage proportional to frequency
5. Stability specs are given with respect to time only.
6. Specifications shown are as they appear in the various manufacturers' literature.

Company	Model	Frequency range	Waveforms generated	Output amplitude	Frequency stability	Unit cost	Other features
	F34	0.03 Hz to 3 MHz	sine, square, triangle, sync	10V p-p into 50Ω	0.25% for 24 hours	$ 495	continuous and triggered sweep, direct-reading sweep limit, toneburst, analog output of frequency, variable-width pulse, trigger, gate, external sync, VCF, output-limit indicator, adjustable dc level
	F51A	0.0005 Hz to 10 MHz	sine, square, triangle, ramp	30V p-p into O.C. — 15V p-p into 50Ω	" " "	$ 595	variable-width pulse, fixed and variable offset, VCF
	F52A	"	"	"	"	$ 795	trigger, gate, variable start-stop, variable-width pulse, fixed and variable offset, VCF
	F53A	"	"	"	"	$ 895	trigger, gate, variable-width pulse, variable start-stop, fixed and variable offset, VCF, phaselock
	F54A	0.0005 Hz to 10 MHz	sine, square, triangle, ramp	30V p-p into O.C. — 15V p-p into 50Ω	0.05% for 10 minutes — 0.25% for 24 hours	$1085	trigger, gate, variable-width pulse, variable start-stop, fixed and variable offset, VCF, toneburst, continuous/triggered/sweep-and-hold sweep, direct-reading sweep limit
	F55	"	"	"	"	$1195	trigger, gate, variable-width pulse, variable start-stop, fixed and variable offset, VCF, toneburst, continuous/triggered/sweep-and-hold sweep, direct-reading sweep limit, phaselock
Krohn-Hite Corp., Cambridge, MA	5000	0.2 Hz to 3 MHz	sine, square, triangle	20V p-p into O.C. — 10V p-p into 50Ω	0.05% for 10 minutes — 0.25% for 24 hours	$ 295	dc offset, auxiliary square wave, infinite-resolution amplitude control
	5100A	0.002 Hz to 3 MHz	sine, square, triangle, ramp, pulse, sawtooth	"	"	$ 395	positive and negative pulse, VCF, auxiliary square wave, variable pulse-width control, dc offset, external sync
	5200	"	"	"	"	$ 495	linear sweep, VCF, trigger, gate, positive and negative ramp, sweep-and-hold, toneburst, sweep burst, auxiliary square wave, variable start level, dc offset
	5300	"	"	"	"	$ 695	positive and negative ramp, linear or logarithmic sweep, trigger, gate, sweep-and-hold, toneburst, sweep burst, dc offset, variable start level
	5400A	0.002 Hz to 5 MHz	sine, square, triangle, ramp, pulse, sawtooth	30V p-p into O.C. — 15V p-p into 50Ω	0.05% for 10 minutes — 0.25% for 24 hours	$ 575	positive and negative ramp, VCF, independent pulse-width control of positive and negative pulses, dc offset, auxiliary square wave
	5600	0.002 Hz to 2 MHz	sine, square, triangle	15V p-p into O.C. and 7.5V p-p into 50Ω $Z_s = 50\Omega$ — 30V p-p into O.C. and 15V p-p into 600Ω $Z_s = 600\Omega$	0.05% for 10 minutes — 0.25% for 24 hours	$ 395	battery/ac line operation dc offset, balanced 600Ω and single ended 50Ω outputs, selectable auxiliary waveforms
	5700	0.002 Hz to 2 MHz	sine, square, triangle	"	"	$ 295	dc offset, auxiliary square wave, balanced 600Ω and single ended 50Ω outputs
Marconi Instruments, Englewood, NJ	2120	0.0008 Hz to 100 kHz	sine, square triangle, ramp	±10V p-p into 600Ω from $Z_s = 600\Omega$ — ±20V p-p into 50Ω from $Z_s = 600\Omega$	±0.1% for 8 hours	$1975	positive and negative ramp, variable phase (−100° to +100°) output, fixed quadrature output, dc offset, VCF, V:f, trigger, gate, sync
Systron-Donner Corp., Datapulse Div. Culver city, CA	401	0.02 Hz to 2 MHz	sine, square, triangle	20V p-p into O.C. — 10V p-p into 50Ω	±0.05% for 1 hour — ±0.5% for 1 month	$ 395	dc offset, FM, FSK
	410	0.0002 Hz to 2 MHz	sine, square, triangle, pulse, sine squared, sawtooth	40V p-p into O.C. — 20V p-p into 50Ω	±0.5% for 1 hour — ±0.5% for 1 month	$ 995	sweep, external triggering of main and sweep generators, AM with 4-quadrant multiplication, two 40V p-p (into O.C.) amplifiers with independent waveform selection and dc offset, FM, gate, toneburst.
	420	2 Hz to 20 MHz	sine, square, triangle, sync	20V p-p into O.C. — 10V p-p into 50Ω	±0.1% for 1 hour — ±0.5% for 24 hours	$ 785	FM, dc offset, trigger, gate
	421	"	"	"	"	$ 895	sweep, calibrated sweep limits, FM, dc offset, trigger, gate
Tektronix, Inc., Beaverton, OR	FG501	0.001 Hz to 1 MHz	sine, square, triangle, pulse, ramp	15V p-p into O.C. — 7.5V p-p into 50Ω	0.05% for 10 minutes — 5% for 24 hours	$ 325	VCF, trigger, gate, hold, toneburst, offset *NOTE:* this unit is a plug-in for Tektronix's TM500 measurement system.

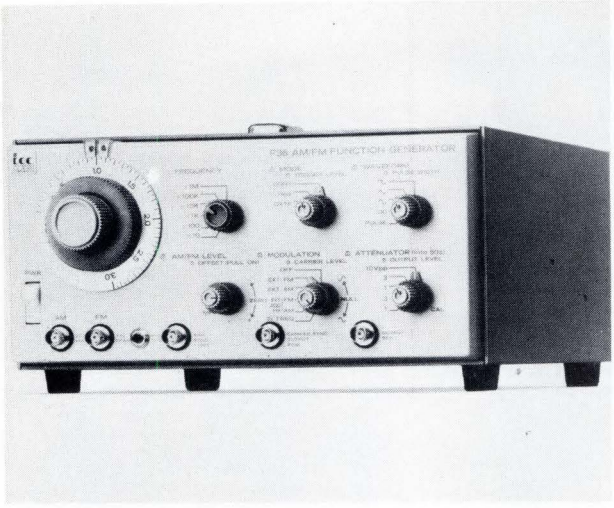
LEGEND

1. O.C.-open circuit
2. VCF-voltage controlled frequency
3. VCA-voltage controlled amplitude
4. V:f-voltage proportional to frequency
5. Stability specs are given with respect to time only.
6. Specifications shown are as they appear in the various manufacturers' literature.

Company	Model	Frequency range	Waveforms generated	Output amplitude	Frequency stability	Unit cost	Other features
Wavetek San Diego, CA	110	0.005 Hz to 1 MHz	sine, square, triangle, sync	30V p-p into 600Ω — 10V p-p into 50Ω	±0.05% for 10 minutes — ±0.25% for 24 hours	$ 445	six simultaneous outputs, 600Ω and 50Ω outputs, dc offset, phaselock, start-stop/threshold trigger, battery operation option ($100 more)
	111	0.0015 Hz to 1 MHz	sine, square, triangle, ramp, sync	"	"	$ 545	seven simultaneous outputs, VCF, FM, sweep, FSK, 600Ω and 50Ω outputs, dc offset, battery operation option ($100 more)
	112	0.0015 Hz to 1 MHz	sine, square, triangle, ramp, sync	30V p-p into 600Ω — 10V p-p into 50Ω	0.05% for 10 minutes — 0.25% for 24 hours	$ 695	VCF, FM, sweep, gate, FSK, dc offset, toneburst, start-stop/threshold trigger over 360°, 50Ω and 600Ω outputs, battery operation option ($100 more)
	113	0.001 Hz to 1 MHz	sine, square, triangle, ramp, sync	"	"	$ 795	VCF, FM, sweep, pushbutton frequency and amplitude selections, 50Ω and 600Ω outputs, 5 simultaneous outputs, dc offset
	114	0.0015 Hz to 1 MHz	sine, square, triangle, offset sine, sync	"	"	$ 795	built-in ramp generator for sweeping, VCF, start-stop/threshold trigger over 360°, sweep-and-hold, FM, FSK, toneburst, dc offset, 9 simultaneous outputs, 50Ω and 600Ω outputs, battery operation option ($100 more)
	115	"	sine, square, triangle, ramp, sync	"	"	$ 745	9 simultaneous outputs, phaselock, VCF, AM, trigger, gate, dc offset, toneburst option ($100 more), battery operation option ($100 more)
	130	0.2 Hz to 2 MHz	sine, square, triangle, sync	20V p-p into O.C. — 10V p-p into 50Ω	"	$ 295	dc offset
	131A	"	"	"	"	$ 395	dc offset, VCF, sweep, FM, FSK
	132	0.2 Hz to 2 MHz	sine, triangle, square, sync, digital and analog noise	20V p-p into O.C. — 10V p-p into 50Ω	0.05% for 10 minutes — 0.25% for 24 hours	$ 795	built-in pseudorandom noise generator for different S/N ratios, dc offset, 600Ω and 50Ω outputs, VCF, FM
	133	20 μHz to 200 kHz	sine, square, triangle, sync	"	"	$ 495	trigger, gate, variable start-stop, VCF, FM, dc offset, 600Ω and 50Ω outputs
	134	0.2 Hz to 2 MHz	sine, square, triangle, sync	"	"	$ 495	built-in sweep generator with ramp and sawtooth waveforms, trigger, dc offset, gate, VCF, FM, toneburst, 50Ω and 600Ω outputs
	135	"	"	"	"	$ 695	built-in sweep generator with ramp and sawtooth waveforms, linear/logarithmic sweep, VCF, FM, toneburst, trigger, gate, dc offset, 50Ω and 600Ω outputs
	136	"	"	"	"	$ 595	VCF, VCA, AM, FM, dc offset, toneburst, FSK, sweep, dc programming
	142	0.0005 Hz to 10 MHz	sine, square, triangle, pulse, sync, sawtooth, ramp	30V p-p into O.C. — 15V p-p into 50Ω	"	$ 595	variable duty cycle, dc offset, dweep variable time symmetry, VCF
	144	"	"	"	"	$ 845	built-in sweep generator, FM, FSK, toneburst, variable duty cycle, dc offset, trigger, gate, sweep-and-hold, VCF.
	146	0.0005 Hz to 10 MHz	sine, square, triangle, pulse, ramp, sync, sawtooth	30V p-p into O.C. — 15V p-p into 50Ω	0.05% for 10 minutes — 0.25% for 24 hours	$1495	built-in auxiliary 10-MHz to 100-kHz generator with 5V p-p (into O.C.) sine, square, triangle and ramp signals, AM/FM with calibrated limits, trigger, gate, variable trigger level, dc offset, variable symmetry, 50Ω and 600Ω outputs
	147	"	"	"	"	$1295	LED amplitude/frequency display (3-digit resolution), variable amplitude, dc offset and symmetry, trigger, gate, sweep, sweep-and-hold, dc voltage source, VCF, FM, V:f
	150	0.01 Hz to 1 MHz	sine, square, triangle	20V p-p into O.C. — 10V p-p into 50Ω	±1% +1 digit	$ 995	4 simultaneous outputs, VCF, trigger, dc offset, FM, remote digital programming for systems applications (local programming for $200 more)
	154	0.001 Hz to 10 MHz	"	"	"	$1995	fully programmable, AM, FM, trigger, gate, programmable dc offset, programmable output dc voltage, analog programming, 50Ω and 600Ω outputs
	157	100 μHz to 1 MHz	"	"		$2995	0.01% frequency accuracy, 1000:1 VCF, trigger, gate, selectable amplitude to 10V p-p, frequency, function and amplitude programming by BCD remotely or by front-panel switching, sync in and out, dc offset, toneburst, complete programming from digital and analog sources, local-programming-only model ($600 less)

LEGEND

1. O.C.-open circuit
2. VCF-voltage controlled frequency
3. VCA-voltage controlled amplitude
4. V:f-voltage proportional to frequency
5. Stability specs are given with respect to time only.
6. Specifications shown are as they appear in the various manufacturers' literature.



AM and FM, as well as trigger, gate and variable pulse width over 0.03 Hz to 3 MHz are available in Model F36 which sells for $645. The instrument contains a 400-Hz sine-wave source used to modulate the output. (*Interstate Electronics*)

The lowest cost 0.1-Hz to 1-MHz function generator is this Model EU-81A. It offers sine, square and triangle waveforms, adjustable dc offset and VCF for only $245. (*Heath/Schlumberger*)

open circuit and 10V p-p into 50Ω. Some data sheets are not clear, though, on what the output should be at a given source impedance, which can be either 50 or 600Ω, or both. This brings us to another question. Should it be 600Ω as some units provide or 50Ω as others do? It is obviously nice to have both, but for high-frequency, 50Ω generators should be the answer, particularly where fast rise-time signals are being produced.

With respect to dial accuracy, usually about 2% of full scale with most generators, it can be much worse on the lower end of the dial, particularly with one having a large frequency range and a percent-of-range accuracy specification. Of course, a user can check the frequency with a counter to be sure, and that is what Wavetek has done in its Model 147 generator which has a built-in digital readout to indicate the correct frequency as well as output voltage amplitude.

Stability is one specification that is not too difficult to find in most data sheets. The ones that do give it almost always specify it under certain conditions that are rarely spelled out in full. When given, stability is usually stated over a few hours, a few days and even a few months, which makes data-sheet comparisons a bit difficult.

Where ICs fit in

To a large extent, ICs have not made too many inroads in function-generator development, at least not yet. Most industry spokesman who were queried felt that ICs have not yet developed to the point where they can be useful for function-generator circuits.

The few areas where ICs have made a penetration have been as voltage regulators in the power supply section, as LED displays (in Wavetek's Model 147), and in the form of monolithic op amps and Schmitt triggers in the control and wave-shaping circuitry. For the latter areas, some ICs produce more distortion than discretes.

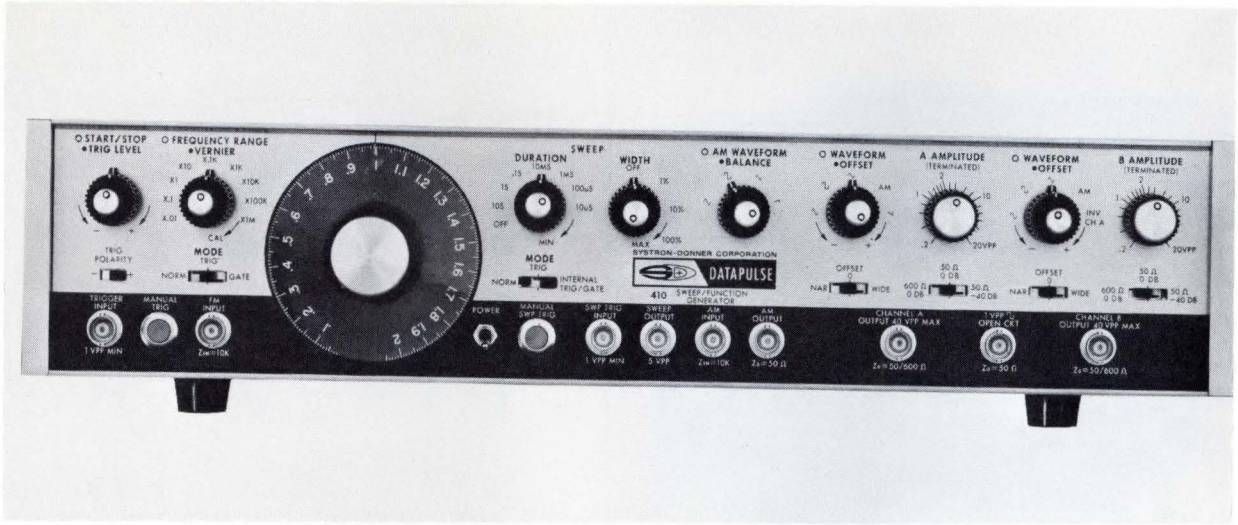
Exact Electronics uses ICs to digitally synthesize its Model 335 generator's waveforms. It contains a digital phase generator producing variable phase related signals which may be gated and triggered and held for indefinite periods of time. The generator also uses ICs in the sine-shaper circuit made up of diode arrays and thick-film resistor networks.

There are quite a few VCO (voltage controlled oscillator) loop ICs on the market that could possibly be used in the basic triangle-square-wave loop. However, they are designed for specific applications and do not lend themselves well to function-generator applications.

Not only do function-generator ICs, available from such companies as Exar Systems, Plessey, Intersil and Signetics, produce more sine-wave distortion (about 5%) than discrete-component designs, they cannot supply the necessary power levels needed for instruments.

It would take high-slew-rate ICs on the order of 10,000/μsec to satisfy the output demand of modern 20-MHz function generators, and that is simply well beyond the state-of-the-art in ICs. When that happens, some see a low-cost IC chip being sold to the instrument manufacturer to use in his system, eventually making function generators even less costly.

The consensus of opinion among function generator instrument manufacturers is that for the frequency range below 1 MHz, digital techni-



Model 410 is loaded with features. These include a 1000:1 sweep ratio, external triggering of both the main and sweep generators, FM and AM with 4-quadrant multiplication and a pair of 40V p-p (into an open circuit) output amplifiers with independent dc offset and waveform selection. The $995 generator features sine, square, triangle, pulse, sine squared and sawtooth waveforms over 0.0002 Hz to 2 MHz. (*Systron-Donner*)

ques will continue, while analog techniques will dominate above 1 MHz for the next five years.

Not all generators are the same

The $300-to-$500 price range mentioned will most often allow a user to buy a function generator with not too much more than the three basic sine, square and triangle waveshapes and VCO provisions. There are many not-so-ordinary generators on the market within this price range or that may cost a little more but have special features worthy of mention.

Wavetek's Model 132 ($795) is not only a 0.2-Hz to 2-MHz function generator but is a noise generator as well. With it, one can add digital or analog noise to the output signal or use the noise for frequency jitter testing for checking PLLs (phase locked loops), logic and timing circuitry.

Exact's Model 335 function generator ($1250) can have any of its basic waveforms stopped and held over 10μHz to 50 kHz at any one of the 2000 bits used for digital synthesis of the output signal which can be very useful for testing amplifier oscillations.

Krohn-Hite's Model 5600 ($395) is a truly portable 0.002-Hz to 2-MHz instrument that is suited for field work. It weighs only 7 lbs. and can be operated from a $70 optional rechargeable NiCd battery from 6 to 10 hours as well as from the ac line.

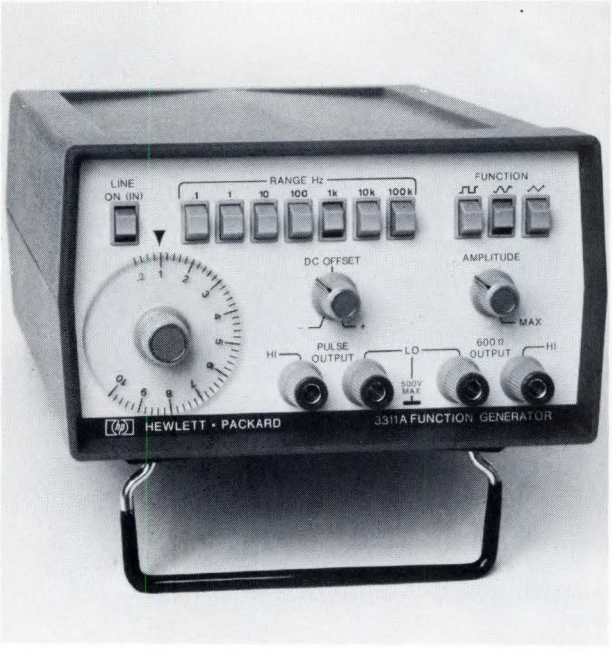
From Feedback's TWG-500 ($1695), one can obtain up to 5 sine waves either displaced from a reference point by 0°, 90°, 180° and 270°, or continuously variable over −180° to +180°; all of this over a frequency range of 0.01 Hz to 100 kHz. In addition, sine, square and triangle waves can be obtained in quadrature from a 0° reference.

The F36 from Interstate Electronics ($645) provides AM and FM capability along with trigger, gate and variable pulse width over 0.03 Hz to 3 MHz. It contains an internal 400-Hz sine wave source that can be used for either AM or FM of the output without the need for a second external signal generator.

Although it costs $995, Model 410 from the Data-Pulse Div. of Systron-Donner is loaded with features such as a 1000:1 sweep ratio, external triggering of both the main and sweep generators, frequency and amplitude modulation with 4-quadrant multiplication and two 40V p-p (into an open circuit) output amplifiers with independent waveform selection and dc offset. This is in addition to the standard sine, square, triangle, pulse, sine-squared and sawtooth waveforms over 0.0002 Hz to 2 MHz.

Hewlett-Packard uses a plug-in approach with its Model 3300A/3301A generator ($775) which covers the frequency range of 0.01 Hz to 100 kHz with sine, square and triangle waveforms. The four plug-ins available include one as an auxiliary unit for basic operation and a second one for single and multiple-cycle operation with adjustable start-stop phase and for synchronizing the main generator with an external signal for adjustable phase control.

A third plug-in provides internal sweeping, dc offset, sawtooth and offset square waves. The fourth supplies internal logarithmic and manual sweep over four decades with calibrated variable start-stop frequency control. Its sweep width is continuously adjustable, and it has manual or external triggering. The sweep can be program-



0.1-Hz to 1-MHz function generator, Model 3311A, is one of the lowest-cost units ($245) on the market. It has sine, square and triangle waveforms and offers dc offset and VCF. (*Hewlett-Packard*)

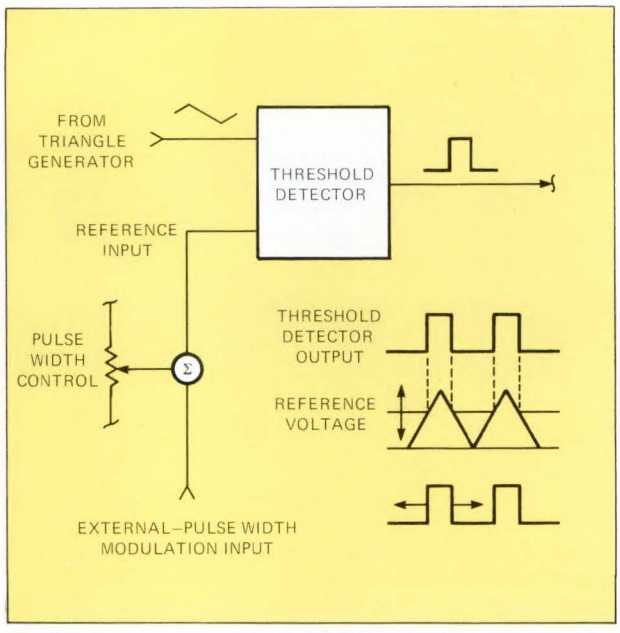


Fig. 4—Another method for producing pulses is with this circuit using a threshold detector which compares the voltage of the triangle with that of a variable reference. When the triangle voltage is less, the detector output is at the ZERO level. When it exceeds the reference level, the detector output jumps to the ONE level. This produces a pulse whose width is equal to the time the reference level exceeds the triangle level. By adjusting the reference level, pulse width can also be adjusted. (Courtesy of Interstate Electronics Corp.)

med by analog methods with horizontal sweep available for driving scopes and recorders.

Ailtech's Model 501 costs only $395 yet can supply sine, square, triangle, pulse, ramp and sync waveforms over 0.005 Hz to 5 MHz with trigger, gate, variable dc, variable offset and VCF features.

More flexibility foreseen

Looking down the road for the next few years, it is not too difficult to predict that, should the present trend in function generators continue, it would lead to even more flexibility and higher frequencies. These instruments are finding themselves in use in the newest breed of electronic systems—automatic test equipment systems, where more and more controllability will be demanded of them.

But better flexibility may not necessarily mean more functions, since more and more functions mean more instrument operating complexity. Instead, we might see more specialized function generators with different combinations of features to suit particular applications. These instruments would probably offer better performance, such as variable as well as faster pulse rise and fall times, lower sine-wave distortion and improved frequency accuracy, stability and resolution. Much depends on improvements in MSI and LSI ICs that may be used for digital waveform synthesis.

One manufacturer states that it is only a matter or time before most function generators will start to incorporate "measurement" capabilities within the same package such as a voltmeter and a frequency counter.

One popular feature that is catching on rapidly is VCA (voltage controlled amplitude). Because of the increase in the number of function generators being used in automatic systems, this and other programming features will increase.

The sine-wave oscillator, the pulse generator, the sweep generator and even some moderate-performance synthesizers can expect the function generator to start making inroads into their markets. □

A Cambion Double "QQ" Product Line

Cambion Makes Millions.

You can build a wealth of design ideas from CAMBION's expanding line of digital products. Our extensive variety makes even your most advanced IC packaging concepts practical. And, we can meet your needs with repeatable Quality no matter how great the Quantity.

CAMBION produces literally millions of IC accessories. Advanced new Cambi-Cards®, card files, drawers, universal panels with and without premounted socket strips and power planes, specific logic function cards, general purpose and discrete component cards, plus strip connectors, cable assemblies, integrated socket strips, component socket adapters, cable cards and card extenders. They're all featured in our new Catalog 119.

We also offer expanded NC wire-wrapping service to speed economical production of your IC system designs.

Make the most of your system ideas *without component restriction.* Get your copy of the new CAMBION Catalog 119. It has 22 more pages than its predecessor showing all the new products to enhance your designs. They all have the CAMBION Double "QQ" approach: The Quality stands up as the Quantity goes on. Order your copy today. Cambridge Thermionic Corporation 445EM Concord Avenue Cambridge, Mass. 02138. Phone (617) 491-5400. In Los Angeles, 8703 La Tijera Blvd. 90045. Phone (213) 775-0472.

Standardize on Circle No. 5

CAMBION®

...the guaranteed Digital Products.

EDN Design Course

CMOS—Part VI

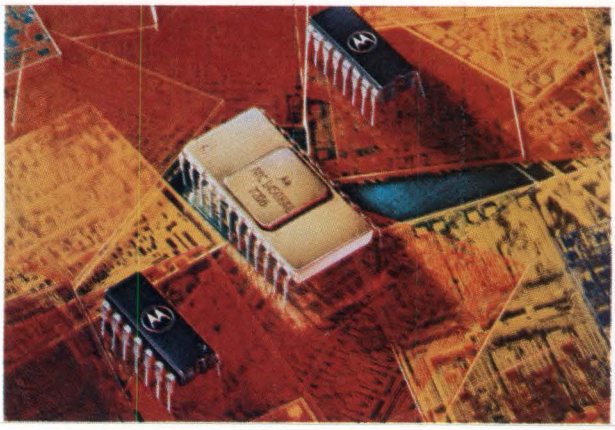
Here's a list of manufacturers, their product lines and bibliography

Bill Furlow, Associate Editor

This is the final chapter of EDN's 6-month CMOS design course, and we will take a look at each company which manufactures standard CMOS products. At the conclusion of this month's chapter, you will find a bibliography that is as complete as we could make it. It should allow you to continue your readings on CMOS at any level you desire, and as you uncover other literature on CMOS, we'd appreciate it if you would pass that information along to us.

This chapter, of course, does not conclude EDN's coverage of new developments in CMOS; we'll be giving in-depth reports on significant products and developments as they evolve. A report on custom CMOS and some guidelines to help you evaluate it for your applications is in preparation now for publication in the June 5th issue. That report is the direct result of several letters we received from readers who requested such information, so don't hesitate to let us know what you would like to see in EDN.

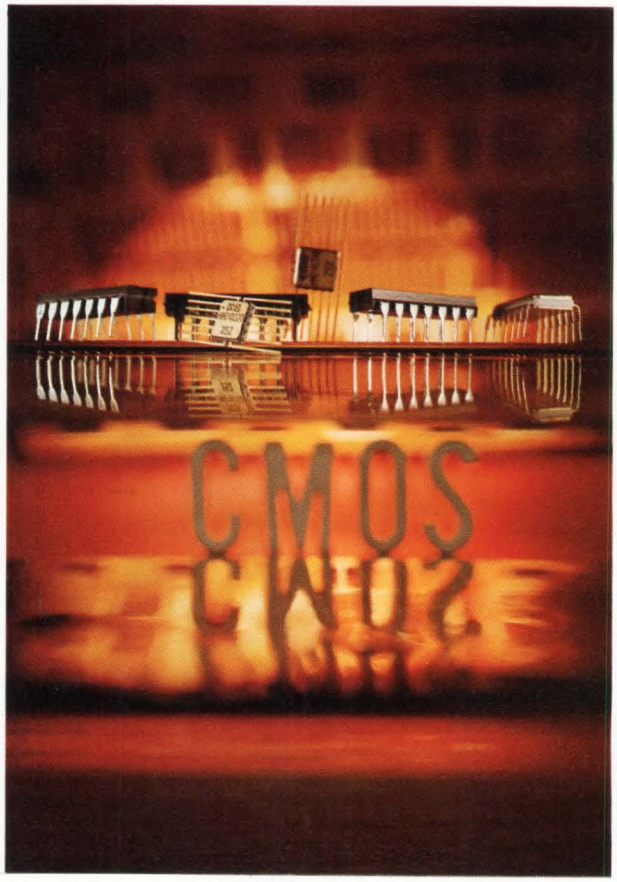
Micro sized paging system, made possible by reduced battery requirements of CMOS, is a joint project of RCA and Martin Marietta. It is already in use under the "Bellboy" trade name by five Bell System companies.



The MC14508 dual 4-bit latch with 3-state outputs is an original Motorola circuit. It consists of two identical, independent 4-bit latches with separate strobe and master reset controls. Separate disable inputs force the output to a high-impedance state and allow it to be used in time-sharing bus applications.

Makers of standard CMOS products

The RCA line of standard CMOS, trademarked COS/MOS, includes 55 circuit types which are presently announced on either a commercial or a preliminary basis.



TTL pinouts and a fanout of one low-power TTL load are several of the design conveniences that National hopes will give their 54C/64C/74C CMOS Series an edge in user preference over the now standard 4000 Series.

RCA pioneered in the development of COS/MOS technology, introducing the first commercial COS/MOS circuits in 1967, low-cost plastic packaged COS/MOS circuits in 1970 and the low-operating voltage (3V) CD4000A Series in 1971. RCA also pioneered in the development of circuits which would operate from a single cell (nominal 1.3V) for special applications such as watches. Further technological developments, such as silicon gate and ion implantation, are incorporated in some of the more recent RCA circuits.

Standard circuit complexity ranges from basic gates through MSI and LSI functions. Included in the MSI and LSI functions are counters, shift registers, multiplexers, adders, memories and an arithmetic logic unit.

Standard circuits are available in plastic packages, ceramic packages (dual-in-line or flat pack) and as chips. High reliability versions, including circuits conforming to the requirements of MIL-S-38510, are also available.

RCA has also pioneered in the silicon-on-sapphire technology which promises a substantial increase in COS/MOS operating speed over presently available COS/MOS circuits.

For more information contact Herbert B. Shannon at RCA Solid State, Route 202, Somerville, NJ 08876. Phone(201)722-3200.

Motorola's CMOS, or McMOS, family presently provides over 50 CMOS digital logic and memory functions. These popular functions range from basic triple- and quad-NAND gates through a wide variety of counters, decoders and shift registers to memories. Both ceramic and plastic packages are provided. Many additional, more complex McMOS devices will be introduced throughout 1973.

Motorola devices, which are second sources to the RCA 4000 Series, are designated the MC14000 Series. Those devices which are proprietary Motorola designs are designated the MC14500 Series.

McMOS devices, which use the latest silicon-gate and ion-implant processes, are available for use at supply voltages of up to 18V dc and across the temperature range of -55° to 125°C.

For more information contact Ron Komatz at Motorola Inc., Semiconductor Products Div., P.O. Box 20924, Phoenix, AZ 85036. Phone(612)244-6368.

National Semiconductor has 29 standard CMOS products available and plans to introduce four new circuits a month. National is building two lines of standard CMOS. The first is the CD4000A Series; the second is the 54C/64C/74C Series, which they originated.

The 54C/64C/74C line consists of CMOS parts which are the pin-out and functional equivalents of their 54L/74L low-power TTL counterparts. Since these gates are spec'd at 5V (TTL) operation and are assumed to drive a 50-pF load, direct comparison to the 4000 Series is difficult; National claims they are 50% faster. Each output is designed to drive one LPTTL input. The 54 Series has an operating temperature range of -55° to +125°C; the 64 Series, from -40° to +80°C; and the 74 Series, the standard industrial rating of 0° to +70°C.

For more information contact Bob Bennett at National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. Phone(408)732-5000.

Solitron Devices is probably the first CMOS maker to actually have used ion implantation on a production-line basis for CMOS. They presently produce about 40 devices for the 4000A Series (their designation is CM4000). Their philosophy is to second source 4000 Series devices as quickly as possible. However, they also have a line of proprietary devices, designated the CM4100 Series, which includes the CM4108, a 16-channel multiplexer, and the 4133, a 1k-bit dynamic RAM. Also scheduled for introduction shortly is the 4117, a 4-decade BCD-to-7-segment liquid crystal driver.

Solitron also has a few TTL pinout versions of CMOS, but has apparently de-emphasized this line in favor of the 4000 Series, or until user acceptance picks up.

For more information contact Irwin Lucks at Solitron Devices, Inc., 8808 Balboa Ave., San Diego, CA 92123. Phone(714)278-8780.

Solid State Scientific specializes in only two technologies, CMOS and RF power transistors. They offer 30 of the standard 4000 Family building blocks, which they call the SCL 4000A Series. Although the SCL 4000 devices are pin compatible, they were designed independently by SSS. All gate devices include double output buffers for improved transfer characteristics. SSS series SCL4400A devices are proprietary circuits and include expandable NAND and NOR gates, the 4412 and 4402, which are similar to the 4012 and 4002. These 4400 Series however, permit the building of "wired-or" systems, as you can with TTL but were previously unable to do in CMOS.

SSS was also the first manufacturer to integrate npn Darlington bipolar transistor drivers onto the CMOS chip for increased output drive capability.

For more information contact Walt Kalin, Solid State Scientific, Inc., Montgomeryville, PA 18936. Phone(215)855-8400

High-speed CMOS families emerge

Harris' DI-CMOS uses dielectric isolation to achieve 2 to 3 times the speed of standard CMOS. The isolation system developed by Harris uses polycrystalline silicon insulators around the tran-

sistor areas, which reduce the gate-output capacitance to nearly zero. In addition, these transistors are larger, thus providing lower output impedances and higher drive capabilities which leads to faster switching times. The devices now available are the 4000, 4001, 4009, 4010, 4011, 4012 and 4013. Those circuits which are original with Harris will be designated the 4800 Series. Harris is shooting for a total of 35 DI-CMOS devices to be available in 1973.

For more information contact Bill Maxwell at Harris Semiconductor Div. of Harris Intertype Corp., Melbourne, FL 32901. Phone(305)727-5430.

Inselek silicon-on-sapphire CMOS also offers high-speed equivalents of the 4000 Series. Although only five circuits, (the INS4007S, 4021S, 4013S, 4027S and 4030S) are presently available, Inselek is intent on producing at least 15 more CMOS/SOS circuits in 1973. SOS circuits are presently spec'd at about 2 to 3 times the speed and frequency of standard CMOS, but the future seems to promise even better. CMOS/SOS units in the laboratory have already operated at frequencies well in excess of 50 MHz.

Inselek has also announced a 4 × 4 analog crosspoint switch in CMOS/SOS, designated the INS-001, which contains 16 linear switches and a 16-bit read-write memory for crosspoint control. Any or all switch paths can be selected and opened or closed in 100 nsec each. A memory data output line permits monitoring of the switch status.

For more information contact Bob Heller, Inselek, University Park Plaza, 743 Alexander Rd., Princeton, NJ 08540. Phone(609)452-2222.

More analog switching

Siliconix's standard CMOS product line centers around signal switching devices. They provide a line of 50 different analog signal switches, ranging in complexity from single-channel SPDT switches (like the DG143, 161, 175 and 187 families) to 16-channel multiplexers (like the DG506). Most of these switches have break-before-make operation and switch in about 200 nsec.

An interesting CMOS circuit from Siliconix (although it's a semi-custom part) is their 250-bit shift register. It is programmable from 25 to 250 bits in 10-bit increments and designed to operate as a variable digital delay line. Operating speed is 8 MHz at 5V and 18 MHz at 8V.

For more information contact Bob Landon at Siliconix, Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. Phone(408)246-8000.

Want to read more about CMOS?

Here's a bibliography of reference material used to compile the EDN design course:

1. MOS

a. Crawford, R.H., *MOSFETs in Circuit Design,* McGraw Hill, 1965.

b. Grove, A.S., *Physics and Technology of Semiconductor Physics,* J. Wiley & Sons, 1967.

c. Wallmark and Johnson, *Field Effect Transistors,* Prentice Hall, Inc., 1966.

d. Hofstein and Heiman, *Proc. IEEE,* 51 pp 1190, 1963, "The Silicon Insulated-Gate FET."

e. Ihartola and Moll, *Solid State Electronics,* Vol. 7, 1964, "Design Theory of Surface FETs."

f. Engineering staff, American Micro-Systems, Inc. *MOS Integrated Circuits,* Van Nostrand Reinhold Co., 1972.

g. Burgess and Daniels, *Electronics,* Aug. 30, 1971, "CMOS unites with silicon gate to yield micropower technology."

h. Boleky and Meyer, *IEEE Journal of Solid-State Circuits,* Vol. SC-7, April 1972, "High-performance low-power COS/MOS memories using silicon-on-sapphire technology".

i. Forsberg, R., *EDN/EEE,* Sept. 1, 1971, "Making sense out of the MOS muddle."

j. Forsberg, R., *EDN/EEE,* Sept. 15, 1971, "What's happening in MOS."

2. CMOS

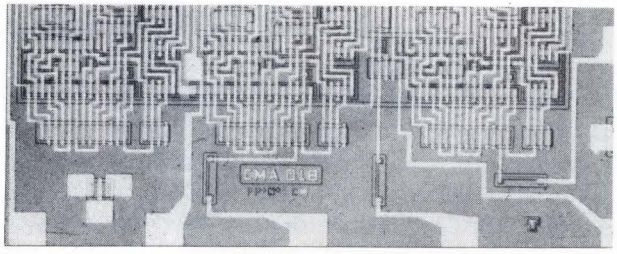
a. Gardener and Ahrons, *IEEE J of SSC,* Vol. 5, No. 1, Feb. 1970, "Interaction of technology and performance in CMOS ICs".

b. Motorola SPD, *McMOS '72*

c. Eaton, S.S., *"COS/MOS logic and applications",* RCA pub. #ST4322,

d. Moore, E.E., *"Low-voltage complementary MOS IC system design considerations"* RCA pub. #ST-4589.

e. George, J., *Motorola Monitor,* Vol. 10, #1, April, 1972, "A strong commitment to CMOS."
Electronic Products, March 15, 1971, "Three volt COS/MOS debut."



Second source availability of the entire 4000 Series is Solitron's aim, as typified by micrograph of Solitron's version of the 4018 divide-by-"N" programmable counter.

f. Pujol, H., *"Power supply considerations for COS/MOS devices"*, RCA pub. ICAN-6567.

g. Solid State Scientific, Inc., *CMOS Data Book.*

h. George, J., *Electro Procurement,* May, 1972, "Motorola's commitment to CMOS ICs."

i. Eaton, S.S., *The Electronic Engineer,* May, 1970, "Complementary MOS logic."

j. Di Massimo, D., *EEE,* Oct., 1970, "Complementary-Symmetry MOS ICs."

k. Cushman, R.H., *EDN,* June 15, 1972, "CMOS finally gets it all together."

l. Herzog, G.B., *Electronics,* Feb. 17, 1969, "CMOS: The best of both worlds."

m. Furlow, B.W., *EDN,* Nov. 11, 1972, "Why go CMOS?"

n. Furlow, B.W., *EDN,* Dec. 1, 1972, "The basic building blocks of the 4000 Series."

o. Schmidt, B., *EDN,* Jan. 5, 1973, "CMOS in system designs."

p. Calebotta, S., *CMOS, the ideal logic family,* National Semiconductor Corp., pub. #AN-77.

q. Dingwall, Jorgensen, Oberman and Waas, *RCA Engineer,* Vol. 17, No. 3, 1971, "CMOS/MOS memory array design."

3. Applications

a. Litus, J., *"Design of fixed and programmable counters,"* RCA pub. ICAN-6498.

b. Heuner, R., *"MSI counters and registers,"* RCA pub., ICAN-6166.

c. Hoover, M.V., *"An introduction to RCA COS/MOS ICs,"* RCA pub. ST-3973.

d. Havasy and Kutzin, *"Interfacing RCA COS/MOS,"* RCA pub. ICAN-6602.

e. Link, F.J., *Computer Design,* Feb., 1971, "The use of CMOS sequence timers."

f. Litus, J., *"Transmission and multiplexing of analog or digital signals,"* RCA pub. ICAN-6601.

g. Havasy, A., *"Arithmetic arrays using standard RCA COS/MOS"*, RCA pub. ICAN-6600.

h. Schmidt, B., *EDN,* July 15, 1972, "Digital error anticipator."

i. Smith, R., *EDN,* July 15, 1972, "CMOS one shot had wide range."

j. Cushman, R.H., *EDN,* July 15, 1972, "Elementary A/D converters."

k. Funk, R.E., *"Low-power digital freq. synthesizers"*, RCA pub. ICAN-6716.

l. Young, A., *Electronics,* Dec. 20, 1971, "PCM plus CMOS spells reliable, low-dissipation data acquisition."

m. Morgan, D., *Electronics,* Sept. 25, 1972, "Micro-power phase locked loop."

n. Halligan, J., *EDN,* Jan. 20, 1973, "Convert CMOS gates to wide hysterises Schmitt trigger."

o. Halligan, J., *EDN,* Aug. 15, 1972, "Psuedo-random number generator."

p. Johnson, D., *EDN,* March 15, 1972, "Low-power digital phase locked loop."

q. Bryant, F., *EDN,* June 15, 1972, "One CMOS package makes universal logic probe."

r. Furlow, B., *EDN,* Feb. 5, 1973, "Interfacing CMOS."

s. Kalin, W., *Expandable CMOS Gates,* Solid State Scientific pub. AN-102

4. Linear Circuits

a. Eaton, S., *"Micropower crystal controlled oscillator design"*, RCA pub. ICAN-6539.

b. Hoover, M.V., *"A cornucopia of linear ICs"*, RCA pub. ST-6060.

c. Wittlinger, H.A., *"Applications of high performance OTAs"*, RCA pub. ICAN-6668.

d. Schade, O.H., *"D to A conversion using the CD4007A"* RCA pub. ICAN-6080.

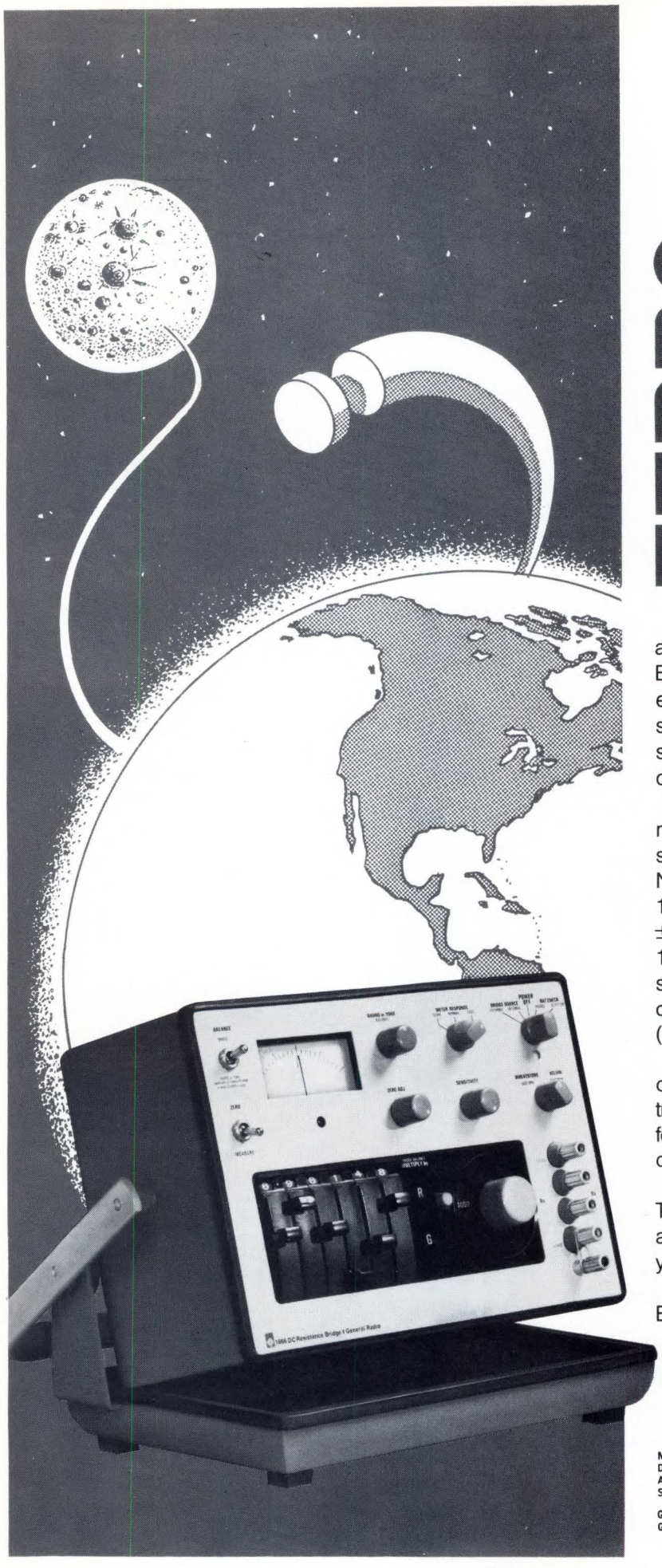
e. Furlow, B., *EDN,* March 5, 1973, "CMOS gates in linear applications."

Want more info?

For more information from each of the manufacturers of CMOS, circle the following reader service numbers:

RCA	circle **120**
Motorola	circle **121**
Solitron	circle **122**
Solid State Scientific	circle **123**
Harris	circle **124**
Inselek	circle **125**
Siliconix	circle **126**

National will respond only to letterhead, phone or TWX inquiries. Their TWX # is (910)339-9240.



GR's Measure-Anything Resistance Bridge

Enough #10 wire to reach the moon will total about 1 megohm. The GR 1666 DC Resistance Bridge will measure that to within ±0.01%, or the equivalent of ±25 miles. Better yet, if a piece as short as 440 yards is removed from the translunar span, the 1666 bridge will resolve the 1-ohm difference.

Most striking about the 1666 bridge is its wide measurement range. It will measure a piece of the same size wire long enough to reach from here to Neptune, 2.7 billion miles (10 gigohms), or a 1½-inch piece (100 microohms), both within ±2% accuracy. And that feat doesn't really tax the 1666; it has enough resolution and detector sensitivity to distinguish between 0 and 2 microohms and between ∞ and 500 gigohms (measured as 2 picomhos conductance).

Here, for $950, is a bridge that will measure contact resistance and dielectric leakage, transformer windings and insulation, diode forward and back resistance, relays open and closed . . . and all with precision.

The 1666 has a *fast-responding* detector. The 1666 is self-contained. The 1666 has guard and Kelvin connections. The 1666 is essential if you measure resistance.

From General Radio, Concord, Mass. and, in Europe, Postfach, CH 8034 Zurich, Switzerland.

General Radio
300 BAKER AVENUE, CONCORD, MASS 01742

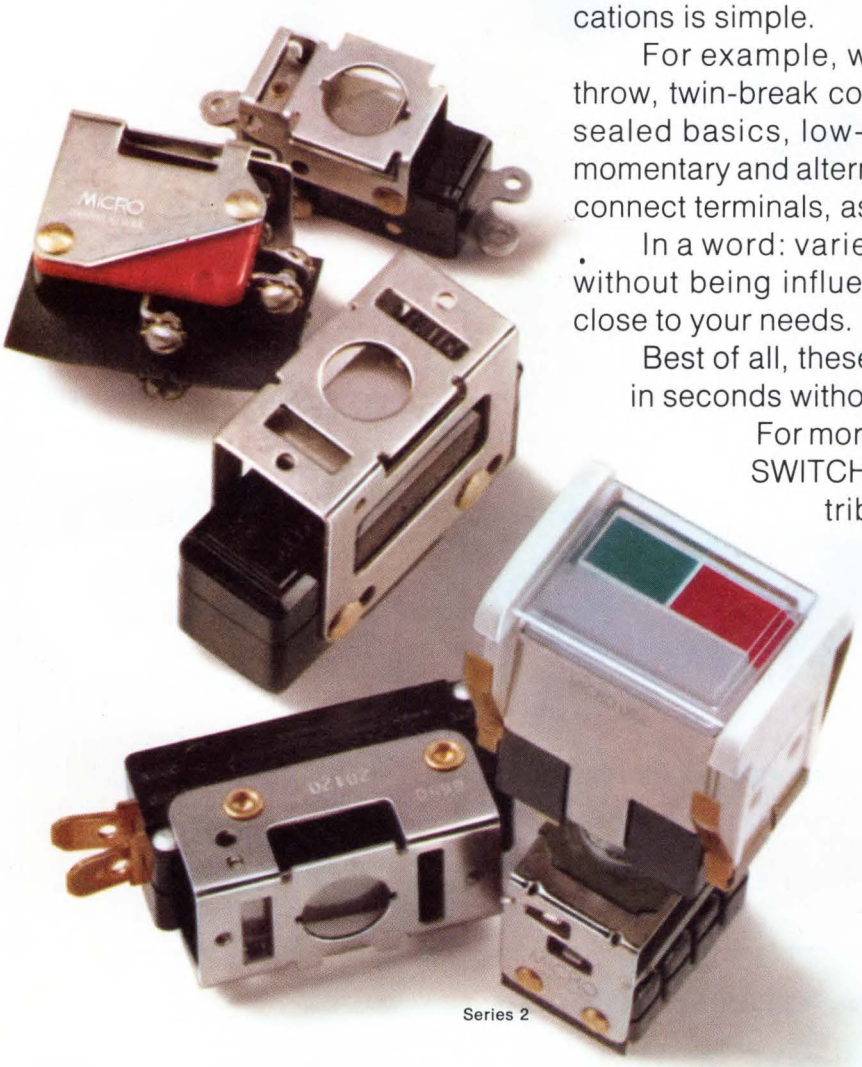
NEW YORK (N.Y.) 212 964-2722, (N.J.) 201 791-8990 • BOSTON 617 646-0550
DAYTON 513 294-1500 • CHICAGO 312 992-0800 • WASHINGTON, D. C. 301 948-7071
ATLANTA 404 457-2485 • DALLAS 214 234-3357 • LOS ANGELES 714 540-9830
SAN FRANCISCO 415 948-8233 • TORONTO 416 252-3395 • ZURICH (01) 55 24 20

GR COMPANIES • Grason-Stadler • Time/Data • Techware Computing Corp.
GR ASSOCIATE • Micronetic Systems Inc.

Circle No. 22

The most versatile switches we make are assembled by you.

Series 6



Series 2

It all starts with your design problem.

You can solve it with the right combination of switch module and lighted (Series 2) or unlighted (Series 6) operator.

Since we have thousands of combinations in circuitry and color display, matching your specifications is simple.

For example, we offer 1, 2, 3 or 4-pole double-throw, twin-break contact arrangements, hermetically-sealed basics, low-energy and heavy-duty ratings, momentary and alternate action, solder, screw or quick-connect terminals, as well as many other variations.

In a word: variety. The kind that lets you design without being influenced by some switch that's only close to your needs.

Best of all, these combinations can be assembled in seconds without special tools.

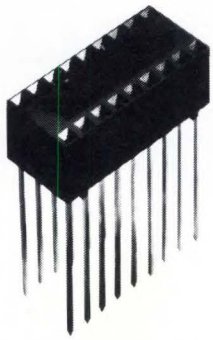
For more information, contact your MICRO SWITCH Branch Office or Authorized Distributor (Yellow Pages, "Switches, Electric"). They'll prove their versatility by helping solve any switch problem you have.

MICRO SWITCH
makes your ideas work.

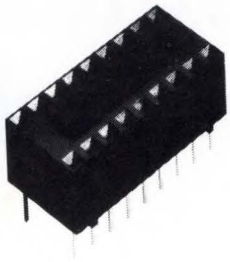
MICRO SWITCH
FREEPORT, ILLINOIS 61032
A DIVISION OF HONEYWELL

MICRO SWITCH products are available worldwide through Honeywell International.
Circle No. 23

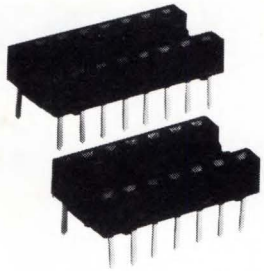
For all your socket requirements We offer hundreds of variations



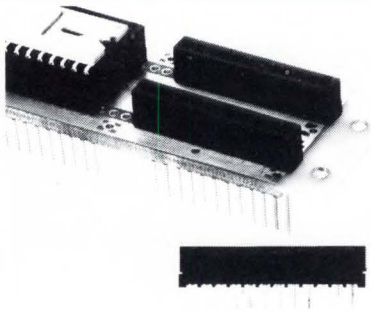
WIRE-WRAP* SOCKETS. 14-, 16- and 18-pin wire-wrap sockets for dual-in-line IC packages. .400" center mounting allows denser packaging. Closed entry cap and various tail lengths available. SERIES 2200.



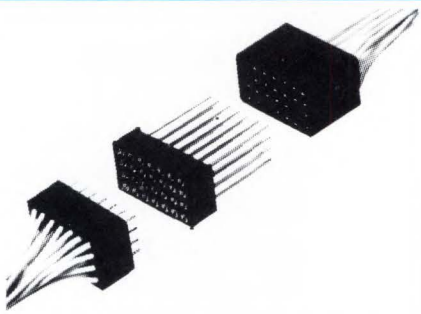
DIP SOLDER SOCKETS. 14-, 16-, and 18-pin dip solder sockets for dual-in-line IC packages. .400"-center mounting allows denser packaging. Closed entry cap optional. SERIES 2900.



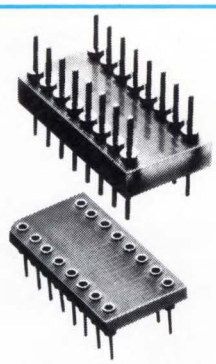
LOW-PROFILE SOLDER SOCKETS. Dip sockets for low-profile packaging of 14-, 16- and 18-pin "bugs". Profile extends .150" above circuit board. Sockets can be mounted end-to-end on .100" centers, and side-by-side on .400" centers. Features anti-wicking wafer and closed entry. SERIES 3100.



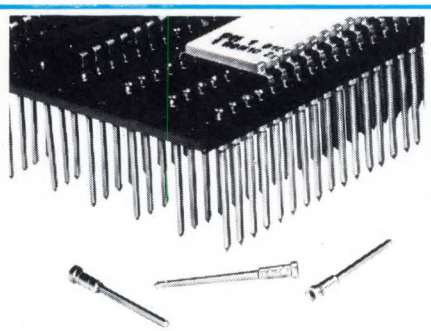
DUAL-IN-LINE SOCKET STRIPS. May be mounted on any center spacing required to accommodate 22-, 24-, 28-, or 40-pin dual-in-line packages. Available with wire-wrap or dip solder terminals, and closed entry cap. SERIES 2300/3000.



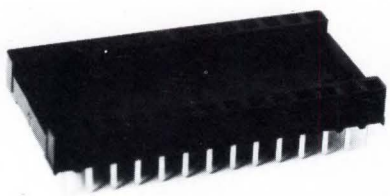
HIGH DENSITY I/O CONNECTOR FAMILY. 28 pins packaged on a .100" grid pattern, for Input/Output and interconnect applications. Features crimp/removable contacts for male plug or female receptacle. SERIES 21/25/2700.



COMPONENT MOUNTING BOARDS. Ideal for integrating discrete components in DIP packaging systems. Two versions (male/male or male/female), with many configurations available. SERIES 6100.



WIRE-WRAP* SOCKET TERMINAL. For high density, low profile IC packaging, or random pin pattern requirements. Press-fit terminal features .060" diameter lead-in with 100° countersink. Available in 3 tail lengths. SERIES W4000.



LOW-PROFILE LSI/MSI SOCKETS. Large scale sockets for low-profile packaging of 28- and 40-pin devices. Profile extends .150" above circuit board. Individual strips also available in 14 and 20 pin configurations. Features anti-wicking wafer and closed entry. SERIES 3200.

DIPSTIK® . . . NEW PACKAGING CONCEPT. Dipstik holds 5 dual-in-line IC's and offers many advantages over usual IC mounting techniques. No soldering. Holds 14-, 16-, or 18-pin bugs. IC replacement takes only seconds. No special tools. 100% test point accessibility. Integral EMI shielding. DIPSTIK SERIES DS110/210. (DS-100 Prototype Kit: $99 list.)

*TM Gardner Denver Co.

Send for our new product data sheet that describes complete specifications on the series of your choice.

Stanford Applied Engineering, Inc.

340 Martin Ave., Santa Clara, CA 95050 (408) 243-9200 TWX 910-338-0132

Your Complete Source for Packaging and Interconnection Systems.

Circle No. 24

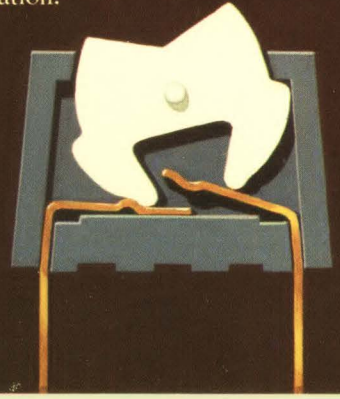
AMP cuts on-board programming problems down to size.

Down to the size of a DIP header—with our miniature Dual In-Line Switch. Because you can use it to program IC's right on the board without remote wiring, it cuts packaging costs, too.

This versatile switch gives you 4 to 10 single-pole, single-throw switches packaged in a housing with leads on .100 x .300-inch centers. Rocker buttons operate at the touch of a pencil to permit instant programming of data input terminals, computer peripherals, testing and control instrumentation. Plug it into a DIP header or into one of several other AMP IC interconnection products. Or flow solder it directly into the pc board. Gold-over-nickel plating on phosphor bronze contacts makes the DIP switch ideal for "dry circuit" applications. Protective covers are available for all switch sizes, 4 to 10 positions.

For information on other AMP switches, just turn the page.

Easy rocker action ensures fast, positive "on-off" switching; off-center rocker design prevents accidental closing from vibration.



AMP pc board switches match

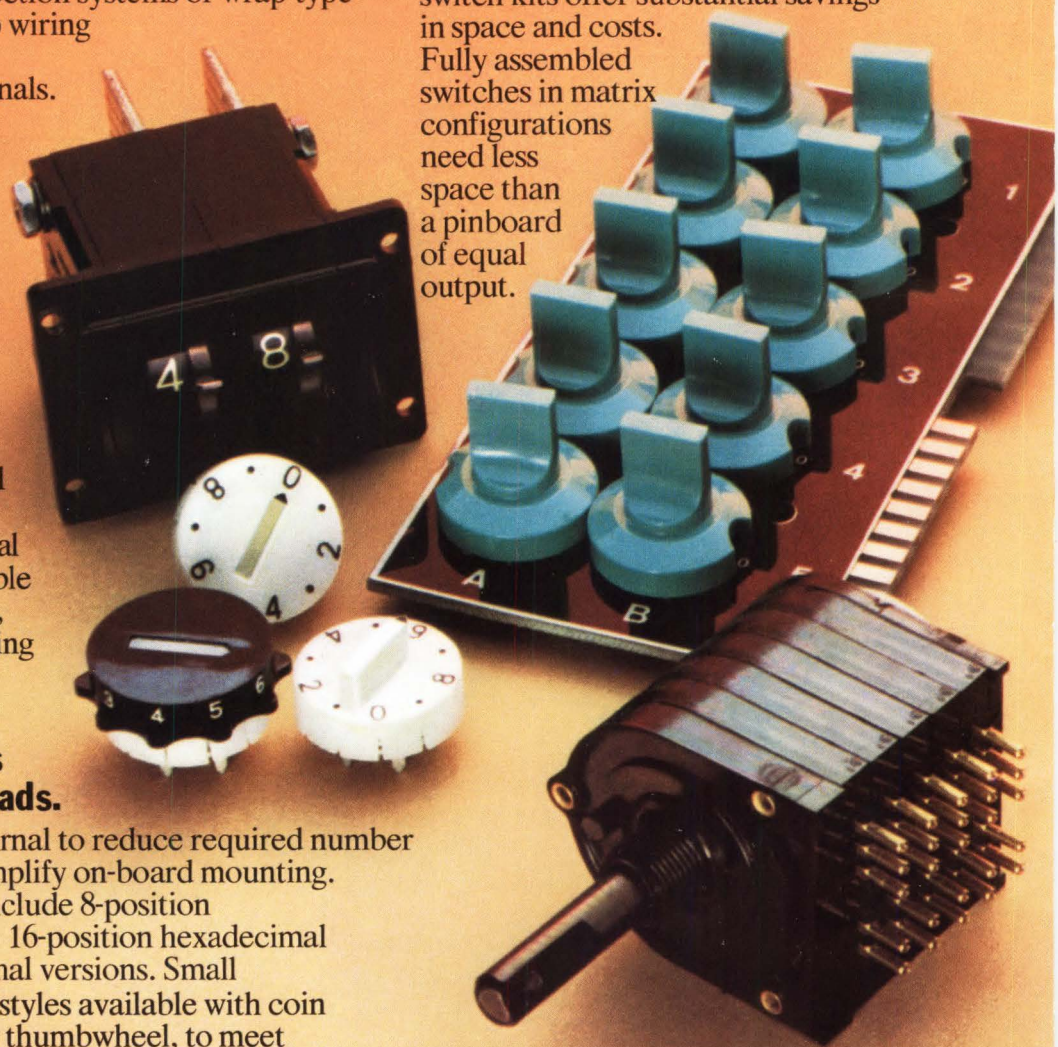
AMP pc board switches are suitable for a broad range of digital memory, sequencing, X-Y coordinate, input/output, and other program switching applications. Some are designed to be mounted to the same pc board as other circuit components. Other AMP switches can be panel mounted and interconnected to mother/daughter board with AMP pc connectors for fast, dependable connect/disconnects. All provide savings in packaging space and assembly costs by performing required program functions without remote switch wiring.

Thumbwheel switches offer broad interconnection flexibility.

Wide choice of back-end design options include contacts for use with post and receptacle interconnection systems or wrap-type and TERMI-POINT clip wiring methods, as well as extended board terminals. Extended board terminals can be flow soldered and will accept pc edge connectors and soldered wires. Compact 10-position switches can be used singly or in "ganged" units; are easily mounted in panel cutouts—from front or rear. Decimal and BCD outputs are standard, with optional coded formats available for special data entry, control or programming applications.

Decimal rotary switch kits eliminate need for external switch wiring.

Because they can be readily designed into the logic board with related components, switch kits offer substantial savings in space and costs. Fully assembled switches in matrix configurations need less space than a pinboard of equal output.



PC rotary switches minimize output leads.

All coding is internal to reduce required number of tab outputs and simplify on-board mounting. Output capabilities include 8-position BCO, 10-position BCD, 16-position hexadecimal plus single-pole decimal versions. Small diameter, low profile styles available with coin slot, bar-type knob or thumbwheel, to meet specific packaging requirements. Switch tabs can be flow soldered or hand soldered to etched circuit patterns.

Multilayer rotary switch provides easy coding changes.

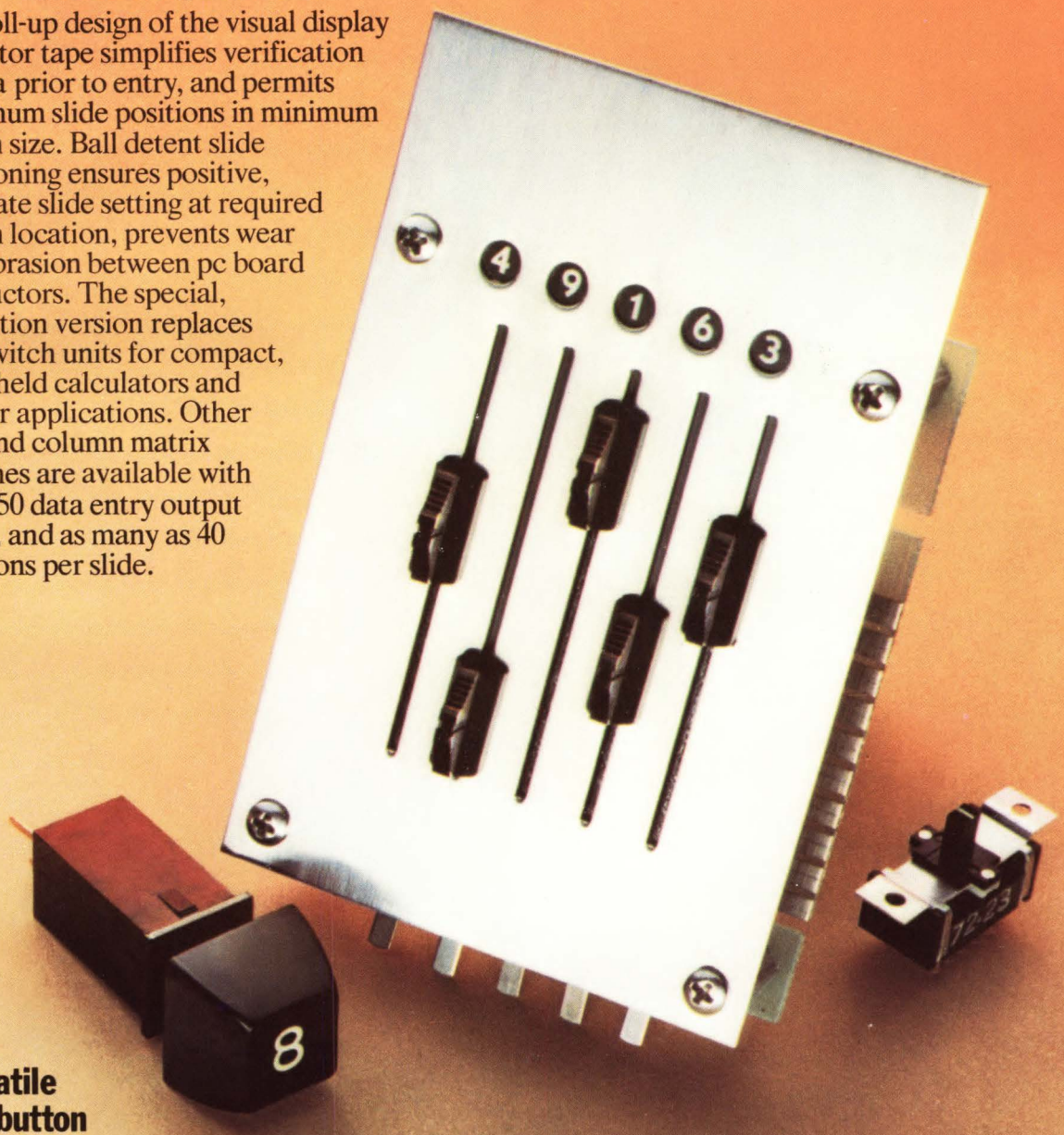
A wide variety of coded outputs are possible in volume requirements by simple substitution of internal pc circuit discs. Output capabilities include decimal, hexadecimal and hexadecimal complement codes with up to 6 contacts and 16 positions per switch layer. Switches are stacked on a common shaft for space-saving installation. Available with post contacts for flow soldering directly to pc board, or with pin type receptacles snapped over posts for terminating to pc board connectors.

your programming needs.

AMP INCORPORATED

Matrix slide switches feature unique visual readout, greater positioning accuracy.

Roll-up design of the visual display indicator tape simplifies verification of data prior to entry, and permits maximum slide positions in minimum switch size. Ball detent slide positioning ensures positive, accurate slide setting at required switch location, prevents wear and abrasion between pc board conductors. The special, 5-position version replaces two switch units for compact, hand held calculators and similar applications. Other row and column matrix switches are available with up to 50 data entry output slides, and as many as 40 positions per slide.



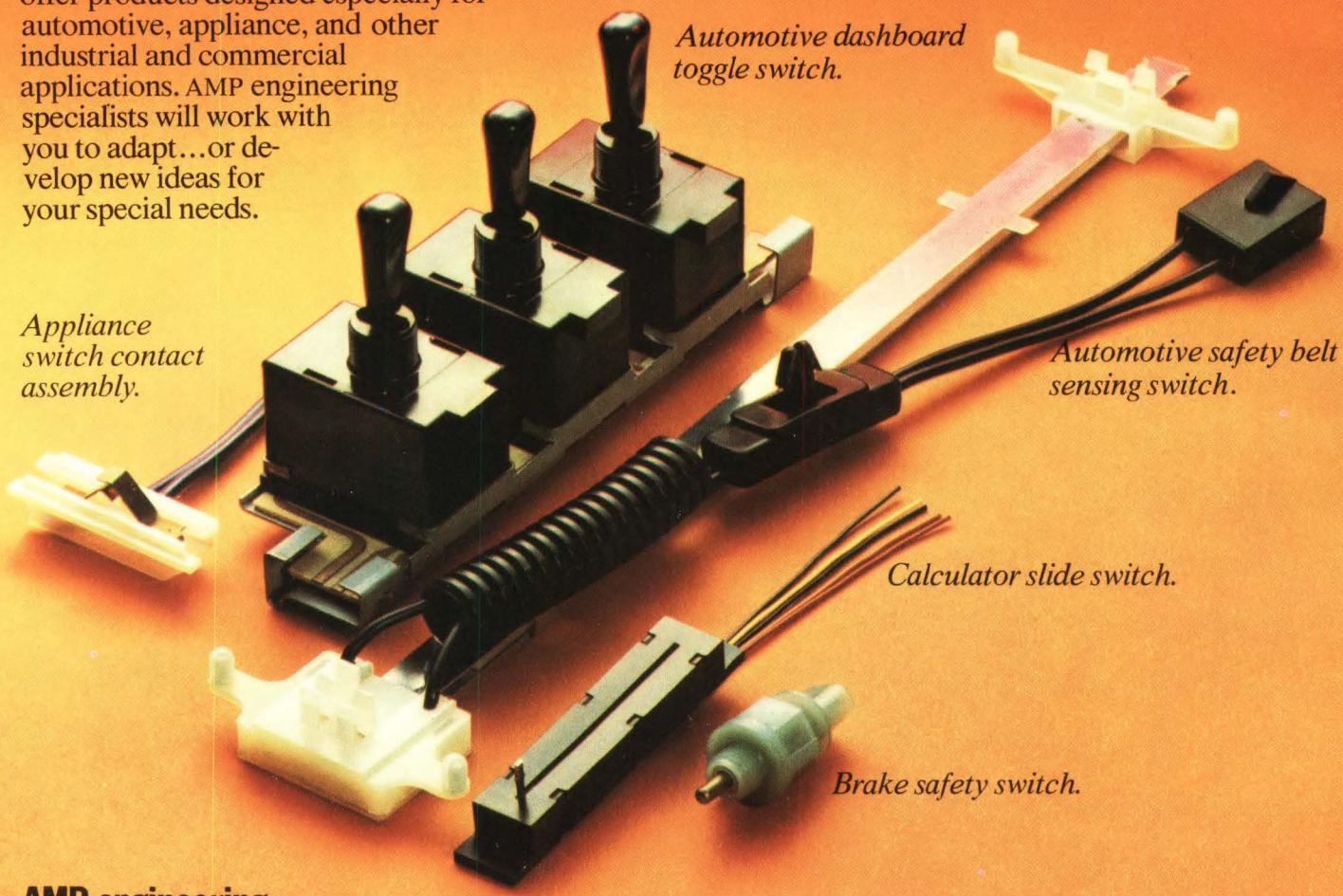
Versatile pushbutton keyboard switch.

Fast acting pushbutton offering a choice of switching functions can be manufactured for specific needs: one SPNO or SPNC; two SPNO or SPNC; one NO and one NC in the same switch.

A contact bounce of less than 1 millisecond makes this the ideal component for momentary switching applications. Gold-over-nickel contacts meet low-level logic current requirements. Pushbutton switches can be snapped into panel cutout or soldered directly to pc board.

AMP also has switch designs for unusual applications.

Developing special products to help individual customers speed production and reduce electrical assembly costs has always set AMP apart. So it is with AMP switches. In addition to our complete line of rotary, slide, rocker, thumbwheel and keyboard switches for electronic packaging, we offer products designed especially for automotive, appliance, and other industrial and commercial applications. AMP engineering specialists will work with you to adapt...or develop new ideas for your special needs.



Automotive dashboard toggle switch.

Appliance switch contact assembly.

Automotive safety belt sensing switch.

Calculator slide switch.

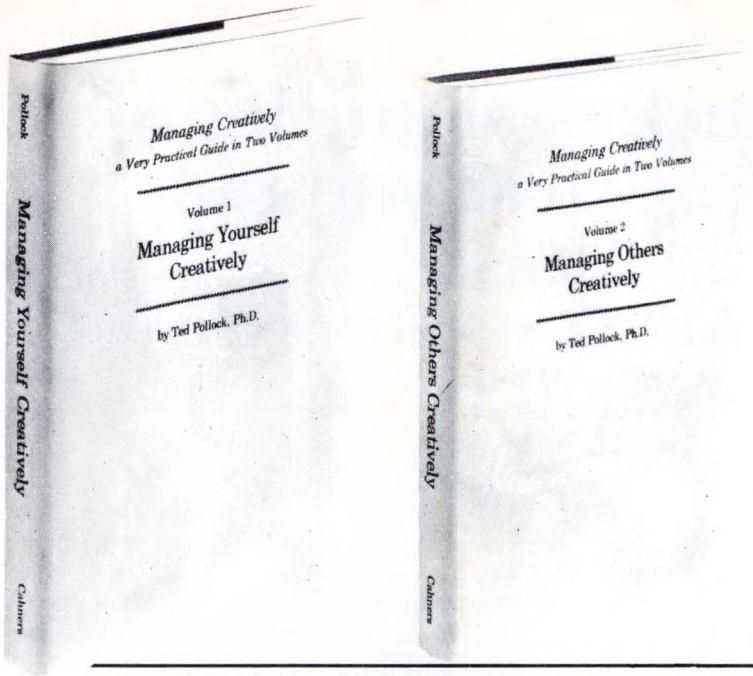
Brake safety switch.

AMP engineering... the key to reliable switch performance. Worldwide.

Standard or special, every AMP switch is backed by the full resources of our engineering and customer services staffs. More than 700 qualified application, sales and service engineers are ready to assist you from the earliest stages of equipment design, to determine the best programming or switching method. AMP products and services are available at AMP plant locations and distribution centers in 16 international markets throughout the world. In United States, district offices are located in California, Georgia, Illinois, Massachusetts, Michigan, Minnesota, New Jersey, Ohio, Pennsylvania, Texas, and the District of Columbia.

For more information on AMP pc board switches, circle reader service number 75, or write AMP Industrial Division, Harrisburg, Pa. 17105.

AMP
INCORPORATED

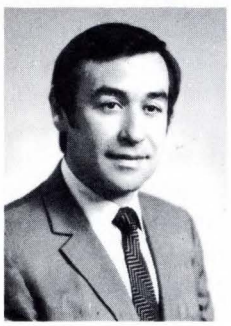


Announcing two great books to help you with people management . . . the most important part of your job . . .

MANAGING CREATIVELY

A VERY PRACTICAL GUIDE IN TWO VOLUMES BY TED POLLOCK

There is no secret to working successfully with people, just a set of principles that have weathered the test of time and kooky laboratory theories.



Ted Pollock, advisor, author and lecturer to American business on the complex problems of working with people distills the essence of his vast experience in these two volumes.

A positive approach, keyed to today's thinking, makes these volumes a must for the executive who has to operate with a minimum of conflicts and hang-ups.

You can't call in a consultant for every personnel problem but you can turn to these volumes written by one of America's top personnel management consultants. It's like having him by your side.

Volume I

MANAGING YOURSELF CREATIVELY

- The Right Way to Delegate Authority
- How to Tackle a Problem and Solve It
- The Art of Making Decisions
- Twenty-Four Ways to Save Time

Volume II

MANAGING OTHERS CREATIVELY

- How Well Do You Handle People?
- How to Give Instructions
- Hiring and Firing
- How to Size Up People
- Put Your Ideas Across Effectively
- Managing for Better Morale
- "The Trouble With You Is . . ."
- Coming to Grips with Employee Gripes
- How to Develop a Top Assistant

Comments by readers on Ted Pollock's advice:

"I read your article 'How to Use Tension'—your technique has been utilized by me and the rewards are not only gratifying but unlimited."

—John E. Martin,
General Foreman
Martin Marietta
Corporation

" . . . have always been impressed by the solid down-to-earth nature of your comments as well as the concise and direct language in which you express yourself."

—Frederick E. Martin,
President
Madison Gas and
Electric Company
Madison, Wisconsin

15-DAY FREE TRIAL EXAMINATION . . .

CAHNERS BOOKS
89 Franklin St., Boston, Mass. 02110
Please send me:

- ☐ Both volumes @ $16.50 a set—MANAGING CREATIVELY
- ☐ Volume I @ $9.50—MANAGING YOURSELF CREATIVELY
- ☐ Volume II @ $9.50—MANAGING OTHERS CREATIVELY
- ☐ Bill Me
- ☐ Bill Company
- ☐ Check Enclosed

NAME _____

COMPANY _____

ADDRESS _____

CITY/STATE/ZIP _____

Add Any Applicable State Tax

S 58/MO809

How to write technical articles, and why you'll be glad you did

You know tech articles are worth reading—that's why you take all those magazines—but what about writing them, is it worth all that effort?

Bill Furlow, Associate Editor

That idea you just talked about at lunch might make a good article, did you think about that? You should, because technical articles give you a chance to communicate with engineers who have the same interests and problems that you have. If your ideas are formulated well enough so that you can convey them to one or two people in an hour, you could probably write a tech article in just a few hours more. Why should you? Let's look at some of the possible reasons for writing tech articles, before we get into the "how to" part. They may not all apply to you, and some of them may seem shallow to you at first, but don't judge too quickly.

Communicate with other designers

That's what you do at coffee or lunch or at professional societies. But how many people do you reach? One, ten, a hundred? A technical article can reach a thousand times as many! And one of the surprising things, at least to new authors, is that tech articles open up a valuable avenue of information exchange. Your article doesn't end the discussion; it begins the discussion. You will receive mail and phone calls from designers who need more information or have some to pass along. And some of the greatest nit-pickers in the world will have carefully examined your design criteria and formulas. If you've made a mistake, you'll learn about it quickly, and that can be the most valuable thing of all—even if it is hard on the ego.

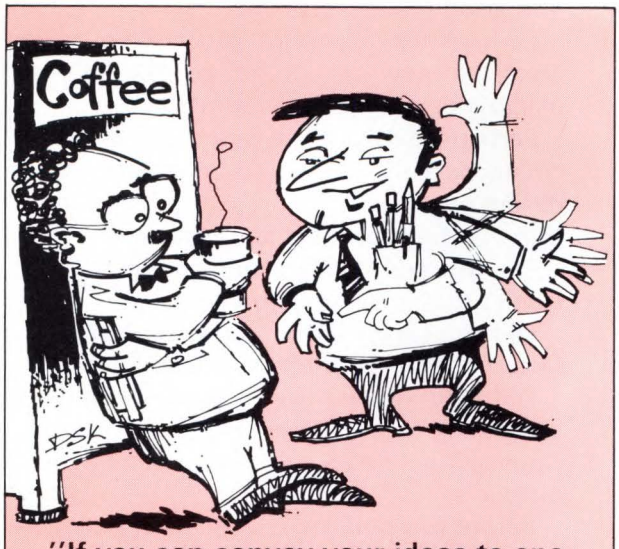
By now, everybody knows that we're living in an information explosion, that the sum total of man's knowledge is doubling every half decade and all that. Perhaps such stunning statistics make you feel that nothing you know could make much of a dent in things. Many engineers have much the same attitude, and it's not due to any feeling of inferiority or even false modesty, it's just that they are so familiar with certain techniques that they assume everyone else is too. But most worthwhile design articles are written by ordinary—but competent—design engineers just like you. The information you have to pass along is significant, and the chances are very good that at least one magazine (there are more than 4000 in the US) will be interested in what you have to say.

Perhaps your writings won't be remembered as long as Tolstoy's, but to a harried and hurried designer who's looking for the answers you have, your article can be a hell of a lot more important.

Enhance your professional status

Engineers are a lot more fortunate than physicists and educators, since the saying "Publish or Perish" doesn't really apply. That's as it should be. A designer shouldn't be penalized for not writing articles, but most authors do feel that their writing has helped their careers. Some of the reasons for this feeling are intangible; others are easy to see. A well-written and well researched article carries a definite air of authority, and many times, the research that's required to back up your article will improve your knowledge in that specific field. It all adds up to technical competence that is made more visible by your articles. That's how design engineers are, or should be, evaluated.

On the other hand, poorly researched tech articles do nothing for anyone. The magazine's stature, and your own, will suffer, and it will be hard for you to publish your next article. You will lose the hard earned esteem of your fellow engineers, and your career may suffer. Don't let that scare you off, though. You'd lose their respect just as quickly by doing shoddy design work, and writing articles is much like your daily design work. If you are successful in your design tasks, you can be successful in your writing. To recap, tech articles can be a logical extension of your daily work that will help you meet other engineers in your own line of work. They will also make you more visible to the management of your own company, and if you stand up to that visibility, your career will be enhanced.



"If you can convey your ideas to one or two people, you can write a tech article and reach thousands more"

Improve your company's image

Almost hand in hand with your own status is that of your company. Improve one and you're almost certain to improve the other. The value of the trade press as a method of improving the corporate image is perhaps better understood by most corporate PR men than by designers. That's why your own PR man spends so much time chasing down tech articles and sending out press releases. Doesn't he? If he doesn't, he won't last long. If you have any doubts about the value of tech articles which carry your name and that of your company, just call the PR department and ask them what they think about publishing these articles. You should check on this anyway, for several good reasons. First of all, many companies pay an extra bonus to employees who publish articles. Then too, the PR group will probably give you whatever assistance they can. They are usually willing to do some editing, or dig up some artwork and photographs for you. They will also help you get whatever corporate approval is required to release your article for publication and give you advice on which magazine they think will be most receptive.

Many companies, especially electronics companies, have made almost overnight reputations through the trade press. You can probably think of a few companies that you're buying products from right now because you found out about them through a design magazine. There is very little doubt that the publication of technical articles is good PR for your company, and that has to benefit you directly.

Earn extra money

Some society journals don't pay anything, in fact, some even charge you for the editing and art department time that is required in preparing your article. On the other extreme, some large-circulation, general-interest magazines pay extremely well. Trade publications tend to pay at somewhat the lower end of the scale. Once you've selected one or two magazines that interest you, contact them and ask about their payment schedule. They'll probably quote an average price "per printed page." This means the page as printed in the magazine, and this figure is usually somewhat flexible. Editors tend to pay less for articles that require a lot of work on their part, and more for good material.

No matter how good your article is, you're not going to get rich by writing for the trade press, but it can be worth your time. In addition, some employers pay bonuses, as we mentioned before. This can range from $25 to $100, normally, and some companies match the payment you get from the magazine. That range of payment will usually be $25 to $150. A half-page circuit design shouldn't take more than a few minutes of your time, since you've probably done the groundwork on the job already. A 6-page article will take a lot longer, but again, if much of the basic work has been done on the job, you'll be surprised how little effort is required to turn it into an interesting article.

There, you have four reasons for writing tech articles, do any of them apply to you? Probably at least one or two will. If you feel they do, then you should start now to plan your article.

Where to get ideas

Let's first dispel two rumors about engineers that have been around so long that even most engineers think they are true. Everybody knows that engineers make lousy managers, right? Besides that, they can't write, right? Wrong! The

"Improve your companies image and you will improve your own"

"Choosing the topic of the article should be the easiest part"

rumor about managerial talent was probably started by managers who had no technical background and were afraid of the engineers they managed. As for writing—especially technical articles—who could be better qualified than a design engineer? The disciplined thought patterns required in your everyday work—the ability to see the problem, think it through and come up with a valid solution—will enable you to write good, solid articles that communicate your thoughts to others and stimulate their thought processes as well.

Choosing the topic of the article should be the easiest part. You probably have one or two ideas in mind already. If you don't have a topic, don't go looking for one. You'll know you're on the right track when the thought "someone should write an article about that" occurs almost naturally to you. On the other hand, if you ask "what can I write an article about?" you're off to a bad start. Here are the major categories for technical articles:

- Developments in the technology
- Design problems and solutions
- Applications
- Design considerations

Whatever your subject, there is one outstanding requirement: you must have some degree of technical experience and expertise in the field. If you don't, it will be apparent. You probably won't be able to get the article past the editor, and you'll never get it past the readers.

You may not realize it, but reams of good material for tech articles pass through your hands in a year's time. A few of these, there are:

- Technical reports on projects you have completed.

  Perhaps the entire project is so interesting that a systems overview type article would find good reader response.

  Perhaps the impact of your system is so great that newspapers and general interest magazines would like a report on it.

  Perhaps there are five or ten subsystem or circuit designs that would be of interest to design engineers.
- Surveys, both product and market.

  Do you see a segment of medical electronics that is being ignored?

  Did you survey all components and manufacturers of a given product area?

  Did you do a systems analysis of two competing technologies?
- Application notes on your company's products.

  Before you publish it, some magazine may be interested in running portions of it, or perhaps the whole thing; check with the magazine you think is most likely to be interested. But after you've printed it, magazines will not be interested.
- Lab notes from your design work.

  If you found a solution to a problem that's been bothering you for a long time, chances are other engineers would like to know about it too.

  Data plots and empirical data from breadboards and production tests will provide good support material for your article.

How do you develop the article?

First, you should take a few minutes to write an outline. It serves the same purpose as a block diagram or flow chart. It will help you to get an overall impression of the article and arrange it in an orderly manner. Often you will find that the subtitles (or "crossheads") of your article will come very close to the main outline categories.

You should also assemble all the illustrations, photographs, schematics and tables that you want to use in the article before you begin to write.

At this point it is best to survey your article and the potential markets for it. In electronics, as in all fields of engineering, there are many different magazines with different approaches and different market segments. Two pages of analysis here couldn't possibly convey as much information as you can glean from reviewing a copy of each magazine. Ten minutes should be plenty of time to get the feel and tone of a magazine. Read the editorial and policy statements, look at the tech articles. Do they seem to be aimed at the audience you are interested in writing to? Once you've decided on one or two magazines, call them and ask if they are interested in your article. There is no formal procedure in the trade press. You can call or write, or send a copy of your

outline, or send the completed article. If you call, you can at least find out if the magazine is receptive to your idea before you invest too much time in preparing it. No one is going to commit themselves to buy an article until they've seen the whole package, but at least you'll know whether you have a reasonable chance of having your article accepted. The editors may even suggest a different approach to your article that will make it more interesting to their readers. This will greatly improve your chances of selling the article, so the phone call is probably the best approach at this stage, and submitting an outline is the second most effective. Submitting a complete article is the most hazardous because it may take weeks or even months before you know whether the article has been accepted. Since ethics dictate that you submit your article to only one magazine at a time, you may spend six months looking for someplace to have it published. Timeliness is all important in electronics design articles, and your technique may become obsolete before you can publish it.

Down to the nitty gritty

Once you have aroused the interest of an editor, your next task will be to write the article. You've probably read enough tech articles and written enough reports that you can handle this without too much assistance. Keep this one point in mind, though, while you are writing: Written and spoken information are distinctly different, yet writing which sounds like conversation is more interesting to read. Try to write more like you talk. Not exactly as you would talk, because writing affords you the time for a more proper selection of words than speech does. Take the time to find the perfect word. That doesn't mean that you should "multisyllabicate" wherever possible; in fact, you should try to use shorter words when you can. Don't say "utilize" when you mean "use". On the other hand, tech articles are read by a well educated audience, so don't be afraid of large words when they are really necessary.

Write in a personal, not a passive, tone. "I found" or "you will find" is much livelier than "it was found" or "it will be found".

Finally, after the first draft is complete, set it aside for a week. After this "cooling-off" period, pick it up, make the changes you think are needed and mail it off.

Mechanical requirements

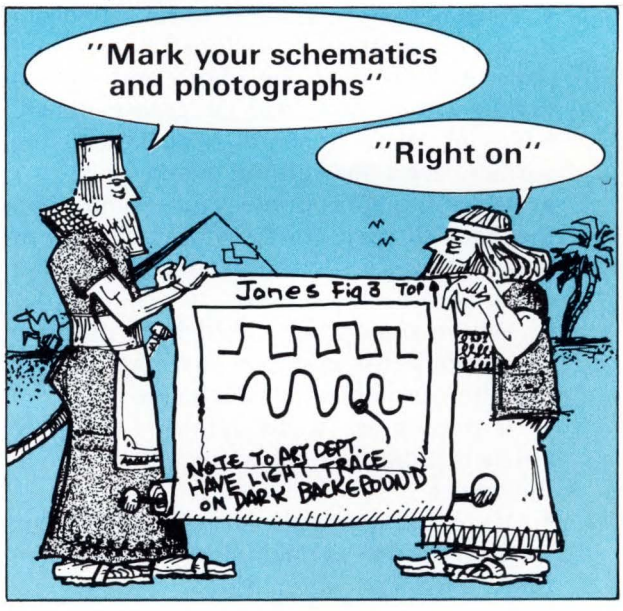
Up to now, we've been talking in broad generalities; but to cover the mechanical requirements, let's look specifically at EDN. Most other trade magazines will have similar requirements, but check because they may vary.

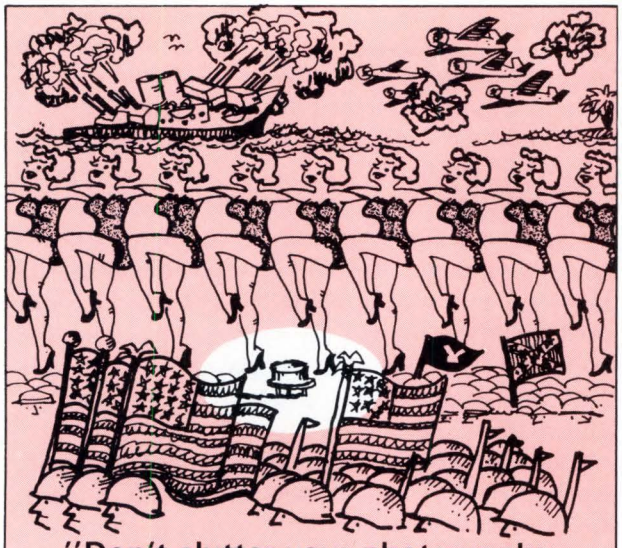
We would prefer to receive all manuscripts typed. It would really please us if you typed on one side of the page, only, in 50-character lines with 25 double spaced lines per page. Put your name, address, telephone number and a working title (it will probably be changed, so don't spend too much time on it) on the first page. Put your last name and the page number at the top of each succeeding page. This will give you a manuscript page containing approximately 250 words. Since most technical magazines average just over 1000 words plus illustrations per page, you can estimate the length of your article from the length of your manuscript.

If you use abbreviations that are not common, explain them. Greek letters and math symbols should be typed or written (legibly) in place.

Put each drawing or diagram on a separate piece of paper. Don't worry about drafting quality if they are neat and legible; we will redraw them, anyway. Here are some other rules to make your drawings more useful to us:

- Express a single idea on each drawing.
- Drawings may be pencil, ink, photostats, etc.
- Parts values and other pertinent data should be clearly marked on each drawing. Do not clutter up drawings with nonpertinent information.
- Drawings should either be supported by a self-contained caption or be referenced to the text in a simple manner.
- Drawings should be on one side of the paper only. If a special part is used on a drawing, instructions on how to make or obtain this part should be included.
- Do not send an original or only drawing. Obtain a print or copy; we cannot be responsible for loss.





"Don't clutter your photographs with nonessential details"

- Number only the parts mentioned in the text and number them consecutively; i.e., R1, R2, R3, C1, C2, C3, etc. NOT R 5001, R 5003.
- Use a consistent set of symbols and other notations and include legends where ambiguity might exist (such as logic symbols).

Here are a few general rules for photographic support of your article:

- Photos accompanying your article should be black and white, glossy finish. Do not send color transparencies or prints unless they have been requested or we have been forwarned.
- "Polaroid" photos usually are marginal for publication but may be sent to further explain an idea. "Polaroids" of scope waveforms are useful and often appear in EDN.

Do not write on photographs or mark them with grease pencil.

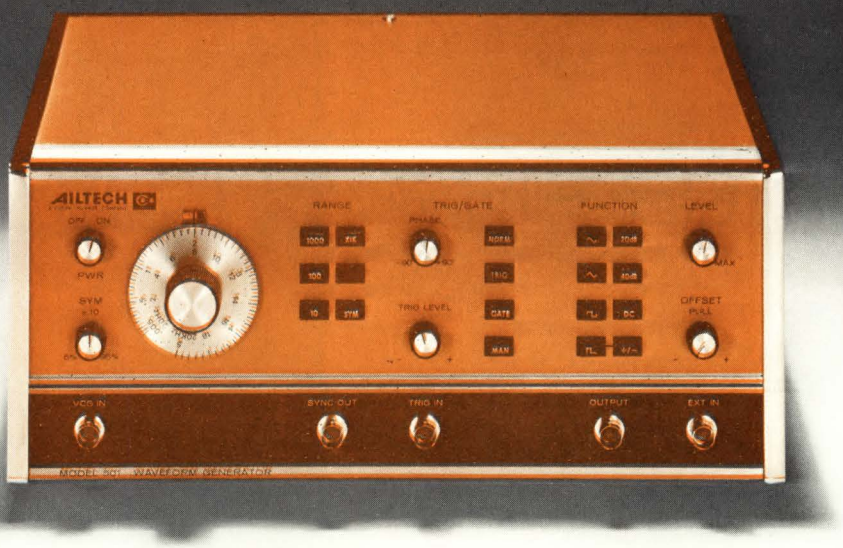
- If something specific is to be called out on a photo, place an onionskin or tissue-paper overlay over the photo and mark it lightly with a soft lead or grease pencil. Ballpoint pens or hard pencils mar the surface, even through the overlay.
- Write the appropriate figure number on the back of each photo with a soft lead or pen. Do not use glue to attach copy or other material to back of photo.
- Where orientation could be a problem (waveforms, for example), use the back of the photo to indicate "which side is up."
- If photos are to be returned after the article is published, please include a note to this effect.
- If you have special instructions regarding the photo, such as deletion of some parts or titles, inform us with a note.
- Do not encumber photos with models (girls) or other distracting items.
- Protect photos with heavy cardboard so they will not be damaged in the mail.

How long does it take?

Again, speaking only for EDN, but assuming that we are fairly typical, all manuscripts are acknowledged when we receive them. If you haven't heard from us within two weeks, you are quite correct in reminding us of the oversight. After your article is received, it is assigned to an editor for review. He will accept or reject the article; normally this will take two to six weeks; and you will be notified immediately. Editing may take another two to four weeks, depending upon the editor's work load (which is always heavy) and the tentative scheduling of your article for publication. At this point EDN's procedure varies from some other trade publications—we return the edited version to you for your approval. We expect you to review the completed article for technical accuracy. Please don't argue with us about titles, punctuation or grammar at this point unless they are totally unacceptable to you. It's not that we are perfect in those areas, we don't even pretend to be, but we do have some feel for reader acceptance and preference. When you receive this approval copy, your article will usually be about eight weeks (or less) from publication, and time is of the essence if all the details that precede publication are to be taken care of. Check it, correct it, and return it without delay.

In closing, let's examine why some of the editing changes that will be made are important, because they really do seem to depart from the good practices of both journalism and engineering reports. The standard practice in engineering report titling, for example, is to specify as accurately as possible what is covered in the report. The aim of general-interest magazines, on the other hand, is to drag as many readers as possible into the story. Those are the two extremes (extremely vertical and extremely horizontal) between which we try to steer our magazine. We attempt to make the article sound interesting to everyone to whom it may be useful, but not to trick anyone to whom it would be a waste of time into reading it.

Who, what, when, where, why, and how—those indispensible tools of journalism—are boiled down mainly to *what, why* and *how* at EDN, at least in the tech article section. This is another area where engineering and journalism diverge, and we think it the best course between them in order to give the reader as much *useful* material as possible in the space available. □



Model 501 5MHz Function Generator

with trigger/gate.

$395

And that's not our only bargain.

There are a few function generators priced lower than $395. But not one that offers trigger/gate. And what's so important about trigger/gate? Simple. Trigger/gate allows you to start and stop as you choose for one-pulse, tone bursts or synchronous timing. Not another instrument at this price offers it.

In addition, our built-in, input-summing, high-output wide-band amplifer allows you to add in your own signals.

Model 501 is making more than just economic waves. It makes sine or square waves or triangles with variable offset or DC. With symmetry control it can make pulses or ramps, and you can FM it with our 1000:1 voltage generator control.

Model 501 is only one of our Solid Gold Series values. There's four more models with frequency rates to 20MHz, with or without trigger/gate.

But don't take our word for it. Ask for a demonstration. Or take a 501 home for a test. Or send for our 'Strictly Straight-Arrow Literature.' Do something. After all, the more you know about function generators, the better for us.

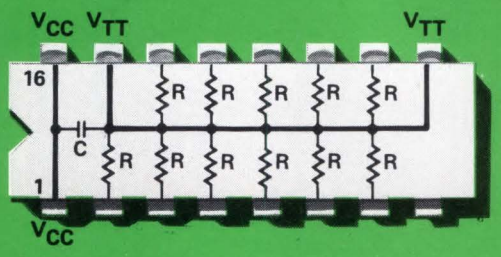
Circle No. 10

THE GOLD LINE SERIES FROM

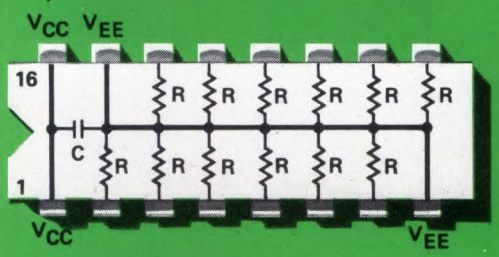
AILTECH
A CUTLER-HAMMER COMPANY
CONTROL

EAST COAST OPERATION • 815 BROADHOLLOW ROAD • FARMINGDALE, NEW YORK 11735 • TELEPHONE: (516) 595-6471
WEST COAST OPERATION • 19535 EAST WALNUT DRIVE • CITY OF INDUSTRY, CA. 91748 • TELEPHONE: (213) 965-4911

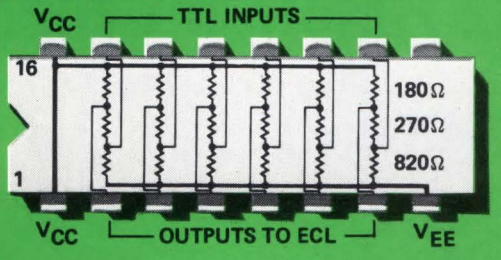
OTHER SOLID GOLD PRODUCTS FROM AILTECH INCLUDE SPECTRUM ANALYZERS, NOISE MEASUREMENT EQUIPMENT, RF POWER SOURCES, OSCILLATORS AND TRANSDUCERS.



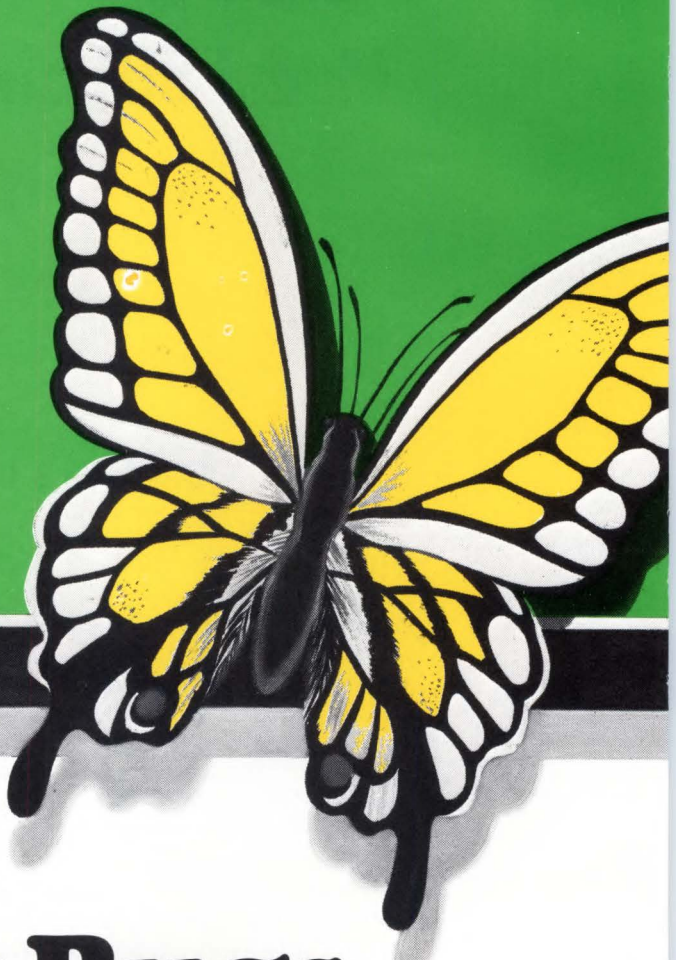
SERIES 898-41 −2.0 VOLT TERMINATORS contain eleven resistors for ECL line termination to a −2.0 volt bus. Each unit includes a 0.01 μF decoupling capacitor to bypass the −2.0 volt bus. Standard R values of 50, 75, and 100 ohms are available and are designated 898-41-R50, 898-41-R75, and 898-41-R100.
Price (1,000-4,999) $1.25



SERIES 898-42 −5.2 VOLT TERMINATORS contain twelve resistors for pull-down to the −5.2 volt bus. Each unit contains a 0.01 μF decoupling capacitor to bypass the −5.2 volt bus.
Price (1,000-4,999) $1.25

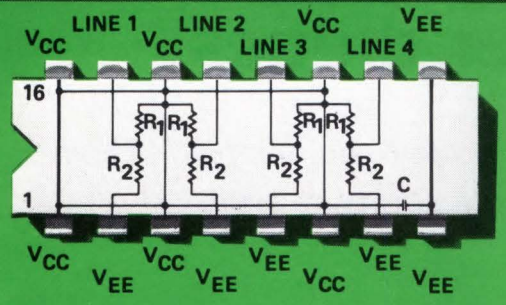


SERIES 898-45 TTL TO ECL TRANSLATOR contains six identical three-resistor sections for direct translation from TTL to ECL, both operating between a +5 volt supply and ground.
Price (1,000-4,999) $1.25



Butterfly
Diurnal insect of the order *Lepidoptera*, characterized by clubbed antenna, a slender body, and large, broad, often conspicuously marked wings. Often found fluttering about the design engineer's stomach.

Our Bugs will get rid of your Butterflies

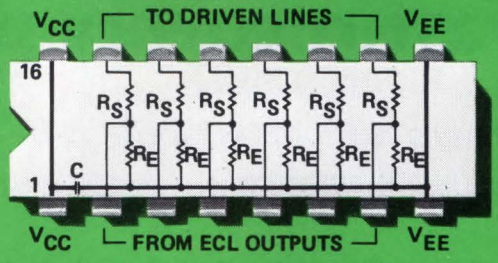


SERIES 898-43 THEVENIN EQUIVALENT TERMINATORS contain four Thevenin equivalent terminator sections. Each terminator section consists of two resistors connected as a divider from the ground bus to the −5.2 volt bus providing a Thevenin equivalent voltage of −2.0 volts. Each unit contains a 0.01 μF decoupling capacitor to bypass the −5.2 volt bus. Series 898-43 units are available with Thevenin equivalent impedances of 50, 75, and 100 ohms.

Series 898-43 R_1 and R_2 Values

Model	R_1	R_2
898-43-Z50	81Ω	130Ω
898-43-Z75	121Ω	195Ω
898-43-Z100	162Ω	260Ω

Price (1,000-4,999) $1.25



SERIES 898-44 SERIES LINE TERMINATORS contain six series terminator sections. Each section is designed for terminating a line at the driven end with a series resistor value equal to the line impedance minus the 7 ohm output impedance for 10,000 series ECL. The second resistor in each section is a pull-down resistor to the −5.2 volt bus. Each unit contains a 0.01 μF decoupling capacitor to bypass the −5.2 volt bus.

Series 898-44 R_S and R_E Values

Model	R_S	R_E
898-44-S43	43Ω	457Ω
898-44-S68	68Ω	682Ω
898-44-S93	93Ω	907Ω

Price (1,000-4,999) $1.25

ECL Terminator Collection

Dependable Beckman ECL terminator networks are specifically designed for, and compatible with, the following Emitter Coupled Logic families:

- Motorola MECL 10,000 Series
- Signetics 10,000 Series ECL
- Fairchild 95K and F10K Series ECL
- Texas Instruments Series SN10000 ECL
- National Semiconductor 10,000 Series ECL

Each Beckman ECL terminator network utilizes thick film resistor materials with layouts specifically designed for low inductance and the high speed requirements of ECL systems. Where possible, the terminator networks include 0.01 μF decoupling capacitors.

Each network is capable of operating in a +85°C still air environment at standard ECL voltage levels and tolerances without heat sinking.

For complete technical data, contact your local Beckman/Helipot representative or write to Beckman Instruments, Inc., Helipot Division, 2500 Harbor Blvd., Fullerton, Calif. 92634.

Beckman®

HELIPOT DIVISION

Circle No. 26

Improve high-power circuit designs with fast-recovery power diodes

Such diodes are not limited to high-frequency power rectification. They can improve performance in low-frequency applications as well.

David W. Borst and **David Cooper,** International Rectifier Corp.

Rectifier diodes with fast-recovery characteristics are becoming increasingly important in the design of high-power equipment. Circuit designers are showing an increasing interest in these devices for such applications as bypass (freewheeling) diodes, high-frequency inverters and high-frequency power rectifiers.

Fast-recovery diodes are available today with ratings upwards of 650A average, and 1300 PRV and higher. Typical of the units available are those shown in **Fig. 1.** The stud mounted versions are rated at 100 and 250A average, while the hockey-puck types are rated at 400 and 650A average. These particular devices may be obtained with recovery times as short as 1.5 μsec maximum when rated 1000V or less and 2.0 μsec when rated 1100 through 1300V.

While rectifier diodes with higher voltage and current ratings and shorter recovery times are available, the general rule is that the higher the voltage rating, the longer the maximum recovery time.

Fig. 1—Typical fast-recovery rectifier diodes have ratings of 100 and 250A for stud mounted types and 400 and 650A for hockey-pucks. Recovery times are typically less than two μsec.

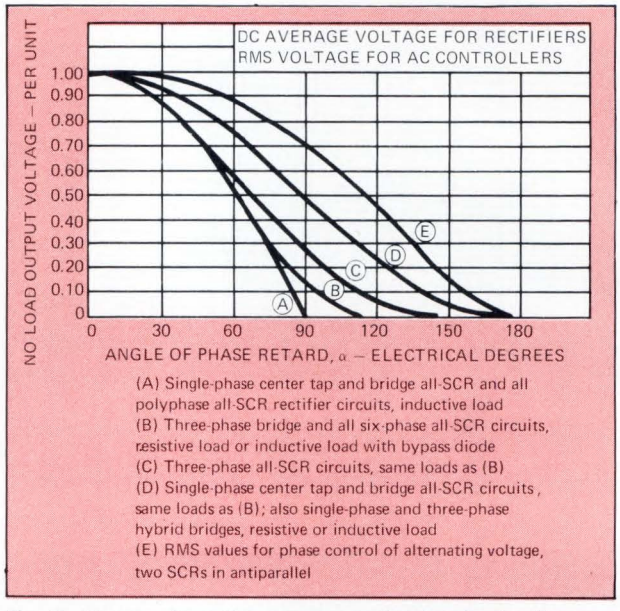


Fig. 2—Curves show the average no-load output voltage vs angle of phase retard for various rectifier circuits and types of loads.

High-frequency power rectification

The most obvious application for fast-recovery diodes is in converting high-frequency ac to dc. The upper frequency for efficient rectification with conventional alloyed or diffused 250A diodes is about 1 kHz. By contrast, the upper frequency limit for efficient operation of the 100 to 650A fast-recovery diodes is about 10 kHz.

At any operating frequency, fast-recovery characteristics result in less power dissipation in the diode during recovery, thus more power may be dissipated during the passage of forward current without overheating the diode. The result is a more efficient circuit and a reduction in spurious diode heating.

Bypass diodes in rectifier units

Large fast-recovery diodes function well as bypass diodes on the output of any single or

3-phase SCR rectifier unit when the load is both resistive and inductive, and when the rectifier-unit output voltage is to be reduced by phase-controlling the SCRs. Failure to use bypass diodes in rectifier units can result in problems when there is an inductive component to the applied load.

If the load is 100% inductive and there is no bypass diode, the inductance would cause current to flow continuously in the SCRs, and zero output voltage would be obtained with 90° phase retard. When the load includes a resistive as well as an inductive component, and large angles of phase-retard are employed, the load current becomes discontinuous. To obtain zero output voltage with this load, it is necessary to use a larger amount of phase retard; therefore, an abrupt change in the relationship between output voltage and phase retard occurs. Essentially, there is a change in the transfer function of the rectifier unit when viewed as a part of a feedback-regulating system.

Fig. 2 illustrates the relationship of average output voltage to phase retard for various rectifier circuits and types of loads. In a 3-phase bridge using all SCRs, the output voltage with an inductive load follows curve A until the load current becomes discontinuous, at which point the output voltage follows a curve not shown, connecting curves A and B. When a bypass diode is used, the rectifier behaves as if it were feeding a purely resistive load. The output voltage therefore follows curve B, and an abrupt transition from curve A to curve B is avoided.

The change in operating mode experienced without the bypass diode may also create severe instabilities in the operation of a closed-loop voltage or current-regulating system. With or without the bypass diode, the same larger range of phase control is needed to obtain zero output voltage, but the abrupt change in transfer function, and the consequent system instability, are eliminated when the bypass diode is used.

Another advantage of the bypass diode is that at reduced output voltage from the rectifier unit, current is carried only intermittently by the SCRs. This reduces heating in the SCRs and increases their reliability.

If a hybrid-bridge (semiconverter) circuit is used to feed a partially inductive load, a bypass diode is recommended when near-zero output voltages from the bridge are desired. With the bypass diode, the bridge circuit will feed an apparently resistive load and behave accordingly. Without it, the SCRs may fail to turn off (commutate) when operating with large angles of phase control. This is similar to a failure in an inverter. The SCRs in a hybrid bridge actually function like inverters at very low output voltages, feeding energy from the diode portion of the bridge back into the ac line. A commutation failure results in loss of control of output voltage from the hybrid-bridge rectifier unit.

Any rectifier diode can function as a bypass diode; however, the advantages of using a type with fast-recovery characteristics include lowering diode junction heating during recovery and reducing the di/dt duty imposed on SCRs in the rectifier unit during diode recovery.

If a bypass diode is conducting when an SCR begins to turn on, a high inrush current will flow during the recovery period of the diode; that is, during the flow of recombination current in the diode junction. If this happens, the SCR turns on into a virtual short circuit, resulting in a high di/dt in the SCR. Damage to both the SCR and the bypass diode could result from these effects.

This circuit action is illustrated in **Fig. 3** where

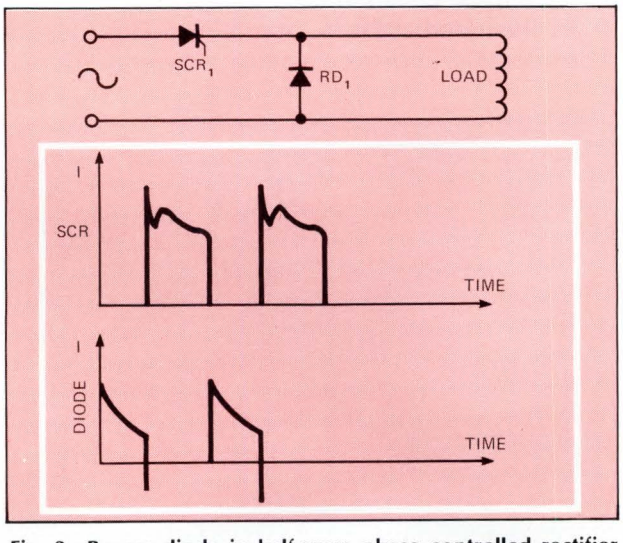


Fig. 3—Bypass diode in half-wave phase controlled rectifier circuit with inductive load experiences large reverse-current pulse during recovery.

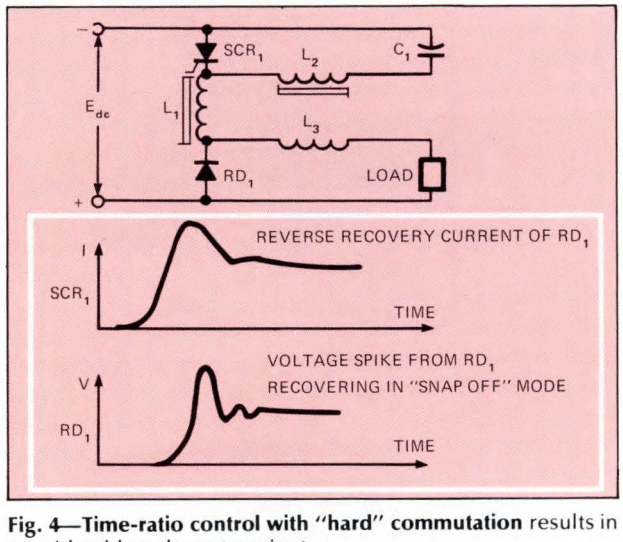


Fig. 4—Time-ratio control with "hard" commutation results in considerable voltage transient.

an SCR feeds half-wave power to an inductive load with a bypass diode. A high spike of current is carried by the SCR when it is first triggered ON, and this same current pulse passes in the reverse direction through the bypass diode. To avoid overheating of the bypass diode during recovery, a snubber network consisting of a resistor and capacitor in series could be placed across the bypass diode. This will limit the rate-of-rise of reverse voltage across the diode while it is recovering, and reduce the heating of the junction during the recovery period; however, this snubber network will increase the di/dt on the SCR in the rectifier circuit.

At 60 Hz, the di/dt stress level may not be inordinately high, but at higher-power frequencies, the SCR may be damaged by high localized junction temperatures during turn-on. To reduce the rate of current rise during turn-on, a limiting inductance could be placed in the circuit; however, when current ceases, this inductance induces a voltage in the circuit that could damage the bypass diode or break over the SCR.

A better solution is an RC snubber network placed across each SCR to provide a current path, and thereby reduce the voltage transients during recovery.

The large apparent stored charge of a conventional diode, which must be removed during recombination, is the basic problem in these cases. By using a fast-recovery diode, and thus minimizing the stored charge, snubber networks might be eliminated altogether. Or, if they are required, snubber-network capacitance may be minimized.

Bypass diodes in dc choppers

As SCR applications have progressed and manufacturers have developed more easily controlled dynamic characteristics of thyristors, greater attention has been focused on inverter and dc chopper applications.

Fig. 4 illustrates a typical early chopper circuit with some pertinent waveshapes. The circuit through which current flows while RD_1 is recovering, stores enough energy in lead inductances and elsewhere to cause a considerable voltage transient when RD_1 recovers. To suppress this transient, an RC network could be inserted across both SCR_1 and RD_1; however, this causes higher circuit losses and more complexity. A far better solution is to use a fast-recovery diode for RD_1.

Bypass diodes in inverters

An inverter using bypass diodes connected in antiparallel with the SCRs is shown in **Fig. 5.** With minor modifications, this type of inverter can be made to generate either a sine or square wave. Similar circuits have been operated up to 25 kHz with output power of 400W. The trace in **Fig. 5** is the voltage across one SCR.

Examining **Fig. 6,** which shows a circuit equivalent to part of the circuit shown in **Fig. 5,** it can be seen that fast-recovery devices are required for RD_1 and RD_2. While the sweepout current of RD_1 flows, the distributed wire inductances of the circuit (L_1 and L_2) assume the polarity shown. After recombination is completed, the current ceases in RD_1 and in L_1 and L_2. Thus both induced voltages across the leakage reactances reverse polarity and tend to generate transients.

The transients generated in L_1 will be in a direction to cause high dv/dt in SCR_1 while transients generated in L_2 will be in a direction to cause high-reverse voltage across RD_1. The resulting transients can be many hundreds of volts, rising almost instantaneously, in a 100V system.

As illustrated in **Fig. 6,** operating conditions are considerably improved with a fast-recovery rec-

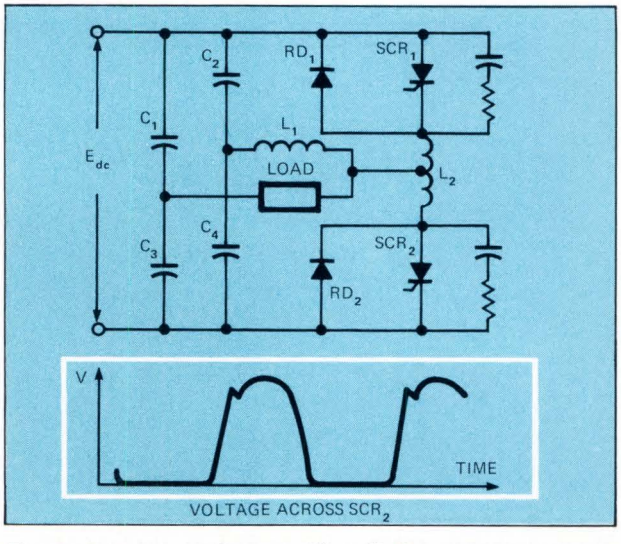


Fig. 5—Inverter employs rectifier diodes connected in antiparallel with SCRs.

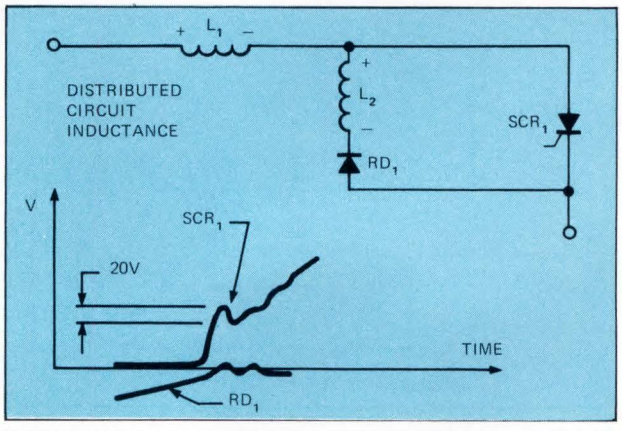


Fig. 6—Voltage overshoot due to rectifier diode recovery and distributed inductance is reduced when fast-recovery diodes are used.

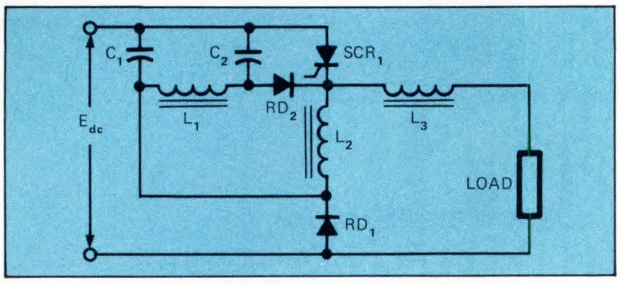


Fig. 7—Time-ratio control with "soft" commutation reduces the necessity for fast-recovery diode for RD_1.

tifier. The voltage generated across SCR_1 when RD_1 recovers is typically 20V in a 125V circuit. A fast-recovery diode is also appropriate here to minimize the energy drawn from the dc supply when the diode is recovering, and to minimize junction heating caused by the recovery action.

SCRs as bypass diodes in inverters

The bypass diodes of **Fig. 5** have the undesirable characteristic of clamping the reverse voltage applied to the companion controlled rectifiers, causing increased turn-off time. SCRs with shorter turn-off time must be used to compensate for this. Where it is not possible to obtain an SCR fast enough to counteract the presence of the bypass diode, it is possible to use an SCR in place of the diode.

The bypass SCR should be triggered by connecting the gate to the anode via an appropriate resistor. When the voltage across the inverter SCR first starts to reverse, the clamping action of the bypass SCR will not be felt until the bypass SCR turns ON. During the delay time of the bypass SCR, the main SCR can be turning OFF with full available reverse voltage applied, thereby assuring fast turn-off action.

Soft commutation

High-voltage inverter-type power thyristors are now available (e.g., V_{DRM} of 1200V) and are being used in large installations such as process control and vehicle drives. In these higher ratings, some of the early quick fixes for sweepout transients are not acceptable. Neither are the sharply rising waveshapes generated by the early types of inverters and choppers (because of the resultant low corona threshold of many components).

At operating frequencies of 5 to 10 kHz, losses in the snubber networks, sometimes amounting to 10% of the load, became unacceptable. Therefore, as SCR applications have developed and operating frequencies of thyristors have increased, the sharply rising waveshape circuits have become less popular, and "soft" waveshape circuits have gained favor.

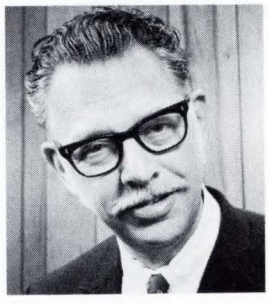
Fig. 7 illustrates a cushioned waveshape circuit that reduces the necessity for a fast-recovery rectifier for RD_1. As the frequency of circuit operation increases, however, this circuit also requires fast-recovery characteristics in the bypass rectifier to hold the SCR stress to a minimum.

Summing it up

Fast-recovery diodes in the 100 to 650A range, capable of handling 1300V or higher, are now familiar components. The need for fast-recovery units resulted from the development of static-power control systems using SCRs. Proper use of fast-recovery diodes reduces the di/dt and accompanying stress levels on SCRs by an order of magnitude, thereby increasing reliability without necessitating additional complex circuitry.

With fast-recovery units, power levels may be increased and costly power losses reduced. The primary advantage, is that junction heating caused by recovery action is minimized. □

Authors' biographies



David Borst has a total of 32 years experience in the area of power rectification, including mercury-arc, germanium and silicon power-rectification systems. He has been with International Rectifier for 11 years and is presently Customer Engineering Manager. Mr. Borst has an ScB in Electrical Engineering from Brown Univ., is a senior member of IEEE and holds two patents.

David Cooper has been with International Rectifier for six years and is presently Vice President of Sales and Engineering. Mr. Cooper graduated from Pratt Institute with a BSEE and attended Penn. State Univ., Brooklyn Polytech and the University of Pittsburg for an ME and PhD work. He is a member of IEEE and has 15 patents to his credit.

line up answers to electronics questions

New, reliable shortcut to solving electronics problems offering greater-than-slide-rule accuracy! Use these practical, straightforward linear graphs as your own "desk-top computer" to work out engineering problems.

Designed for immediate application, nomographs are the ideal tool for electronics engineers, circuit/systems designers, technicians and engineering management — or as a teaching aid for electronics students.

Available November 1972
Approx. 300 pp.
$27.50 (Tentative)

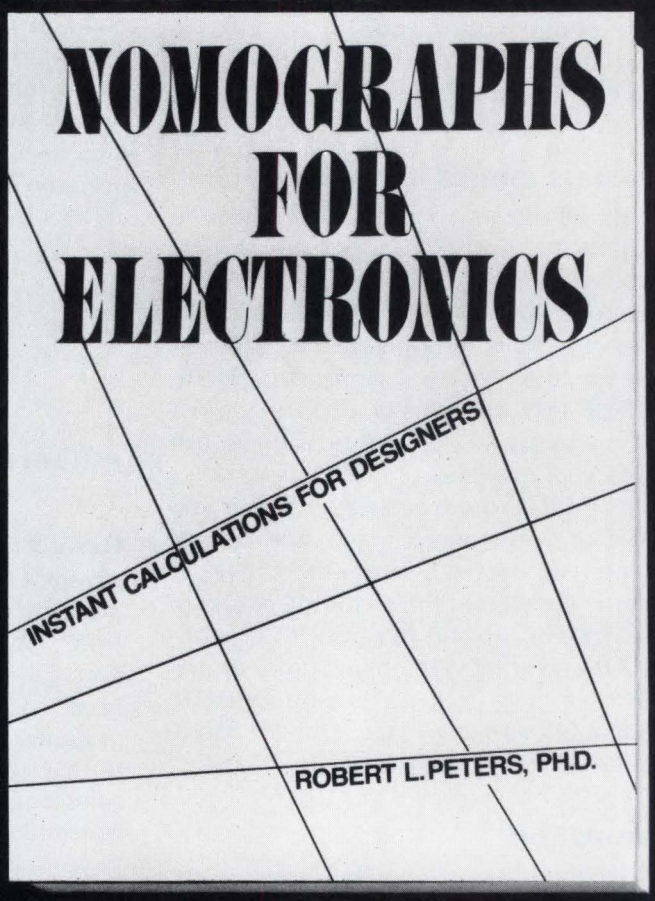


Table of Contents:

1. Ac and Dc Networks and Basic Parameters
2. Transistors and Tubes
3. Time Dependency
4. Magnetic Design
5. Control Systems and Response
6. Heat
7. Capacitors
8. Delay Lines
9. Filters
10. Inductors and Solenoids
11. Relays
12. Motors and Generators

Cahners Books
89 Franklin Street, Boston, Mass. 02110

Gentlemen:

Please send me_____copies of NOMOGRAPHS FOR ELECTRONICS @ $27.50 ea. I understand that if I am not completely satisfied, I may return the books within 15 days for a complete refund or credit.

☐ Bill me ☐ Bill company ☐ Payment enclosed (Cahners pays postage)

Name_____

Company_____

Address_____

City/State/Zip_____
(Massachusetts residents add 3% sales tax.)

S58/M0809

New from DATEL SYSTEMS

a breakthrough in price/performance

16 bit D/A Converter

$89.00 Single Quantity

Features

- High Resolution – one part in 65,535[1]
- Programmable Voltage Output – 0 to +10V, to −10V, or ±5V[2]
- Programmable Current Output – 0 to +2.0 mA or ±1mA
- Binary and Four Digit BCD Coded Models
- 150 μvolt or 30 nA Output Resolution
- 5 MHz update Rate
- 750 nsec Output Settling Time
- Thin Film Stability
- Includes Reference Source and Output Amplifier
- TTL Compatible Inputs
- 2″Lx 2″w x .375″h Total Size

(1) Four Digit BCD Model – one part in 10,000
(2) Output Current – ±5mA

Datel System's growth is based on breakthroughs. We make it our business to produce products that are a combination of increased reliability, with more sophistication, smaller in size, yet lower in cost. If you're at the IEEE Show, come to Booth 2609 and we'll show you some of the things we're proud of. If you miss the Show, call our nearest representative or write us for complete details.

DATEL SYSTEMS, INC.

1020 TURNPIKE STREET, CANTON, MASSACHUSETTS 02021 • TEL. (617) 828-6395 • TWX: 710-348-0135 • Telex: 924461

Circle No. 33

Cascade adder improves system speed for high-speed multiply operations

This easily implemented method of multiplying will speed the processing of formulas and equations, no matter which logic family you're using.

James E. Partridge, System Development Div. IBM Corp.

The multiply instruction can be a very fast computer operation, and a simple design approach makes this possible. It consists of a cascade of carry-save adders to handle partial products, thus avoiding the slower techniques that have seemed necessary in the past.

The cascaded technique does away with the iteration problem, at the same time giving a good, reliable method of multiplying. The system is very fast; not only because fast circuits are used in today's logic, but also because the logic is designed to take greatest advantage of the speed of the circuits. The key to the efficiency is the use of the carry-save adders to handle partial products. The approach can be used with any type of logic; but because of the relatively high number of individual circuits used, it proves most attractive with newer, high-density logic. Its use is not limited to the multiply instruction; it can also be applied to any operation that requires repeated addition.

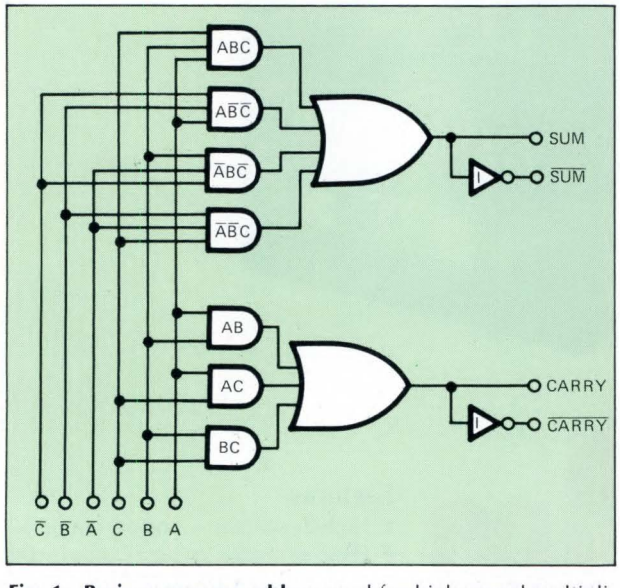


Fig. 1—Basic carry-save adders used for high-speed multiplication can be implemented with AND, OR and INVERT gates as shown here, or with parity generator ICs.

An easily implemented example of logic for a multiply operation is made up of the following:

- The multiplicand and multiplier registers
- An AND matrix fed by the outputs of the registers
- The cascaded carry-save adders (CSAs)
- A conventional carry-propagate adder

The functions of both the AND matrix and the carry-propagate adder can be handled by other approaches.

The CSA used here is shown in **Fig. 1.** This is a relatively slow carry-save adder but one that still gives an advantageous systems speed for the design used in the example.

Fig. 2 shows the basic scheme for the example using 6-bit multiplicand and multiplier registers. The outputs of the registers pass through the AND matrix into the cascade carry-save adders. Each CSA has 3 or less input legs and two outputs, sum and carry. Each input and output leg represents all required polarities. The sums and carries are combined and reduced to one or two bits per radix position and finally enter the carry-propagate adder.

The AND matrix that "sorts" the data from the multiplier or multiplicand to the proper radix position and obtains the partial product is shown in **Fig. 3.** The outputs of the "sorters" become the inputs of the CSAs and the beginning cascade.

Let us trace one radix position through the example in **Fig. 2,** say position 9 of the multiplier register. The output of that position is gated by the six ANDs giving 1 1 1 0 1 0 (at AND gates 4C, 5C, 6C, 7C, 8C and 9C). In other words, position 9

is gated by all 6 positions of the multiplier: $2^2 \times 2^0 = 2^2$; $2^2 \times 2^1 = 2^3$; $2^2 \times 2^2 = 2^4$, etc.

The CSAs combine the sums obtained from the various radix positions. Again using position 9, the CSA designated H is fed by the outputs of the ANDs of position 9, 10 and 11 of the multiplicand register, and position 9 (plus positions 10 and 11) of the multiplier. This 3-legged adder produces two outputs, a sum of 1 and a 0 carry. The sum, in this case, goes directly to the carry-propagate adder; the carry to another CSA. Other positions are similar, but some require as many as four CSAs in the cascade to complete the addition before the carry-propagate adder completes the operation.

The example just given shows the reduction of six partial products to one or two outputs per position in four levels of CSAs for a 6-bit multiply. A 32-bit multiply needs eight levels of CSAs. The time required for a 32-bit operation is only double that for a 6-bit multiply (more than five times as many bits). This is possible because the bits of

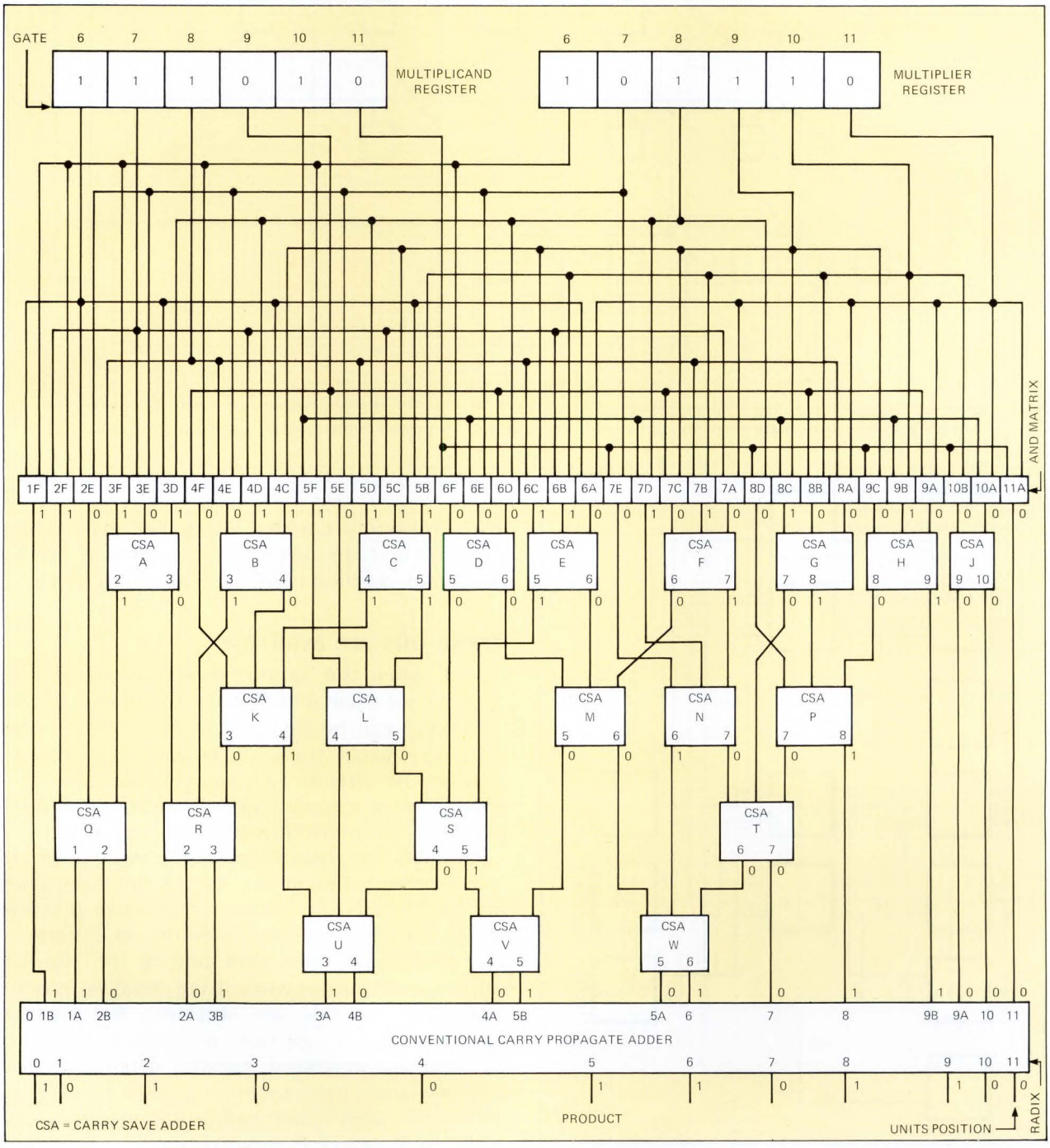


Fig. 2—Complete high-speed 6-bit multiplier provides a relatively inexpensive alternative to the more common, but slower, approach of iterative multiplication. Since multiplication is one of the more frequently used operations in scientific machines, a high-speed multiplier can bring a marked improvement in overall efficiency. Inverse functions, as shown in **Fig. 1,** have been omitted for clarity.

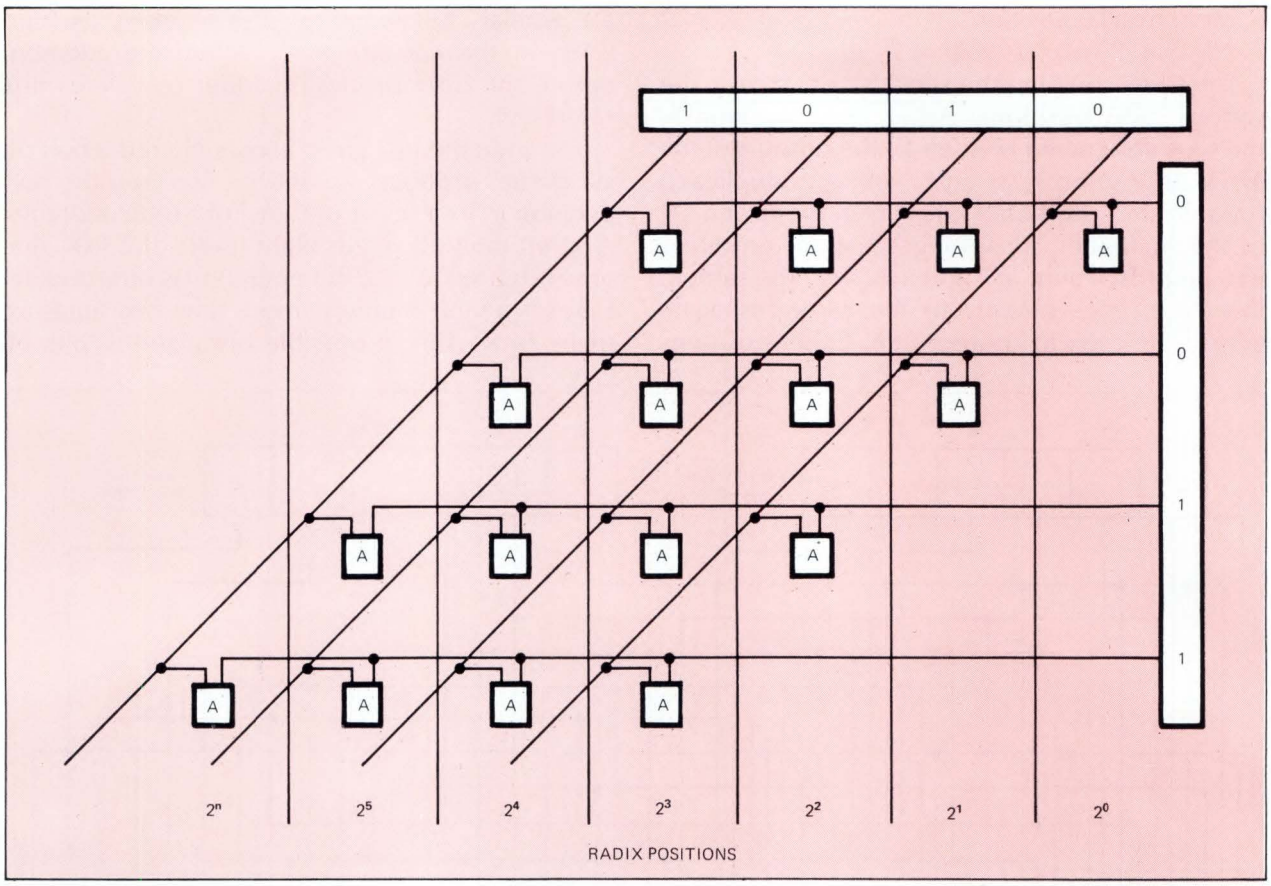


Fig. 3—An AND matrix sorts data from multiplier and multiplicand to proper radix position, and obtains partial product.

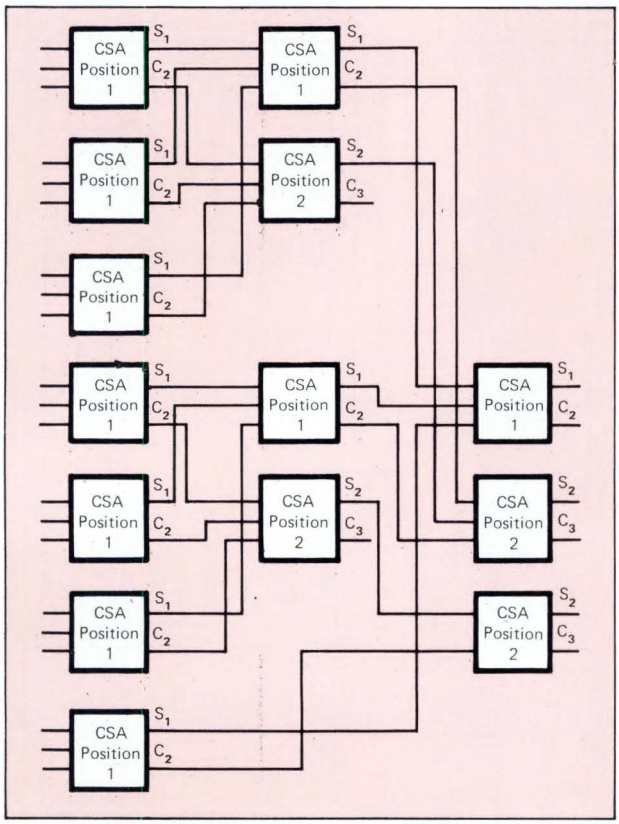


Fig. 4—Parallel use of CSAs, as much as possible within each radix position, is the key to fast multiplication. The best price/performance balance for your design will be found by weighing serial vs parallel layouts of CSAs.

each position are added in parallel, maintaining the proper radix position for sums and carries until each position is reduced to one or two bits.

Trade-offs are available

It is when the various modifications of this scheme are examined that the full impact of the technique can be realized. In every case, however, the usual trade-off between speed and number of circuits still applies. Because the speeds are at a much higher level than would be expected, even the slower designs are attractive.

Probably the greatest possibility as far as speed is concerned lies in the use of the carry-save adders. This is the technique that can make a multiply or any repeated addition, an extremely fast operation rather than one of the slowest encountered, as it is when using iterative procedures. The strategy for obtaining the highest speeds is, within one radix position, to combine as much as possible in parallel, grouping sums together and carries together as shown in **Fig. 4.** When the carry combination has processed as much as is practical, it becomes "raw data" for the next radix position. Avoid as much as possible the rippling effect shown in **Fig. 5,** which is obtained when each carry is introduced to the

next position as soon as it is generated.

The best design of the carry-save adder will probably be determined by circuits available to you or by your required speed. Both polarities of each output are required for the inputs to the next level of CSAs. When economy must take priority over speed, an inverter circuit can provide complements of the CSA outputs. In the 6-bit multiply of the example, the four levels of CSAs built with 10 nsec circuits would take in the order of 80 nsec where inversion is required. But where speed and a longer multiply are necessary, there is an inverse function available for both the sum and carry generators in parallel with the original function, as shown in **Fig. 6.** With this design each CSA would require 10 nsec. Thus, the partial products of a 32-bit operation could appear at the inputs to a conventional adder in the same 80 nsec.

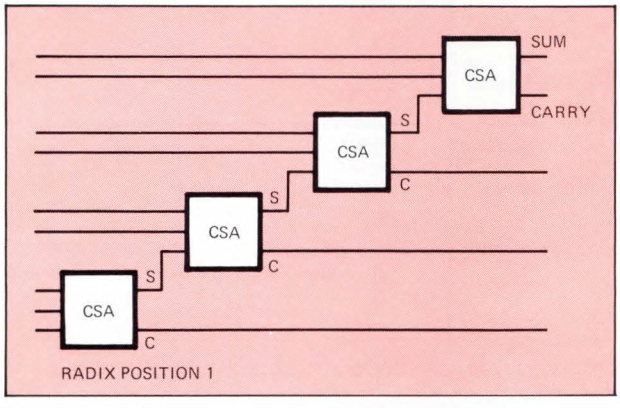


Fig. 5—"Rippled" carry-save adders prove to be a very slow technique. Groupings of parallel functions should be used to avoid the routing of the sum outputs through successive stages of CSAs wherever possible.

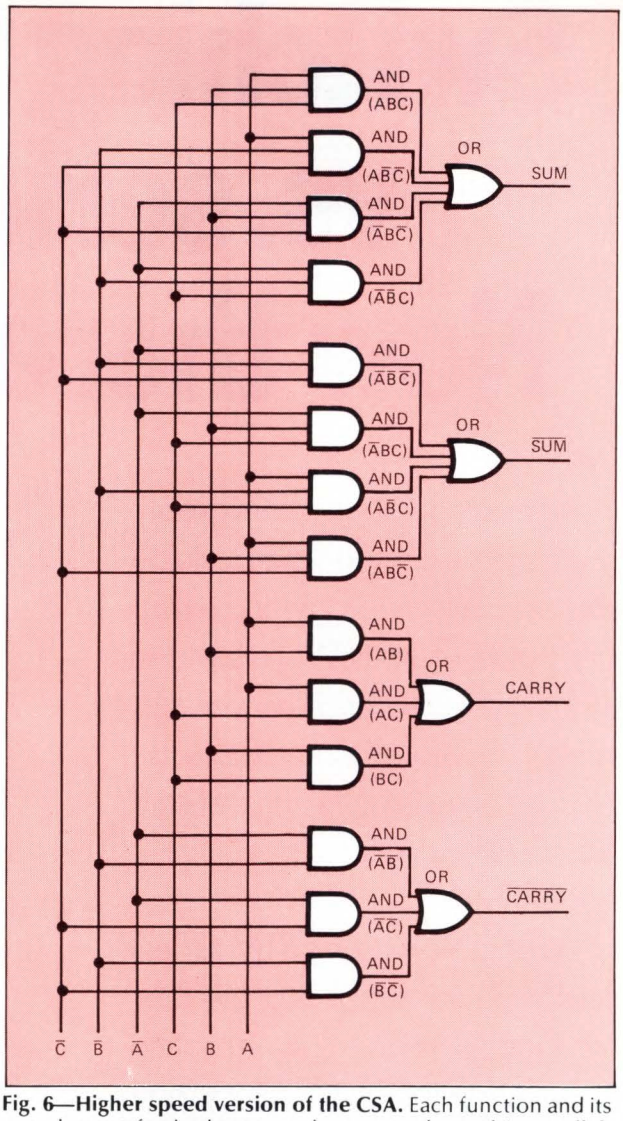


Fig. 6—Higher speed version of the CSA. Each function and its complement for both sum and carry are formed in parallel, rather than by serial inversion, as compared to the CSA in **Fig. 1.** The parts cost for this CSA will be higher, but delay time will be 2 propagation delays, rather than 3.

If, when the multiply is complete, the information is needed in a register, then the outputs can be latched. If the information is used directly, it may be possible to omit the latches.

The "sorter" function of the AND matrix can also be handled by alternate methods. It doesn't matter how the partial products are obtained. For instance, circuits with more inputs could be used in the matrix. This would cut down on the number of carry save adders required because some of the combining would be done before the data entered the cascade section.

Many advantages are obtained from the use of a cascade of carry-save adders to sum the partial products in a computer multiply operation. First, the speed is increased to compare favorably with other arithmetic instructions. In addition, the designer has a substantial choice of approaches that he can use in each stage of the operation. Very high speeds can be obtained at the cost of additional circuits, but economis in circuits can be made and relatively high speeds retained. The technique is not confined to any particular type of logic, but it appears to be most attractive with the very dense logic being used today. □

Author's biography

James Partridge is a technical associate engineer at IBM's Kingston, NY, development lab., where he has worked on multiple simultaneous-addition logic for the last 6 years. He attended Clarkson College and has been an IBM employee for 16 years.

Switching technology vs. series-pass. Now there's a choice.

Series-pass regulation offers great advantages in compact size, established design technology and exceptionally clean output. While switching technology is theoretically even more compact, it's virtually impossible to produce because of the inherent high noise and RFI problems.

Right?

Wrong. Sorensen's STM series of modular power supplies prove the point. First, for a given power rating, STM's offer twice the efficiency, half the size and lower price than equivalent series-pass units (and all STM's have built-in overvoltage protection). Plus a big plus. Low RFI and noise. We ran conducted interference tests and fully met the requirements of MIL-STD-461A above 20KHz.

Specification	Sorensen STM5-24	Brand "X"
Size	$3\frac{5}{16} \times 5\frac{1}{8} \times 9\frac{1}{2}$	$4\frac{15}{16} \times 7\frac{1}{2} \times 9\frac{3}{8}$
Volume	160 in^3	344 in^3
Price	$229	$235
Efficiency	58%	29%
Regulation (line & load combined)	0.05%	0.2%
Temperature Coefficient	0.01%/°C	0.03%/°C
Overload Protection	Current limiting-adjustable electronic	
Overvoltage Protection	Built-in adjustable, all models	Optional @ $30 (except built-in, fixed, on 5-volt model only

Compare this point-by-point spec-check between Sorensen's STM5-24 and Brand "X".

The STM series presently consists of 30 switching transistor power supplies — with 10 models to follow shortly. STM efficiencies approach 75% keeping dissipation low. In many systems applications these high efficiencies obviate the need for forced air cooling systems.

Switching technology is no longer a bugaboo. It works. Beautifully. Send for our complete catalog and see for yourself (and see our great series-pass supplies too). Write Sorensen Company, a unit of the Raytheon Company, 676 Island Pond Rd., Manchester, N.H. 03103. Telephone (603) 668-4500. Or TWX 710-220-1339.

STM: twice the efficiency, half the size.

Sorensen
POWER SUPPLIES

Circle No. 32

KEMET® Ceramics:

The new "Blue Max."

Meet the KEMET "Blue Max" maximum-range line—a whole new flight of subminiature, precision epoxy-dipped, radial-leaded, monolithic ceramic capacitors.

"Blue Max" Capacitors achieve new heights in precision manufacturing. With a protective epoxy sheath that coats the case, not the leads.

And "Blue Max" Capacitors win highest honors for selection range.

Ultra-stable NPO, stable X7R, or general-purpose Z5U dielectric. Six basic case sizes in over 300 different models, in values from 2.2 pf to 4.7 uf. For 50, 100 or 200 VDC working voltages. All with easy-to-read markings and solder-coated, copper-clad steel leads—ready to assemble in your circuits.

For excellence of performance, specify new KEMET "Blue Max" Capacitors—a new achievement in precision-dipped, radial-leaded ceramics from Union Carbide. Available now.

Write for specification data and free engineering samples.

UNION CARBIDE COMPONENTS DEPARTMENT

P.O. Box 5928, Greenville, S.C. 29606
Phone: (803) 963-7421 TWX: 810-287-2536

In Europe: Union Carbide Europe, S.A.
5 Rue Pedro Meylan, Geneva 17, Switzerland

Circle No. 28

Trilogic, a three-level logic system provides greater memory density

Do you need to design in more computing power without grossly expanding circuitry? Maybe trilogic is the answer.

Akavia Kaniel, Digital Equipment Corp.

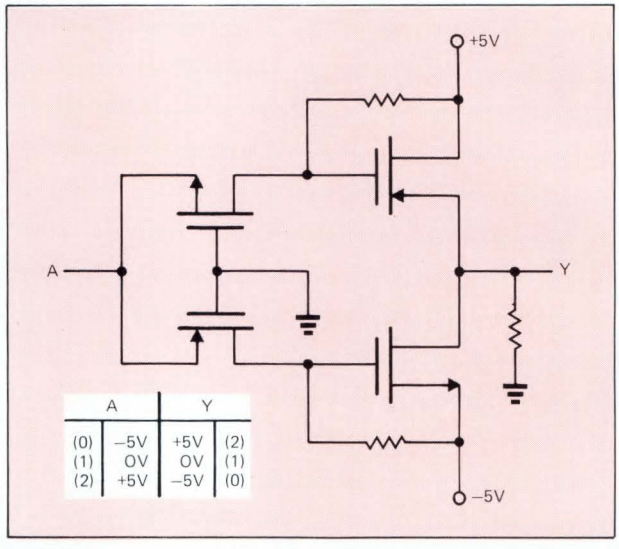
Binary systems, despite the ease with which they lend themselves to logical yes-no, on-off functions, are not very efficient at counting. A base-three system may introduce certain logical complexities, but it has a great counting advantage. For example, if a number can be expressed as $N = a_0r^0 + a_1r^1 + a_2r^2 + \cdots\cdots a_nr^n$ where

$n = 0, 1, 2, 3 \cdots\cdots \infty$

r = base of the number system

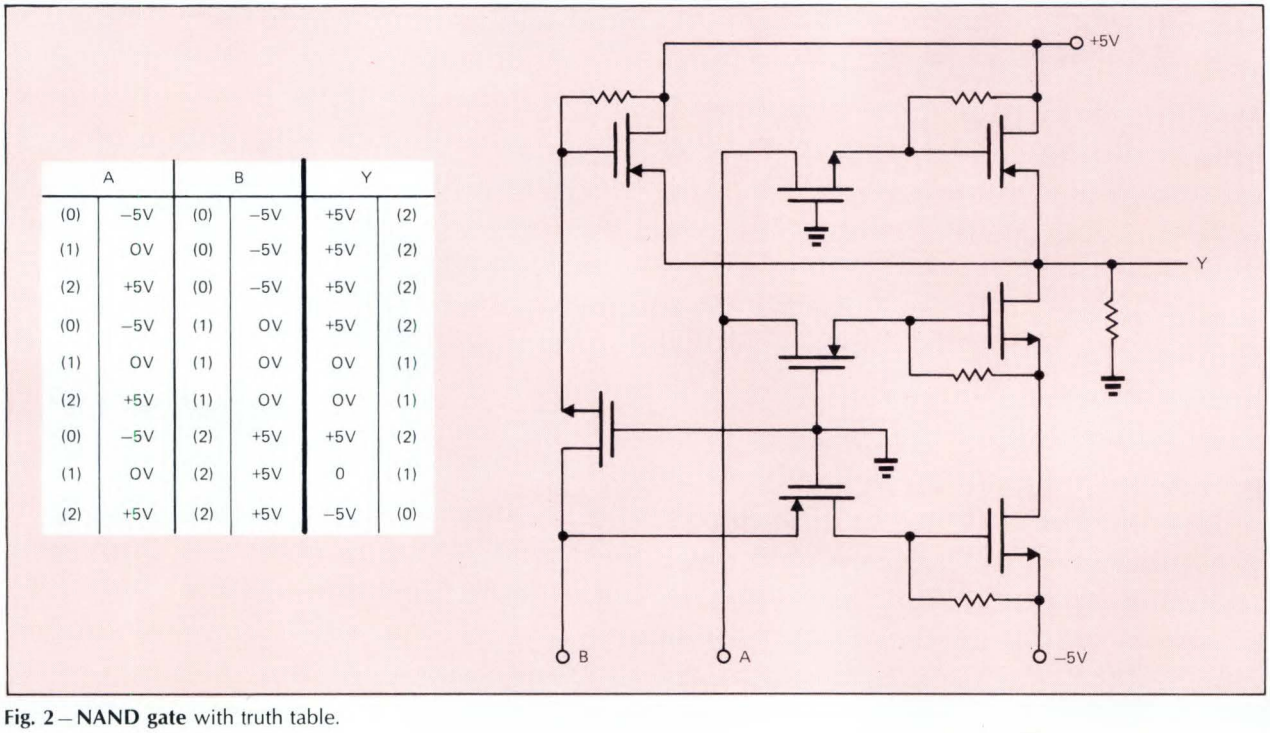
a = digits with values between 0 and $r - 1$

then, in a base-2 numbering system where the maximum value of a is 1, the maximum 4-digit value of N is $1(2)^0 + 1(2)^1 + 1(2)^2 + 1(2)^3 = 15$. In a base-3 system where the maximum value of a is 2, the maximum 4-digit value of N is $2(3)^0 + 2(3)^1 + 2(3)^2 + 2(3)^3 = 80$. Thus, the same four bits that will count to 15 in binary can be used to count to 80 in trilogic, an obvious improvement in information density.



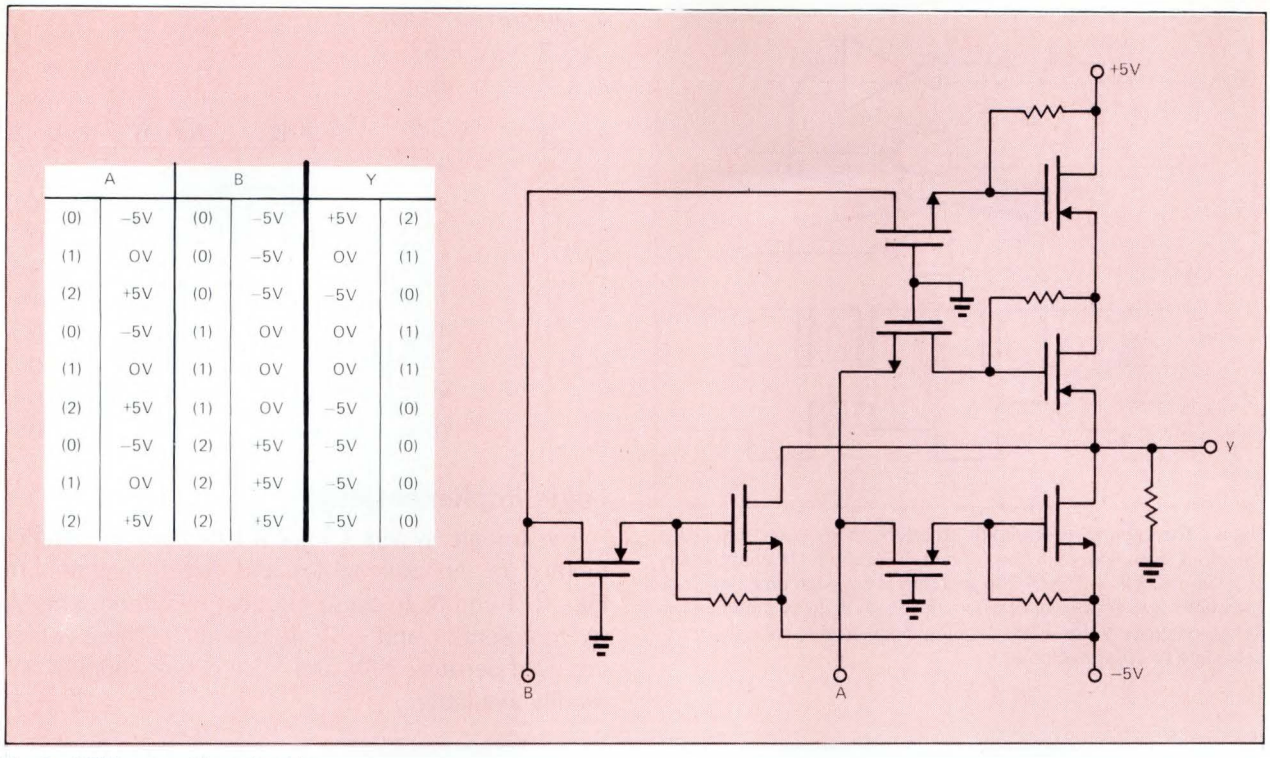
A		Y	
(0)	−5V	+5V	(2)
(1)	OV	OV	(1)
(2)	+5V	−5V	(0)

Fig. 1 – Inverter with truth table.



A		B		Y	
(0)	−5V	(0)	−5V	+5V	(2)
(1)	OV	(0)	−5V	+5V	(2)
(2)	+5V	(0)	−5V	+5V	(2)
(0)	−5V	(1)	OV	+5V	(2)
(1)	OV	(1)	OV	OV	(1)
(2)	+5V	(1)	OV	OV	(1)
(0)	−5V	(2)	+5V	+5V	(2)
(1)	OV	(2)	+5V	0	(1)
(2)	+5V	(2)	+5V	−5V	(0)

Fig. 2 – NAND gate with truth table.



A		B		Y	
(0)	−5V	(0)	−5V	+5V	(2)
(1)	0V	(0)	−5V	0V	(1)
(2)	+5V	(0)	−5V	−5V	(0)
(0)	−5V	(1)	0V	0V	(1)
(1)	0V	(1)	0V	0V	(1)
(2)	+5V	(1)	0V	−5V	(0)
(0)	−5V	(2)	+5V	−5V	(0)
(1)	0V	(2)	+5V	−5V	(0)
(2)	+5V	(2)	+5V	−5V	(0)

Fig. 3 – NOR gate with truth table.

If the logic of a 3-digit (0, 1, 2) system is not quite as apparent, this article will show that it is not too difficult to use, once the basic logical relationships are understood. Finally, logic diagrams and circuitry which are necessary to implement a trilogic system are considered.

The basic logical relationships for trilogic are given in the following truth tables.

"A" and "B" can be in the (0), (1) or (2) state.

1) Inversion

A	$\bar{A}$
0	2
1	1
2	0

2) OR

Y = A + B

A	B	Y
0	0	0
1	0	1
2	0	2
0	1	1
1	1	1
2	1	2
0	0	2
1	2	2
2	2	2

3) AND

Y = A · B

A	B	Y
0	0	0
1	0	0
2	0	0
0	1	0
1	1	1
2	1	1
0	2	0
1	2	1
2	2	2

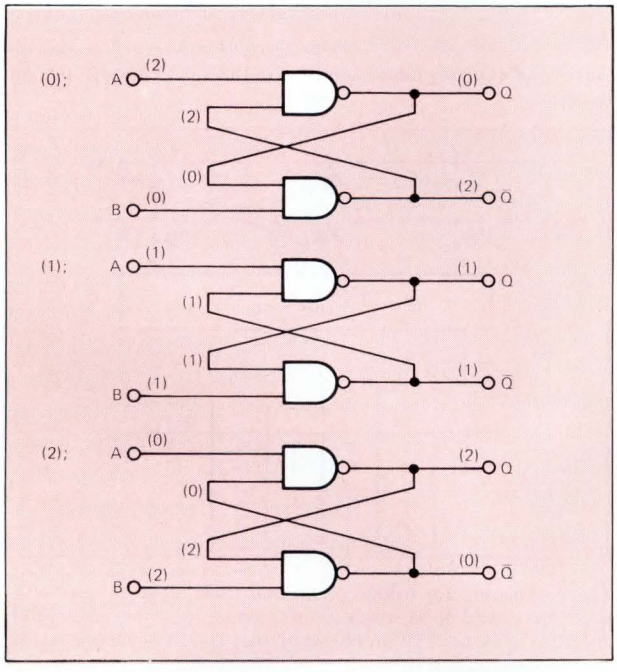
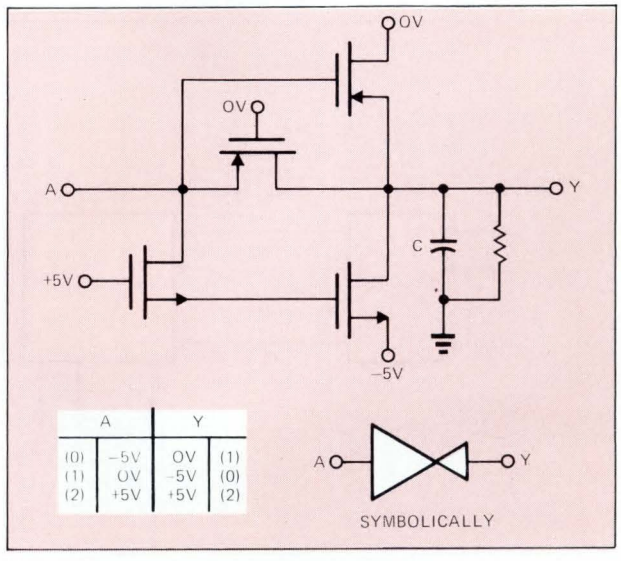


Fig. 4 – Tri-flop is set to the 0, 1 and 2 states by pulsing the input lines. After it is set, the input lines will automatically return to the steady-state condition (2,2).



A		Y	
(0)	−5V	0V	(1)
(1)	0V	−5V	(0)
(2)	+5V	+5V	(2)

Fig. 5 – A shifter must be introduced in order to design a tri-flop that can count. C is placed at the output to store information for a short time during switch transition.

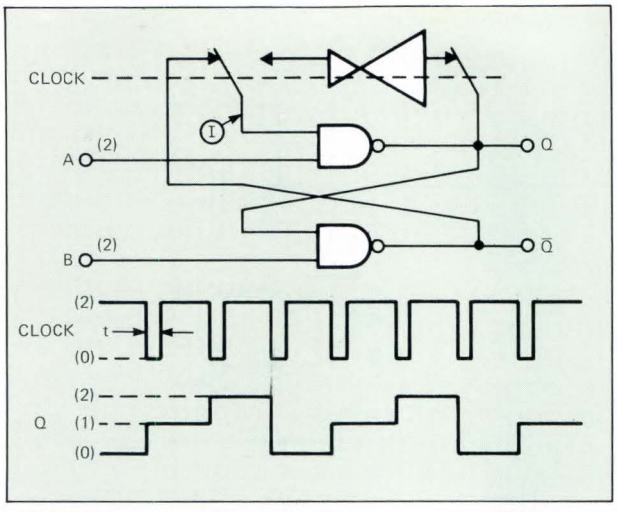


Fig. 6—Three-bit tri-flop trilogic counters. In the counter diagram the clock actuated switching circuit is represented symbolically as a simple switch. The tri-flop switches states each time the clock goes from 2 to 0 causing Q to count sequentially as shown in the timing diagram. Pulse width (t) of the clock is wide enough for the new state to appear at point I.

4) Demorgan's Law

$\overline{A \cdot B} = \bar{A} + \bar{B}$

$\overline{A + B} = \bar{A} \cdot \bar{B}$

A	B	$\overline{A \cdot B}$	$\bar{A} + \bar{B}$	$\overline{A + B}$	$\bar{A} \cdot \bar{B}$
0	0	2	2	2	2
1	0	2	2	1	1
2	0	2	2	0	0
0	1	2	2	1	1
1	1	1	1	1	1
2	1	1	1	0	0
0	2	2	2	0	0
1	2	1	1	0	0
2	2	0	0	0	0

Logic implementation

The trilogic system's logical functions are implemented in the truth tables and circuit diagrams of **Fig. 1, 2** and **3**. In these circuits +5V represents 2, 0V represents 1 and −5V represents 0. These values are used because +5V and −5V power supplies are readily available.

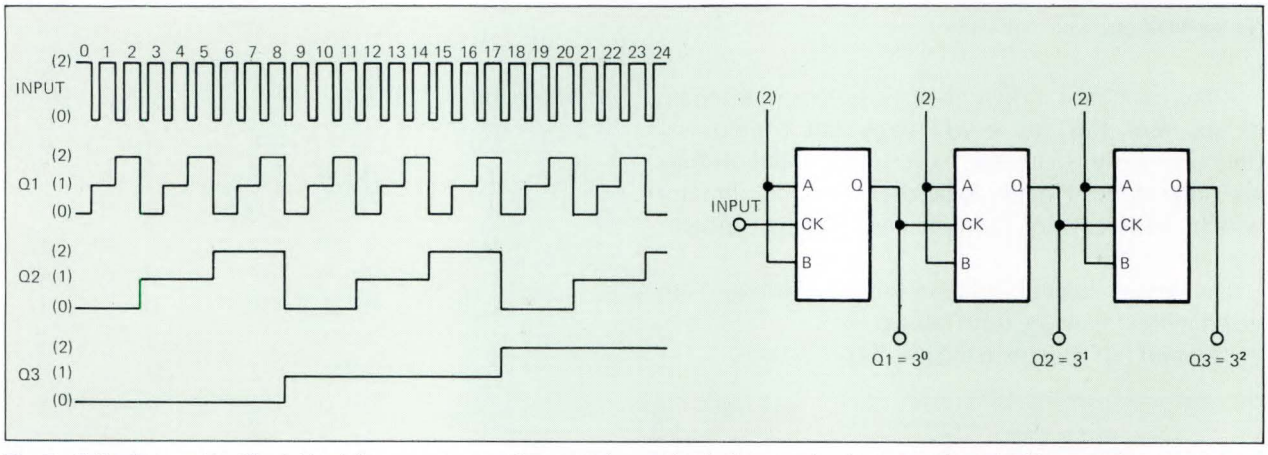


Fig. 7—Trilogic counter. The 3-bit tri-flop counters can be ganged very simply for counting larger numbers. In this example we can count up to $2 \times 3^2 + 2 \times 3^1 + 2 \times 3^0 = 26$, compared to 7 in a 3-bit binary counter.

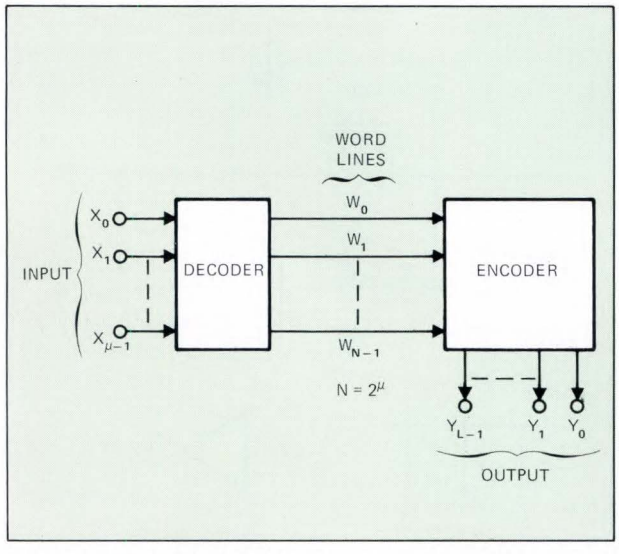
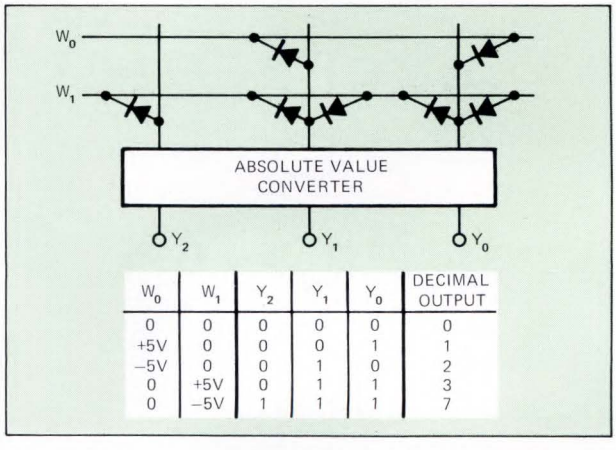
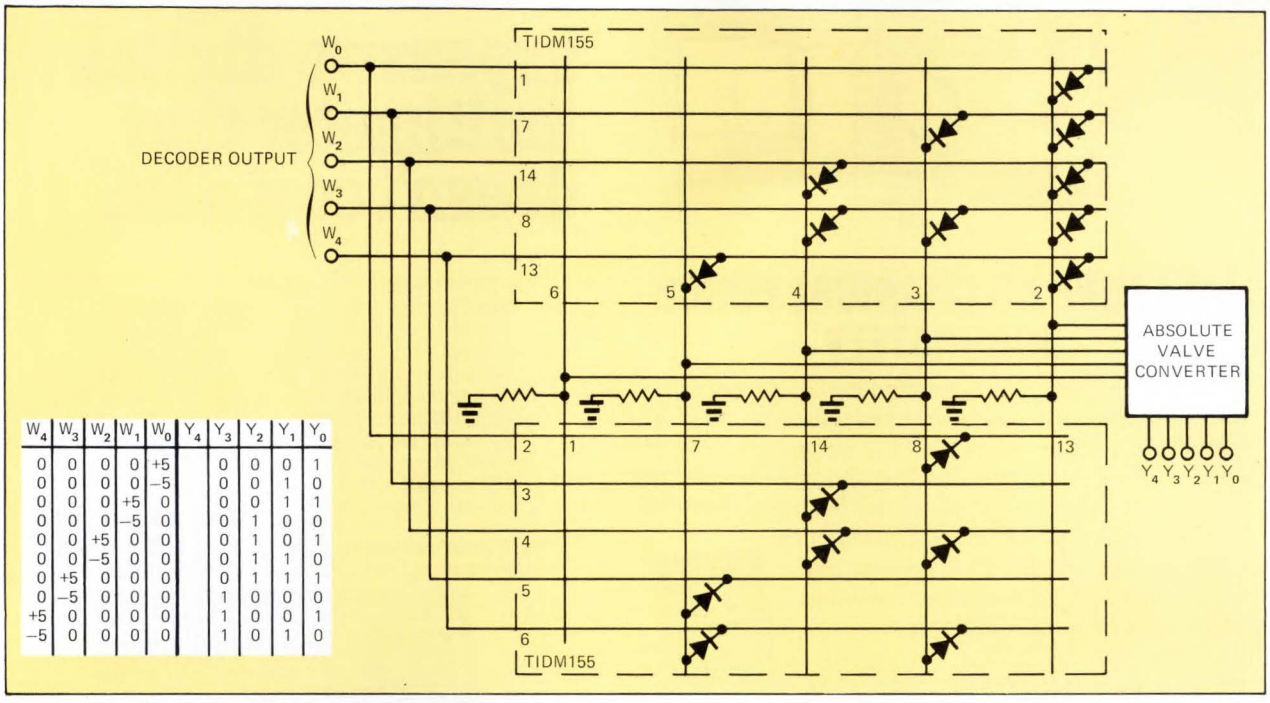


Fig. 8—Binary or trilogic ROM. A binary ROM's encoder is usually a diode matrix with one N-bit word stored in memory for each word line. An encoder for a trilogic ROM is described in **Fig. 9**.



W_0	W_1	Y_2	Y_1	Y_0	DECIMAL OUTPUT
0	0	0	0	0	0
+5V	0	0	0	1	1
−5V	0	0	1	0	2
0	+5V	0	1	1	3
0	−5V	1	1	1	7

Fig. 9—Encoder for trilogic ROM and truth table. In three-level logic there are 2 N-bit words for each word line. They are enabled by either −5V or +5V on the word line. Thus, the capacity of the memory matrix can be doubled without increasing the number of word lines. An absolute value converter (**Fig. 11**) converts the 3-level outputs of the encoder to 2-level outputs to interface with binary systems.



W_4	W_3	W_2	W_1	W_0	Y_4	Y_3	Y_2	Y_1	Y_0
0	0	0	0	+5		0	0	0	1
0	0	0	0	−5		0	0	1	0
0	0	0	+5	0		0	0	1	1
0	0	0	−5	0		0	1	0	0
0	0	+5	0	0		0	1	0	1
0	0	−5	0	0		0	1	1	0
0	+5	0	0	0		0	1	1	1
0	−5	0	0	0		1	0	0	0
+5	0	0	0	0		1	0	0	1
−5	0	0	0	0		1	0	1	0

Fig. 10 – Trilogic encoder implemented with available hardware. This is how the encoder described in **Fig. 9** would look if it was built with two Texas Instruments diode matrices (TIDM 155s). The particular configuration chosen is in the form of a binary 0-10 look-up table which stores in its hard wired memory the binary numbers 1 to 1010 for the decimal numbers 1 to 10. This encoder will convert trilogic to binary for interfacing with binary systems.

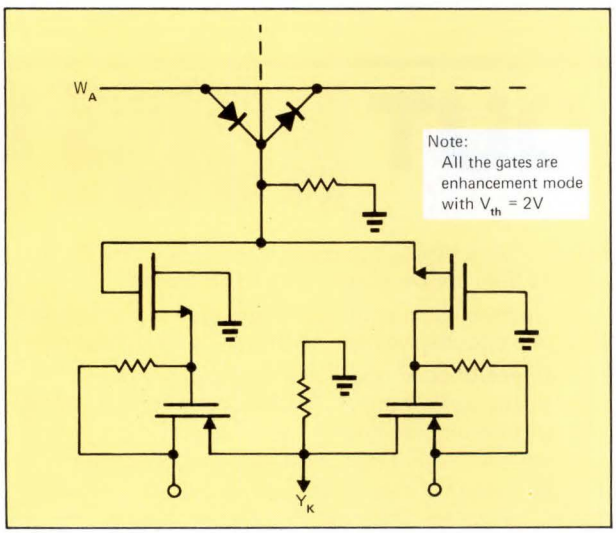


Fig. 11 – Absolute value converter used in **Fig. 9** and **10** convert the −5V output to +5V. 0V and +5V are left on the output lines. Thus, the final step in converting to a 2-level output for interfacing with binary systems is accomplished by this circuit.

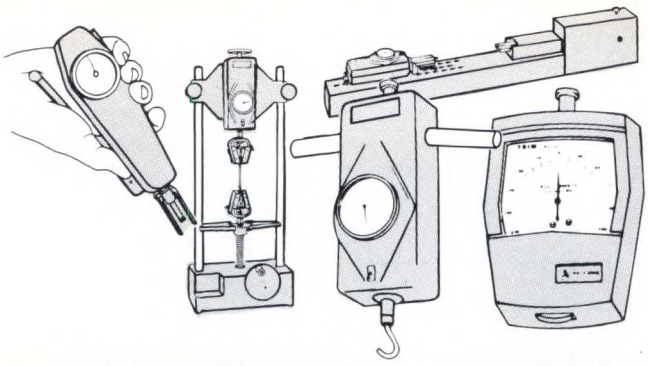
If an ordinary flip-flop, as shown in **Fig. 4**, has three level inputs (0, 1, 2) instead of two (0, 1), it becomes a tri-flop capable of producing 0, 1 or 2 in its output. Looking at the NAND gate truth table in **Fig. 2**, we can see that there are a number of input combinations capable of producing 0, 1 or 2 outputs. Some combinations, such as 0, 0 in, violate the logical symmetry by producing Q = 2 and $\overline{Q}$ = 2. (Q = 1 and $\overline{Q}$ = 1 are acceptable as established in the truth table for inversion). Some others are not used for the sake of convenience.

If 2 is applied to both A and B inputs in any one of the tri-flops shown in **Fig. 4**, there is no change in the output. Thus, we have a convenient steady-state condition. The output state can be changed by momentarily pulsing one or both input lines with 0 or 1. After pulsing, it will remain in the condition just set when both inputs return to 2. **Fig. 4** shows the tri-flop being set to each of the three output states.

Logic functions and flip-flops alone do not make a computer. It is necessary to combine the logic elements in the proper way to handle trilogic. **Fig. 5** through **11** develops some additional networks necessary for building a trilogic system and interfacing it with binary systems. □

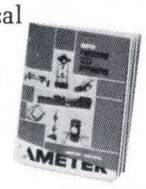
Author's biography

Akavia Kaniel is a project engineer at Digital Equipment Corp., Maynard, MA. He is currently designing an analog data acquisition system for minicomputers. He was previously employed at the Columbia Univ. Astrophysics Laboratory. Mr. Kaniel received his BSEE and MSEE from Columbia Univ.



MEASURE MECHANICAL FORCE ACCURATELY

Hunter Spring offers you a complete line of precision test apparatus for measuring resistance to push or pull loads, tensile strength, and gripping strength. Ideally suited for design and inspection departments, production lines, laboratories, and field use, Hunter's line consists of hand-held mechanical force gages, portable pull testers, and bench-type universal testing machines. Write today for *free* Bulletin.



AMETEK/Hunter Spring, Hatfield, Pa. 19440 (215)822-2971

AMETEK / Hunter Spring

AMETEK

Circle No. 29

Introducing the expensive digital multimeter that doesn't cost a lot.

The B&K Precision Model 281.

This 2½-digit unit is so versatile, its range covers 99% of your measurements. And its DC accuracy is 1%. The stable 281 also gives you positive over-range and wrong-polarity indications.

It's easy to use and easy to read across all 32 ranges, 100mV to 1000V.

Naturally, we're enthused about our Model 281. You will be, too, when you see our complete specs.

Call your B&K distributor. Or write Dynascan Corporation.

Very good equipment at a very good price. B&K **$169.95**

Product of Dynascan Corporation
1801 West Belle Plaine Avenue, Chicago, Illinois 60613

Circle No. 30

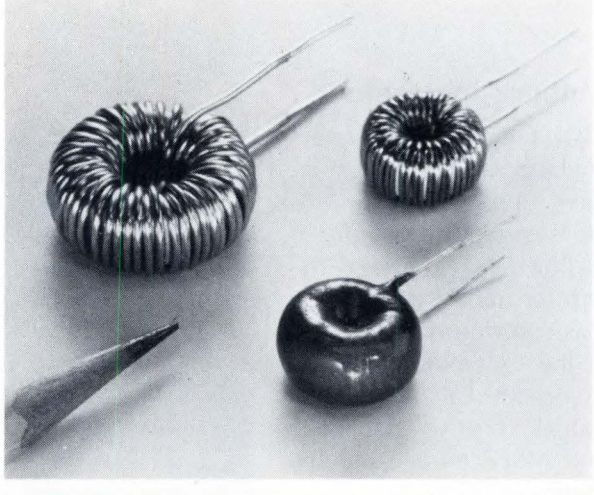
HELP STAMP OUT NOISE!

And we'll help you do it!

How? With our new line of SN noise-absorbing coils that out-perform conventional ferrite or tape-wound cores.

Our core material is powdered iron whose range of up to 15,000 gauss provides four to five times higher saturation magnetic flux densities than any ferrites now on the market.

We have 36 configurations from 2 to 60 amps. All eliminate noise from thyristors, relays or other AC devices... plus power line noise pickup. And they all cost less than conventional noise suppressors.



If your application is tough electrical systems or delicate electronic circuits, we have an SN coil to meet the need.

They are designed to upgrade compact circuits and mount easily on PC boards. The Polyvinyl Formal copper windings have tinned leads.

SN coils have constant permeability throughout the frequency range of control circuit noise as well as high relative loss factor. They remain efficient even at elevated temperatures.

If your work involves noise suppression anywhere from consumer products to high-speed switching systems, tell us your problem. We'll help you hush up the whole thing.

National Micronetics, Inc. is the leading basic materials company in the industry. We're first in disc recording heads, first in tantalum chip resistors and way up front in thin film and ferrite products too.

Send for our free SN coil literature and we'll even give you a placard with our ad headline on it. It may keep things quiet while you read about our noise suppressors.

NATIONAL MICRONETICS, INC.
Route 28, West Hurley, N. Y. 12491
Tele. 914/338-0333

Circle No. 31

EDN DESIGN AWARDS

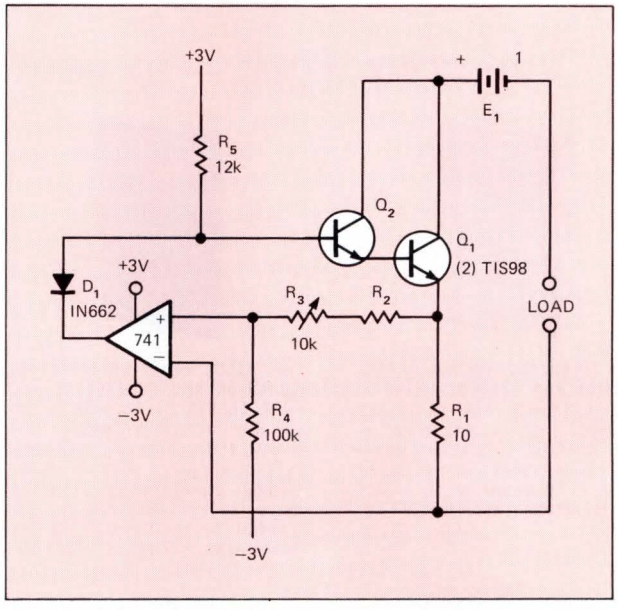
Isolated current source

Ralph Tenny
Texas Instruments Inc., Dallas, TX

I needed a floating current source to power a strain gage bridge, and the battery operated circuit shown here gave me adequate stability for a system with ±0.2% accuracy. As shown, the voltage compliance is equal to E_1 − 1.4V, and the temperature stability is +0.7 μA/°C from 0-50°C, with a current output level of 20 mA.

Q_1 and Q_2 control the current in the external loop with R_1 sensing the current. If R_1 is chosen for 0.5Ω/mA, the sensitivity is adequate without dissipating excess power. R_2, R_3 and R_4 provide an offset voltage to set the output current. R_5 and D_1 insure that the circuit will start regardless of the initial offset of the op amp.

Four alkaline pen cells provide ±3V for the 741, and E_1 should be chosen to give adequate voltage compliance for the intended load at maximum load current and lowest acceptable end-point voltage for E_1. The end-point voltage may be defined by rise in noise output of E_1 as it is depleted. □



This simple, battery operated op-amp circuit provides good current and temperature stability over a wide range.

To Vote For This Circuit
Check 160

A programmable pulse-edge selector

C.F. Reeves
Naval Electronics Laboratory, San Diego, CA

This circuit generates an output pulse at terminal C as a function of either the leading edge or the trailing edge of the input pulse at terminal A. The logic level at terminal D determines which edge is selected. This "programmable" feature lends itself to applications which require generation of a strobe on one edge of pulses in a given train but the decision of which edge to use is the result of concurrent logic operations. Additionally, it can be used as a switchable relay.

The circuit employs two IC packages: a Quad 2-input EXCLUSIVE OR and a Quad 2-input NAND. No external components are required.

The circuit takes advantage of the fact that a 2-input EXCLUSIVE-OR gate can be made to function as an inverter or as a non-inverter simply by applying logic ONE or logic ZERO respectively to the second input terminal. This property is illustrated by the truth table in **Fig. 1**.

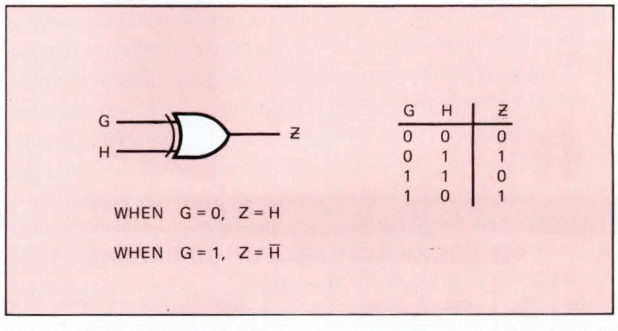
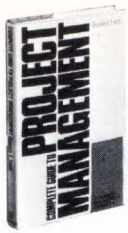


Fig. 1—Exclusive-OR gate can serve as a programmable invert/non-invert buffer. A control input at G can set the output, Z, equal to or complimentary to the signal input at H.

Referring to the circuit diagram in **Fig. 2**, the signal at point B is the same as the input signal but shifted in phase by the propagation delay of the

CAHNERS BOOK DIVISION

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

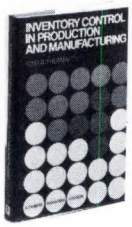


101. **COMPLETE GUIDE TO PROJECT MANAGEMENT** by Dennis L. Locke. Systems and techniques which can be used with profit in large or small plants, on projects worth $200 or $2 million. Costing, controlling, evaluating an industrial project so that it is completed on time, according to specs, within budget.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

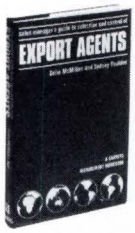
POLLUTION — A Cahners Critical Issues Report

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

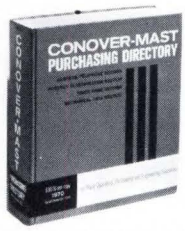
111. **Vol. 2.** Environmental Management — Pollution Control Legislation. $5.00



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



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



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

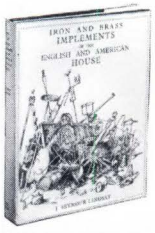
105. **IRON AND BRASS IMPLEMENTS OF THE ENGLISH AND AMERICAN HOUSE** by J. Seymour Lindsay (D.C.M., F.S.A.). Revised and enlarged edition includes new illustrations and new material from American museum and private collections. Covers hearth hardware and furnishings, early lighting, cooking utensils,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

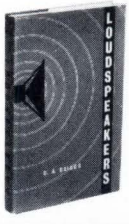
106. **LOUDSPEAKERS** by G. A. Briggs. 5th edition. All aspects of the design and performance of loudspeakers and enclosures are dealt with in non-technical terms. Separate chapters are devoted to Electrostatic Speakers and Stereo. A classic by a world-renowned, witty writer and audio expert. 336 pp.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

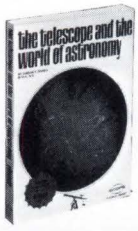
107. **THE TELESCOPE AND THE WORLD OF ASTRONOMY** by Marvin F. Riemer. 3rd edition, revised and enlarged. Deals with equipment, planets, universe, constellations, nebulae, galaxies, double stars, clusters, variable stars, visitors to our skies, photography, satellite tracking. Author a member of N.Y.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

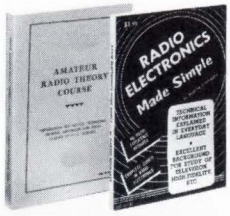
108. **AMATEUR RADIO THEORY COURSE** by Martin Schwartz. Revised. Complete, simplified home study course covering requirements for Novice, Technician, Conditional and General Classes of Ham licenses. 260 pp. illus. $3.95

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









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

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

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

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

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

Check Enclosed ☐ Bill Me ☐ Bill My Company ☐

Name_____

Title_____

Company_____

Address_____

_____

_____ Zip_____

S58/MO809

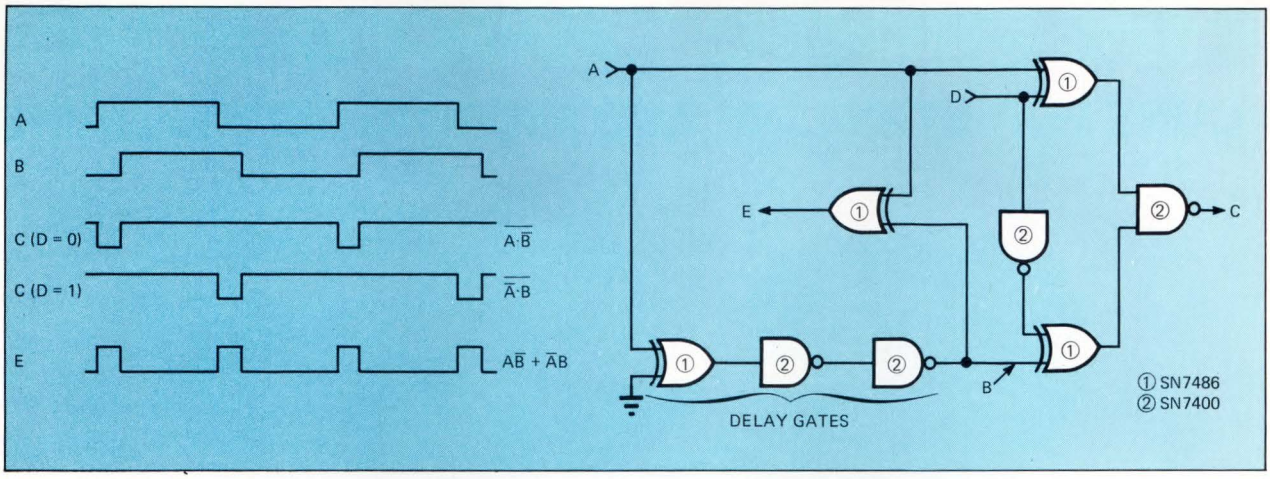


Fig. 2—2 TTL packages make a simple pulse-edge selector. The control signal at D determines whether the output pulses at C will coincide with the leading or trailing edge of the input signal at A. In addition, the output at E will signal both leading and trailing edges of the input.

three delay gates. When terminal D is at logic ZERO, the output at C is $A \cdot \overline{B}$ which is the inverted leading-edge pulse. When D is at logic ONE, the output at C is $\overline{A} \cdot B$. This is the inverted trailing-edge pulse.

At no extra cost in components, a bonus output at terminal E supplies pulses at both leading and trailing edges of the input by exclusive OR-ing the signals at A and B. This output provides double-edge trigger pulses independent of the logic level at D. It can also be used as a times 2 frequency multiplied signal. The double-frequency waveform is symmetrical; however, only if the duty cycles of the input pulse train is 50%. All of the edge pulses are approximately 35 nsec wide. This represents the total propagation delay of the three delay gates. Maximum input frequency is 10 MHz. □

To Vote For This Circuit
Check 161

Circuit selects larger of two analog signals

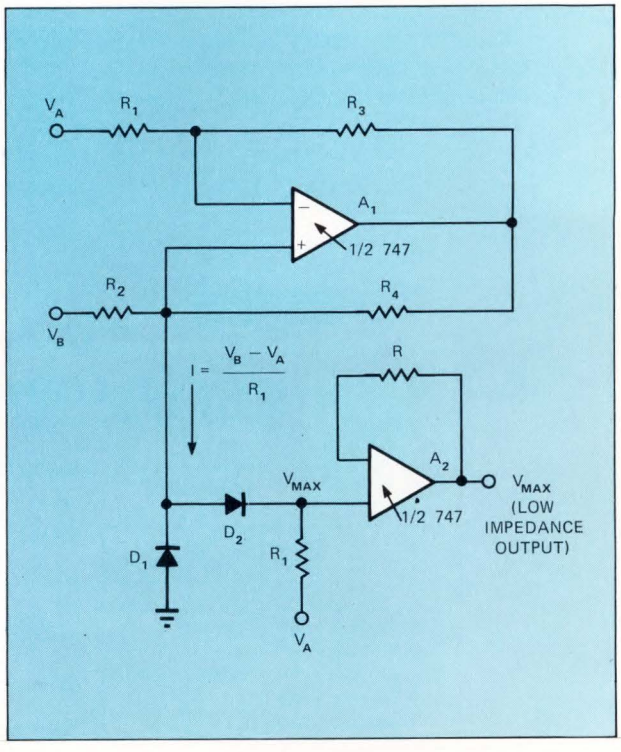
Werner Gruenebaum
Loral Electronic Systems, New York, NY

Using a differential current source and a few more components, it is possible to design a circuit requiring no switching to select the larger of two analog voltage inputs and provide a precision output of that voltage.

Considering the first op amp, A_1 in the schematic, which is similar to a common bilateral current source, but with V_B added:

$$e_0 = (e - V_A)\frac{(R_1 + R_3)}{R_1} + V_A \qquad (1)$$

$$e_0 = e + \left(1 + \frac{e - V_B}{R_2}\right) R_4 \qquad (2)$$



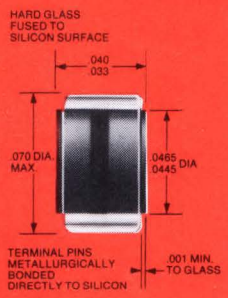
This circuit selects the larger of two analog signals, V_A and V_B through the A_1, D_1, D_2 network and represents that voltage at the output, V_{MAX}.

PIN diode "Micro Pills"

A CURE FOR STRIPLINE AND MICROSTRIP HEADACHES

RUGGED, HERMETICALLY SEALED PIN DIODES ALSO PROVIDE CONTINUOUS RELIEF FROM MICROWAVE CHIP PROBLEMS.

They're immune to shock, dirt, moisture, scratches and other handling hazards, because they're voidless, metallurgically bonded and fused-in-glass for optimum reliability. Though small enough to use like ordinary chips, Unitrode "Micro Pills" can dissipate 15 watts of average power and 60 kilowatts of peak power. And they can withstand thermal cycling from −195°C to +300°C without permanent degradation. Carrier lifetimes exceeding 2.5 μ sec assures low distortion performance. They're ideal for stripline and microstrip applications. Used as switches, duplexers, phase shifters, attenuators, amplitude modulators, or receiver protectors, they operate as a variable resistance controlled by a self generated or externally applied bias circuit. The unique construction allows remarkable assembly flexibility, withstanding temperatures up to 400°C when soldering or brazing "Micro Pill" PIN diodes to various circuit media. They're as low as $4.00 each in 10K quantities. Switch to UM7900 series "Micro Pills" and feel better all day long.



For free samples, call or write Howard Kaepplein at (617) 926-0404 collect, Unitrode Corporation, Dept. 8Z , 580 Pleasant St., Watertown, Mass. 02172. For the name of your local Unitrode distributor or representative, dial (800) 645-9200 toll free, or in New York State (516) 294-0990 collect.

UNITRODE

UNITRODE CORPORATION
Dept. 8Z , 580 Pleasant St., Watertown, Mass. 02172.

☐ Please send technical data on the following PIN diode "Micro Pills"

Type	Voltage Rating (volts)	Series Resistance @ 100 mA (ohms)	Total Capacitance (pf)
UM7901A	100	1.0 MAX	0.8 MAX
UM7902A	200		
UM7904A	400		
UM7906A	600		
UM7910A	1000		

NAME: _____ TITLE: _____

CO.: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

TELEPHONE: _____

See EEM Section 4800 And EBG Semiconductors Section for more complete product listing.

Since **Eq. 1** must equal **Eq. 2,** this results in

$$I = \frac{(e - V_A)\dfrac{(R_1 + R_3)}{R_1} + V_A - e}{R_4} - \frac{(e - V_B)}{R_2}$$

$$= \frac{V_B}{R_2} - \frac{V_A R_3}{R_1 R_4} + e\left(\frac{R_3}{R_1 R_4} - \frac{1}{R_2}\right)$$

If $R_1 = R_2$ and $R_3 = R_4$.

$I = \dfrac{V_B - V_A}{R_1}$, independent of the load through which I is conducted (provided the amplifier remains in the linear region).

The current I will flow through D_2 only if it is positive, namely, $V_B > V_A$. Otherwise, it is conducted through D_1.

Therefore, the positive input to A_2 (V_{MAX}) is equal to:

$$V_{MAX} = V_A \text{ for } V_A > V_B$$

$$= V_A + \left(\frac{V_B - V_A}{R_1}\right) R_1 = V_B \text{ for } V_B > V_A.$$

Amplifier A_2 (a voltage follower) is added if a low-impedance output is required. □

To Vote For This Circuit
Check 162

Simple electronic timer is compact and accurate

Maxwell Strange
Goddard Space Flight Center, Greenbelt, MD

The timing obtained with this inexpensive self contained timer is highly accurate, linearly adjustable and independent of supply voltage.

When the switch is placed in the START position power is applied to the circuit and amplifier A_1, connected as an operational integrator, produces an output voltage, v, starting at V and going negative with a constant slope of

$$\frac{V - V_B}{C R_1} \text{ V/sec}$$

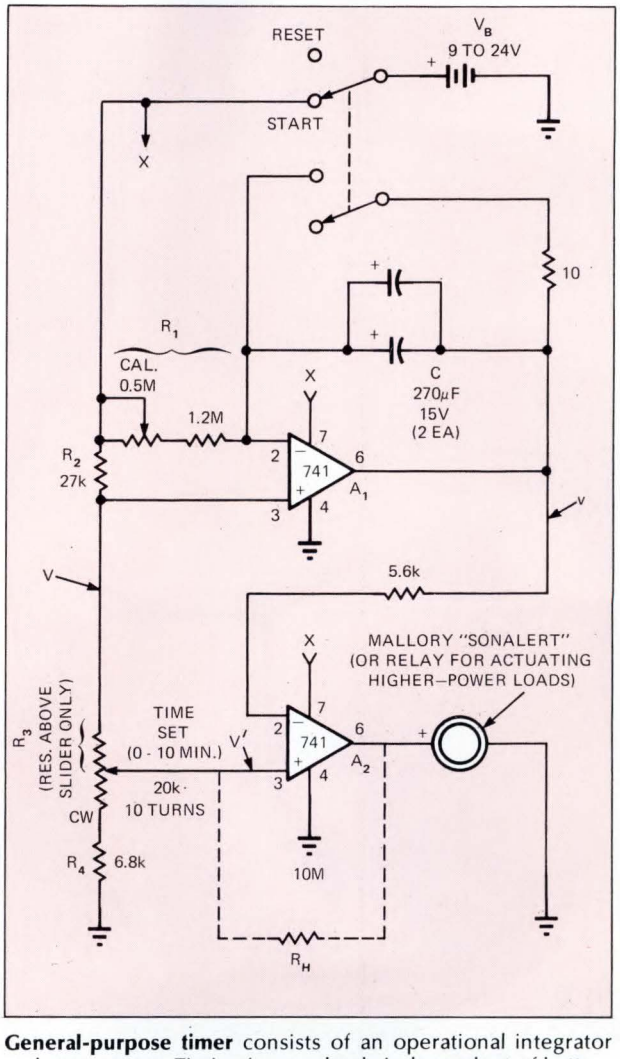
A_2 functions as a comparator. When voltage v reaches the set value V, A_2's output goes positive.

Time delay, t, is given by the equation:

$$t = \frac{C R_1 R_3}{R_2}$$

R_4 should be as small as possible relative to R_2 for maximum charging slope, but not so small that A_2's common-mode input range is exceeded. Capacitor C is preferably a low-leakage wet-slug tantalum type; 50μF per minute of available delay will bring timing into the range of the calibration pot.

An important feature of this circuit is that both charging current and comparator threshold voltage are proportional to supply voltage, so that the latter's effect on timing is cancelled. The setting may be revised without error while the unit is timing, as long as a final setting is made before



General-purpose timer consists of an operational integrator and comparator. Timing is completely independent of battery voltage because the latter affects charging slope and comparator threshold equally.

CTS puts the squeeze on space wasters

CTS Cermet "Saver Pac" Resistor Networks

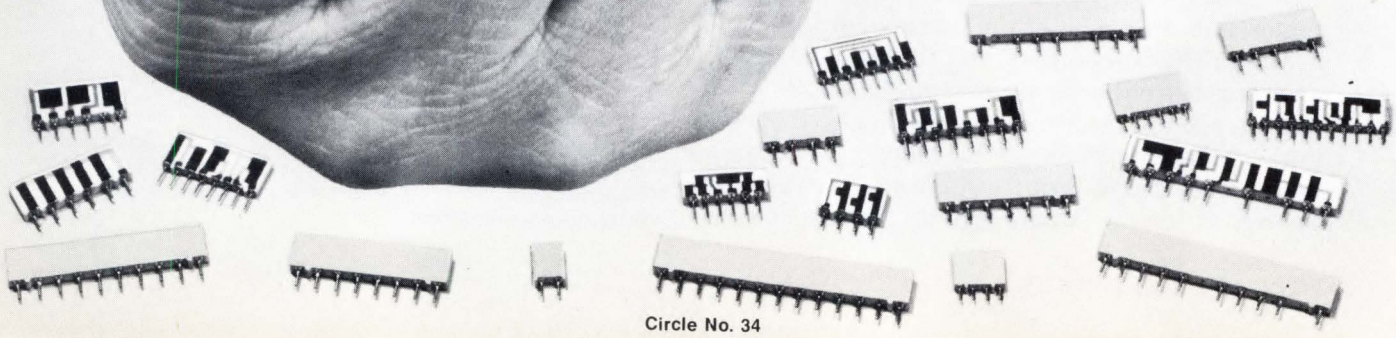
Increase Circuit Density . . . At Economical Prices

Space comes *high!* So you'll like how much a CTS 750 Series "SAVER PAC" network can save you, and your circuit. Less space . . . fewer components . . . greater system reliability . . . quicker, easier installation . . . reduced handling costs . . . and faster inspection. Consolidate up to 13 discrete resistors into one compact in-line resistor module. CTS can do it easily with twenty standard packages . . . available in .100″, .125″, or .150″ lead centers. High power capabilities to 4.3 watts @ 70°C per module.

CTS 750 series cermet thick-film resistors assure proven performance—ultra high stability and reliability—backed by over 700,000,000 hours of test data. Hand install or use automatic assembly equipment... they're designed for either. Pick a SAVER PAC today. Large or small orders welcome. CTS of Berne, Inc., 406 Parr Road, Berne, Indiana 46711. Phone: (219) 589-3111.

CTS CORPORATION

A world leader in cermet resistor technology.



Circle No. 34

"timeout". R_H provides regeneration to produce a clean logic output, if needed.

The circuit as shown was built for a delay range of 0 to 10 minutes, using a 10-turn 0.1% linearity TIME SET pot with a "watch dial" knob. After calibration, accuracy was within 1 sec at any setting. Long-term drift depends on the stability of the capacitor and resistors used. The original timer has been in everyday use for 4 years with no degradation in accuracy. □

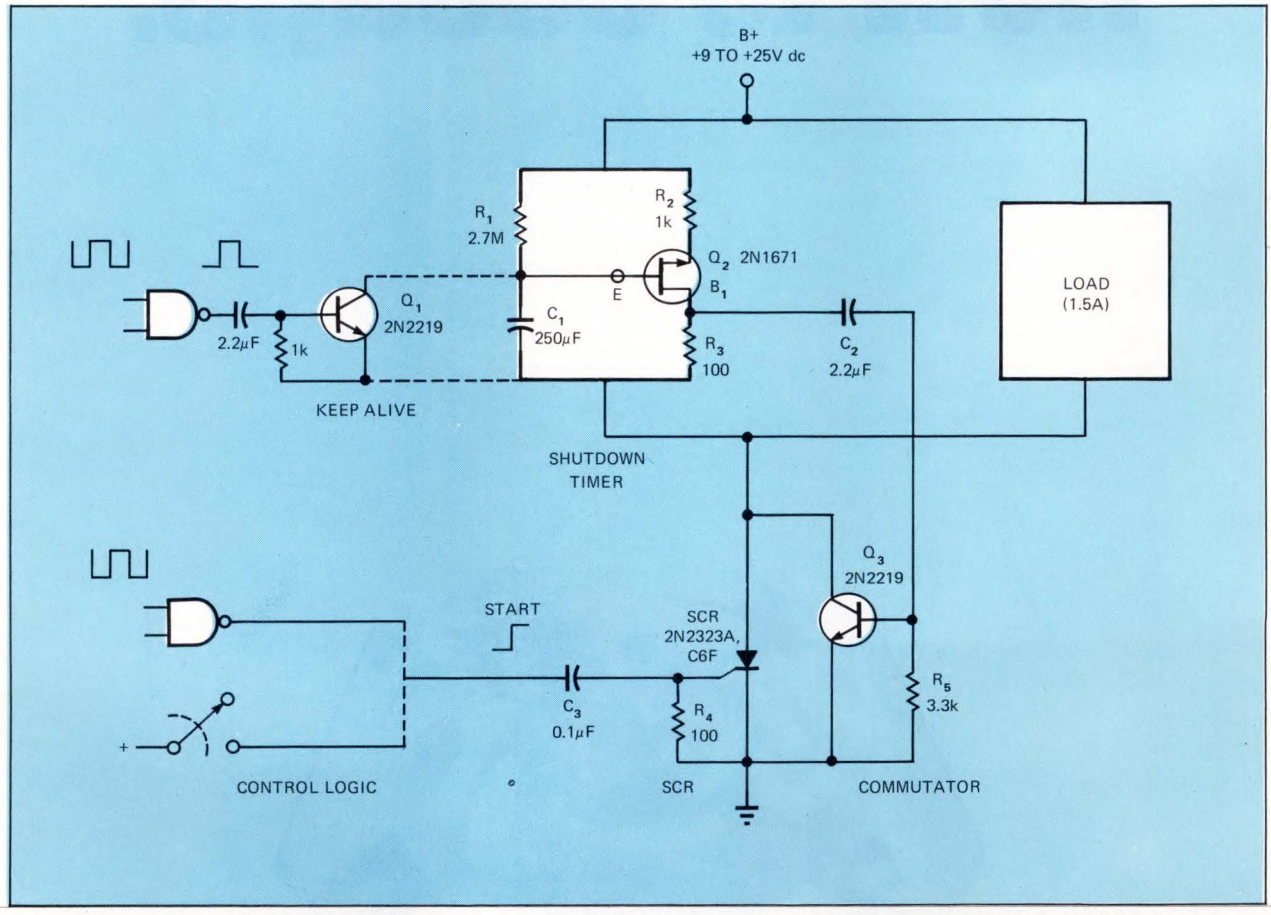
To Vote For This Circuit
Check 163

Battery saver has automatic turn-off

Dave Weigand
Gulf and Western, Swarthmore, PA

An automatic turn-off battery saver is often required for alarm, remote control, toy or unattended electronics. The versatile circuit shown here can be designed for a wide range of voltage, power and delay.

The SCR is triggered on by external control logic or contact closure. This connects ground to the load and to the shutdown unijunction timer, Q_2. After the C_1R_1 delay, unijunction Q_2 fires, discharging C_1 timing capacitor into R_3. The resulting pulse across R_3 is coupled by C_2 into the base of commutating transistor Q_3. Q_3 commutates the SCR by momentarily shunting the SCR current below holding current. With the SCR commutated OFF, only leakage currents through the reverse SCR junction will drain the battery.



Simple battery circuit is enabled only when needed. While the circuit is OFF, leakage currents through the SCR are the only drain on the battery.

A keep-alive feature can be incorporated into the load or control logic to discharge C_1, the timing capacitor, well ahead of Q_2's firing voltage. □

To Vote For This Circuit
Check 164

We're telling 44 million prisoners in the United States how to escape.

For a free booklet on how to stop smoking,
call or write your local unit of the **American Cancer Society**

The quiet one. Zero bounce noise.

This new flexing spring contact with four distinct current paths practically eliminates arcing line noise—makes I-T-E Rowan's 2190E Mod A Relay ideal for power relay applications in place of or in conjunction with solid state circuitry where noise-free contact closure is critical.

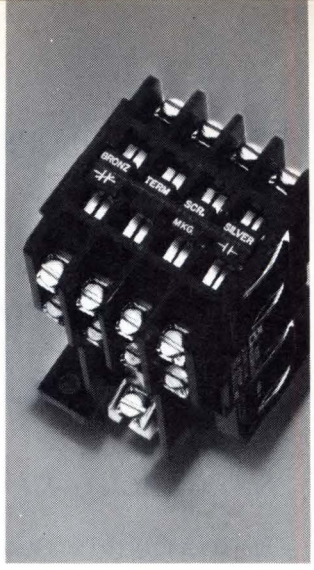
The Mod A provides a power relay of 10 A 300 VAC with virtually zero bounce—less than 1 millisecond. Standard non-flexing contacts result in bounce exceeding 5 milliseconds on closing with each arcing bounce producing noise.

The quiet one represents a unique design concept in contacts. It's a double-break, bifurcated movable contact fashioned entirely of flexible spring silver. The industry's standard solid bar movable contact is normally made of heavy non-flexing brass with fine silver buttons.

I-T-E Rowan's new Mod A Relay offers an extremely low contact resistance, a high fidelity (low energy) contact, while providing excellent resistance to accidental contact opening under vibration or shock. Independent tests show no contact malfunction, 0-5 KHz vibration, up to the machine test level of 6.5 g's.

All these features are incorporated in the I-T-E Rowan standard 2190E Mod A, 1 through 8 poles in combinations of N/O-N/C, plus solid state timer and latching version. Also available with gold flashed contacts for dry circuits. Another versatile relay in the tradition of Reliable Controls from I-T-E Rowan.

For further information: I-T-E Imperial Corporation, Spring House, Pa. 19477.



I·T·E Imperial

Circle No. 35

Versatility and flexibility characterize 4-channel transient recorder

PROGRESS IN INSTRUMENTATION

The Model 1015 Transient Recorder provides performance characteristics and features not previously available in a multichannel portable recorder. Foremost among these is the ability to record up to four simultaneous analog input signals with bandwidths to 25 kHz. The recorded resolution of each input signal is one part in 1024 (better than 1/10%).

A variety of record rates can be selected, and the control and triggering functions incorporate a digitally adjustable delay of as much as ten times the record length. One of the trigger-delay and control functions permits the trigger to be received before, during or after the signal has occured. This "pretriggered" capability ensures capture of the leading baseline and rise of a random signal.

Front-panel selector switches permit the unit to be configured (1) as a single-channel recorder with 4 times the recording time, while retaining an input bandwidth of up to 25 kHz; (2) as a 2-channel unit, with twice the record time per channel; or (3) as a 4-channel unit, capable of recording up to four separate signals, one-at-a-time, from a single input into each of the four storage channels while "holding" each previously recorded signal.

The recorder has three types of outputs: one digital and two analog. The digital output produces 10-bit amplitude and 12-bit address (time) data at convenient asynchronous rates via a bit-parallel/word-serial interface at standard TTL levels. One of the analog outputs is a repetitive type that will produce a flicker-free display on an oscilloscope or CRT display. The other is a very slow analog output for reproducing the recorded signals on a strip-chart or X-Y recorder.

A unique feature of the Model 1015 is its capability of either displaying on a CRT or plotting on an X-Y recorder the signal from one channel versus the signal from another channel. This X-versus-Y feature allows the user to examine immediately the relationships between variables for signals with bandwidths from dc to very high audio frequencies.

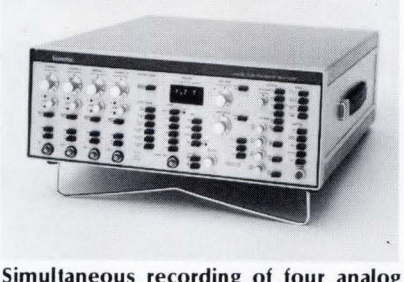
Another feature which extends the usefulness of the recorder is the accessibility of the record clock rate and triggering signals for conveniently synchronizing the operation of several units.

The memories in the Model 1015 are MOS shift registers. The total memory capacity is 4096 X 10-bits arranged as four 1024 word memories. The input channels and memories are configured to permit switch selection of single-channel recording, with 4096 points of storage; two-channel recording, with 2048 stored points each; and the normal four-channel/1024 points per channel operation. Also switch selectable is the ability to record from one input into any one of the 1024-word memories while retaining or "holding" the contents of the other memories.

Selectable record rates are available from an internal crystal oscillator, or an external sample rate input can be used. The nineteen internal sample rates range from 100 kHz to as slow as 0.1 Hz.

The adjustable delay in the trigger and control circuits is settable by means of convenient digital switches in increments of ten sample intervals to a maximum of almost 10,000 sample intervals. This delay, along with accurate, adjustable trigger circuits, permits the user to define a precise "recording window" with respect to a given or detected trigger event.

The "pretrigger" record mode of the Model 1015 is unique to transient recorders and is analogous to recording with a tape loop on a tape recorder. Once the 1015 is armed (the tape loop is started), the unit records continuously, storing new data and, after the memory has been refreshed once, erasing old data. When the recording is stopped, as the result of a trigger event, the memory in the 1015, like the tape loop on the tape recorder, contains information which occurred prior to the time that the recording was stopped. Use of the internal trigger detection capability and the



Simultaneous recording of four analog input signals with bandwidths up to 25 kHz is possible with the Model 15 Transient Recorder.

readily set trigger delay (set for example to 500 sample intervals of 1/2 the memory length of one channel) gives a recording of half of the recorded signal which occurred prior to the detected trigger point on the signal and half which occurred after the trigger point. This powerful capability permits the setting of the trigger level to be quite high—well above the sometimes noisy baseline of the signal—and yet assures that the leading baseline and risetime of the signal is also captured.

The CRT display output is a repetitive replica of the recorded signal(s), producing a flicker-free presentation. A four trace presentation on the CRT is possible for each trace. A linear horizontal sweep ramp is also produced for the CRT and this may be "expanded" up to 10 times to allow full-width examination on the CRT of as little as one tenth of each trace. In addition, each of the four traces can be set to have 1/4 full-scale vertical amplitude. Alternatively, any one trace can be viewed individually with full-scale vertical amplitude. A single trace of the entire 4096 word memory contents is selectable as well as two CRT traces of 2048 words each. Price of the Model 1015 is $4950, delivery is 30 days ARO.

Biomation Corp., 1070 E. Meadow Circle, Palo Alto, CA 94306. **150**

True 3.5-digit DMM gives 5000-count resolution for 2000-count prices

PROGRESS IN INSTRUMENTATION

Most people know what you mean when you talk about a 3-1/2-digit DMM, but what about a 3.5-digit DMM? What's the difference?

The difference is 3000 counts according to Data Technology of Santa Ana, CA, who just introduced the Model 30, the first 5000-count DMM.

This instrument has a 4-digit display like most 3-1/2-digit DMMs, but the most significant digit may be anything from a 1 to a 4. If this sets a new trend in digital instruments, it will make more sense to talk about 2000-count or 5000-count or 20,000-count instruments, rather than 3-1/2 or 4-1/2-digit meters.

Actually, the Model 30 has a traditional 4-1/2-digit Sperry display, but the first digit is never used and the second digit is used to read values only as high as 4999 under normal conditions.

The display will actually read up to 5999, but after you pass 4999 it flashes, meaning you have exceeded the normal range of the instrument and the accuracy is deteriorating.

Why has Data Technology taken this approach? According to John Dunn, Product Marketing Manager, the company conducted a study that shows about 50% of all measurements taken on a DMM require a first digit between 2 and 5. They concluded that a low-cost 5000 count meter was needed.

Typical applications that the Model 30 was designed to meet include: 5 and 20V logic, 20 and 30V telephone applications, 24V industrial supplies, 28V aerospace and analog applications, 36V military and 230/440/480V industrial voltages.

The 5000-count meter will give you 4-digit resolution in this range, whereas previously you had to buy a 4-1/2-digit (20000-count) meter.

The advantage is cost. Priced at $279, it is below most 2000-count instruments while the specs are still comparable to most of those instruments in the $300 price class.

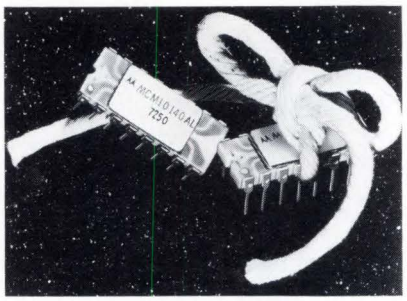
Worst-case dc accuracy is ±0.1% of reading ±0.06% of full scale, which means that accuracy will not be quite as good as most 4-1/2-digit meters, but is good for 3-1/2-digit units.

The new Model 30 is a 5-function, 23-range instrument. The heart of the analog section is a high-impedance FET circuit working into a dual-slope integrator with its inherent noise cancellation. A unique divider circuit uses a single precision resistor network for dc volts, ac volts and kΩ.

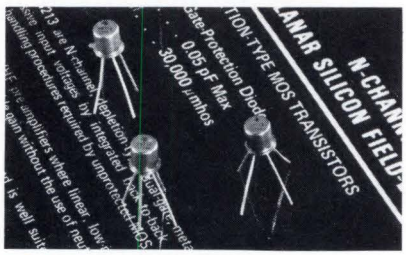
Because of the extended range to 5000 counts, the five functions include: five dc voltage ranges from 500 mV, with 100 μV resolution, to 1200V; five ac voltage ranges from 500 mV, with 100 μV resolution, to 1000V, five resistance ranges from 500Ω, with 0.1Ω resolution, to 50MΩ; four ac and dc current ranges from 500 μA, with 100 nA resolution, to 2A. All digits flash when the inputs exceed 4999 counts, however, the meter continues to 5999 counts with slightly degraded accuracy. Delivery is 30 days.

Data Technology Corp., 200 S. Fairview St., Santa Ana, CA 92704. Phone (714)546-7160. **151**

5000-count DMM is designed for applications requiring low-cost instrument with 4-digit resolution up to 4999.

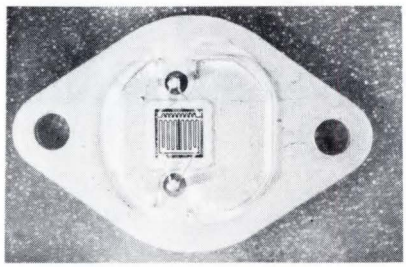


ECL MEMORIES ZIP ALONG AT 10 nsec. Both are 64-bit RAMs organized as 64 1-bit words. All specifications for the 2 devices are identical except for loading. The MCM10140 is specified for driving loads of 90Ω, while the MCM10148 is specified for 50Ω loads. These 2 RAMs offer high-speed operation, full-binary decoding on chip and chip-enable inputs for use when building large memory arrays. Packaging is in a 16-pin ceramic DIP which is hermetically sealed. Prices are: MCM10140AL: (1-24) $25.50 each; (100 up) $17.00 each. MCM10148AL: (1-24) $28.50, (100 up) $19.00. Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, AZ 85036. Phone(602)244-3466. **170**

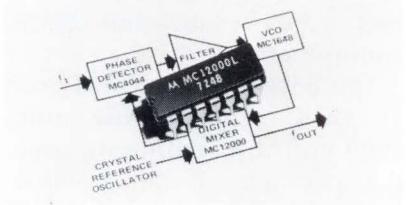


MOS FETs OFFER IMPROVED CHARACTERISTICS. Three N-channel dual insulated-gate field-effect transistors feature improved high-frequency gain over similar units. Designated the 3N211, 3N212 and 3N213, these depletion-type MOS transistors have a high forward transconductance (y_{fs}) rating of 25 micromhos (typically). Additionally, these devices offer low-noise figures and high power gain. Typical common-source spot-noise figure is 2 dB at 200 MHz. Typical power gain is 28 dB. Prices in 100-999 quantities are: 90¢ each for the 3N211 and 3N212 and 95¢ for the 3N213. Texas Instruments Inc., Box 5012, Dallas, TX 75222. Phone(214)238-2741. **171**

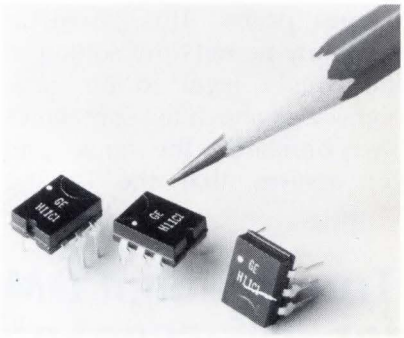
TWO LINEAR IC ARRAYS OFFER DESIGN FLEXIBILITY. The super-beta array, designated CA3095E, consists of a super-beta differential cascade amplifier and 3 independent, general-purpose high-voltage npn transistors. Features of this device include: 2 super-beta npn transistors ($h_{FE} > 1000$); input bias current < 1 nA; 3 separate high-voltage (V_{CBO} = 45V) 50 mA npn transistors. The npn/pnp transistor arrays, designated CA3096E and CA3096AE, consist of 5 independent transistors, 2 pnp and 3 npn. The main difference between these types is that the CA3096E has a matched npn transistor pair. RCA/Solid State Div., Rt. 202, Somerville, NJ 08876. Phone(201)722-3200. **172**



MONOLITHIC DARLINGTONS SWITCH 20A AT 400V. Applications for the high-current, high-voltage units include off-line switching power supplies and consumer equipment such as TV sweep circuits. The 20A version is particularly well suited in applications where SCRs or a multitude of paralleled transistors were formerly used. The Darlingtons have sustaining breakdown voltage ratings (collector to emitter) of 300V (Type SVT 6060); 350V (SVT 6061) and 400V (SVT 6062). V_{CE} (sat.) is 2.0V and typical switching time is 300 nsec. The units are housed in a standard TO-3 package. Price for the SVT 6060 in 100-level quantities is $15.54. TRW, Inc., 1880 Wilshire Blvd., Los Angeles, CA 90024. Phone(213)820-2606. **173**



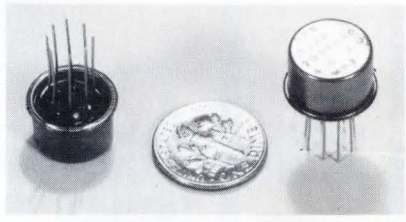
DIGITAL MIXER PROVIDES PLL SIGNAL. The MC1200 generates an output frequency which is the difference between its 2 input frequencies. The mixer consists of a "D" flip-flop, together with TTL-to-ECL and ECL-to-TTL translators. Frequencies up to 250 MHz can be generated without the need for tuned circuits. The mixer is expected to find use as a prescaler in phase locked loop applications where the voltage controlled oscillator operates above 10 MHz and a relatively narrow tuning range is required. Pricing/quantity is: $7.50, 1-24; $6.25, 25-99, $5, 100-up. Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, AZ 85026. Phone(602)244-3466. **174**



PHOTON COUPLERS PROVIDE SCR OUTPUT. This H11C series provides a simpler, more economical way for IC logic to control ac power. Typical isolation input to output is $10^{14}\Omega$ at voltage capabilities up to 2500V. Type H11C1 provides an isolation of 2500V and type H11C2 is rated at 1500V. Both feature a blocking voltage rating of 200V making the SCR output compatible with 120V ac line operation, and utilize input signals compatible with logic-level outputs. They are available in DIP packaging. Prices range as low as $2.50 in lots of 1000. General Electric Co., Electronics Park Bldg. #7, Mail Drop 49, Syracuse, NY 13201. Phone(315)456-2021. **175**

MONOLITHIC 10A DARLINGTONS INTRODUCED. Identified as the SDM 3100-3400 Series, these devices are packaged in 3-lead TO-66 and 4-lead TO-5 cases. Typical features include: V_{CEO} from 40V to 80V; multiple-gain selections at 2.5A or 5.0A; typical 5.0A H_{FE}, 1000 minimum; typical 1.0A H_{FE}, 10,000 minimum; low-leakage planar construction (less than/μA at 80% of V_{CBO} V_{EBO}); high speed (ft = 40 MHz typical, rise and fall times 200 nsec typical). The SDM 3100-3400 Series is priced at $5 for TO-66 versions and $3 for TO-5 versions in quantities of 1-99. Solitron Devices, Inc., Semiconductor Div., Riviera Beach, FL 33404. Phone(305)848-4311. **176**

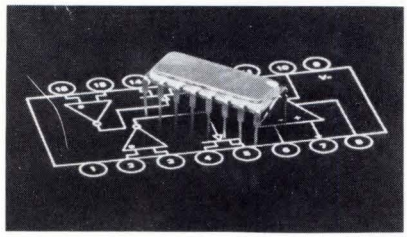
SEMICONDUCTORS



CRYSTAL-CLOCK OSCILLATOR HOUSED IN TO-8. The JKTO-79 thick-film crystal-clock oscillators are available in a standard frequency range from 500 kHz to 25 MHz. They offer excellent long-term stability (±25 ppm) over a temperature range of 0°C to 70°C. The TO-8 package saves design time and component cost as it can eliminate up to 14 discrete parts with no sacrifice in performance over larger oscillator units. Input is +5V dc ±0.5V each at 27 mA typical, available as complimentary, multiple binary related outputs capable of driving 5 TTL loads. (Sine wave outputs optional). CTS Knights, Inc., Sandwich, IL 60548. Phone (815)786-8411. **177**

POWER STROBE LOWERS SYSTEM POWER REQUIREMENTS. A prime application for the HD-6600 quad power strobe is in any ROM system. Use of it can reduce standby power requirements by as much as an order of magnitude. Access times from the HD-6600 input to a HpROM-1024 memory output is typically 100 nsec. The HD-6600 has TTL compatible input characteristics and represents a load of 1. Up to 150 mA (typical) can be delivered at each of the devices for outputs with no more than a 250 mV drop. Prices in quantites of 100-999 are: HD-6600-5 (0°C to +75°C) $5.65; HD-6600-2 (−55°C to +125°C) $8.50. Harris Semiconductor, Melbourne, FL 32901. Phone(305)727-5407. **178**

POWER-SWITCH/AMPLIFIER ICs ARE PROGRAMMABLE. Designated CA3094T for operation up to 24V, CA3094AT for up to 36V and the CA3094BT for up to 44V, they have an input with the characteristics and flexibility of an operational-transconductance amplifier (OTA). The output circuit is a power Darlington stage capable of "sinking" or "sourcing" an average current of 100 mA or 300 mA peak. These devices can also be programmed to idle at μW power levels. Because of their programmable input impedance, they can be designed into economical timers to give delays in excess of 4 hr. Pricing is as follows: CA3094T and CA3094S—$0.75 (100-999). CA3094AT and CA3094AS—$1.19 (100-999). RCA Solid State Div., Rt. 202, Somerville, NJ 08876. Phone(201)722-3200. **179**

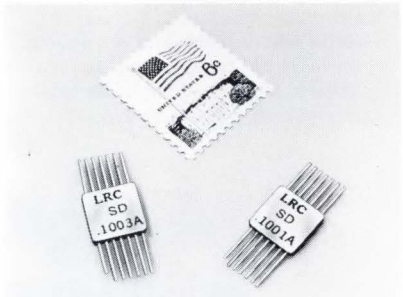


HYBRID-ANALOG MODULE IS A "JACK OF ALL TRADES". The CSH101 hybrid sample-and-hold circuit combines 2 separate FET analog switches and an FET input op amp in one 16-pin DIP. All sections of the circuit are uncommitted. The 3 sections can be connected in many different ways to meet a wide variety of applications. Typical uses are 2-channel sample-and-hold, integrating sample-and-hold, sample-and-hold with charge cancellation, voltage sensitive latching relay and dual-slope integration. Unit price, depending on quantity, is $29.40 to $39.75 for the military version (CSH101A) and $22 to $29.75 for the industrial version (CSH101B). Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. Phone(617)491-1670. **180**

FREE "VARICAP" VARACTORS FOR QUALIFIED DESIGNERS. The TRW Varicap line is believed to be one of the broadest in the industry. It includes types with capacitance from 2.2 pF to 1000 pF at 1 MHz, Q of 100 to 700 and capacitance change ratios from 2:1 to 8:1. Design engineers need only fill out a simple form to indicate the technical parameters of the desired device and a brief description of the application. The proper Varicap is then shipped at no charge. To receive a copy of the request form, write Sales Manager, TRW Semiconductors, an Electronics Components Div., of TRW Inc., 14520 Aviation Blvd., Lawndale, CA 90260. Phone(213)-679-4561. **181**

CALCULATOR CHIP HAS POWER-SAVING FEATURES. A 9-digit, 28-pin calculator chip, designated type 4206, features an internal-clock generator, low-battery indication circuit, automatic power-on clearing and right- or left-hand entry capability. The 4026 also has an automatic power saver which changes the internal-clock frequency when the chip is sitting idle. Normal operational power of 50 mW is thereby reduced to approx. 20 mW. Power required by display devices can also be reduced. After depression of any key, a delay is triggered which causes the display to be turned off after from 10 to 30 sec. Nortec Electronics Corp., 3697 Tahoe Way, Santa Clara, CA 95051. Phone(408)732-2204. **182**

SEMICONDUCTORS



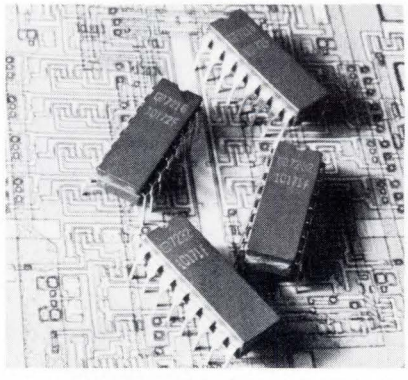
HIGH-SPEED DIODE-SWITCH DRIVERS ARE TTL COMPATIBLE. Two high-speed switch drivers for use with shunt, series and series/shunt diode switches are available from stock to 20 days including units screened to MIL-STD-883 Level B. Models SD-1001A and SD-1003A are noninverting, switch drivers which exhibit less than 10-nsec total switching time. Both units are designed to operate from a 12V power supply. Steady-state output current is ± 30 mA (1001A) and ± 10 mA (1003A). Convenient dc testing of these microwave switches is provided by a built-in circuit. Price in quantities from 1 to 9 is $65. LRC, Inc., 11 Hazelwood Rd., Hudson, NH 03051. Phone(603)883-8001. **183**

4-CHANNEL SCHOTTKY SENSE AMPLIFIERS ARE ac COUPLED. The TSA 1544 is designed for application in the military temperature range (−55°C to +125°C) and its companion unit, the TSA 1444, is designated for the industrial range (0°C to 70°C). They are designed for high-speed plated wire and thin-film memory applications. The circuit selects 1- of 4 differential inputs by means of 2 channel select inputs and can detect a signal from memory of less than 1m. TSA 1544 is $12.75 in 1-24 quantities and $10.25 for 25-99. Delivery is from 6 to 8 weeks. Transitron Electronic Corp., 168 Albion St., Wakefield, MA 01880. Phone(617)245-4500. **184**

100-W DARLINGTONS FEATURE GAIN OF 750. Designated 2N6055 and 2N6056, these 60 and 80V devices are manufactured with a double epitaxial construction which provides good forward and reverse second-breakdown capability. Their high gain makes it possible for them to be driven from ICs without the need for a predriver in the low- and medium-frequency power applications for which they are designed. Type 2N6055 is priced at $1.50, and 2N6056 at $1.67, in 100-unit quantities. RCA Solid State Div., Box 3200, Somerville, NJ 08876. Phone(201)722-3200, Ext. 2561. **185**

BROADBAND TRANSISTORS ARE INTERNALLY MATCHED. The PH2010C delivers a reliable 10W broadband 1.8 to 2.1 GHz with 2.7W of drive and 28V. Typical narrowband performance at 1.5 GHz is 17W. The MAC-PAC series features multi-cell, gold metalized, emitter ballasted, transistor chips and MOS capacitor matching. The result is a ruggedized transistor with very low thermal impedance. This series can be operated in both class C and linear class A applications. Price: 1-24 quantity, $165. Power Hybrids, Inc., 1742 Crenshaw Blvd., Torrance, CA 90501. Phone(213)320-6160. **186**

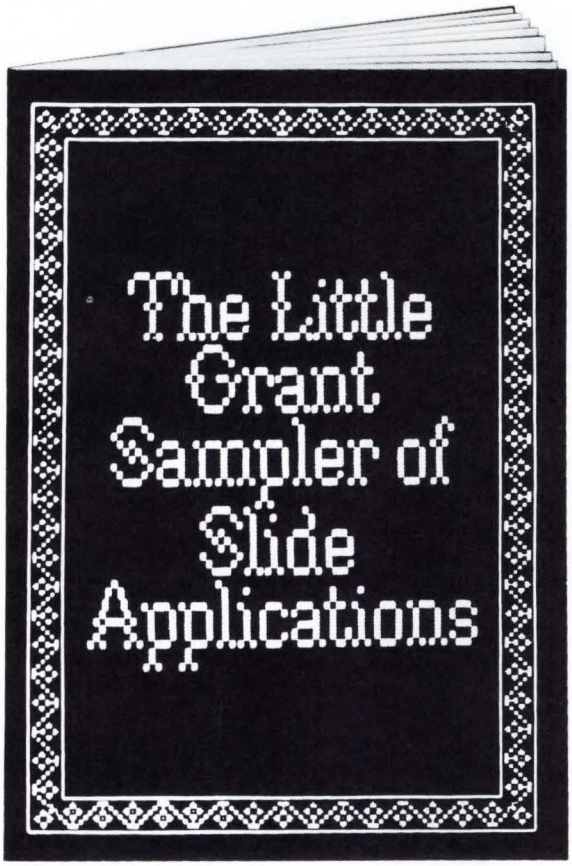
LOW PRICED PLASTIC TRIACS ARE RATED AT 6A. Types 41014 and 41015 are gate controlled full-wave ac switches with 3 leads to facilitate mounting on pc boards. They have on-state current ratings of 6A at a case temperature of 80°C, peak surge full-cycle ratings of 60A and repetitive off-state voltage ratings of 200V (41014) and 400V (41015). The JEDEC TO-220AB package provides ease of mounting and low-thermal impedance, which allows operation at case temperatures up to 100°C and permits reduced heat-sink size. $0.94 in 100 units for the 41014, and $1.13 for the 41015. RCA Solid State Div., Box 3200, Somerville, NJ 08876. Phone(201)722-3200, Ext. 2561. **187**



DEMULTIPLEXER'S ICs DECODE DATA IN 4.0 NSEC. Two high-speed ECL circuits have been designed for use as dual 1-line-to-4-line demultiplexers in crossbar switch applications as high-fanout 1-of-4 decoders and as memory chip select decoders. Outputs of the model 10171 are HIGH until selected, at which time they go LOW. Outputs of the second IC—the Model 10172—are LOW until selected, at which time they change to HIGH. Data paths are noninverting. When purchased in lots of 100, the price is $5.42 each. Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. Phone(408)-739-7700.

FREE SAMPLER

There is now available a little booklet **which shows 20 ways** in which 20 manufacturers have used **Grant Slides to make** their products better and more efficient.



The products range from refrigerators to radio receivers, medical equipment to trailer bodies and military electronics to piece goods manufacturing machinery.

Slides make sense. They take hold of good products and increase their value. They can add dollars to your sales cost/product because your customers want (and need!) the performance only slides can produce.

The little sampler book of slides will make for fast, interesting reading. It can be quite a money saver, too!

Free, on request.

GRANT
WE KEEP THINGS MOVING

GRANT HARDWARE CO., a division of Buildex Incorporated
81 High Street, West Nyack, N.Y. 10994

Circle No. 46

THE MINNESOTA TWINS

46 of these . . . 0.125 ctrs.

46 of these . . . 0.100 ctrs.

Here's a hot new idea in direct card connectors . . . our new Series 9 has 92 standard models: 0.100 or 0.125-inch centers, *any* number of dual positions from 5 to 50! Bifurcated dual contacts, 5 mounting options, .025 sq. wrap tails. Between-contact polarization even on the 0.100-inch size. And we won't freeze you out on delivery . . . or cost, they're all standard!

Write for free information today:

NATIONAL CONNECTOR
5901 So. County Road 18 / Minneapolis, Minnesota 55436 / (612) 935-0133
DIVISION OF FABRI-TEK INC.

Circle No. 44

Another Beede digital panel meter

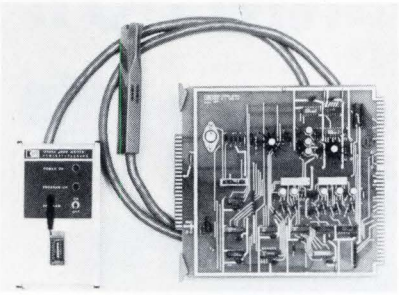
- Up to twelve indicator lights available in Model DM-232 for displaying an instrument setting such as a switch position, range, alarm, etc. Illustration shows Beede DPM used in General Radio Co.'s Linear IC Tester Model 1730.
- Other models in line offer suppressed readings, linearization, special noise rejection, multiple range, adjustable conversion rate, ratiometric readings, etc.
- Optional 60-pin solder-type edge connector includes BCD output for driving printers and other digital instruments.
- Heavy dust-sealed diecast case leaves plenty of room for additional circuitry.
- 3½ digits plus automatic polarity sign and selectable decimal-point position.

Write for Bulletin DM-2. Beede Electrical Instrument Co., Inc. Penacook, N.H. 03301. Phone (603) 753-6362; TWX 710-364-6977.

BEEDE 5387

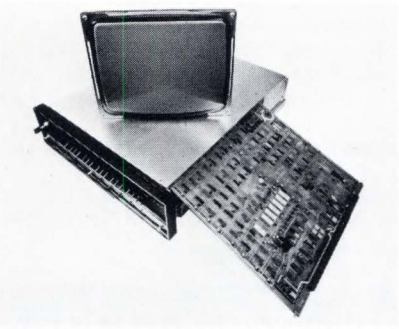
—anyone else would call it a "special"

Circle No. 45

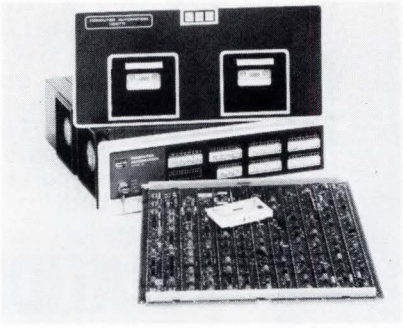


MINICOMPUTERS CAN BE USER MICROPROGRAMMED. The 2100S is offered with both hardware and software for microprogramming. Users can store 256, 24-bit microinstructions on each of 3 writeable control store (WCS) cards. A single WCS module provides enough user programmable storage to effectively double the machine's instruction set. The programs on these WCS modules can be read or written under program control. For permanent storage, the microprograms can be fused by the computer's pROM writer into read-only-memory chips. The 2100S is supplied with a complement of 102 microinstructions and 86 basic machine language instructions. Cycle time is 196 nsec. $16,000 or lease. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. Phone(415)493-1501. **277**

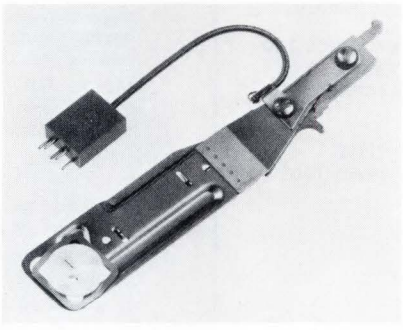
FREE METRIC CONVERTER will help to make every design engineer's conversion to metrics easier. This unique pocket-size calculator will assist the design engineer in converting lengths, areas, weights and volumes quickly and easily from the in./lb system to metrics. It provides dual dimensioning at a glance, right in the palm of the hand. Also included in the converter is a quick conversion table of standard weights and measures, a fahrenheit to centigrade conversion table and a simple in. or metric rule. Compact 8 × 3-3/4-in. size fits any pocket. American Koyo Corp., 500 Westgate Plaza, Box 16038, Cleveland, OH 44116. Phone(216)333-4250. **278**



CRT CONTROLLER IS MOUNTED ON NOVA-TYPE pc CARD. An alphanumeric display for Nova™ computers, the Lexiscope 2000 features a 2000-character MOS-RAM organized to give a convenient 80-column × 25-row format. Use of a random-access memory eliminates latency time and the need for interrupt programming. It also includes a complete keyboard control at no extra cost. Operation of the display and keyboard control does not require the use of the teletype interface. Lexicon Inc., 60 Turner St., Waltham, MA 02154. Phone(617)891-6790. **279**



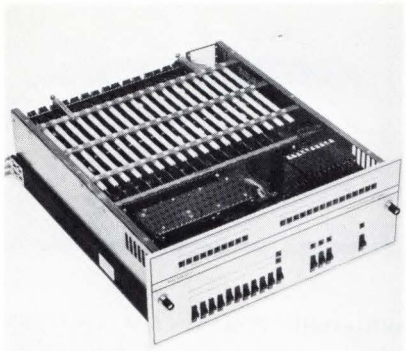
CASSETTE SYSTEM FEATURES HIGH-SPEED SEARCH. Available in a single, dual, triple or quad configuration, the system reads and writes at 12 IPS and searches at 120 IPS. Single cassette storage capacity is about 250,000 bytes on a standard 300 ft tape. In direct access mode of operation, the system devotes one of its dual tracks to prewritten marks so that the entire length of the tape can be treated as a sectored disc. Individual sectors can be addressed directly at high speed so that the entire tape can be searched with a nominal access time of 10 sec. The complete single cassette system, including the cassette transport, interface controller, cabling and software, is priced at $2850. Computer Automation Inc., 895 W. 16th St., Newport Beach, CA 92660. Phone(714)642-9630. **280**



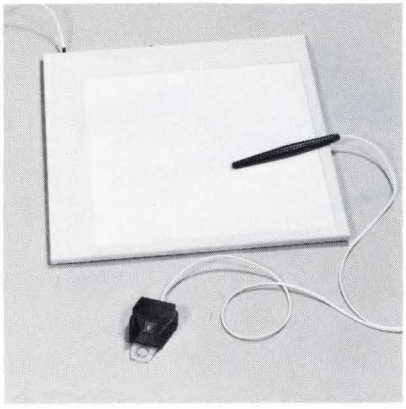
DISC-PACK RECORDING HEAD is designed for the updating of 2314 systems to 3330 capability. Model R 4400-NT is ideal for use in quadruple density 2314-type and cartridge disc-pack systems. It writes 200 tracks/in., with a recording density of 4400 bpi. The read/write head has the same flying height as conventional 2314 heads. Operating frequencies are 1.25 and 2.5 MHz nominal. Output signal is a minimum of 1mV, and resolution exceeds 50%. Operating environment is 60°F to 120°F. Each head is supplied with detailed dynamic test and mechanical data. Information Magnetics Corp., 5743 Thornwood Dr., Goleta, CA 93017. Phone(805)964-6828. **281**

HAND-HELD COMPUTERS FEATURE PROGRAMMING MEMORIES. The micro computers feature 2 scratchpad-program memories, with 80 steps each. Models 324 Scientist and 344 Statistician enable the user to have 2 separate programs in memory at the same time. The user performs his calculations once and it is available for automatic execution. Also the program may be verified while entering it. The statistical model can be programmed to perform such analyses as nonlinear regression, chi square and analysis of variance. The Models 324 and 344 are battery operated, have multiple-storage registers, and calculate with true 13-digit accuracy. Computer Design Corp., 12401 W. Olympic Blvd., Los Angeles, CA 90064. Phone(213)829-3501. **282**

TAPE SYSTEM IS COMPATIBLE WITH ALL MINIS. All DEC Tapes® and classic LINC tapes may now be read and written on Novas equipped with a CO-500 LINC tape with a CO-571N option. This permits interchange of all existing 10-track format tapes between Novas and all DEC equipment. Thus, data bases created on DEC Tapes may be processed on Data General equipment. In addition, data produced on Data General equipment may now be processed by DEC machines. Similar capability will soon be available for other machines. The option is available on any Nova/LINC system for $850 at the time of order. Computer Operations, Inc., 10774 Tucker St., Beltsville, MD 20705. Phone(301)937-5377. **283**



DATA-ACQUISITION SYSTEM INTERFACES WITH MINICOMPUTERS. The Milliverter II accommodates up to 64 low-level signals for as little as $125 per channel, 256 high-level channels for less than $35 per channel, or any combination of low- and high-level signals. Because of its modular construction, the unit can be expanded at any time to 1024 channels for 20-30% less than comparable systems. The system features either fixed or programmable gain track and hold amplifiers. The high-resolution, 15-bit analog-to-digital conversion occurs in less than 15 μsec. $3250 plus amplifier cards. Data Technology, 2700 S. Fairview Ave., Santa Ana, CA 92704. Phone(714)546-7160. **284**

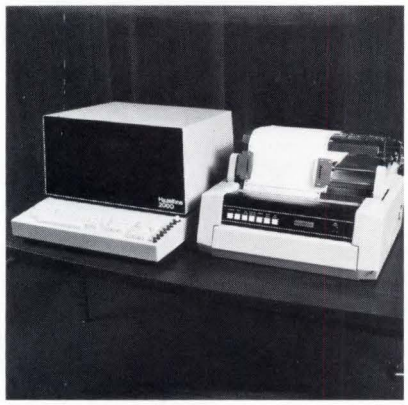


DATA TABLET FEATURES RESOLUTION OF ±0.005 IN. The data tablet is usable with both inking stylus and free cursor. It combines accuracy, linearity, stability and repeatibility all with less than 1/2 LSB error. It generates absolute coordinates in both point and stream modes at repetition rates variable up to 200 coordinate pairs/sec. Coding is either binary or BCD. Operation is silent, but an audible annunciator is available. The tablet is immune to environmental influences such a noise, dust, humidity and temperature. Tablets range from small to those large enough to accommodate E-size digitizing tasks. Scriptographics Corp., 398 Kings Highway, Fairfield, CT 06430. Phone (203)384-1344. **285**

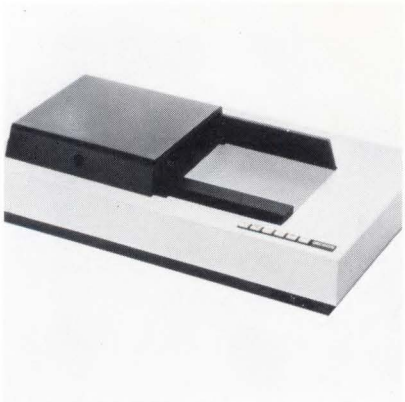
COMPUTER PRODUCTS

CRT TERMINAL HAS LARGE SCREEN AND CHARACTERS. The model 3001 CRT communications terminal features a 15-in. display that can display 80 alphanumeric characters per line over a 16-line field. The characters are between 25 and 50% larger than those of comparable computer terminals. The size of the characters are 0.25 by 0.10 in. arranged on a 5 × 7-in. dot-matrix format. The units have full and half-duplex operation. Other standard features include blink, automatic key repeat, addressable cursor and switch-selectable send rates. Interactive Terminals Corp., Southfield, MI 48076. Phone(313)352-6233. **286**

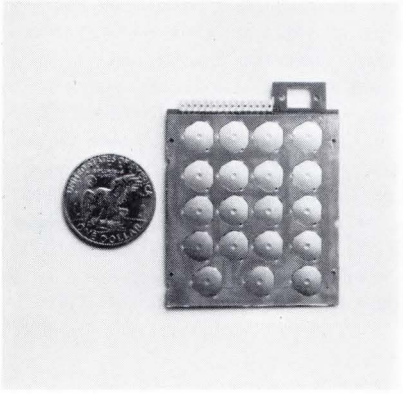
MINIATURE PCM DECOM FEATURES TWO'S COMPLEMENT CONVERSION. The Model ECO-3 PCM encoder-checkout unit is a miniature stored format frame, subframe demultiplexer and word selector that operates directly from a PCM encoder or from a bit synchronizer. The features of the ECO-3 include 4 switchable formats, data rates from 1 bps to 5 Mbps, decimal thumbwheel selection of any word from the frame or subframe, data word display via decimal LEDs and via digital LEDs, and code acceptance compatible with IRIG 106-71. Also featured are parity checking and subframe synchronization. Under $3700 with 60 days delivery. Coded Communications Corp., 1620 Linda Vista Dr., San Marcos, CA 92069. Phone(714)744-3710. **288**



PRINTER DESIGNED FOR CRT TERMINALS. High-print quality provided by an engraved font and a low-noise level are 2 features of this impact printer. The interface has been specially designed for the Hazeltine 2000 terminal. The printer is available in 2 basic configurations. Model 1200 prints at speeds up to 120 cps with a choice of 80- or 120-column carriage widths and has a tractor-type paper feed. Model 300 prints at speeds up to 30 cps and is available in 80- or 118-column carriage widths with friction, pin or tractor feed. $3400 for Model 300 and $3995 for Model 1200. Hazeltine Corp., Greenlawn, NY 11740. Phone(516)261-7000. **287**



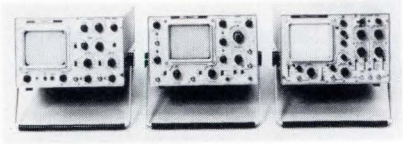
DATA-ENTRY SYSTEM USES OPTICAL SCANNING. The OMR 6500 moves optical-reading devices scanning a fixed page, rather than continuously moving paper across a scanning device. Paper may be fed manually or an automatic-paper feeder is available that moves the page after it has been fully scanned. Even folded, mutilated and spindled paper can now be read. It can read data as an off-line optical reader, or, when connected to a computer, data-entry or processing system, can be placed under complete program control. Error detection and data formatting can be interactively accomplished under program control extension. $4900. DECISION, Inc., 5601 College Ave., Oakland, CA 94618. Phone (415)654-8626. **289**



CALCULATOR KEYBOARDS AVAILABLE AS pc BOARDS with the snap-action contacts in place, or complete with key caps and metal frame as a finished assembly. The pc board has circuitry an 1 side only, with no staples or plated holes to create circuit problems. This means that the board has a completely insulated back which electrically isolates it from the remaining calculator electronics. The board also features a low profile and a unique 3-point mounting design for the contact button which assures positive contact-wiping action. Bowmar Instrument Corp., 8000 Bluffton Rd., Ft. Wayne, IN 46809. **290**

CARD READER RECOGNIZES ERASURES. The MR 300 optical-mark reader features a unique vacuum pick and has a hopper capacity of 450 cards. Operating at speeds of up to 300 cards/min., it is one of the few optical-mark readers that reliably recognize an erasure as "no mark" and yet recognizes a mark reinserted into a smudged erasure area. Also, it does not require special pencils or "completely filled-in" blocks. Each card passing through the unit is closely monitored for potential trouble conditions such as "feed", "motion" and "stack" error. If any are detected, a monitor light signals the operator, and the unit stops. Electronic Associates, Inc., W. Long Branch, NJ 07764. Phone(201)229-1100. **291**

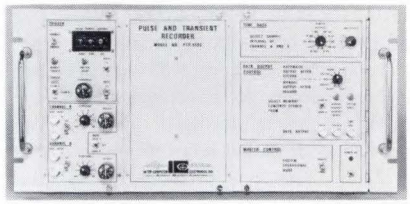
FIXED-HEAD DISC MEMORIES FOR TIME-CRITICAL APPLICATIONS. The FASTRACK™ 3 family of fixed head disc memories speed throughput and terminal response times for virtual memory systems. It is available in #3600 rpm and 6000 rpm, both with 120,000 bits per track. The 010 Series has a useful capacity of 1.875 megabytes. The 100 Series models have useful capacities of 2.8325, 5.675 and 11.25 megabytes. Pacific Micronetics, Inc., 5027 Ruffner St., San Diego, CA 92111. Phone (714) 279-7500. **292**



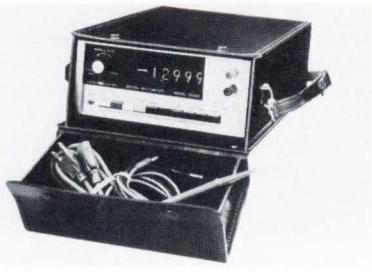
THREE NEW SCOPES. Model 1040A $1200 dual-channel 40-MHz unit has delayed and mixed sweeps, a 10-kV 8 × 10-cm CRT, 1-mV/cm sensitivity, and up to 200 nsec/cm sweep (20 nsec/cm with 10X magnifier). The $745 20-MHz 5-mV/cm (up to 1 mV/cm with cascading) Model 1066B, a replacement for the 1066A, has an 8 × 10-cm CRT, ac, dc and TV frame-rate and line triggering, a delay line, and up to 500 nsec/cm sweep speed (50 nsec/cm with magnifier). The $495 10-MHz 5-mV/cm dual-channel Model 1010A has up to 1 μsec/cm sweep (100 nsec/cm with magnifier), and ac and TV-frame triggering. Ballantine Laboratories, Inc., Box 997, Boonton, NJ 07005. Phone(201)335-9000. **189**

THERMOCOUPLE-LINEARIZER AMPLIFIERS cover −100°F to +2000°F in 8 models. The modular units convert the outputs of thermocouples to a displayed 1 mV/degree and offer the convenience of being located close to the point of measurement. An 8-segment analog system provides a conformity of ±1°F to NBS type J, K, and T thermocouple curves. They can be specified in either °F or °C and have resolutions and repeatabilities of 0.1°F or °C. Reference-junction compensation error is ±0.05°F for a 1°F ambient-temperature change. Required power is ±12V at 25 mA. $249. Electronic Research Co., 10,000 W. 75th St., Overland Park, KS 66204. Phone(913) 631-6700. **190**

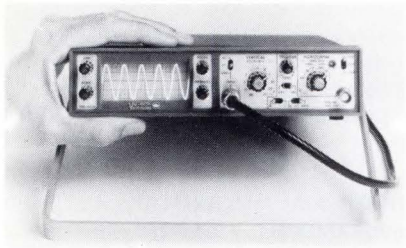
ULTRA LOW-POWER/SIZE 3 TO 4-1/2-DIGIT DPMs HAVE 3-YR WARRANTIES. The Impac line of 3, 3-1/2, 4 and 4-1/2-digit units, all within 1.7-in.² of front-panel space and 3-in.³ of behind-the-panel volume, consume only 0.3W in standby and 1W when all LED characters are lit. Features include automatic zero, accuracy of 0.1% (3 and 3-1/2 digits) and 0.05% (4 and 4-1/2 digits), 7 and 10/sec sampling rates, 0°C to +50°C temperature range, 3.5-oz weight, standard BCD, strobe, end-of-conversion, sign and overload outputs, and 115/230V ac or +5V dc operation. $112 (3 digit), $125 (3-1/2), $169 (4), and $225 (4-1/2). Varian/Velonex, 560 Robert Ave., Santa Clara, CA 95050. Phone(408)244-7370. **191**



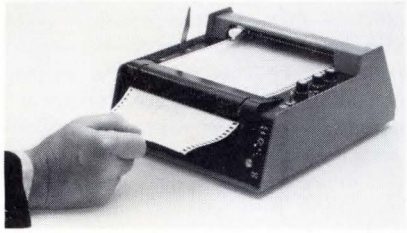
PULSE/TRANSIENT RECORDER DIGITIZES 8 BITS UP TO 100 MHz. Model PTR-9200 can store over 2800 words, records transient waveforms and repetitive signals, accepts differential inputs from ±50 mV to ±5V full scale, and store 110 points of baseline and leading edge of signal in the pre-trigger mode. The unit digitizes signals directly via an A/D converter, stores the data in a memory and transfers this data into a computer for processing at the required time without the use of a scope. Memory output speed is dc to 4 MHz and sampling interval is from 10 nsec to 50 sec. $9850. Inter-Computer Electronics, Inc., Box 507, Lansdale, PA 19446. Phone(215)822-2929. **192**



4-DIGIT DMM WITH 25 RANGES COSTS ONLY $595. Systron-Donner's Model 7004A offers ac and dc voltage measurements, ac and dc current measurements and resistance checks. Dc accuracy is 0.01%. Ac response extends to 100 kHz. Color coded pushbuttons simplify range and function selection. The input is fully guarded. A $95 rechargeable-battery pack option is available for internal mounting. Another option costing $45 provides BCD output for measurements to be recorded on digital printers. Systron-Donner Corp., 10 Systron Dr., Concord, CA 94518. Phone(415)682-6161. **193**

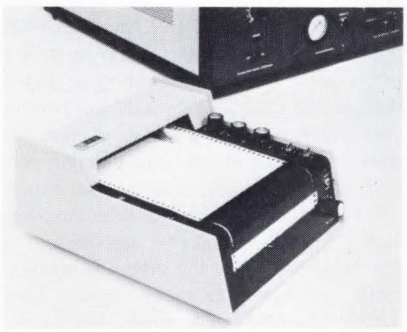


20-MHz 7-LB (WITH BATTERY) SCOPE FITS INTO A BRIEFCASE. The Model PS910A has dimensions of 1-3/4-in. high, 8-1/2-in. wide, and 12-in. deep. Besides operating from 8 "C" size rechargeable NiCd (up to 4 to 5 hrs), alkaline and carbon-zinc batteries, the scope can operate from the ac line as well. Sensitivity is 10 mV/div., sweep speed is 100 nsec/div. to 100 msec/div., risetime is 18 nsec, and the CRT has 4 × 10-1/4-in. divisions. Internal and external triggering is available with automatic or manual-level and slope selection. $595 plus $50 for set of 8 NiCd batteries. Vu-Data Corp., 7101 Convoy Ct., San Diego, CA 92111. Phone(714)279-6572. **194**



METRIC STRIP-CHART RECORDER COSTS ONLY $520. Model 726M offers chart speeds of 0.5, 1, 2, 4, 8 and 16 cm/min. and cm/hr spanning 1 mV to 100V full scale at a constant 10MΩ input impedance. Its accuracy is 0.5% of full scale and weight is 7 lbs. The 726M is designed with a front mounted fingertip control panel and an automatic clutch for rewinding or advancing. Disposable felt pens are standard and can be ordered with a remote pen lift. Options include battery operation, event markers, alarm-control switches and retransmitting potentiometers. Precision Standards Corp., 1701 Reynolds, Santa Ana, CA 92706. Phone(714)546-0431. **195**

HIGH-SPEED PULSER PAIR TEST TOP-SPEED LOGIC ICs. A pair of pulser plug-ins with repetition rates up to 100 MHz are designed for TTL-S, ECL-I, ECL-II and low-power ECL high-speed logic. Each has variable transition time, variable offset and a variety of output formats and operating modes. Each is externally controllable. Model 8007B holds nonlinearity of transition slopes under 3% (for transition times more than 20 nsec) and costs $1750. Model 1916A has 5% nonlinearity and costs $1290. Transition times may be varied from 2 and 2.5 nsec, respectively, up to 250 μsec. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone(415)493-1501. **196**



5-IN. SCALE POTENTIOMETRIC RECORDER COSTS $595. Model A-5 recorder features chart speeds of 0.5, 1, 2, 5, 10 and 20 cm/min. and cm/hr, full scale ranges of 1, 10, 100 and 1000 mV, pen-response time of 0.35 sec and accuracy of 0.5% of full scale. The A-5 has an adjustable zero setting over its full scale. Its input is single ended and floating and has a resistance of 10 MΩ. The input is critically damped on all ranges. Operation is from 115V ac 60 Hz or 220V ac 50 Hz. Varian Instrument Div., 611 Hansen Way, Palo Alto, CA 94303. Phone (415)493-4000. **197**

TRANSMISSION-LEVEL TEST SET WEIGHS JUST 35 LBS. Model 420 solid-state unit measures 2-wire return loss, 4-wire attenuation, impedance, frequency response and noise. It displays test results on a built-in scope and has swept and single frequencies from 50 Hz to 150 kHz. Other features include stepped attenuation control on transmitter and receiver, lighted display grid, automatic scale selection, battery operation ($300 option) and calibration check. $1995. Noise measurement is a $345 option. Wavetek, Box 651, San Diego, CA 92112. Phone(714)279-2200. **198**

OEM POWER SUPPLIES COME IN 2/3 RACK SIZE. Lambda's LX-8 Series has 7 single-voltage-output models: 5, 6, 12, 15, 20, 24 and 28V ±5% at 80, 70, 50, 45, 32, 30 and 28A, respectively, at 40°C, each with adjustable overvoltage protection. Each supply has no need for blowers and is convection cooled. All supplies contain Lambda's hybrid power-voltage regulator and are guaranteed for 5 years. Prices are $560 for each of the LX-8 models. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, NY 11746. Phone(516)694-4200. **199**

EQUIPMENT

DIGITAL-TEMPERATURE STANDARD HAS 0.1-DEGREE RESOLUTION. Model DS-350 transfer standard eliminates lookup tables by providing a direct and continuous digital display. The DS-350 is the indicator portion which works with a transfer standard that is optional. A built-in reference junction permits connection to the device to be calibrated with standard TC hookup wire. An overload protection circuit prevents damage to the standard even if the output is inadvertently connected to the ac power line. $1045. Doric Scientific Corp., 7601 Convoy Ct., San Diego, CA 92111. Phone(714) 277-8421. **200**

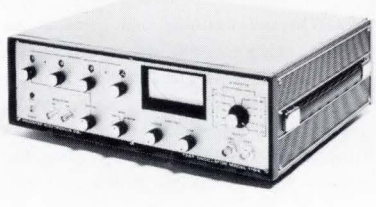
PRECISION ac/dc CALIBRATORS PROVIDE 0.005% dc-VOLTAGE ACCURACY. Series 300 E/I/R calibrators can be used for 3-, 4- and 4-1/2-digit meters, A/D converters and analog meters. Ac-voltage accuracy is 0.05%. Six voltage ranges are provided to 1 kV, 6 current ranges to 10A and 6 resistance ranges to 1 MΩ. Utilizing a single set of terminals for all tests, the calibrators use digital indicating dials for output settings, and a deviation dial for percent-of-reading error. Manual and remote programming operation is provided. Rotek Instrument Corp., 40 Guinan St., Waltham, MA 02154. Phone(617)899-4611. **201**

VOICE-FREQUENCY TRANSMISSION ANALYZER OPERATES FROM BATTERY. Model K2001 level tracer which can operate from the ac line as well, is an improvement over the older K211 unit. It is lighter in weight (approximately 33 lbs), smaller in sizer (approximately 17.6 × 7.7 × 17.5 in.), has a larger CRT display and features simplified controls. Its electronic sweep replaces the K211's mechanical sweep. Increased accuracy and sensitivity are also featured. The K2001 operates over 200 to 4000 Hz and costs approximately $4000. Siemens Corp., 186 Wood Ave. S., Iselin, NJ 08830. Phone(201)494-1000. **202**

IC-DISPLAYS TEST SOCKETS PROTECT READOUTS FROM DAMAGE. These sockets feature gas-tight elastomeric contacts which allow the testing of delicate liquid-crystal and MOS packages without any degradation of metallized-contact areas. The sockets can be obtained in integrated multiple stations which can be interconnected and/or multiplexed. Sockets are continuously rated at −55°C to +125°C, contact resistance is 0.1Ω and contact center distances are available down to 0.025 in. Chomerics, Inc., 77 Dragon Ct., Woburn, MA 01801. Phone(617)935-4850. **203**

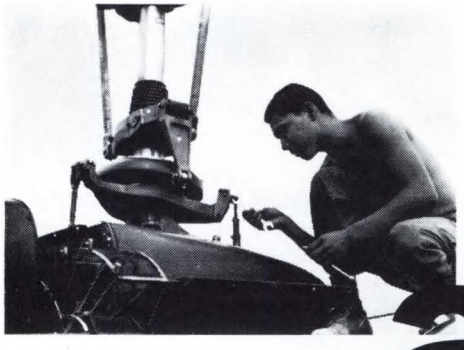
IR-THERMAL IMAGER SCANS AT UP TO 60 FRAMES/SEC. Model 209 is basically a closed-circuit TV system that observes heat images on a screen. Based on an indium-antimonide cryogenically cooled detector, the system's camera head scans an object for heat emission and converts these heat signals to electrical ones. Model 209 scans the 2 to 5.6-micron region and can resolve 0.5°C with a 10° field of view. Display modes include image and line-scan displays whereby a temperature vs position graph is shown. Dynarad, Inc., 1416-20 Providence Hwy., Norwood, MA 02062. Phone(617) 762-9450. **204**

COMPUTING RATIOMETER RIVALS MINIS FOR INDUSTRIAL APPLICATIONS. Model 290 preset unit utilizes ROMs for computing and conversion of dedicated functions that are sometimes done faster than with a minicomputer. It measures the period of 2 input frequencies, then digitally computes a ratio and displays it in terms of a normalized or preset readout. Its overall accuracy is 1 part in 10^5. Low-frequency ratios are measured to 5-digit accuracy in 1 sec. $1600. Time Systems Corp., 1130 W. Evelyn Ave., Sunnyvale, CA 94086. Phone(408)736-0840. **205**



PROGRAMMABLE 10-Hz TO 10-MHz OSCILLATOR HAS DIGITAL SELECTION. Model 110 sine-wave test source is said to maintain a constant output amplitude throughout its digitally selectable frequency range with 50 and 600Ω short-circuit-proof outputs. The oscillator features standard dc coupled AM and FM capabilities and remote programming. Output is 0.1 mV to 3V full scale over a 10-range attenuator and base price is said to be under $1000. Progress Electronics Co. of Oregon, 5160 N. Lagoon Ave., Portland, OR 97217. Phone(503)285-0581. **206**

Hire the veteran. Hire ability.

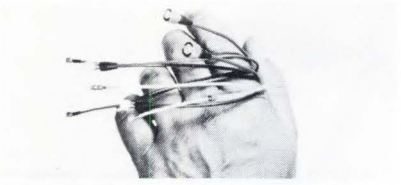


The ability to do a job well. To learn. To take orders. And to give them. ■ The Armed Forces spend over $3 billion yearly on training servicemen. That means many veterans have skills *you* can use from the moment they're hired. And if they need further training, monthly allowances under the GI Bill can supplement their wages while they are in approved training programs. ■ Hire veterans. Put their ability to work. ■ For help in hiring veterans, contact your local office of the State Employment Service; for on-the-job training information, see your local Veterans Administration office.

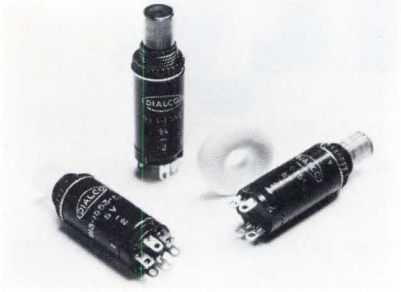
Don't forget. Hire the vet.

JOBS FOR VETERANS

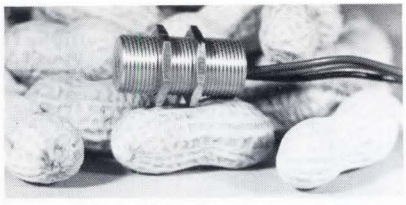
ADVERTISING COUNCIL



CONNECTORS ARE HERMETICALLY SEALED. This line of ultra-miniature 4-, 7- and 12-contact connectors feature hermetically sealed panel mounts. They are designed to meet the needs of high-density packaging in space, aircraft, ICs, instrumentation, transducers, and medical applications for every phase of electronics in industry and the military. The 4-, 7- and 12-contact connectors have basic outer diameters of 1/4, 5/16 and 3/8 in., respectively. Overall length of the plugs are less than 1/2 in. Prices are as low as $2.75 each in quantities over 1000. Microtech, Inc., 777 Henderson Blvd., Folcroft, PA 19032. Phone(215)532-3388. **243**

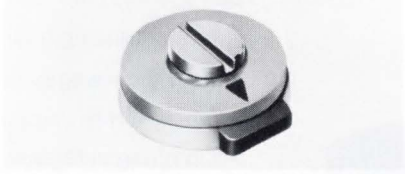


MOMENTARY-ACTION SWITCH CONTAINS LED. Model 913 miniature switch has a LED for its light source and operates from a 5V dc supply. The switch is ideal in applications where extra-long life or low power is required. It is supplied with a long, cylindrical lens cap with an internal-fresnel ring for uniform light distribution. Its overall dimension is 1.790 in. In quantities of 1000 each switch is priced at $2.59 each for N.O. and N.C. and $2.73 each for 2 circuit. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. Phone(212)497-7600. **244**



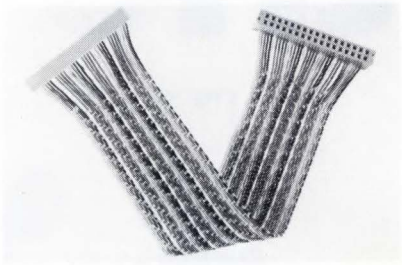
SOLID-STATE SWITCH HAS THREADED BUSHING. The 103SS line of switches offers a magnetically operated Hall-effect chip encased in an in.-long package that is moisture and shock resistant. The switches are designed to operate at up to 100,000 times/sec. The switches also use current-sinking output. Ratings for the 103SS line include supply voltages of 9V dc (continuous) and 10V dc (pulsed); a load voltage of 10V dc; output loads of 10 mA and an operating temperature range of −55°C to +105°C. (−67°F to +221°F). Maximum electrical characteristics include a supply current of 4 mA; an output voltage of 0.4V; an output leakage of 5 μA; an output switching rise time of 0.5 μsec and fall time of 0.5 μsec (10% to 90%). Micro Switch, Div. of Honeywell, Inc., 11 W. Spring St., Freeport, IL 61032. Phone(815)232-1122. **245**

CERAMIC PACKAGE HAS LARGE DIE ATTACH CAVITY. The AlSiPak brand 600 Series side-brase DIP package has 0.300-in. square die attach cavity for LSI-type circuits. Packages in this series are available with 24, 28 and 40 leads. These packages feature all-alumina, monolithic ceramic construction for maximum reliability. They are available in white or black 94% alumina. Such standard features as a special disconnect notch with which to isolate the seal ring and the chip pad are included. Prices, in 100,000 unit lots, will range from 88¢ each for the 24-lead package to $1.25 for the 40-lead package. American Lava Corp., Chattanooga, TN 37405. Phone(615)265-3411. **246**

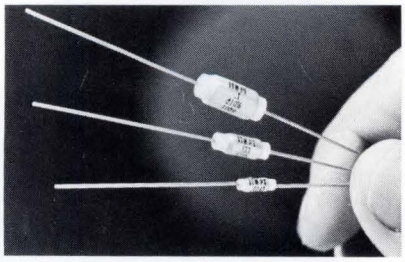


CAPACITOR DEVELOPED FOR THICK-FILM HYBRID AND pc MOUNTING. The diameter of the vertical-tuning subminiature ceramic capacitor is 0.212 in. except for the terminal portion, which is 0.232 in. The projecting "ears" on the stator are metallized to provide terminal points. The high-alumina stator is designed for convenience in handling and soldering to the substrate or pc board. Both the rotor and stator have lapped-bearing surfaces for smooth tuning and long life. Nominal capacity range if 5.0 to 35.0 pF. Working voltage is 100V dc to 85°C and 50V dc to 125°C. E.F. Johnson Co., Waseca, MN 56093. **247**

INDUCTOR FEATURES ELECTROMAGNETIC SHIELD. The IMS-5 meets the requirements of MIL-C-15305D, Grade I, Class A (MS-75087, 88, 89). Produced in an inductance range from 0.10 to 100,000 μH, the inductance tolerance is ±10%. Self-resonant frequencies are from 250 to 0.11 MHz and rated dc current is from 1790 to 11 mA. Protected by a flame-retardant epoxy molded covering the IMS-5 is 0.410-in. long × 0.162-in. diameter. 46¢ each in 1000 quantities, 1 μH value. Dale Electronics, Inc., Box 609, Columbus, NB 68601. Phone(402)564-3131. **248**

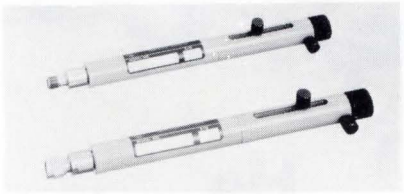


WOVEN FLAT CABLE DEBUTS. The cable has been designed for the electronics user who wants flat-cable configurations, color coded random wiring and the electrical properties of twisted pairs. Parallel-lay and twisted-pair configurations are available in 28-gauge PVC insulated stranded wire and the standard NEMA 10-color code. Conductor counts are available up to 25 twisted pairs or 50 wires parallel lay. Also available in 28 ga. are versions with FEP insulation. A 24-gauge stranded-wire cable in 18-pair twisted and 36-wire parallel lay with PVC insulation also is offered. 3M Co., Box 33686, Dept. EL3-4, St. Paul, MN 55133. Phone(612)733-1590. **249**



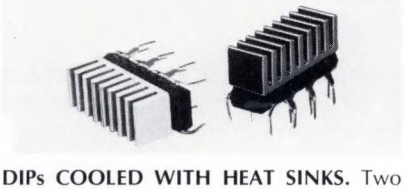
POLYESTER FILM CAPACITOR. A polyester-dielectric capacitor with a range of 0.001 to 0.15 mf at up to 600V is expected to replace traditional wrap and fill types of capacitors. Smaller in size than conventional wrap and fill capacitors, the polyester micromatic is available with tolerance range of ±5 to ±20%. The capacitor's 20-gauge tinned, steel-core copper-wire leads serve as the winding mandrels in their manufacture. Electrode foils and lead wires are separated by 3 layers of dielectric and no dielectric is in direct contact with a lead wire in the electrical field. This insures against voltage breakdown in the area of lead-wire penetration. Paktron, Div., Illinois Tool Works, Inc., 1321 Leslie Ave., Alexandria, VA 22301. Phone(703)548-4400. **250**

COMPONENTS/MATERIALS

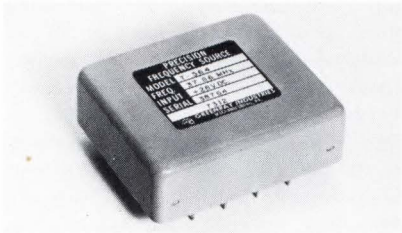


SLIDING TERMINATIONS USE MINIATURE CONNECTORS. The Model 450 and 480 are movable low-reflection terminations utilizing MSM miniature connectors (equivalent to OSM). The units are available with male or female connectors and feature low-terminating element VSWR over their full range. The Model 450 is designed to cover the 1.8 to 12.4 GHz range while the Model 480 covers 8.2 to 26 GHz. The Model 480 has the additional feature that its center conductor is movable, allowing it to achieve a butt condition of the center contacts. This eliminates the discontinuity which can be excessive at the higher frequency ranges. Maury Microwave Corp., 8610 Helms Ave., Cucamonga, CA 91730. Phone(714)987-4715. **251**

WIREWOUND-TRIMMER POTENTIOMETERS. Five series of low-cost, high-quality, pots include a 1-1/4-in. rectangular unit, Series 40; a 1/2-in. sq trimmer, Series 20; 2 5/16-in. cube trimmers, Series 30 and 31; and a 3/8-in. sq unit, Series 70. Except for the Series 70, all of these devices are rated at 1W at 70°C, and are supplied in 12 standard resistances from 10Ω to 50 kΩ, ±10% tolerance, with operating temperature range of −55°C to +125°C. The Series 70 is rated at 0.75W at 85°C in standard resistance values from 10 to 20 kΩ. TRW/IRC Potentiometers, 2801 72nd St. N., St. Petersburgh, FL 33733. Phone(813)347-2181. **252**



DIPs COOLED WITH HEAT SINKS. Two heat sinks for protecting plastic and ceramic DIPs, the 650 and 651 type coolers allow lower-operating temperatures for applications that are marginal without a heat sink. Two types are required to provide the extruded-fin direction needed by the air-flow requirement in natural or forced convection. Type 650 and 651 are made of extruded aluminum alloy 6063-T5 per QQ-A-200 with black anodize ("B" suffix) or gold iridite ("G" suffix) finish. Prices: 1-2500 quantity: Types 650-B and 651-B, 22¢; 650-G and 651-G, 19¢. Wakefield Engineering Inc., Audubon Rd., Wakefield, MA 01880. Phone(617)245-5900. **253**



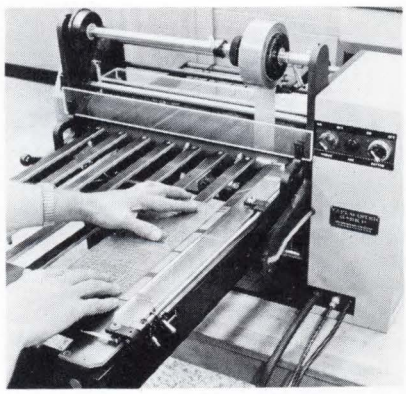
OSCILLATORS ARE TEMPERATURE COMPENSATED. The Model T-563 thru T-569 Series crystal oscillators provide frequency stability up to $\pm 5 \times 10^{-7}$ over $-40°C$ to $+70°C$ without the use of an oven. This stability is attained by using electronic compensation which results in lower cost, smaller size, increased reliability and lower power consumption. Models are available from 3 to 600 MHz. Output is available in sine wave or square wave, compatible to TTL logic up to 100 MHz. Package size is approx. 5 cu. in. Greenray Industries, Inc., 850 W. Church Rd., Mechanicsburg, PA 17055. Phone(717)766-0223. **254**

RELAYS FEATURE SPIRAL-WRAP COIL CORE. Series 12 general-purpose relays are designed to minimize eddy-current losses for cooler and more efficient operation. Available operating voltages include 6-110V dc or 6-230V ac. Nominal coil power is 1.2W dc or 2.0 to 2.7 VA ac, continuous duty. Contact arrangements include SPDT, 2PDT or 3PDT and are rated at 10A resistive 24V dc/115V ac. A variety of standard mounting styles are available, with or without dust cover. Prices in 100 quantities start at $2.24. North American Philips Controls Corp., Frederick, MD 21701. Phone(301) 663-5141. **255**

FLAT-TOP LAMP IS ONLY 0.912-IN. LONG. Ready for easy mounting on pc boards, the T-2 TU-PIN subminiature lamp series may be used in a wide variety of applications, including status indication for panel display of logic circuits, busy lamp fields, (such as PABX) and when used with color lenses, for general fault or status indication. Diameter is only 0.240 in. Mounting construction makes the T-2 series interchangeable with T-1 3/4-in. bi-pin types. Seventeen voltages from 4 to 48V are offered, with current ranges from 12 to 80 mA. Price is 36¢ in 1000 piece quantities. Sylvania Miniature Lighting Products Inc., W. Main St., Hillsboro, NH 03244. Phone(603)464-5533. **256**

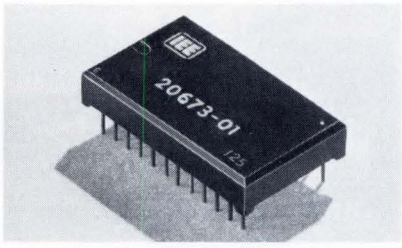
20-POSITION ROTARY SWITCH HAS ENVIRONMENT PROOFING. This rotary switch has 20 positions at 18° indexing. Switch diameter is 1-1/8 in. Each deck consists of 3 modules and 2 rotors and is completely enclosed. One-piece terminals and contacts are molded into the body of the switch. Internal interconnection of adjacent terminals and decks eliminates soldering. Several options are available on this newly designed rotary, including multi-deck, adjustable or fixed stops; optional contact materials; dual-concentric control; attached line switch and/or potentiometer; front, rear vertical or side position pc terminals. Stackpole Components Co., Box 14466, Raleigh, NC 27610. Phone(919)828-6201. **257**

pc BOARD JUMPERS PLUG INTO PREMOUNTED PIN SOCKETS. These round-conductor circuit-board jumpers featuring excellent flex life, uniform electrical characteristics, light weight, and low cost, provide a reliable, quick connect/disconnect interconnection between 2 boards. Series FLR features precision placement of insulation, leaving exposed conductors in an absolutely clean and undamaged condition, ready for plating and insertion into the sockets and/or plated thru holes. The mating-pin sockets for use with these jumpers are individually mounted directly into the pc board. Flex-Link Products, Inc., 1923 First St., San Fernando, CA 91340. Phone(213)365-9355. **258**

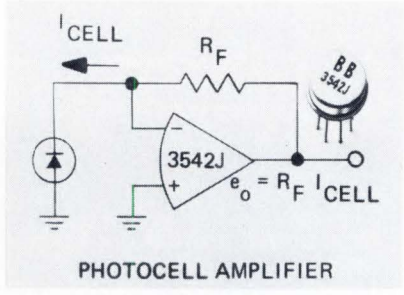


TAPE DESIGNED FOR pc PROTECTION DURING ELECTROPLATING. Scotch-brand electrical tape 1280, a differential-plating tape, prevents electroplated build-up of tin/lead or bright acid on pc patterns during solder stripping and final gold or rhodium plating of finger tabs. It can be used in differential- or dual-plating operations. The tape features excellent mask-line resolution and can be applied in continuous production. It can be removed from pc boards without adhesive transfer. Dielectric Materials and Systems Div., 3M Co., Box 33686, St. Paul, MN 55133. Phone(612)733-9654. **259**

MAGNETICALLY OPERATED HALL-EFFECT SWITCH IS 1/8-IN. THICK. Model 6SS makes use of a Hall-Effect sensor, a trigger and an amplifier on a silicon IC chip. The switch is magnetically operated and works from −55° to +125°C. It can function at up to 100,000 operations/sec, has a digital output, and can sink 4 mA per output for a max. output voltage of 0.4V. The 6SS accepts supply voltages of 9V dc continuous and 10V dc pulsed. Max. load voltage is 10V dc. Rise and fall times are 0.1 and 0.2 μsec, respectively. Micro Switch Div. of Honeywell, Inc., 11 W. Spring St., Freeport, IL. Phone(815)232-1122. **260**

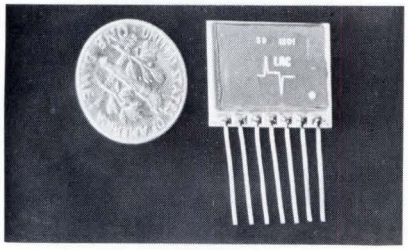


HYBRID DECODER/DRIVER COMES IN A 24-PIN DIP. Series 20673 has overall dimensions of 0.762 × 1.277 in. and a high-drive capability of 300 mA at 30V. Operating from a standard 5V logic supply, the chip is designed to decode 8-4-2-1 BCD to 12 outputs, or, if only 10 decoded outputs are required, the 2 remaining may be connected as lamp buffers. It is DTL/TTL compatible, with or without memory, and features lamp blanking as standard. Model 20673 in reverse-data style costs $17 (1000 quantities). Industrial Electronic Engineers, Inc., 7720 Lemona Ave., Van Nuys, CA 91405. Phone (213)787-0311. **261**



PHOTOCELL AMPLIFIER

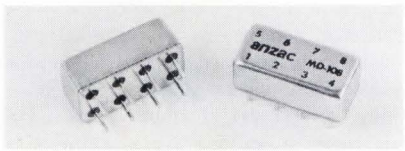
LOW-COST IC FET OP AMP FEATURES ±50 μV/°C DRIFT. Model 3542J offers guaranteed input bias current of −25 pA at 100-quantity unit price of $4.50. Hermetically sealed in a TO-99 package, the unit is pin compatible with 741 op amps. Source impedances up to 1 MΩ, initial voltage offset of as low as 20 mV at 25°C and the minimum dc voltage gain of 88 dB are other features. Full-power frequency response is 8 kHz and slew rate is 0.5 V/μsec. Output is ±10V at ±10 mA. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706. Phone(602)294-1431. **262**



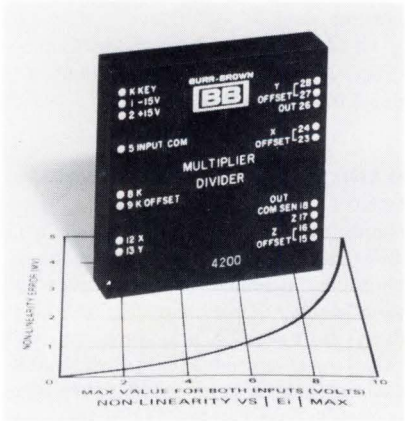
SPST SWITCH DRIVER HAS ONLY 10-nsec DELAY. Compatible with TTL Model SD-1201 used with shunt and series switches provides both positive and negative outputs. Ten switches can be driven from each TTL gate. Demand-current spikes are provided to facilitate high-speed switching by injecting and removing carriers from the switching-diode junction. Supplied in a flat-pack, it meets MIL-STD-883 and operates over the temperature range of −55°C to +125°C. The switch driver features fail-safe operation. $85. LRC, Inc., 11 Hazelwood Rd., Hudson, NH 03051. Phone(603)883-8001. **263**

7-BAR SEGMENT DISPLAY COSTS DOWN TO $2.30 (1000 quantities). The Series 1080 is also being offered 18¢ per lamp in the same quantities. This "easy-to-read" unit features standard based lamps for ease of installation and replacement (front or rear), single-plane viewing, a choice of screen colors (red, blue, green, grey or amber) and a plug-in package with no external hardware. Available options include a caption display with up to 6 message areas, conventional rear-projection 12-message display, decimal points and/or colon and a module with + and − and overflow "1". Industrial Electronic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405. Phone (213)787-0311. **264**

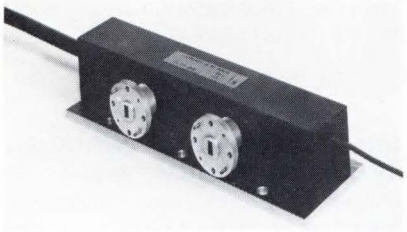
412-IN.³ POWER SUPPLY DELIVERS 500W. The 668 Series delivers this output power over the operating temperature range of −20°C to +40°C without moving-air requirements. Efficiency is 70% and combined line and load regulation is ±0.2%. Model 668A-05 with 5V at 100A operates from 102 to 130V ac or 198 to 256V ac with no circuitry changes. Output noise and ripple is only 50 mV p-p measured differentially. The 668A-05 weighs 18 lbs and costs $750. Standard features are overload and overvoltage protection and external heat sinks for operating above +40°C. Trio Laboratories, Inc., 80 Dupont St., Plainview, NY 11803. Phone(516)681-0400. **265**



500-MHz SUBMINIATURE DOUBLE BALANCED MIXER COSTS ONLY $7. Model MD-108 mixer in an 8-pin relay/header package provides LO (local oscillator) and rf ports that operate down to 5 MHz and an i-f port down to dc. A low-conversion loss (7.0 dB max. from 5 to 150 MHz and 9.0 dB max. from 150 to 500 MHz), a low profile of 0.312 in., and standard header spacing of 0.2 in. between pins for convenient microstrip mounting are other features. The unit is housed in an rfi shielded metal case. Anzac Electronics, 39 Green St., Waltham, MA 02154. Phone(617)899-1900. **266**

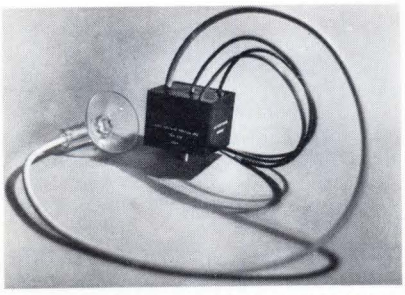


PULSE-MODULATION ANALOG MULTIPLIER OFFERS 0.1% ACCURACY. Model 4200 has untrimmed accuracy of 0.2% (20 mV) and a maximum total-error drift of 0.02%/°C over −25°C to +85°C. Power supply stability is 0.005%/% of supply change. Output is ± 10V at 5 mA min., input is ±30V max., output noise from dc to 10 kHz is 1 mV rms, and scale-factor (gain) error vs temperature is 0.01%/°C. The thin-film hybrid network requires no external op amps. $129. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706. Phone(602)294-1431. **267**



38- TO 40-GHz TWT WITH 40-dB GAIN MEASURES 1.6 × 1.8 × 6.7 IN. Siemens' compact RW4010 traveling-wave tube is a 10W output-power unit that has an average life expectancy of 5000 hrs and is guaranteed for 10,000 hrs. The tube utilizes a coupled-cavity structure instead of a helix to achieve better heat dissipation and efficiency. It is designed primarily for microwave radios in local-distribution systems for message, data and TV transmissions. Siemens Corp., 186 Wood Ave. S., Iselin, NJ 08830. Phone(201)494-1000. **268**

HYBRID-POWER OP AMP WITH 7A OUTPUT HAS LOW DISTORTION. The TA8651A 100W linear amplifier has an output section that can be externally biased for Class AB operation with intermodulation distortion of 0.05% at 50 mW and low total harmonic distortion. Terminals are available for external-frequency compensation, short-circuit protection, and inverted and noninverted inputs. Intermodulation distortion is also low in audio applications (0.1% at 50 mW). $12.90 (1000 quantities). RCA Solid State Div., Rt. 202, Somerville, NJ 08876. Phone(201)722-3200. **269**



PALM SIZED HV TRIPLER MULTIPLIER IMPROVES TV FOCUSING. Model TMX600 is designed for CRT applications in TVs, monitors and display systems. The improvement offered in focusing is said to be the result of the use of improved rectifiers and ceramic capacitors which have reportedly increased the tripler's reliability. Input is an 8.3-kV flyback-type pulse waveform and output is 25 kV no load. Maximum output current is 2 mA continuously and operating and storage temperature range is −37°C to +85°C. High Voltage Devices, Inc., 7485 Ave. 304, Visalia, CA 93277. Phone(209)733-3870. **270**

LOG IF AMPLIFIERS PROVIDE ±1-dB ACCURACY. Models CTL60S and 60D single and dual 60-MHz units, respectively, provide ±1 and ±2-dB accuracies (−1 and −2 versions, respectively) and 25-MHz bandwidths. Designed to meet MIL-E-5400 requirements, they feature an input dynamic range of −75 to −5 dBm, rise time of 50 nsec, gain scale factor of 30 mV/dB and video output drive of 0 to +2.1V into 100Ω. Operating temperature range is −20°C Operating temperature range is −20°C to +65°C. $650. Circuit Technology, Inc., 160 Smith St., Farmingdale, NY 11735. Phone(516)293-8686. **271**

LED SCANNER COMES FULLY PACKAGED. Model S-4 scanner is a reflective-type unit using an infrared source and matched phototransistors inclined at an angle within a Noryl plastic housing. Maximum LED voltage is 2V and maximum LED current is 40 mA. Phototransistor maximum voltage is 30V. The scanner has an optimum reading distance of 0.1 to 0.2 in. from the front surface of the housing. It is fully assembled with a 6-ft rubber covered 5-conductor shielded cable—2 conductors for the LED and 2 for the phototransistor and a fifth for ground. The scanner can detect objects or marks as small as 0.025 in. Scanning Devices Co., 226 Broadway, Cambridge, MA 02139. Phone(617)354-7226. **273**

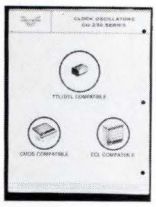
SINE-WAVE OSCILLATORS ARE TUNABLE BY EXTERNAL RESISTORS. Series 440 precision-quadrature oscillators provide buffered low-distortion (0.08%) quadrature outputs (90° ±0.1°) with amplitude-ratio tracking to better than 100 ppm/°C, and output amplitudes externally adjustable from 2V to 20V p-p. They are externally tunable over a 1000:1 range with 2 equal resistors. Three models, 440, 442 and 444, cover the range of 0.05 Hz to 20 kHz with max. frequencies at 50 Hz, 500 Hz and 20 kHz, respectively. From $56 each (100 quantities). Frequency Devices, Inc., 25 Locust St., Haverhill, MA 01830. Phone (617)372-6930. **274**

POWER SUPPLY FOR VOLATILE MEMORIES HAS UNINTERRUPTABLE OUTPUT. Model PM2400 OEM supply with multiple outputs can provide 140W of convection cooled power to 32k-by-18 or 65k-by-9 MOS RAMs at worst-case temperatures. Operating from 115V ac, it can furnish output power for up to 20 msec in the event of an ac power line failure with an automatic-switchover circuit to a backup battery. A recharge circuit is standard. Dimensions are 7-in. high × 5.25-in. wide × 11-in. deep (not including battery). Pioneer Magnetics, Inc., 1745 Berkeley St., Santa Monica, CA 90404. Phone(213)829-3305. **275**

WIDEBAND PREAMPLIFIERS FEATURE LOW NOISE. The 26 Series preamplifiers for ultrasonic-signal conditioning includes Model 26A which incorporates a selector switch for 5X or 50X gain control with input noise sensitivity at 5 MHz of 15 μV rms. Model 26B has selectable gain of 200X or 2000X and a 3-dB bandwidth of 7.5 MHz. Both amplifiers have a roll-off characteristic ideally suited for transient-phenomenon applications, since minimum ringing or distortion will result. Dimensions are 1-1/4 × 1-1/8 × 2-1/4 in. Model 26A: $285, Model 26B: $825 and Model 100B power supply: $200. Nanodyne Corp., 33 Union Ave., Sudbury, MA 01776. Phone (617)443-3133. **276**

LITERATURE

CALIBRATION TABLES FOR THERMOCOUPLES. Based on data released by NBS, these tables are not yet available from any other source in handbook form. The 36-pg. *Thermocouple Calibration Table and Alloy Data Reference Handbook* contains the NBS calibration tables for all thermocouples in use in industry. It contains no advertising or product information. Omega Engineering Inc., Box 4047, Stamford, CT 06907. **207**



CLOCK OSCILLATORS. This brochure details a broad line of TTL, CMOS and ECL compatible clock oscillators ranging in frequency from 1 Hz through 200 MHz. The oscillators range in stability from ±0.01% through ±0.0001% and are available in pc board mount and DIP-compatible packages. Vectron Labs., Inc., 121 Water St., Norwalk, CT 06854. **211**

APPLICATION DATA ON TRACKING-WAVE AND SPECTRUM ANALYZERS are included in a brochure. Topics include transfer-function analysis, amplitude-response testing, mechanical-signal analysis, signal enhancement, phase measurements, cross spectral density, random-signal analysis and a brief history of the development of wave and spectrum analyzers. Quan-Tech Div., KMS Industries, Inc., 43 S. Jefferson Rd., Whippany, NJ 07981. **215**

APP NOTE DESCRIBES FETs AS VOLTAGE CONTROLLED RESISTORS. A 16-pg. note discusses the characteristics of junction FETs as VCRs and draws performance comparisons between the JFET VCR and conventional fixed-value resistors. Numerous circuit applications are presented, in addition to means of reducing signal distortion via feedback techniques, and an analytical approximation of predicting FET VCR behavior. Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. **208**

TANTALUM CAPACITORS. This free 62-pg. catalog is divided into 3 sections. The first section on military style tantalum capacitors condenses 475 pages of mil specs on the subject into 58 pages. The remaining 2 sections on wet-electrolyte and solid-electrolyte sintered tantalum-anode capacitors complete the catalog. Comprehensive details on every type of tantalum capacitor make this a must for the design engineer. NCI Corp., 5900 Australian Ave., W. Palm Beach, FL 33407. **212**

APP NOTE COVERS DESIGN OF LOW POWER CRYSTAL OSCILLATORS. A 6-pg. note for 2 low-power oscillator designs is now free to readers for applications with supply voltages of 3 to 15V dc. The note contains a circuit description, schematics, component values, operating parameters, theory and graphs for voltage/current/frequency as well as oscillator phase relationships. Statek Corp., 1233 Alvarez Ave., Orange, CA 92668. **216**

DESIGN-AUTOMATION SYSTEM FOR MICROPROGRAMMING. An app note *Microprogramming Software Aids* is designed to assist engineers in implementing microprogrammed systems. The 6-pg. note emphasizes the need for engineers to plan their software support when they begin design of a microprogrammed system. Design-automation techniques are cataloged, including the numerous advantages offered by a general-purpose microcode assembler. Signetics Memory Systems, 520 Clyde Ave., Mt. View, CA 94040.

TRANSDUCERS, ACCELEROMETERS AND SWITCHES. This brochure entitled *Anti-Bang, Zip, Rattle, ZZZup, Shimmy, Buzz, Ping, Whoosh, Tilt, Zing, Bing, Ding, Crackle, Fizz, Fizzle, Flop* provides a complete description of pressure, displacement, acceleration and vibration transducers, proximity switches and engine-vibration monitoring systems for a wide variety of applications and marketplaces. Gulton Industries, Inc., Servonic/Instrumentation Div., 1644 Whittier Ave., Costa Mesa, CA 92627. **213**

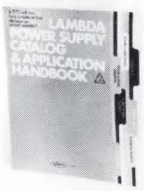
DIFFERENTIAL AMPLIFIERS. A 4-pg. brochure describes the full line of B & F's 700 Series of differential amplifiers. The three solid-state models described (700-10D, 702-10D and 707-10D) allow a choice of features and options to perfectly match many signal-conditioning requirements. The amplifiers feature complete "box-within-a-box" construction which allows total isolation of input circuits and ability to withstand as much as 600V p-p of common-mode voltage. B & F Instruments, Inc., Cornwells Heights, PA 19020. **217**

SYNCHRONOUS MOTORS. *Permanent Magnet Synchronous Motors for Light Motive and Timing Applications* is a brochure that discusses how innovations in synchronous-motor designs are useful in selecting the proper motor for a great variety of applications. The compact motors, less than 2 in. in diameter and only 7/8-in. deep, have 200-in. oz torques at 1 rpm and can operate at speeds varying from 1/5 rph to 240 rpm. Controls Company of America, 9655 Soreng Ave., Schiller Park, IL 60176. **210**

THERMAL CUT-OFFS. A family of thermal cut-offs for backup protection in electrical and electronic devices is described in this 12-pg. illustrated brochure. The booklet describes the capabilities and performance of thermal cut-offs and lists their applications. It also covers determining cut-off temperatures; mounting and design, and product specifications. 3M Co., Dielectric Material & Systems Div., Box 33686, St. Paul, MN 55133. **214**

DATA-COMMUNICATIONS CATALOG. A 32-pg. data-communications catalog details data-communications products and describes typical communications applications. The catalog contains information on Data General's synchronous-communications controller, synchronous-line adapter, programmed-asynchronous multiplexer, asynchronous single-line controller, multiprocessor-communications adapter and an IBM 360 interface. Data General Corp., Southboro, MA 01772. **218**

LITERATURE



1973 CATALOG AND APPLICATION HANDBOOK. This 196-pg. book is subdivided into 7 sections: power components; power kits; standard power supplies; custom power supplies; power systems; power instruments; and applications. Each section contains data on available models, sizes, electrical specifications and prices. Dimensional mounting drawings, photos of the packages and connection diagrams are also included. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, NY 11746. **219**

MEMORY SYSTEMS. This 13-pg. app note describes use of the 1024-bit AMS 6002 MOS RAM in building a compact, general-purpose memory module. This memory module, referred to as the AMS basic storage module (BSM), has a 425,984-bit capacity and is housed in a 6-1/2-in. high, 19-in. wide rack-mountable chasis, complete with control circuits and TTL-to-MOS voltage-shifting circuits. Advanced Memory Systems, Inc., 1276 Hammerwood Ave., Sunnyvale, CA 94086. **240**

COMPREHENSIVE REPORT DESCRIBES IMPACT OF LSI. The 150-pg. report is the result of a year of research and hundreds of interviews with manufacturers of semiconductors and electronic products. *LSI-New Product Horizons* describes and analyzes the forces applied by LSI's low cost, small size and design flexibility on the traditional relationships between component suppliers and equipment manufacturers. In the report, Quantum's research staff examines in detail, the opportunities and current trend of semiconductor companies to use LSI to increase their share of the market value of a final product, producing systems rather than individual components. Price is $450 per copy. Quantum Science Corp., 851 Welch Rd., Palo Alto, CA 94304. **241**

FREQUENCY SIGNAL SOURCES are described in an 8-pg. catalog. Shown are the F300 Series oscillators with complete specifications and application data. All F300 instruments contain internal-metering devices, making them particularly useful for production and proof testing and general laboratory use. AILTECH, City of Industry, CA 91748. **242**

signals and noise

The gauntlet is down...

Dear Sir:
As readers of EDN and former members of the Engineering Industry, we at the U.S. Chess Institute invite your readers to compete in our industry-wide postal chess tournament.

Let's find out where the "engineering grandmasters" really are.

Postal Chess is an old story from which many chess players have received a great deal of pleasure.

You need no experience to play chess by mail. It's the same as over-the-board chess except that you send your moves on postcards.

In our postal chess tournament each member is placed in a section, based on his self rated ability, with eight opponents. Each player will play one game simultaneously with each of the other members in his section. Records of the games are maintained on the scoreboard sheets that are provided each player. Moves are dispatched by *sending* a postcard to each of his opponents against whom he plays white. In turn, he *receives* opening moves from the games in which he plays black. Descriptive chess notation is used in describing his move and scoresheets are provided, each containing a chess-board layout to keep track of the game status.

Each player receives simple instructions along with scoreboard sheets, his section assignment and a list of eight opponents.

Each member also receives a periodic published report of all wins and losses for every player in each section as well as a periodic newsletter published by the USCI containing many chess facts and other items we hope will be of interest.

More information is available by writing directly to the U.S. Chess Institute, 6 E. 43rd St., New York, NY 10017.

Yours truly,
Dyan Parker
Secretary
U.S. Chess Institute

Getting our pins straight...

Dear Editor:
Although the article on our quad 741 op amp the RM4136, (EDN, Jan. 20, 1973) is very well written, it made several points which are inaccurate. For example, pin 11 has become the standard in the industry for linear products in the 14-pin dual-inline package, not pin 14. Witness the $+V_{CC}$ pin for the LM101A, LM106, LM107, LM108, LM110, LM111, LM112, μA709, μA711, μA741, and the RM4136. The dual 741 (μA747) uses pins 9 and 13, while the μA723 uses pin 12. Only the Motorola MC3301 and National LM3900 uses pin 14. Every one of the single dual-operational amplifiers mentioned above have multiple sources.

If you compare pin outs for the Motorola and National quad with the RM4136, you would see that connecting the 4136 in an application is simple, since all amplifiers have their inputs and outputs on adjacent pins. Take a look at the LM3900 pin out: the input pins for amplifiers 1 and 3 are crossed over all pins for amplifiers 2 and 4; wierd!

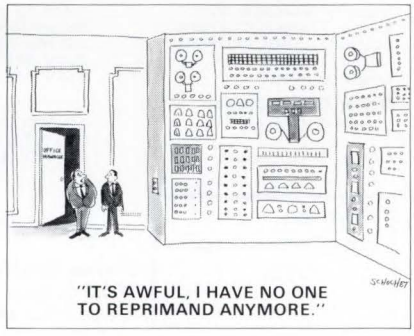
As for the reversed input current due to the PNP input stage, the direction of input current flow is not a consideration, unless an unbiased blocking diode is placed at either input, an application which has never been encountered by any of our customers.
Cordially,
Daniel W. Bellack
Raytheon Company
Mountain View, CA 94040

Want more info?

Dear Mr. Egan:
Here are some sources from which your readers can get information. Re: my article published in the January 20, 1973 issue of EDN, entitled "Keeping Up with the Latest Engineering Information."

1. The "ASIDIC Survey of Information Center Services" is available from Mr. R. Bruce Briggs, Center for Information Services, Campus Computing Network, University of California, Los Angeles, CA 90024. The cost of this study is $7.50 (make check payable to ASIDIC).
2. The ASEE-ESLD guides are available from the Publication Sales, ASEE, Suite 400, One Dupont Circle, Washington, DC 20036 at $1 for single copies, but $.26 each if 10 or more of one title is ordered. Please specify by title.
3. SIA Science Information Association is based at 3514 Plyers Mill Road, Kensington, MD 20195, and 2480 16th St. N.W. Washington, DC 20009.

Sincerely,
Karen Takle Quinn
Senior Librarian and
ITIRC West Coast Representative



"IT'S AWFUL, I HAVE NO ONE TO REPRIMAND ANYMORE."

ADVERTISERS INDEX

SALES OFFICES

Foreign

GERMANY
Mr. G. Stelmaszyk
IPC Business Press(West German Off.
Wiesenstrasse, 7,
7146 Tamm/Ludwigeburg, Germany
Telephone: Tamm 7141 3 23 78
Telex: 7 264 780

FRANCE
Mr. D. Soubeyran
Compagnie Francaise d'Editions
Division Internationale
40 Rue de Colisee
Paris 8e, France
Telephone: Paris 225 7750
Telex: France 28274 F

ITALY
Mr. F. A. Corti
ETAS-Kompass SpA
Servizio Estero
Via Mantegna 6
20154 Milano, Italy
Telephon: Milan 347 051
Telex: 33152 Kompass

HOLLAND
Mr. D. Anema
C. Misset NV
Ijsselkade 32
Doetinchem, The Netherlands
Telephone:Doetinchem 8340 25151
Telex: 45481

SWITZERLAND
Mr. H. P. Iff
Agentur Iff AG
Neustadt 57
8201 Schaffhausen, Switzerland
Telephone: Schaffhausen 53 54983
Telex: 76388

JAPAN
Mr. K. Utsumi
Asia Magazines Ltd. (IBP Division)
Akiyama Building
25 Akefune-cho
Shiba Nishikubo
Minato-ku
Tokyo, Japan
Telephone: Tokyo 03 (403) 5623
Telex: J28245 IBP JPN

UNITED KINGDOM
Mr. Douglas Jens Smith
IPC Business Press (Overseas) Ltd.
161-166 Fleet St.
London, EC4P 4AA, England
Telephone: London 01-353-5011
Telex: 267449

INTERNATIONAL COORDIN.
Mr. John Hitch, General Manager
IPC Business Press (Overseas) Ltd.
33/39 Bowling Green Lane
London, EC1R ONE, England
Telephone: 837-1277
Telex: 23839

Domestic

Hugh R. Roome
Publisher
221 Columbus Ave.
Boston, Mass 02116
(617) 536-7780

NEW YORK CITY 10017
Mason Fackert, Regional Manager
205 E. 42nd St.
(212) 689-3250

BOSTON 02116
Richard Parker, District Manager
Hal Short, District Manager
221 Columbus Ave.
(617) 536-7780

PHILADELPHIA 19103
Steve Farkas, District Manager
Penn Towers
1819 John F. Kennedy Blvd.
(215) 569-2424

ATLANTA 30328
Newman Ladabouche,
Regional Manager
6065 Roswell Rd.
(404) 252-7753

CHICAGO 60521
Terry McDermott, District Manager
Frank Sibley, District Manager
15 Spinning Wheel Rd.
(312) 654-2390

DENVER 80206
John Huff, Regional Manager
270 St. Paul St.
(303) 388-4511

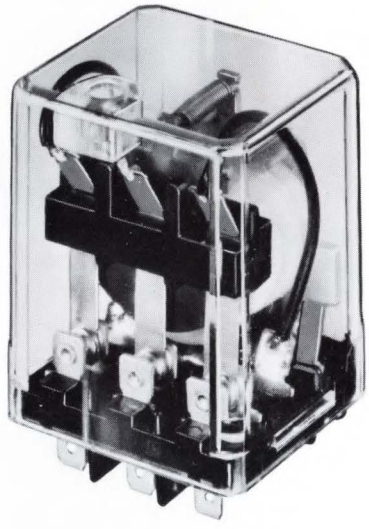
SAN FRANCISCO 94103
William J. Healey, District Manager
1111 Hearst Building
(415) 362-8547

LOS ANGELES 90036
Ed Schrader, Regional Manager
5670 Wilshire Blvd.
(213) 933-9525

INDEX TO ADS, PRODUCTS AND LITERATURE

Use card for free product information

GP



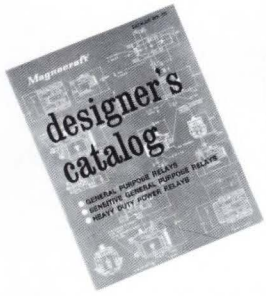
MAGNECRAFT'S NEW CLASS 388 GENERAL PURPOSE RELAY

Magnecraft is pleased to introduce the new Class 388 General Purpose Relay. This inexpensive, high performance line of stock relays offers many quality features found only in custom built versions. Available in either a covered plug-in or open style with a wide choice of AC or DC coil voltages and SPDT, DPDT, or 3PDT 10 amp contacts.

All Class 388 relays have 3-way pierced terminals. While spaced for standard plug-in mounting, the flat terminals (0.187″ x 0.020″) also accept quick-connect receptacles or direct soldering. For plug-in use, three types of chassis mounted sockets are available; quick-connect, solder, or printed circuit terminals. Covered plug-in version has a tough clear polycarbonate plastic cover.

In a highly competitive business, delivery can be a deciding factor. If delivery is important to you, be aware that Magnecraft ships better than 90% of all incoming orders for stock relays, received before noon, THE SAME DAY (substantiated by an independent auditing firm). In addition to our shipping record, most stock items are available off-the-shelf from our local distributor.

FREE!



DESIGNER'S CATALOG

The purpose of this 36-page catalog is to assist the design engineer in specifying the proper relay for a given application. The book completely describes General Purpose, Sensitive General Purpose, and Mechanical Power Relays. New products include the complete line of Class 388 General Purpose Relays.

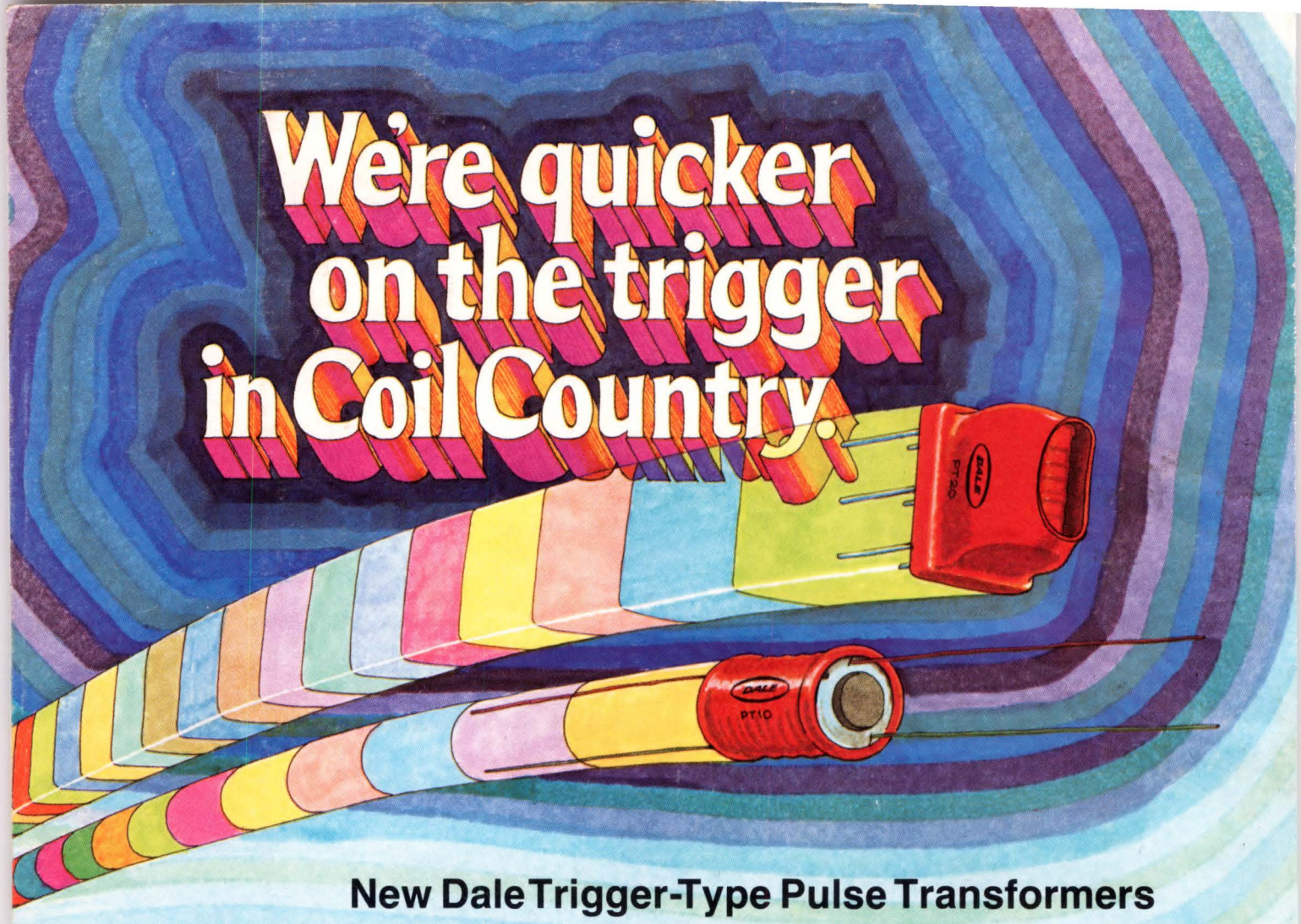
See Us at WESCON, Booth 2400

Magnecraft® ELECTRIC COMPANY

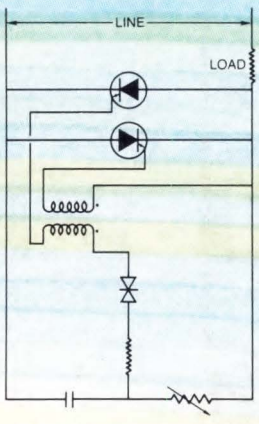
5575 NORTH LYNCH AVENUE • CHICAGO, ILLINOIS 60630 • 312 • 282-5500 • TWX 910-221-5221

Circle No. 1

We're quicker on the trigger in Coil Country.



New Dale Trigger-Type Pulse Transformers



Available fast for SCR control circuits. New Dale Trigger-Type Pulse Transformers match your performance and budget requirements for industrial and commercial applications. Two styles with PC pins (PT20) or bobbin type leads (PT10) for use where trigger source isolation is employed in half or full wave SCR power control circuits. Available with turns ratio of: 1:1, 1:1:1, 2:1, 2:1:1 and 5:1. Primary inductance from 200 μh to 5000 μh. Interwinding capacitance as low as 400 pf. Leakage inductance as low as 3 μh.

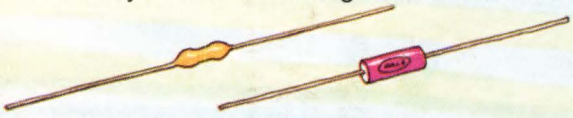
The price—very competitive in most any quantity. Phone today for a quote: 605-665-9301 or write:

DALE ELECTRONICS, INC.
East Highway 50, Yankton, S.D. 57078
A subsidiary of The Lionel Corporation

DEPENDABLE
DALE®

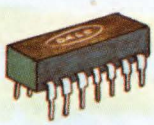
Check our expanded inductor capabilities...

Standard or special, Dale is moving up as a preferred source for inductive components. Readily available among our broadened standard lines are:



Conformal Coated Chokes
Type IR-2, IR-4. Durable epoxy coating give equivalent performance, lower price than molded styles. Machine insertable. Tolerance ±10%. Inductance: .10 μh to 1000 μh.

Flame Retardant Molded Chokes
Type IM-2, IM-4. Meet MIL-C-15305D, Grade 1, Class A, B. Tolerances: ±5%, ±10%, ±20%. Inductance: .10 μh to 1000 μh.



DIP Pulse Transformers
Type PT-14, PT-16. Machine insertable, 14, 16 pin styles. Inductance: 1 μh to 2 mh. Tolerance ±20%. Leakage inductance: As low as 0.2% of inductance. Interwinding capacitance: As low as 3 pf. ET product: Up to 10 volts/μsec.

PC Mount Toroids
Series TE. Meet MIL-T-27C. Type TF5SX20ZZ. Epoxy encapsulated. High Q and wide selection of Q vs. frequency ranges. Inductance: .050 mh to 20 h. Tolerances: ±1%, ±2%, ±5%.

Custom Chokes, Toroids, Bobbins, RF Transformers, Variable Pitch Inductors
Complete facilities to design and produce everything from prototype quantities to high volume production runs.

For a fast quote or immediate design help, phone 605-665-9301 or write Dale Electronics, Inc., East Highway 50, Yankton, S.D. 57078. Circle 80 for Inductor Catalog.