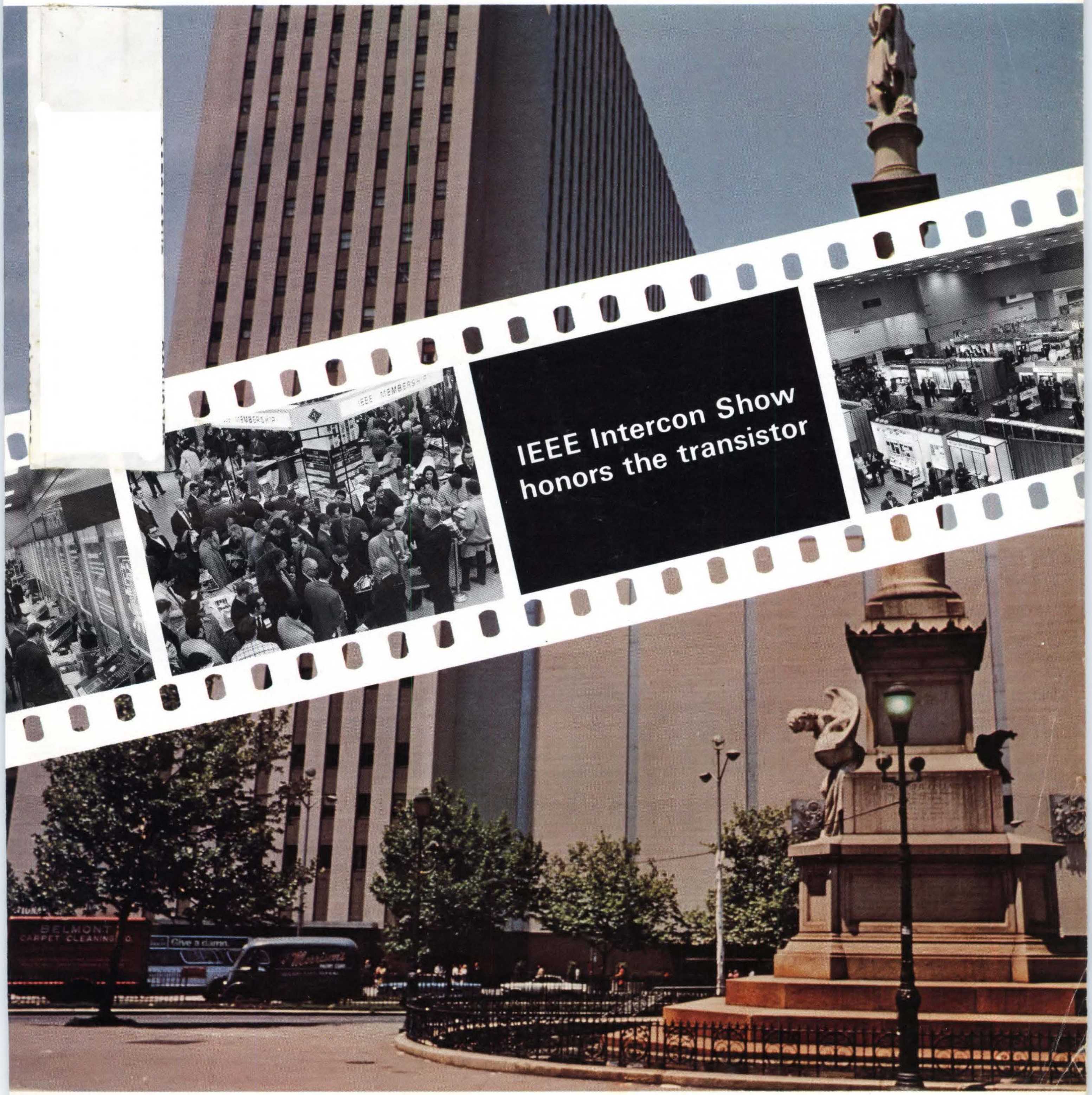
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

EDN

The delta-sigma A/D converter: low in cost but not performance

Intermediate coding saves ROM in dot-matrix displays



A CAHNERS PUBLICATION

MARCH 20, 1973

meet the new members of...

the family of PANAPLEX II™ PANEL DISPLAYS

Now there's more reason than ever for you to specify Burroughs' PANAPLEX II panel displays. We've taken our years of experience and come up with the best numeric display to fit your application. They're low priced, as low as $1.00 per digit*. They're small in size, with a variety of character heights including .25", .4", and the new .2" and .70". Our PANAPLEX II panel displays offer you maximum application versatility in 8 to 16 digits of numeric readout. The 7-segment characters are bright and readable.

Each compact, thin, in-plane panel is packed with features that keep your cost down: MOS compatibility, low cost associated circuitry (in some cases direct interface to MOS), design flexibility, long life and low display power (under 5 mw per segment). All PANAPLEX II panel displays offer you Burroughs' assured reliability. If your products use numeric displays, specify the PANAPLEX II panel display.

You'll get the best readout at the best price, tailored for your application from Burroughs, the leader.

For additional information, write Burroughs Corporation, Electronic Components Division, P.O. Box 1226, Plainfield, New Jersey 07061; or call our special applications assistance number, (201) 757-3400.

**50,000 tube quantity, 12-digit panel; even less per digit, 16-digit panel.*

Burroughs

See us at IEEE Show Booth #2709-2717

CHECK NO. 2

Push-button promises.

Atmosphere. That intangible social, professional or creative influence that you have been a part of since you started your working career. We don't have to tell you how important the right working atmosphere is. Nor do we have to tell you how often it's maligned in recruitment propaganda through gross exaggeration. It's an important part of packaged promises designed to get you onto the payroll. We at Fairchild don't discount the importance of atmosphere. But, at the same time, we aren't going to make any false claims about the Fairchild atmosphere. Collectively, we are a multi-division company comprised of thousands of highly-skilled professionals. But, individually, we are people. And as people we react differently to different situations. Challenge to some may be frustration to others. Some need regimentation. Others won't tolerate it. Some must lead, others cannot. Some companies can't understand this. Fairchild can. That's the Fairchild atmosphere. A place for the highly-skilled. But still a place for people. If you're interested, we would like to talk to you. Call or send us your resume. Employment Opportunities, Fairchild Semiconductor Components Group, Dept. 20, 465 National Avenue, Mountain View, California 94040. (415) 962-3401.

An Equal Opportunity Employer M/F.

FAIRCHILD

A Fairchild career...more than a pretty package.

CHECK NO. 5

Here's what you get in this Designers Kit — recent technical articles on Power Supply Design, IEEE papers, excerpts from a forth coming text book, 12-page brochure on designing switching regulators, and full descriptive material on CDE's new UFT Low Inductance Aluminum Electrolytic Capacitor.

Write on your company letterhead to Cornell-Dubilier Electronics, 150 Avenue L, Newark, New Jersey 07101 — if you can't wait, call (201) 589-7500.

CDE CORNELL-DUBILIER

313 (CDE)

W-J is on the Market with

EBS (Electron Beam Semiconductor) AMPLIFIERS

Four years of research and development have resulted in Watkins-Johnson offering four entirely new electron devices to perform a variety of power amplification and control functions.

These devices make use of a modulated energetic electron beam to control the current in a semiconductor, a technique which provides performance not found in existing solid state or electron tube devices. They are described below.

1) WJ-3650 is a video pulse amplifier, capable of producing ±125 volts pulse output into a 50 ohm load with pulse risetimes less than 1.5 nanoseconds. Efficiencies as high as 50% have been measured for this device, making it perfect for amplification of low-voltage, fast-risetime pulses. It is especially suited for rapid modulation of CRTs and electro-optic modulators.

2) WJ-3652 is a grid-controlled, short-pulse modulator which will produce 100 amperes into a load impedance up to one ohm with approximately 2 nanoseconds risetime. It can be used in any application where high currents with very fast risetimes or very short pulses are desired, and it is particularly suited for use as a high speed pulser for injection lasers. Maximum duty cycle is 0.05 percent.

3) WJ-3653 is an ideal high-voltage switch for pulsing high-power grid controlled microwave amplifiers such as TWTs or klystrons. It produces 400 volts output with a 3-nanosecond risetime into 100 ohms and a 10-nanosecond risetime into 100 ohms in shunt with 30 picofarads capacitance. It also provides a total delay from the ten percent point of the input waveform to the corresponding point on the output pulse of less than 3 nanoseconds. It can be operated up to two percent duty factor. These unique features make this device desirable for use in deception repeater, pulsed radar or dual-mode ECM systems.

4) WJ-3660 is a pulsed linear RF power amplifier with a low pass bandwidth. Two versions are available: a) 150 watts peak power from dc to 160 MHz with 25 dB gain and b) 50 watts peak power from dc to 320 MHz with 20 dB gain. Maximum duty cycle is 2 percent.

Further details are available from our Field Sales Office/Representative in your area or from Watkins-Johnson Applications Engineering.

See Us at the Barbizon-Plaza Studio G During INTERCON/IEEE

WATKINS-JOHNSON

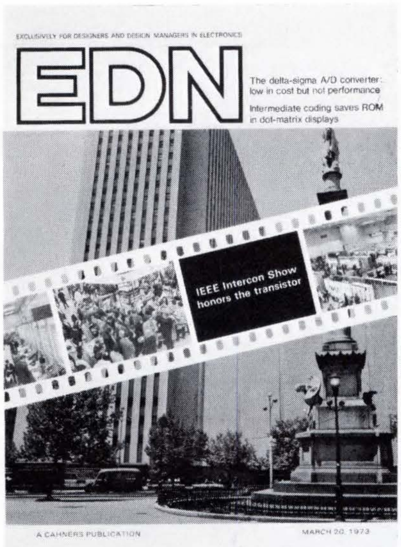
3333 HILLVIEW AVE., STANFORD INDUSTRIAL PARK, PALO ALTO, CALIF. 94304 • (415) 493-4141

CHECK NO. 6

MARCH 20, 1973
VOLUME 18, NUMBER 6

EDN with EEE

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



COVER

1973 IEEE INTERCON salutes the 25th anniversary of the transistor. For a rundown on the technical sessions and a preview of new products to be displayed at the show, see article starting on pg. 36.

DESIGN NEWS

DESIGN FEATURES

PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

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


SKT electronics
The only resistor catalog with a built-in expeditor.
SKT electronics, inc.
208 S. LaSalle Street
Chicago, Illinois 60604
312 • 372-1465

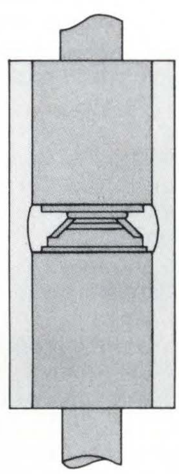
CHECK NO. 7

Hard-boiled hermetics...
TI's rugged 1-amp glass rectifiers.

TI's 1-amp glass rectifiers are tough, high-performance units you can depend on.

They're proven through extensive high-reliability testing—like 168 hours in a pressure cooker at 15psi, 120°C (no failures). This high reliability is achieved by combining the best processing, construction and packaging technologies.

The silicon mesa oxide-passivated structure has additional nitride and glass passivation over the junction. Double-plug construction provides highest mechanical integrity. Matched coefficients of expansion of the glass case and dumet leads provide hermeticity under widely varying temperatures (−65° to 175°C max operating range).



Glass hermetic package, double-plug construction.

Designated 1N4001 through 1N4006, the 1-amp devices offer a reverse voltage range of 50 to 800V. Repetitive peak forward current (10 cycles, 75°C or below) is 10 amps. Peak surge current is 30 amps. Static reverse current is 10 microamps at 25°C and 50 microamps at 100°C.

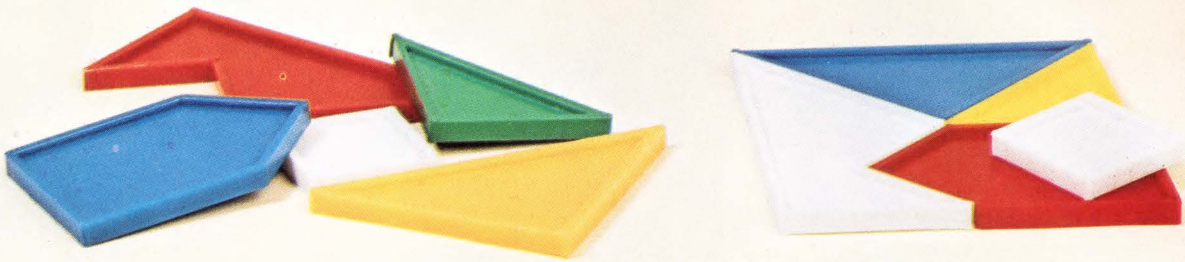
For more information

For price and delivery, call your local TI sales office or authorized TI distributor. For complete data sheet covering the 1N4001-1N4006 1-amp glass series, circle 251 on the reader service card. Or write Texas Instruments Incorporated, P.O. Box 5012, MS 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

84088

This problem should take you about 17 minutes to solve.



Four shapes make a perfect square.† So do five.
As an engineer, you should solve this in 17 minutes.*

With P&B's Reed-Triggered Triacs you solve critical switching, longevity and mounting problems. Immediately.

Controlled and isolated by a reed relay, these solid state AC switches provide a modern means for interfacing DC logic signals and AC-powered loads such as motors, relays, solenoids and lamps. Expected life exceeds 1 million operations so they are especially suited to highly repetitive applications.

Switching capabilities range from 1.7 to 20 A rms, 60 Hz depending upon type of package and mounting method. All have a 1 Form A (SPST-NO) "contact" as well as an internal RC network that provides dv/dt suppression. All feature the inherent long life and the ability to switch high inrush loads that characterize thyristors.

ECT Series. Steady-state rms current ratings (at 25°C) range from 2 to 20 amperes depending upon the method of mounting. Coil voltages are from 5 to 48V DC. Power requirements are 290 mW for 120V, 60 Hz operation and 450 mW for 240V, 60 Hz. .250″ quick-connect terminals are standard with .187″ and .205″ also available.

EBT Series. The solid-state "contact" is designed to carry a maximum load current of 7A rms, 60 Hz at 25°C ambient. This series provides the convenience of octal plug-in terminals and may be mounted in a socket having screw terminals.

JDB Series. This fully-encapsulated, low-profile (.350″ height) hybrid will switch 1.7A AC loads. It is being used in modern machine tool controls, food packaging equipment and similar applications requiring DC input and AC out-put switching.

EKU Series. Rated at 7 amperes, 60 Hz at 25°C, the EKU is housed in the versatile KU-style case and has .187″ quick-connect terminals. It may be mounted direct to a chassis or in a socket having screw, solder or printed-circuit terminals. A wide variety of P&B relays and solid state time delays are housed in this same case.

For complete information, call your local P&B representative or Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. 812 385 5251

**Like to try your hand at solving the puzzle shown above? Ask your P&B representative for one.*

Solving switching problems is what we're all about.

AMF
Potter & Brumfield

†"Madagascar Madness". Copyright Behavioral Sciences, Inc.

CHECK NO. 8

Try it doctor . . . you may like it

Health in the United States is big business, with billions spent annually on direct medical care and even a greater amount on peripheral areas related to health.

To the dismay of the electronics industry, only a miniscule portion of these vast sums is spent on electronic, or related, equipment. Some companies, of course, are doing quite well in the field of medical electronics. But for everyone of these there are probably four or five who are either now struggling or who didn't make it.

If we assume that the field of electronics can, indeed, make a substantial contribution to the health and medical fields—an assumption which we firmly believe to be true—what then is the solution? How can the full potential of electronics be realized?

We don't even pretend to know the answer to such a complex problem. Certain things, though, do stand out. Foremost among these is the fact that the major stumbling block is the individual (the doctor) and not the institution (the hospital). This is in contrast to electronics in education, where the stumbling block is the institution (the school) and not the individual (the teacher).

Hospitals are moving into the world of electronics on an ever-increasing scale. Electronic equipment in intensive-care units, cardiac-care units and operating rooms is commonplace. And more and more hospitals are employing engineers to evaluate, select and monitor it.

Individual doctors are another matter. Progress in convincing them to investigate and use electronic devices is painfully slow. They plead lack of familiarity, lack of confidence and lack of time. If this is the case, what can be done to accelerate things? Probably very little with present physicians. But for medical students, how about one or more courses in principles and applications of electronic instrumentation?

We don't mean a course devoted exclusively to present medical instrumentation, but one covering various types of instruments, the fields they serve and the benefits their use has brought about. It could also cover the problems and interactions that occur when connecting individual instruments into systems. Such a course would provide a perspective against which the students, as practicing physicians, would later make judgements on electronic equipment and its use.

Although such an approach would not insure confidence in medical electronics on the part of the doctor, it might replace much of the apprehension that now exists with an equal measure of open-mindedness.

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*
Bill Furlow, *Associate Editor*
Jerry Moseley, *West Coast Editor*
Art Stapp, *West Coast Editor*

Art Staff
Dan Kicilinski, *Director*
Patricia Rawlins, *Illustrator*
Ezio Mattassi, *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

Publishing Consultant
E. Patrick Wiesner

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

Assign your "clockwatching" to specialists:
the Guardian Angel and

GUARDIAN TIME DELAY RELAYS

Need a time delay relay that counts parts of a second . . . or one that counts half an hour? From 25 milliseconds to 2,000 seconds, Guardian's got them all. In your choice of electromechanical, hybrid or pure solid state. In standards that come right off the shelf or in custom designs. In just about any size, shape, form, or delay range your application can demand. Isn't it time you get all the facts on Guardian Time Delay Relays? Send today for specs and application data.

GUARDIAN®

GUARDIAN ELECTRIC MANUFACTURING CO.
1574 West Carroll Avenue, Chicago, Illinois 60607

In a hurry? Call your Guardian Distributor.

CHECK NO. 10

The inside story on Spectrol trimmers...

(p.s. they're a bargain!)

High quality/low prices

Don't let the high quality of our Spectrol trimmers fool you . . . check our prices — they're competitive!

Broad line/all types

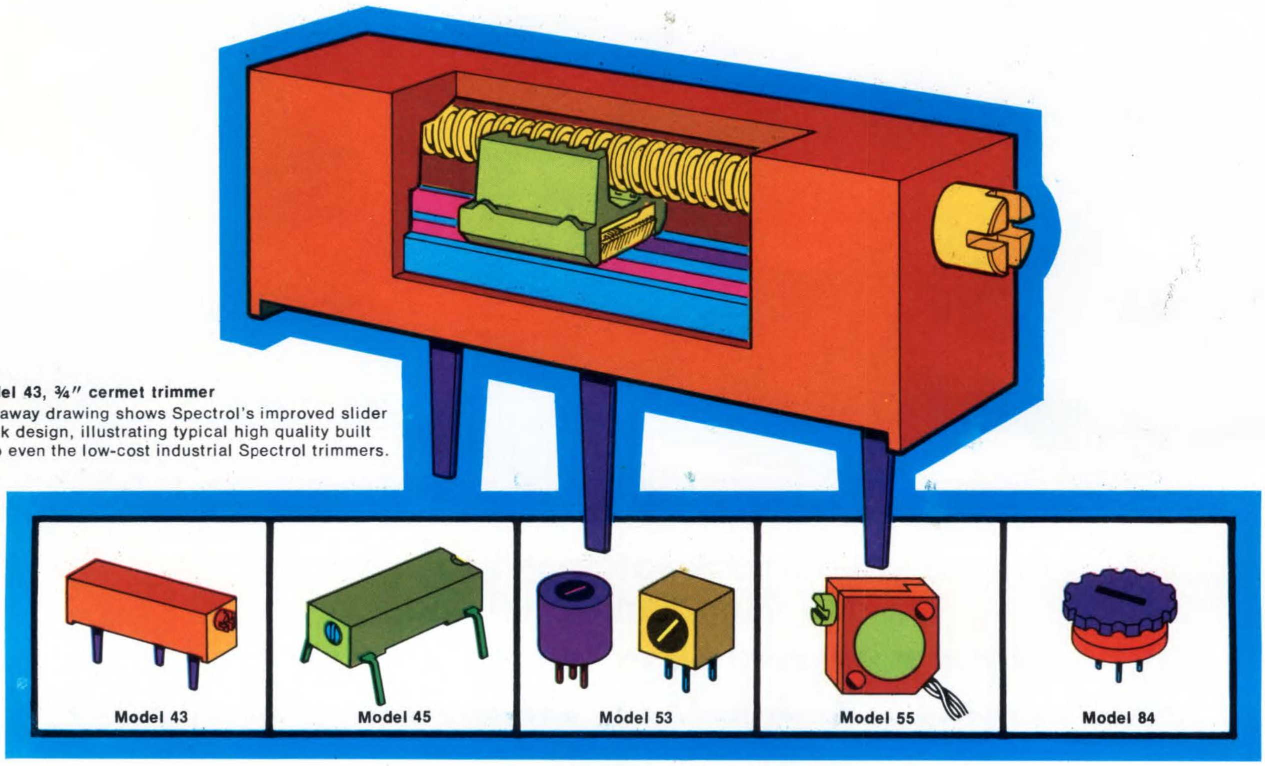
Rectangular, square, round, cubic, or TO-9 packages, wirewound or cermet elements, industrial or MIL-Approved models — we've got them all!

Local stock/off-the-shelf

Looking for products in a hurry? Try your local Spectrol distributor . . . there are over 75 authorized outlets in the United States and Canada, and we have factories in England and Europe as well.

Get a Spectrol quote before you buy!

Break that careless habit of sole-sourcing your trimmer buys — or that dangerous habit of buying on price alone . . . demand high quality as well as low prices — get a Spectrol quote before you buy! Contact our local distributor or call us directly. (The reader service card will get you our Short Form Catalog.)



Model 43, ¾" cermet trimmer
Cut-away drawing shows Spectrol's improved slider block design, illustrating typical high quality built in to even the low-cost industrial Spectrol trimmers.

Spectrol

SPECTROL ELECTRONICS GROUP

UNITED STATES Spectrol Electronics Corporation 17070 E. Gale Avenue, City of Industry, Calif. 91745, U.S.A. • (213) 964-6565 • TWX (910) 584-1314

UNITED KINGDOM Spectrol Reliance Ltd. Drakes Way, Swindon, Wiltshire, England • Swindon 21351 • TELEX: 44692

ITALY SP Elettronica spa Via Carlo Pisacane 7, 20016 Pero (Milan) Italy • 35 30 241 • TELEX: 32242

CHECK NO. 11

Switching, plain and not so plain

The hybrid time delay relay featured below (at d) is a business-like combination of modern electronics with a reliable, inexpensive electromagnetic relay. A single package wraps up the whole deal. It is for places where you want a switching delay of from 1 to 120 sec. repeatably accurate to ±3%, fixed or variable; and prefer not to provide the timing elsewhere. The idea is neither original nor recent. Sigma does it more compactly, reliably and *cheaper*.

10,000 volt switching doesn't sound like a subject that belongs on this page. It wouldn't under common circumstances, but item c is an elegant means of grounding the high voltage in an office copier when somebody has to reload it. Would you believe it's an internally illuminated photoconductive element dropping open circuit resistance of 10^{12} ohms to 100k?

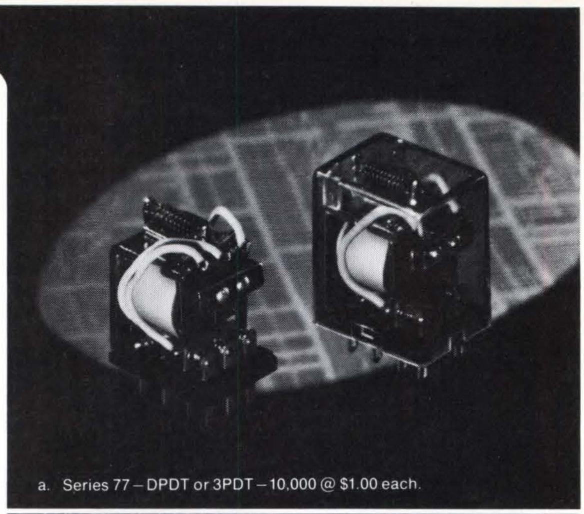
Light controlled photoconductor relays in standard packages were brainchildren of a Sigma division specializing in solid state photoconductors. Great merit and flexibility results from use of these Datacels® as we call them; viz. total isolation of input from output or outputs (1 to 4)—with outputs passive and nearly as compatible as resistors. The latest variety was invented by our lady physicist and is imaginatively known as a "Ladybug."

A Ladybug-relay combination solved a recent delayed alarm problem for a Sigma customer. By using a Neon light source for control, the Ladybug imposed *no load* on the timing circuit, operated directly from 120 volts with lock-on alarm. It makes quite a time delay device—up to 60 sec. after *opening* a control circuit. Ladybugs and Datacels® have the flexibility of three alternative internal light sources: Incandescent, Neon and LED.

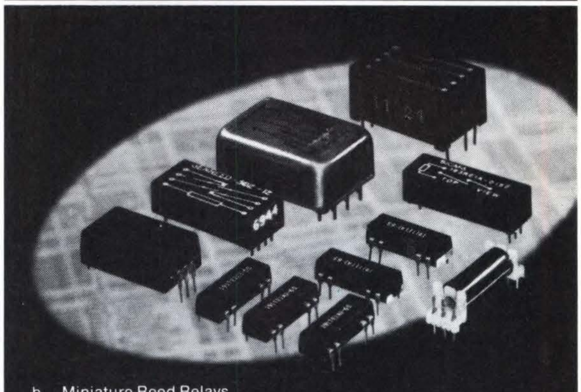
Savvy switching is a worthwhile specialty to know about when you can use it. Sigma has it and has had it since the late thirties.

If you'll circle No. 12 on the beano card, you'll get a fistful of poop. If you write on a specific question, we'll answer it carefully along *with* the poop; and if you make it a personal letter to relay marketing chief, Stu Knapp, with your problem and project laid bare, the action will be sudden and substantial. Write Sigma Instruments, Inc., 170 Pearl St., Braintree, Mass. 02185. Telephone 617-843-5000.

SIGMA
INSTRUMENTS INC

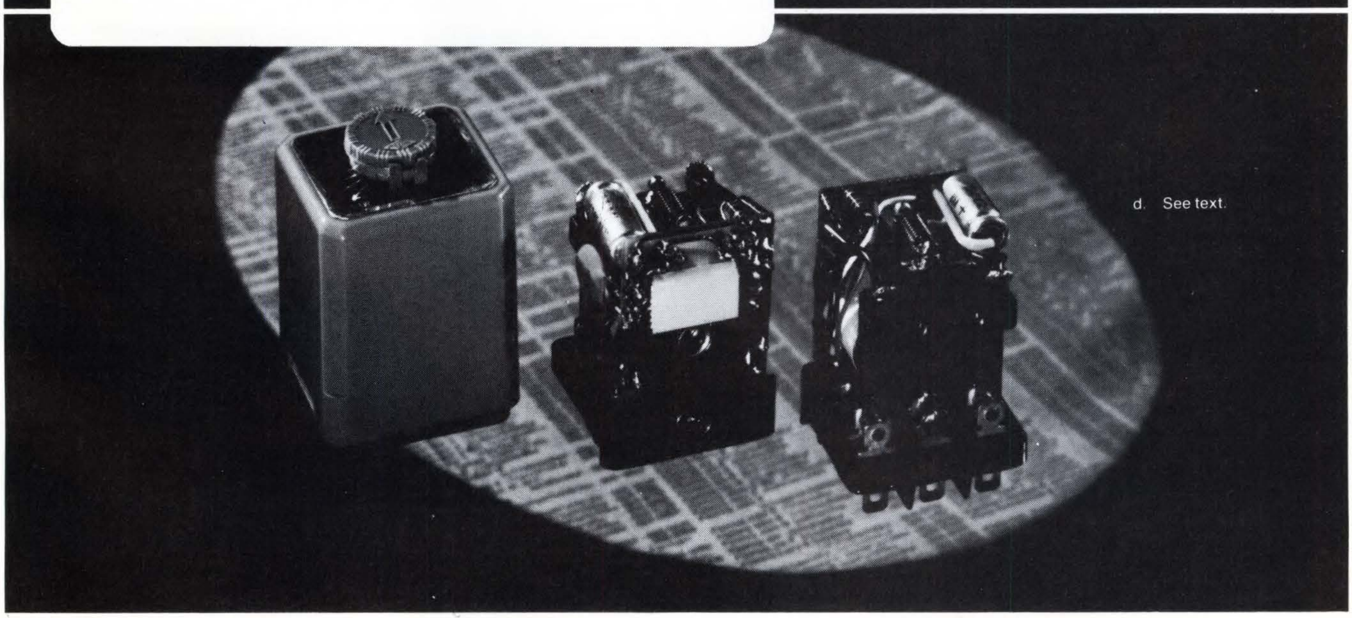


a. Series 77—DPDT or 3PDT—10,000 @ $1.00 each.



b. Miniature Reed Relays

c. See text.



d. See text.

CHECK NO. 12

THE SMALLEST 5 AMP GENERAL PURPOSE RELAY

Available now, Teledyne's new Mini-T.

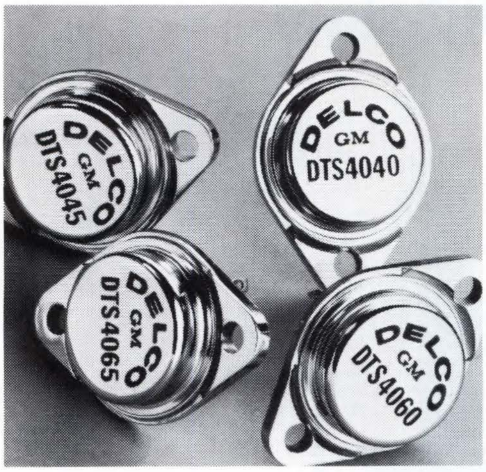
This industrial, heavy-duty 120 volt 5 amp relay features a life expectancy of over 10 million dependable operations. The space-saving 2PDT Mini-T with transparent dust cover has a full line of complementary sockets and hold down clips for P.C. board or chassis mounting. This Teledyne relay employs an 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

CHECK NO. 13

HIGH ENERGY THE KOKOMOANS.



backed by safe operating curves up to 600 volts, as shown at left. And to further aid your circuit design h_{FE} is plotted continuously from 15mA to the maximum collector current rating of 15A.

As you expected, the new DTS-4000's are in stock and ready for delivery. Contact us or your nearest Delco distributor for complete details. Ask for Application Note 52 on the switching regulator.

Now available from these distributors in production quantities:

ALA., BIRMINGHAM • Forbes Distributing Co., Inc. (205)-251-4104
ARIZ., PHOENIX • Sterling Electronics (602)-258-4531
CAL., LOS ANGELES • Kierulff Electronics, Inc. (213)-685-5511 • Radio Products Sales, Inc. (213)-748-1271
CAL., PALO ALTO • Kierulff Electronics, Inc. (415)-968-6292
CAL., REDWOOD CITY • Cramer/San Francisco, (415)-365-4000
CAL., SAN DIEGO • Radio Products Sales, Inc. (714)-292-5611
CAL., SAN DIEGO • Kierulff Electronics, Inc. (714)-278-2112
COLO., DENVER • Cramer/Denver (303)-758-2100
CONN., NORWALK • Harvey/Connecticut (203)-853-1515
FLA., MIAMI SPRINGS • Powell/Gulf Electronics (305)-885-8761
FLA., ORLANDO • Powell/Gulf Electronics (305)-859-1450
ILL., ROSEMONT (Chicago) • Kierulff Electronics (312)-678-8560
ILL., SKOKIE (Chicago) • Bell Industries (312)-282-5400
IND., INDIANAPOLIS • Graham Electronics Supply, Inc. (317)-634-8202
MD., BALTIMORE • Radio Electric Service Co. (301)-823-0070
MASS., NEEDHAM HEIGHTS • Kierulff Electronics, Inc., (617)-449-3600
MASS., NEWTON • The Greene Shaw Co., Inc. (617)-969-8900
MICH., FARMINGTON • Harvey-Michigan (313)-477-1650
MINN., MINNEAPOLIS • Stark Electronics Supply Co. (612)-332-1325
MO., NO. KANSAS CITY • LCOMP Kansas City, Inc. (816)-221-2400
MO., ST. LOUIS • LCOMP-St. Louis, Inc. (314)-647-5505
N.J., CLIFTON • Eastern Radio Corporation (201)-365-2600, (212)-244-8930
N.Y., BINGHAMTON • Harvey/Federal (607)-748-8211
N.Y., EAST SYRACUSE • Cramer/Syracuse (315)-437-6671
N.Y., ROCHESTER • Cramer/Rochester (716)-275-0300
N.Y., WOODBURY • Harvey/New York (516)-921-8700, (212)-582-2590
OHIO, CINCINNATI • United Radio, Inc. (513)-761-4030
OHIO, CLEVELAND • Pattison Supply (216)-441-3000
OHIO, DAYTON • Kierulff Electronics (513)-278-9411
PENN., PHILADELPHIA • Almo Electronics (215)-676-6000
PENN., PITTSBURGH • RPC Electronics (412)-782-3770
S.C., COLUMBIA • Dixie Radio Supply Co., Inc. (803)-253-5333
TEXAS, DALLAS • Adleta Electronics Co. (214)-741-3151
TEXAS, FORT WORTH • Adleta Electronics Co. (817)-336-7446
TEXAS, GARLAND • Kierulff Electronics, Inc. (214)-271-2471
TEXAS, HOUSTON • Harrison Equipment Co., Inc. (713)-224-9131
UTAH, SALT LAKE CITY • Cramer/Utah (801)-487-3681
VA., RICHMOND • Meridian Electronics, Inc., a Sterling Electronics Company (703)-353-6648
WASH., SEATTLE • Kierulff Electronics, Inc. (206)-763-1550
CANADA, ONT., SCARBOROUGH • Lake Engineering Co., Ltd. (416)-751-5980

ALL OVERSEAS INQUIRIES:
General Motors Overseas Operations
Power and Industrial Products Dept.
767 Fifth Avenue, New York, N.Y.
10022. Phone: (212)-486-3723

Kokomoans' Regional Headquarters.
Union, New Jersey 07083, Box 1018, Chestnut Station, (201) 687-3770.
El Segundo, Calif. 90245, 354 Coral Circle, (213)-640-0443.
Kokomo, Ind. 46901, 700 E. Firmin, (317) 459-2175 (Home Office)

GM
MARK OF EXCELLENCE

CHECK NO. 15

Force-Switchable Diodes (FSDs) offer possibilities for low-cost solid-state switching

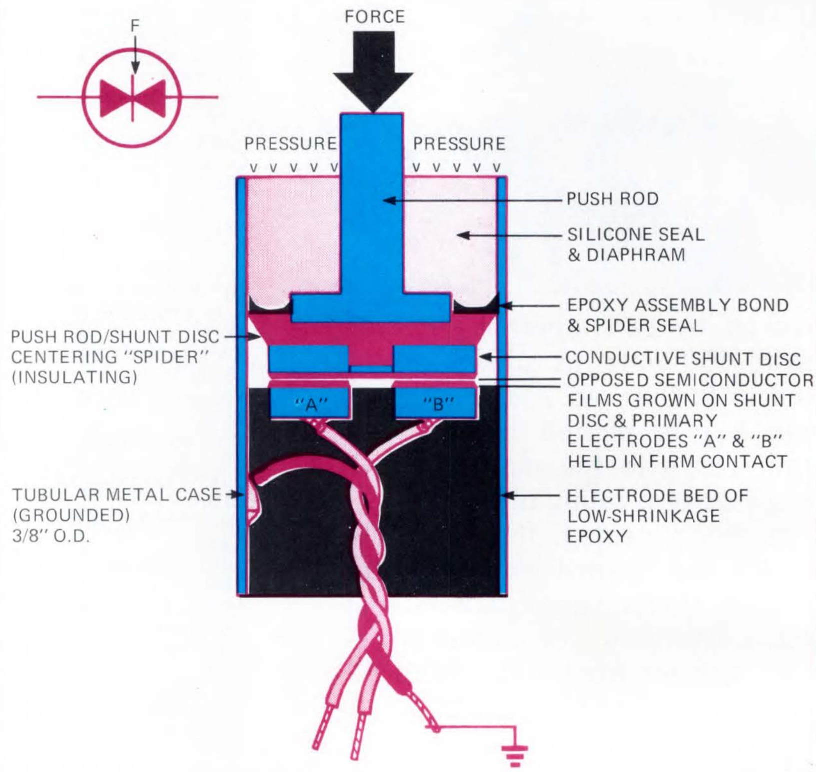
A new solid-state switch that is actuated by a predetermined force and is capable of handling a maximum of 1A at 120V ac or dc has been developed by Innovation Labs of Altadena, CA.

The new devices, called Force-Switchable Diodes (FSDs), have the characteristic of providing a virtual infinite resistance with no load and avalanching to near zero resistance when a predetermined force is applied.

Potential applications of FSDs range all the way from simple ON-OFF switches to arrays with up to 86 line-per-inch resolution for encoding written data or reading embossed cards.

Switching threshold a controlled parameter

The symbol used for FSDs by Innovation Labs and construction of a typical evaluation-prototype unit are shown in **Fig. 1**. Two or more opposed diodes in series block current flow at voltages up to 120V as long as no force is applied to compress the semiconductor film. When force is applied to the push rod or pressure is exerted on the silicone diaphram seal, the semiconductor film is compressed. At a certain force level determined by manufacturing parameters, the avalanche effect occurs and conduction begins. In most designs, this effect is symmetrical.



TYPICAL ASSEMBLY OF PROTOTYPE "FORCE-SWITCHABLE DIODES" (FSDs) RATED 120 V (AC or DC). DEVICE EXHIBITS SYMMETRICAL SWITCHING CHARACTERISTICS IN OPPOSITE DIRECTIONS, WITH THE AVALANCHE EFFECT OCCURRING BELOW 16 OUNCES OF APPLIED FORCE.

UNIT MAY ALSO BE SWITCHED BY FLUID PRESSURE APPLIED TO SILICONE DIAPHRAM.

Fig. 1—**Electrochemically grown films** on conductors form opposing diodes that block current flow. When a predetermined force is applied, compression of the films creates an avalanche condition allowing current to flow in either direction.

One of the interesting characteristics of the device, however, is that it may be manufactured so that one diode avalanches before the other. The result is that at one force level, half-wave rectification is achieved. As more force is applied, the other diode avalanches, providing a virtual short circuit for current flow in both directions.

A certain amount of hysteresis is characteristic of the standard device, as shown in **Fig. 2**. Deswitching is said to occur typically at 80% to 90% of the force at avalanche. This prevents deliberate or accidental "teasing" of the switch. Ultimate switching times have not yet been established under best conditions, but have been observed at less than 100 nsec. Forward voltage drop when the device is switched on is less than 1V. Deswitching occurs when force is released to the appropriate value, independent of the voltage level across the device at that time.

FSDs have been made with various maximum voltage ratings and a wide range of force ratings. As voltage across the switch is reduced from the maximum rating, the force required to actuate is increased as indicated by **Fig. 2**. The manufacturer states that theoretically, switch life should also be extended with reduced voltage, but to date the only failures that have occurred have been the result of greatly exceeding the current or voltage ratings. When currents larger than 1A have to be handled, FSDs could be used in Triac, SCR or power transistor gating circuits.

By controlling the manufacturing process, a given load-bearing area can be made to avalanche at forces ranging from a fraction of an ounce to hundreds of pounds at a given voltage. It is not possible at this time to produce switches with precision avalanche points, but by combining a low-force switch with an adjustable spring, a precision assembly could be made. For example, an FSD with a 2 oz. ±1 oz. switching force could be used to make a 50 pound pressure switch with a 1 oz. actuating tolerance by back-biasing a "static" loading diaphram or bellows with an adjustable spring to 49 lbs. 14 oz. Switching would then occur between 49 lbs. 15 oz. and 50 lbs. 1 oz.

Innovation Labs prefers to grow a film for a higher force than that ultimately needed and then mechanically bias the FSD to the desired operating range. It is claimed that this will extend switch life and that there is less likelihood that shrinking of the potting compounds will trigger the device when this approach is taken.

The switches have a slight negative temperature coefficient of change in force and an upper operating temperature limit of 100°C. No observable changes in characteristics with time have been reported as long as the films are sealed to eliminate moisture contamination.

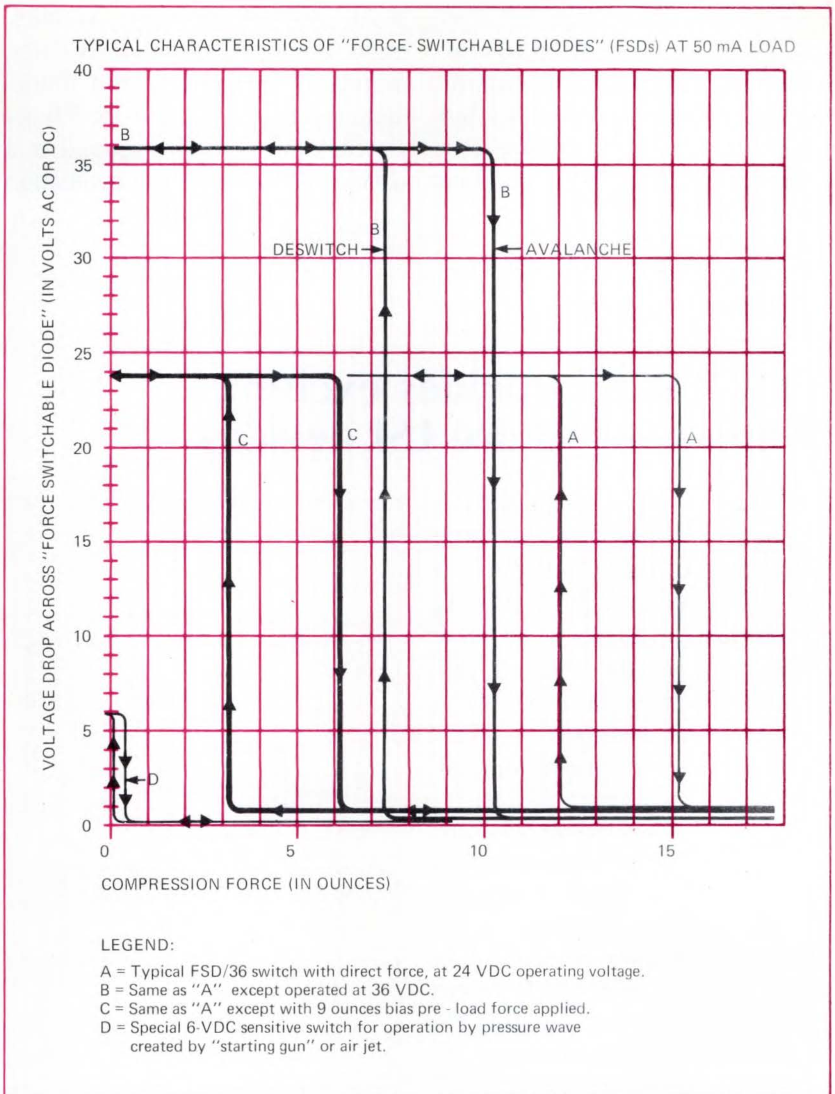


Fig. 2—Typical switching characteristics of FSDs shows difference in switching and deswitching force levels. Voltage drop in the ON condition is less than 1V and diminishes virtually to zero as additional force is applied.

Electrochemical process means low cost

While the exact nature of the FSD semiconductor film has not been disclosed, it is known that the film is grown on conductors by an electrochemical process on which patents are still pending.

The films are presently being grown with prototype production equipment under laboratory conditions. In production quantities, the developer anticipates that nominal-accuracy individual FSD barriers could ultimately be produced for a few cents each.

Total displacements required to avalanche an FSD are in the range of normal stress/strain relationships of solid materials. Because displacements are in the microinch category, a wide range of loading methods could be used, such as: static diaphrams, clamped bi-metals, piezo-ceramic transducers, thermally expanded pellets, magneto-strictive devices, etc. The extremely small displacements involved also permit stacking of FSDs in mechanical series for actuation by a single transducer. In this case, individual elements could be connected either in series or parallel.

To date, applications that have

been either developed or considered include: FSD relays actuated by tiny "bender" ceramic transducers, latching switches, bin-level indicators, electronic keyboards, electronic tablets, static float switches, pressure switches, multi-output encoding switches, burglar-alarm sensors and traffic-actuated light switches in buildings.

FSDs are presently available in a 24V or 120V, or 50 mA evaluation prototype unit that measures 3/8 in. O.D. by 5/8 in. long including the push rod. For more information, contact Innovation Labs., PO Box 176, Altadena, CA or circle Reader's Service No. **252.**—*AS* □

20th ISSCC provides exciting glimpses of future LSI devices

Philadelphia - Many of the devices presented at IEEE's International Solid State Circuit Conference in the past have been those nearing the production phase. If the same holds true for the devices discussed this year, there will be a cornucopia of exciting new semiconductor devices ready to spew forth.

The first two morning sessions, D-to-A and A-to-D conversion and FET memories, quickly aroused the interest of those attending. In the conversion session no less than three 10-bit monolithic DACs were described. As you can see from the performance characteristics in **Table I**, Precision Monolithics (Santa Clara, Calif.) Analog Devices (Norwood, Mass.) and Signetics (Sunnyvale, Calif.) have taken three independent paths to reach a similar goal, and at nearly the same time. Since theirs is a pre-production device, Analog Devices declined, understandably, to release performance figures for their DAC, but it seems to be in the same league as the DACs from Precision Monolithics and Signetics. It's interesting to note, too, that the superior sheet resistivity of ion implanted resistors, as used by Signetics, didn't seem to give them the overall advantage in chip size that might have been expected. In fact, they ended up with the largest chip of all. The smallest chip, that of Analog Devices, was achieved by depositing thin-film resistors on top of the glass-passivation layer. Technically, this may not be an "on-chip" resistor technique, but it has such obvious advantages for reducing chip area, capacitance and resistor variation, that it may well become a standard practice in the near future.

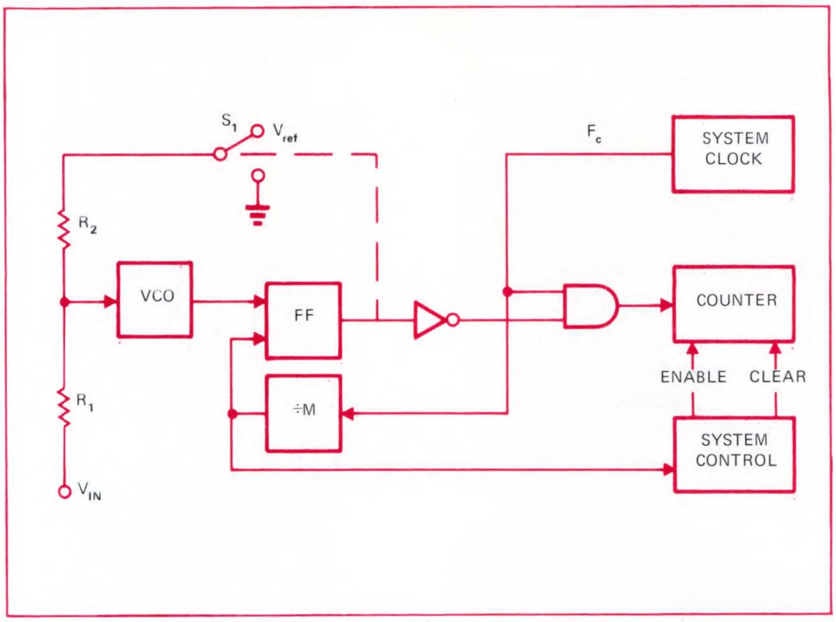


Fig. 1 – **Basic CMOS A/D converter** patented by General Electric uses a VCO and counting circuits to achieve conversion. The technique is reported to provide accuracy of ±0.05% ± 1/2 LSB, and can be integrated into a monolithic CMOS IC.

A new A/D technique

The conversion session also revealed a truly fresh approach to analog-to-digital conversion developed by M.C. Kidd of GE. While most manufacturers have been trying to develop a monolithic DAC first, with the idea that an on-chip comparator and some control logic could later be added to provide A/D conversion, Mr. Kidd has patented a technique, shown in **Fig. 1**, that can be readily integrated on a single CMOS chip. Mr. Kidd's patent has been assigned to GE, who is negotiating licensing arrangements with several semiconductor manufacturers.

Single-transistor cells

A year ago, Intel reported on a 4k-bit MOS/RAM. This year, three designers from the Philips Research Laboratories, Eindhoven, Holland, presented a paper describing their one-transistor per bit 4k-RAM. R. Proebsting and N. Green of Mostek Corp., Carrollton, Texas revealed their one transistor and one capacitor memory cell, shown in **Fig. 2**, from which they have assembled a 4k-bit RAM. This N-channel RAM, operating at 2.5 MHz, consumes only 60 μW/bit.

Microsystems International, Ltd, of Ottawa, Ontario, Canada, who was the first to announce a commercially available 4k-bit RAM late in 1972, displayed more of their LSI prowess in R. F. Harland's paper describing an 8k-bit shift register. Their N-channel, silicon-gate array consumes only a 2 mil^2 area per bit, operates from a single +5V supply and has a data rate of 10 Mbits/sec (if operated at +8V). The device which contains an unbelievable 49,328 transistors is packaged in a standard 22-pin DIP.

More memory power

From IBM's Watson Research Center, at Yorktown Heights, NY came the report of Messrs Yu, Dennard, Chang and Hatzakis describing experimental work on high-density memory fabrication using electron-beam lithography. This technique has already allowed them to fabricate an experimental memory array with densities of 8 bits/mil^2! This represents a 10:1 improvement over today's photographic techniques and is certain to play a major part in future LSI break-throughs.

IBM's coup was an 8k-bit RAM, shown in **Fig. 3**, using a single FET per memory cell.

Fabricated using a P-channel self-aligned poly-silicon gate (P-SAG) process, the chip measures 145 by 201 mils, and is internally organized 128 words by 64 bits.

The single cell area is 1.84 mils^2 – about half that of a conventional three-transistor unit.

In addition, the chip contains all the support circuitry needed to operate it. On-chip circuitry includes: data registers, address inverters, decoders, word line biasing, phase drivers, input biasing and chip select.

The memory chip was developed by IBM's System Products Division Laboratory at Essex Junction, Vermont, and was described by William K. Hoffman and Howard L. Kalter.

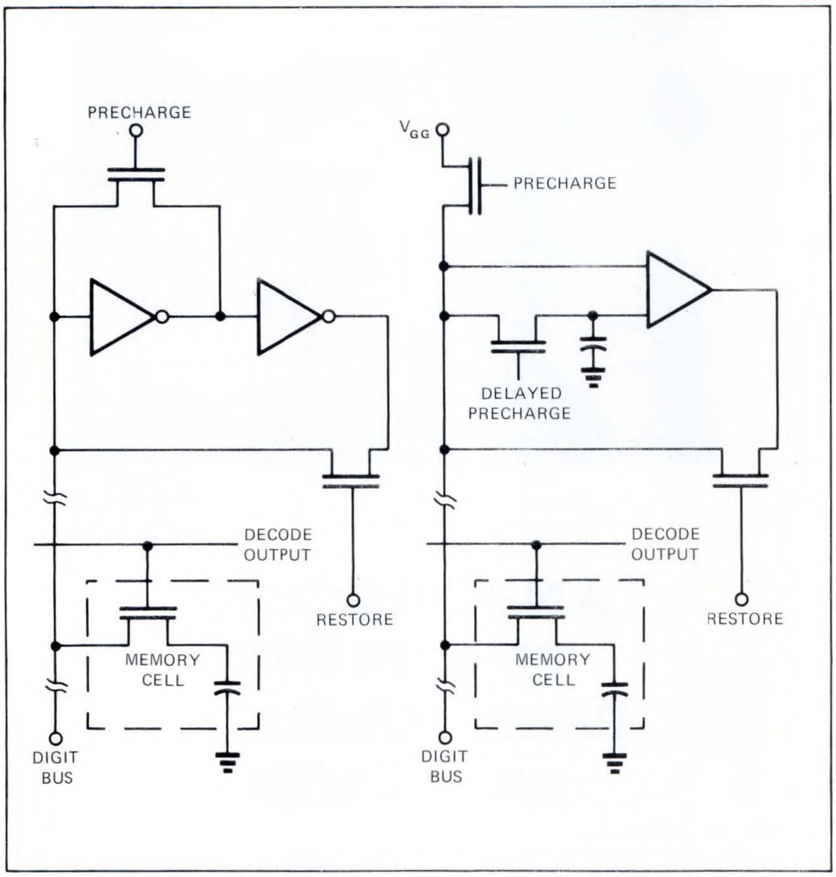


Fig. 2 – Mostek's 4k-RAM uses one FET and one capacitor for storage of each bit. Sense amplifier techniques, shown here, provide a read-access time of less than 300 nsec, and a power consumption of 60μW/bit at 2.5 MHz.

ford's straightforward answers are very refreshing; for instance when the rest of the panel, especially the bipolar advocates, were trying to field a question from the audience on how many devices comprise an "equivalent gate", Crawford responded "I'll define a gate as one load resistor, regardless of whether there is one or twelve transistors tied to it." Not a perfect answer, perhaps, but a good place to start.

At the readout session R. D. Webb of Sigmatron, Santa Barbara, Calif. amazed the audience with the sheer beauty of a large light-emitting-film display. The bright yellow display is undoubtably the most visually attractive thing available, but the 650V p-p drive requirements are very hard to provide in hand-held calculators. Discussion also covered LEDs, gas discharge, liquid crystal and thermal printing displays.

The automotive session allowed itself to get sidetracked on catalytic converters, electric cars, propane fuels and other topics for a long time before getting into the field of electronics. There was a great deal of concern about the capabilities of semiconductor manufacturers to supply both Detroit and their traditional customers. Even the Detroit representatives seemed a little worried, but several manufacturers were very strong in their insistance that they could supply Detroit's requirements without hurting other customers. This is a gnawing problem, and only time will tell whether

Evening sessions are lively

When the lectures begin at 9 AM, it really takes something worthwhile to draw a crowd at 8 PM, but ISSCC's evening sessions have always been well attended, and this year was no exception. There were informal discussion groups concerned with calculator readouts, fast auxiliary memories, auto electronics, D/A and A/D converters, bipolar vs FET for microwave, low power digital circuits, amplifier frontiers, microwave diode power amplifiers and charge-coupled devices.

The low power logic session nearly turned into a FET vs bipolar argument and really seemed to boil down to the fact that MOS devices are gaining on bipolar in speed, and bipolars are gaining on MOS in density. Silicon-gate CMOS/SOS seems capable of operating at 100 MHz at about 1/4 the power of the ECL circuits that are available today. R. Crawford of Mostek attempted to add some sanity to the MOS vs bipolar argument when he pointed out that the technology that wins out in any particular area may not win on its own technological merits. He feels that such variables as inertia in the marketplace (i.e. PMOS) or company management may have more to do with the victory than will technical arguments. Mr. Craw-

Table I – Comparison of 10-bit monolithic DAC design and performance.

	Precision Monolithics	Analog Devices	Signetics
Chip size (mils)	82 X 148	75 X 90	113 X 124
Linearity (%)	0.05	N/A	0.05
Settling time (μsec)	1.5	N/A	2
Output slew rate	40	N/A	20
Transistors (qty)	182	77	140
Diodes (qty)	33	0	25
Capacitors (qty)	6	1	0
Total resistance (kΩ)	280	1500	530
Resistor type	diffused	thin film	Ion implant
Power dissipation (mW)	300	250	

Fig. 3 – 8k-bit memory chip size reference, shows an amoeba (dark area), a one cell organism which is as large as 40 of the one-transistor memory cells in IBMs new device.

the electronics industry will suffer from the semiconductor-automotive industry tie-in that is presently under way.

Informal discussions with several semiconductor manufacturers were quite revealing. Most informed EDN that they were keeping a very close eye on their customer lists and would not allow themselves to become over committed to any one market segment, whether that segment was military, automotive or anything else. Some expressed concern that Detroit wants custom MSI and LSI devices rather than assemblies of more standard units. The direction shown by Motorola and National Semiconductor with their family of low-cost quad amplifiers and comparators offers the auto makers both design versatility and ready-made second supply sources that aren't so easy to achieve in custom units. On the other hand, they offer the semiconductor manufacturer a product line that is very attractive to a broad base of customers.

CCD's cause a stir

Charge-coupled devices drew considerable attention this year, accounting for six papers and one evening session. The advances have been astounding and justify a separate report which will appear in the next issue of EDN.

Digest of papers

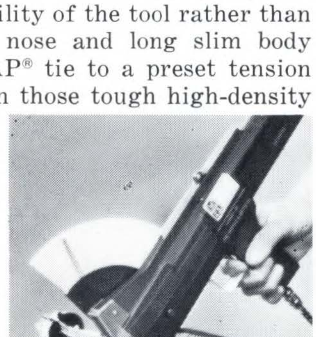
Digests of the technical papers delivered at the 20th ISSCC are available to IEEE members for $15, and to nonmembers for $20 from:

ISSCC
Philadelphia Section IEEE
Moore School of Electrical
Engineering
Univ. of Penn.
Philadelphia, PA 19174

–BF □

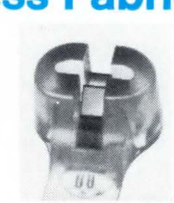
Cut Costs at Each Step of Harness Fabrication

1. Tying a large variety of bundle diameters? The new WT-193 tool gives you an improved level of control and convenience. The accurate preset tension control makes tying uniformity the responsibility of the tool rather than of the installer. The narrow nose and long slim body reaches in, cinches the TY-RAP® tie to a preset tension and trims it evenly . . . even in those tough high-density areas.

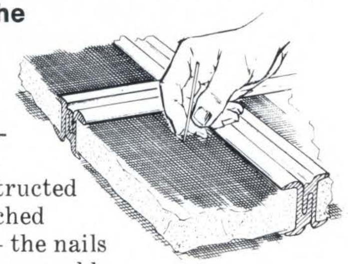


2. Repetitious tying in large quantities? The new TR-300 high-speed tool gives you several benefits. In 8/10th of a second, it installs a TY-RAP tie around a bundle up to 5/8″ diameter, cinches and trims evenly.

3. Here's the most important reduction benefit! The ultimate key to savings is the locking device in the cable tie. Only TY-RAP ties give you a "grip of steel." A patented, non-magnetic, stainless steel locking wedge is embedded in the nylon cable tie. It's in every self-locking tie, from the miniature 3 inch for 1/16″ dia. to the 30 inch tie for 9 inch bundles. It is used in virtually every modern aircraft, communicaiton, business machine and electrical equipment application... in general wherever wire is used.



4. Tired of the recurring costs of harness boards? Our new modular harness board is designed to substantially reduce costs while providing convenience. It is constructed of polyethylene foam sandwiched between two metal screens — the nails can be pushed in by hand. It's reusable. It's reversible. It's modular — boards interlock in seconds to produce any size board needed.



Write for new catalog, The Thomas & Betts Company, Elizabeth, New Jersey 07207 (201) 345-4321. In Canada, Thomas & Betts Ltd., P. Q.

509

Sold Only Through T&B Distributors

T&B ENGINEERED THOMAS & BETTS

Division of Thomas & Betts Corporation

CHECK NO. 18

The RAM game.

We've just doubled the odds in your favor.

Most companies crank out a couple of different MOS RAMs and leave it at that. That's good business for them, but not so good for you. At AMI, we want to solve all your RAM problems. So we've more than doubled our product line, our production and the number of our distributors.

Right now, we can cover 90 percent of 1024-bit MOS RAM applications right off the shelf. Only one other company even comes close. And nobody else can build RAMs using any one of five different processes.

Besides our 2103, a pin-for-pin replacement of the 1103, we have some really fast numbers. Our 3103, for example, is almost twice as fast at 180 ns. Then we have the S4006 quasi-static read/write memory, which is pin-for-pin with Mostek's 4006, with an access time of less than 400 ns. As well as the slightly slower S4008.

Soon we'll be introducing a 4K N-Channel RAM that will knock the industry on its ear. We also have a 1024-bit static RAM in the works, and we've run some of the first C-MOS high-density RAMs.

So instead of jumping around from source to source, why not let us fill all your RAM needs? It's a sure way to circuit compatibility. And it will save you time and aggravation, too.

Our distributors throughout the country are well stocked with our standard RAMs. Write us to find out the name of the one nearest you, as well as complete details about our products.

American Microsystems, Inc., 3800 Homestead Road, Santa Clara, California 95051.

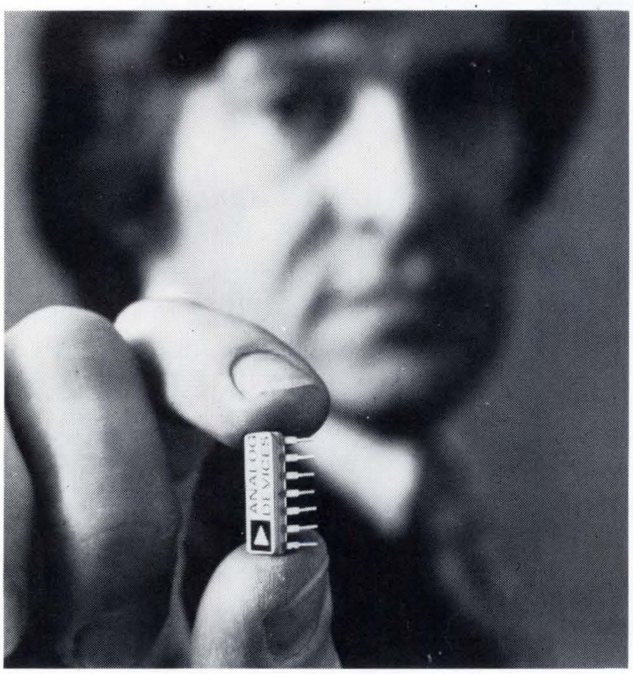
A.M.I.

AMERICAN MICROSYSTEMS, INC.

First with the MOS.

CHECK NO. 19

If you thought our first I.C. multiplier solved a lot of your problems, take a look at this one.



AD531. The first programmable XY/Z Multiplier/Divider. From $20 in 100's.

If you have anything to do with I.C. multipliers, you know our two-year-old AD530 line of monolithic multiplier/dividers has become the industry standard.

That kind of reputation we like. And we know our new AD531 will keep it going nicely.

The AD531 has our proven high performance design of a differential transconductance multiplying element, stable reference, and output amplifier combined on a single chip. And we've added a variable scale factor which allows you to set any fixed value of a Z by an external resistor, or to dynamically vary the value of Z by an externally controlled simple reference circuit.

Plus a differential V_X input with 75dB of common mode rejection. All this makes a lot of complex applications very simple. Like automatic gain control.

True RMS-to-DC conversion. Absolute value.

Vector summation.

You can use the instrumentation amplifier input to reject common mode noise. Or to subtract two input signals prior to further processing.

Or you can use the AD531 just to multiply, divide, square, or square root.

The AD531 will help you do all of this and more with an error guaranteed to be less than 0.5%.

The package is the TO-116 14-pin ceramic DIL for high reliability and handling ease. You can choose from three accuracy versions (J,K,L) for operation over the 0°C to +70°C temperature range, and one for −55°C to +125°C operation(S).

For the next 60 days we're offering five evaluation samples of any version of the AD531 at the 100-piece price.

Call for complete applications and price information. We'll also tell you about two other additions to our I.C. multiplier line. The AD530L, the highest accuracy addition to our AD530 line: 0.5% maximum error. And the availability of the AD530 in a ceramic 14-pin DIL package.

I.C. multipliers are just another of the unique solutions we bring to more of your problems.

Analog Devices, Inc., Norwood, Massachusetts 02062.

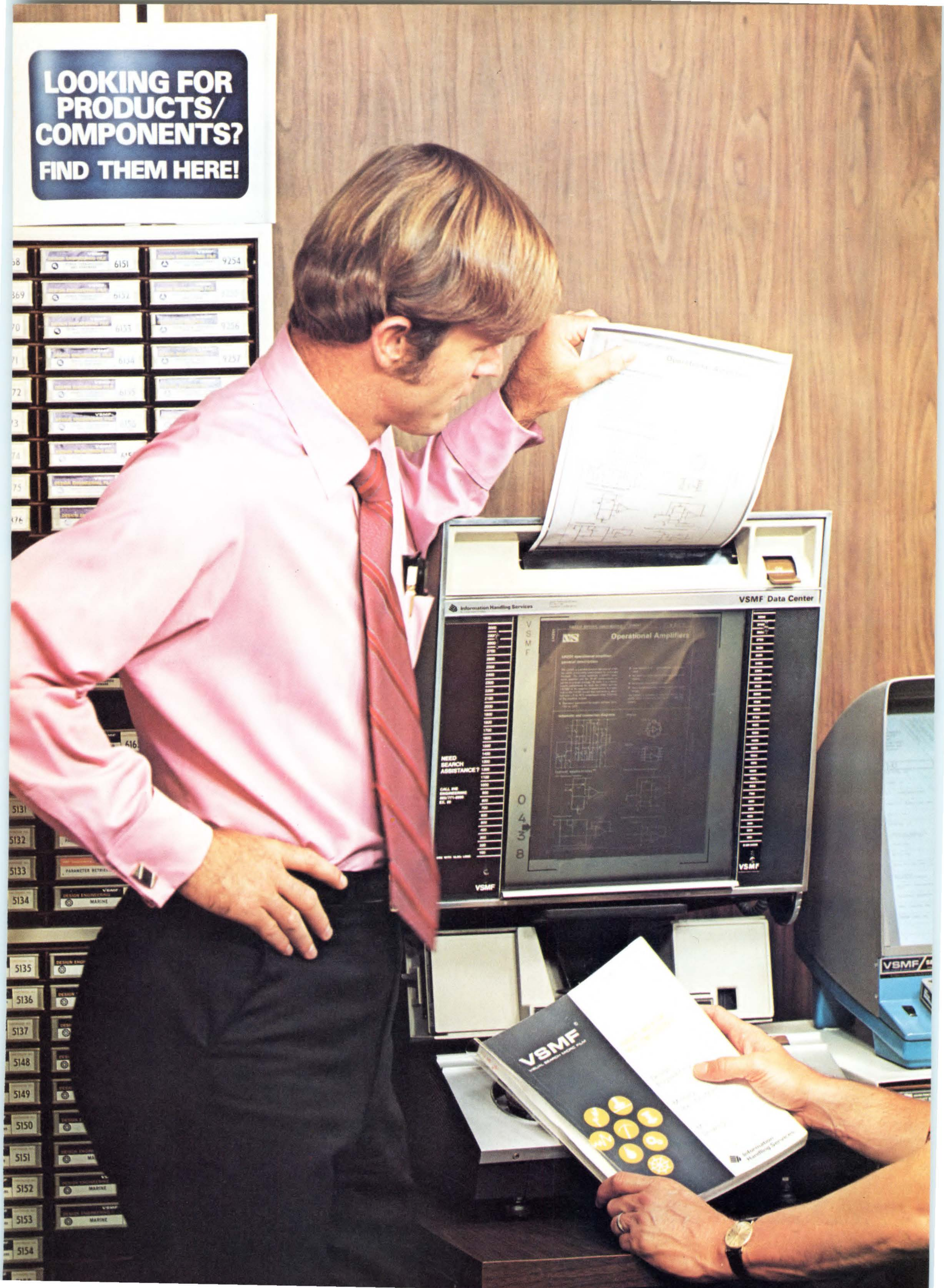
ANALOG DEVICES

Call 617-329-4700

for everything you need to know about multipliers.

CHECK NO. 20

CHECK NO. 21


LOOKING FOR PRODUCTS/ COMPONENTS?
FIND THEM HERE!
VSMF Data Center
Information Handling Services
Operational Amplifiers
NEED SEARCH ASSISTANCE?
VSMF
VSMF
VSMF

having trouble deciding which semiconductor to use?

Visual Search Micro Film (VSMF), the modern technical data retrieval service, helps you decide quickly—helps you choose the one semiconductor that's best for your design.

The VSMF Service Is Called Parameter Retrieval. It lists devices by increasing values of important characteristics, letting you know what's available *before* you start your design.

To Locate Your "Best" Semiconductor, you turn to the family of devices that meets your *most* important parameter needs. There you'll find other major parameters also listed in increasing order of performance value.

Quickly, you satisfy your design needs. You also find second sources, and local sales offices to speed up getting parts for test and evaluation.

VSMF Keeps Engineers Up-To-Date. Hundreds of people back at Information Handling Services' Denver Headquarters gather, sort, organize, index and microfilm all this semiconductor product and supplier information, handling thousands of pages daily. Parameter Retrieval is one of the many services that emerge from this effort, providing frequent updates to keep you current with the fast-changing world of semiconductors. You no longer need to be concerned about out-of-date catalogs, or incomplete and inefficient filing systems.

Price? VSMF costs less than a file clerk, and takes up no more space than an office desk. If you would like more information about this modern data retrieval system, or a demonstration at your office, fill out the coupon and mail it today. Or, call (303) 771-2600.

Information Handling Services, Dept. ED-1
Denver Technological Center
P.O. Box 1154
Englewood, Colorado 80110

Please send more information about:

☐ Design Engineering Service & Parameter Retrieval
☐ MIL/FED Spec's and Standards Service
☐ All other VSMF Services
☐ Please call me for an appointment

Name:____________________

Title:____________________

Company:____________________

Address:____________________

Phone:____________________

See us in Booth 1304 during the IEEE show, March 27-30 in New York City.

Information Handling Services
An Indian Head Company

CHECK NO. 22

new, pocket-size Tri-Phasic™ multimeter

MODEL 245, ACTUAL SIZE

Try It

$295.00
COMPLETE

You can't match Data Precision's Model 245 for price/performance, size, reliability and usability.

PERFORMANCE: .005% RESOLUTION, .05% BASIC ACCURACY FOR 6 MONTHS, MEASURES ACV, DCV, DC AND AC CURRENT, AND RESISTANCE WITH 100% OVERRANGING.

DC Volts, 1 volt to 1000 volts full scale, 100 μV resolution.
AC Volts, 1 volt to 500 volts RMS full scale, 100 μV resolution, 30HZ-50kHZ.
DC Current, 1 ma to 1A f.s., 1 μA resolution.
AC Current, 1 ma to 1A f.s., 1 μA resolution, 30HZ-50kHZ.
Resistance, 1 KΩ-10MΩ full scale, 100 milliohms resolution.
Calibration guaranteed 6 months minimum.

PRICE: $295 COMPLETE
Includes rechargeable battery module, line cord/recharger, fused input probes, carrying case and strap, complete software and test documentation, full Data Precision calibration Instruction Manual and separate Operator's Manual, and one year warranty.

RELIABILITY:
Proven LSI P-MOS and C-MOS Components plus our improved autozeroing Tri-Phasic™ conversion, Isopolar™ reference, Ratiohmic™ resistance provide reliability normally found in instruments costing 3 to 4 times as much.

USABILITY: IDEAL FOR LAB, PRODUCTION OR FIELD USE. Truly portable, pocket size 1¾" x 3½" x 5½" packaged in a rugged impact resistant case, rechargeable 6 hour battery for in-spec operation and line recharge.

To get your hands on this remarkable instrument, phone your local sales representative.

AL	(205) 883-2530	IL	(312) 286-6824	NJ	(215) 925-8711
AZ	(602) 946-7252	IN	(317) 253-2087	NM	(505) 265-6471
CA(N)	(415) 321-7323	MA	(617) 273-0198	NY(N)	(315) 446-0220
CA(S)	(714) 540-7160	MD	(301) 588-7790	NY(S)	(516) 482-3500
CO	(303) 449-5294	MI	(313) 482-1229	OH(N)	(216) 243-7430
CT	(203) 527-1245	MN	(612) 781-1611	OH(S)	(513) 298-3033
FL(N)	(305) 241-4445	MO(E)	(314) 426-2331	TX(N)	(214) 234-4137
FL(S)	(305) 563-8056	MO(W)	(913) 236-6600	TX(S)	(713) 461-4487
GA	(404) 457-7117	NC	(919) 787-5818	WA	(206) 767-4330

Data Precision Corporation
Audubon Road Wakefield, MA 01880
(617) 246-1600

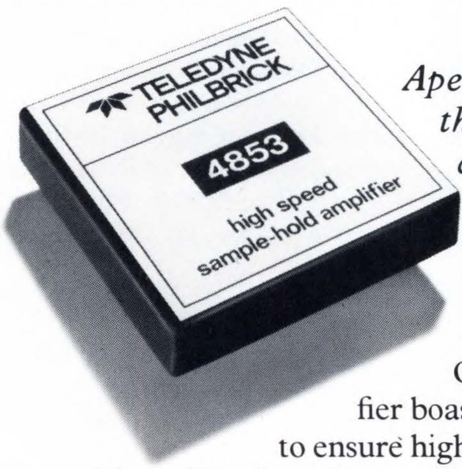
DATA PRECISION
...years ahead

CHECK NO. 24

For designs you can count on...*faster*
87034
72565
0.743851
Divide-by-10 150 MHz Counter
OUT
½ MC10131 A
½ MC10131 A
½ MC10131 B
½ MC10131 B
510
IN
76802542

Two decisive differences!

The aperture-time uncertainty. The feed-thru.



Aperture-Time Uncertainty—the tolerance of the delay between a hold command and the actual opening of the hold switch, i.e., the repeatability of the aperture time.

Feed-thru—the effect of input on output when in the hold mode, usually a function of input signal level and frequency.

Our Model 4853 high speed sample-hold amplifier boasts a low aperture-time uncertainty (± 1 nsec) to ensure high accuracy in data acquisition systems even with rapidly changing input signals. And the 4853's exceptionally low feed-thru (1 mV for a 20V step) means you can multiplex during conversion, increasing thru-put.

Other features provided by our proprietary circuit design include an exceptionally fast settling time with minimum sample-to-hold offsets and "glitches", excellent linearity, low acquisition time, and low cost. All in a low profile module.

Ask your local Philbrick representative for the 4853 data sheet. It tells the *whole* story. Or write, Teledyne Philbrick, Allied Drive at Route 128, Dedham, Massachusetts 02026. For toll-free ready data, dial (800) 225-7883. In Massachusetts (617) 329-1600.

See us at IEEE Booth 1607.

Philbrick Circuit Modules.

The best makes the difference.

CHECK NO. 82

Cinch Dura-Con 0.050″ centers Small. Dependable. Available.

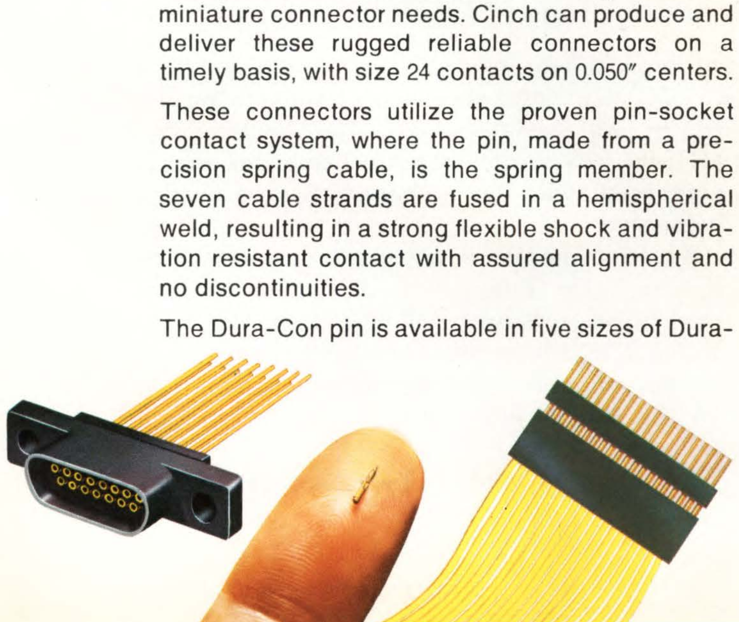
Now you have an effective source for your micro-miniature connector needs. Cinch can produce and deliver these rugged reliable connectors on a timely basis, with size 24 contacts on 0.050″ centers.

These connectors utilize the proven pin-socket contact system, where the pin, made from a precision spring cable, is the spring member. The seven cable strands are fused in a hemispherical weld, resulting in a strong flexible shock and vibration resistant contact with assured alignment and no discontinuities.

The Dura-Con pin is available in five sizes of Dura-Con D-configurations as well as single row strip configurations. It can also be supplied in custom insulators.

The size 24 contacts with 0.050″ centers are supplied factory terminated, with pigtail or wire leads. Size 22 contacts, on 0.075″ and 0.100″ centers, are crimp removable.

Cinch Dura-Con Micro-Miniature Connectors are described in Bulletin PBC-174, available from Cinch Connectors, an Electronic Components Division of TRW Inc., 1501 Morse Avenue, Elk Grove Village, Illinois 60007, (312) 439-8800 CM-7305



TRW® CINCH CONNECTORS

CHECK NO. 27

IEEE INTERCON '73: "Solid State Shapes the Future"

Once again, this year's IEEE Intercon Convention and Exhibition, which is expected to draw 30,000 people, is heavily emphasizing the practical in its 59 technical sessions, all being held in one place at the Americana Hotel. Each session consists of an average of three to four papers, compared to four to five last year, as a result of an effort to concentrate more specific papers into each technical session.

The sessions cover topics in optoelectronics, computers, instrumentation, communications, medicine, marketing, consumer electronics and urban technology. Two topics that dominate the sessions are semiconductors and the growing energy crisis and what to do about it.

Approximately 40% of the technical sessions are devoted to semiconductors. These range from advances in solid-state imaging, memories for computers, MOS/LSI ICs, power semiconductors and consumer electronics to the use of solid-state devices in microwave circuits. There is even an interesting session on utilizing bipolar ICs in LSI form for high packing density.

The heavy concentration of papers on semiconductors comes on the heels of the transistor's 25th anniversary. In fact, the first floor of the exhibitor's area will have a special SIAC (semiconductor innovations and applications center) exhibit consisting of a large corridor lined with booths related to the transistor's development. There will also be a multi-media full-color film presentation on the impact the transistor and ICs are having on electronics.

Four sessions on energy focus on practical methods of energy utilization as ways to relieve future energy shortages. These sessions are being held by some of the most notable energy experts in the country. The energy crisis is receiving so much importance this year that for the first time in the IEEE's history, two sessions, a highlight session on the energy crisis and a keynote session on society's limits to growth featuring a general discussion of energy's relevance to future growth, will be open to the general public free of charge.

The exhibits, which should number about 200, down by about 10% from last year, are designed to parallel the technical sessions in content and will only use two floors of space in the Coliseum, something walk-weary individuals of previous IEEE shows are certain to appreciate.

For the first time, show attendants will be able to experience an actual pc-board line fabrication process from beginning to end in a first floor area designated for printed circuits. This will not be a demonstration by someone else, but an attempt by anyone who desires to actually make a pc board on the spot, all by himself.

One noticeable change this year is the drop in foreign exhibitors, who make up only about 8% of the total number of booths. One IEEE spokesman felt that the new and growing European Common Market may be the reason for this; foreign exhibitors are diverting their attention toward the European continent.

THE TECHNICAL SESSIONS IN REVIEW

Semiconductors: Branching out in all kinds of directions

The continuing progress in solid-state device performance is reflected in papers which report the many different applications of these devices—mass memories for computers, microprocessors, microwave amplifiers and oscillators and many consumer applications such as TV and the automobile.

One session (**23**) devoted to MOS/LSI circuits, seeks to enhance the awareness of their present and projected future capabilities by presenting illustrative LSI circuit examples with improved performance.

Discussed will be the pros and cons of n-channel MOS, CMOS and iso-planar MOS. In addition, the design and performance of MOSFET circuits fabricated on silicon-on-insulating substrates will be discussed. The analysis of a MOSFET read/write memory using this process combined with the n-channel process will be presented.

As an example of advances in MOS circuit design, T. De Franco, H. Bodio and W. Jordan of Intel Corp. (**session 2**) will describe the hardware and system design of a 1-million byte mainframe memory module using MOS dynamic memory for add-on use in IBM 370/155 and /165 computer systems.

IC designers would not want to miss one very important session (**30**) entitled "High Packing Density Bipolar Technology for LSI." The five papers that make up the session will be devoted to discussions on how to produce bipolar circuits in LSI form.

Because LSI circuits are moving into prominence, with some dual-in-line package circuits utilizing more than 24 pins, the problems of packaging, reliability and servicing ICs are given attention in a session (**50**) on IC packaging.

Several proposed packaging schemes will be explored. One paper by Ron Boger and Jack Norrie of Amp, Inc., discusses several of the newer IC packaging techniques in detail as evidence that packaging technology is indeed keeping pace with IC technology.

For the consumer, papers will discuss the role new ICs are having in television. Described will be digital AFC circuits that facilitate quick and easy digital pushbutton TV channel selection, and a single chroma-processing IC that combines several TV circuit functions into one package. CMOS watch circuits and a miniature IC transmitter will also be reported (**session 51**).

Electro-optics: charge coupled devices lead the way

Charge coupled devices (CCDs) are indeed coming into their own. They are now finding applications in image sensing, analog signal processing and digital shift-register memories.

Papers will be presented detailing CCD use in TV cameras as self scanned image sensors (**session 1**). In addition, the use of electron beam scanned silicon mosaic targets and photodiode arrays for scanning images in TV cameras will also be detailed.

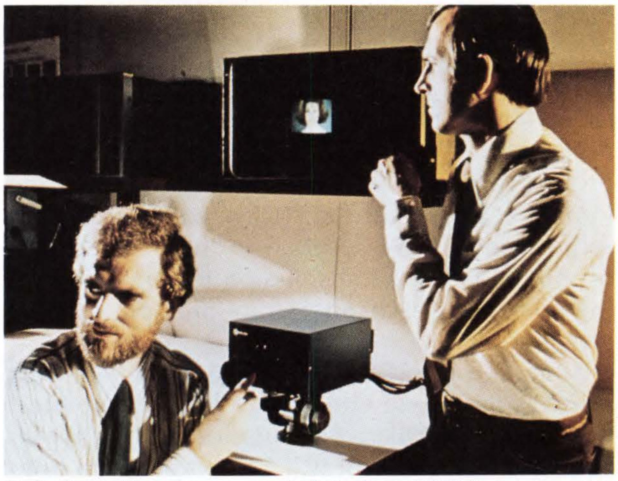
Although magnetic storage dominates the mass-memory field at this time, much of the research effort is oriented toward optical, electro-optical and beam-recording technologies. These latter approaches will be examined and evaluated in the session (**9**) on archival and mass memories using optical devices.

The use of the hologram and a photodichromic color center as mass memories are presented in separate papers. A review is also given on recently proposed and potential future electron-beam mass-storage systems.

How to display graphic and alphanumeric computer data best has always intrigued designers. Many techniques have emerged in recent years to challenge the conventional CRT display. These include dot-matrix LED arrays, ac plasma displays, digitally addressed flat-panel CRTs and gas-discharge panel displays, all to be reviewed in **session 33**.

Light-valve projection-display systems with the compatibility of operating in real time at TV rates, for both color and black-and-white systems, will be the subject of a session (**26**) on projection display systems. Reviewed will be the status of TV projection devices, which include the CRT-Schmidt systems, the laser projector and light valves.

Probably, one of the best applications where optoelectronic devices have been used is in circuit control. The phenomenal growth rate of optoelectronic couplers can easily attest to this. These devices are more dependable and cost less than alternate means. The use of optoelectronic couplers in industrial interface applications, in the field and in the factory, will be carefully scrutinized (**session 31**).



Only three tiny charge coupled devices (CCDs) make up the image sensors for this solid-state color TV camera. Developed by engineers at Bell Telephone Laboratories, it is expected to lead to a new generation of color TV cameras that are much lighter, smaller and less expensive than conventional cameras using cumbersome vacuum-tube and electron-beam-scanning systems.

Energy: a growing major crisis in need of fast solutions

Without a doubt, the growing fuel shortages of the world are causing scientists and world leaders grave concern. A session (**6**), devoted to ways of alleviating this, discusses several possible sources for virtually unlimited, and nearly pollution-free, energy.

Three basic themes will be covered: nuclear fusion by both magnetic confinement and laser energy, solar power utilizing both ground based and satellite systems, and energy produced from water by either electrolytic or chemical injection of energy to produce hydrogen.

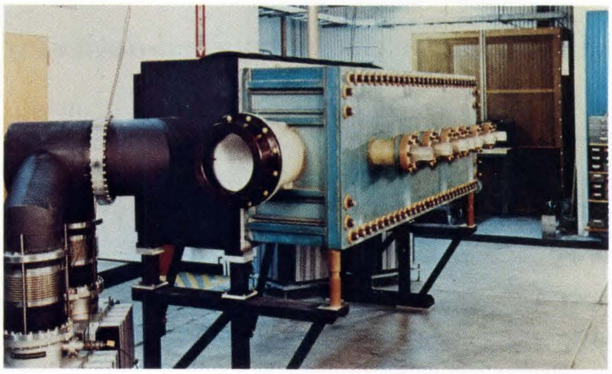
Although the concepts discussed may be decades away from commercial large-scale application, they are by far the most promising prospects for the future for satisfactory solutions to the problems posed by our all-too-finite reserves of fossil and nuclear-fission fuels.

Getting the most out of present power systems is the subject of a session (**13**) on energy storage. The general design, role and value of a Swedish air-storage gas turbine power station that makes use of compressed air for operating the turbine is discussed as a way of increasing power-system efficiency. Superconducting inductors and electrochemical energy are discussed in two papers as other means for storing electric power system energies.

A session (**20**) on power system control shows different approaches for computer control of power. Varied papers cover new equipment for on-line simulation, a centralized approach for controlling a multiple-area system and a discussion on the existing CEGB power system in England, with respect to its organization and expected developments.

A highlight session open to the general public on the energy crisis will present the viewpoints of the academic world, the power industry and the professional power societies on this matter.

Another keynote session, also open to the general public, will explore the role of the engineer and engineering in today's and tomorrow's societies. Does new technology necessarily mean a better world? Could an anti-technology attitude grow amongst the public? How can technology best serve us with our limited resources? These and other questions will be debated in this "Limits-to-Growth" keynote session.



A 10.6 μm laser amplifier operates at 1k J for 0.1 nsec pulse lengths. A prototype unit for 10^4–J laser system is now in design at the Los Almos Scientific Laboratory, University of California.

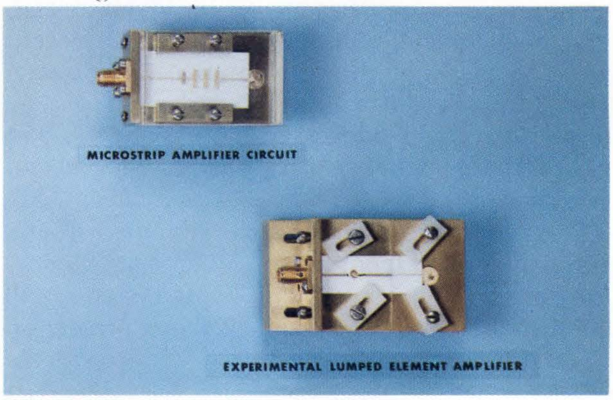
Communications: improving transmissions via satellite to extend our horizons

Satellite communication is no longer a distant dream, but an everyday reality. Methods to improve these communications are constantly being looked at and evaluated. Heavy communications requirements have resulted in the development of multiple-access transmission techniques starting with single-channel into multiple-channel schemes.

A session (**5**) will examine the multiple-access route as the key to effective satellite communications. In particular, communications networks having central control will be compared to ones with autonomous local control. Time-division multiple-access (TDMA) of the Intelstat satellite system and for the defense satellite communications system (DSCS) will be explored. Various multiple-access techniques planned for the Canadian domestic satellite communication network will also be presented.

A specific session (**12**) on satellites will review four of the new system applications likely to be in operation during this decade: the Telesat system for domestic communications, the Navy's Fleetsat system, a commercial Maritime system for ships at sea and a potential satellite system for U.S. postal communications.

A panel session (**47**) on the significance of satellite telecommunications for developing countries provides an international outlook with the participation of representatives from Algeria and Brazil, together with two panelists from the Comsat Corp. and one from Teleconsult, Inc., of Washington, DC.



Wideband Trapatt amplifiers, such as the microstrip (top) and an experimental lumped-element unit (bottom) from the Sperry Rand Research Center, should find applications in phased-array radars and point-to-point communication systems. These 2-terminal, circulator coupled devices operate on a negative-resistance principle, induced by the application of an external sinusoidal signal whose amplitude exceeds a critical value.

State-of-the-art microwave devices, needed to fulfill these communications requirements, will be looked at (**session 48**). Devices discussed include Trapatt diodes, Transferred-Electron and Impatt amplifiers and GaAs FET and silicon bipolar power transistors. Such performance parameters as power output, gain, efficiency, bandwidth and noise will be discussed and compared.

Television communications will be explored (**session 39**). A video recording system that utilizes a pressed disc which is read out optically will be explained. So will methods for improving cable TV broadcasting.

Discussions are not necessarily limited to communications via the airwaves. A session (**10**) on interior information transfer using multiplexing is planned. A generalized time-division multiplexed (TDM) loop network is first described followed by two papers describing the application of multiplexing to two specific systems—a space station and the B-1 bomber aircraft. A final paper addresses itself to the problem of the proper selection of a multiplexing system's control element—often a very critical decision.

Bio-Engineering: a new hope for the visually handicapped

Modern medicine, safety standards and hygienic conditions have done much to reduce the incidence of blindness throughout the world. Nevertheless, with all of the miracles of medicine, a sizable number of blind people had no hope for surgical or other methods of correction. But there is hope now, thanks to sophisticated electronic, biological and computational methods being employed in a variety of ways to alleviate this age-old problem.

Four interesting papers (**session 37**) will be directed at implementing electronic devices to aid the visually handicapped. Jonathen Allen of MIT's Research Laboratory of Electronics and Dept. of Electrical Engineering will provide a historical review of aids for the blind, from the earliest devices up to current research efforts. The recent evolution of devices is then compared to these requirements, and future trends are predicted.

Two authors, Edward Snow of Reticon Corp. and Carter Collins of the Smith-Kettlewell Institute of Visual Sciences, will team up to describe a solid-state image-sensor system that uses tactile image perception for visual prosthesis.

Snow will report on a 32 X 32 self-scanning photodiode matrix used for image perception by the blind. Collins will discuss a 32-line, 3-mm monolithic TV camera that electronically impresses onto a blind person's skin its images, point-for-point, with an array of 1024 electrodes. Blind subjects can locate, recognize and retrieve objects, read graphs, meters and oscilloscopes, and can even distinguish colors.

A final paper on stimulation of the human visual cortex by F.T. Hambrecht of the U.S. Dept. of Health, Education and Welfare will talk about work being done on the evaluation of potential biomaterials, the electrochemical, histopathological and neuropathological effects of long-term electrical stimulation of neural tissues and results from human visual cortex stimulation studies.

Blind seeing aid uses a miniature camera and tactile stimulation to aid the blind to locate, recognize and retrieve objects; read graphs, meters and oscilloscopes and also to distinguish colors. The camera was developed by the Smith-Kettlewell Institute for Visual Sciences and the 32 x 32-element self-scanning photodiode matrix was developed by Reticon Corp.

Computers: taking on bigger and bigger roles in all fields

A glance at some of the technical sessions will show that computers are to be found everywhere—in manufacturing, in design, in marketing, in management and in decision making, to name just a few areas. And they're getting international in character, being installed in more and more countries of the world. It is getting so that large computer systems are creating their own set of problems—how can they be managed effectively?

The computer's role in marketing is fully explored in one session (**4**). Looked at will be its role in market research, surveys, planning, modeling and information systems. Another session (**8**) will examine computer application to the manufacturing environment. Three papers will explore the use of analysis in the manufacturing design phase, and limitation of hardware and software in present advanced computer systems.

How can the computer help the designer? Two sessions should provide the answer. One (**27**) illustrates the interaction of the computer from the standpoint of the engineer's needs, and provides several examples of how he can use this means to enhance his effectiveness. Another (**18**) documents specific cases where the computer has helped in scientific and engineering studies for analyzing and evaluating designs, understanding and optimizing processes and analyzing human factors.

The legal considerations that must be weighed when using computers in public systems, as in cases of automatic monitoring and recording of filed access data, are examined in a special session (**4**). Another session (**22**) will analyze the current and future status of the electronic data processing (EDP) industry from the viewpoints of an economist, a venture capitalist and two EDP experts. This session will analyze the problems and potentials of EDP as a business opportunity.

On the hardware side, a session (**19**) on bus organized interconnection techniques includes a discussion by proponents of both microwave and optical means of bus interconnections. The multiplexed bus organized interconnection scheme is needed where many portions of large computer systems must communicate with each other using a minimum number of hard wire interconnections.

The full capabilities of minicomputers will be detailed in a workshop panel session (**15**). The panel will attempt to define the areas where a minicomputer should be used as a most effective tool. The uses and abuses of the minicomputer will come under careful scrutiny.

It has been said that the state of computing outside the U.S.A. is "two years behind" in application, equipment and market development. This assumption will be examined in a session (**25**) that provides an overview of world market development and the status of the computer in foreign countries.

Instrumentation: sophisticated automatic testing is the byword

With IC devices reaching new highs in complexity, the need for high-speed automatic testing is becoming more and more necessary. But automatic test systems are not without problems, not to mention the expensive price tags they carry.

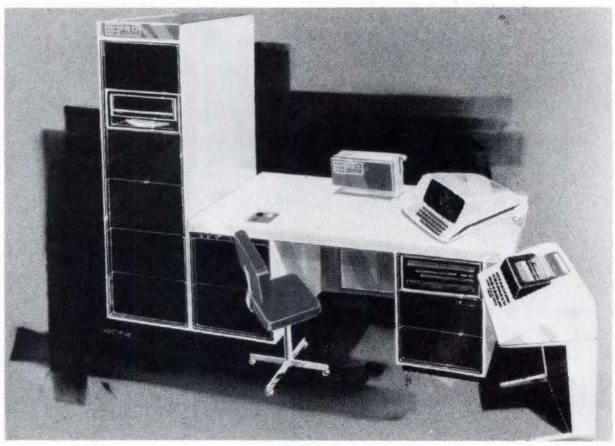
Just how does a computer controlled test system save money? What is its economic justification? How should resources be reallocated when it is used? What job can it do best? Should a designer build a system from the ground floor up—or buy and integrate its pieces—or purchase a "turn-key" system? These and many other questions will be answered at a session (**52**) on applying computer controlled test systems.

The unique aspects of testing extremely functional and analog devices, such as computers on a chip and voltage-to-frequency converters, will also be explored. Jim Cunningham of Systron-Donner Corp. provides a refreshing step-by-step guide in acquiring computer controlled automatic test systems.

A session (**38**) devoted to instruments for computer controlled test systems describes the testing problems and limitations of available equipment. How bench instruments can serve and survive in a system's environment will also be discussed. One paper presents a new method for interfacing the many instruments that make up an automatic test system.

As an example of how sophisticated test systems can be, Ernst Forster of PRD Electronics presents a paper (**session 38**) on automatic complex-waveform analysis. He will discuss how such systems can analyze complex video-signal parameters ranging all the way from nanoseconds to seconds.

One major headache of computer controlled test systems has always been the software. Four papers (**session 45**) will deal with this subject. Two of them describe computer languages designed to make it easier for the noncomputer oriented



Sophisticated automatic computer controlled test systems will become more and more an economic necessity as IC and other devices become more complex. Shown above is PRD's new CAST system which can automatically analyze the most complex video waveforms ranging from nanoseconds to seconds.

IEEE '73 INTERCON TECHNICAL PROGRAM SESSION CHART

Session 1 Progress in Solid State Imaging ☐

Session 2 Semiconductor Main Frame Memories ☐

Session 3 Precision Marketing/Can Computers Help? ☐

Session 4 Computers in Public Systems ☐

Session 5 Satellite Multiple Access – The Key to Effective Utilization ☐

Session 6 Prospecting for Energy ☐

Session 7 Optical Computing ☐

Session 8 Computer Application in the Manufacturing Environment ☐

***Session 9** Archival and Mass Memories ☐

Session 10 Interior Information Transfer – An Application of Multiplexing ☐

Session 11 The Evolution of Large Government Computing Systems ☐

Session 12 Communication Satellite System Applications – Extending Our Horizons ☐

Session 13 Energy Storage ☐

Session 14 Information Theory After 25 Years Synopsis ☐

***Session 15** Minicomputers: Boon or Blight – A Workshop Panel Session ☐

Session 16 Video Storage; Present and Future Impact on Communications, Information Retreival, and Data Display ☐

***Session 17** Maintaining the Competitive Edge in International Markets ☐

Session 18 Hybrid Simulation: What is it – and How Viable? ☐

***Session 19** Bus Organized Interconnection Techniques ☐

Session 20 Power System Control ☐

Session 21 Implementing Random Logic with Microprocessors ☐

***Session 22** EDP as a Business Opportunity ☐

Session 23 LSI – MOS Circuits ☐

***Session 24** Outlook for Purchasing Components for '73 ☐

Session 25 State of Computing Outside the U.S. ☐

Session 26 Projection Display Systems ☐

Session 27 Can Direct Interaction With a Computer Serve You? ☐

Session 28 The Philosophy and Methodology of Technological Forecasting ☐

***Session 29** The Transistor – Yesterday, Today and Tomorrow ☐

Session 30 High Packing Density Bipolar Technology for Large Scale Integration ☐

***Session 31** Control – Utilizing Light Sensitive Devices ☐

Session 32 Electro-Mechanical Versus Solid State ☐

Session 33 Matrix Displays ☐

Session 34 New Developments in Signal Generators ☐

Session 35 Technology Assessment and Applications ☐

Session 36 Environmental Electroacoustics ☐

Session 37 Electronics for the Visually Handicapped ☐

Session 38 Instruments for Computer – Controlled Test Systems ☐

Session 39 Television ☐

Session 40 Cybernetics and Man – Machine Systems ☐

Session 41 Resistor Trimming ☐

Session 42 Surface Acoustic Wave Devices in Real Systems ☐

Session 43 Numeric and Alpha-Numeric Displays for Instruments ☐

***Session 44** Engineering and Purchasing: Allies or Adversaries ☐

Session 45 Program Generation for Automatic Test Equipment ☐

***Session 46** What Detroit Really Needs From the Electronics Industry ☐

***Session 47** The Significance of Satellite Telecommunications for Developing Countries ☐

Session 48 Microwave Solid – State Amplifiers and Oscillators – Two or Three Terminal Devices ☐

Session 49 Advances in Transducer Design ☐

Session 50 Advanced Micro-electronic Packaging for Cost, Reliability and Field Service ☐

Session 51 Solid State for Consumer Electronics ☐

Session 52 Applying Computer – Controlled Test Systems ☐

***Session 53** Multinational Marketing of Semiconductors by U.S. Manufacturers ☐

***Session 54** Automated Machine Control Technology ☐

Session 55 MIC's in Instrumentation ☐

***Session 56** Impact of New Technologies on Silicon Devices and Circuits ☐

***Session 57** Industrial Application of Power Semiconductors ☐

Highlight Session Session 8 p.m. Energy Crisis ☐

Keynote Session 8 p.m. Limits To Growth ☐

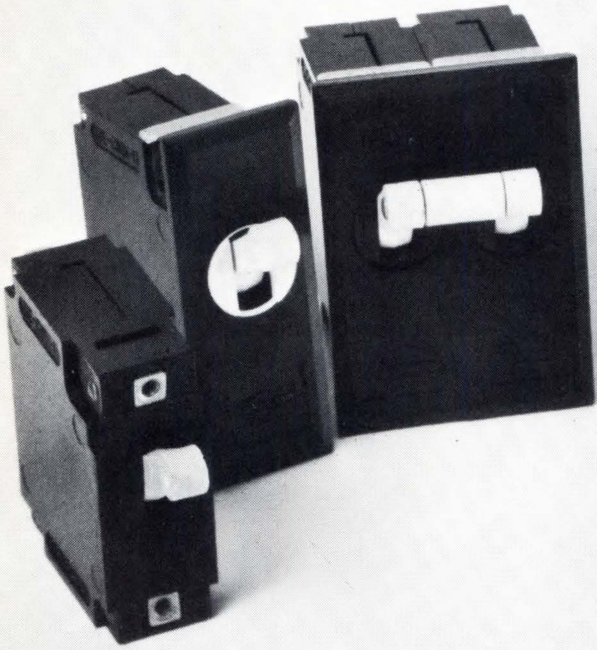
Preprint copies are available for each session at $2.50. Check the session to be ordered and send check or money order to:

IEEE Convention Dept.
345 E. 47th St.
New York, NY 10017

* Not all papers in this session are available as copies.

user to write his own test programs. Two other papers are addressed to current problems and present achievements in automatic test-program generation.

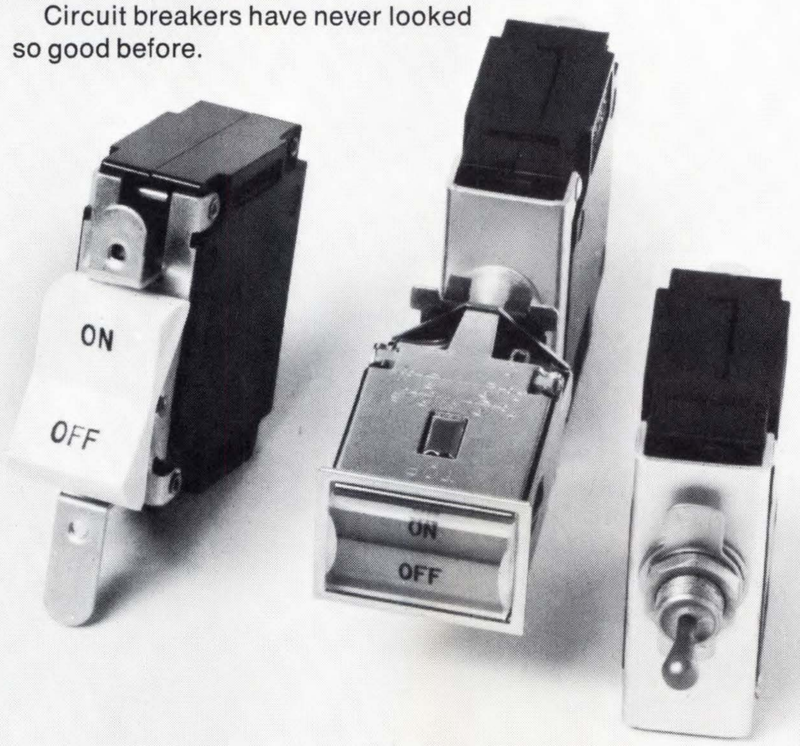
A look at new developments in signal generators (**session 34**) will examine the latest in signal generation techniques using direct digital methods and phase locked high-frequency oscillators. Newly developed test methods for instrument performance and new applications due to improvements made in signal generators will be heard.☐



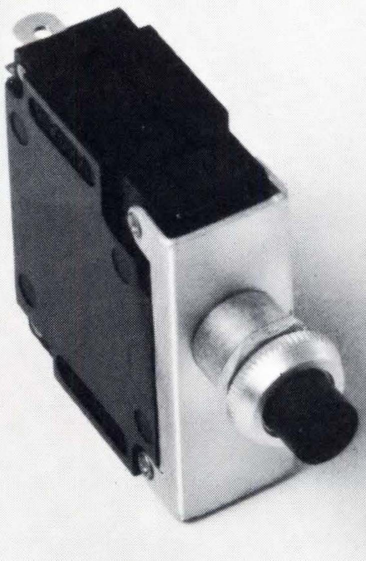
Toggle handles in white. Rocker handles in white, gray, black, or custom colors. Rectangular pushbuttons, lighted green for ON, white for OFF. Cylindrical pushbuttons, not lighted at all. An environment-protected model with a sealed bat handle. A model for fast snap-in mounting.

Our Type J line.

Circuit breakers have never looked so good before.



You don't have to settle for homely circuit breakers anymore.



They're hydraulic-magnetic, of course, and therefore offer you exceptional performance capabilities: precise, temperature-stable current ratings and trip points; a choice of time-delay characteristics (or non-time-delay operation); the option of a half-dozen special-function internal circuits.

All are available for operation on any of the commonly used DC or AC voltages (60Hz or 400Hz). In any current rating from 0.020 to 30 amp.

All are reasonably priced. Even in modest OEM quantities.

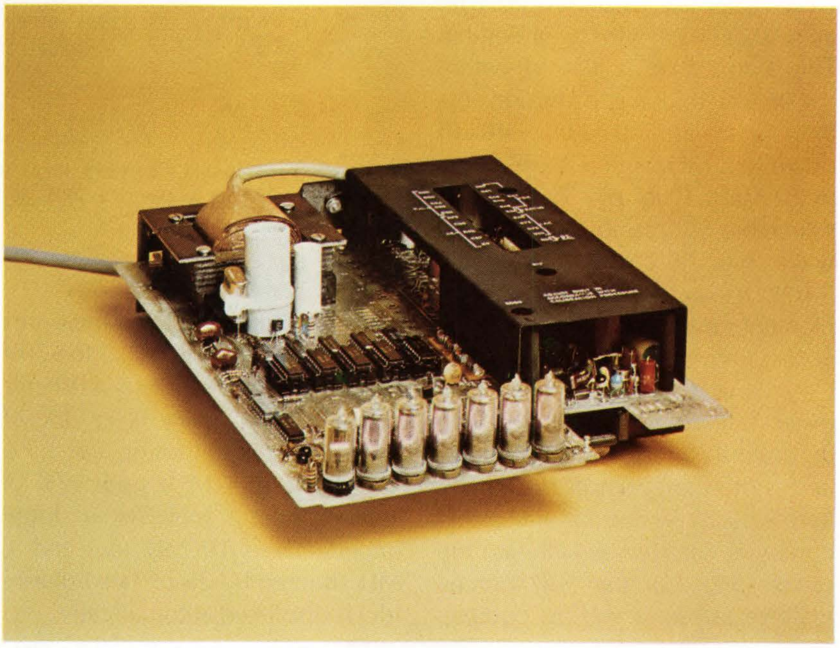
We'll be glad to send you detailed technical literature. Just tell us to whom and to where. Heinemann Electric Co., 2626 Brunswick Pike, Trenton, N.J. 08602.

HEINEMANN

CHECK NO. 26

5292

5-1/2-digit DPMs offer resolution down to 1 μV dc



1-μV dc resolution is what this 5-1/2-digit DPM will deliver, the only one of its type on the market.

Data Precision has taken its recent 2540A1 digital multimeter and stripped it down to a 5-1/2-digit DPM line known as the Series 3000. Thus, the new DPMs have become the highest resolution units on the market with the most accuracy. There are no other 5-1/2-digit or even 5-digit DPMs available at the moment.

Aimed at industrial instrumentation and control markets where signals from small transducers can range down to microvolts, the series consists of five standard models offering full-scale ranges of ±0.100000, ±1.00000, ±10.0000, ±100.000 and ±1000.00V dc for resolutions of 1 μV, 10 μV, 100 μV, 1 mV and 10 mV, respectively. The five models are the 3001 ($695), 3002 ($645), 3003 ($645), 3004 ($645), and 3005 ($645), in order of decreasing resolutions.

The dual-slope integrating DPMs, which include Triphasic conversion and Isopolar reference circuits, feature 20% overranging (except for the Model 3005), autopolarity indication, bipolar, floating, true-differential and guarded inputs that are fully isolated from the outputs, and automatic zero settings.

Accuracy over 6 months at 23°C ±5°C for the 1-μV DPM (Model 3001) is ±0.008% of reading, ±0.004% of full scale, ±1 least significant digit. For all others, it is ±0.007% of reading, ±0.001% of full scale, ±1 least significant digit. Temperature coefficient over the range of 0°C to +50°C is ±0.001% of reading ±0.001% of full scale per °C (Model 3001 1-μV DPM), down to ±0.001% of reading ±0.0002% of full scale per °C for all others. Input impedance for the 1, 10 and 100-μV units is 1000 MΩ and 10 MΩ for the 1- and 10-mV units.

Other features include Nixie tube readouts, 160-dB CMRR (dc) and 120 dB (50/60Hz), 60-dB NMRR, a reading rate of 3/sec (internal trigger), and up to 4/sec (external trigger), 1-2-4-8 BCD output and 10W power dissipation from either 105 to 125V ac or 210 to 250V ac, 47 to 430 Hz.

Dimensions are 3-in. high by 8-in. wide by 11-in. deep, and weight is 3-1/2 lbs. Numerous options are available.

Data Precision Co., Audubon Rd., Wakefield, Ma 01880. Phone (617)246-1600.

Booth No. 2628 Check No. 100

5-function lab instrument sets new concept

Look into any enginnering laboratory and you'll probably find a minimum number of basic instruments consisting of at least a power supply, frequency counter, scope, multimeter and a signal source. Each instrument has usually had to be purchased separately at a cost of a few hundred to a few thousand dollars.

With the introduction of the Versatester I from Systron-Donner's

Datapulse Div., a new concept has begun in laboratory instruments. This instrument houses five individual instrument functions in one metal case: It's a function generator, a pulse generator, a frequency counter, a multimeter and a power supply—all for a price of only $1250.

Here's what the Versatester I can do. It generates sine and square waves from 20 Hz to 20 MHz with an accuracy of ±0.1% of setting. The sine wave is flat to within ±0.25 dB and has distortion less than 0.5% to 500 kHz, −40 dB down to 2 MHz and −30 dB down to 20 MHz. Output is 3V rms, into selectable 50 or 600Ω. The square wave has 95% time symmetry, 5-nsec rise and fall times and complement outputs provided from 50Ω sources, from −5 to +5V.

As a pulse generator, the Versatester I features a repetition rate that spans 20 Hz to 20 MHz, delay and width from 20 nsec to 20 msec and 5-nsec rise and fall times. Accuracy is ±0.19% of setting. Output is −5 to +5V from 50Ω sources. Positive pulse, as well as complement outputs, are provided. The pulse generator portion also has external triggering from dc to 20 MHz, a sync output and pulse pairs up to 10 MHz.

As a frequency counter, the autoranging Versatester I measures frequencies from 20 Hz to 20 MHz using a 4-digit display at 100-mV sensitivity. Input impedance of the counter is 1 MΩ and time-base stability is ±1 part in 10^6.

Five instruments in one for $1250. It is a 20-MHz sine- square-wave and pulse generator; a 20-MHz frequency counter; a 500V ac and dc voltmeter; an ohmmeter and a power supply.

The multimeter section measures ac and dc voltage from 0.5 to 500V full scale in four ranges at a 0.1-mV resolution. Accuracy is ±0.1% of reading ±1 count for dc and ±3% of reading to 1 MHz and ±7% of reading over 1 MHz for ac. Input impedance is 10 MΩ (dc) and 1 MΩ shunted by 25 pF (ac) Polarity (dc) is displayed automatically.

The multimeter can also measure dc resistance. It does this in four ranges from 5 kΩ to 5 MΩ full scale at a resolution that extends down to 1Ω. Accuracy is specified as ±0.5% of reading ±1 count up to 500 kΩ and ±0.1% of reading ±1 count up to 5 MΩ.

As a power supply, the new instrument supplies outputs of +5V to 1A, +15V and −15V to 200 mA each and ±30V by the proper external grounding of the floating ±15V outputs. Ripple is 5 mV for the +5V output and 10 mV for the others. All outputs are stable to within ±1% and feature current limiting.

The Versatester I also has some capabilities not usually found in many laboratory instruments. For example, the frequency of pulses, sine and square waves may be precisely set on its 4-digit counter readout. Output levels of each can also be precisely set on its multimeter readout.

Datapulse Div. of Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, CA 90230. Phone(213)871-0410.

Booth No. 2326 Check No. 101

Ultra-linear 16-bit D/A converter with 1.5 ppm/°C TC

D/A converters with 16 bits of resolution are devices that yield resolutions of 1 part in 65,000, calling for ultralow nonlinearities to be effective. One such device is Datel's new DAC-HR16B which offers an excellent linearity error of ±0.00015%, accuracy of ±0.00015% of full scale and an astoundingly low temperature coefficient—just 1.5 ppm/°C! And at a price to beat—just $495.

Such accuracy and stability is said to be due to a precision thin-film ladder network which tracks to within ±0.5 ppm/°C, an oven controlled zener reference with a TC of only ±0.25 ppm/°C which is current controlled within a high-gain servo loop and the use of four highly uniform monolithic quad switches whose betas track together, both initially and with temperature.

Output settling time of the DAC-HR16B is 200 nsec to 0.025% of full scale, and 1 μsec maximum to 0.00015% of full scale. The settling time includes switch delay, nonlinear slewing time and final exponential decay time. The converter may be used either for unipolar or bipolar operation.

For unipolar applications, full scale output is 0 to −2 mA; and for bipolar operation, it is ±1 mA at a maximum voltage compliance of ±1V. Provisions are provided for the user to connect an extra op amp for scaling, sign inversion, voltage or current amplification and impedance transformation.

Terminating, feedback and bipolar offset resistors are included internally. These resistors have TCs matched to the ladder network. The values of the internal feedback and bipolar resistors are set to produce a unipolar (0 to +10V) or bipolar (±5 or ±10V) output from the external amplifier which should be selected to suit particular applications.

Input digital coding is straight binary for unipolar output and offset binary for a bipolar output. All digital inputs are compatible with standard TTL/DTL logic levels and are positive logic. Input power requirements are ±15V dc at ±35 mA.

TC of 1.5 ppm/°C and 0.00015% linearity characterize this 16-bit D/A converter. The fully repairable encapsulated unit has a 1-μsec maximum settling time to 0.00015% of full scale.

To compensate for long-term drifts, offset and gain adjustments are provided. The 2 × 4 × 0.4 in. encapsulated converter module is fully repairable.

Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617)828-6395.

Booth No. 2609 Check No. 102

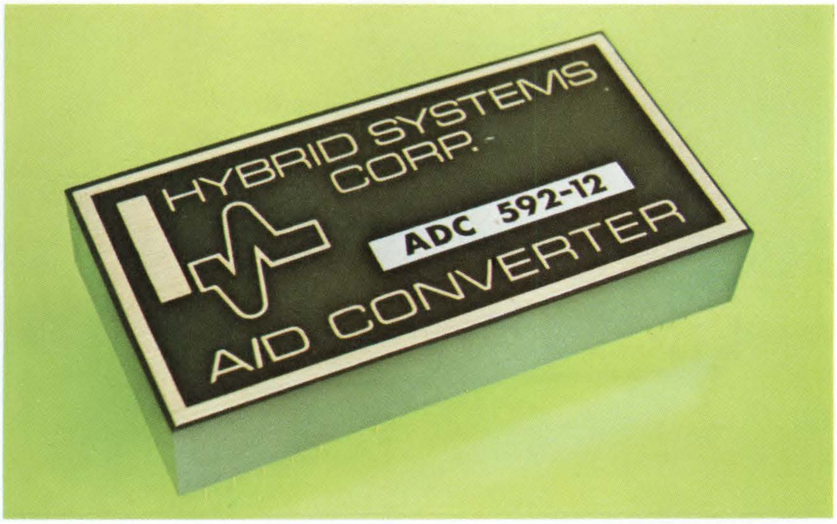
A 12-bit A/D converter with 3.5-μsec conversion time

Hybrid Systems has introduced a new high-speed $395 12-bit A/D converter known as the Model ADC592-12. It features a maximum sampling rate of more than 30,000 samples/sec, converting all 12 bits of input data in under 3.5 μsec.

The ADC592-12 features an accuracy vs. temperature of 50 ppm/°C over an operating temperature range of 0°C to 70°C. Linearity vs. temperature is specified as 30 ppm/°C.

The high speed/accuracy combination is said to be the result of a precision D/A converter used in conjunction with a proprietary variation of the successive-approximation conversion technique. This is claimed to allow the D/A converter to settle in 50 nsec with an accuracy of 0.0125%.

Complete with all references, logic and timing circuits, the ADC592-12 accepts input signals in three different ranges: 0 to +1V, 0 to +10V and ±5V. Range selection is through a simple pin interconnection. The output coding is binary and is fully compatible with TTL/DTL logic levels.



This 12-bit A/D converter features a 3.5-μsec conversion time. Packaged in a DIP-compatible module, the 50-ppm/°C unit requires no trimming or external components.

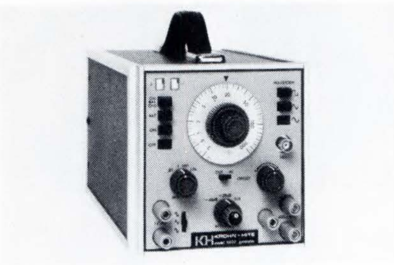
For packaging convenience, the new A/D converter has dual-in-line pin spacing for plugging into standard IC socket cards, and is available in a 2 × 0.4 × 0.8 in. module. It operates on ±15V and +5V. No trimming or external components are required.

Hybrid Systems Corp., 87 Second Ave., Burlington, MA 01803. Phone(617)272-1522.

Booth No. 2632 Check No. 103

IEEE/INTERCON—PRODUCTS

Portable lightweight 2-MHz function generator.



Model 5600 portable function generator is a lightweight unit (only 7 lbs including battery pack) that can be operated from a battery as well as the ac line, and provides sine, square and triangular waveforms over a frequency range of 0.002 Hz to 2 MHz. The instrument's internal rechargeable batteries are rated to operate continuously for up to 10 hrs.

Priced at $395 ($70 for the battery kit), the Model 5600 provides both a 50Ω single ended and 600Ω balanced output at either 15V p-p or 30V p-p, respectively. The output is controlled by a 3-position attenuator and amplitude vernier. An additional 1V auxiliary output is provided. The tuning dial features a 1000:1 tuning ratio. Kron-Hite Corp., 580 Massachusetts Ave., Cambridge, MA 02139. Phone(617)491-3211.

Booth No. 2427 Check No. 104

Low-cost 50-MHz pulse-generator pair

Both the Phillips $765 PM5715 and $575 PM5712 offer pulse repetition rates from 1 to 50 MHz with a variable output amplitude from 200 mV to 10V. A separate fixed-amplitude auxiliary output on each unit provides full TTL compatibility without any adjustments. The dc baseline is vernier controlled (the PM5715 has a ±2.5V range; and the PM5712, a range of −5 to +2V).

The PM5715 offers variable transition times from 6 nsec to 500 nsec while the PM5712 offers a fixed 4-nsec transition time. Each has independently settable pulse delay and duration via selector switches and verniers from 10 nsec to 100 msec. Selectable operating modes include external trigger, gated output, single and double pulse, and square wave. Test & Measuring Instruments, Inc., 224 Duffy Ave., Hicksville, NY 11802. Phone(516)433-8800.

Booth No. 2108 Check No. 105

50-MHz pulse generators with constant duty cycle

The P23 and P25 pulse generators feature constant duty cycle modes that allow the setting and maintaining of an established timing relationship between pulse width and period that is not affected by changing frequencies. Both instruments cover 1 Hz to 50 MHz and provide simultaneous ±10V pulses into 50Ω, as well as their positive and negative complements.

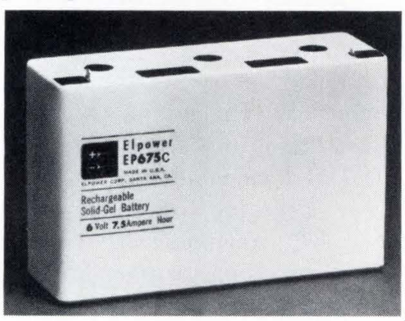
The P23 offers 3.5-nsec rise and falltime pulses, and the P25 offers independently adjustable rise- and falltimes down to 5 nsec. Repetition-rate, rise/fall, delay and width controls for both units feature a continuous, 2-decade operating range. An extra 10:1 coarse/fine control is included for fine tuning. $625 (P23) and $995 (P25). Interstate Electronics Corp., 707 E. Vermont Ave., Anaheim, CA 92803. Phone(714)

Booth No. 2617 Check No. 106

Rechargeable standby "super-power" batteries

The rechargeable line of Solid-Gel (patent pending) leakproof batteries are said to be "super-power" batteries that are specifically engineered to provide reliable standby power. Available in either 6 or 12V versions, they are reported to have long shelf-life and can be connected in series or parallel and operate in any position at temperatures from −40°F to +140°F.

Specific ratings and prices (depending on quantity) follow: 6V, 3 AH, from $5.50 to $11.21; 6V, 4.5 AH, $6.50 to $12.95; 6V, 7.5 AH, $7 to $14; 6V, 8 AH, $7 to $14; 12V, 4.5 AH, $10 to $17.95; 12V, 8 AH, $12.50 to $24.14. In view of their leakproof characteristics, the Solid-Gel batteries are reported to be approved for shipment without precautionary packaging by the U.S. Postal Service. Elpower Corp., 2117 S. Anne St., Santa Ana, CA 92704. Phone(714) 540-6155.



Booth No. 1625 Check No. 107

Ac/dc/ohms 4-1/2-digit microvoltmeter for $895

Keithley's Model 171 digital multimeter for $895 features 1-$\mu$V dc and 10-$\mu$V ac resolution, and ac and dc current plus resistance-measurement capabilities. It measures 1 μV to 1 kV dc full scale in 6 ranges at ±0.02% accuracy, and the same voltage span for ac in 5 ranges from 40 Hz to 100 kHz, at ±0.3% midband accuracy.

Ac and dc current are both measured from 1 μA to 2A full scale in seven ranges. Resistance measurements can be made in seven ranges from 1 kΩ to 2 MΩ full scale. Input resistance is as high as 1000 MΩ, and line-noise rejection is 70 dB. The Model 171 may have its input circuit floated up to ±500V with respect to chassis ground. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139. Phone(216) 248-0400.

Booth No. 2309 Check No. 108

4-bit A/D converter with 25-MHz conversion time

Model ADC-4B-25MHz is a 3-in. wide by 5-in. long by 1-in. high module that can perform 4-bit conversion in 40 nsec (throughput rate of 25 MHz). Costing only $1250, it utilizes a parallel/serial/parallel conversion scheme and boasts ±0.8% accuracy and differential linearity. The temperature coefficient for differential linearity is ±50 ppm/°C and ±25 ppm/°C of reading for full scale and gain.

Specified accuracy for 4 bits of resolution is maintained over an operating temperature range of 0°C to +70°C. A larger operating range of −25°C to +85°C is available at extra cost. Output is straight binary and TTL/DTL compatible. Input is 0 to −2.55V and long-term stability is ±0.4%/year. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. Phone (617)828-6395.

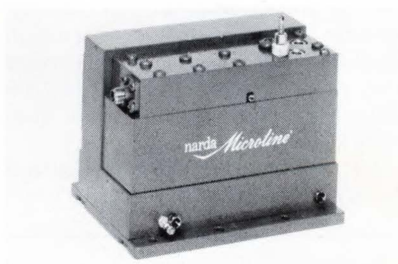
Booth No. 2609 Check No. 109

Frequency agile phase locked signal sources

Units in this series of signal sources are available to cover two bands of frequencies: 4.5 to 4.8 GHz and 4.5 to 5.3 GHz (Models 461-F5-001 and 502-F5-002, respectively), with approximately +10 dBm of output. The input reference may be provided either by a switched crystal bank or a frequency synthesizer.

Each unit's source will track a sweeping input signal, or if switched to a new input signal, lock it to within 0.1 sec. Output VSWR is 1.5:1; residual FM is 55 Hz rms in any 3-kHz slot between 10 and 100 kHz away from the carrier; spurious rf output is 75 dB down (in band) and 50 dB down (out of band). Narda Microwave Corp., 75 Commercial St., Plainview, NY 11803. Phone(516)433-9000.

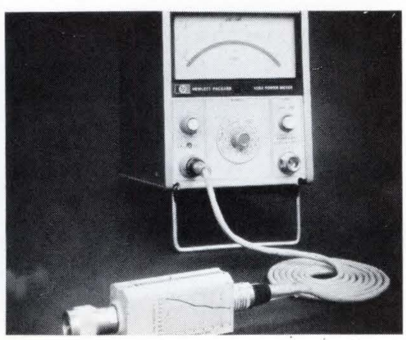
Booth No. 2426 Check No. 110



High-accuracy microwave power meter

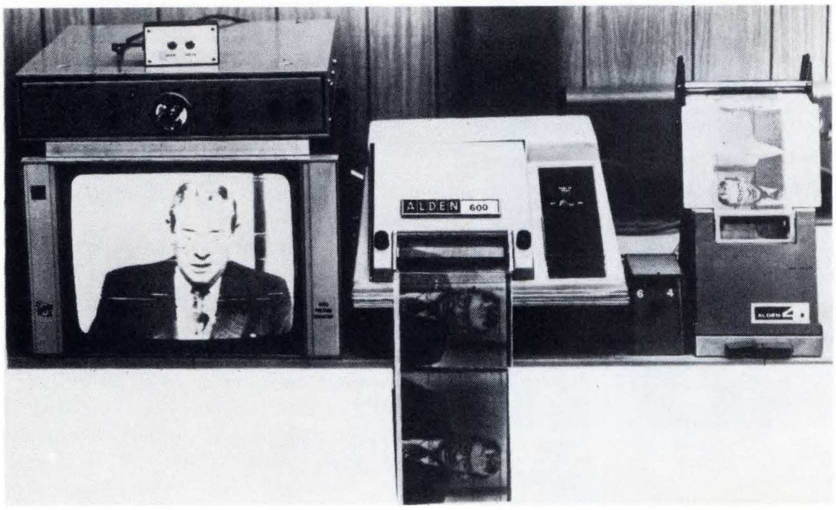
The 435A power meter/8481A power sensor system measures power over a 55-dB dynamic range (300 nW to 100 mW) from 10 MHz to 18 GHz. The sensor's SWR is under 1.2 from 30 MHz to 12.4 GHz, and under 1.3 from 12.4 to 18 GHz. The system consists of the power sensor which contains the thermocouple and a FET chopper stabilized amplifier and the power meter with a built-in rf calibration source.

Features include over a 300-mW thermocouple burnout level, a precise 1.00-mW 50-MHz calibration source, remote power monitoring, sensor calibration data that consists of a chart displaying calibration factor vs. frequency on each sensor plus computer calibration magnitude and phase data at 17 frequencies and automatic push-button zeroing. $350 (sensor); $550 (meter); and $100 (optional battery). Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone(415)493-1501.



Booth No. 2400 Check No. 111

Recorder/converter system for live TV images

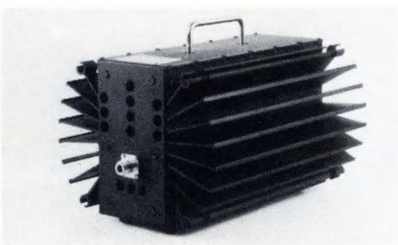


Live TV images are stored in a storage tube and later reprinted on demand in 45 sec or transmitted over dial-up phone lines and printed out as permanent hard-copy records on a frame-by-frame basis at voice-band speeds. The system includes an Alden 400 or 600 "push-to-print" recorder interfaced to a scan converter.

Two systems are available: one with a resolution of 1300 TV lines/diameter at 50% modulation orthagonal read right (80 characters/line) and another with 750 TV lines/diameter at 50% modulation orthagonal read right (50 characters/line). From $795 to $2500 (without converter). Alden Electronic & Impulse Recording Equipment Co., Inc., Alden Research Center, Westboro, MA 01581. Phone(617)366-8851.

Booth No. 2519 Check No. 112

Dry rf load handles 0.5 kW of power



The Model 8431 Termaline rf load resistor has a continuous input power rating of 500W in the horizontal position and 600W standing vertically. The new load is used for terminating 50Ω transmission systems during design, measurement and maintenance operations. It has a high-conductivity ceramic substrate.

Specifications include low VSWR of 1.1 from dc to 1 GHz, 1.25 from 1 to 2.5 GHz, continuous power dissipation of 500/600W in ambients from −40°C to +45°C and 50Ω impedances. The Model 8431 is normally supplied with a female N connector and costs $250. Bird Electronic Corp., 30303 Aurora Rd., Cleveland, OH 44139. Phone(216)248-1200.

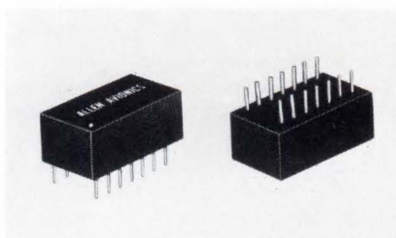
Booth No. 2509 Check No. 113

14-pin DIP delay line offers delays to 1 μsec

LC DIP is a tiny 14-pin dual-in-line tapped lumped-constant delay line that offers delay times up to 1 μsec. It incorporates 10 equal delay taps and is available in standard units with time delays from 10 to 1000 nsec. These units are available in time-delay-to-rise-time ratios of 5:1.

Because of the dual-in-line packaging of the LC DIP and its low silhouette, it is compatible with semiconductor and other assemblies where circuit board height is restricted. Each unit has a working voltage of 50V dc and is epoxy encapsulated. Cost is approximately $20 in small quantities. Allen Avionics, Inc., 224 E. 2nd St., Mineola, NY 11501. Phone(516)248-8080.

Booth No. 1722 Check No. 114



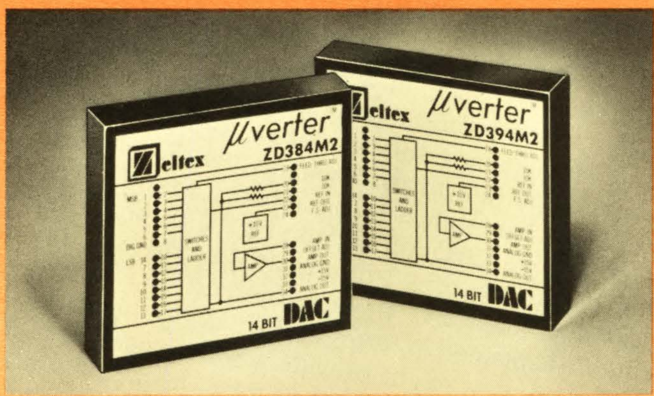
4-digit DMM features a 2-speed clock

Model DMM-40 clock increases conversion speed while maintaining high accuracy and high noise rejection. An additional feature of this digital multimeter is an overrange capability that extends up to 140%. The Model DMM-40 autoranges over all 20 ranges of its five measurement functions. These functions include ac and dc voltage, ac and dc current and resistance. The price for the basic unit is $695. Lear Siegler, Inc., 714 N. Brookhurst St., Anaheim, CA 92803. Phone(714)774-1010.

Booth No. 2302 Check No. 115

NEW! from ZELTEX...

14-Bit DAC's from $85



LOW COST 14-BIT DAC's—The new ZD300 Series include ten new models that offer excellent linearity, fast settling, current and voltage outputs, bipolar and unipolar coding, slaveable reference, and two quadrant multiplication. Prices range from $85 to $179 in single quantities.

FAST SETTLING TIMES (1 us)—Settling times as fast as 1 us for current output models and 2 us for voltage output DAC's makes the ZD300 Series useful in a variety of data conversion applications.

UNIPOLAR, BIPOLAR OUTPUTS—Unipolar and bipolar operation is specified at 0 to ±10V, and ±10V, respectively. Current output models are rated at 0-2 mA. Voltage output models also feature current output capability as well as two-quadrant multiplication-up to 100 kHz.

LINEARITY 0.005%—High performance units feature linearity error of only 0.005% of full scale. Moreover, the extremely low linearity temperature coefficient of only 0.0005%/°C ensures high resolution accuracy.

SMALLEST 14-BIT DAC's—The ZD300 Series modular DAC's measure only 1.96 x 1.76 x 0.40 inches high—less than 1.4 cubic inches in volume. Low profile, DIP pinning compatibility and interchangeability of models make the series highly desirable for OEM usage.

APPLICATIONS—The versatility of the ZD300 Series makes them an excellent choice for use in process-control systems, automated test equipment, servo/synchro/resolver systems, and biomedical instrumentation.

Multiplying capabilities further enhance their use for CRT character generation, digital modulation, and polar-to-rectangular coordinate conversion.

Zeltex INC. LEADERS IN DATA CONVERSION TECHNOLOGY

CALL or WRITE TODAY for detailed data on these and other ZELTEX Conversion and Linear products.

1000 CHALOMAR ROAD • CONCORD, CALIFORNIA 94518 • (415) 686-6660 TWX 910 - 481-9477

CHECK NO. 81

You can get expert help with your designs if you know where to look

An EDN editor relates his experiences with his supplier's applications engineers and how they helped him with a new small system design.

Robert H. Cushman, Special Features Editor

The process of design often seems like a race against one's stupidity. You may know your goal and have some pretty good initial ideas about how to get there, but as your design progresses, you find there are so many little (and big) details that are just beyond your knowledge and experience. You wonder how you can ever get the product out on schedule and be confident in its performance.

There is one place you can go for help—to the savvy experts among your suppliers. These guys know the details of the components you're using a lot better than you, and they are motivated to help you. It is their job, and besides, many of them have gravitated into their jobs because they enjoy helping people. There are a few who will put you down with a haughty sneer at the pathetic quality of your design, but we found the majority of these fellows bend over backwards to politely and patiently hear your problem out, carefully examine your circuits, and then freely and ungrudgingly give of their own hard-won expertise. In fact, we've found the more they are truly experts, the more likely they are to want to sincerely help you.

Our case history

To prove our point, we want to give you a running account of the help we've received from specific application engineers—and we'll be naming names—on a design project that seems important to us. This was the digital transducer system shown in breadboard form in **Fig. 1** and circuit diagram form in **Fig. 3.** The basic concept was described briefly at the end of a previous article (**Ref. 1**), and this version's operation is explained in terms of the waveforms in **Fig. 4.** We think it might provide a widely needed building block for industrial systems. It's a self-contained unit complete with its own power supply. It needs

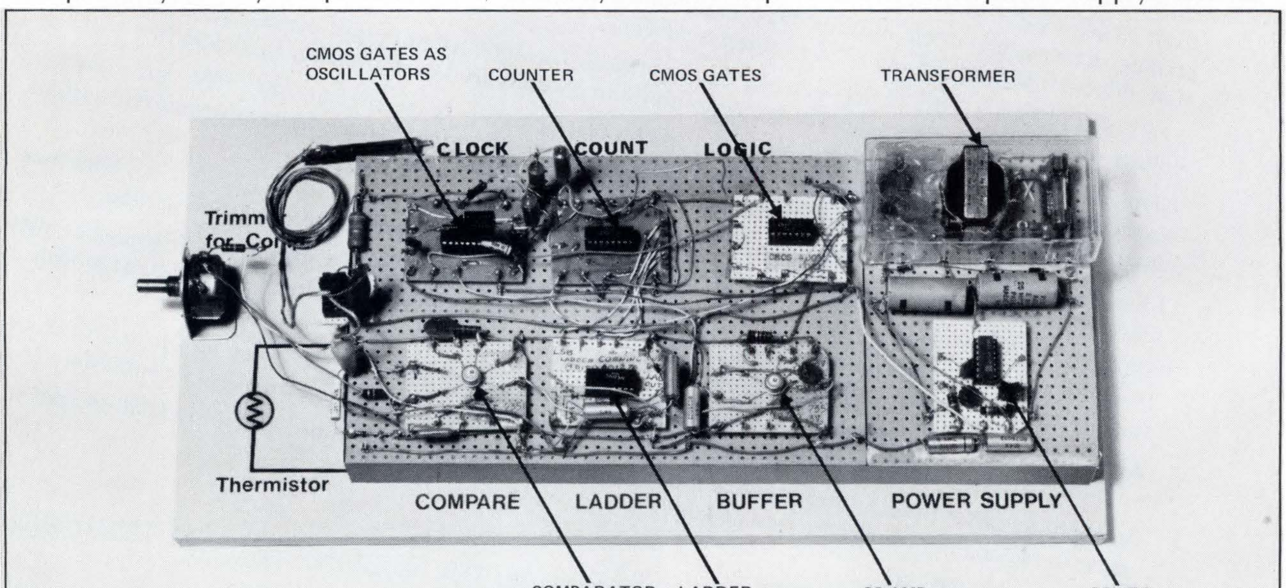


Fig. 1—Breadboard proved that the system would work and that the power supply was adequate. The author likes to first mount all the ICs on small 2×1-1/2-in. carrier boards that bring all the IC terminations out to standard positions, regardless of the IC pinouts. Then these carriers make the whole pc resemble a block diagram which helps troubleshooting and visualization of system improvements.

less than 50 mW power and will provide up to 8 bits resolution (only 4 bits are shown in **Fig. 3** to save space). We see it as especially useful for remote monitoring of analog variables over telephone lines.

The complexity of even a seemingly small and simple system like this in these days of high levels of component integration is one reason why you should have your thinking reviewed by outside experts. For example, even though our system consists of just a half dozen or so DIP packages, as can be seen in **Fig. 1,** each of these DIPs represents a whole little system in itself. There are a total of about 500 transistors in the circuit shown in **Fig. 3,** and our final design will probably grow another DIP or two to include 1000 transistors.

Furthermore, quite a few different technologies are contained in the half dozen DIPs, each with its own sphere of know-how, as you can see from **Fig. 3.** The 4029 counter is an MSI unit with nearly 100 internal gates. The two op amps must have all the elegant design and processing that produces low input leakages, wide input voltage ranges and operating-point stability. Even the passive components as in the ladder and thermistor demand

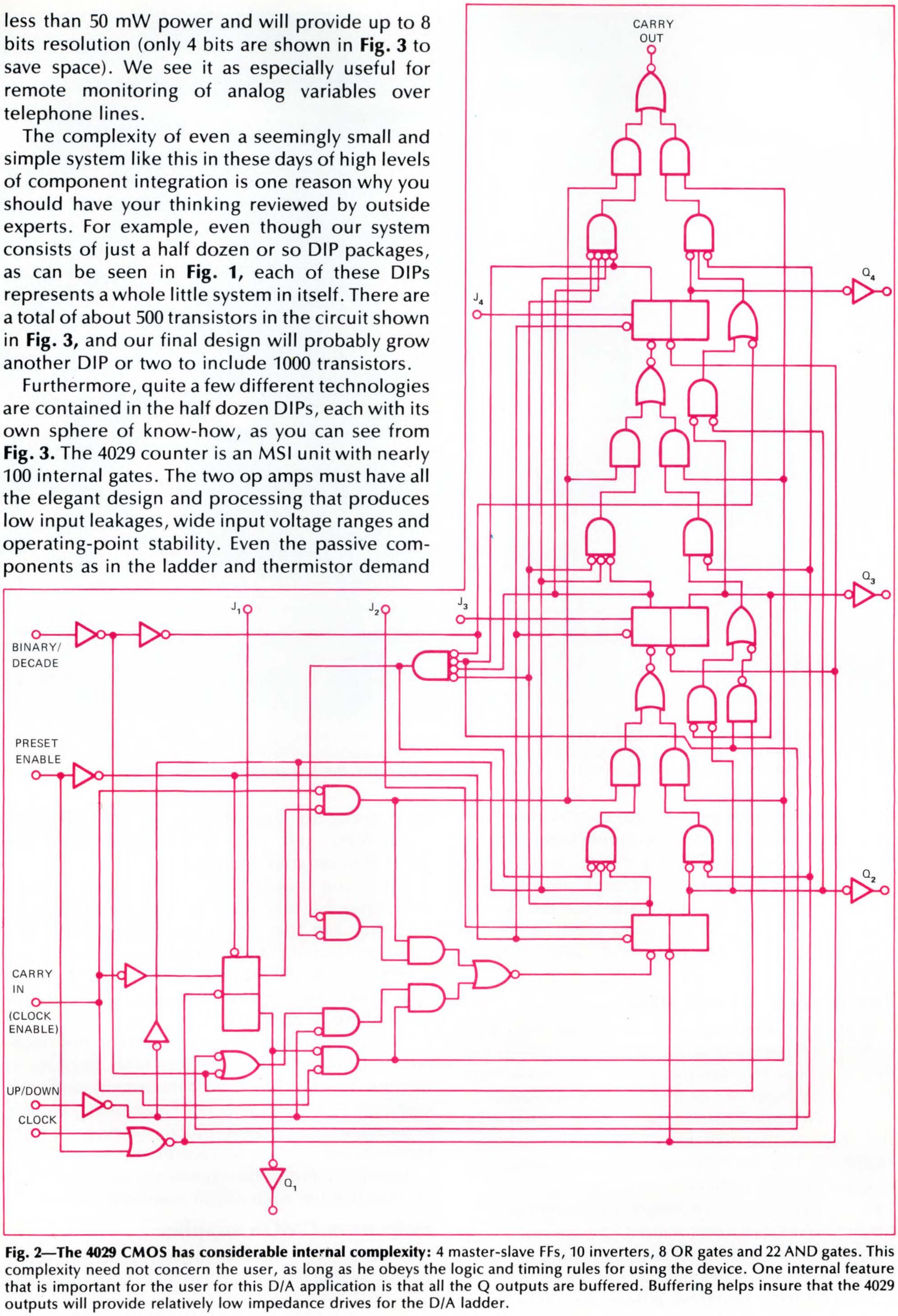


Fig. 2—The 4029 CMOS has considerable internal complexity: 4 master-slave FFs, 10 inverters, 8 OR gates and 22 AND gates. This complexity need not concern the user, as long as he obeys the logic and timing rules for using the device. One internal feature that is important for the user for this D/A application is that all the Q outputs are buffered. Buffering helps insure that the 4029 outputs will provide relatively low impedance drives for the D/A ladder.

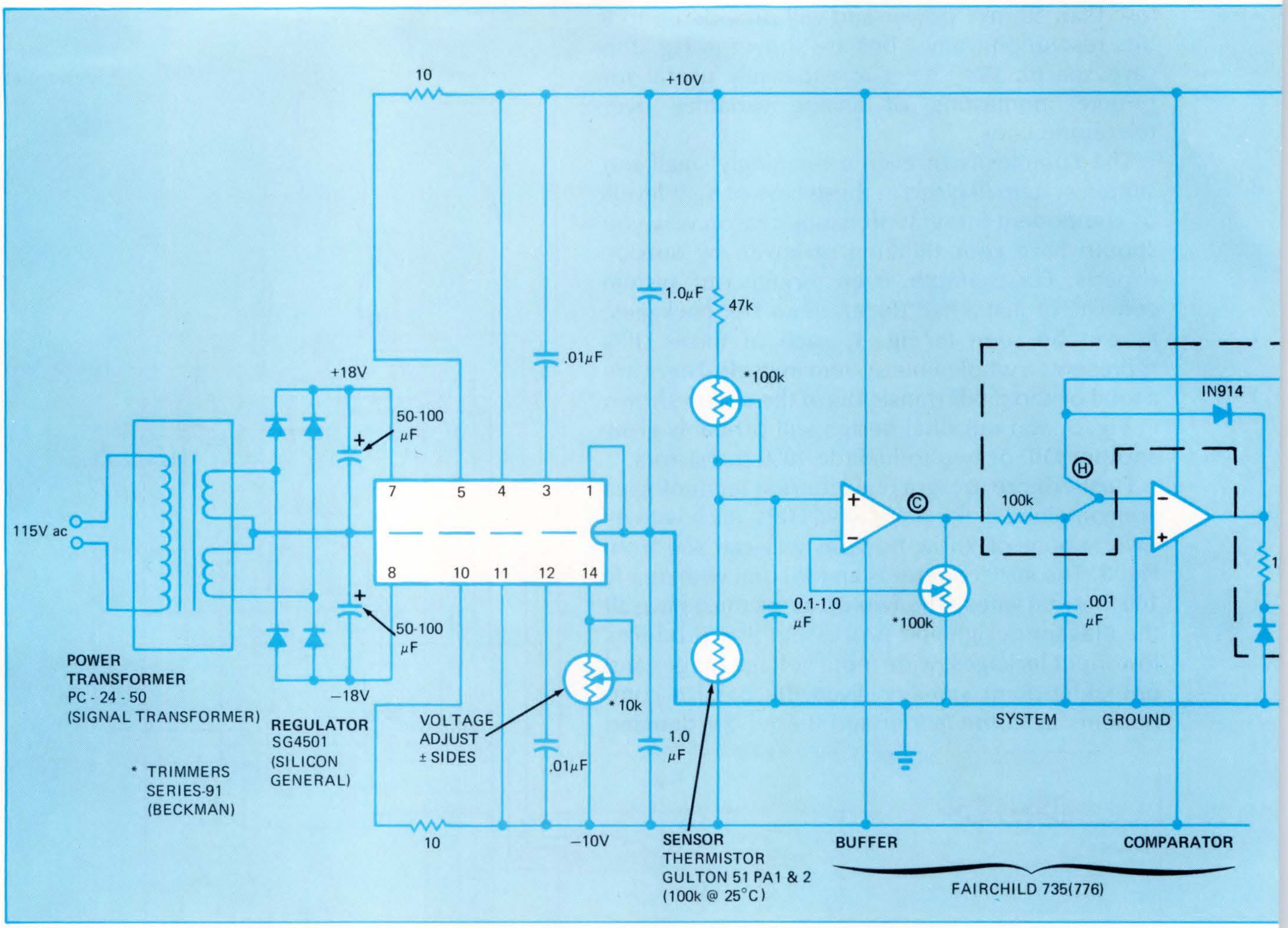


Fig. 3—Complete circuit for the digital temperature transducer: the aim was to produce a self-contained building block that would convert variable-voltage (and therefore also variable resistance) signals into digital form. The four main sections are shown here left to right, the power supply, the transducer, the A/D and the control.

considerable supplier technical contribution, for they must have accurate and predictable characteristics over a temperature range, and be interchangeable. This circuit places unusual demands on its power supply also, for the power supply must serve as balanced precision reference for the analog "front end" and the D/A converter.

The communication steps

Before launching into a component-by-component account of the help we received, I'd like to summarize the procedure I think best for getting the most out of these outside experts:

First, you must break your system down into the regions that will be of interest to various suppliers. You can only expect a given application engineer to feel justified in commenting on those parts of your system of potential sales interest to his employer. He won't mind if you are not using his product in your initial design, as long as it is a "socket" his product could fit into.

Second, you must be willing to show your design to him. If company secrecy prevents you from doing so, you will end up only talking in generalities and you won't really have him zeroing in on your problem.

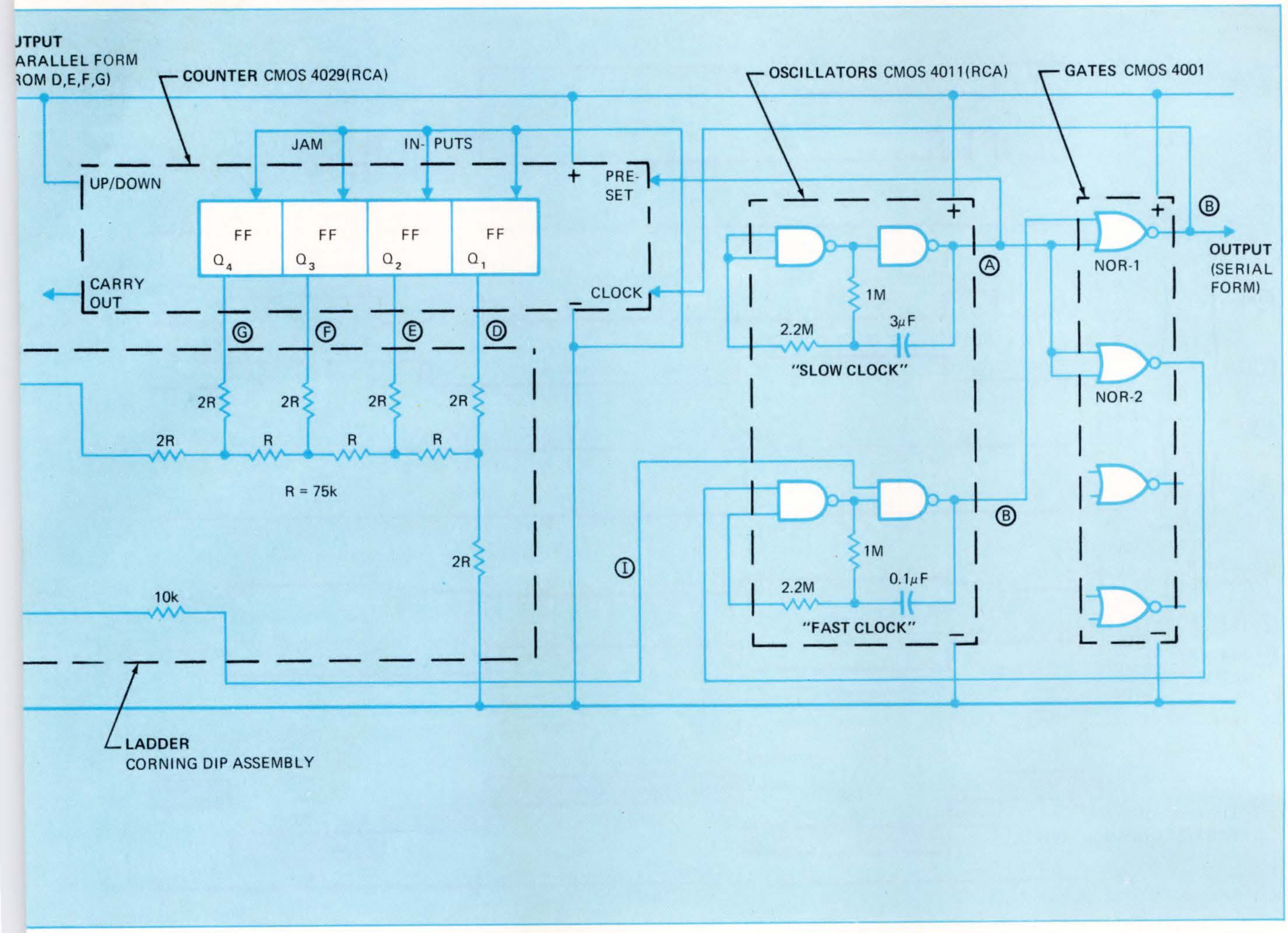
Third, you should listen very, very carefully to everything he tells you. It may seem like he is rambling, but later, if you've taken careful notes (and I personally like to tape record their verbal comments), you'll find out he was, in fact, giving you pearls of wisdom that you just did not understand or appreciate.

Finally, you should not be upset if the back-and-forth communication takes time, because in the end, it will save you embarrassment, and your company's money will be catapulted towards dependable perfection much quicker. It is a matter of taking *time* to save *time*.

Now for some of the comments we sought out and received in each of our component areas.

Help from CMOS supplier

The D/A calls for a CMOS counter to also serve as the analog switches that feed the 0 and 10V precision reference voltages to the ladder. The concept is to put the clean rail-to-rail output



switching of CMOS logic gates to work and thus simplify the system. We chose the 4029 counter because of its flexibility, versatility and expandability. It is a 4-bit "slice" of a counter that can be "programmed" by logic levels to count up or down and to count in binary or BCD (**Fig. 2**). There are carry-in and carry-out terminals that permit 4029s to be cascaded for higher counts. It even has presetting inputs that, when tied to ground (as in **Fig. 3**), can be used to reset the counter via a preset-enable input.

Our first concern about the 4029 was whether it was the best choice among the growing number of counters in the 4000 family. Dick Funk of RCA, after reviewing our design and our statement of its purpose, assured us the 4029 was an acceptable choice, but that for our information there were others. He suggested longer counters like the 7-bit 4024 or the 12-bit 4040 (which would give spare counts we might use for timing purposes). He shot down our thought that we might use the 4017 because, he explained, internally it uses Johnson coding and that would be incompatible with our standard binary weighted ladder—to his knowledge nobody was using Johnson counters in D/As.

Dick agreed that we could use the Motorola 4510 and 4516s, which are specialized versions of the 4029 with essentially the same pinouts. (We've found we can sometimes plug them into a 4029 socket.)

Our next concern was whether the 4029s' output resistances would be low enough to accurately drive the ladder. The specifications and our measurements have shown this to be under 1k and satisfactory for our high-resistance (R=75k) ladder, but what safety margin would our design have over all the variables of alternate counter types, production spreads, operating voltage changes, temperature, etc.? It had come to our attention that Otto Schade of RCA had written an application note (**Ref. 2**) on just that subject, so we showed him a copy of our design. Otto set our mind at ease saying that he had found little difficulty in building up 8-bit systems of this sort with 1% metal-film resistors selected from the parts bin. He also opinioned that he thought we might be overly concerned about tempco's, unless we intended our system for the full military temperature range.

Dick Funk came along with the best suggestion of all, and one we plan to try as soon as we can.

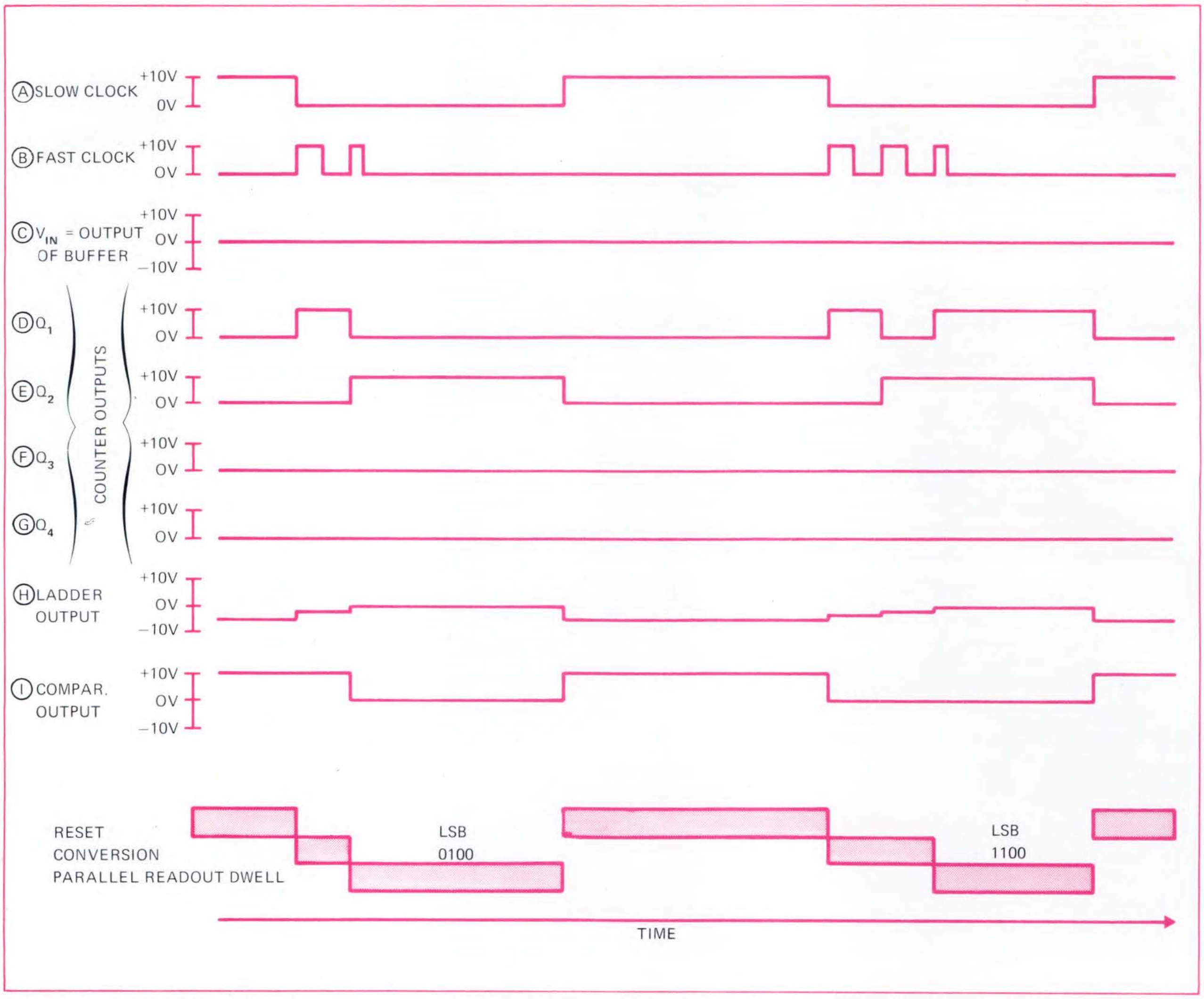


Fig. 4—**Circuit waveforms** for points (A) to (I) in **Fig. 3.** Slow clock output (A) periodically releases 4029 counter and starts fast clock whose buffered output (B) causes counter to count up. Outputs of counter (D,E,F,G) drive ladder positive, and when ladder counteracts unknown negative input (C) and pulls comparator input (H) up through system ground, comparator flips and its output (I) stops the fast clock. Counter holds state until slow clock output (A) again resets it.

"If you are worried about the fact that regular CMOS devices don't have as low an output resistance in their ON state as you'd like, why don't you drive the ladder via our recently announced 4041 quad buffer. This has both true and complementary outputs, and the true outputs are made with large area, symmetrical inverters that have specified ON resistances of 100Ω, and typically run as low as 50Ω at the 10V of your circuits."

The more we think about this option, the more we're glad it is there in case we need it. We can use it in two ways. We could lower the ladder resistance from our present R=75k to, say 10k, and impose less of a performance penalty on our comparator op amp (as will be discussed later on) and have faster conversion speed. Or we could use it to raise the accuracy margin of our present system and possibly extend our system to 9 or 10 bits.

We don't think we will want to be too hasty to lower our ladder resistance because that would raise the power consumption of our system, and this is one of its unique attributes—the basic A/D needs only 10mW. However, we definitely want to evaluate whether we can raise our accuracy reserve. A side benefit from using the 4041 will come when the application calls for taking the output off the counter in parallel. Then we can use the complementary outputs from the 4041 for added logical flexibility in driving readouts. Some of the BCD-to-7-segment display drivers we've been looking at need this signal inversion, and it would be nice to know that our display drive was not loading our ladder switches. In other situations, we can use the availability of both true and complementary outputs to simplify following decoding logic.

Help from ladder supplier

We really got concrete help from Corning. It was in the most tangible form of three custom DIP

Table Cost comparisons: discretes vs. DIP assembly (Corning AO 1276 for EDN)				
Quantity	100 pieces		1000 pieces	
Approach	Discrete	DIP	Discrete	DIP
Components		100 @ \$3.15 = \$315.		1k @ \$1.70=\$1700
R-NA55	1200 @ \$0.11 = \$132		12k @ \$0.088 = \$1056	
D-IN914	200 @ \$0.17 = \$ 34		2k @ \$0.10 = \$200	
Insertion cost	1400 @ \$0.06 = \$ 84	100 @ \$0.06 = \$6	14k @ \$0.06 = \$840	1k @ \$0.06 = \$60
Total cost	\$250	\$321	\$2096	\$1760
Savings?	DIP costs \$71 or 28% more		DIP saves \$336 or 16% less	

ladder assemblies for 4, 6 and 8 bits (**Fig. 5**). We got involved with Corning because we had been using their RN55D 1% metal-oxide film resistors in our earliest discrete-resistor ladders. Mark Slifkin of Corning, who is on the marketing side, but quite knowledgeable, and who has a team of application design engineers, told us that Corning's investigations had shown that 1% metal-film resistors with 100 ppm/°C tempcos would handle 8-bit ladders "without any problem," but that "they just can't make it at 10 bits."

Mark then asked us whether we had considered using these resistors assembled in Corning's CORDIP™ component network packages and volunteered to make up several samples to our designs. We jumped at this opportunity because it had been one of our goals all along to put as much of the circuitry as possible into DIPs. Though it might be said that Mark did this only because he knew his product would be getting publicity in this article, we got the distinct impression that Corning will make up custom samples without charge for any designer whose plans seem serious. Corning seems very proud of the way they can turn out these custom CORDIPs on short notice.

When you go custom, you owe it to yourself to learn as much as you can about your supplier's method of fabrication. Then you can optimize your use of his technology. In the case of this component, we had the opportunity to visit "our supplier" at his factory and let him show us his technology firsthand. Mark first showed us Corning's discrete resistor production line, and then took us step by step through the process by which they design and assemble their resistors and other components (note in **Fig. 3** and **5** that there are also diodes in our 4-bit network and, in addition, Corning can put their ceramic and small tantalum capacitors into DIPs). We saw for ourselves how Corning's investment in assembly automation for these packages could provide the savings that Mark had calculated for our design at the 1000-piece level (see table in **Fig. 5**).

Just like it helps communication if the expert sees your circuit, so it helps if you can see his process.

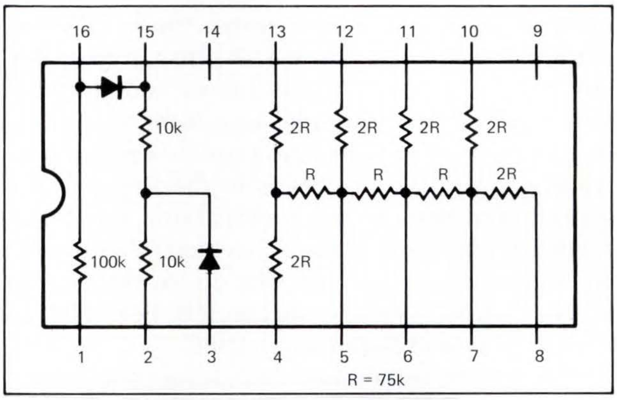


Fig. 5—The Corning custom DIP network contains a 4-bit ladder and some neighboring circuitry (note the diodes). A feature of this configuration that was appreciated later was the fact that so many of the network nodes are brought out to pins. This made it easy to investigate design modifications during breadboard phase and yet have a compact DIP package. It suggested flexible patterns for the final production DIPs.

Corning is of course not the only supplier making custom DIP networks. Sprague, Dale, Allen-Bradley, Beckman, Centralab, CTS, Mepco, etc., are among the many others (**Ref. 3**). What we like about Corning at this initial stage of our product's evolution is that their construction has such quick turnaround and allows such easy changes.

Corning puts small discrete components into a "Swiss Cheese" matrix (like pegs in a pegboard) and then machine molds a plastic case around them. Your final part looks like any other DIP, but as it is composed of discrete components, you can readily ask for changes in component values. Further, Corning's clever manner of printing the cured-silver plastic conductive patterns (not epoxy) on the top and bottom surfaces of the Swiss Cheese matrix allows them to make up new circuit interconnections in hours.

The one question a designer always has about getting help from a supplier is, "how long does it take?" We sent Corning the circuit diagram of **Fig. 3,** in which we indicated the discrete components we wanted in the 4-bit CORDIP by the dashed line. Within two weeks they sent back the quote that specified their CORDIP, of which the circuit and pricing is shown in **Fig. 5.** Then after we gave them the go-ahead, they delivered the samples within two to three weeks.

When we put the DIP networks into our breadboard, we found out that through a mistake on our part, we had called for a 1R rather than a 2R resistor in the final tail of the ladder going to the comparator. We called Mark on this, and he told us it could be fixed by simply dropping the correct resistance value in the next lot. Meanwhile, we began to find some other unexpected virtues in our supplier's product. The Corning method of construction forces them to bring many circuit nodes out to DIP pins. At first, this struck us as not too elegant, but we soon found it very helpful. For example, as will be described more fully later in the section on the comparator, we began to have doubts as to the utility of the clamping diode in the comparator op amp's feedback. Because of the access to circuit nodes, we found it easy to wire this out of the circuit. We've found similar unexpected flexibility in using the 6- and 8-bit ladder DIPs.

The point is sometimes there is no communication quite like that which you get from the supplier's product itself. There may be designers so smart they never need this interchange, but one doubts it.

Help on ladder details

So far as the ladder circuitry itself was concerned, we had a little fallout of luck in going to the DIP assembly. We had originally planned to use an R=100k ladder to be sure of not loading the 4029. But Mark told us Corning could not make the miniature resistors that would fit into their CORDIPs with values greater than 150k—there just wasn't room to machine the long, fine spirals needed to make higher values. This meant we could not use an R greater than 75k.

But this limitation has turned out to be a blessing, because it now appears that R=75k is about as high in ladder resistance as you can go before you ask too much of a moderately priced comparator and also start to limit your system operating speed. At R=75k, you are at the upper limit of source resistance that any bipolar op amp should be looking at, and you are getting into the region where you ought to be using one of the more expensive FET-input op amps.

Another happy accident was that in drawing our dashed line (**Fig. 3**) to show what the DIP should include, we had encircled the 100k resistor on the unknown input side of the comparator input. We now see that it makes a lot of sense to have this resistor also "locked" into the DIP because then it is certain that this resistor will be made by the same factory and by the same process that made the rest or the ladder, and so this whole analog network that governs the system accuracy will temperature-track better. We asked Mark about our thinking here, and he agreed. He said that while the resistors themselves were individually good to just 100 ppm/°C tempcos, they would track each other to 50 ppm/°C. Now we are thinking that perhaps we ought to try to make this resistor on the negative side, 3R or 225k, to match the value seen looking back into the ladder, and thus obtain even better tracking. However, as we mentionned earlier, Otto Schade of RCA said he thought we were letting ourselves become overly concerned with tempcos, for after all, we are only shooting for 8 bits resolution.

More to come

In a following issue we'll go on to the comparator, buffer, power supply and thermistor sensing sections of the design. We'll tell you of the help we've received from experts at Silicon General, Victory Engineering, Signal Transformer and other companies.

But by now you should be at least partially convinced that there is expert help out there; you only have to go after it in the right manner. Consider what it has done for our humble design. Just think how much more uncertain we'd be about it now if we had not had it looked over and commented upon by these experts.

Why go it alone when such help exists? □

Any comments other suppliers or readers may have about the process of obtaining help from experts or about this design example will be greatly appreciated. We would like to work such comments into future parts of this "rambling saga of a design's progress."

References

1. "Elementary A/D Converters Can Be Efficiently Implemented in CMOS," *Cushman, R.H., EDN, July 15, 1972, pg. 26. Fig. 3 introduces the A/D circuit that is further developed in this article. (The final 2R resistor in that figure should be labeled 50k rather than 100k, and there are a number of places where signal lines at the op amp input were mistakenly shown shorted to ground.)*

2. "Digital-to-Analog Conversion Using the RCA-CD4007A COS/MOS IC," *(ICAN-6080), available from RCA Solid State, Somerville, NJ (or in RCA Databook SSD-203A). It contains specific data on selection of resistors for CMOS-driven ladders up to 9 bits. Also described is a novel voltage-follower op amp that operates with a wide swing off a single supply. It is claimed that conversions as fast as 250 nsec (settling time) are possible.*

3, "Dip Resistor Networks Can Save You Time and Money," *Slifkin, M. A., available as reprint from author Slifkin at Corning Glass Works, Corning, NY 14830. Presents general arguments for assembling discrete components into custom DIPs, as arguments apply to all makes of passive DIPs, not just Corning's.*

expand your power

NEW UES 500 SERIES GIVES YOU HIGHER CURRENT HANDLING CAPABILITIES— UP TO 50A.

with ESP rectifiers

It's another good reason to believe in ESP. We're continually expanding and improving the line to help you design with more Efficiency, Speed and Power. Packaging is now industry-standard with the 50A series in the DO-5 and the 20A series in the DO-4. The advantage is that Unitrode provides up to twice the current output of other devices in the same packages. Recovery time is the fastest available in a power rectifier—typically 15 to 25nsec in any circuit. Voltages to 150V in all four series. And leakage is low even at high temperatures. They're designed to operate over the full military range of −65°C to +175°C and they are radiation tolerant. ESP rectifiers are also available in high efficiency assemblies as center tap rectifiers, bridges and higher current modules.

Check the table/coupon below for details on standard ESP rectifiers. They're on the shelves at your local Unitrode distributor. And you don't need ESP to locate him. You can find out by simply dialing (800) 645-9200 toll free, or in New York State (516) 294-0990 collect. For immediate action on any specific problem, call Sales Engineering collect at (617) 926-0404, Unitrode Corporation, Department 6Z, 580 Pleasant Street, Watertown, Massachusetts 02172.

UNITRODE

Unitrode Corporation, Dept. 6Z, 580 Pleasant Street, Watertown, Mass. 02172
Please send complete technical information and prices on the following ESP Rectifiers:

Type	PIV	Maximum Average D.C. Output Current	Non-Repetitive Sinusoidal Surge (8.3ms)	Maximum Forward Voltage Drop	Leakage Current @ PIV 25°C	Maximum Reverse Recovery Time
Check Here ☐ 1N5802 ☐ 1N5803 ☐ 1N5804 ☐ 1N5805 ☐ 1N5806	 50V 75 100 125 150	2.5A	35A	0.875V@1A	1μA	25ns
☐ 1N5807 ☐ 1N5808 ☐ 1N5809 ☐ 1N5810 ☐ 1N5811	50V 75 100 125 150	6A	125A	0.875V@4A	5μA	30ns

Type	PIV	Maximum Average D.C. Output Current	Non-Repetitive Sinusoidal Surge (8.3ms)	Maximum Forward Voltage Drop	Leakage Current @ PIV 25°C	Maximum Reverse Recovery Time
Check Here ☐ 1N5812 ☐ 1N5813 ☐ 1N5814 ☐ 1N5815 ☐ 1N5816	 50V 75 100 125 150	20A	250A	0.900V@10A	10μA	35ns
☐ UES501 ☐ UES502 ☐ UES503 ☐ UES504 ☐ UES505	**50V 75 100 125 150**	**50A**	**500A**	**0.95V@50A**	**25μA**	**50ns**

NAME__________ TITLE__________

COMPANY__________

ADDRESS__________

CITY__________ STATE__________ ZIP__________

TELEPHONE__________

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

"We're at the state of the art, and we got there by using proven, available parts like MMI P. ROMs."

. . . JIM LEARD
Manager, Electrical Purchasing
ITEL/ISS

"We're using close to 10,000 MMI 1024-bit P.ROMs a week, now. Went to P.ROMs over a year ago, when a lot of other companies opted to go with RAMs. It was a happy decision for us. We use almost 500 different patterns in our systems, and there's a long debugging time inherent in new equipment. The MMI 6300 P.ROM is a logical intermediate step on the way to low cost masked ROMs. This step has saved us tons of junked ROMs.

"About the only serious problem we had with P.ROMs was delivery. And MMI has solved that for us."

Thanks, Jim. Rest assured. MMI delivers P.ROMs IN QUANTITY. In point of fact, we are the largest supplier of P.ROMs in the industry. We developed and marketed the 1K and 2K P.ROMs a year earlier than any other supplier. As a result we have the product knowledge and production capacity to deliver to many companies like ITEL/ISS that have volume requirements.

Now: How about those of you who are still hung up about P.ROMs? We've got 256-bit, 1024-bit, and 2048-bit parts on our distributors' shelves. Send a P.O. Need programming? No problem, either. Ask us or your distributor to help. Or do it yourself. (2 to 10 seconds per IK part) on our Model 530 Programmer. Our Model 531 tape reader makes it even easier.

Proven, available MMI P.ROMs

MMI P.ROM CHOICES P.ROM	Size	Access (nsec)	Output	Unit Price @ 100 Qty.	ROMMATE
MM 6300	256x4	60	Open Collector	$ 35.00	MM 6200
MM 5300	256x4	60	Open Collector	$ 57.00	MM 5200
MM 6305	512x4	90	Open Collector	$ 72.00	MM 6205
MM 5305	512x4	90	Open Collector	$100.00	MM 5205
MM 6330	32x8	50	Open Collector	$ 12.00	MM 6230
MM 5330	32x8	50	Open Collector	$ 20.00	MM 5230
MM 6331	32x8	50	Tristate	$ 12.00	MM 6231
MM 5331	32x8	50	Tristate	$ 20.00	MM 5231
MM 6330N	32x8	50	Open Collector	$ 9.00	MM 6230N
MM 6331N	32x8	50	Tristate	$ 9.00	MM 6231N

If you need parts, call, TWX, or write Dale Williams today.

Monolithic Memories, Inc.

1165 East Arques Avenue, Sunnyvale, CA 94086 • (408) 739-3535 • TWX: 910-339-9229

Monolithic Memories INCORPORATED

Representing your best buy in memories: ALABAMA, Huntsville (205) 539-1771; ARIZONA, Phoenix (602) 264-7971; CALIFORNIA, Los Angeles (213) 398-6239; San Diego (714) 747-3015; Palo Alto (415) 369-4671; COLORADO, Denver (303) 623-8713; CONNECTICUT, North Haven (203) 239-9762; FLORIDA, Orlando (305) 423-7615; ILLINOIS, Chicago (312) 455-5100; INDIANA, Ft. Wayne (219) 744-4331; Indianapolis (317) 844-3241; IOWA, Cedar Rapids (319) 362-8155; KENTUCKY, Louisville (502) 893-7303; MARYLAND, Baltimore (301) 825-3330; MASSACHUSETTS, Boston (617) 653-3158; Needham (617) 444-2484; MICHIGAN, Detroit (313) 358-2020; Grand Rapids (616) 451-8901; MINNESOTA, Minneapolis (612) 929-6721; NEW JERSEY, Teaneck (201) 692-0200; NEW YORK, N.Y.C./L.I. (201) 692-0200; Utica (315) 735-5566; NORTH CAROLINA, Raleigh (919) 834-6591; OHIO, Cincinnati (513) 521-2290; Dayton (513) 298-9546; Columbus (614) 888-9396; Cleveland (216) 228-7525; OKLAHOMA, Tulsa (918) 627-4159; OREGON, Portland (503) 292-5656; PENNSYLVANIA, Willow Grove (215) 674-3850; Pittsburgh (412) 242-0100; TEXAS, Dallas (214) 239-9148; Houston (713) 721-1054; WASHINGTON, Bellevue (206) 455-2778

CHECK NO. 40

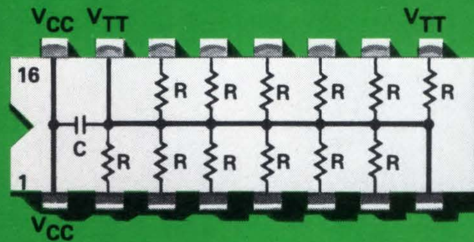
CHECK NO. 41

This is the EJ, an extended life version of our famous "J" pot. Same dependable performance. Same power handling capability. Same quality throughout, but with a tremendous difference in rotational life. One good turn after another for more than 1,000,000 cycles (under normal use within ratings per Publication 5230). Specify the EJ for electronic organs, lift trucks, automotive and process control applications. Hot molded composition, 2.25 watts. Resistances from 50 ohms to 5.0 megs. Usable from −55°C to +120°C. Five standard tapers. Single or dual sections.

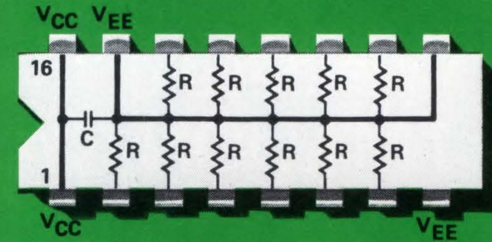
Request Publication 5230. Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, New Jersey 07003. Canada: Allen-Bradley Canada Limited, Galt, Ontario. United Kingdom: Jarrow, County Durham NE32 3EN.

Allen-Bradley
Milwaukee, Wisconsin 53204

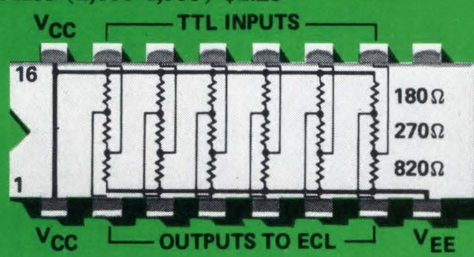
CHECK NO. 31



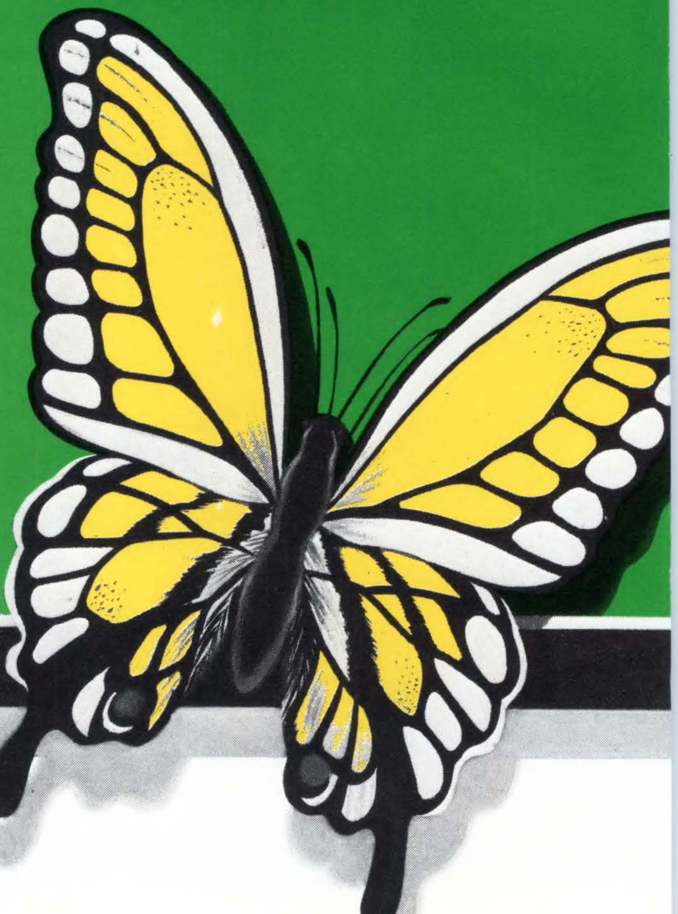
SERIES 898-41 −2.0 VOLT TERMINATORS contain eleven resistors for ECL line termination to a −2.0 volt bus. Each unit includes a 0.01 μF decoupling capacitor to bypass the −2.0 volt bus. Standard R values of 50, 75, and 100 ohms are available and are designated 898-41-R50, 898-41-R75, and 898-41-R100.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

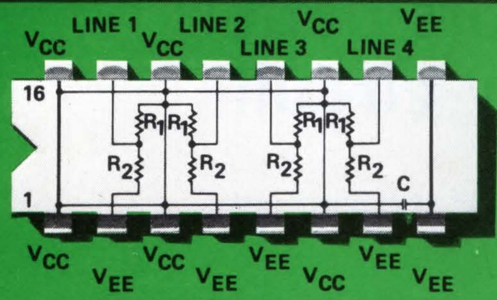


SERIES 898-45 TTL TO ECL TRANSLATOR contains six identical three-resistor sections for direct translation from TTL to ECL, both operating between a +5 volt supply and ground.
Price (1,000-4,999) $1.25



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

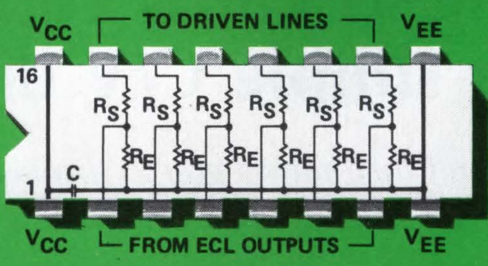


SERIES 898-43 THEVENIN EQUIVALENT TERMINATORS contain four Thevenin equivalent terminator sections. Each terminator section consists of two resistors connected as a divider from the ground bus to the −5.2 volt bus providing a Thevenin equivalent voltage of −2.0 volts. Each unit contains a 0.01 μF decoupling 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

CHECK NO. 32

Getting to know capacitors better with a simple C/V display circuit

Here's a circuit that allows you to display capacitance vs. voltage interactions on an oscilloscope.

Jerald Graeme, Burr-Brown Research Corp.

If you are dealing with a capacitance that is voltage sensitive, the output voltage waveshape displays a capacitance vs. voltage (C/V) response. By being able to display this response readily on an oscilloscope, one can examine varactor diodes, measure voltage sensitivities of fixed capacitors or monitor MOS oxide purity.

For example, representative C/V responses for these three applications are illustrated in **Fig. 1.** From the varactor response, the capacitance variation that will be produced by a given drive voltage can be seen. The C/V display for a fixed capacitor permits prediction of filter detuning by signal voltage, and also prediction of the resultant distortion. The third C/V response illustrated is representative of MOS capacitors used in monitoring monolithic fabrication processes. Ions in the MOS oxide are detected by observing bias induced shifts in the transition point of this response.

Three op amps do the trick

Low-frequency capacitance measurement with a capacitance vs. voltage display is provided by a three op-amp circuit. A measure of fixed capacitance is provided by the dc output voltage from the circuit.

To make both the capacitance measurement and the C/V display, only a ramp generator and a differentiator are needed, as in **Fig. 2,** followed by a dc voltmeter or an oscilloscope.

When the capacitance to be measured is inserted as the differentiating capacitor, an output voltage is developed that is a measure of the capacitance. This output voltage is

$$e_0 = -RC\frac{de_r}{dt}$$

Since the slope of the ramp, de_r/dt, is a constant other than during reset, the above voltage is directly proportional to the capacitance C. If C is independent of voltage, the output is a dc level interrupted only by short reset pulses. A dc voltmeter then serves as a capacitance readout. If C is voltage sensitive, the output voltage will vary as the ramp changes the capacitor voltage. The ramp produces a linear rate-of-change in capacitor voltage, so the output waveshape is linearly related to the C/V response.

Using two op amps to generate the ramp, the complete circuit can be realized as in **Fig. 3.** A gain-limiting resistor, R_1, is added to the differentiator shown to control transient response. This resistor is chosen to eliminate ringing following reset transients when measuring the lowest intended capacitance. To generate the ramp, a comparator with hysteresis is connected as feedback to an integrator. When the comparator output is positive, positive feedback thru

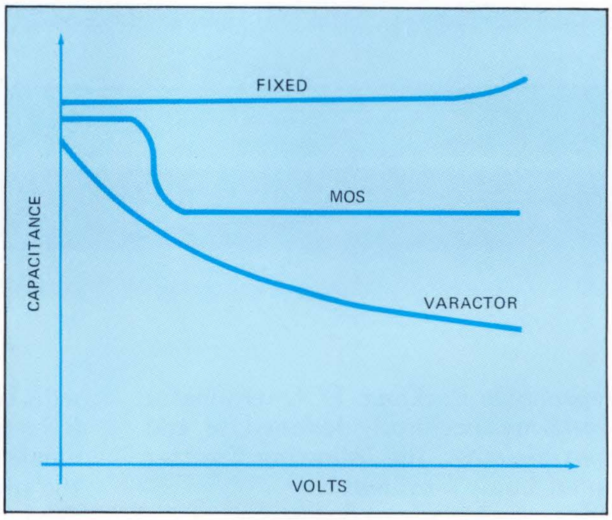


Fig. 1—C/V displays of varactor responses, voltage sensitivities of fixed capacitors and MOS C/V response shifts caused by oxide ions.

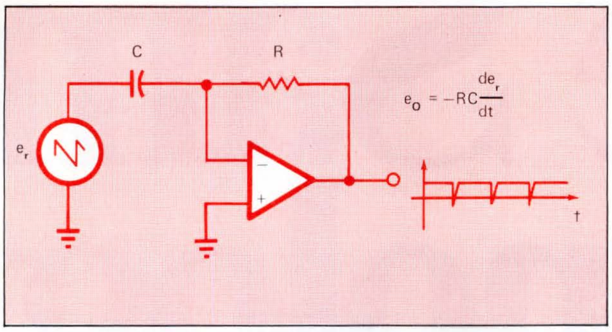


Fig. 2—Response of a differentiator to a ramp input voltage is linearly related to the capacitor since the slope of the ramp is essentially constant.

R_5 shifts the trip point. This sets the ramp voltage peak at

$$e_{rP} = -\frac{R_4}{R_5} V_Z$$

where V_Z is the zener voltage. However, when the comparator output is negative, D_2 disconnects the positive feedback, and the integrator output alone causes switching when it crosses zero. The result is a unipolar ramp, as is sometimes convenient for varactor diodes where one ramp polarity would simply forward bias the diode. For a bipolar ramp, D_2 is not used.

The frequency of the ramp is set by the zener level and the integrator response. By means of D_1 and R_3, the time duration of the positive output integration is made much shorter than that of the negative integration. This produces a ramp instead of a triangle wave, and makes the signal frequency essentially determined by the slower integration. In developing the greatest difference in integration times, a time delay produces an amplitude error that must be corrected by selecting a bypass capacitor for R_4. When this is done, the frequency of the ramp train will be

$$f_r = \left(\frac{R_5}{R_4}\right)\left(\frac{1}{R_2C_1}\right)$$

From this frequency and the previously defined amplitude e_{rP}, the slope of the ramp is

$$\frac{\Delta e_r}{\Delta t} = \frac{e_{rP}}{1/f_r} = \frac{V_Z}{R_2C_1}$$

The resulting differentiator output, e_0, defines the capacitance by

$$C = \frac{R_2e_0}{R_7V_Z} C_1$$

Errors associated with this circuit are primarily due to the dc errors of the differentiator and the response limitations of all three op amps. During the reset time of the ramp, the differentiator output is momentarily interrupted. This reduces the average output voltage measured by a voltmeter readout, unless this interruption due to amplifier response limits is a negligible fraction of the ramp period. A low-frequency ramp reduces this error but simultaneously makes dc errors greater. With general purpose op amps, a 100-Hz ramp frequency is a good compromise for errors limited to 1%. ☐

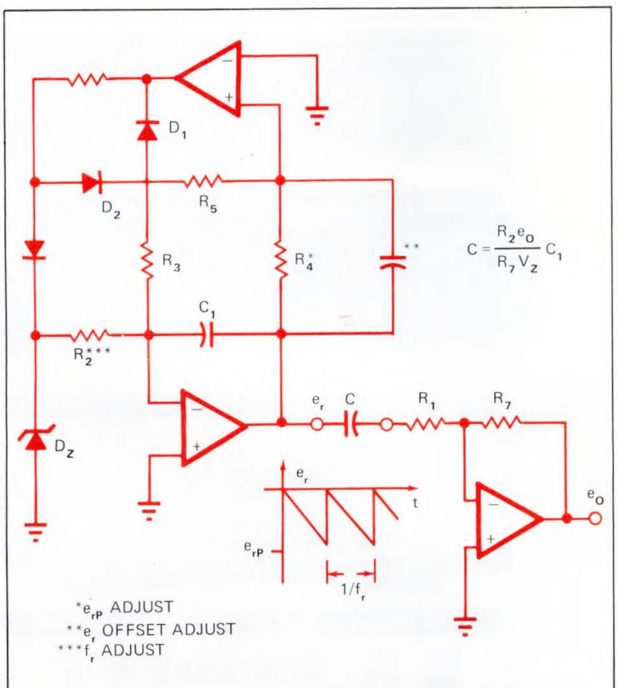


Fig. 3—Only three op amps are needed to form this capacitance measuring, C/V response-generating circuit.

References

1. L. McMillan, "MOS C-V Techniques for IC Process Control", Solid State Technology, September, 1972.
2. G. Tobey, J. Graeme, L. Huelsman, *Operational Amplifiers; Design and Applications,* McGraw-Hill, 1971.

Author's biography

Jerald G. Graeme is manager, monolithic engineering, at Burr-Brown Research Corp., Tucson, AZ. Jerry received his BSEE from the Univ. of Arizona and his MSEE from Stanford Univ. He joined Burr-Brown in 1965 as an amp circuit designer. Since that time he has developed bipolar, FET and chopper stabilized op amps, as well as instrumentation amplifiers. He now directs the development of monolithic analog and analog/digital circuits. During this time, he has had two patents issued to him and has been a frequent contributor of circuit design material to electronic trade publications.

The Same Technology Instruments Makes Them

Take DVMs for example...

Today you can buy more performance for your dollar with HP's new "Self Test" 3490 and "Snap-On" 3470. Both have the features you've told us you wanted, and both were designed to make them easy on your budget. The key is HP's advanced technology. Look what your dollars will buy with these four quality members of HP's DVM family.

Self-Test 3490 makes double use of its internal ICs to bring you HP's exclusive "Self-Test" capability without extra cost. The basic 5-digit 3490, ready to measure AC, DC and Ohms sells for only $1,650 (and at low added cost you can have isolated BCD output and isolated remote control, or the highly-useful remote control with ASCII bus). Compare the 3490 with any other multimeter in its class and you'll find an unusual blend of features and performance for the money.

Snap-On 3470 provides you with an economical 4-digit LED display unit that you can equip to meet your exact measurement needs. Get DC only for $475 total, AC/DC/Ohms for $600 total, or DCV/DCA/Ohms for $875 total (5-digit versions are $700, $825 and $1,100). Add on a battery pack center for $200, BCD output center for $175 or an exclusive

HP That Makes Better...Now Cost Less

HP "Self Test" accessory for only $50. You end up with a modern custom-tailored system for very little money.

Multi-Mode 3450 lets you add up to 12 modes of high-accuracy measurement capability to your automated system. You can have true-rms, 4-terminal ratio, 4-terminal ohms and the unique limit test in addition to the usual functions. The 3450 is both fast and accurate, with 15 readings/sec. and accuracy to (0.008% of reading +0.002% of range). Prices start at $3,300 for the 5-digit DC volts and Ratio model, go to $5,900 for total 12-mode capability.

Speed Star 3480 is systems oriented, but fine for the bench as well. This 4-digit, ±0.01% unit delivers an unmatched 1,000 readings/sec. Get the exact capability you need by selecting plug-ins. For example, you can have DC, Ohms and true-rms AC for $2,900 (isolated BCD output and isolated remote control are low-cost options). You can even turn the 3480 into an inexpensive A-to-D converter with a sample and hold option that also lets you take peak readings or do transient analysis. Or, add data storage that stores up to 50 readings or do transient analysis. Or, add data storage that stores up to 50 readings at the 1000/sec. rate and employ a low-cost printer to output the data.

Check your DVM measurement needs. You'll find that HP can fit them closely, whether they call for state-of-the-art performance or real economy. For more information on the entire HP family of DVMs and multimeters, contact your local HP field engineer. Or, write Hewlett-Packard, Palo Alto, California 94304. In Europe: HPSA, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

Send for our 70-page Application Note 158, RS 33 .

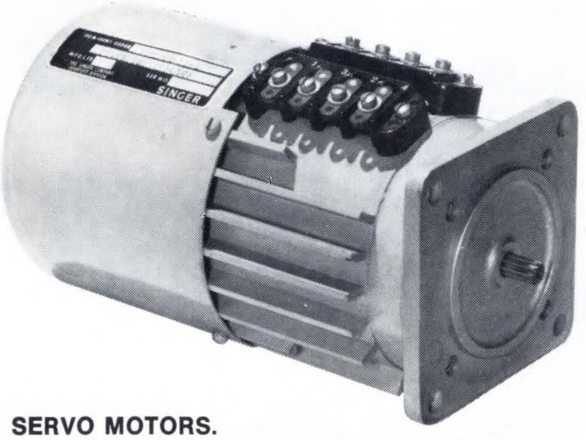
093/42

HEWLETT hp PACKARD

DIGITAL VOLTMETERS

CHECK NO. 33

Singer is here to Servo you.



SERVO MOTORS.

Kearfott offers you a complete line to fit just about any application. From a ¾" diameter motor with an acceleration of 150,300 rad/sec² to units such as the 7" diameter 1 HP Servo Motor shown above.

SERVO AMPLIFIERS.

Choose from 1.4 watt output amplifiers to the new 2200 watt unit above. Only 10" long and weighing just 7 lbs., the XA-2200 is a highly-efficient solid-state amplifier that furnishes output required by 1 HP motors.

PRECISION POWER SERVO DRIVES.

Our broad line of Servo Motors (to 1 HP) are the primary drive source for our Power Servo Drives. Typical units give you: accurate positional feedback information; low backlash; highest performance/pound.

SERVO PACKAGES.

We can give you the "tightest" job, the lowest price and meet your delivery dates. How? We make thousands of Servo components, from motors to clutches. We design and build all associated electronics, from Servo amplifiers to switching networks.

We can meet almost any Servo requirement you may have from a single source—Singer's Kearfott Division.

For nearly 30 years Kearfott has been a pacesetter in the development of small motors and their associated electronics. Today we can offer you a wider variety of Servo components than any other single supplier.

All components are built to the highest order of precision, both in concept and construction. In addition, we'll design and produce units to your special requirements.

To learn more about Kearfott Servos and capabilities, mail the coupon now, for our information-packed 24-page brochure "Servo Motors". We'll rush it to you. The Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, New Jersey 07424.

SINGER

AEROSPACE & MARINE SYSTEMS

CHECK NO. 34

The Singer Company, Kearfott Division
1150 McBride Avenue
Little Falls, New Jersey 07424

Gentlemen:

Please send me your 24-page booklet on Servo Motors.

Name________________

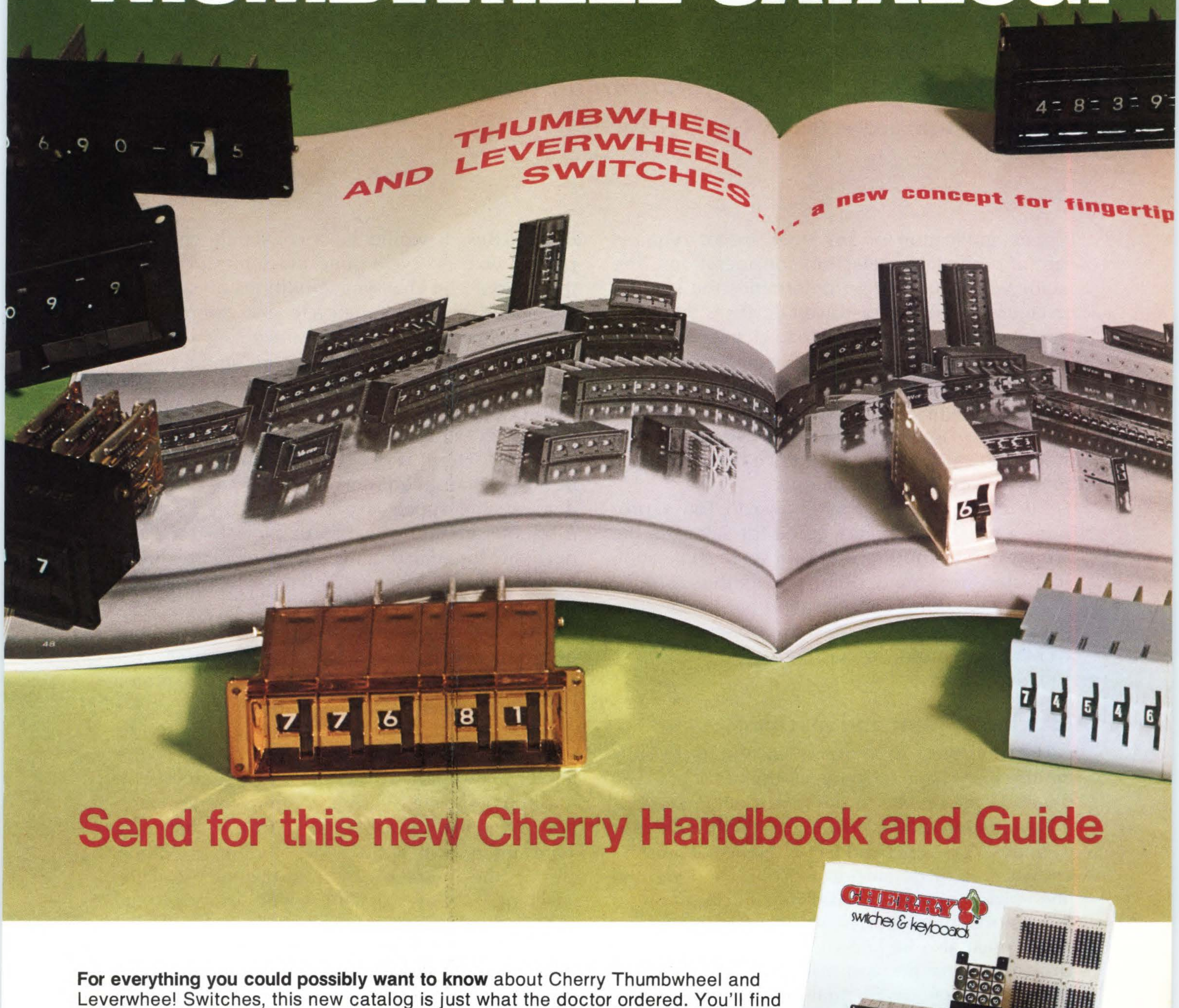
Title________________

Company________________

Address________________

City________ State______ Zip____

OPEN WIDE AND SAY "Ahhh...
Now that's what I call a
THUMBWHEEL CATALOG!



Send for this new Cherry Handbook and Guide

For everything you could possibly want to know about Cherry Thumbwheel and Leverwhee! Switches, this new catalog is just what the doctor ordered. You'll find details and specs on nine series of Thumbwheels and Leverwheels—available in hundreds of variations. You'll find truth tables . . . cross-indexed product listings . . . application data . . . specials . . . and more. You'll also find never-before-published "inside" information on Cherry's Thumbwheel Switch **total** in-house manufacturing capabilities: Including printed circuit, precious metal plating, silk screening, metal stamping and plastic molding operations. All in a handsome, new, easy-to-use 72-page format. **And it's yours for the asking:** Just TWX 910-235-1572 . . . or PHONE 312-689-7703 . . . and ask for Frank.

CHERRY ®

CHERRY ELECTRICAL PRODUCTS CORP.
3622 Sunset Ave., Waukegan, Ill. 60085

Cherry affiliates worldwide: Hirose Cherry Precision Co., Ltd., Tokyo • G. W. Engineering Pty. Ltd., Sydney
Cherry Electrical Products (U.K.) Ltd., St. Albans, Herts • Cherry Mikroschalter GmbH, 8580 Bayreuth, Bavaria

CHECK NO. 35

Designers Guide to:
Fractional-horsepower motors (Part 1)

There's more than meets the eye to choosing the right motor for a given application. Here's a rundown on the things to consider.

Engineering Staff, Bodine Electric Co.

Proper application of any small motor requires careful preliminary selection considerations. The factor which most often determines the success or failure of the motor-driven device is the initial care exercised in matching load characteristics of the machine to be driven with performance characteristics of the motor to be used as the driving member. A motor too large or too complex is unnecessarily expensive, while a motor too small might fail to drive the load under abnormal operating conditions.

The characteristic chart shown in **Fig. 1** provides a good preliminary guide for selecting the proper type of motor for a given set of application characteristics. Many other factors though must also be taken into consideration before the final selection is made. The most important are:

- Matching motor to machine
- Cost

Matching motor and machine

The first step in motor selection is to fully define the characteristics of the device to be driven as they relate to the motor parameters.

Power source: The power available for a motor is, in most cases, a fixed factor. Hence, it must be known if ac or dc current is to be used and the line voltage or voltages available. Furthermore, if the source of power is ac, the frequency and phase must also be known. Sometimes there is a choice of currents and voltages; and in other cases, unusual or fluctuating voltages or frequencies must be contended with. It is essential, therefore, that the power source be fully defined and understood before proceeding with the next step in the solution of the problem.

Machine: An analysis of the requirements of the machine to be driven must precede any consideration of the various types of motors.

One way of doing this is to start by preparing a detailed chart listing in sequence the various operations of the machine. In some cases, there would be only one operation—i.e., a shaft turning at constant speed under a steady load; in other cases, it would be a constantly changing pattern with no cycle quite the same; in others, there would be changing conditions of, say, load and speed, but a definite cycle as to stopping and starting. In many applications, reversing would be required. The variables making up the operational pattern would be direction of rotation, speed, load, length of the operation, continuous or intermittent duty and mechanical factors.

Speed: Here it should be known if it is desirable that speed remain constant with load or if a variable speed is desirable or permissible. Also, the amount of variation allowable and the necessity for adjusting the speed while the motor is running or while standing still should be determined.

Direction of rotation: Is unidirectional operation sufficient or is reversing required? And if reversing is necessary, must it be while the motor is running or standing still?

Horsepower: What horsepower is required to operate the machine? In what manner is the power to be applied? Will the torque required be maximum during starting, running or acceleration? Will the torque applied to the shaft stay constant or will it fluctuate at different points during the operation of the machine? Will the machine run at constant speed or will it be required to run at different speeds under varying conditions of operation?

One of the most important considerations in regard to the above is an analysis of the starting conditions. In some machines, the initial load is primarily one of friction: as speed increases, the power requirements increase rapidly. In other applications the motor is brought up to speed before a load is imposed. Here, friction and inertia comprise the initial load. If the motor is of sufficient capacity, no trouble is likely to be encountered in meeting the requirements of the working load.

Some applications require a motor that is equipped to handle a heavy starting torque. The heaviest demands on the motor are therefore during starting and acceleration. After full speed of the rotating member is achieved, less power is needed to keep the unit in operation.

Length of the duty cycle: Is the machine to be operated continuously over long periods of time without shutdown? Or is the machine to be operated intermittently?

Mechanical factors: Mechanical factors to be considered are: space available for the motor, weight limitations, coupling requirements,

		SPLIT PHASE	SHUNT OR COMPOUND	SHADED POLE	POLYPHASE	SYNCHRONOUS SPLIT PHASE	SYNCHRONOUS POLYPHASE	SYNCHRONOUS CAPACITOR.START	SYNCHRONOUS PERMANENT CAPACITOR SPLIT	SYNCHRONOUS 2 VALUE CAPACITOR	HYSTERESIS SYNCHRONOUS PERMANENT SPLIT CAPACITOR	CAPACITOR START	PERMANENT SPLIT CAPACITOR	2 VALUE CAPACITOR	SERIES 2 LEAD	SERIES 4 LEAD	SERIES SPLIT FIELD	SERIES GOVERNOR	2 PHASE SERVO CONTROL
CURRENT SUPPLY	A.C.	●		●	●	●	●	●	●	●	●	●	●	●					●
	D.C.		●																
	A.C. OR D.C.														●	●	●	●	
DUTY	CONTINUOUS	●	●	●	●	●	●	●	●	●	●	●	●	●					●
	INTERMITTENT														●	●	●	●	
UNIDIRECTIONAL				●											●			●	
REVERSIBLE AT REST ONLY		●				●		●		●		●		●					
REVERSIBLE AT REST OR DURING ROTATION			●		●		●		① ●		① ●		① ●			●	●		●
SPEED	CONSTANT FIXED	●		●	●	●	●	●	●	●	●	●	●	●					●
	CONSTANT ADJUST.		●															●	
	VARIABLE														●	●	●		
STARTING TORQUE	LOW			●					●		●		●						●
	NORMAL	●	●			●									② ●	●			
	HIGH				●		●	●		●		●		●			●	●	
STARTING CURRENT	LOW			●					●		●		●						●
	NORMAL	●	●		●	●	●	③ ●		③ ●		③ ●		③ ●					
	HIGH														●	●	●	●	

① UNDER FAVORABLE CONDITIONS ② HIGH WITH FULL LOAD SPEED ABOVE 7500 R.P.M. ③ LOWER THAN FOR SPLIT PHASE

Fig. 1—The characteristics of a particular motor type determine whether or not it is suited for a specific application. The most important motor characteristics are shown here as they relate to specific motor types.

mounting requirements, changeability of position, exposure, climatic and atmospheric conditions, ambient air temperature surrounding the motor, requirements as to quietness of operation, provisions for lubrication, end thrust on shaft, restriction of shaft end play, vibration of machine or effect of motor vibration on functioning of machine, safety requirements and other mechanical requirements such as terminal leads, connectors, cords, plugs and switches.

Motor drive: Once the power source and driven machine have been fully defined, it is time to investigate the types of motors available and their characteristics. The broad categories to consider are ac vs. dc, speed reducers vs. nonspeed reducers and constant speed vs. variable speed motors.

In all cases, a motor must be selected with sufficient capacity to do the job without overloading it. Overloading may result in the motor being heated beyond safe limits. The safe allowable temperature rise, of course, varies depending upon whether the motor is an open frame or a totally enclosed motor. Excessive motor temperature also plays havoc with good lubrication causing friction and shorter life.

Where a reduction in speed is needed, built-in speed reducer motors should be considered. By combining the motor and speed reducer in one unit, all cumbersome and complicated speed reducer transmissions are eliminated. In selecting the proper gear ratio, due regard to the strength of the gears and their adaptability for the application intended must be carefully considered. Where conditions specify and strength warrants, laminated or molded nonmetalic gears may be used to achieve quietness in operation.

Cost considerations are subtle

The cost considerations involved in selecting small motors are extremely important, particularly because of the subtle nature of many of them. Purchase price is the first, but by no means the only, cost. Frequently it is a lesser factor than some of the associated costs. Some important economic considerations in motor selection are:

- Life expectancy
- Associated components required
- Installation cost
- Cost of rejections
- Cost of incorrect application
- Cost of servicing
- Purchasing policy
- Special motor features

Life expectancy: Some machines are expected to operate quite continuously for a number of years with very little servicing. Others operate infrequently and are used for a rather limited time. An example of the former would be the motor for an on-line chart recorder, while the latter could be the motor for a one-shot experimental set-up. You would pay top prices for a motor you could expect to give a number of trouble-free years of service in a chart recorder, but it would be poor economy to invest in any other but a low priced unit for an experimental set-up which will be discarded after operating only a few months.

Associated components: Adapting a motor to a machine always requires the use of one or more other components such as a coupling, belt and pulleys, chain and sprockets, gears, brake, clutch, mechanical or electrical speed control device, limit switch, etc. These components are obtainable from different sources. Most of them are also obtainable as part of the motor drive. Some of these components represent a considerable initial investment. Whether to purchase a motor which incorporates them within itself or to purchase separate units requires a comparison of the following factors:

1. Package price vs. sum of prices of separate components.
2. Cost of one purchase order vs. several.
3. Assembly cost of package vs. assembly and adjustment of individual components.
4. Guaranteed performance of one unit vs. a number of components.
5. Cost of designing around a standard package vs. flexibility of combining individual components to best advantage.

The decision on these points may be dictated by other than economic factors; but when economic factors predominate, the number of machines produced usually enters into the consideration. Economy generally favors a packaged unit where production quantities are limited, and separate components where the quantities are sufficient to support a single-purpose design. In the latter case, of course, the manufacturer of the end item must possess the required engineering and specialized manufacturing facilities.

Installation cost: The time and precision required to install a packaged unit is usually insignificant compared with assembling and adjusting components. Frequently separate components mean extra precision machine work on parts of the driven machine, as well as extra supporting parts such as castings, brackets, bearings, shafts, gears, enclosures, etc. Special motor features, such as special shaft extensions, flanged end shields and special machined surfaces, often reduce installation time. Usually, however, it is less costly to adapt to standard motor features where only a few machines are to be built.

NAMEPLATE RATINGS	PERFORMANCE PARAMETERS ADVERSELY AFFECTED BY NAMEPLATE DEVIATIONS									
							STARTING DEVICES			
	TORQUE	SPEED	TEMPERATURE	NOISE	VIBRATION	THERMAL O/L PROTECTORS	CURRENT SENSITIVE	CENTRIFUGAL CUT-OUTS	CAPACITOR LIFE	MOTOR LIFE
VOLTAGE	●	●	●	●	●	●	●		●	●
FREQUENCY	●	●	●	●	●	●	●	●	●	●
TORQUE (HP, RPM)	●	●	●	●	●	●	●			●
TEMPERATURE RISE	●	●	●			●	●			●
CAPACITOR	●	●	●	●	●	●			●	●
DUTY			●			●	●	●	●	●

Fig. 2—Deviation from the nameplate ratings of a motor can seriously degrade the motor's operating performance.

Rejections: Rejections of delivered motors can be caused by marginal performance in matching motor to machine, by critical tolerances on dimensions, by vibration, noise, etc., or by loose production control of motors or machine elements, or both. Rejections can be more costly than one might expect and can seriously reduce the profits from the final product.

Application: As noted previously, faulty or marginal application of motors can result in costly rejections. It also results in more fussiness than is justified in the assembly and adjustment of the driven machine. This affects the labor component of cost, and reduces efficiency and output. Probably the most serious effect of misapplication is the cost of servicing the end product on location. The greatest insurance against this is to take a little extra time getting into full production by first producing a pilot run of machines for field testing.

Servicing: Cost of servicing is reduced by thorough and conservative motor application engineering, by selection of all components (including the motor) so that they meet expectations of durability and reliability, and by motor and machine design which accommodates replacement and adjustment of components. For instance, commutator-type motors should be so located in the machine that brushes can be replaced without removing the motor or any of the other components. When standard motors are used, location of service stations affects service cost. Special motors usually require factory attention. Service cost is reduced in the case of special motors, and time is saved, by including extra motors with quantity production orders.

Purchase policy: Purchasing policy must of course be tuned to the particular nature of a business. It is difficult, especially in a large operation, to maintain adequate control of the purchasing function, yet keep it flexible enough to take advantage of the savings obtainable through most effective use of the supplier's facilities. Good sales forecasting and inventory control can result in considerable savings. Where the nature of a business permits setting a production pattern, it should be integrated into the motor supplier's pricing structure to obtain the most favorable motor price. Where special motors are used, it is poor economy to risk running out of stock. On the other hand, it is false economy to overorder just to fit into a price bracket. The planning of motor purchases should also include an allowance for the motor manufacturer's lead time. In addition, consideration should be given to the economy of including the quantity of motors required for service replacements in the production run order.

Special motor features: For the purpose of this discussion, a special motor is defined as one which embodies components the supplier does not manufacture for use in his standard units, or one whose components are assembled in an other than standard orientation. Such a motor may incorporate only a very minor special feature, or it can be entirely special as to basic design. Somewhere between these two extremes lies the most economical special motor for a particular machine application. In some instances, a standard motor may prove to be the most economical, even for a special application.

When should special motor features be considered? The premium cost of producing special motors varies with the quantity of the production run and with the degree of off-standard modifications. Economically, the added cost of a special motor over that of a standard motor should be considered only where the additional cost is offset by associated economies, such as time savings or elimination of additional machine operations. A feature which is considered a minor modification by one motor manufacturer could be considered a major one by another. It all depends on the nature of his facilities.

The following modifications are sufficiently common to be considered minor by those motor manufacturers who regularly produce special motors. They can usually be produced in minimum quantities somewhere between ten and one hundred.

1. Special winding
    - for increased or reduced output for odd voltage
    - for special performance characteristics
2. Special rotors to modify performance (limited)
3. Special shaft extensions
    - diameter
    - length
    - special material
    - hardened
    - drilled and/or tapped
    - milled flat
    - keyway (rectangular or woodruff)
    - groove or shoulder
    - threaded
    - pinion or spline (using available tools)
    - tapered
    - square or tongue
    - worm or spiral groove
4. Special terminal leads
    - number
    - length
    - material
    - cord sets with or without plugs and switches
    - with eyelet or spade terminals
    - terminal box
5. Off-standard bearings (including end thrust provisions)
6. Special end shields (designs already tooled and produced in limited quantities)
7. Special stator housings (designs already tooled and produced in limited quantities)
8. Special mounting features and bases (designs already tooled and produced in limited quantities)
9. Special machine work on motor frames (operations which utilize existing tools and gauges)
10. Special oilers, seals and hardware (only items readily available and practical to assemble)
11. Thermal overload protection
12. Special lubricant (limited)
13. Dynamic balance to special limits

Major modifications are those which usually require extensive engineering and/or tooling or those which require manufacturing facilities that lend themselves to only large quantity production. Major modifications are generally economically practical for the machine manufacturer as well as the motor supplier only when production quantities are in multiples of 1000. A customer should expect to pay tooling charges for major modifications. When the special features involve basic motor design (requiring special lamination punching dies or casting dies), it is generally advisable to anticipate ordering quantities of the nature of 10,000, and assure steady production for at least several years.

Some special motor features which are generally considered major modifications are:

1. Special rotors (involving special tooling and/or extensive engineering)
2. Special end shields not produced before
3. Special stator housings not produced before
4. Special mounting features and bases not produced before
5. Special machine work requiring new tools, fixtures and gauges
6. Some forms of climatic and/or high-voltage protection
7. Special finishes
8. Special gear ratios
9. Completely new special purpose motor frame
10. New basic motor design

Importance of nameplate ratings

A primary purpose in placing a nameplate on a motor is to convey sufficient information to the user to assure that it will be applied and operated in accordance with its design criteria. In general, the criteria used by reputable motor manufacturers is based upon established motor industry standards and recognized safety standards.

Satisfactory running performance of a motor will be achieved within the normal expected line variations of ±10% of nameplate voltage and ±5% of nameplate frequency even though other nameplate values may not be met. The hazards of operating motors at other than nameplate values do not apply with the normal variations in voltage and frequency, but rather to abnormal values such as those created by uncondoned and deliberate deviations taken in adapting a motor to an application.(**Fig. 2**).

Original equipment manufacturers can avoid such hazards by seeking the assistance of the motor manufacturer.

The purpose of the following paragraphs is to create an awareness of the effects of deviations from nameplate ratings on the performance of both alternating and direct current motors. Judging from problems commonly encountered, some of these effects are often overlooked by design engineers.

HORSEPOWER		WATTS				FULL LOAD TORQUES IN. OZ.					
FRACTION	DECIMAL	1-1/2 LOAD	FULL LOAD	3/4 LOAD	1/2 LOAD	1125 RPM	1725 RPM	3450 RPM	4000 RPM	5000 RPM	6000 RPM
1/200	.005	5.59	3.73	2.79	1.86	4.47	2.91	1.45	1.26	1.01	0.85
1/100	.010	11.19	7.46	5.59	3.73	8.96	5.84	2.92	2.52	2.01	1.71
1/90	.011	12.42	8.28	6.21	4.14	9.96	6.49	3.24	2.80	2.24	1.90
1/80	.012	13.98	9.32	6.99	4.66	11.19	7.29	3.64	3.15	2.52	2.13
1/70	.014	15.97	10.65	7.98	5.32	12.80	8.35	4.17	3.60	2.88	2.44
1/60	.016	18.63	12.42	9.31	6.21	14.94	9.74	4.87	4.30	3.32	2.85
1/50	.020	22.38	14.92	11.19	7.46	17.93	11.69	5.84	5.04	4.02	3.42
1/40	.025	27.97	18.65	13.98	9.32	22.38	14.61	7.30	6.30	5.04	4.27
1/30	.033	37.29	24.86	18.64	12.43	29.88	19.47	9.73	8.60	6.65	5.70
1/20	.050	55.95	37.30	27.97	18.65	44.82	29.18	13.61	12.60	10.08	8.55
1/10	.100	111.90	74.60	55.95	37.30	89.64	58.46	29.23	25.21	20.17	17.10

Fig. 3—Torque and wattage ratings are shown for various horsepower motors.

Do not operate motors at other than ±10% of nameplate voltage. Higher voltages produce adverse effects on motor temperature, noise, vibration, operation of current-sensitive starting relays, motor life and capacitor life, and could result in nuisance operation of thermal overload protectors. Lower voltages create starting problems with current-sensitive starting relays and could cause thermal overload protectors having internal heater coils to operate at winding temperatures which exceed the maximum allowable limits as specified in U.L. Standard #547.

Do not operate motors on nominal power source frequencies other than specified on the nameplate! With the exception of brush type motors, it is a well recognized fact that the motor speed will vary directly with frequency. The use of a motor on more than one frequency is an understandable goal of original equipment design engineers. Often overlooked, however, is that a change in operating speed will have an adverse effect on the operation of centrifugal cutout switches (when present).

At high frequencies, output torque is reduced, current-sensitive starting relays may fail to engage the auxiliary winding, capacitor voltage ratings may be exceeded (resulting in shorter capacitor life) and fan noise may become objectionable. Additionally, the amount of noise and vibration emanating from a motor will generally change directly with frequency. These changes could create undesirable levels of noise and vibration if the frequency is coincident with the natural resonant frequency of the mounting surface, or enclosure, or falls within a more sensitive hearing range of the human ear.

At lower frequencies, motor winding temperature will increase with corresponding decrease in motor life, and nuisance "trip-outs" could be expected from thermal overload protectors.

Do not overload motor in excess of nameplate output rating! Where nameplate rating is in horsepower, the rated output torque can readily be determined from **Fig. 3** or from the following equations relating speed, torque and horsepower.

$$HP = \frac{2\pi R \times N \times W}{33{,}000} = \frac{T\text{ (in. -lb.)} \times N}{63{,}025}$$

$$HP = T\text{ (in. -oz.)} \times 9.917 \times N \times 10^{-7}$$
$$= \text{(approx.) } T\text{ (in. -oz.)} \times N \times 10^{-6}$$

$$P = EI \times \text{power factor} = \frac{HP \times 746}{\text{motor efficiency}}$$

T = torque or twisting moment
N = revolutions per minute
HP = horsepower (33,000 ft. -lbs. per min.)
E = input voltage
I = current in amperes
P = power input in watts

In the case of gearmotors, rated torque is usually stated directly and is a function of either the capacity of the motor portion or the gearhead portion of the gearmotor. Operation at higher torque loads will result in lower speeds, higher winding temperatures, shorter motor, gear, and bearing life and nuisance operation of thermal overload protectors (if present).

At very light torque loads, permanent split capacitor motors will generally exhibit higher winding temperatures, with possible nuisance operation of thermal overload protectors and could result in improper operation of current-sensitive starting relays with 2-capacitor start, 1-capacitor run-type designs.

Noise and vibration are also a function of

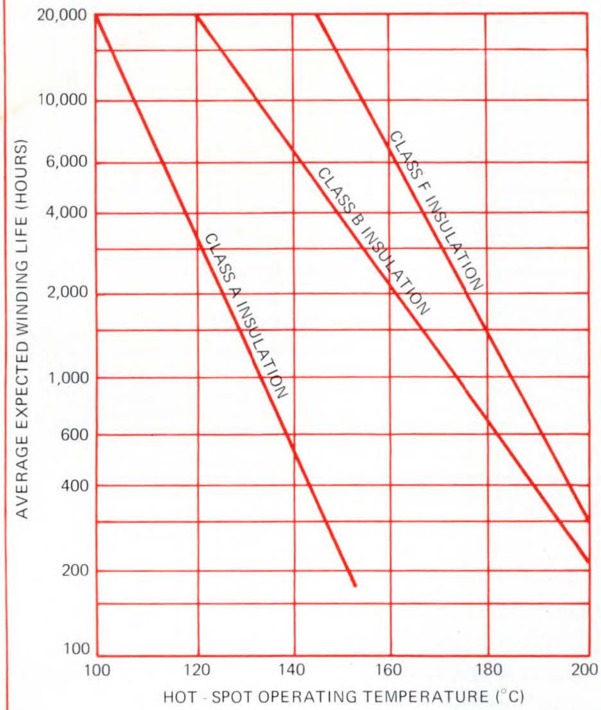


Fig. 4— Motor winding life is approximately cut in half for every 10°C increase in motor operating temperature over the recommended hottest-spot temperature limit. The rated hottest-spot temperature for the different insulation classes are 105°C for class A, 130°C for class B and 155°C for class F.

torque loading. An in-depth discussion on any of the above points would have to be associated with a specific motor or gearmotor design. Technical assistance should be requested from the motor/gearmotor manufacturer.

Do not exceed nameplate temperature rise. The temperature-rise rating is based on the motor winding temperature when operating in a specific ambient temperature in accordance with the nameplate parameters, and represents a safe value for long motor life. Specifically, the temperature-rise rating represents the number of degrees centigrade that the winding temperature may safely exceed the ambient temperature and is based on a maximum ambient of 40°C. Lack of air intake, obstructions to the ventilation flow and excessive deviations from the nameplate parameters will result in a higher temperature rise.

Operation at higher temperatures will reduce motor insulation (**Fig. 4**) and lubricant life and, in general, will also result in decreases in motor torque and speed. High temperatures could also result in nuisance operation of thermal overload protectors and motor start failures where current-sensitive starting relays are employed. These hazards can sometimes be avoided by designing equipment to provide heat sinks (for enclosed motors) or adequate air intakes and exhausts (for ventilated motors). Assistance should be requested from the motor manufacturer when unusual problems arise. Proper selection from the wide variety of motor constructions available will often solve temperature problems.

Do not change the value of capacitance indiscriminately. This precaution applies mainly to permanent split capacitor motors. (Motor start capacitors, used with split-phase motors, are normally specified to achieve maximum starting torque and/or minimum locked current, and deviations are not usually made by the user.) Deviating to a higher value of capacitance will provide increases in starting torque and in some instances speed, but at the risk of certain hazards. Higher values of capacitance will result in higher winding temperatures, shorter motor life, nuisance operation of thermal overload protectors and increases in the level of noise and vibration. The voltage rating of the applied capacitor must also be consistent with the voltage across it.

Another side effect is that problems may be encountered with safety testing laboratories when the applied capacitor is of a different rating than that specified on the nameplate. The proper approach would be to obtain assistance from the motor manufacturer to evaluate the proposed deviation with the possibility of changing the nameplate rating or developing a more satisfactory motor design.

Do not subject the motor to duty cycles for which it was not designed. Continuous (cont.) or intermittent (int.) duty as stamped on the nameplate indicates the designed mode of operation of the motor and is generally based on the insulation class system of the motor and the watts that the motor must dissipate when energized. Adverse effects will develop from operating a continuous duty motor in an application requiring a high frequency of starts and stop. Adverse effects will also be encountered if an intermittent duty motor is operated continuously or at other than the designed mode of operation.

Generally, an adverse deviation in duty will result in higher winding temperatures with a shortening of motor life and the possibility of nuisance operation of thermal overload protectors. Increased frequency of starts could result in failure of electrolytic motor start capacitors and a reduction in the life of motor starting switches or relays. □

The performance characteristics of the various motor types available to the designer will be covered in Part 2 of this Designers Guide, to be published in the April 5 issue.

Only Perkin-Elmer could produce a 12 bit D-to-A converter with ½ LSB accuracy over the full military temperature range.

Introducing Varidac™ Multiplying-Digital-to-Analog Converters from Perkin-Elmer. Accuracy at temperature extremes is only half the story. Reliability is the other half. These new Varidac Converters deliver long term stability of more than 0.001% per year. Perkin-Elmer has added input gate protection and infinite short circuit protection to +125°C.

Varidac Converters are small — 2.32″ x 2.87″ x .48″ high — and weigh only three ounces. All this at a low cost—significantly lower than any comparable converter.

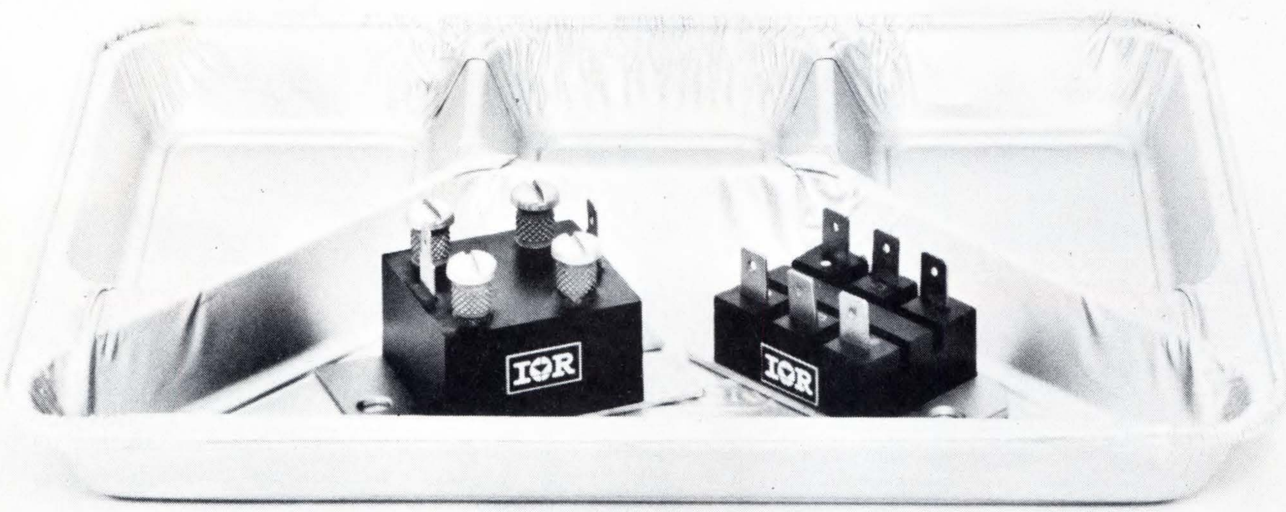
This advanced new product won't surprise anyone who knows Perkin-Elmer. Or even knows a few Perkin-Elmer achievements in science and technology. Such as its alignment systems for missiles and space platforms. Astronomical telescopes for the Copernicus orbiting observatory. Flight guidance and control instruments. Atomic absorption spectrophotometers. Laser measuring instruments. Precision transformers and ac potentiometers.

Perkin-Elmer would like to send you a data sheet on the new Varidac Converters. Write or call Perkin-Elmer Corporation, Electronic Products Division, Main Ave., Norwalk, Conn. 06856. Tel. (203) 762-4786.

PERKIN-ELMER

CHECK NO. 36

A new concept in packaged power circuits as convenient as the TV dinner.



The International Rectifier PACE/pak™ is the device behind this new concept.

They are power integrated circuits, made up of SCRs, diodes, triacs, etc. which give you a complete control circuit function in a single package. And like the TV dinner, they take most of the shopping and assembly times out of the job.

But that's just the beginning of the benefits they offer.

Smaller size. PACE/paks (Passivated Assembled Circuit Elements) are electrically isolated up to 2.5 kV. There's no need for a separate isolated heatsink, so you get up to 60% reduction in space requirements.

A better designed system. With the smaller size of these power hybrid control circuits you get more design and packaging flexibility. And since you don't have to spend time designing with discrete components, you have more time to make other improvements.

One-fifth the assembly time. No more do you have to assemble five to seven devices for single and 3-phase functions. With the PACE/pak there is just one part to mount, one part to interconnect with push-on or screw terminals. Your system reliability is higher, too.

Just think of the other savings you can make in testing, inspection and field servicing.

Lower inventory costs. We estimate a 7-to-1 reduction in inventory, plus savings in procurement time and costs. Standard PACE/pak circuits now cover 90% of single-phase power circuit requirements, with more in development for 3-phase applications.

They are available as standards with 25 or 42.5 Amp current ratings, in either 120 or 230 Volt RMS versions.

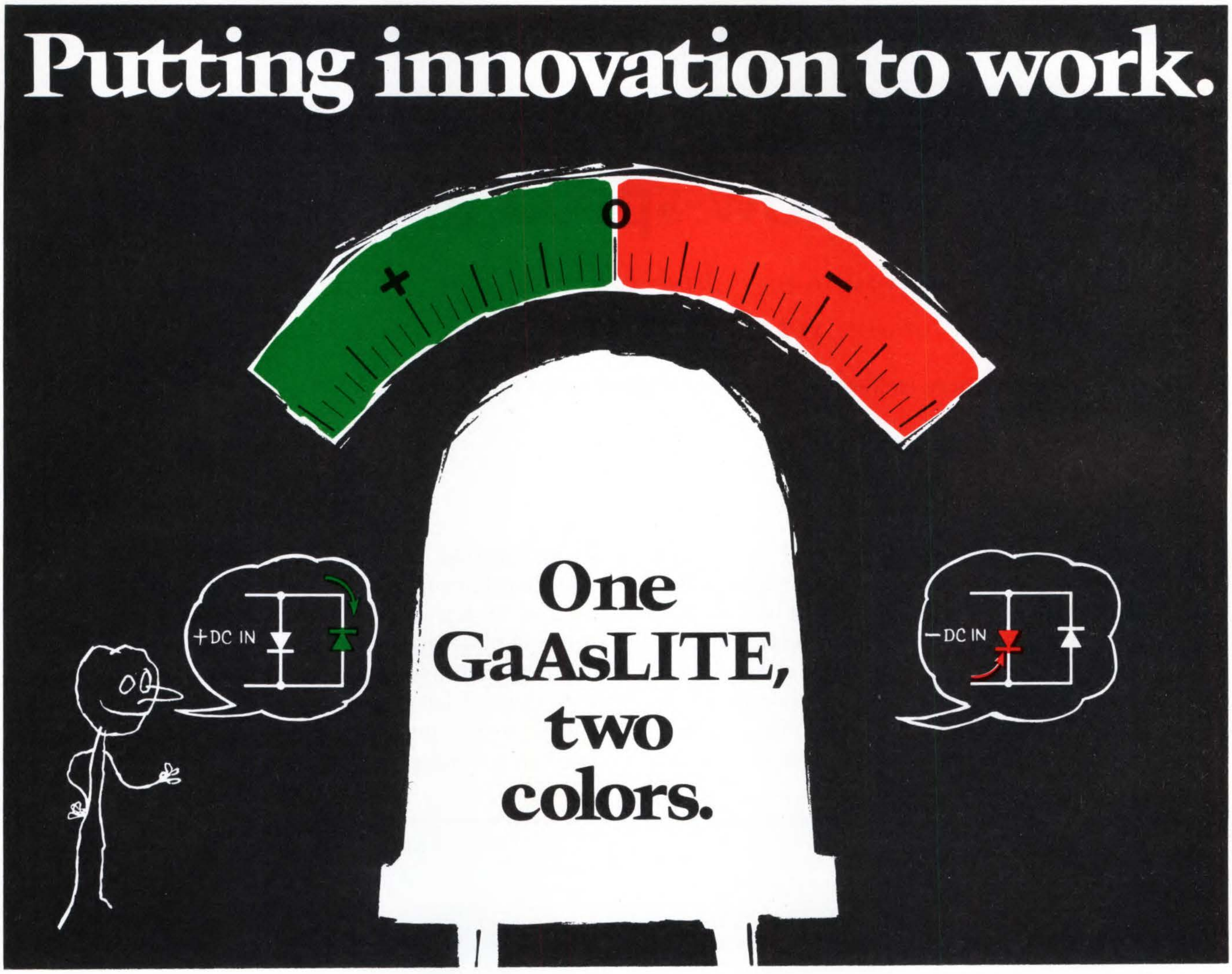
Find out how PACE/paks will revolutionize your designs like dc motor controls, inverters, chopper drives, generator exciters, solid-state circuit breakers, battery chargers and variable dc power supplies.

Call your local IR sales office for details or contact the factory: *International Rectifier • 233 Kansas Street, El Segundo, CA 90245 • (213) 678-6281 • TELEX: 67-4666.*

International Rectifier

. . . the innovative power people IOR

CHECK NO. 37



Think what you can do with our new bi-color and AC GaAsLITEs:

We've taken two light-emitting diodes and put them in one pop-in panel mounting package. Result? A tri-state device (*red, green,* and *off*) that is a nifty nulling circuit all by itself. Or a battery charge-discharge indicator. Or a self-contained polarity meter. Or whathaveyou.

ON DISTRIBUTORS' SHELVES:

MV 5094
AC RED 0.8 mcd @ 20 mA (typ.)

MV 5491
RED/GREEN
1.5 mcd @ 20 mA (typ.) RED
0.5 mcd @ 20 mA (typ.) GREEN

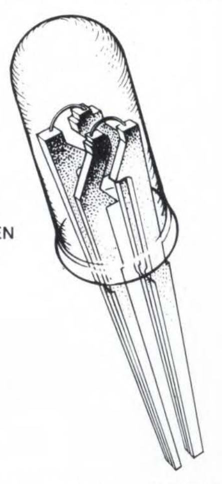
AVAILABLE ON FACTORY ORDER:

MV 5591
RED/YELLOW

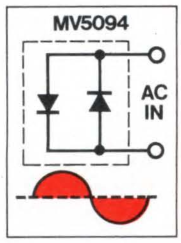
MV 5691
YELLOW/GREEN

MV 5291
AC GREEN

MV 5391
AC YELLOW



AC GaAsLITEs



By putting two red, green or yellow chips in the package, we give you the world's first line of AC light-emitting diodes. Run them with up to 110 V and a simple resistor. No flicker. Prices start at 99¢ (1,000's).

So call your distributor for your first quantities or the data sheet.

Monsanto Commercial Products Co.
Electronic Special Products
10131 Bubb Road
Cupertino, California 95014
Phone: (408) 257-2140

Distributed by: Alta Electronics, Elmar Electronics, Hammond Electronics, Kierulff Electronics, Kierulff/Schley, Liberty Electronics, Schweber Electronics, Semiconductor Specialists, Wesco Electronics, Western Radio; Canada: Canadian Dynamics, Ltd., Cesco Electronics, Ltd.

CHECK NO. 38

Monsanto

Delta-sigma A/D conversion can save $$ in slow-speed applications

This novel A/D conversion technique has good performance at low speeds and medium resolutions, yet only uses three precision components.

Thomas Harrison, George Hellwarth and **Richard Jaeger,** IBM Corp.

There are many analog-to-digital (A/D) conversion applications where speed is not a significant requirement. The designer is then able to trade off the speed parameter for others, such as resolution and cost. The delta-sigma technique of A/D conversion is ideally suited to such applications. It provides a low-cost converter that has good performance at a resolution of 10 bits plus sign and a speed of 100 conversions/second.

A delta-sigma modulator is used as the basis of the delta-sigma A/D converter (Ref. 1 and 2), which is shown in block diagram form in **Fig. 1**. In the circuit, the comparator, switchable reference and filter network form a delta-sigma modulator. The unknown voltage, V_x, is applied to one input of the filter, and a reference voltage, either $+V_r$ or $-V_r$, is connected

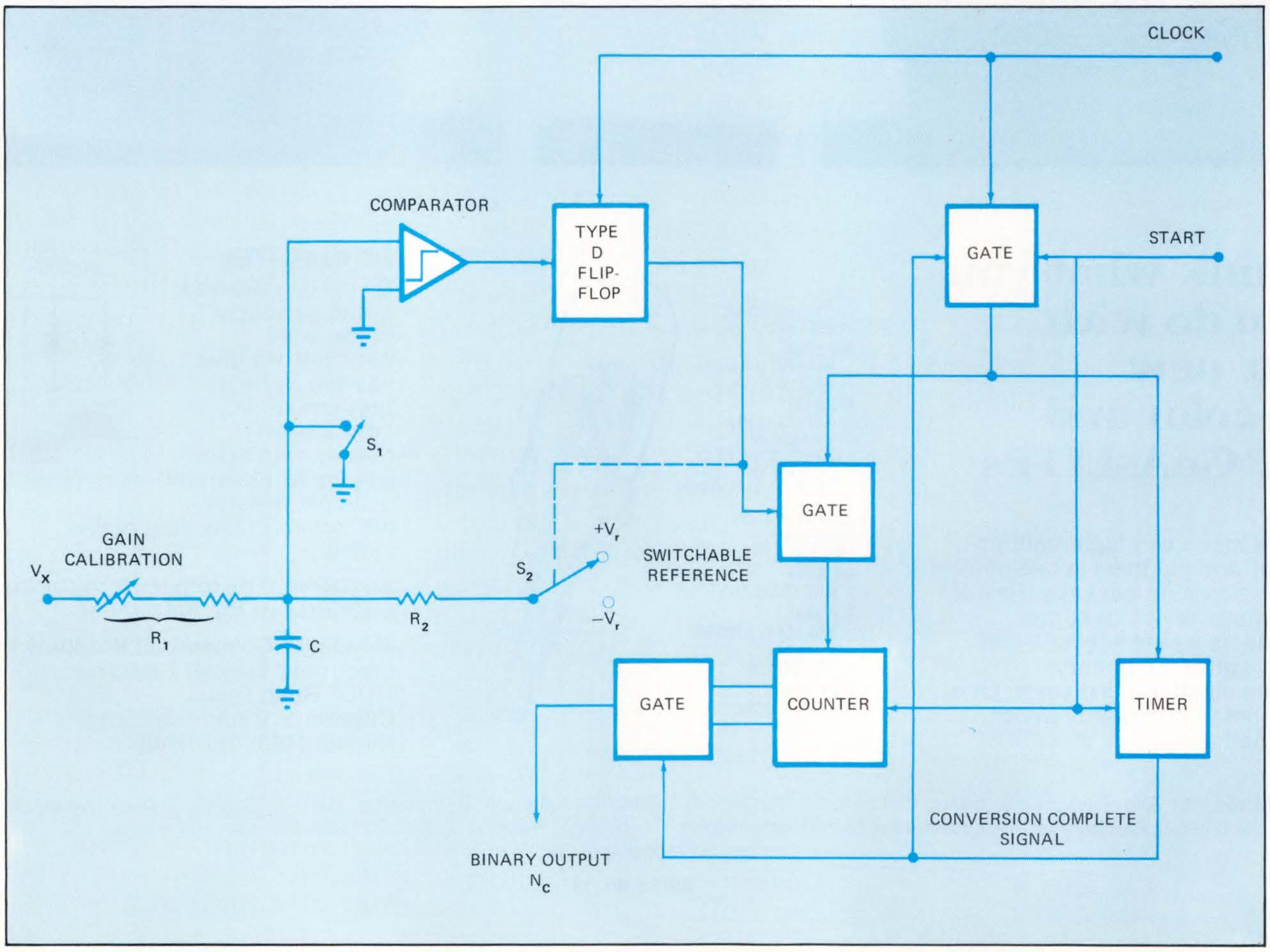


Fig. 1 – The delta-sigma A/D converter makes maximum use of digital circuits and minimum use of precision components.

to the second filter input. The operation of the delta-sigma modulator is such that the reference voltage selected will be that which tends to force the voltage on capacitor C, and hence the comparator input, to zero. Changes in the reference voltage polarity are permitted only at fixed clock times. The number of clock periods during which the negative reference is used, compared to the total number of clock cycles in the measurement period, is related to the unknown value of V_x.

In operation, the circuit of **Fig. 1** functions as follows: Prior to the start of conversion, switch S_1 is closed to provide a zero input to the comparator, and switch S_2 is connected to $+V_r$. When the START CONVERT signal is given, switch S_1 is opened and capacitor C charges toward a positive potential at a rate determined by the magnitudes of V_x, V_r, R_1, R_2 and C. If V_c is positive at the end of the first clock cycle, the state of the comparator output causes the flip-flop to change state which, in turn, causes S_2 to switch to the reference source $-V_r$. The clock pulse is counted in the timer circuit but not the counter.

At the end of the second clock interval, the capacitor voltage, V_c, may be either positive or negative. If it is positive, the state of the flip-flop and switch S_2 remain unchanged. The clock pulse is again accumulated only by the timer. If V_c is negative, the flip-flop changes state, causing S_2 to change state to connect $+V_r$, and a clock count is accumulated by both the timer and the counter.

This cycle of events continues with clock pulses being accumulated in the timer on every occurrence and in the counter whenever switch S_2 is in the $-V_r$ position. When 2^{N+1} clock cycles have occurred, where $N + 1$ is the number of binary stages in the timer, the timer overflows, providing a signal that the conversion is complete. The overflow signal inhibits further clock pulses from entering either the timer or the counter, resets switch S_1 to the closed position and activates the read-out gate of the counter. The number in the counter, N_c, at the end of conversion is equal to the number of clock cycles during which the reference $-V_r$ was used.

A detailed analysis of the circuit shows that the number N_c is related to the circuit parameters by the expression:

$$N_c = 2^N \left[\frac{R_2}{R_1}\frac{V_x}{V_r} + 1\right] \quad (1)$$

From this equation, the unknown voltage V_x is determined as:

$$V_x = \left(\frac{N_c}{2^N} - 1\right)\frac{R_1}{R_2} V_r \quad (2)$$

Since all values on the right side of **Eq. 2** are known, V_x is uniquely determined. Examination of the expression also shows that V_x will be represented by an offset binary coded value of N_c. Thus, the circuit provides bipolar analog-to-digital conversion with a resolution of N bits plus sign.

Two adjustments are required for calibration of the converter. One attenuates either the input voltage, V_x, or the reference voltage, V_r, to obtain full-

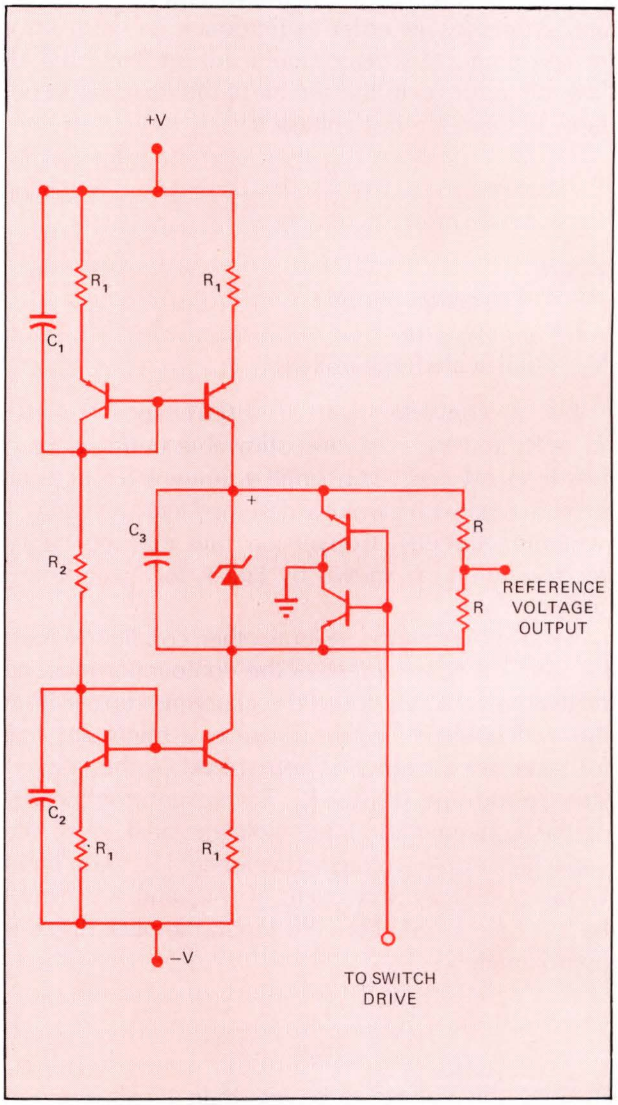


Fig. 2—One version of the switchable reference circuit uses a zener reference biased by a pair of current sources.

scale or gain calibration. A second is used to adjust the symmetry of the modulator waveform to obtain zero or offset calibration. The counter, timer and gating circuitry of **Fig. 1** may be constructed with any suitable logic family.

Application of the signal V_x and reference voltages $\pm V_r$ to the same input of the comparator, together with starting switch S_1, remove the necessity of an initialization interval which would be required in the case where V_x and the delta-sigma modulator output are applied to opposite comparator inputs (Ref. 3). The converter yields an output which represents the average of the input during the conversion period. The conversion period is fixed and independent of the magnitude of unknown input signal V_x.

What are the performance limitations?

The prime performance limitation of the delta-sigma converter is the required adjustment and stable maintenance of the reference waveform timing and symmetry. In order to introduce an offset error of less than 1/2 a least significant bit (LSB), the allowable error, ϵ, in the timing of the changes in polarity of the reference voltage is:

$$\epsilon \leq \frac{R_1}{R_2} \frac{V_{fs}}{V_r} \frac{T}{2^{2N+2}} \quad \textbf{(3)}$$

where
T = conversion period
ϵ = timing error
V_{fs} = full-scale input voltage

For a converter with T = 0.01 sec, N = 10, $R_1 = R_2$ and $V_{fs} = V_r$, the allowable timing error is less than 2.4 nsec. This small a timing tolerance can be achieved with carefully designed logic and analog switching circuits. Conversion rate may be traded for resolution, as shown by **Eq. 3,** for given timing errors.

To insure linearity, several other conditions must be met. The bias current of the comparator must be negligible with respect to the charging current from the switchable reference. There is a minimum size for capacitor C, which is determined by the conversion period and resistor R_2. To prevent nonlinearity of the converter for input voltages near zero, the capacitor ripple voltage developed for zero input voltage (a 50-50 duty cycle of $+V_r$ and $-V_r$) must be less than 1 LSB. For zero input, the peak ripple is approximately:

$$V = \frac{V_r}{2R_2C} \times \frac{T}{2^{N+1}} \quad \textbf{(4)}$$

Insuring this voltage to be less than 1 LSB requires:

$$C \geq \frac{T}{4R_2} \times \frac{V_r}{V_{fs}} \quad \textbf{(5)}$$

When operating at a conversion rate of 100 conversions per second and a resolution of 10 bits plus sign (a clock frequency of about 100 kHz is required at this frequency), double buffering of the comparator output has been found helpful in reducing nonlinearity caused by metastable flip-flop conditions.

One implementation of a polarity-switchable reference with accurate timing is shown in **Fig. 2**. A floating reference voltage is obtained by biasing a zener diode with a pair of current sources. The reference potentials are obtained by switching either the positive or negative terminal of the floating source to ground through inverted complementary bipolar transistors. The resistive voltage divider and zener diode are the only precision components used in the converter. ▭

References

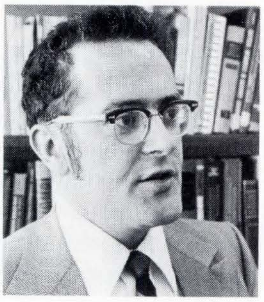
1. H. Inose and Y. Yasuda, "A Unity Bit Coding Method by Negative Feedback," Proc. IEEE, pp. 1524-1535, Nov., 1963

2. H. R. Schindler, "Delta Modulation," IEEE Spectrum, pp. 69-78, Oct., 1970.

3. D. J. G. Janssen and N. V. Phillips, "Recent Advances in Digital Voltmeter Design," 1972 ISSCC Digest, pp. 152-153.

4. P. E. Prozeller, "An Inexpensive Millivolt A/D Converter," 1972 ISSCC Digest, pp. 150-151.

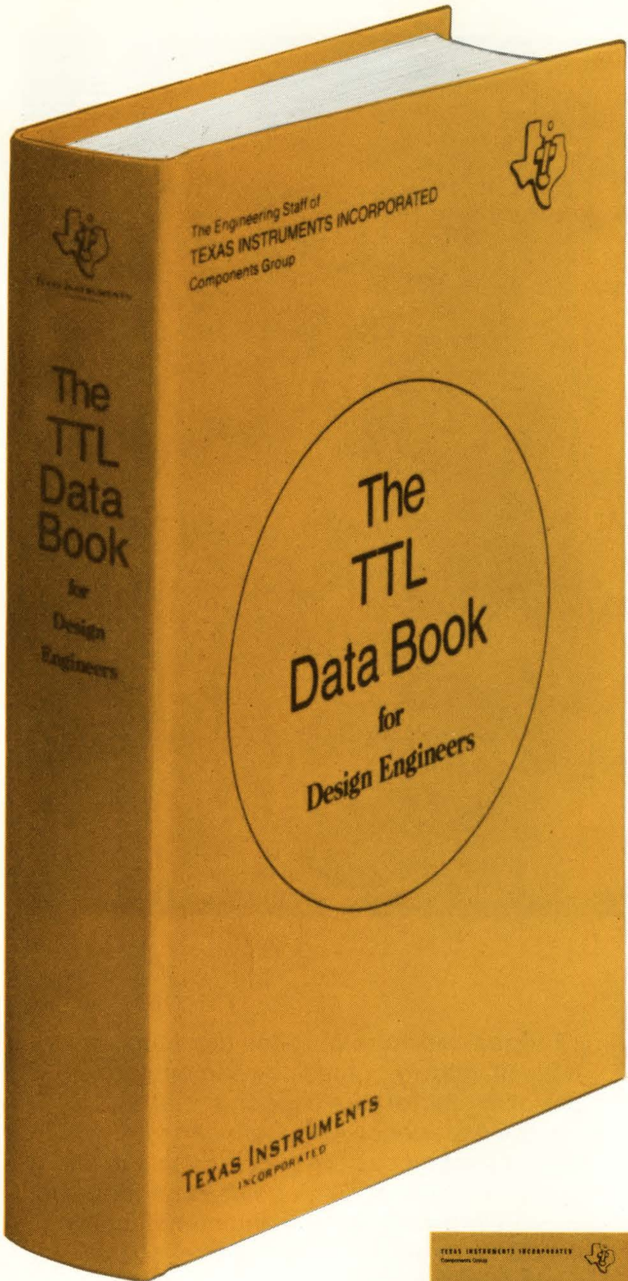
Authors' biographies



Dr. Thomas Harrison is manager of advanced development for sensor based computing systems at IBM's General Systems Div. in Boca Raton, FL. He also participates in language development and standards activity sponsored by the ISA. Dr. Harrison holds a BS and MS in electrical engineering from Carnegie-Mellon Univ. and a PhD in electrical engineering from Stanford Univ.

Dr. George Hellwarth is a senior engineer at IBM's General Systems Div. in Boca Raton, FL. He is currently involved in advanced development work for sensor based computing systems. Dr. Hellwarth holds a BSE in electrical engineering, an MSE in nuclear engineering and a PhD in electrical engineering, all from the Univ. of Michigan.

Dr. Richard Jaeger is an advisory engineer at IBM's General Systems Div. in Boca Raton, FL. He is also involved in advanced development of sensor based computing systems. Dr. Jaeger holds a BSEE, MEE and PhD in electrical engineering, all from the Univ. of Florida.



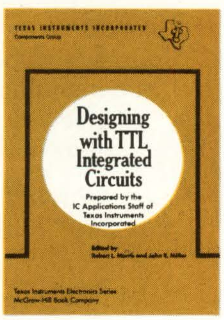
NEW
only $3.95
The TTL Data Book

Complete specifications on industry's broadest IC line –more than 320 MSI and SSI functions.

54/74 Schottky and low-power Schottky; 54/74 high-speed, standard and low-power; Series 29000/29300; beam-lead devices; radiation-tolerant circuits; MACH IV Hi-Rel procurement specification; JAN IC data and cross reference guide.

The brand new TTL integrated circuits Data Book for Design Engineers offers you the most complete, up-to-date and comprehensive design information now available. Contains data sheets for every TI TTL product, including 140 MSI functions, 16 memory functions and more than 100 Schottky-clamped circuits.

The 640-page, hard-bound book is indexed by both type number and function, and includes helpful cross-reference guides and a glossary of terms.



And here's a valuable design companion to the new data book.

"Designing with TTL Integrated Circuits" covers a full range of digital system applications, as well as design philosophy, economics, basic descriptions and electrical characteristics. Comprehensive and practical, it is written for electronics engineers, computer designers, systems analysts and managers who want information on the best use of these devices. Written by TI's application staff, published by McGraw-Hill. 384 pages. **$18.50.**

TO:
Texas Instruments Incorporated
P. O. Box 3640, M/S 84 Dallas, Texas 75221

☐ The TTL Data Book. $3.95 ☐ Designing with TTL Integrated Circuits. $18.50

Enclose check or money order. Books sent postage paid in U.S.

NAME ____________________

ADDRESS ____________________

CITY ____________________

STATE ____________ ZIP ____________

EDN

TEXAS INSTRUMENTS
INCORPORATED

CHECK NO. 86

87235

For real reliability in rolled capacitors, buy EXPERIENCE.

The real measure of rolled capacitor reliability ultimately comes down to one critical, controlling factor: the capacitor manufacturer's experience. *And you can measure El-Menco's rolled capacitor experience in the hundreds of millions.* El-Menco's experience in design — in improved testing and manufacturing techniques — in better quality and reliability through closer control of purchased materials and manufacturing methods — all combine to give you, the customer, experience in failure-free equipment in the field.

Why settle for less than the priceless assurance of continuous, trouble-free operation?

A glance at some of the El-Menco rolled types, shown here actual size, tells you the space these compact capacitor packages can save. They are available in several dielectrics, in capacitance ranges from .001 to 1.0 mF, in voltage ratings from 50 to 2000 V, with axial or radial leads, and in operating temperatures as low as −55°C and as high as +125°C.

Write for comprehensive engineering data

El-Menco Rolled Capacitor Types:

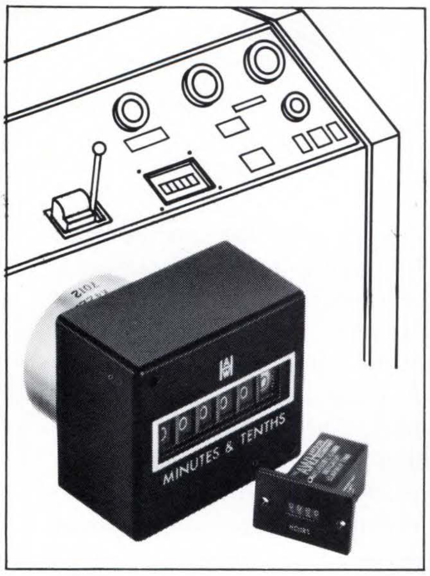
- Mylar-paper, dipped (Type MPD)
- Mylar, dipped, epoxy (Type MDE)
- Mylar, dipped, epoxy, flat (Type MDEF)
- Mylar-paper, ceramic tube, epoxy end fill (Type MPCE)
- Paper, ceramic tube, epoxy end fill (Type PCE)
- Mylar, impregnated, dipped (Type MDR)
- Mylar, Mylar wrap, round (Type MWR)
- Mylar, Mylar wrap, flat (Type MWF)
- Polypropylene, dipped (Type PPD)

El-Menco

THE ELECTRO MOTIVE MFG. CO., INC.
Willimantic, Conn. 06226
West Coast: Collins and Hyde Co.
Nationwide: Arco Electronic Distributors

CHECK NO. 39

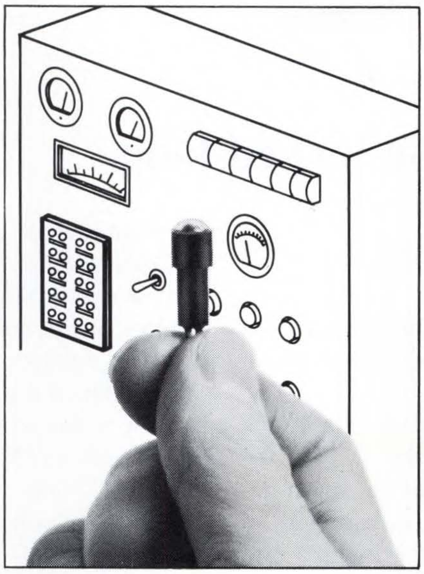
Compact design ideas for monitoring things.



TIME-BILLING MAINTENANCE

You can keep track of a lot of hours, minutes or seconds utilizing very little space with The A.W. Haydon Company's Elapsed Time Indicators. Choose from 21 standard size low-cost models or from a wide range of smaller units down to microminiature devices measuring only 37/64" square. Accurate digital readout is assured by precision Geneva gearing. These indicators operate from a wide range of power sources, both AC and DC, and are available in many mounting configurations. When you must monitor time for billing purposes, or maintenance programs such as lubrication, overhaul or recalibration, our indicators will do the job using a minimum amount of space. Write for complete technical information.

CHECK NO. 28

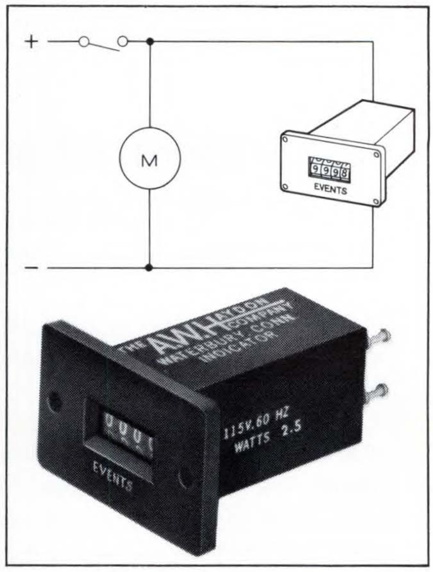


FAULT ISOLATION

These microminiature Fault Indicators not only signal a malfunction, but they "remember" that it happened, too. The electrically actuated display latches magnetically until reset. This "latch memory" assures positive isolation and indication of both transient and continuous malfunctions. The The A. W. Haydon Company's BITE (Built-In-Test-Equipment) Indicators are low power devices that operate on pulses of milliseconds duration and can be mounted directly on PC boards or grouped on remote panels. Their cost is unusually low for the function they perform.

You can design these BITE Indicators into your circuitry, or let our engineers design a complete fault isolation system for you. Write for literature, today.

CHECK NO. 29



EVENTS-BILLING MAINTENANCE

If monitoring how many times anything has happened is a big problem, you don't need a big counter to solve it. This Events Counter, illustrated, is only 37/64" square x 1.250" deep. Yet, small as it is, it provides a 4-digit readout of up to 9999 events before recycling. Non-resettable, it is ideal for both billing and preventive maintenance programs because it is tamper-proof and provides a fast (1,200 cpm) accurate count of everything that has happened. It requires minimum power, too — only 2.5 watts max. at 115 VAC 60Hz. If you need high speed totalizing for data processing equipment, business machines, vending machines or production line machinery and operations find out about these miniature Events Counters. Write for literature.

CHECK NO. 30

A.W. HAYDON CO. PRODUCTS

NORTH AMERICAN PHILIPS CONTROLS CORP.

A NORTH AMERICAN PHILIPS COMPANY
Cheshire, Conn. 06410 • (203) 272-0301

A synchronized phase locked loop

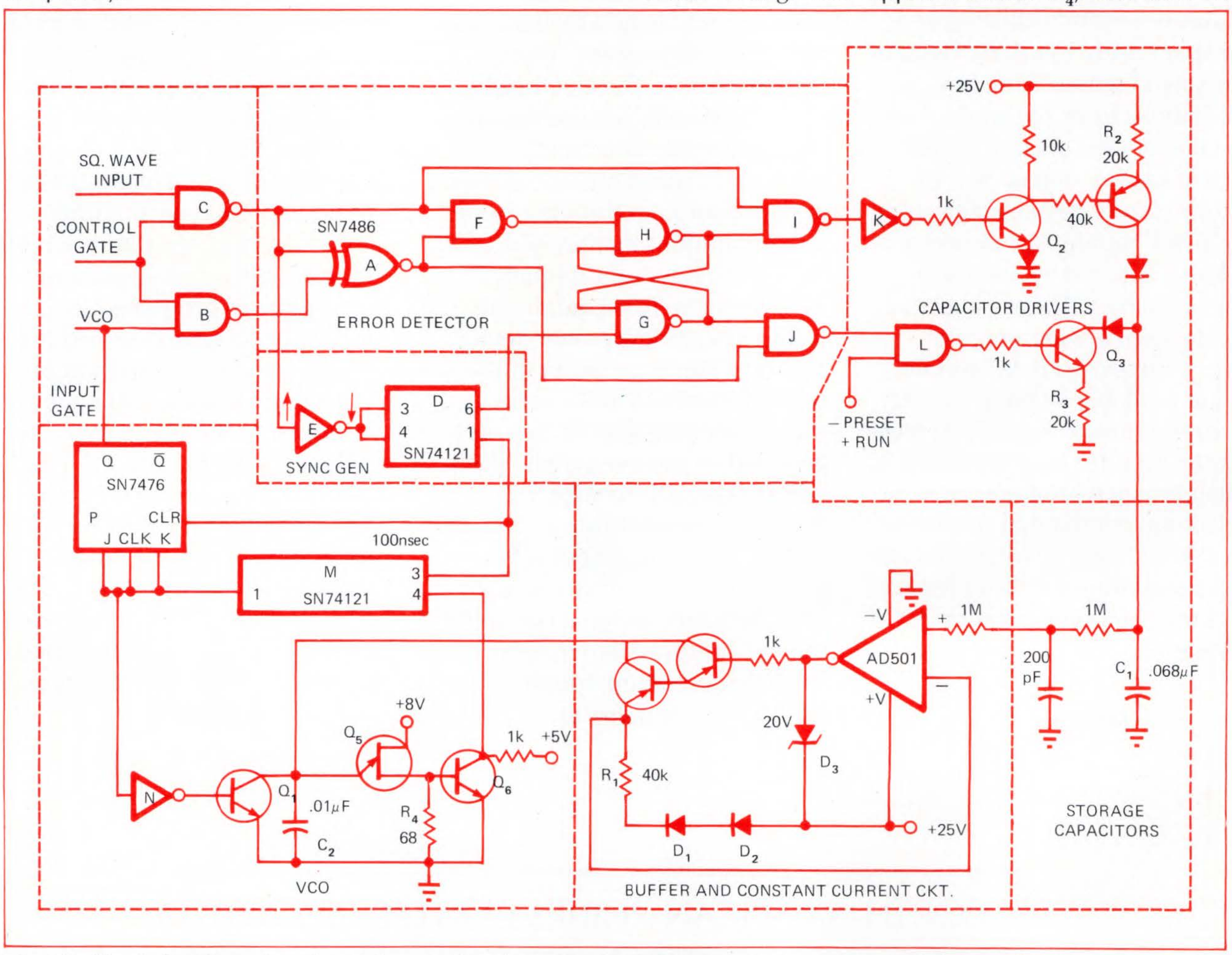
Robert Bohlken
Honeywell Inc., Hopkins, MN

A problem that exists in measuring the frequency of short-signal bursts is the long acquisition time of phase locked loops.

A short time from signal acquisition to phase lock was obtained by synchronization of the VCO to the input phase. This allows correction pulses to be developed in the correct polarity only. Lockup times of less than 10 cycles of input are achieved with a 1 to 10 kHz using an idling frequency of 12 kHz for the VCO (PRESET). A high idle frequency is used because it is easier to slow the VCO from a high to low frequency.

Input signals are compared to the synchronized VCO at exclusive-OR A, gating of the error pulses by gate F and flip-flop G-H allows I or J to drive current pulses of the correct polarity into storage capacitor C_1. The voltage correction on C_1 is proportional to the width of the error pulses and can be controlled by the value of R_2 and R_3. The voltage on C_1 is buffered with a FET input op amp, AD501, which drives the VCO with a constant current inversely proportional to C_1 voltage. When the control gate is turned OFF, Q_3 and Q_4 are turned OFF allowing the VCO to run at lockup frequency which is equal to input frequency.

The VCO in provided with a fast discharge time. When voltage first appears across R_4, one-shot M



Phase locking in less than 10 cycles of the input is achieved by idling a high frequency and "pulling down" the VCO, rather than the more common approach of idling at mid range.

turns on Q_1 which dumps C_2 much faster than Q_5 could. The sawtooth of the VCO is synchronized by use of pulses derived from the positive edge of the input, into the OR gate of one-shot M. The output of M is also fed into J-K flip-flop P which is synchronized into the proper state. The output of P is at VCO frequency which can be fed into a counter, or the analog voltage on C_1 can be ultilized. Range of frequency can be changed by varying R_1. D_1, D_2 and D_3 provide limiting VCO voltage. □

To Vote For This Circuit Check 160

True RMS measurements using IC multipliers

Karl Huehne and **Don Aldridge**
Motorola Semiconductor Products Div. Phoenix, AZ

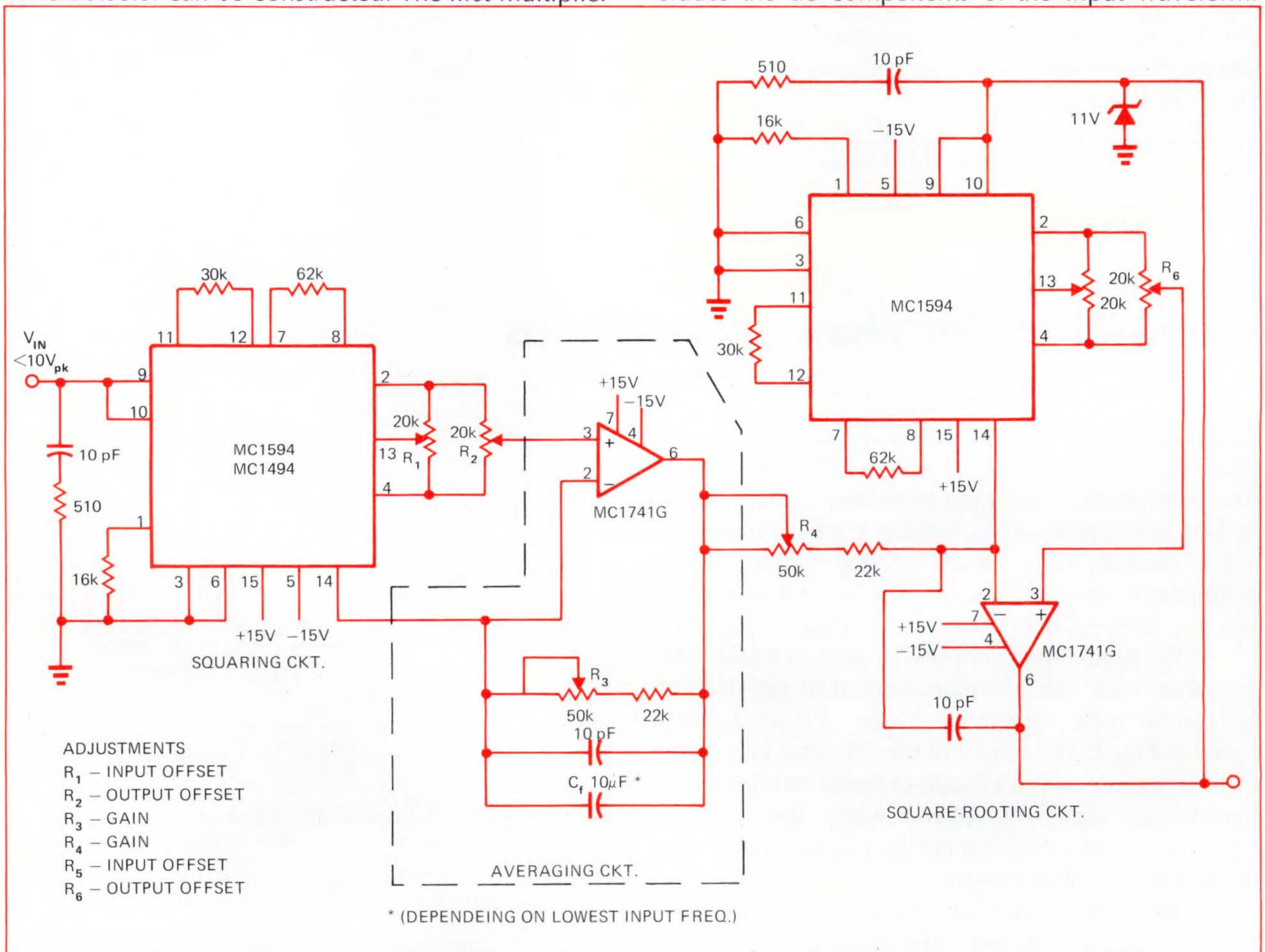
Mathematically, the RMS value of a function is obtained by squaring the function, averaging it over a time period T and then taking the square root:

$$V_{RMS} = \sqrt{\frac{1}{T}\int_o^t V^2 dt}$$

In a practical sense this same technique can also be used to find the RMS value of a waveform. Using two MC1594 multipliers and a pair of op amps, an RMS detector can be constructed. The first multiplier is used to square the input waveform. Since the output of the multiplier is a current, an op amp is customarily used to convert this output to a voltage. The same op amp may also be used to perform the averaging function by placing a capacitor in the feedback path. The second op amp is used with a multiplier as the feedback element to produce the square root configuration.

This method eliminates the thermal-response time that is prevalent in most RMS measuring circuits.

The input-voltage range for this circuit is from 2 to 10V pk. For other ranges, input scaling can be used. Since the input is dc coupled, the output voltage includes the dc components of the input waveform.



This RMS circuit follows math procedures of squaring instantaneous input values, averaging over time and taking the square root.

The maximum frequency for a sine-wave input is about 600 kHz and the accuracy over the input voltage range is about 1 to 2%. The overall calculation of the output voltage is

$$V_o = \sqrt{\frac{1}{RC}\int_o^t V_{IN}^2\, dt}$$

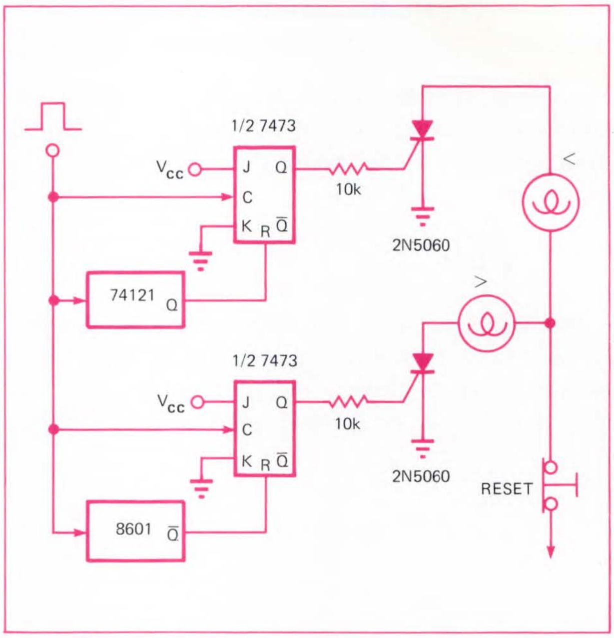
where $R = R_3 + 22\ k\Omega$

$C = C_f + 10\ pF$ □

To Vote For This Circuit Check 161

Three ICs monitor pulse width

Joseph Kish, Jr.
Diebold, Inc., Canton, OH



Very often in pulse circuits, it is necessary to monitor pulse width in terms of "greater than" but "less than" given specified values. The circuit described here measures both limits constantly, and a fault indication will latch until manually reset.

The 74121 is set to coincide with the minimum pulse width spec. Should the pulse under observation fall to ground before the one-shot recovers, the J-K is clocked and the "less than" SCR is triggered.

The 8601 is set to coincide with the maximum pulse width spec. Should the pulse under observation fall to ground after the one-shot recovers, the second half of the J-K is clocked and the "greater than" SCR is triggered. □

To Vote For This Circuit Check 162

Phase-shifter for phase locked loops

J. S. Krikorian, Jr.
Warwick, RI

Phase locked loops can be utilized as synchronous AM demodulators or tone detectors. Other phase locked loop applications require a measurement of signal strength or a means of determining signal acquisition. The quadrature detector illustrated in **Fig. 1** is employed to obtain such signals. Frequently, an RC phase-shift network is used to obtain the 90° phase-shift. An alternate method of phase-shifting can be implemented using logic circuits, as illustrated in **Fig. 2**. The output of this circuit is especially suitable for use with FET gate-chopper multipliers or hard-limiter logic multipliers, while the input is compatible with a VCO that has a square wave output within its voltage limits.

The logic phase-shift circuit uses a flip-flop to divide the frequency by two. The input, f, and the output, f/2, of this flip-flop are fed into an equivalence

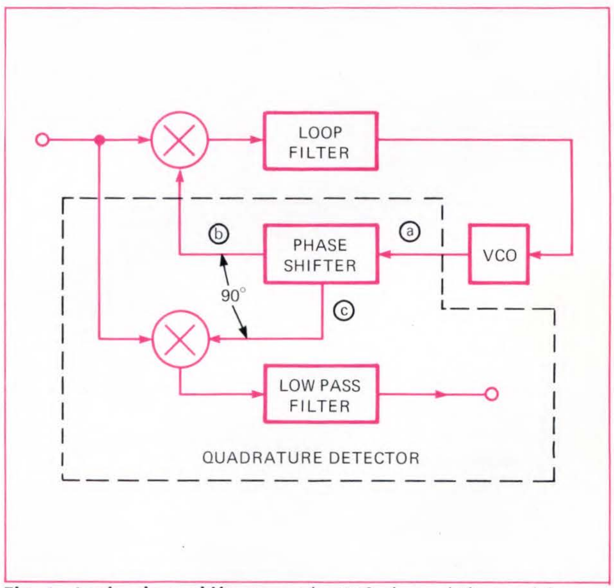


Fig. 1—Logic phase-shifter provides 90° phase-shift signal for use by the quadrature detector.

logic circuit to obtain a square wave, f/2-90°, that is shifted in phase by 90° with respect to the output, f/2, of the flip-flop. An exclusive-OR in place of the equivalence logic circuit would also provide a 90° phase-shift. To compensate for the frequency division by two, the VCO center frequency has to be doubled.

Because of its insensitivity to frequency changes, this circuit is useful for wideband phase locked loop applications. High-frequency accuracy is dependent on the speed of logic circuitry used in the implementation. Along with the associated circuitry for the quadrature detector, the logic phase-shifter can be incorporated into a self contained phase locked loop IC package. □

To Vote For This Circuit
Check 163

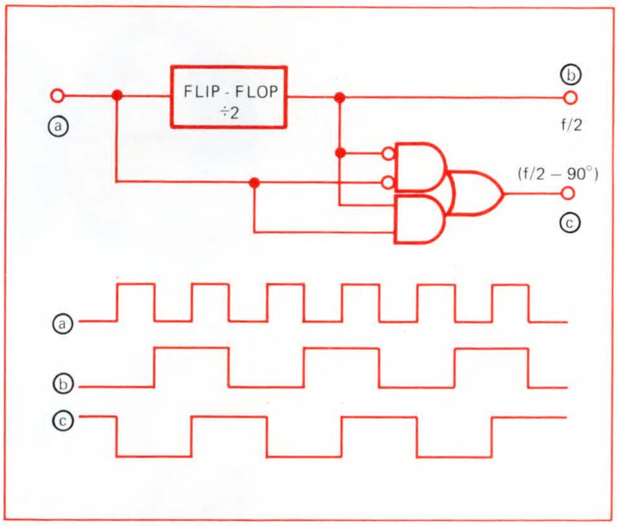


Fig. 2—Details of logic phase-shifter showing flip-flop, equivalence circuit and associated signals.

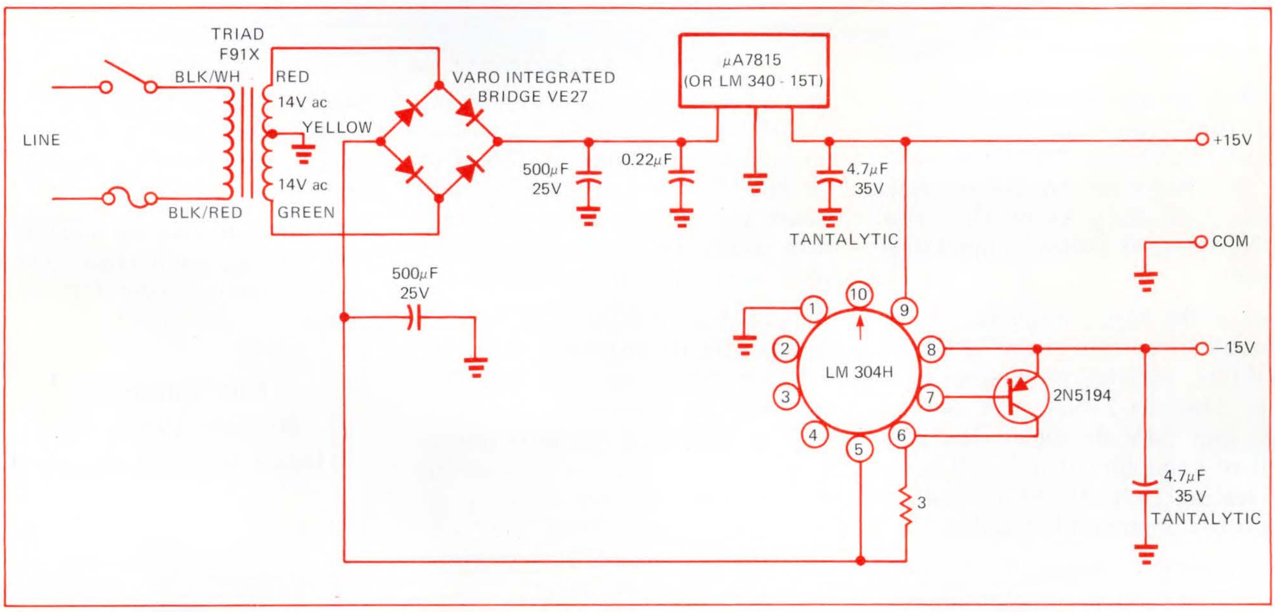
Simple ±15V regulated supply provides tracking

Hank Olson
Stanford Research Inst., Menlo Park, CA

A simple ±15V regulated supply which provides tracking can be built using only four semiconductor packages. The output current capability as shown is 100 mA, but this can easily be increased to about 200 mA using a larger rectifier-filter section.

The μA7815 is a positive, fixed output regulator with built-in current limiting at about 230 mA. It would seem a simple task to use two of these power ICs to obtain ±15V, but this requires two isolated transformer windings. The circuit shown uses only one center tapped transformer winding and an integrated bridge (as two full-wave rectifiers). By using the National LM304 and an outboard current-carrying PNP, and the +15V from the μA7815 as an external reference, a simple −15V companion regulator is obtained. The LM304 does not even require compensation, as do most IC regulators. Depending on the application and construction methods, the 0.22 μF and two 4.7 μF capacitors may not be needed. □

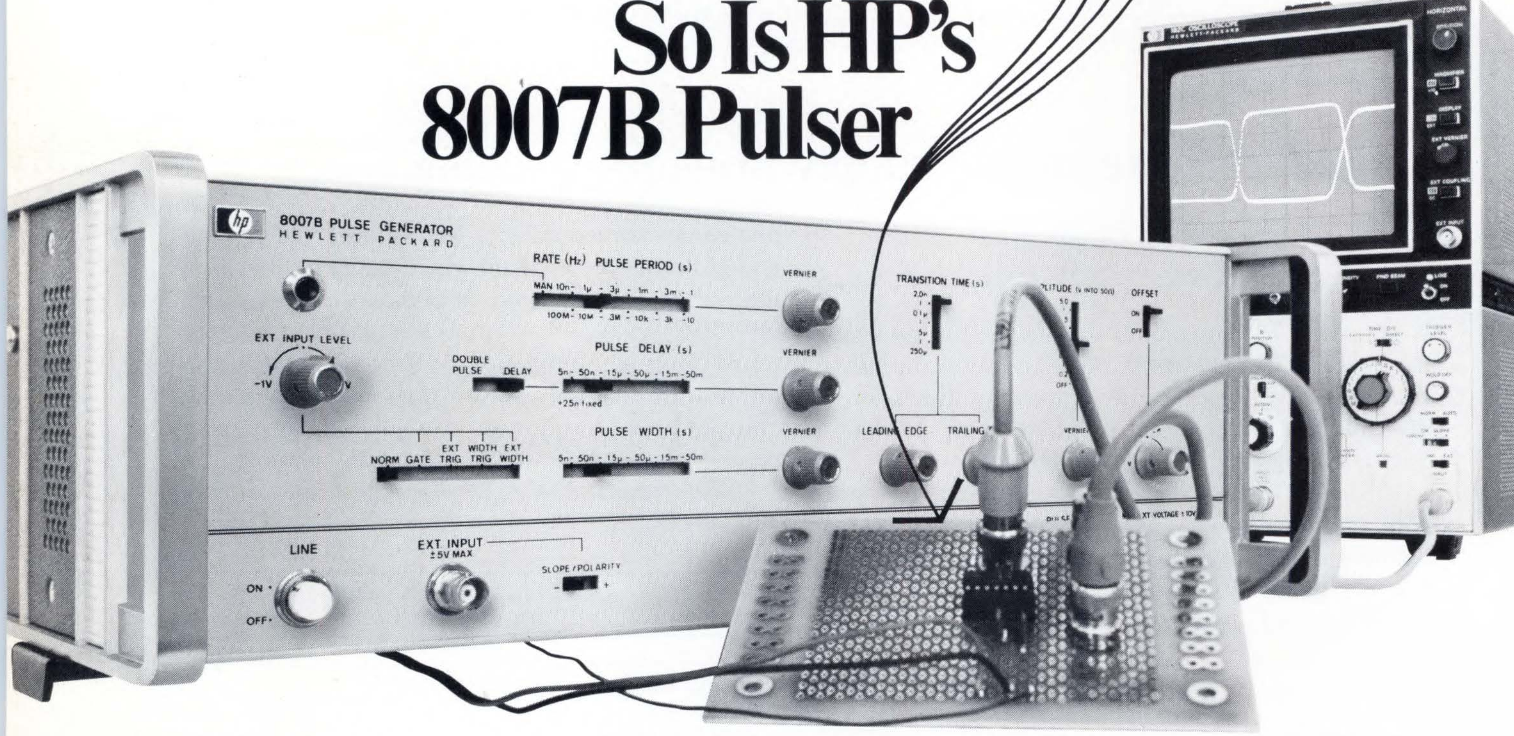
To Vote For This Circuit
Check 164



Tracking 100 mA regulator provides ± 15V and can be boosted to 200 mA output by using a larger rectifier section.

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. 83

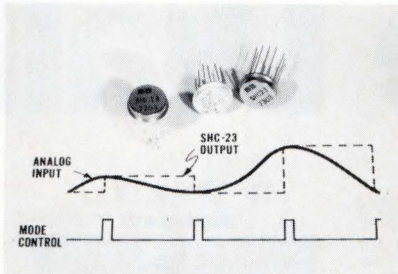
Low-cost adjustable TO-8 S/H amplifier is versatile

PROGRESS IN PACKAGED CIRCUITS

Designed for applications requiring a broad range of acquisition times, Burr-Brown's new SHC23 sample-and-hold (S/H) amplifier in a hermetically sealed TO-8 can have its acquisition time adjusted from as low as 25 μsec with the selection of an appropriate external storage capacitor.

A 0.005-μF storage capacitor provides the 25-μsec acquisition time (to 0.01%) while a 1-μsec storage capacitor allows the user to hold the output for more than 15 minutes with less than 1% error.

Costing only $31 (100-up quantities) and $45 in single quantities, the SHC23 amplifier offers an accuracy spec that is surprising for a device in its price class: maximum total dynamic nonlinearity from input to output is ±0.01% for a 20V step. This is the total nonadjustable error.



A 25-μsec acquisition time (to 0.01%) is available from a new $45 TO-8 S/H amplifier, and is set by the addition of an external capacitor.

Droop rate is 20 μV/msec max., and throughput nonlinearity is 1 mV. Other characteristics include an 80-kHz, 3-dB bandwidth, a 20-kHz full-power bandwidth and output slew rate of 1V/μsec. The maximum aperture time is specified as 50 nsec. Noise is 100 μV rms max., and unity gain error is ±0.01% max.

Input voltage range of the SHC23 is ±10V at 100 MΩ minimum input impedance. Bias current is 30 nA. The output is ±10V at 5 mA. The unit is TTL/DTL input compatible and operates over 0°C to +70°C from ±15V dc at 30 mA. A military version that operates over the temperature range of −55°C to +125°C is also available (Model SHC23ET) at a slightly higher cost.

Needless to say, the quality of the external capacitor to be used should be high, preferably of teflon or polystyrene, since it controls the length of acquisition time and effects droop and charge offset.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706. Phone(602) 294-1431 **165**

Dc-to-dc converter family features triple outputs and low-thermal impedance

PROGRESS IN CIRCUIT MODULES

Aimed specifically at the commercial and industrial markets, the 1000 Series dc-to-dc converters offer the user a choice of single, dual or triple outputs. All three versions of the new series—namely, 1, 3 and 6W—are available with single or dual outputs, while the 3 and 6W versions can be had with single, dual or triple outputs.

Stock units are available with input voltages of 5, 6, 12, 24, 28 and 48V dc, with other input voltages available on request. Output voltages available are 3.6 to 24V dc for single-output units, 10 to 24V dc for dual-output units and either 5V dc and ±15V dc or 5V dc and ±12V dc for the triple-output units.

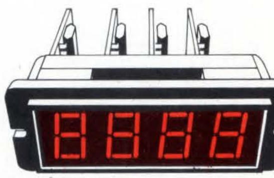
All units are fully encapsulated and have 0.1% max. line regulation, 0.3% load regulation and typical temperature regulation of 0.007% per °C. Short-circuit and overload protection is incorporated, and the converters are reverse-polarity protected to 100V dc, except for the 5 and 6V input models.

Dialight sees a need:

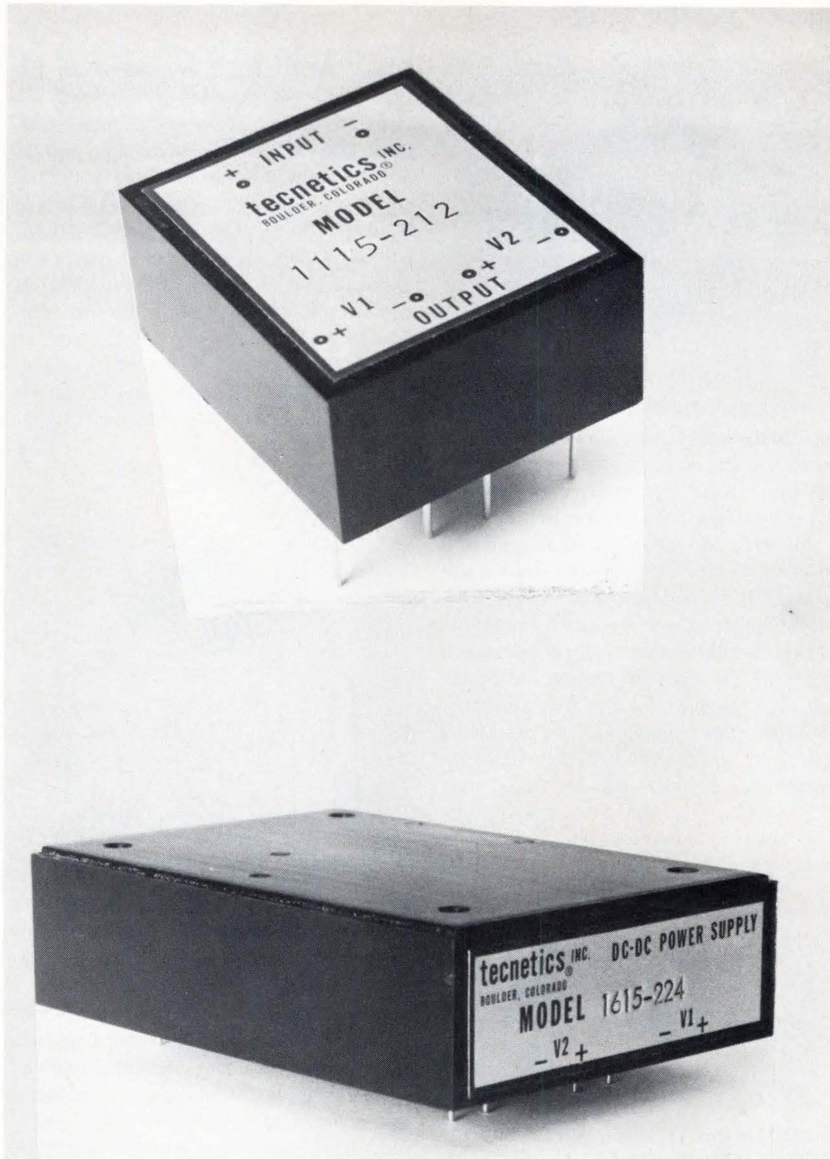
(**Need:** A large 5/8″ high LED readout at a low $4.95* price.)

See Dialight.

Each digit in this bezel assembly contains a Dialight light-emitting diode, decoder/driver, and resistor network that produces a bright, highly visible readout that can be easily installed in a panel. The readout display is supplied with discrete gallium phosphide or gallium arsenide phosphide diodes arranged in a seven-segment format. These generate a bright, highly legible red character (0.625 inch



high—the largest size character in the industry) with the lowest power consumption for a character of this size. Ideal for mounting on a control panel, or in a digital clock, meter, credit-card verifier, TV channel indicator, or hospital room status-board indicator. The contrast ratio between the illuminated and non-illuminated segments is further enhanced by a one-piece red nonglare window.

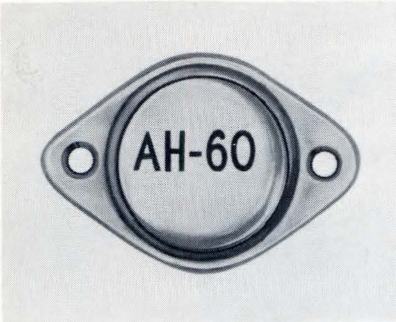


Mechanical ruggedness and electrical protection features allow the Series 1000 converters to be serviced by inexperienced personnel. The top converter shown dissipates 1W and the bottom 6W.

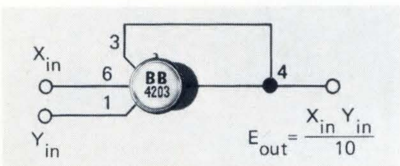
A unique packaging concept is used with the Series 1000. The converters are built around an integral heat sink, with all heat-producing components, such as pass transistors and inverter transistors, bonded to the heat sink. This keeps thermal impedance to a minimum within the converters. However, if external heat sinking is needed, the mounting plate offers an easy way to accomplish it. On the 3 and 6W models, the heat sink can also be used as a mounting plate. All of the 1000 Series converters may also be mounted directly to a printed circuit board by means of pc pin terminals. On 3 and 6W units, there are inserts which allow the converters to be bolted to either a heat sink or a pc board. This assures a rigid mount in high shock and vibration applications.

Delivery of most of the 1000 Series modules is from stock. Maximum delivery is four weeks after receipt of the order. Prices are: 1W units with single output $44, dual output $49; 3W units with single output $69, dual output $79 and triple output $89; 6W units with single output $79, dual output $89 and triple output $99.

Tecnetics, P.O. Box 910, Boulder Industrial Park, Boulder, CO 80302. Phone(303)442-3837. **166**

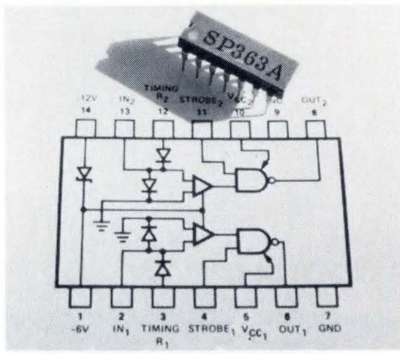


AMPLIFIER PROVIDES OUTPUT POWER OF +20 dBm. Optimax Model AH-60 modular amplifier, is designed for direct insertion into microstrip circuitry and comes in a TO-3 package. Operating frequency is 5-300 MHz and it has a nominal gain of 9 dB at +24V dc. The amplifier has a noise figure of 8 dB and an impedance of 50Ω. The amplifier presents economies of time and cost to the design engineer because it eliminates the need for customized design and development of a comparable amplifier. The plug-in model may be used for a variety of applications including: ECM receivers, RF amplifiers and test equipment. $75 in quantities from 1-9. Optimax Inc., P.O. Box 105, Advance Lane, Colmar, PA 18915. Phone(215)822-1311. **170**



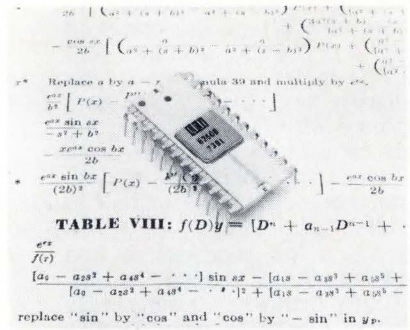
IC MULTIPLIER/DIVIDER NEEDS NO EXTERNAL COMPONENTS. Model 4203, hermetically sealed and internally laser trimmed in a TO-100 package, delivers a guaranteed accuracy of 1% (4203K). In addition to division and 4-quadrant multiplication, square-rooting may also be performed. The 4203 has a 1-MHz bandwidth and a slew rate of 25V/μsec. Unit prices in 1-24 quantities are as follows: 4203J, 2% accuracy, $29; 4203K, 1% accuracy, $39; 4203S, 1% accuracy, Mil temperature, $51; and 4203SQ, 1% accuracy, Mil temperature with Mil-Std 883 screening, $63. Small quantity delivery is from stock. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706. Phone (602)294-1431. **171**

SIX CMOS ICs JOIN LINEUP. The SCL standard 4000A CMOS logic series has been expanded to include a decade counter/7-segment decoder with display enable (SCL 4026A, $4.71 in 1k quantities), a decade counter/7-segment decoder with ripple blanking (SCL 4033A, $4.65 in 1k quantities) and a quad clocked latch (SCL 4042A, $2.70 in 1k quantities). In the CMOS SCL 4400A series, a pair of new devices are offered. A decade counter/7-segment decoder with display enable and bipolar outputs (SCL 4426A) and a decade counter/7-segment decoder with ripple blanking and bipolar outputs (SCL 4433A) will be available at a price of $5.65 each in 1k quantities. A CMOS 256-bit RAM organized 64 words × 4 bits is the new addition to the company's CMOS LSI product line. SCL 5555D costs $19.40 in 1k quantities. Solid State Scientific, 1405 Locust St., Philadelphia, PA 19102. Phone(215)735-3535. **172**

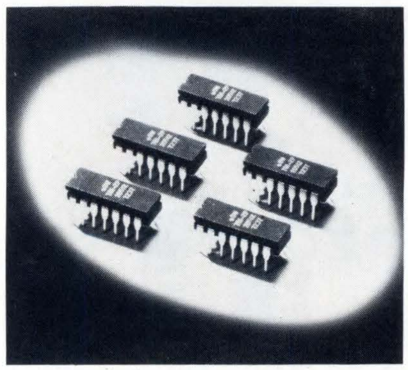


DUAL ZERO-CROSSING DETECTOR IS VERSATILE INTERFACE CIRCUIT. The Model 363 can also be used as a high-stability one-shot, a bidirectional one-shot, a frequency doubler, a stable low-frequency oscillator, a linear amplifier and a frequency-to-voltage converter. The input amplifier is referenced to 0V and employs temperature compensation to ensure stable thresholds. Low-level analog waveforms may be converted to digital signals as long as they exceed ±30 mV, the input uncertainty region. Packaged in a plastic DIP, single units sell for $2.15. Signetics Inc., 811 E. Arques Ave., Sunnyvale, CA 94086. Phone(408) 739-7700.

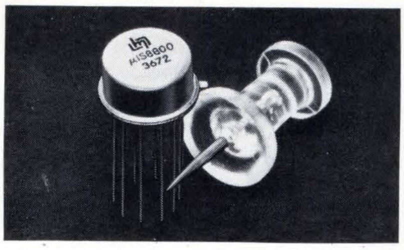
2k-BIT SHIFT REGISTER HAS 10-MHZ RATE. This multiplexed dynamic shift register, HDSR 2048, utilizes ion implantation to minimize gate overlap capacity and achieve its high-shifting rate. The device is structured as a dual 1024-bit shift register and is also available as a single 1024-bit (HDSR 1024), a dual 512-bit (HDSR 1025) and a quad 256-bit (HDSR 1026). Inputs can be directly driven by MOS, TTL, or DTL ICs. Both bipolar and MOS circuits can be driven to the output stages. Power dissipation is typically 300 mW at 25°C for 10 MHz operation with 50% duty cycle clocks per 1024 bits. HDSR 2048 is priced at $36 in quantities of 100. Hughes Aircraft Co., P.O. Box 90515, Los Angeles, CA 90009. Phone(213)670-1515. **173**



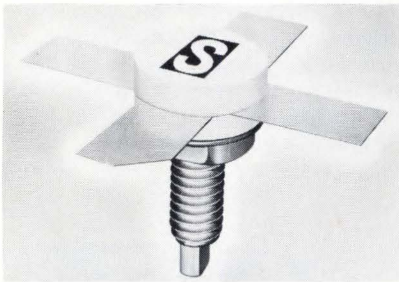
9k BIPOLAR ROM PROVIDES HIGH-DENSITY STORAGE. The MM5260/6260 is organized as 1024 × 9, offers 120 nsec access time and dissipates 50 μW/bit. It may be ordered as a 7 × 9 font character generator and is DTL/TTL compatible with 1/10 of standard TTL input load. Three enable inputs are provided to permit memory expansion. The ROM has open collector outputs and operates from 0° to +75°C (MM6260) or −55° to +125°C (MM5260). The 9k ROM is packaged in a 24-pin ceramic DIP, as is the 8k ROM announced earlier. Delivery is from distributor stock. Pricing for the MM6260 is $65 in lots of 100. Monolithic Memories, Inc., 1165 E. Arques Ave., Sunnyvale, CA 94086. Phone(408) 739-3535. **174**



IC FOR AUTO TACH DRIVER. The SW-781 is a special-purpose monostable multivibrator with high-input threshold. This makes possible its use in electrically noisy automotive environments; and the units extremely stable pulse output allows it to maintain accuracy over automotive temperature ranges and over wide battery voltage ranges. In a typical tachometer application, trigger pulses are tapped off the distributor using 2 discrete resistors and a capacitor. The SW-781 converts each input trigger to a pulse of closely controlled width and amplitude. These output pulses are applied to a conventional dc meter movement through a discrete resistor. Stewart-Warner Microcircuits, 730 E. Evelyn Ave., Sunnyvale, CA 94086. Phone(213)370-8551. **175**

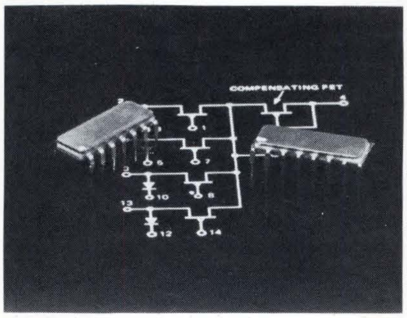


DUAL-VOLTAGE TRANSLATORS SPEED INTERFACE CHORES. The μIS7800 is rated for −55°C to +125°C; the μIS8800 operates from 0°C to 70°C. Both units are electrically identical and offer a 31V maximum output swing with normal power dissipation of 1mW. Operation is from a standard 5V supply and the dual-channel translators are compatible with all MOS devices. Typical applications for the series include analog switching from DTL or TTL logic levels and bipolar-to-MOS shift register and memory interfacing. They are available in a 10-pin, TO-100 package. The 100 lot prices are $9 and $6 each. Integrated Microsystems, Inc., 16845 Hicks Rd., Los Gatos, CA 95050. Phone(408)268-2410. **176**

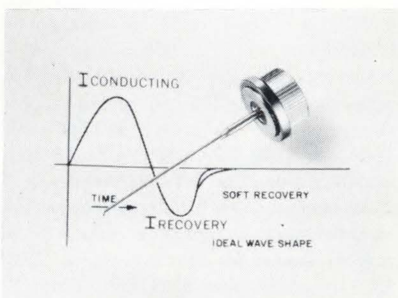


RF POWER TRANSISTOR FAMILY. The 2N6080, 2N6081, 2N6082, 2N6083, and 2N6084 devices provide 4, 15, 25, 30 and 40W respectively at 12.5V, 150 to 175 MHz. Designed specifically for VHF mobile and marine transmitter applications, this series is available in MT-72 stripline packages. Solitron/Microwave also offers the same capabilities in a variety of RF packages for ultimate design flexibility. The units are priced at $8 each in quantities of 1-99. Solitron/Microwave, Solid State Products Div., 1440 W. Indiantown Rd., Jupiter, FL 33458. Phone(305)764-8311. **177**

HIGH-VOLTAGE COMPLEMENTARY SILICON TRANSISTORS drive gas-discharge displays. A line of high-voltage, NPN and PNP transistors—designated DTN and DTP 203, -04, -05 and -06, in plastic TO-106 packages are intended for use as gas-discharge display anode and cathode drivers. They are now in volume production and are being supplied to calculator and DPM manufacturers. Continuous collector current is rated at 50 mA, with a gain of 40 or greater at 10 mA. Voltage ratings are 200V for the DTN/DTP 203, to 125V for the DTN/DTP 206. Prices are 34 to 52¢ in 1-99 quantities; 17 to 25¢ in 10,000 quantities. Dionics Inc., 65 Rushmore St., Westbury, NY 11590. Phone(516)997-7474. **178**

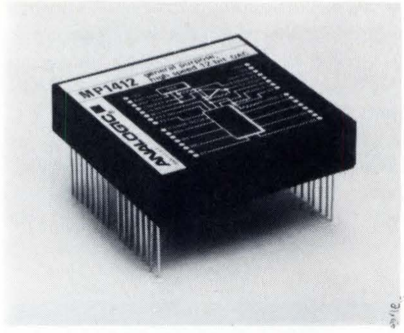


FET ANALOG GATES FOR $1 PER SWITCH POINT. The 1H5009 Series feature ON-resistance of less than 150Ω. The ON-resistances are matched within as close as 5Ω for critical applications, and the units include an extra FET for temperature compensation of the feedback resistance. These gates can be driven directly from TTI or HNIL logic. IH5009 series gates are intended for shunt or summing point switching of signals up to ±15V, or series switching of signals under 200 mV. All types are available in industrial as well as military versions, and sell in 100-piece quantities for approximately $1 per switch point. Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. Phone(617)491-1670. **179**

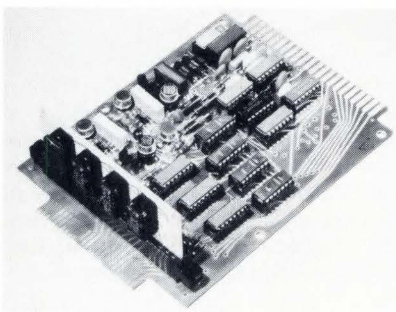


EPITAXIAL POWER DIODES FEATURE LOW NOISE AND FAST RECOVERY. Maximum recovery time of the S6453 Series is 200 nsec with a soft-recovery curve. Rated at 10A, with an IFSM of 150 and an I²t of 135, they are available in PIV ratings of 25, 50, 75 and 100V. The units are housed in DO21 hermetically sealed cases, 11/32 in. high × 5/8 in. diameter. Sarkes Tarzian, Inc., Semiconductor Div., 415 N. College Ave., Bloomington, IN 47401. Phone(812) ED2-1435. **180**

CIRCUITS



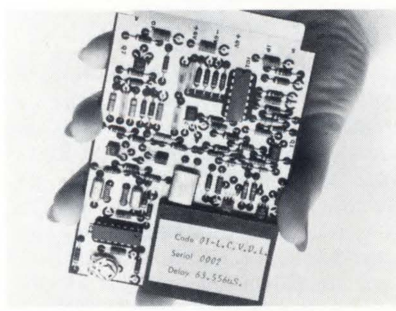
LOW-COST 12-BIT $39 D/A CONVERTER Model MP1412 features settling times (1/2 LSB) of 5 μsec, 0.012% linearity and relative accuracy and a temperature coefficient of 15 ppm/°C. The price of $39 each is in quantities of 100. The MP1412 with MSI components has an MTBF of 500,000 hours. An internal precision reference supply, ladder network and output amplifier are included. The MP1412 is packaged in a 2 × 2 × 0.4-in. MODUPAC encapsulated case and is designed to operate over the 0°C to +70°C range. Analogic Corp., Audubon Rd., Wakefield, MA 01880. Phone(617) 246-0300. **181**



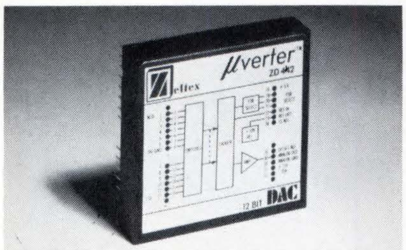
A/D CONVERTER Model IAD 32000-00 is a 3-1/2-digit precision unit on a standard 4-1/2 × 6-1/2-in. card. The accuracy of the converter is within 0.05% of the reading ±1 count. The display (0.6 or 0.25-in. LEDs) plugs directly into the card or can be positioned remotely using 3M Scotchflex cable. The card can be mounted in a card cage or as part of a module. The unit provides BCD, 7-segment and reset outputs, conversion-on-process, print-command, overrange and polarity signals for data processing. $210. QCI, Inc., 2908 Scott Blvd., Santa Clara, CA 95050. Phone(418)247-2345. **182**

LED ARRAY for continuous line and bar-graph applications. The ARL-18 is a common-cathode, 8-diode array with 75-mil lead spacing and 100-mil centers between lights. Any number of arrays can be placed end-to-end to provide a continuous line of light sources. The output of each diode is 100 ft L. An 8-diode array requires only 16 mW of power per diode. It is used for indicating status on pc boards since it only stands 0.105-in. high and directs its light parallel to the board. Available at $5.10 (100-999) or $3.95 (1000 units). Litronix, Inc., 1900 Homestead Rd., Cupertino, CA 95014. Phone(408)257-7910. **183**

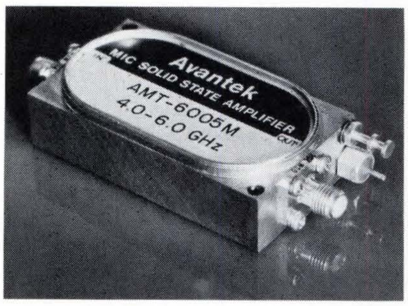
LOW-PROFILE POWER SUPPLY Model 108 is a regulated dc supply which utilizes high-efficiency switching techniques to provide 6 to 12V dc of adjustable output at 3A. Input is 115V ac, 50 to 70 Hz. 230V ac units are available. The unit is only 1.72 × 3.5 × 7.9 in. and features continuous short-circuit and overload as well as crowbar over-voltage protection, factory set at 14V. Regulation is ±1 mV for a ±10% change in input line voltage, and 2 mV max. for a zero-to-full-load change. Ripple is 2 mV p-p max. From $99 down to $85 at the 100-piece level. RO Associates, Inc., 3705 Haven Ave., Menlo Park, CA 94025. Phone(415)322-5321. **184**



COMPACT VIDEO DELAY MODULES for drop-out compensation or image-enhancement applications, range in price from $250 for 1 module to $150 each in quantities of 1000 or more. Because the modules, which use glass delay lines, are provided complete with interfacing electronics, they fit easily into video recorder designs. Inputs and outputs are both at video frequencies. Specifications are time delay of 63.5 μsec nominal, a 3-dB bandwidth of 4.5 MHz min., a signal-to-noise ratio of 55-dB p-p/rms and differential phase of less than 2.5°. Time delays can be provided from 60 to 64 μsec ±25 nsec. Corning Glass Works, 3900 Electronics Dr., Raleigh, NC 27602. Phone (919)828-0511. **185**

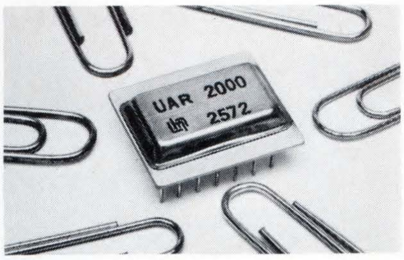


FAST-SETTLING 12-BIT D/A CONVERTER. Model ZD442 features a 5-μsec settling time, 0.05% (0.002%/°C) scaling error, zero offset error and 0.01% (0.002%/°C) linearity. Input coding is offset binary or unipolar binary and the output code can be selected from 0 to +10V or ±5V. All digital inputs are DTL/TTL compatible. Packaged in a standard Zeltex Microverter case (patent pending), the unit includes a built-in reference. $65. Zeltex, Inc., 1000 Chalomar Rd., Concord, CA 94518. Phone (415)686-6660.
186

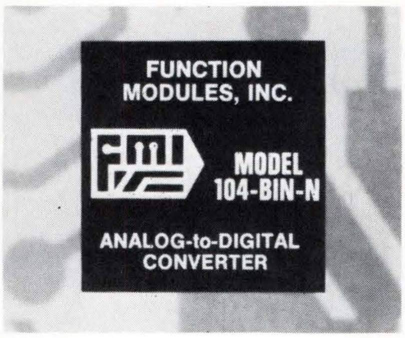


WIDEBAND MIC AMPLIFIER OPERATES TO 6 GHz. The AMT-6005M operates over 4 to 6 GHz. Housed in a minature (2.3 × 1.3 × 0.6 in.) hermetically sealed, stainless-steel case, it features min. gain of 28 dB, max. gain variation of ±1.5 dB, a max. noise figure of 10 dB and max. VSWR of 2.0:1, in and out. Power output for 1-dB gain compression is +10 dBm min. The unit is powered by +15V dc at 150 mA. Price in small quantities is under $4700. Avantek, Inc., 2981 Copper Rd., Santa Clara, CA 95051. Phone (408)739-6170.
187

DIGITAL DELAY MODULES. Designed for precision DTL/TTL timing applications, these modules eliminate the need for external components. A built-in interface allows for direct plug-in without the need for additional components. Modules with total delays from 50 to 250 nsec with 5 equally spaced taps are available from stock. Series 20330 through 20332 units feature 4-nsec risetimes that are independent of delay time. They are available in 16-pin DIP-compatible units. Pulse Engineering Inc., Box 12235, San Diego, CA 92112. Phone (714)279-5900.
188



UNIVERSAL ACTIVE FILTER section Model μAR2000 is a universal active resonator designed for oscillator, timer, active filter and other applications. The μAR2000 operates from ±12 to ±15V supplies and provides an output swing of ±10V from dc to 10 kHz. It contains a state-variable active resonator plus a fourth, uncommitted op amp. When used as a filter, the center or corner frequency is set by the addition of 2 external resistors. A third resistor determines the filter Q. Packaging is in a 16-pin ceramic and metal DIP. The 100-lot price is $12.85. Integrated Microsystems, Inc., 16845 Hicks Rd., Los Gatos, CA 95030. Phone(408)268-2410.
189



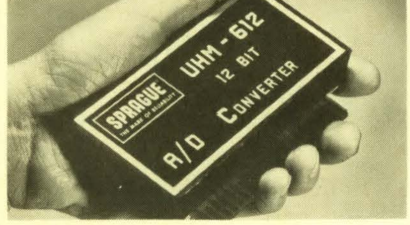
A/D CONVERTER has lowest price, smallest package and a choice of 4 models. The Model 104 family of integrating A/D converters includes converters that are complete units having their own internal reference, but can also operate from an external reference. There is also a choice of 0 to +10V or 0 to −10V inputs and binary or BCD coding. Conversion times is 20 msec for binary coded units and 8 msec for BCD coded units. Packaged in a module that is only 2 × 2 × 0.4 in., each unit costs $59 in 100 quantities. Function Modules, Inc., 2441 Campus Dr., Irvine, CA 92664. Phone (714)833-8314.
190

TRUE-rms-TO-dc-CONVERTER. This unit allows any dc meter to accurately measure true rms. It will increase the sensitivity, frequency response and accuracy of any multimeter or DVM. The unit converts any wave shape to a dc output, has an accuracy of 0.3%, a bandwidth to 500 kHz and its own input ranging amplifier of 1 mV to 150V. The converter is portable, 3 × 4 × 6.5 in., and sells for $198. UFAD Corp., Box 96, Ada, MI 49301. Phone (616)676-9000.
191

CIRCUITS

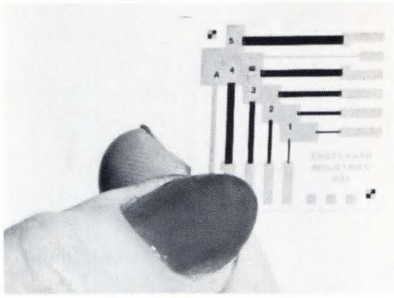
OP AMP WITH EXTENDED VOLTAGE RANGE CAPABILITIES. Model 1034 op amp provides a modular solution to problems requiring a high common-mode voltage range or a high output-power-drive capability. Specifically, the unit features a full ±20V common-mode voltage capability and an output which will deliver a min. of ±20 mA at ±20V. Other specifications include 25-nA bias current, 1-MHz min. bandwidth, 6V/μsec slew rate and 86-dB min. CMRR. The package is low-profile (1.5 × 1.5 × 0.4 in.) module from $30 in 100 quantities. Teledyne Philbrick, Allied Dr. at Rte 128, Dedham, MA 02026. Phone (617)329-1600. **192**

A NEW THERMAL CONNECTOR. Designers and producers of power circuits can now provide their customers with plug-in modules that disconnect thermally as well as electrically with a new thermal connector which provides a quick disconnect between heat-producing components and the heat sink. Power-supply and power-output circuits traditionally have been hard mounted, causing long MTTR (mean time to repair) and complications. Now external case cooling has become considerably more practical, thus simplifying evironmental and EMI sealing. Electro-Module, Inc., 2855 Metropolitan Pl., Pomona, CA 91767. Phone (714)593-3565. **193**



SUCCESSIVE-APPROXIMATION A/D CONVERTERS. Series UHM-600 converter units are available in 2-1/8 × 4 × 3/4-in. epoxy modules that contain internal references, clocks, conversion logic, comparators, switches and nickel-chromium thin-film ladder networks. Input voltage swings of 5, 10 and 20V can be obtained. The digital output is 8, 10 or 12 bits binary, offset binary, or BCD. The rated operating temperature range is 0°C to +70°C or −25°C to +85°C. Sprague Electric Co., Marshall St., N. Adams, MA 01247. Phone (413)664-4411. **194**

CIRCUITS



PRINTED THIN-FILM RESISTORS. The networks are reportedly half the cost of the least-expensive thick-film resistors available. The hybrid-resistor systems are based on the use of organo-metallic compounds. At present, the range of the resistor line is limited. However, the manufacturer is exploring the low-cost marketplace in the electronic field to see if requirements advise broadening this economical line. Engelhard Industries, A Div. of Engelhard Minerals & Chemicals Corp., 231 N J Railroad Ave., Newark, N J 07105. Phone (201)242-2700. **195**

VOLTAGE CONTROLLED AMPLIFIER Model 202 provides a 130-dB linear control range. The modular unit provides a linear voltage-per-decibel gain range from −100 to +30 dB with excellent linearity and unit-to-unit tracking. Input noise is 6 μV, yet peak signal may be as high as 100V. Frequency response is flat to 20 kHz and distortion products do not exceed 0.07%. The unit is packaged in a 1 × 2 × 1/2-in. can with 1/8-in. gold plated pc pins. $47. DBX, Inc., 296 Newton St., Waltham, MA 02154. Phone (617)899-8090. **196**

MODEL SG71 STRAIN-GAGE AMPLIFIER-POWER SUPPLY is both a signal conditioner and a power supply for strain-gage bridge circuits. Each SG71 provides buffered short-circuit proofed dc excitation to a bridge circuit and amplifies the output to a level sufficient to operate most data-gathering systems and tape recorders. Each has 2 outputs. Output A provides ±10V dc from as low as 1 mV/V output from the bridge circuits. Output B provides ±10 mA into 50Ω to operate oscillograph galvanometers. A 15-turn screw-driver control balances the bridge circuit. Validyne Engineering Corp., 19414 Londelius St., Northridge, CA 91324. Phone (212)886-8488. **197**

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)

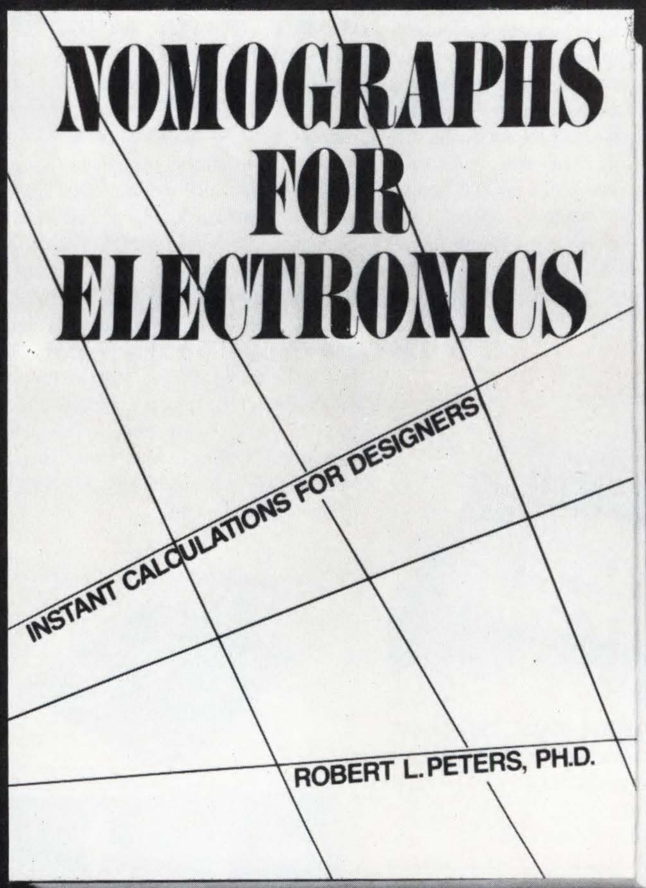


Table of Contents:

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)

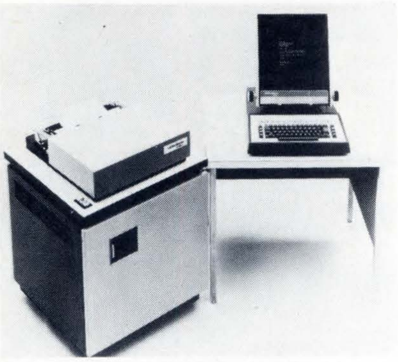
Name_______________

Company_______________

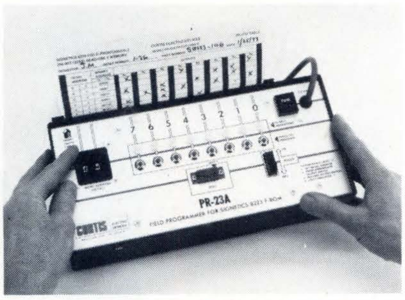
Address_______________

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

S58/M0809



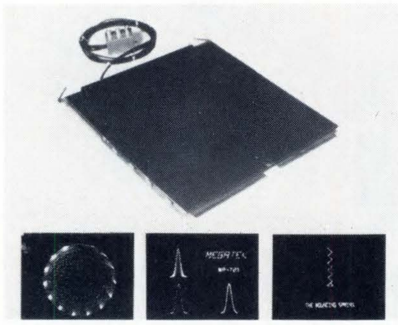
WORD-PROCESSING UNIT PERMITS CRT EDITING. The Videotype-I text processor is designed for those who need easily edited, quickly recalled copy. As text is typed it appears on a display screen to permit editing before hard-copy production by the printer/logic console. Simultaneously, the data is recorded on a cassette tape in the console. Each cassette holds up to 30 pages of copy. "Edit," "delete," "insert" and similar command keys permit rapid editing & arrangement of text. $16,000 or leased for $375 per month. Lexitron Corp., 9600 De Soto Ave., Chatsworth, CA 91311. **220**



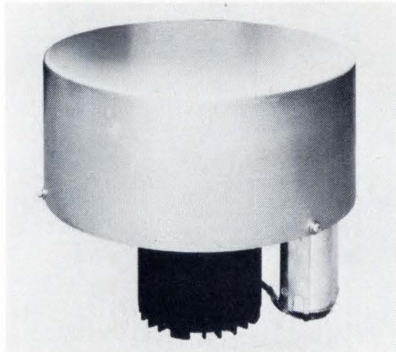
LOW-COST FUSIBLE ROM PROGRAMMER. The PR-23A allows manual programming of the Signetics 8223 256-bit field programmable ROM in the field by unskilled personnel. To program a device, the operator places a blank F-ROM in the test socket, selects the appropriate octal word address and presses one of 8 output pushbuttons to open the selected fusible link. Program sequence is automatic and independent of operator timing to ensure uniform program conditions. A typical pattern can be programmed in about 5 minutes. Eight indicator lamps provide a continuous display of output states. A slot at the rear of the instrument holds the truth table in proper alignment with panel markings. $199.50. Curtis Electro Devices, Inc., Box 4090, Mt. View, CA 94040. Phone (415)-964-3136. **221**

CASSETTE TERMINAL OFFERS ON-LINE AND OFF-LINE CAPABILITIES. In its on-line mode, the 345 CMTT ties in directly with all major minicomputers. As an off-line device it permits serial modem-to-modem communications at transfer rates of 110 and 300 baud, (10 and 30 cps). It incorporates logic for remote control (off-line) by transmission of standard ASCII control characters from serial devices. When operating in an on-line mode, the CMTT allows communication between the attached serial devices and the computer. It is supported by an extensive library of cassette-operating system software. $3300. DICOM INDUSTRIES, 715 N. Pastoria Ave., Sunnyvale, CA 94086. Phone (408)732-1060. **222**

FLEXIBLE DISKETTE SYSTEM SPEEDS COMPUTER DATA ENTRY. The 3740 incorporate flexible diskettes for capturing data. They resemble small phonograph records yet can hold as much information as 3000 80-column punch cards and are reusable. They are oxide coated Mylar devices with 48 tracks/in., sealed in 8-in. sq protective plastic envelopes. With a density of 3200 bpi, each has a capacity of 5078 8-bit bytes/track and 391,006 bytes/diskette. A new drive unit spins the diskette at 360 RPM, and a read-write head accesses the diskette through a slot in the plastic envelope. Data rate is 250,000 BPS, and track-to-track access time in 50 μsec. International Business Machines Corp., 1133 Westchester Ave., White Plains, NY 10604. Phone (914)696-1900. **223**



FULL-GRAPHICS CAPABILITY AVAILABLE FOR MINICOMPUTERS. The BP-721 interface converts any X-Y oscilloscope or larger X-Y display into a full-graphics display terminal. The unit, with its internal semiconductor refresh memory, enables the minicomputer user to plot points, lines, alphanumerics and real-time dynamic displays. Software is supplied for programming with simple BASIC language commands. Installation, which requires no hardware modification, is accomplished by inserting it into a vacant minicomputer slot and connecting to the X, Y and Z inputs of the oscilloscope. Interfaces for all Data General NOVA series minicomputers are available. $1095. Megatek Corp., 1526 W. 240th St., Harbor City, CA 90710. Phone (213)530-0654. **224**



MEMORIES COMBINE MINI-DISC AND DRUM TECHNOLOGIES to provide OEM manufacturers with a large data base in a 10-in. package weighing only 25 lbs. Storage capacities range from 16k 16-bit words to 262k words. Five models are offered: 4-, 8-, 16-, 32- and 64-track versions. Each has a 4096 words/track recording density. Word transfer rate is 122 kHz. Designed for terminal applications Series 55 processes data in a bit-serial stream at a rate of over 2-million BPS. Cost/bit ratios are attractive, particularly for applications such as point-of-sale-systems and inventory control systems. $1550 for 16k-words to $2950 for 262k. Datum, Inc., 170 E. Liberty Ave., Anaheim, CA 92801. Phone (714)879-3070. **225**

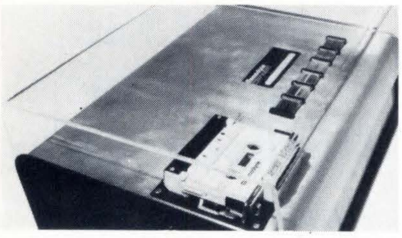
KEYBOARDS FEATURE MOS ENCODING AND BI-PAC SWITCHES. A series of TTY-33 keyboards, featuring redundant contact BI-PAC switch modules and a 40-pin ceramic MOS chip for encoding 4 mode ASCII code, and offering N-key rollover, is available for interactive computer printing, display terminals and related ASR-33 compatible applications. The encoder design reliably maintains sequential key outputs even at maximum "burst" typing speeds. MOS chip operation also requires less than 200 mA power consumption. The +5 to −12 output is Tri-State or TTL compatible. Price: $125 in 1-25 quantity; $59 in 5000 quantity. Controls Research Corp., 2100 S. Fairview, Santa Ana, CA 92704. Phone-(714)557-7161. **226**

PRINTERS INTERFACED TO SYSTEM 7. The controller can interface 2 Centronics printers, 1 located locally at the System 7 site and 1 containing a modified RS-232 interface board located up to 1000 ft away. Under software control, data can be transmitted to either or both printers. The controller receives a parallel 8-bit input from the CPU and transmits this data in parallel to the local printer and serially to the remote printer. Baud rate for the remote printer is selectable up to 9600. $975. Centronics Data Computer Corp., 1 Wall St., Hudson, NH 03051. Phone(603)883-0111. **227**

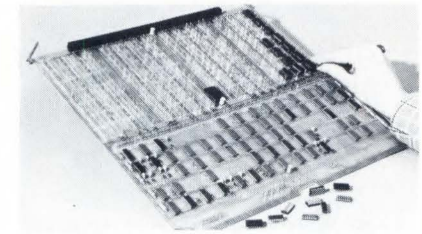
DATA ENTRY AND DISPLAY TERMINAL IS TELETYPE COMPATIBLE. The Model 440 TTY-Plus provides 3 × 6 in. window through which the viewer can observe 80 characters/row and up to 8 rows. The keyboard is virtually identical with that of a standard teletypewriter so that retraining of operators is minimal. It is designed to replace impact-type teleprinters where hard copy is not a requirement. It can operate in a block transit mode; data can be prepared off-line and transmitted in a block with only 1 keyboard and can be switched at standard line rate from 110 to 9600 baud. Less than $1000 in large quantities. Conrac Div., 600 N. Rimsdale Ave., Covina, CA 91722. Phone(213)966-3511. **228**

MULTIPLEXER CONTROLS SELECT ANY SEGMENT OF CHANNEL ADDRESS. Intended for use in data acquisition systems to examine a selected group of channels, the Model GMC logic control system permits choice of the first and last channels from front panel switches. Any number of sequential channels can be selected with this system. It is useful in process control, automatic production testing and scientific data analysis systems where the A/D converter and its display can be used as a time-saving measuring device. A separate control permits selection of either continuous re-cycling, or "single-shot" starts of each scan sequence. Prices start at $755 for a 32-channel system. Preston Scientific, Inc., 805 E. Cerritos Ave., Anaheim, CA 92805. Phone(714)776-6400. **229**

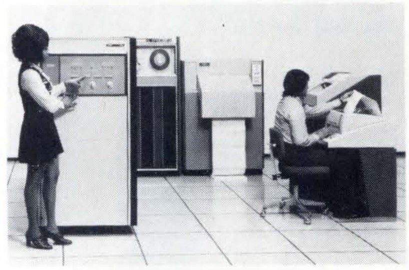
REAL-TIME PROGRAMMERS SEQUENCE PROCESS OPERATIONS. These solid-state units control 10 to 30 operations in any sequence. They provide up to a 16.5-hr. range and have an accurate electronic clock which can select down to 1/4-sec intervals for process control. Real-time operation time intervals can be programmed directly in hr, min and sec. Time intervals can be altered by simply removing or adding pins on the front panel without affecting other time intervals. All time intervals are accurate and repeatable to ±0.25 sec. $2500 to $4900. Hugle Industries Inc., 625 N. Pastoria Ave., Sunnyvale, CA 94086. Phone-(408)738-1700. **230**



DIGITAL CASSETTE IS COMPATIBLE WITH STANDARD INTERFACES. The 1000 Series provides a cassette (storage) record and playback system which is directly plug compatible with any teletypewriter, terminal, modem, acoustic coupler, or computer which is equipped with standard EIA RS232C interfaces. The incremental feature of this series allows data to be recorded at keyboard rates and later read at maximum rates and played back 1 character at a time to eliminate the need for external buffering. Two models are presently available; Model 1113 operates up to 60 cps (at baud rates up to 600 baud) and Model 1173 operates up to 120 cps (at baud rates up to 1200 baud). Model 1113: $1395, Model 1173: $1595. Memodyne Corp., 369 Elliot St., Newton Upper Falls, MA 02164. Phone-(617)527-6600. **231**

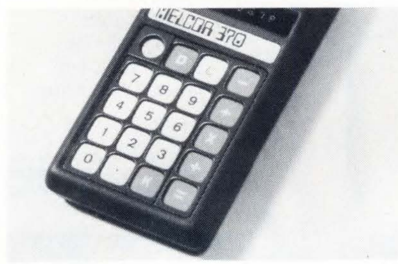


I/O INTERFACE BOARD FOR NOVA MINIS. The interface board contains all necessary circuitry to connect the user's logic to the I/O bus of any Nova series minicomputer. Provision is made for multiple controllers on a single board. It can mount up to 105 14- and/or 16-pin wire-wrap sockets with allowances for mounting of 24- to 40-pin sockets. User logic is connected to the I/O logic by a set of wire-wrap posts dividing the 2 sections. The interface is packaged on a 15 × 15 in. board with 2 100-pin connectors and can be mounted directly in a single slot of the Nova computer chassis. The user has the option of up to 4 16-bit registers, a data-channel interface and counter logic for zero word count detection. $250. MDB Systems, Inc., 981 N. Main St., Orange, CA 92667. Phone(714) 639-7238. **232**



GENERAL-PURPOSE COMPUTER SYSTEM STRESSES MAINTAINABILITY. The 530, designed for both scientific and commerical applications, is priced in the minicomputer range while offering many capabilities usually available only with larger computers. These include the ability to enter and retrieve information with a minimum of computation interruption, advanced methods for interrupting normal computation to take care of high-priority items and a capability for computer trouble-shooting via long-distance telephone lines. $21,700. Xerox Corp., Stamford, CT 06904. Phone(203)-329-8711. **233**

HIGH-SPEED ADD-ON MEMORY AVAILABLE FOR PDP-11. Computer users can add the Model SG-11 semiconductor memory system to PDP-11 computers in the field. The self powered memory unit is contained in its own enclosure and is fully hardware and software compatible. It cables directly to the Unibus connector block and operates with a cycle time of 650 to 750 nsec. It is fully wired for expansion to 28k or memory parity available as an option. The basic 4k system costs $2200 and a full 28k memory bank $7300. Signal Galaxies, Inc., 6955 Hayvenhurst Ave., Van Nuys, CA 91406. Phone(213)988-1570. **234**



SWITCHLESS CALCULATOR FEATURES PRESSURE-SENSITIVE KEYBOARD. The Model 370 8-digit calculator adds, subtracts, divides, multiplies and performs chain and mixed calculations. Additional features include credit balance, 4 function constant, floating decimal, automatic battery life extender, storage power of 10^{-20} to 10^{79} and low battery indicator. It measures 5-7/8 in. × 3 in. × 3/4 in. and weighs 6-1/2 ozs. Melcor Electronics Corp., 1750 New Highway, Farmingdale, NY 11735. Phone(516)694-5570. **235**

Now... a fully packaged SPERRY display for only $15 a decade*

the real bargain is IDI reliability.

These bright, clear displays will even look good to the guy who signs the checks! The flat, .6" characters are readable from 40 feet...at 130° viewing angle...in the brightest of ambient light! Completely packaged in heavy-duty extruded aluminum case with easily customized bezel; 3 to 8 digits; optional built-in power supply. Readouts have life expectancy of 100,000 hours.

FOUR MAJOR VERSIONS...decode display, uni- and bi-directional counter display, all with or without memory...fully packaged, shipped from stock...and a complete line of compatible digital printers and power supplies in a wide range of extremely versatile configurations.

*RD Series Decode Display, 50 decades.

SEE WHAT KELTRON HAS TO OFFER. . .

IDI/INSTRUMENT DISPLAYS DIVISION

KELTRON CORPORATION
225 Crescent Street
Waltham, Massachusetts 02154
Telephone: 617-894-0525

CHECK NO. 85

COMPLETE PACKAGING CAPABILITY

only from Vero

CASES
CONNECTORS
CARD FRAMES
MODULE RACKS
VEROBOARD
CARD HANDLES
FRONT PANELS
PANEL HANDLES

ALL DELIVERED FROM STOCK

VERORACK 3

The ULTIMATE PC CARD FRAME

• Exceptional Strength • Precision Aluminum Extrusion Guide Rails • Concealed Guide Mounting • Identification Strip Standard in Front — Optional in Rear • Noryl Guide Temp. Range −60 +125 C • Selection of Guide Lengths • 4" & 4½" Wide Guide Blocks With.5" Cards Spacing for Fastest Assembly Guides Slide Into Extrusions • Individual Variable Spaced Guides from .4" Available • Combine Guide Lengths for Extra Length Cards With Special Center Extrusion • Unique Extruded Connector Rails Allow Connector Mounting at any Point and Identification of Connector Position.

vero

Vero Electronics Inc.
171 Bridge Road, Hauppauge, N.Y. 11787
Tel.: 516-234-0400 • TWX510-227-8890

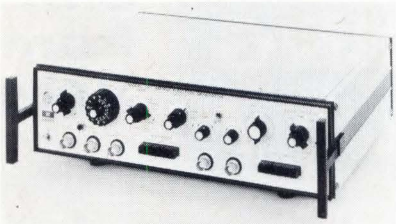
CHECK NO. 58

SUBJECT: *Toroidal Cores–Data Sheets*
USE: *RF Coils, Chokes, Filters, Transformers*
FREQ: *To 200 MC.*
SOURCE: *Micrometals*

MICROMETALS

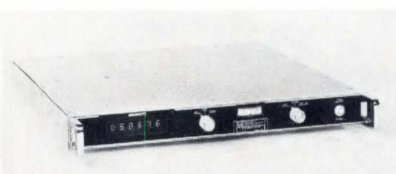
228 N. SUNSET, CITY OF INDUSTRY, CALIFORNIA 91744
(213) 968-4718

CHECK NO. 59

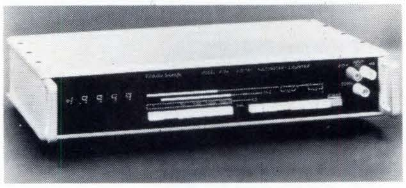


AM/FM FUNCTION GENERATOR WITH BUILT-IN MODULATION SOURCE. Model 129 contains 2 independent generators, 1 of which provides the carrier frequency and a second which provides the AM or FM modulating signals. Both offer sine, triangle and square-wave outputs from the internal generators. The carrier generator covers 0.1 Hz to 5 MHz. It can be triggered (single cycle) or gated (tone burst, pulse burst) from either the internal AM/FM generator or an external source. Carrier output level is 10V p-p into 50Ω and 20V p-p open circuit. The AM/FM generator produces frequencies from 1 Hz to 1 MHz. $795. Exact Electronics, Inc., Box 160, Hillsboro, OR 97123. Phone(503)648-6661. **198**

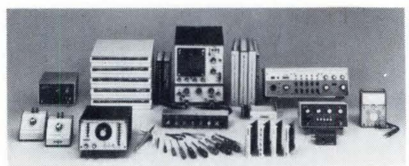
10-MHz SCOPE FOR ONLY $425. Model 5310 can be ac or dc coupled and uses digital circuitry for stable triggering to 15 MHz. Vertical ranges are from 10 mV/cm to 50V/cm in 12 calibrated ranges and accuracy is ±3%. An uncalibrated continuously-variable control increases sensitivity to 5 mV/cm. Sweep ranges are from 0.5 μsec/cm to 0.2 sec/cm in 18 calibrated steps and linearity is 1% through the full horizontal sweep. The 5310 has an 8 × 10-cm display. A 2.5-kV accelerating potential and P31 phosphor produce a clear, high-contrast trace. Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, OH 44108. Phone(215)541-8060. **199**



TWO FREQUENCY COUNTERS IMPROVE RECEIVER TUNING ACCURACY and stability by employing digital automatic frequency control (DAFC). Designated the DRO-315 for 100-kHz-to-500-MHz coverage, these units provide a receiver tuned frequency lock to within ±1 kHz as long as power is applied. The counters have selectable presets of 8, 10, 21.4 and 60 MHz and 1 optional preset selected at the time of order. Both counters provide LED displays and each requires only 1-3/4 in. of vertical space in a standard 19-in. rack. Watkins-Johnson Co., 6006 Executive Blvd., Rockville, MD 20852. Phone(301)881-3300. **200**



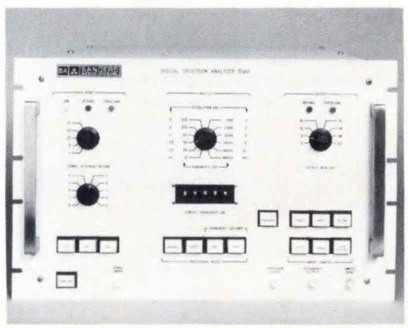
4-1/2-DIGIT DMM/COUNTER WITH GATED FREQUENCY COUNTING to 200 MHz includes 5 ranges of dc and ac volts with 10-μV resolution, 5 ranges of dc and ac current with 10-nA resolution, 6 ranges of resistance with 10-MΩ resolution and 5 ranges of true frequency counting. The counter's wideband frequency multiplier option allows low-frequency signals to be measured virtually error-free in 1/100 of the normal time, independent of zero-crossing distortion. A 10-Hz signal can be resolved to 0.001 Hz in 10 sec. Basic accuracy for dc volts and frequency is 0.01%, 0.02% for resistance and 0.1% for ac volts. $590. Valhalla Scientific Inc., 7707 Convoy Ct., San Diego, CA 92111. Phone(714)277-2732. **201**



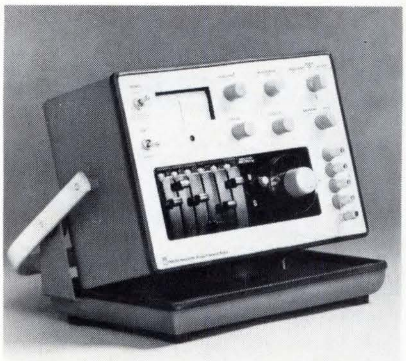
LOW-COST LAB STATION. The EU-99A lab station includes such instruments as the EU-70A 15-MHz dual-trace scope and the EU-81A 1-Hz-to-1-MHz function generator. Digital instrumentation includes the EU-801A A/D designer (a system that allows investigation of virtually any analog or digital circuit) and the additional plug-in logic circuit cards necessary to convert it to a computer logic training system. As the need arises and the budget permits, additional instrumentation and components may be added. Teaching/learning software is included and requires no prior electronics background. $2035. Heath/Schlumberger Scientific Instruments, Benton Harbor, MI 49022. Phone(616)983-3961. **202**

ELECTRONIC VOLTMETER Model 2425 features true-rms, average and peak indications. Other features include a linear frequency range from 0.5 Hz to 500 kHz, sensitivities from 1 mV to 300V full scale, calibrated amplification 60 dB and ac and dc outputs. A hold function for peak measurements and a provision for a variable-meter time constant are included. Two built-in meter time constants, interchangeable meter scales and line or battery operation are other features. B&K Instruments, Inc., 5111 W. 164th St., Cleveland, OH 44142. Phone-(216)267-4800. **203**

32-MHz AUTOMATIC COUNTER features a counting range from 5 Hz to 32 MHz, a crystal controlled clock, a 5-digit long-life LED display and automatic ranging for full resolution. Decimal points are automatically positioned as is the display of units of measurement and non-significant zeros are automatically blanked. Operating from the ac line or an optional battery pack, the Model 150A has a built-in test position and an overrange indicator in the manual mode. $475. The optional 10-hr NiCd battery pack, including charger and carrying case, costs $200. United Systems Corp., 918 Woodley Rd., Dayton, OH 45403. Phone-(513)254-6251. **204**



1024-LINE REAL-TIME SPECTRUM ANALYZER. Model DSA-2004 covers a center-frequency range of dc to 40 kHz for use in radar and sonar signal processing, acoustic spectrum-level measurement, and noise and vibration analysis. It features digital circuitry for translation, filtering, Fourier analysis, post processing and storage. The unit, which has modular construction and built-in self-test capabilities, provides resolutions selectable from 0.01 to 40 Hz and an analysis bandwidth of 10 Hz to 40 kHz. The DSA-2004, with an internal simultaneous multi-channel processing capability, provides linear and logarithmic outputs for electrographic recorders, X-Y chart recorders, CRT displays and scopes. Sanders Associates, Inc., 95 Canal St., Nashua, NH 03060. Phone(603)885-5875. **205**

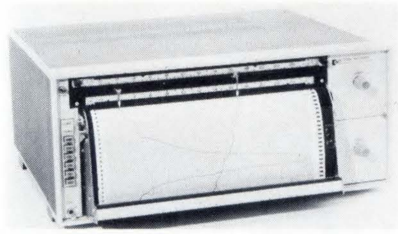


Dc RESISTANCE BRIDGE Model 1666 will measure both 500 $\mu\Omega$ and $7 \times 10^9\Omega$ to an accuracy of better than 1%, and less extreme resistance values to an accuracy of better than 0.02%. Four ±0.02% bridge circuits and 6-digit resolution give it a total measurement range from 1 $\mu\Omega$ ($10^{-6}\Omega$) to 1 teraohm ($10^{12}\Omega$) It easily measures both open (leakage) and closed (contact) resistance of relays and switches, plus forward and reverse diode resistances. It also measures transformer winding resistance, insulation conductance and resistance thermometers, and dielectrics. Comparisons between similar resistances can be made to a resolution of 2 parts per million. $950. General Radio, 300 Baker Ave., Concord, MA 01742. Phone(617)369-4400. **206**

20-MHz FUNCTION GENERATOR Model 420 features fequency modulation with a range of better than 200:1, a 10V p-p output into 50Ω through an 80-dB attenuator (20V p-p open circuit), a ±10V dc offset, trigger and gate modes. The generator includes sine, square and triangular wave outputs with sine wave distortion under 0.5% to 200 kHz and square wave aberration of 5%. The generator's frequency range is from 2 Hz to 200 MHz in 7 decades at ±2%-of-reading accuracy (to 2 MHz) and ±10% to 20 MHz. $785. Systron-Donner Corp., Datapulse Div., 10150 W. Jefferson Blvd. Culver City, CA 90230. Phone(213)836-6100. **207**

FUNCTION GENERATOR Model 5700 provides a balanced 600Ω output over 0.002 Hz to 2 MHz. This low-cost instrument (only $295) provides sine, square and triangle waveforms with a frequency accuracy of ±5% of reading for the entire 1000:1 tuning range of the dial. The output is controlled by a 2-position dB step attenuator and amplitude vernier, providing both a 50Ω single ended and a 600Ω balanced output. The outputs provide 15V p-p and 30V p-p, respectively. A 1V auxiliary output is also supplied. Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge, MA 02139. Phone(617)491-3211. **208**

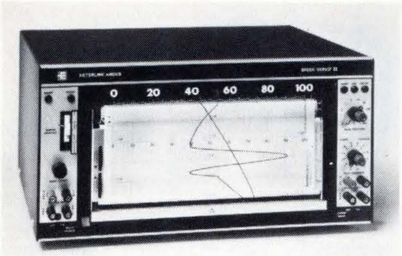
EQUIPMENT



TWO OEM 1 AND 2-PEN STRIP-CHART RECORDERS feature more than 50 options that let the user customize these 10-in. units for specific applications at low cost. Designed to allow a user to choose spans, speeds and other options, the single-span Model 7130A/B (2-pen) and the Model 7131A/B (1-pen) units can be ordered with one of 6 available chart speeds from 6 in./min to 1 in./hr. Options are available for adding a second speed; 4 or 8 speeds plus an external input. One of 6 input spans from 1 mV to 100V per channel can be specified. Input is single ended and floating, with 1 MΩ resistance on all spans. Price is $1250 (7130A/B) and $850 (7131A/B). Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone(415)493-1501. **209**

FIELD-EFFECT LIQUID-CRYSTAL-DISPLAY DPMs include 2-1/2-, 3-1/2- and 4-1/2-digit models with prices starting as low as $47 each (2-1/2-digit unit in 100 quantities). The TA300 Series features custom MOS/LSI ICs, and a proprietary Poly-Tek A/D conversion technique. It includes 39 different models with plug-in voltage and current range modules, bipolar operation, a shielded-transformer power supply, all-metal cases and optional fully isolated parallel BCD output. Each DPM requires 1.5W of input power. I/O signals are provided for external digital linearization, curve fitting and scale factor control and serial BCD output is standard. Tekelec, Inc., 31829 W. La Tienda Dr., Westlake Village, CA 91361. Phone(213)889-2834. **210**

THREE-IN-ONE VOM/TRANSISTOR TESTER Model HM-310 combines all the functions of a VOM with the added capability of measuring capacitor and transistor parameters. The self contained unit features 100Ω/V, an impedance taut-band movement, a 3-in. mirrored scale and burn-out protection. Measurement capabilities are: ac and dc voltage, resistance, ac and dc current, dB, capacitance, and transistor alpha, beta and leakage current. 2-1/2 × 5-1/6 × 6-1/2 in. $59.95. HM Electronics, Inc., 10975 San Diego Mission Rd., San Diego, CA 92108. Phone(714)280-6050. **211**



INKLESS-WRITING SERVO RECORDER. The Speed Servo II 10-in. strip-chart recorder uses thermal-sensitive chart paper and an electrically heated stylus. This provides advantages of convenience use in applications with excessive oscillation of the writing element, very slow-changing input signals, slow chart speeds and continuous, unattended long-term recording. The user gets a long stylus life (8700hr min.), the ability to tilt the recorder to any position and no limitation of recorder response. The recorder can be converted easily to throw-away ink-pen cartridges. Warm-up time is a nominal 10 sec. Esterline Angus, A unit of Esterline Corp., Box 24000, Indianapolis, IN 46224. Phone(317)244-7611. **212**

REGULATED LAB POWER SUPPLIES. With only 100 μV of ripple, the PSR series of dc power supplies also feature load regulation of 0.01%. Other features offered are overload protection, an accurate D'Arsonval meter calibrated for voltage and current, and current-limiting burnout protection. Two models are available: Model PSR 12-25 whose output is 0 to 25V dc at 500 mA and Model PSR 12-50 with an output of 0 to 50V dc at 250 mA. Both operate from 105 to 125V ac, 50/60 Hz. Dimensions are 5-1/4 in. high × 3-1/2 in. wide × 9-1/8 in. deep. EPSCO, Inc., 920 Westwood Ave., Addison, IL 60101. Phone(312)543-0410. **213**

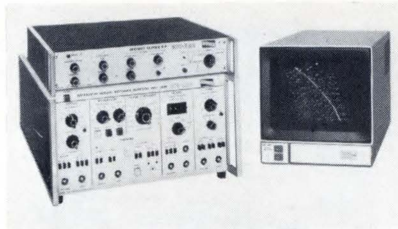
GRAPHIC-DATA DIGITIZING SYSTEM USES MAGNETIC CARDS and features digital display of the X-Y coordinate values and a stylus to digitize the points. Data from graphics, patterns, layouts, X-ray negatives, photographs, templates and drawings is recorded on a magnetic stripe on standard tab cards. Storage capacity up to 26,000 bits combines the data density of magnetic tape with the convenience of cards. Visual information may be typed, stapled or written on the cards and filed for future use. Price of a complete system is $6995. AM economy model with only Teletype and RS-232 outputs costs $3600. Elcomp General, 1937 Kilmer Dr., Placentia, CA. Phone-(714)540-4412. **214**

CHECK NO. 64

CHECK NO. 65

TDM-MODEM TEST SET Model 1310 is designed to test and analyze all digital data-communication systems which may contain low-speed asynchronous or high-speed synchronous modems, and time-division or frequency division multiplexers. Part of the Range Rider line, the Model 1310 generates and analyzes pseudo-random data sequences in the form of start-stop asynchronous characters. 5-, 6-, 7-, or 8-level data characters with odd, even or no parity and 1, 1.4 or 2 stop bits may be selected for analysis. It calculates and directly displays bit, character or block error rates and mark-to-space transitions. Three pseudo-random patterns, alternate, mark, space, R, Y and asterisk, and U sequences are also generated and analyzed for errors. $2150. International Data Sciences, Inc., 100 Nashua St., Providence, RI 02904. Phone(401)-274-5100. **215**

AUTOMATIC DIGITAL-CIRCUIT TESTER Model 721A provides verification of truth tables and dc parametric specifications of digital circuits having up to 16 pins. Operation is accomplished by simply inserting a device program card and selecting the appropriate limits for the family being tested. Model 721A may be readily used as a classification tool, an incoming-inspection tool, a high-speed wafer test tool, or an automatic digital test tool used in conjuction with a circuit handler. It can run a typical device test sequence in approximately 20 msec—performing thousands of combined functional and parametric tests to an accuracy of ±1.5%. $4950. Computest Corp., 3 Computer Dr., Cherry Hill, N J 08002. Phone(609)424-2400. **216**



3D DISPLAY AND CONTROL FOR REAL-TIME SPECTRUM ANALYZER. Model SAI-503 generates and controls a 3D display of spectral data derived from the Honeywell/Saicor real-time spectrum analyzer. It interfaces with standard storage displays and scopes. The 3D real-time display—spectrum amplitude vs frequency vs time—is obtained by displacing successive frequency scans vertically and horizontally to form an isometric pattern. The SAI-503 operates in 4 modes: continuous, single, triggered and 2D. Other features include simple controls for X, Y, and Z-axis positioning and scaling, a threshold control that eliminates background noise and automatic or manual display erase. $900 when purchased with Saicor real-time analyzer. Signal Analysis Operation, TID, Honeywell, Inc., 595 Old Willets Path, Hauppauge, NY 11787. Phone(516)234-5700. **217**

FLOATING DIFFERENTIAL AMPLIFIER FEATURES 1-μV FULL SCALE. The X-MOD 706 features input isolation of 10 Gigaohms (10^{10}) and 20 switch-selectable input ranges from 1 μV to 1V full scale. Full scale output is ±10V at 10 mA and is short-circuit proof. A center-scale null meter permits rapid system calibration and adjustment. Any of 3 bandwidths—0.1, 1 and 10 Hz can be selected by a front-panel switch. Long-term stability is 0.1% for 6 months, and temperature drift is only 0.1 μV/°C. CMR is 120 dB from dc to 60 Hz. $695. Preston Scientific, Inc., 805 E. Cerritos Ave., Anaheim, CA 92805. Phone(714)776-6400. **218**

LSI MEMORY TEST SYSTEM. Spartan 770 "Bit Rider" for testing semiconductor memories features a modular design that allows each customer to customize his Spartan to meet individual requirements. It includes 32 memory channels, 15 drivers and a high-speed, 10A resolution comparator. The unit offers 1-nsec timing resolution with 1-ppm clock stability. A microprogrammable RAM allows for test pattern storage and pattern generation at 5 MHz to test efficiently both recursive and random logic circuits. The Spartan offers a diagnostic panel for device/program trouble shooting. $59,770. Western Digital Corp., 19242 Red Hill Ave., Newport Beach, CA 92663. Phone(714)-557-3550. **219**

Statham

Zeroes in...

On your

Test Chamber

requirements!

They may range from 300° below zero to 600°F above.

Because we zero in on your requirements, we can provide a test chamber to fit them.

One of Statham's high-performance test chambers is the SD60, a bench-top model with push-button temperature control and an adjustable visual front-panel failsafe that can be set to any desired range between +100° and +600°F. Your test specimens, and the test chamber itself, cannot be damaged.

But we don't stop there. Statham also builds test fixtures, custom-designed to solve your temperature-testing problems.

Statham can meet any test chamber requirements. If yours are really far out, we will build a new test chamber to meet them.

You provide the target – Statham will hit it!

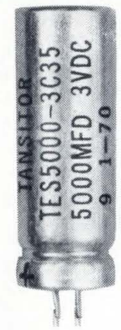
Write or call today. Statham can help you.
Statham Instruments, Inc., Industrial Division,
2230 Statham Blvd., Oxnard, CA 93030
(Area Code 805) 487-8511

stay with Statham

CHECK NO. 76

Tansitor

means Tantalum Capacitors.



We're the specialists. The firm that offers you a full line of wet, foil and miniature solid tantalum capacitors. The right capacitors for your specifications . . . at the right price for your budget . . . and the right delivery schedule. For tantalum capacitors that meet your expectations . . . count on your first choice. Tansitor.

For more information call your Tansitor Representative or contact:

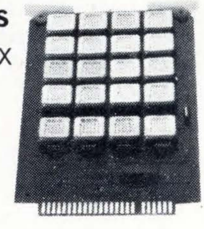
Tansitor
ELECTRONICS
DIVISION OF AEROTRON, INC

West Rd., Bennington, Vt. 05201 • Phone: (802) 442-5473 • TWX: (710) 360-1782

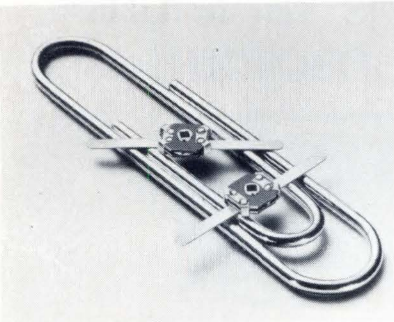
CHECK NO. 53

All-in-one-card RAM. Very fast access time: 125 ns. Very fast delivery: right off the shelf. Contains memory address register, decoding, storage sense amplifiers, write amplifiers, output buffers–everything needed for complete memory function. Up to 18K on a single card. For more words by more bits, just wire the cards together. Power consumption is less than one milliwatt per bit. Price is lower than any other card memory in this speed range. Give us a call. We'll quote price on the phone and ship one to you on a memorandum receipt that gives you a **Free Thirty Day Trial Period.**

All this from the people who know memories. **Electronic Memories & Magnetics Corp.** Phoenix Semiconductor Facility, 3883 North 28th Avenue, Phoenix, Arizona 85017. Phone: (602) 263-0202.



CHECK NO. 54

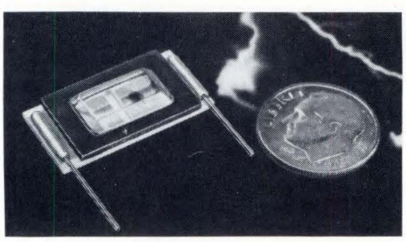


VARIABLE CAPACITORS HAVE BEAM LEADS. The Series 9401 trimmers feature Qs of >10,000 at 100 MHz and lead configurations perfect for stripline, hybrid circuit and pc mounting. They are uniquely suited as replacements for many chip capacitors and provide a means of easily and reliably trimming without cut-and-try adjustment techniques using abrasives. Applications include impedance matching and trimming solid-state circuits, balancing semiconductors and microwave components, VHF-UHF coupling, as well as equalizing fixed capacitors. The series includes 5 models having capacitance ranges from 0.2 to 4.0 pF with additional models available up to 50.0 pF. All models have test voltages of 500V dc. 95¢ each, in volume. Johanson Mfg. Corp., 400 Rockaway Valley Rd., Boonton, N J 07005. Phone(201)334-2676. **236**

TEMPERATURE COMPENSATED UNIT COMPARES WITH OVEN OSCILLATORS. Model K1098A crystal oscillator has none of the inherent drawbacks of oven oscillators such as warm-up time or on/off power surges for heating. The elimination of the oven and its thermostat eliminates the majority of reliability problems. Stability is ±1 × 10^{-7} over the temperature range of 0°C to 55°C. It is well suited for application in frequency counters and in laboratory instruments such as synthesizers and signal generators. Motorola Communications and Electronics, Inc., 1301 E. Algonquin Rd., Schaumburg, IL 60172. Phone(312)358-7900. **237**

INDUCTOR REPLACES DEVICES, 10 TIMES LARGER. The magnetically shielded, transfer molded chip inductor measures just 0.160 × 0.125 × 0.125 in. and features an inductance range from 0.1 μH to 1000 μH, with a "Q" factor as high as 80. (Typical Q characteristic is 75 min. at 56 μH and 2.5 MHz test frequency.) Completely compatible in size and mechanical configuration with chip resistors, diodes and capacitors, the microminiature chip inductor is suitable for reflow soldering techniques and for automatic chip insertion equipment, while its size permits extra high density packaging. The "SUPER Q" meets or exceeds the requirements of MIL-C-15305 and operating temperature range from −55°C to 125°C. Vanguard Electronics, 930 W. Hyde Park Blvd., Inglewood, CA 90302. Phone(213)678-7161. **238**

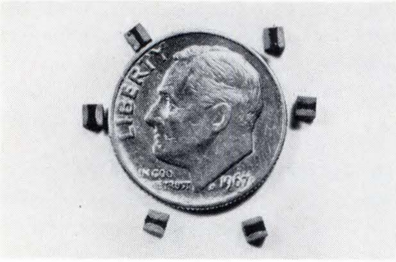
LONG-LIFE, WOUND-TYPE FLAT MOTOR. Thickness is about 1/3 to 1/4 of conventional motors. Previously, flat motors used a printed rotor—the coil being printed on a resin disc to form the rotor. Conventional printing techniques limited the number of flat motor windings, and made the motor unsuitable for high-voltage operation. This is an improved version of the commutator motor. Motor life is 2 to 3 times longer than conventional commutator motors and efficiency is about 20% higher. It's capacity can be increased to 800W, and it can be operated on household current by using a diode. Matsushita Electric Corp. of America, Pan Am Bldg., 200 Park Ave., New York, NY 10017. Phone(212)973-4980. **239**



MICRO ARRESTER IS FIRST TO USE CERMET CONSTRUCTION. It protects high-frequency circuits from damage by high-voltage pulses caused by transients and lightning. It is designed to edge mount in a minimum of board area. A sealed-glass cover permits periodic inspection of the spark gap for transient damage. Radioactive gas inside the arrester's sealed cover permits maintenance of breakdown voltage at a constant level and insures low-peak breakdown voltage. The arrester is capable of withstanding 20 pulses of 1000A peak. Breakdown voltages available are 350, 500, 800 or 1000V. Price (in 100-piece quantities) is $1.99 each. Dale Electronics, Inc., P.O.Box 609, Columbus, NB 68601. Phone (402)564-3131 **240**

LEDs PROVIDE FULL-FLOOD VIEWING. The RL-4403 and RL-4440 contain a gallium-arsenide-phosphide LED in a newly designed red-diffusive molded package. The viewing area extends 0.140 in. beyond the face of the mounting clip allowing wide angle viewing. The radiating area is 0.2 in. in diameter and presents an ideal visual display for indicating functions on instruments and control panels. For easy installation, the leads are 0.025 sq for wire-wrapping, soldering or pc board mountings. In addition, these devices operate on only 1.7V at 20 mA. The RL-4403 is rated at 0.8 MCD min. at 20 mA, and 1.2 MCD typical. The RL-4440 is a lower brightness, lower-cost version of the RL-4403. The RL-4403, 65¢; RL-4440, 49¢. Litronix, Inc., 19000 Homestead Rd., Cupertino, CA 95014. Phone (408)257-7910. **241**

HIGH-PERFORMANCE HEAT SINKS COST ONLY A PENNY. The Penny Pincher heat sink duplicates the most effective heat transfer methods now in use, such as fin tubing. It uses any number of stackable fins, depending on the heat dissipation needed and is made of anodized aluminum for corrosion protection and high thermal conductivity. Available in type TO-18 and TO-5 with a 1-sq. in. radiation surface per fin, they can be used with silicone grease compound to further reduce the thermal impedance between the semiconductor case and the heat sink. Carbidex Corp., 1 Carbidex Rd., Southgate, MI 48195. Phone(313) 287-8600. **242**

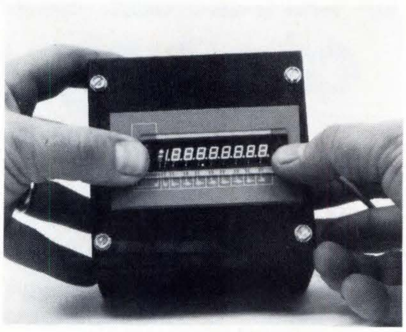


CHIP INDUCTOR. The MAGNA-CHIP measures 0.080 × 0.080 in. with a maximum thickness of 0.080 in., dependent upon value. This chip inductor is supplied with palladium-gold terminations usable with a wide assortment of attachment and bonding techniques. The inductance range is 0.2 to 5 μH, with a current rating of up to 1A. Q is a minimum of 20, dependent upon the inductance value. Typical T.C. is 150 ppm/°C over temperature range of −55°C to +125°C. Series resistance is typically 0.2 to 0.3Ω for values less than 0.5 μH and up to 1Ω at the 5 μH level. Standard tolerance is 20%. $2.50 to $5 in 1000-piece quantities. San Fernando Electric Mfg. Co., 1509-35 First St., P.O. Box 351, San Fernando, CA 91341. Phone(213)365-9411. **243**

THERMISTOR IS INDIRECTLY HEATED. The K365 unit features a combination heating element and thermistor bead enclosed in a glass bulb and is unaffected by changes in ambient conditions. When power is applied directly to the thermistor bead, the magnitude of temperature change is based on a temperature increase of 1°C per each 0.015 mW (nominal). Applied power of 0.04 mW (nominal) to the heater element will cause the element to indirectly heat the thermistor bead, resulting in a temperature increase of 1°C and changing its resistance on a typical heater power vs. bead resistance curve from 50,000Ω to 15,000Ω. Fenwal Electronics, 63 Fountain St., Framingham, MA 01701. Phone(617)872-8841. **244**

FREQUENCY OF UNIVERSAL ACTIVE FILTER EXTENDED. Utilization of multiloop negative feedback allows simultaneous highpass, lowpass and bandpass transfer functions. Independent tuning of gain, center frequency and Q is accomplished with the addition of external resistors. Qs as high as 1000 can be obtained at frequencies below 100 kHz. The FS-30 is in a 14-pin DIP configuration measuring 1.5 × 0.5 in. Operating temperature range is 0°C to 70°C, and power consumption is 156 to 225 mW at ±15 to ±20V. Kinetic Technology, Inc., 3393 De La Cruz Blvd., Santa Clara, CA 95050. Phone(408)296-9305. **245**

COMPONENTS/MATERIALS



TEST SOCKETS OVERCOME BURN-IN PROBLEMS. The sockets for LCDs and MOS packages feature gas-tight elastomeric contacts which allow testing of delicate packages without degradation of metallized contact areas. These sockets can be obtained in integrated multiple stations which can be interconnected and/or multiplexed utilizing Chomerics' ability to produce multilayer circuitry on a resilient, nonconductive surface. There are few limitations on configurations, and custom designed testing circuit pads are available. The sockets are continuous-duty rated at from −55°C to +125°C; contact resistance is typically 0.1Ω, and contact center distances are available down to 0.025 in. Chomerics, 77 Dragon Court, Woburn, MA 01801. Phone (617)935-4850. **246**

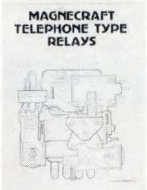
MINI-MOUNT USED FOR BREADBOARDING LSI PACKAGES. Without drilling holes, you can assemble your circuit prototype on any flat surface. Pressure-sensitive adhesive on the back of the LSI-42 MINI-MOUNT holds it in place while interconnecting wires are installed. The mounts can be moved or exchanged as the circuit develops, yet will remain firmly in place in the finished assembly. This breadboarding system provides a fast and flexible method of assembling high-performance electronic circuits—including analog, digital and RF circuits from dc to the GHz region, without restraining you to a fixed-grid pattern. They come in different configurations to fit 14- and 16-pin DIPs, 6- to 12-pin TO-5 style cans, transistors, inductors, resistors and other components. Cristiansen Radio, Inc., 3034 Nestall, Laguna Beach, CA 92651. Phone(714)497-1506. **247**

YOKE MINIMIZES CIGARING ON ALPHANUMERIC DISPLAYS. The LY916 position-write yoke eliminates the need for electrostatic deflection plates. It is a high-speed high-Q ferrite-core deflection yoke featuring fast position and write and is excellent for resonant circuits. It has 0.25% perpendicularity and 0.1% maximum residual magnetism. The LY916 is for 90° deflection angle on a 1-7/16-in. CRT neck diameter. (Also available for 52° and 70° deflection angle.) CELCO/Constantine Engineering Labs. Co., 70 Constantine Dr., Mahwah, N J 07430. Phone(714)621-2662. **248**

THUMB SIZED XENON LAMP DELIVERS 200K cp. An arc lamp that measures only 2 cu in. is the reading light for optical character reading machines for computers. It provides an exceptionally consistent white light, ideally compatible with existing inks and papers formulated for use with OCR machines. It is the first arc-type light source in which the electrodes, reflector and lens are sealed into a single, pressurized unit. The lamp's efficiency is 3 to 4 times that of previous high-intensity arc lights, but the unit is only a tenth as large. The X6207 is a 150W unit whose light is virtually identical to sunlight. It can be operated in any position. EIMAC Div. of Varian Assoc., 301 Industrial Way, San Carlos, CA 94070. Phone(415)592-1221. **249**

RADIAL LEADED MONOLITHIC CAPACITORS ARE EPOXY COATED. CLOVER CAPS are electrically and physically interchangeable with all popular leaded capacitors. They are available in 6 physical sizes with capacitance ranging from 2.2 pF to 4.7 mF. Fifty and 100V configurations are standard in 3 ceramic formulations. The Ultra-Stable series insures complete stability of capacitance with variations in temperature, frequency and voltage and also where low loss and/or high Q are necessary. The Semi-Stable series is designated for applications where moderate variations in capacitance may be tolerated. The General Purpose series is used in circuits where wider variations in capacitance are acceptable. Varadyne Capacitor Div., 2110 Broadway, Santa Monica, CA 90404. Phone (213)829-2984. **277**

FREQUENCY REJECTION FILTER. The filter has the characteristics of the Twin "T" R-C filter and is most suitable for applications where the pass frequencies lie outside of the 0.4 to 2.5 fn range. It produces optimum attenuation at 25°C (±10°C) with the rms input voltage less than 1.4V and dc input voltage less than 10V (dc). The filter has a minimum of 38 dBV attenuation when tested at 25°C, 0.7 Vrms input at the rejection frequency. Source and load impedances are 600Ω max. and 100 kΩ min., respectively. Price (in 100-500 quantities) is $8.35. Dale Electronics, Inc., Dept. 860, P.O. Box 609, Columbus, NE 68601. Phone (402)564-3131. **254**

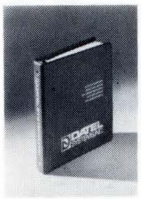


TELEPHONE-TYPE RELAYS. This 60-pg. catalog is a complete guide to applications and selection of telephone-type relays. The wide variety of relays include unitized subminiature, miniature, small and medium size relays. Also contained in this catalog are special features, accessories, enclosures, complete specifications, photos, dimensional line drawings, relay definitions, standard contact forms and ordering information. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, IL 60630. **255**

BULLETIN DETAILS EXPANDABILITY IN CMOS LOGIC GATES. The bulletin outlines SSSI method of employing added buffer stages and is complete with diagrams on the configurations possible. Also carried are tables on dynamic and output drive characteristics as well as circuit capabilities and overall performance characteristics. Those interested in obtaining the details on CMOS EXPANDABLE GATES should address their requests, specifying Bulletin AN-102, to Solid State Scientific, Inc., Montgomeryville, PA 19102. **257**

ANALOG PANEL METERS. This 6-pg. brochure describes API's line of analog panel meters. Shown are Series 7000 panel meters which feature advanced styling with a 3-way choice of mounting (front, bezel or lens) and slide-out scales. Taut-band movement and 1% tracking are standard in most popular dc ranges. Prices and dimensions are listed. LFE Corp., 1601 Trapelo Rd., Waltham, MA 02154. **262**

PHASE AND AMPLITUDE RESPONSE OF A VARIABLE ELECTRONIC TIMER is the title of a 16-pg. application note that describes a simple, general method for determination of phase and amplitude response of high-pass, low-pass and bandpass filters for 4-pole Butterworth and Bessel filters. Tables and normalized plots of phase and amplitude response of high-pass, low-pass and commonly used bandpass settings are provided. A complete set of data including cutoff frequencies, center frequency, bandwidth, noise bandwidth and filter gain is tabulated for any bandpass setting. Ithaca, Inc., 735 W. Clinton St., Ithaca, NY 14850. **266**



A/D AND D/A CONVERSION DEVICES. A comprehensive 3-ring binder catalog contains detailed electrical and mechanical information on a line of data-conversion modules subsystems and systems. Products described are A/D and D/A converters, sample-and-hold modules, digital panel meters, dc power supplies and data acquisition systems. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. **268**

MEASUREMENT AND CONTROL HANDBOOK. The 288-pg. book begins with an introduction to measurements and describes in detail elementary transducer elements through design considerations of complete measurement systems. It is written in a manner which permits the information to be readily understood by a wide range of readers. Mathematical discussions are minimized in favor of description, illustrations and other graphic presentations. Free to transducer and controls instrumentation designers. $7.95 to others. Schaevitz Engineering, P.O. Box 505, Camden, N J 08101. **258**

MINIATURE NEON LAMPS. The 127-pg. book, *Miniature Neon Lamps: Elements of Electronic Versatility*, gives detailed information on aspects of construction and applications as indicators, in voltage regulation and reference, and as electronic circuitry components. A handy reference to the characteristics of most available neon lamps also is included. Glowlite Corp., Sub. of El-Tronics, Inc., Pauls Valley, OK 73075 **264**

CATALOG LISTS DATA FOR SNAP ACTION SWITCHES. Included in the catalog are complete product listings, engineering drawings, specifications, operating characteristics, and technical data on general purpose panel-mount pushbutton, low-torque, subminiature, open type, and standard gold "crosspoint" contact switches. A handy switch selector-locator gives instant access to the entire line, and makes finding the right snap-action switch for any application just a matter of seconds. Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, IL 60085. **273**

4-1/2-DIGIT DMM. Performance characteristics, design features and complete specifications of the Data Precision Model 245, 4-1/2-digit, low-cost, portable digital multimeter (DMM) are presented in an 8-pg. brochure. Model 245 is a $245 portable instrument that packs the performance of expensive laboratory instruments into a pocket sized unit. Data Precision Corp., Audubon Rd., Wakefield, MA 01880. **276**

OPTO DEVICES AND DISPLAYS. A 48-page "Solid-State Display and Optoelectronics Designer's Catalog" contains data sheets for all of HP's line of opto devices and solid-state displays. The four sections of the catalog contain detailed operating characteristics of photodetectors, isolators, LED lamps and LED displays. Each section has a selection guide high-lighting characteristics of each device important to the designer. Hewlett-Packard, Inquiries Manager, 1501 Page Mill Rd., Palo Alto, CA 94304. **256**

SEMICONDUCTOR FUSE HANDBOOK. It deals with fast-acting fuses, fuse characteristics, coordinating fuses with semiconductors and other applications. Copies of the 100-pg. handbook, HB-50, are available by writing on company letterhead to International Rectifier Corporation, Semiconductor Division, 233 Kansas Street, El Segundo, CA 90245.

THE 1973 INSTRUMENT CATALOG. Instrumentation covered in the 232-pg. catalog includes power, sweep, noise, AM/FM synthesized and programmable signal generator; precision terminations; fixed-variable and programmable attenuators; wave analysers and selective microvoltmeters; field-strength meters; spectrum analyzers; wideband microvoltmeters and power meters; impedance and reflection measuring equipment; R, L, C and Q meters; diode, transistor and IC testers; TV measuring equipment; and sound-level meters. Rohde & Schwarz Sales Co. (USA), Inc., 111 Lexington Ave., Passaic, N J 07055. **275**

HANDBOOK SPEEDS SOLUTIONS TO DESIGN PROBLEMS. Nomographs offer a way to get fast, accurate answers to design problems, and it is a rare engineer indeed who hasn't wished he could reach into his file to get just the nomograph he needs. Filling this wish is the just published book *Nomographs for Electronics: Instant Calculations for Designers* by R. L. Peters, Ph.D. (Cahners Books, Boston, 320 pp., $27.50). The author has assembled a collection of nomographs covering areas from basic electrical circuitry to supporting systems components such as motors and generators into an easy-to-use desk top directory. Cahners Books, Div. of Cahners Publishing Co., Inc., 89 Franklin St., Boston, MA 02110. **260**

VOLTAGE VARIABLE CAPACITOR GUIDE AIDS SELECTION. A 4-page selection guide, with design selection parameters for over 350 voltage variable capacitor diodes presents the important design parameters of capacitance—Q—PIV—and device type. On the fourth page of the literature, another important design tool a nomograph, is included. By using this nomograph, the design engineer can quickly determine the capacitance ratio between two operating voltages V_1 and V_2 and/or the capacitance at V_2 when the capacitance at V_1 is known. Codi Semiconductor Div. of Computer Diode Corp., Pollitt Dr. South, Fair Lawn, N J 07401. **272**

WAVEFORM GENERATORS are described in an 8-pg. catalog. The F200 Series are said to provide the most versatile and comprehensive features available. Complete specifications are provided as well as how-to-do-it information for generating a variety of waveforms AILTECH, 19535 E. Walnut Dr., City of Industry, CA 91748. **259**

MICROCIRCUIT DESIGN HANDBOOK. This 24-pg. publication features comprehensive guidelines for converting discrete component circuits into thick-film microcircuits. It offers complete sections on microcircuit applications, designing by plan, production and product reliability. Among design considerations discussed are definitions of current performance and packaging requirements, and evaluations of component power dissipation, density and compatibility. Helipot Div., Beckman Instruments, Inc., P.O. Box 11866, Santa Ana, CA 92711. **267**

LITERATURE

TAPE TRANSPORT INTERFACING. A 90-pg. OEM users manual provides the system designer with a comprehensive description of designing an interface for any of Pertec's synchronous digital magnetic-tape transports. The manual covers motion control, PE writing and reading, NRZI writing and reading, read-only and multiple transport configurations as well as a description of NRZI and PE tape formats. $2.75. Pertec Corp., Dept 735, 10880 Wilshire Blvd., Los Angeles, CA 90024. **265**

RELAY CATALOG describes 740 items. This 32-page, 2-color catalog completely describes stock relays for custom applications. Includes photos, dimensional drawings, specifications, prices and ordering information. Many new items have been added to this year's edition which includes general purpose, power, reeds, coaxial, telephone type, time delay, solid state, and mercury displacement relays. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, IL 60630. **269**

ELECTRONIC INSTRUMENTATION CATALOG. This 52-pg. catalog provides detailed descriptions and specifications for the complete Heath/Schlumberger line of design and lab instrumentation. Included is a series of vhf counters that can provide capability to 600 MHz for as little as $795, and a complete line of oscilloscopes, generators, power supplies and digital voltmeters. Digital instrumentation includes the lowest cost patchable minicomputer interface system on the market, complete digital systems for design, research and teaching, individual modules and a wide variety of plug-in circuit cards for functions in both the analog and digital domains. Heath/Schlumberger Scientific Instruments, Benton Harbor, MI 49002. **263**

EPOXY B REPORT. This 16-pg. booklet describes the properties and test results of a new semiconductor IC package material. The report includes background information on the development of Epoxy B and the results of various studies conducted on devices made with Epoxy B. The test data is based on thermal intermittent studies, operations life tests, moisture resistance tests including humidity at high temperature and salt atmosphere, and other considerations. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **271**

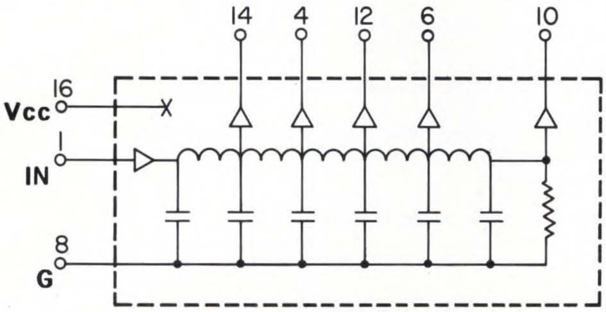
LED PRODUCT SELECTOR GUIDE. The 72-pg. guide is divided into nine product categories—Light Sources; Ultra-Miniature Indicators; 0.625-in. Readouts and 0.205-in. Readouts; 0.300-in. Readouts; Decoder/Drivers; Switches and Opto-Isolators. All the units described work with or contain LEDs. For each product category, complete specifications, curves, applications and mounting details are given. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. **270**

SUB-MINI/SOLID STATE LAMPS Cataloges include the Miniature Lamp (3-6253) in which the bulb sizes are given in in. and metric equivalents. This is the first time for any GE lamp cataloge. Others include the Sealed Beam Lamp (3-6251); the Sub-Miniature Lamp (3-6252); Solid State Lamps (3-6254) and an Index (3-6255) which lists all lamps and the specific cataloge in which they appear. Please identify cataloge number. Inquiry Bureau, General Electric, Nela Park, Cleveland, Ohio 44112.

APP NOTE DETAILS OPERATION OF COUNTER TIME-BASE IC. The versatile low-power divider chain contained in the MK 5009 replaces eight TTL decade dividers, as well as other logic. Note describes these useful applications for the MK 5009 P, universal time-base circuit: A low-power frequency counter; wide range pulse generator; thumbwheel programmed timer. Also included is descriptive information about the 5009's on-chip oscillator circuit. Along with frequency counters, the 5009 is useful in a variety of other instrument, timer and clock applications. Mostek Corp., 1215 W. Crosby Rd., Carrollton, TX 75006. **261**

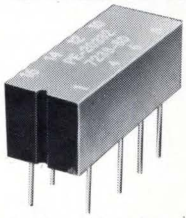
LINEAR SHORT-FORM CATALOG is a guide to all of Philbrick's latest developments in analog technology. Specially featured is Philbrick's 1421, 1422, 1424, 1425, 1426, 1428 and 1429 Series of economy FET microcircuit op amps; Model 1324 fast-settling monolithic op amp; the 1028, 1029, 1030, 1702 and 1703 discrete op amps; and the 1423 and 1427 microcircuit units. A section of nonlinear function modules and low-cost modular power supplies completes the product descriptions. Teledyne Philbrick, Allied Dr., at Rte. 128, Dedham, MA 02026. **274**

NOW Available Without DELAY



Exclusive from Pulse Engineering

DIGITAL DELAY MODULE



actual size

Designed specifically for TTL and DTL compatibility.

Built-in interface allows direct plug-in without additional components.

Module load incorporation reduces number of required components for specific delays, offering your most economical approach to precision digital timing.

Valuable board space saved because all drivers, buffers, terminations contained in the DDM.

PE No.	Delay Time	Delay/Tap	No/Taps	Rise Time
20330	50ns	10ns	5	4ns
20331	100ns	20ns	5	4ns
20332	250ns	50ns	5	4ns

SPECIFICATIONS

Supply Voltage Vcc	+4.5 to 5.5 V DC
Logic 1 Input Current	50 μa Max.
Logic 0 Input Current	−2 ma Max.
Logic 1 Vout	2.4V Min.
Logic 0 Vout	0.4V Max.

Drive Capabilities:

Logic 0 Output	10 TTL Loads/Tap Max. (20 TTL Loads/Unit Max.)
Logic 1 Output	20 TTL Loads/Unit Max.

Pulse Engineering Inc.

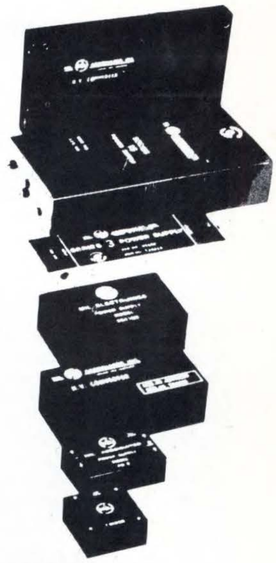
A Varian Subsidiary

Pulse Engineering, Inc.
P.O. Box 12235 • San Diego, Calif. 92112
Phone 714-279-5900 • TWX 910-335-1527

CHECK NO. 77

MIL

DC to DC POWER SUPPLIES



- NEARLY 1,000 STANDARD MODELS TO CHOOSE FROM
- HIGH VOLTAGE—LOW VOLTAGE
- METAL CASE—EPOXY CASE
- PRINTED CIRCUIT PINS—SOLDER TERMINALS
- UP TO 20 WATT PACKAGES
- REGULATED—UNREGULATED
- UNITS QUALIFIED TO MIL SPECS.
- DELIVERY FROM STOCK TO 2 WEEKS

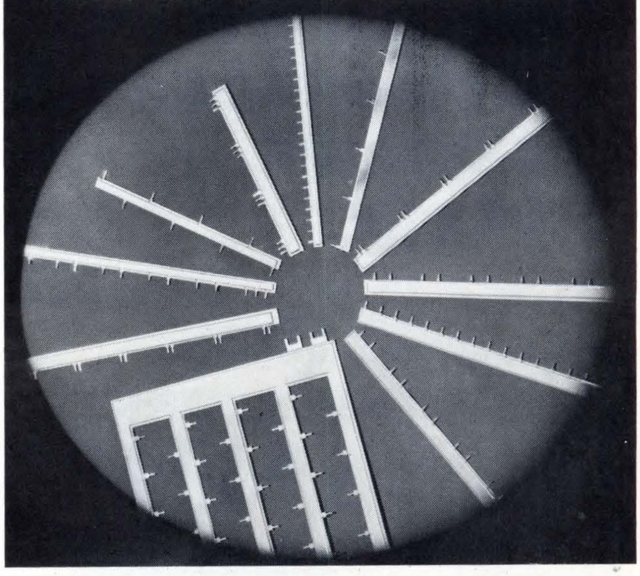
SEND FOR FREE CATALOG

MIL ELECTRONICS, INC.
LOWELL, MASS 01854
617 - 453 - 4142

CHECK NO. 51

Millions already in use

NEW KIT LETS YOU TRY IT



Evaluation kits @ $25 in stock.
Standard parts on 2 weeks delivery, or less!
Custom parts 4 to 6 weeks delivery!

MINI/BUS The low-cost, noise attenuating, high packaging density, power distribution system for PC boards. Ask for data.

Rogers Corporation / Chandler, Arizona 85224
West: (602) 963-4584 **East: (203) 774-9605**

CHECK NO. 87

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.
161 Fleet Street
London, EC4P 4AA, England
Telephone: London 01-353-5011
Telex: 267449

Domestic

Hugh R. Roome
Publisher
221 Columbus Ave.
Boston, Mass 02116
(617) 536-7780

NEW YORK CITY 10017
Richard Miller, District 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
Eli Warsaw, District Manager
5670 Wilshire Blvd.
(213) 933-9525

The perfect combination.

A synthesizer/signal generator that sets a new standard in RF performance–all the way to 1300 MHz!

The new HP 8660B Synthesized Signal Generator has all the precision and stability you'd expect from a synthesizer. Plus performance features, operating functions and ease of operation far surpassing what you would normally find in a signal generator.

The keyboard, plus its 10-digit LED display, gives you error-free fingertip control of operating frequencies. For example, enter your center frequency and then the frequency increment corresponding to channel spacing. Now you can change the frequency up or down by that precise increment just by pushing the STEP button. Similarly you can enter sweep width for precision swept frequency testing. For total operating flexibility you can also tune the generator manually over its entire frequency range. In all these modes you get accurate signals with synthesizer stability and spectral purity.

The instrument's modular concept allows for great flexibility in both frequency coverage and modulation. Two RF plug-in units have these outstanding characteristics: 0.01 to 110 MHz or 1 to 1300 MHz frequency coverage, settable in 1 Hz steps; −80 dB spurious; < 1.5 Hz residual FM; 3×10^{-8}/day stability; +10 to −146 dBm calibrated output. Precision AM and FM modulation capability, available as an option, greatly increases the 8660's versatility.

The 8660B keyboard-entry mainframe is $6000. RF plug-ins, 0.01 to 110 MHz, $1975; 1 to 1300 MHz, $4800. Modulation plug-in, $900. A lower cost unit ideally suited for remote program applications is the 8660A mainframe. The variety of modular options makes it possible for you to "custom-tailor" a system to your exact needs, with prices for a complete system starting at $5875.

Ask your field engineer for complete information about the immensely versatile 8660 Synthesized Signal Generators. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

04204

HEWLETT hp PACKARD

SIGNAL GENERATORS

Think big

50,000 Volts

For long-term continuous loading, Dale Type F film resistors provide working voltages to 14 KV, pulse voltages to 50 KV with less than 1% change after 2,000 hours. Lead and/or threaded cap terminations. Write for Bulletin M7C.

1,000,000,000 Ohms

Fill ultra-high resistance requirements with Dale Type M and MH film resistors. Miniature sleeved or glass enclosed models with values from 60 Meg. to 1KM. Excellent stability (0.5%/yr.). Tolerances as low as 1%. Write for Bulletin HV8C.

1,000,000 pieces RL20...3¢

RL07 and RL20 needs can be swiftly met with a choice of two materials—metal film (Type CM) and metal oxide (Type F). Fast delivery in quantity. Call for details.

Think Dale

DEPENDABLE DALE®

Save selection time...send for and use Dale's helpful and complete **Guide to Film Resistors.** Circle Reply Number for your free copy.

DALE ELECTRONICS, INC., 1300 28th Ave., Columbus, NE 68601
A subsidiary of The Lionel Corporation • In Canada Dale Electronics Canada, Ltd.

CHECK NO. 3