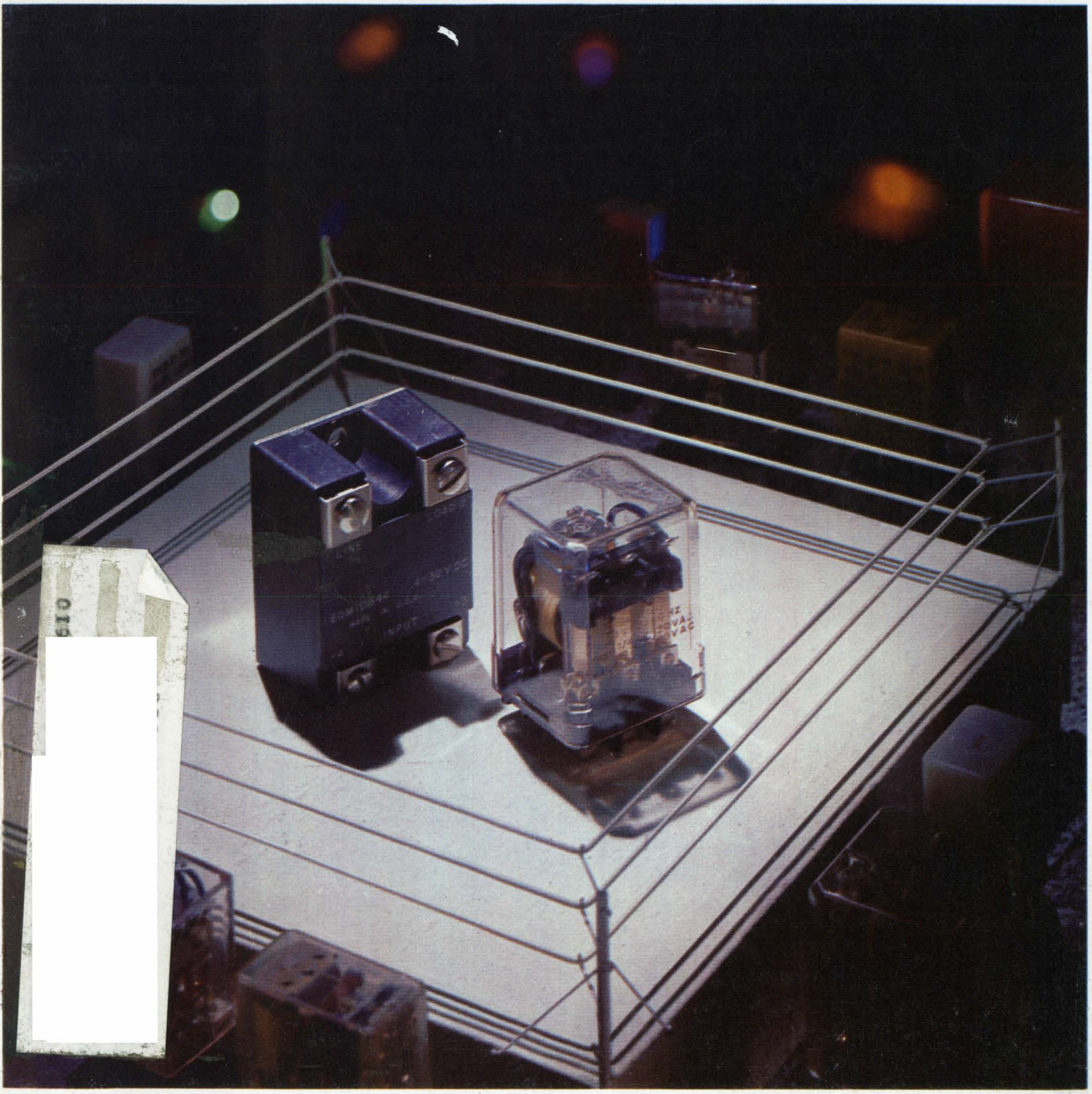
VOL. 24 NO.

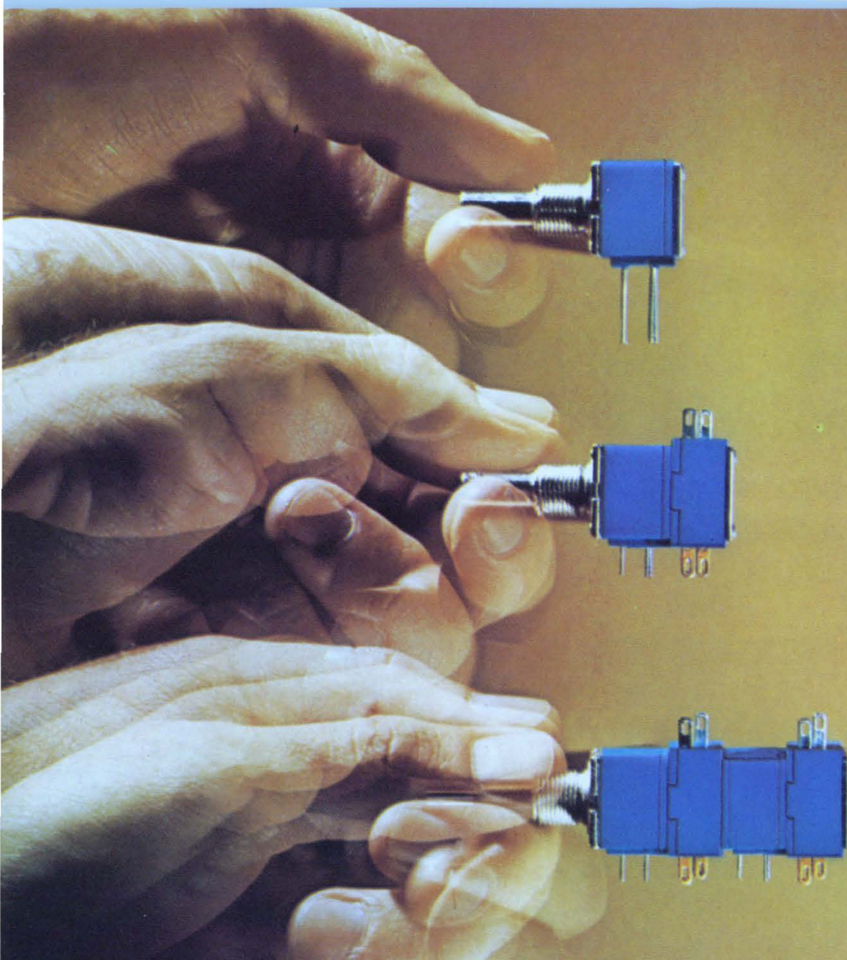
Electronic Design 26

FOR ENGINEERS AND ENGINEERING MANAGERS

DEC. 20, 1976

Solid-state relays fight for sales with winning punches. But load specs are often feints, not true performance. And transients and heat can deliver knock-out blows. However, SSRs can be winners with silent operation, long life and zero-voltage turn-on. Make sure you're in the right corner. Get a ringside view on p. 48.





FEEL
the pot . . .

CLICK
the switch . . .

GANG
the modules . . .

and add "feel appeal" to your product.

FEEL THE POT . . . a smooth, quality feel, only from Bourns® 81/82 Model Potentiometers. Rotational torque range, only .3 to 2.0 oz. inch, is consistent for one, two, three or four cup assemblies.

Independent linearity of ±5% and low 1% CRV provide exceptional setability in both cermet and conductive plastic element types.

CLICK THE SWITCH* . . . one that really clicks, with positive action detent at either CW or CCW end. The Bourns Model 85/86 potentiometer/switch combination is rated at 2 amps in DPST style and 1 amp in DPDT. Contacts are constructed of fine silver with gold overlay. This provides exceptionally low contact resistance, for reliable operation at low level analog or logic signal levels — or any application requiring an "on-off" function.

GANG THE MODULES . . . potentiometers and switches. Up to 4 modules can be ganged on the same single or dual concentric shaft, without sacrifice to the satin-smooth feel or the sure-fire click. Other options include a wide choice of bushing and shaft styles, P.C. pins or solder lugs. Think of the possibilities! Now you can specify custom pots and switches assembled from "off-the-shelf" modules — at standard cost and leadtime.

Add "feel appeal" to your equipment with BOURNS Model 80 Family of Modular Potentiometers and Switches. Write or call today for complete technical information, direct or through your Bourns distributor.

FEEL, CLICK, GANG . . . BEAUTIFUL!

TRIMPOT PRODUCTS DIVISION, BOURNS, INC., 1200 Columbia Avenue, Riverside, California 92507, Telephone (714) 781-5122 — TWX 910 332-1252.

*Patent pending

BOURNS®

Int'l Sales Offices: European Hdqtrs. — Switzerland, 042/23 22 42 • Belgium 02/218 2005 • France 01/2039633 • Germany 0711/24 29 36 • Italy 02/32 56 88 • Netherlands 070/88 93 18 • United Kingdom 01/572 6531 • Japan 075 92 1121 • Australia 86 9410 • Brazil 257-3535

CIRCLE NUMBER 252

You probably remember our Model 3000 (shown at left)—the AM/FM phase-locked signal generator that covers the 1 to 520 MHz frequency range? Well, now we've got a companion model that's even better. The new Model 3001 is identical to the 3000 except: (1) FM accuracy is now 0.001%; (2) A ±5 kHz frequency vernier is provided in all modes; (3) You can lock the 3001 to an external frequency standard (optional at $150); and (4) An internal reference frequency standard (with 5 x 10^{-9}/day stability) is also an available option at just $500.

At just $2,600, the Model 3001 is a downright bargain when you consider its accuracy, stability, programmability, and ease of operation.

We'll gladly send you detailed specifications on our competitive new signal generator. When we're competing with ourselves, we know everything about the competition.

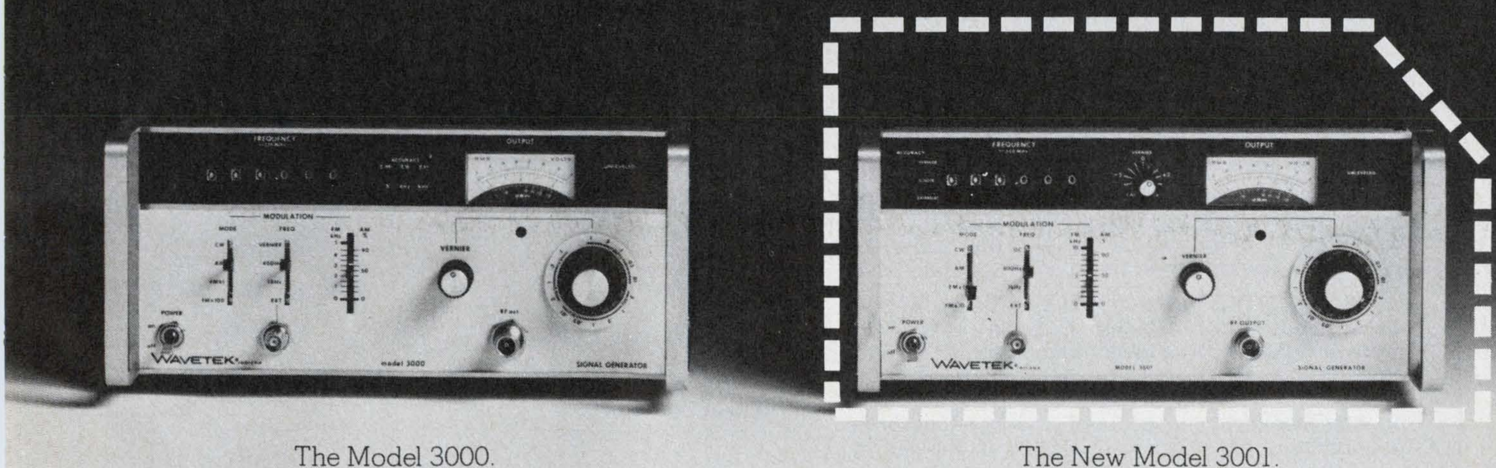
Model 3001 Specifications:
Frequency Range: 1-520 MHz
Frequency Accuracy: ±0.001% (all operating modes)
Resolution: 1 kHz
Stability: 0.2 ppm per hour
Output Range: +13 dBm to −137 dBm
Flatness: ±0.75 dB
AM Modulation Range: 0-90%
FM Deviation Ranges: 0-10 kHz and 0-100 kHz
Internal Modulation Rates: 400 Hz and 1 kHz
Dimensions: 12" wide x 5½" high x 13¾" deep

WAVETEK Indiana Incorporated, P.O. Box 190, 66 North First Avenue, Beech Grove, Indiana 46107, Phone (317) 783-3221, TWX 810-341-3226.

WAVETEK®

CIRCLE NUMBER 2

The signal generator competition never showed up. So we're it.



The Model 3000. The New Model 3001.

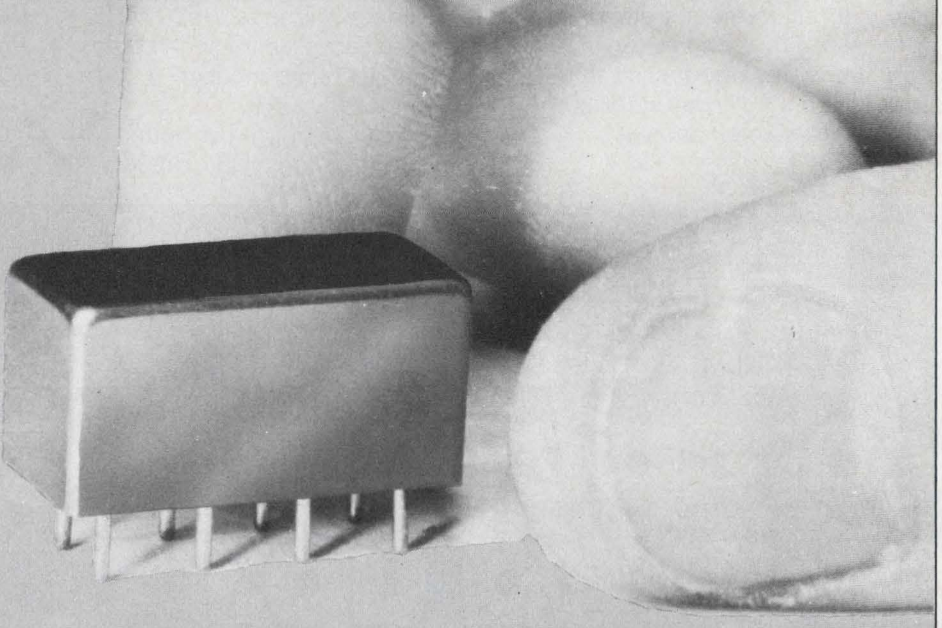
The only Double-Balanced Mixers with a 2-YEAR GUARANTEE*

featuring Hi-Rel tested diodes-

still only

$7.95 **(500 pieces)**

$9.95 (1-49)



***including diodes!**

Yes, a two-year guarantee for DBM's is now a reality . . . made possible by an accelerated-life diode screening program adopted at Mini-Circuits.

Each Schottky diode used in Mini-Circuits' SRA-1 mixers is now preconditioned by the HTRB (High Temperature Reverse Bias) technique, previously reserved almost exclusively for semiconductors assigned to space applications. With HTRB testing, each diode is operated for 168 hours at 150°C with one volt reverse bias applied.

To screen out "infant mortality", the diodes are deliberately stressed to accelerate aging and to force time-related failure modes to take their toll. In conventional testing or "baking", the diode does not experience anywhere near the stress encountered with the HTRB program. Hence, the ability at Mini-Circuits' to locate the potentially-unreliable diodes before they are assembled into SRA-1 units And, with double-balanced mixers, the overall reliability hinges almost entirely on the diodes used.

Yes, the HTRB procedure costs us more and screens out more devices. But our goal is to improve reliability to a level unmatched for off-the-shelf DBM's at no increase in cost to our customers. You — our customers by your overwhelming confidence in our product line have made us the number one supplier of DBM's in the world.

To earn your continuing support, we are now employing HTRB Hi-Rel testing for every diode used in the SRA-1, at no increase in cost to you. So, for the same low price of $7.95, you can purchase our SRA-1, with a two-year guarantee, including diodes.

To ensure highest system reliability demand highest quality diodes on your source-control drawings and purchase orders. Specify SRA-1 mixers, with HTRB tested diodes from Mini- Circuits:.. where low price now goes hand-in-hand with unmatched quality.

MODEL SRA-1

Freq. range (MHz) **LO** - 0.5-500, **RF** 0.5-500, **IF** dc-500

Conversion loss (dB)		**Typ.**	**Max.**
One octave from band edge		5.5	7.5
Total range		6.5	8.5
Isolation (dB)		**Typ.**	**Min.**
Lower band edge to	**LO-RF**	50	35
one decade higher	**LO-RF**	45	30
Mid range	**LO-RF**	45	30
	LO-IF	40	25
Upper band edge to	**LO-RF**	35	25
one octave lower	**LO-IF**	30	20

Min. Electronic attenuation (20 mA) 3 dB

Signal, 1 dB compression level + 1 dBm

Impedance all ports 50 ohms

HTRB Tested (High Temperature Reverse Bias)

Mini-Circuits Laboratory

MCL

A Division Scientific Components Corp

837-843 Utica Avenue, Brooklyn, NY 11203
(212) 342-2500 Int'l Telex 620156
Domestic Telex 125460

International Representatives: **AUSTRALIA** General Electronics Services, 99 Alexander Street, New South Wales, Australia 2065; **ENGLAND** Date Electronics, Dale House, Wharf Road, Frimley Green, Camberley Surrey; **FRANCE** S. C. I. E. - D. I. M. E. S., 31 Rue George - Sand, 91120 Palaiseau, France; **GERMANY, AUSTRIA, SWITZERLAND** Industrial Electronics GMBH, Kluberstrasse 14, 6000 Frankfurt/Main, Germany; **ISRAEL** Vectronics, Ltd., 69 Gordon Street, Tel Aviv, Israel; **JAPAN** Densho Kaisha, Ltd., Eguchi Building, 8-1 1 Chome Hamamatsucho Minato-ku, Tokyo; **EASTERN CANADA** B. D. Hummel, 2224 Maynard Avenue, Utica, NY 13502 (315) 736-7821; **NETHERLANDS, BELGIUM, LUXEMBOURG:** Coimex, Veldweg 11, Hattem, Holland. **NORWAY** Datamatik AS, Ostensjoveien 62, Oslo 6, Norway

US DISTRIBUTORS: NORTHERN CALIFORNIA Cain-White & Co., Foothill Office Center, 105 Fremont Avenue, Los Altos, CA 94022 (415) 948-6533; **SOUTHERN CALIFORNIA, ARIZONA** Crown Electronics, 11440 Collins Street, No. Hollywood, CA 91601 (213) 877-3550

For complete product specifications and U.S. Rep. listing see MicroWaves "Product Data Directory," Electronic Designs' "Gold Book" or Electronic Engineers Master "EEM"

CIRCLE NUMBER 3

VOL. 24 NO.

Electronic Design 26

FOR ENGINEERS AND ENGINEERING MANAGERS

DEC. 20, 1976

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: by Business Arts, courtesy of Potter and Brumfield, Princeton, IN

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 50 Essex St. Rochelle Park, NJ 07662. James S. Mulholland Jr., President. Printed at Brown Printing Co., Waseca, MN. Controlled circulation postage paid at Waseca, MN and New York, NY, postage pending Rochelle Park, NJ. POSTMASTER: Please send form 3579 to ELECTRONIC DESIGN, P.O. Box 13803, Philadelphia, PA 19101.

The only microcomputer with the power of a PDP-11. The PDP-11/03.

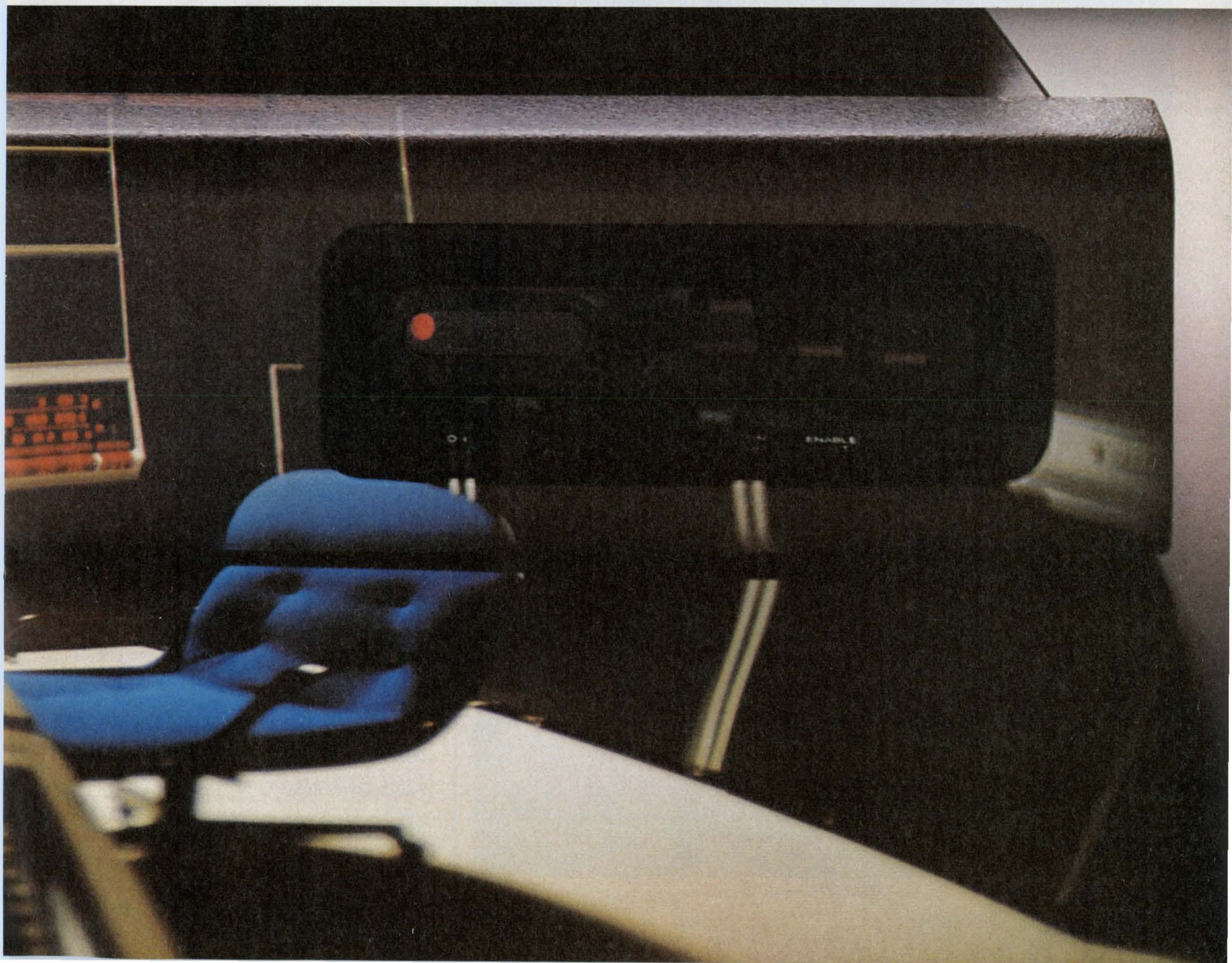
If you've been looking for a microcomputer with minicomputer power at a micro price, join the hundreds of OEMs who've already found it with the DIGITAL microcomputer. The PDP-11/03.

The 11/03 gives you everything you could ask for in a small computer. High performance. High reliability. And a low price — just $1,357 in quantities of 50. And that micro price buys you mini features that quickly translate into benefits OEMs appreciate. Features like full PDP-11 instructions with eight general purpose registers for fast program development. RAM (MOS or Core) and PROM memories that let you match the memory with the application. Hardware vectored interrupts with stack processing for real computer power. And multiple-sourced components for sure delivery.

Buying our 11/03 also buys you the chance to start small without staying small. Because you can add up to 32K words of memory, fast floating point instructions, and more. Whenever you and your customers are ready.

Besides growing bigger in size, the 11/03 lets you grow bigger in scope. It's software compatible with every other PDP-11 we offer. From our LSI-11 all the way up to our medium scale PDP-11/70. That means you can take full advantage of Digital PDP-11 software and services.

You can also take advantage of Digital's OEM Referral program — your chance to take on an international marketing and support team without hiring them. The OEM Referral program can help you locate new custom-



Across the Desk

Guess what's hiding in the calculator?

Anyone using Texas Instruments' SR-52 might be interested to know that up to 28 "software" data registers are "hidden" within the calculator. It doesn't mention these registers in its user's manual. Program memory can be automatically partitioned into these 28 additional registers, each of which has a length of eight storage locations.

Keyboard addresses of these registers range from 70 (location 000) to 97 (location 216), inclusive, and are accessed via STO and RCL operations. Even though these software registers are not cleared by the CMs key, they do prove useful in the storage of both program codes and data for transfer to magnetic cards.

The user must keep careful track of the program-address space; however, the remainder of memory can be used to store data in register locations lying above the program. Data are automatically formatted for either scientific or fixed and floating notation. A microprogram performs the address conversion and data formatting.

J. M. Davidson
Research Engineer
Applied Automation, Inc.
Pawhuska Rd., RB2 106
Bartlesville, OK 74004

Forget us not

Having read Stanley Runyon's "Focus on Network Analyzers" (ED No. 16, August 2, 1976, p. 50), I was quite surprised to find that EMR's Model 1172 Frequency Response Analyzer had been deleted from the article, particularly since our primary competitor, Bafco, was included, and EMR was included in the vendors' list at the end of the article.

Marshal Fram
Product Line Manager
Dynamic Analysis Instrumentation
EMR Telemetry
Weston Instruments, Inc.
P.O. Box 3041
Sarasota, FL 33578

What's in a name . . .

In our News Briefs section of the November 8, 1976 issue (Vol. 24, No. 23, p. 16), we accidentally referred to American Microsystems, Inc., as *American Micro Devices*. Our apologies. *Moreover, the company doesn't make an all-solid-state telephone—just the circuits.*

Loved the article, but . . .

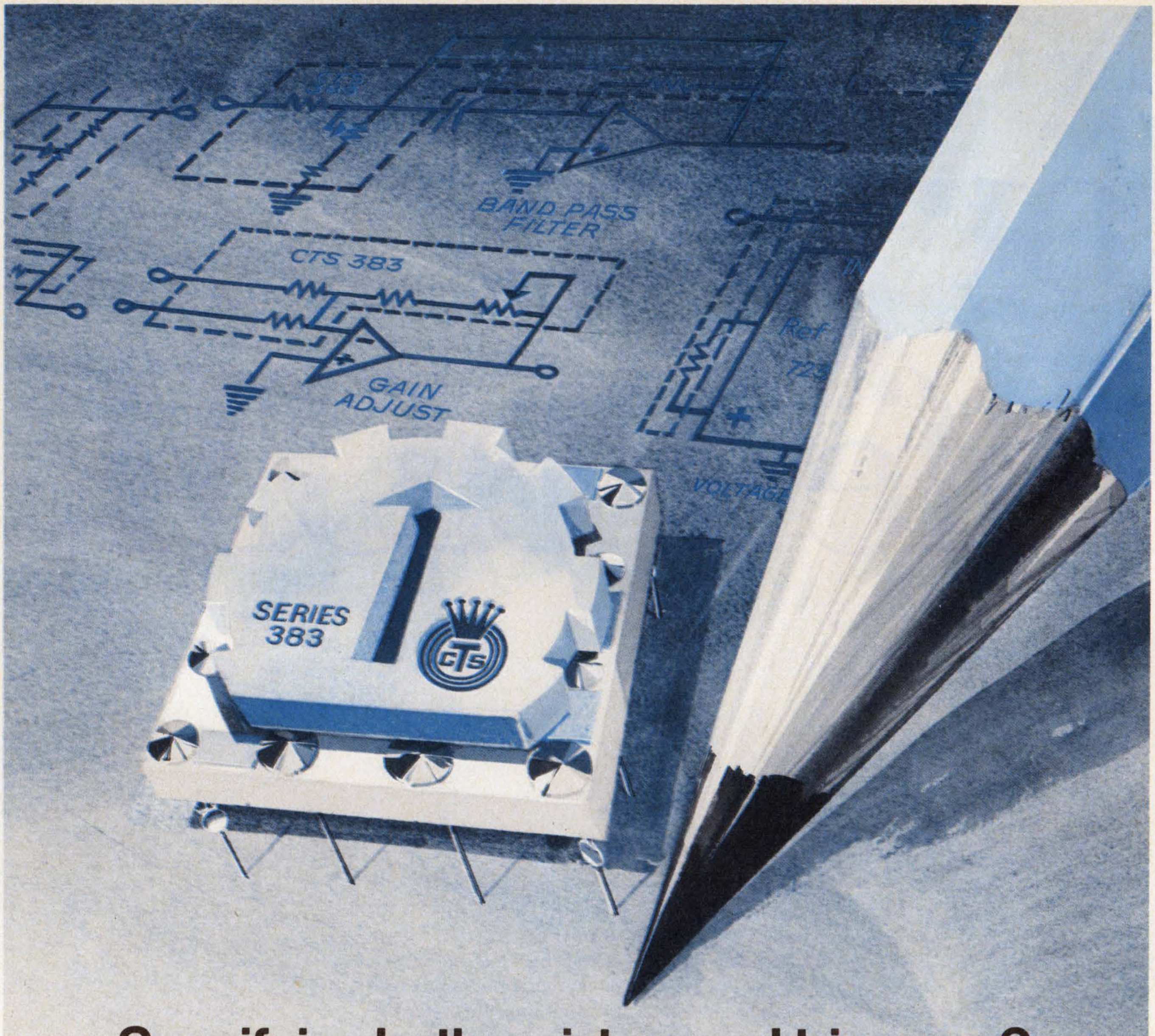
Thank you for "FCC Swamped with Complaints as Sources of RFI/EMI Increase" (ED No. 20, September 27, 1976, p. 24). The article is well written, presents the problem in a readily understandable manner and is one of the best general articles on the subject of interference and its control that I have read.

There are a few minor inaccuracies. In the section, "Battle lines drawn," you refer to the Citizen's Radio *Station* of EIA. This should be Citizen's Radio *Section*. In the same paragraph, you refer to John Sadowsky as EIA staff vice president of communications. His name is John Sololski and his title is Staff Vice President, Communications Div. On page 34, paragraph 2, you say that the FCC proposes to discard its *1948* maximum-emission

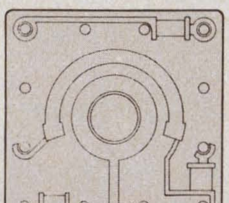
(continued on page 13)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St. Rochelle Park, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

Dance
It's the Tri-



Specifying both resistors and trimmers? Here's a single solution from CTS.



CTS proudly presents a single solution to many of the problems you face in specifying resistors and trimmers . . . the Series 380 thru 384 Cermet Resistor/Trimmer combinations.

Have Board Space Problems? The Series 384 offers you up to eight fixed resistors plus a trimmer in a .46" square (.275" high) package.

Need Hefty Power Capability? All units in this Series can handle one watt at 70°C and ¾ watt at 85°C.

Need Cermet Stability? ±250 ppm/°C is the standard temperature coefficient in this Series with ±100 ppm available for your critical needs.

Want Rock Bottom Prices? The Series 383 (shown above) provides you combinations of three fixed resistors plus a trimmer for only 35¢ in production quantities. The Series 380 trimmer only is priced under 25¢. This economical space saving form factor is available as a trimmer only, in resistor/trimmer networks, and as resistor networks only. Let the Application Engineer from CTS Microelectronics help you decide which Series is best for your design.

CTS MICROELECTRONICS, INC., 1201 Cumberland Avenue, West Lafayette, Indiana 47906. Phone (317) 463-2565.

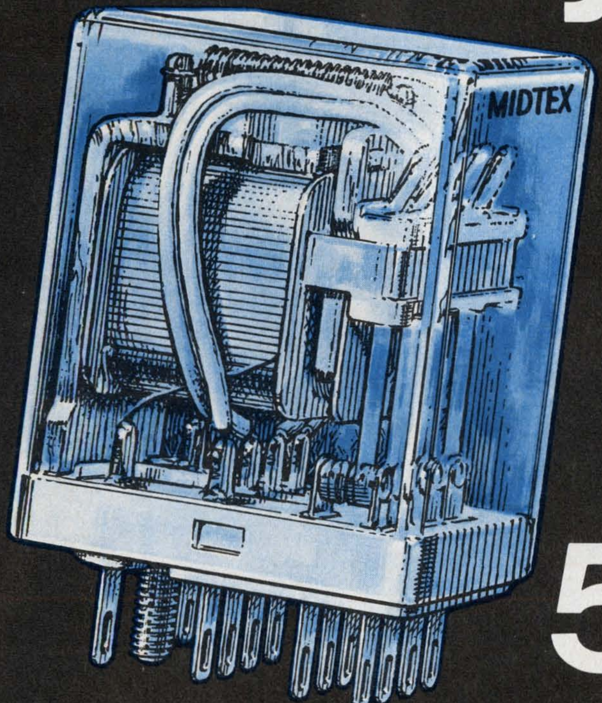
CTS CORPORATION
Elkhart, Indiana
A world leader in cermet and variable resistor technology.

CIRCLE NUMBER 6

CIRCLE NUMBER 7 ►

Meet the cost cutter

New wire-wrap relay socket cuts costs up to 50% per connection



Here is the first wire-wrap® socket in the industry for a standard industrial relay. It can cut your connection costs in half because now you can wire-wrap industrial relays, too! It's another new idea from Midtex.

Wrapped wire connections cut costs because they're faster. Less than half the time it takes to solder.

Wrapped wire connections cut costs because they're cleaner. No solder splatter or wire clippings to short.

Wrapped wire connections cut costs through standardization. PCBs and relays *all* can be wire-wrapped . . . at once.

Designed for our Type 156 4PDT 3 amp relay, the Midtex wire-wrap socket provides 14 mating terminals, .031″ x .062″ x .75″, and will accept solid wire wrapped or stranded Termi-point connections ranging in size from 20 AWG to 26 AWG. Terminals will provide for three separate connections. Socket dimensions: .75″ x 1.55″; two .160″ diameter mounting holes are 1.3″ center-to-center. Socket body is U/L approved G.P. Phenolic.

Our job is to help you make your job more profitable through relays and relay assemblies. Midtex, The Total Relay Company.

® Trademark of Gardner-Denver Co.

MIDTEX
INCORPORATED
1650 TOWER BLVD., N. MANKATO, MN 56001
PHONE 507 625-6521 TWX 910-565-2244

PROGRAMMERS / TIME DELAY RELAYS / MINIATURE COAXIAL RELAYS / INDUSTRIAL RELAYS / MERCURY-WETTED CONTACT RELAYS

You get variety, unique design, economy and more when you specify AMP's DIP sockets. You get more performance.

And that's what all the features of AMP's DIP and microprocessor sockets add up to.

Take variety. You can choose from standard and low profile housings, a wide range of sizes, tin or gold plated contacts, in widths of .300″, .400″ or .600″. And that's only the beginning.

There's design and economy. DIP socket contacts include a unique retention feature. It makes sure that every socket you insert into a pc board will stay there, even during the soldering process.

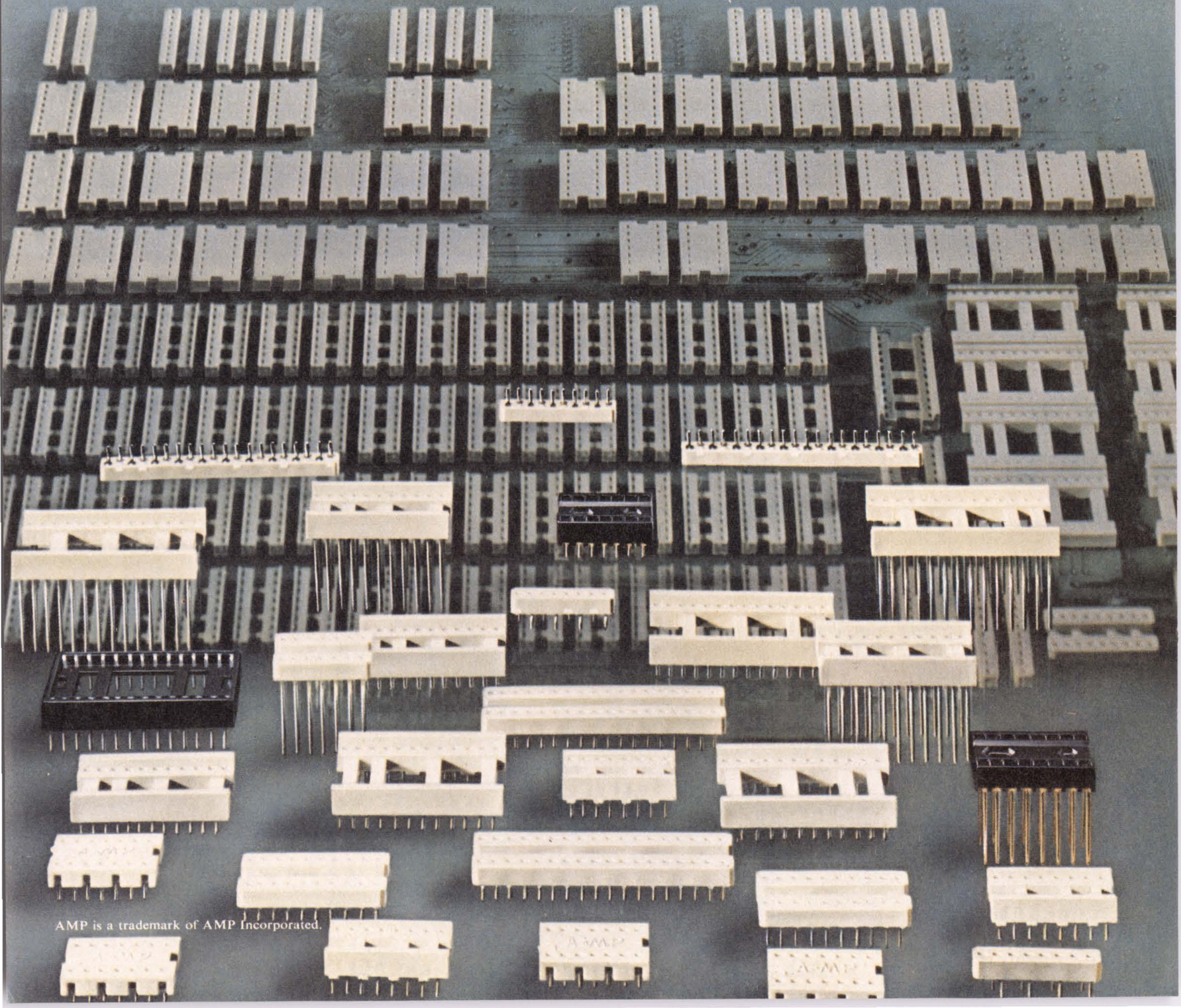
The design also prevents solder wicking problems. And with AMP automatic insertion equipment, the sockets can be installed at rates to meet your production needs.

And don't forget AMP's solid backup. You can count on it with the kind of personal attention your product line deserves.

So why not get AMP quality when you need DIP and microprocessor sockets. Just call Customer Service at (717) 564-0100. Or write AMP Incorporated, Harrisburg, PA 17105.

AMP
INCORPORATED

CIRCLE NUMBER 8



ACROSS THE DESK

(continued from page 7)

standard of 15 μV/m at $\lambda/2\pi$. Actually, this standard was first adopted in 1938 and has been in effect under various rule numbers since that date.

Herman Garlan, Chief
RF Devices & Experimental Branch

Federal Communications Commission
Washington, DC 20554

Misplaced Caption Dept.

This new geiger counter runs for three years on a single D cell. Then you need a sword to cut through the corrosion when you change the battery.

Sorry. That's Francisco Goya's "General Jose de Urrutia," which hangs in the Prado Museum in Madrid.

Don't start a trend we are trying to avoid

In your article on CRTs (ED No. 17, August 16, 1976, p. 26), you state:

"A widespread misconception about CRTs is that if you don't buy a standard item, you will pay more for the device. That may be true in some cases, but in most instances a tube design can be fit to an application with no engineering charge by putting together existing gun, screen and envelope designs."

For some time, we and some of our customers have been striving to achieve a higher degree of standardization of CRT types and CRT parts. Your comment encourages a counter trend.

Many manufacturers in our industry are plagued by short runs of a large variety of sophisticated tube types. This greatly reduces the effectiveness of our engineers, deteriorates the profit margins in our industry and reduces the effectiveness of our products.

Our customers are unable or unwilling to support the costs of retooling and preparing new processes for revised types. The changes, which often appear to be simple, embody subtle problems that result in schedule delays as well as excess cost to the user and the manufacturer.

Unless our industry can return to a higher degree of use of common tube types, the deterioration of the quality and potential of the industry will continue, and a very essential aspect of the U.S. display industry will be further compromised.

William N. Moody
President

Tubes & Devices Corp.
DuMont Electron
DuMont Div.
750 Bloomfield Ave.
Clifton, NJ 07015

Whose 2909, 2911?

You'd never know it from the article, "Bipolar Controllers—They're Fast, Cheap and Easy to Use" (ED No. 22, October 25, 1976, pp. 106-110), but two leading bipolar microprogram sequencers, the 2909 and 2911, were pioneered by Advanced Micro Devices of Sunnyvale, CA.

Interested now?

CIRCLE NO. 88

Second glance at naked model

In our June 7, 1976 Computer '76 Issue (ED Vol. 24, No. 12, p. 88) Computer Automation was incorrectly mentioned as offering the Naked Milli LSI-3/04. The correct model number is the Naked Milli LSI-3/05.

TEN-FOUR, CB-LAND, DO YOU COPY?

. . . Hammer up and lay an eyeball on this copy for a minute. We don't want to overmodulate, but we've got four handbooks that, for not much lettuce, can have you doing your thing in the left lane in no time.

How to get your license from Uncle Charley. How to select and set up a rig. How it works. How to fix your set when something's dusting your ears. Do you copy . . . it's all here!

Whether you're a green apple or a trucking guy, even if you drive a pregnant roller skate and want help the next time you get bubble trouble, here's the information, tips and techniques you need.

Use the coupon and put down your handle (name) and 10-20 (address) to order the book (s) you want. They come with a 15-day money back guarantee. And keep the wheels spinning and the beavers grinning.

HAYDEN BOOK COMPANY, INC., 50 Essex St., Rochelle Park, N. J. 07662

☐ **MOST OFTEN ASKED QUESTIONS AND ANSWERS ABOUT CB RADIO**
CB Magazine Staff

Everything from "WHAT DOES CB MEAN?" to "HOW DO RG-58 and RG-59 CABLE DIFFER?" Over 160 questions sent in to *CB Magazine* cover all you need to know to really enjoy your rig. 5747-4, $3.95.

☐ **CITIZENS BAND RADIO Revised 2nd Edition**
Allan Lytel

Compares different types of equipment . . . how they work . . . maintenance and repair . . . the FCC and you. 5737-7, $4.90.

☐ **PRACTICAL CB RADIO SERVICING Revised 2nd Edition**
R. R. Freeland

How to handle just about every problem you'll ever face. Step-by-step instructions, including spot-testing and trouble-shooting. Filled with charts, diagrams, illustrations. 0869-4, $6.95.

☐ **CBers' HOW-TO BOOK**
Leo G. Sands

How to select and install equipment, including mobile and base stations . . . codes and channels . . . how to modify your rig for greater convenience and performance. 0718-3, $4.95.

Please send the books checked on 15-day examination. Enclosed is my check for $______—Include your state sales tax (NJ-5%, CA-6%, FLA-4%) and 65¢ per book for postage & handling. I understand that I may return the book(s) within 15 days for a complete refund if not satisfied.

Name ________________

Address ________________

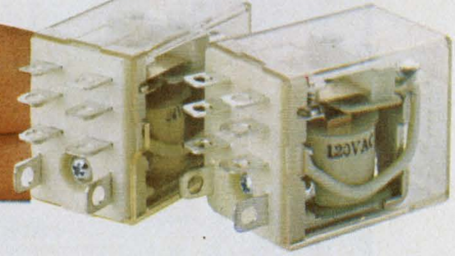
City ________________

State/Zip ________________

76-47

THIRTEEN JUST BECAME YOUR LUCKY NUMBER

NEW! 1390 and 1395 DPDT



Two new 1300 series relays give you the most complete line of miniature enclosed relays to meet your most exacting specifications.

Your Guardian Angel calls these relays the 1300 series. You'll call them miraculous. Check these specs for proof:

1310 AC and 1315 DC relays, 4 PDT, 5 amp in your choice of .107″ solder lug or .059″ printed circuit termination.

1330AC and 1335DC relays, DPDT, 5 amp with .098″ solder lug or .059″ printed circuit termination.

NEW! **1345DC relay, SPST-NO, SPST-NC, or SPDT, 10 amp.** Termination is standard .055″ x .030″ printed circuit. Just over a cubic inch small, yet specifically designed for low cost, high reliability.

NEW! **1390AC and 1395DC relays, DPDT, 13 amp.** Dual type .187″ or solder lug termination. Space saving, compact. Give large control capacity in about half the size of competitive relays that do the same job. Small price, too.

1360AC and 1365DC relays, DPDT, 5 amp with .060″ diameter, 13/64″ long terminal pins on .1″ grid spacing for PC board. Also available in SPST and SPDT up to 50 amps.

Mounting sockets and hardware. A complete line of solder lug, PC and wire wrap sockets. Plus, side mounting/permanent stud hardware that allows you to mount these relays in any position.

NEW! 1345 SPST-NO, SPST-NC, SPDT

Send for the free book that tells it all:

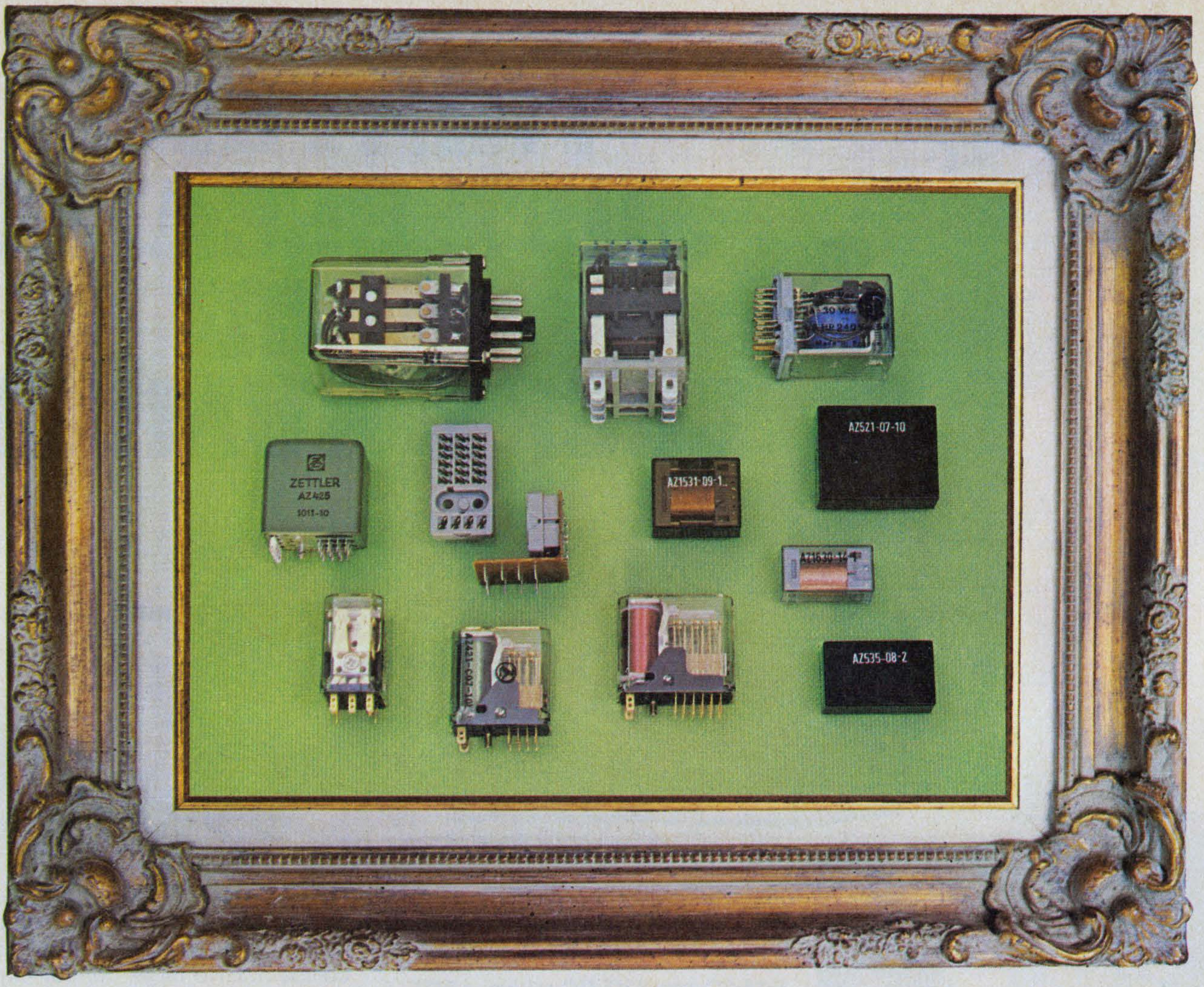
Guardian's 48 page relays catalog. Full of facts and specs to make selecting a relay a snap.

This mark indicates recognition under the componet program of Underwriters Laboratories, Inc.

GUARDIAN®

GUARDIAN ELECTRIC MANUFACTURING CO. • 1572 W. Carroll Ave., Chicago, Ill. 60607

CIRCLE NUMBER 10



Masterworks Circa 1977

American Zettler takes genuine pride in offering to you its beautifully crafted relays.

There's a very real heritage of technical competence and consistent quality behind the Zettler name. Although we are an *American manufacturer*, the design and fabrication of our relays reflect the 100-year-old tradition of Zettler . . . now one of the world's largest makers of precision electromechanical products.

American Zettler invites you to examine its relays carefully. You'll find elegant design, true precision construction, generous use of high-quality materials, and workmanship that meets tight specifications . . . all at most attractive prices.

Compare our products with those of our biggest competitors and you'll agree that Zettler relays are Masterworks.

The full American Zettler line includes hundreds of configurations in the most popular and important electromechanical relay styles.

MINIATURE GENERAL PURPOSE RELAYS

DPDT through 6PDT models • AC/DC coils • dry circuit to 5 amp contacts • UL and CSA approved • hermetically sealed versions also available

LOW-PROFILE THINPAK® RELAYS

Unsealed and sealed styles • Less than 0.5 inch high • SPDT through 4PDT models • DC coils • dry circuit to 5 amp contacts • UL approved • magnetic latching versions also available

GENERAL PURPOSE HEAVY DUTY RELAYS

SPDT through 4PDT models • AC/DC coils • 5 to 10 amp contacts • octal/11-pin or quick-connect versions • UL and CSA approved

Over 40 American Zettler representatives and distributors in the U.S. and Canada stand ready to help you with your applications or order. Contact us today for a full-line catalog, the location of your nearest representative, and evaluation samples.

"It's a Better Relay"

AMERICAN ZETTLER, INC.

16881 Hale Avenue • Irvine, California 92714 • Phone (714) 540-4190 • Telex 67-8472

CIRCLE NUMBER 11


120 VAC
INTERNATIONAL RECTIFIER
IOR CRYDOM DIVISION
SOLID STATE RELAY
D1210
PATENT NO. 3,723,769
3-32 VDC
8 AMP SERIES 2 FOR HEATSINK OR PANEL MOUNT
Two models, S218 (120 Vac) and S228 (240 Vac), feature standard 0.187" terminals for push-on connectors or bare-wire solder connection, positioned to provide maximum isolation between signal and power circuits. Offset positioning of the terminals permits side-by-side gang mounting for high packaging density. Occupying less than 1.0 cubic inch, they provide a full 8 ampere (rms) current rating and a high surge current capacity suitable for control of the toughest loads. The S218 units are $5.90 in 1,000-piece lots.
From the originators of the photo-isolated solid-state power relays that have become the industry standard . . .
CRYDOM
S218
A QUANTUM STEP
IN SIZE
AND PRICE
REDUCTION!
TWO NEW CRYDOM
CHALLENGER
SOLID-STATE RELAYS!
The new Crydom Series 2 and 3 SSRs combine small size and low price, challenging all comparably rated SSRs, hybrid relays, and in-house designs on a size/cost/performance basis. They provide photo isolation, zero voltage switching, high current rating and rugged packaging — first established by the original Crydom Series 1, now the world's leading SSR design. Designed for UL/CSA approval, they offer the advantages of long life, RFI-free switching, logic level control, and excellent electrical and mechanical isolation of signal and power circuits.
The application of SSRs is no longer limited by size and cost. Crydom Challengers have knocked down these barriers. SSR control of motors, heaters, lamps, transformers, solenoids, valves and contactors now becomes practical in many new applications.
Think about it for your product . . . and join the Challengers!
IOR INTERNATIONAL RECTIFIER CRYDOM SOLID STATE RELAY S312
2 AMP SERIES 3 FOR PC BOARD MOUNT
Two models, S312 (120 Vac) and S322 (240 Vac), provide a higher power handling capability than any SSR of equal size. Occupying less than 0.4 cubic inch, Series 3 SSRs achieve a full 2 ampere free-air rating in a 40° ambient. A low 3/8" profile allows 1/2" spacing of rack mounted printed-circuit boards. The S312 units are $4.90 in 1000-piece lots.
INTERNATIONAL RECTIFIER
IOR CRYDOM DIVISION
1521 Grand Avenue, El Segundo, CA 90245 (213) 322-4987
. . . the pacesetters!
CIRCLE NUMBER 121

DELCO'S NEW 25-AMPERE HIGH VOLTAGE DARLINGTONS WITH THE SPEED AND ENERGY CAPABILITY YOU ASKED FOR.

Good news for motor speed control designers who have expressed a need to upgrade horsepower ratings. The 25-ampere gain of these new Darlingtons permits increased horsepower ratings of existing AC motor speed control systems and a reduction in paralleling in new designs. However, grouping of t_{off} is available for current sharing in designs with parallel Darlingtons. A speed-up diode is built into the DTS-4074 and DTS-4075 permitting data sheet t_f typicals of $1.0_{\mu s}$. Drive circuit techniques involving $I_{B2} \geqq 2A$ and a Baker clamp produce t_f typicals in the $0.4\text{-}0.6_{\mu s}$ range for the DTS-4066, DTS-4067, DTS-4074, and DTS-4075.

Our experience with tolerances, faults, transients, and start-stall conditions in most systems convinces us that these Darlingtons have the right trade-off between speed and peak power handling capability. Note the greater than 10kVA region of the reverse bias safe operating graph. All this, and you still get Delco's traditional solid copper TO-3 hermetic package that has a conservative 0.75°C/W thermal resistance.

These Darlingtons are already in high volume production and are available on distributor shelves. For prices, applications literature and data sheets, visit your nearest Delco sales office or Delco distributor, or mail in the coupon on the right.

MAJOR PARAMETER LIMITS

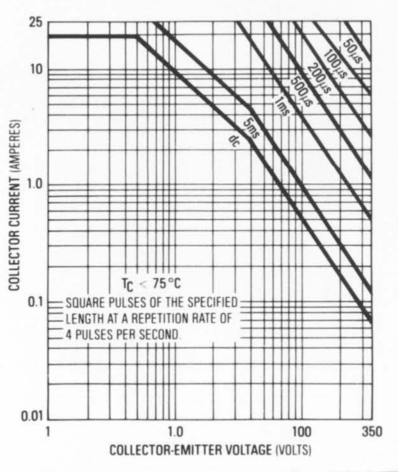
Type	h_{FE} @25A	h_{FE} @10A	V_{CEO} (sus)	V_{CE} (sat) @20A	I_{CEO} @600V
DTS-4066	5	75	350V	3.5V	0.25mA
DTS-4067	10	150	350V	2.0V	0.25mA
DTS-4074	5	75	350V	3.5V	0.25mA
DTS-4075	10	150	350V	2.0V	0.25mA

TYPICAL SWITCHING

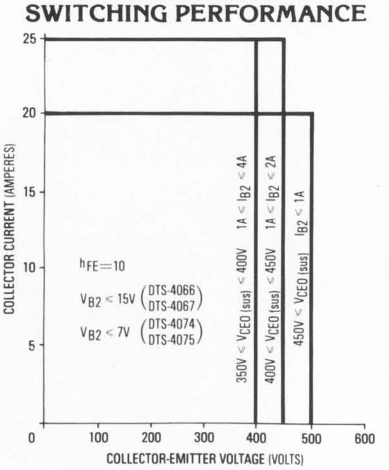
	DTS-4066 DTS-4067	DTS-4074 DTS-4075
t_r	0.5μs	0.5μs
t_s	5.0μs	3.2μs
t_f	4.5μs	1.0μs

NPN triple diffused silicon Darlingtons are packaged in solid copper cases conforming to JEDEC TO-3 outline dimensions.

SAFE OPERATING CURVES

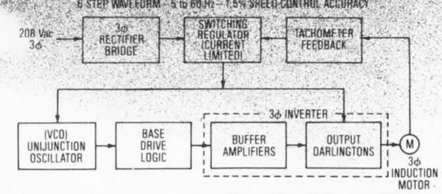


CLAMPED INDUCTIVE SWITCHING PERFORMANCE



208/220 Vac, 3φ MOTOR SPEED CONTROL

6 STEP WAVEFORM – 5 to 60 Hz – 1.5% SPEED CONTROL ACCURACY



FOR MORE INFORMATION ABOUT DELCO'S NEW 25-AMPERE HIGH VOLTAGE DARLINGTONS, MAIL THIS COUPON TO:

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General Motors Corporation
Marketing Services MS A-213
700 E. Firmin Street
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Kokomo, Indiana (317) 459-2175
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CIRCLE NUMBER 122

CIRCLE NUMBER 123

48-pin IC Tester: Total programming flexibility and no program boards put the IT-200 in a class by itself.

Here is an extremely flexible integrated circuit tester that can handle virtually *all* digital devices.

Its 100 kHz functional capability, coupled with a powerful DC parametric capability, allows testing of CMOS, NMOS, PMOS, ECL, and TTL devices of any complexity. The particularly powerful DC parametric test capacity provides current ranges from ± 200 na to ± 200 ma, and voltage ranges up to ± 20 V.

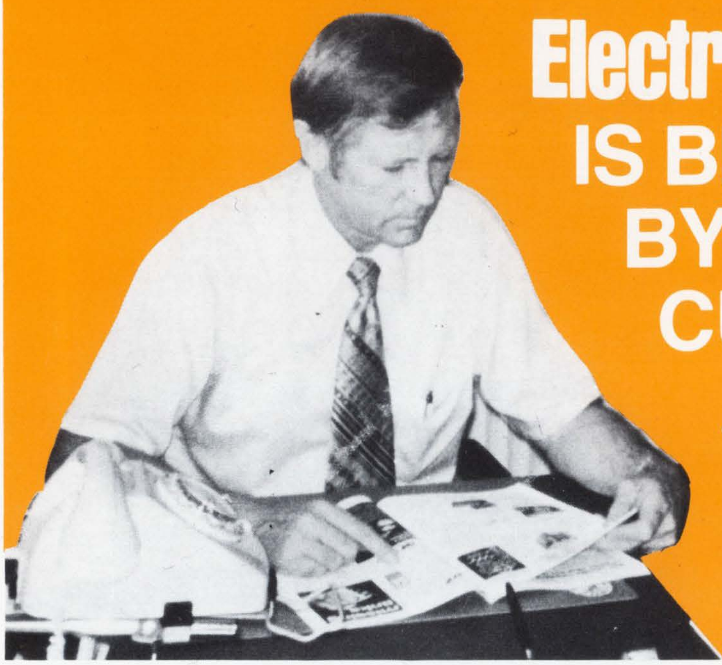
The versatile IT-200 operates under ROM or RAM program control (software load) and readily interfaces with handlers, probers and other instrumentation.

Check out the IT-200. You'll find the specs are truly in a class by themselves and the price is surprisingly low. For complete details, write or call:
Siemens Corporation, Computest Products, 3 Computer Drive, Cherry Hill, New Jersey 08034
(609) 424-2400.

IT-200 is manufactured by Imperial Technology and marketed by Siemens.

SIEMENS

ITT CANNON FOUND OUT...



Electronic Design IS BEST READ BY ITS CUSTOMERS AND PROSPECTS

Theodore Knudson, an American dedicated to assisting the European aerospace community at ESTEC, Noordwijk, Holland, states: "I usually read each issue of *Electronic Design* for its unique features. I also find E.D. useful in the form of a resource material depicting recent state-of-the-art advances that is not totally theoretical and therefore can be suggested for application in our real life designing and procurement processes."

If you read *Electronic Design,* you're in good company. Almost 90% of those firms who have taken the trouble to find out which magazines their customers read, rank *Electronic Design* in first position.

For example: ITT Cannon mailed 1,000 questionnaires to a portion of their prospect list (respondents to advertising and publicity releases in many publications).

The survey asked: "Designate in order of importance those publications which you are now receiving and read on a regular basis." Here are the top winners:

PUBLICATION	READ REGULARLY (ITT Cannon Prospect List)	
	REPLIES	RANK
ELECTRONIC DESIGN	**732**	**1**
EDN	668	2
ELECTRONICS	416	3

PASS THE WORD

Maybe your advertising brass doesn't know as much about the power of *Electronic Design* as you do. If your company wants to reach engineers and engineering managers . . . *pass the word.* Tell your sales, marketing and advertising people which publication will bring highest readership among the engineers who make the wheels go round in this industry . . . *Electronic Design.*

Electronic Design

BEST READ ELECTRONICS PUBLICATION IN THE WORLD

SSR UPDATE

We've got 87 answers to your AC solid state relay needs.

Teledyne Relays can handle virtually any AC solid state relay switching application. The reason? A family of AC SSRs with 87 models — and more on the way. We offer a broad range of voltage ratings up to 600V peak, with current ratings from 0.5 to 40 Amps. Add to that a variety of packages for pc board, chassis, or heat sink mounting and you have the industry's most complete line of AC SSRs.

But hardware isn't the only answer. You need assurance of the best available applications engineering support.

And we've got it — backed by seven years as a pioneer and leader in SSR technology to enable you to use our SSRs to their maximum advantage.

That know-how, for example, is reflected in Teledyne's new 970 Series MOV transient suppressors designed specifically to protect our AC solid state relays against high voltage transients.

Contact your local Teledyne Relays people. You'll find we have the experience, technical support and products to meet your SSR needs.

A. 601 Series*
5 and 10A (to 600V peak). Optically isolated, zero voltage turn-on. Screw terminals, quick disconnects, and pcb pin options.

B. 611 Series*
10, 15, 25 and 40A (to 600V peak). Optically isolated, zero voltage turn-on. Dual purpose screw/quick disconnect terminals.

C. 675 Series*
Low profile (0.5" max.) pc board SSRs. Output rating 3A, up to 600V peak. Optically isolated, zero voltage turn-on.

D. 671 Series
I/O Converter Modules. Special purpose SSRs for use in programmable controllers, machine tool controls, etc. Mounting panel available.

E. SerenDIP® Series*
TO-116 DIP package. Output rating 1A/280VRMS. Logic compatible 3.8 to 10VDC input.

F. 970 Series MOVs
High voltage transient suppressors designed specifically for use with all Teledyne AC SSRs.

**UL recognized/CSA certified.*

TELEDYNE RELAYS

3155 West El Segundo Boulevard, Hawthorne, California 90250
Telephone (213) 973-4545

CIRCLE NUMBER 13

DECEMBER 20, 1976

Popular μP bit slice has an even better twin

A pin-compatible version of the 2901, the most widely used μP bit slice, is 20 to 30% faster, 30% cheaper, and 50% stiffer in Y-output drive currents, yet uses 25% less power. The 2901A will also be available next month from Advanced Micro Devices, Sunnyvale, CA.

Functionally, the 2901A chip is identical to the 2901. But plugging in the 2901A in place of the 2901 cuts the typical time for a read/modify/write cycle from 105 to 75 ns and the I_{CC} from 280 to 200 mA (at V_{max} and 125 C). The 2901A also boosts I_{OL} on the Y output from 16 to 24 mA and improves noise immunity by increasing V_{IL} from 0.7 to 0.8 V max.

Die size is cut from 33,000 to 20,000 square mils. Cost in 100s drops from $21 for the 2901 to $14.70 for the 2901A.

The 2901A's improvements are the result of two-layer metallization and internal logic simplifications.

The 2901A's improved speed will not affect the throughput in every application: Its impact depends on the microcode-sequencer architecture used with the bit slice. AMD plans to offer other aids to improve throughput, including a 2930 program control chip that can relieve the 2901A of program counting.

Although several other manufacturers may soon announce similar devices, AMD's 2901 remains the leading bit-slice part and the fastest TTL slice available. The 74S481 from Texas Instruments is not yet out, although its introduction had been planned for the fall of 1976. (See "Bipolar bit slice μP's shrink the size and cost of minis and controllers," ED 10, May 10, 1976, p. 34.) Raytheon and Motorola are alternate sources for the 2901.

Since 2901 users have had to develop microcoding capability, Motorola, an alternate 2901 source, now offers training courses on the 2901 hardware and microprogramming. A 2901-2901A microprogram assembler will soon be available on Computer Sciences Corp.'s Infonet time-sharing service.

The availability of the microcoded 2901 has led several computer manufacturers to design universal device controllers, identical hardware units, for such peripheral devices as printers, tapes and discs. At system-generation time, the central processor specializes each controller by loading its RAM with a microcode-program design for the peripheral device it controls.

CIRCLE NO. 318

Solderless interconnect system shown by Augat

A new interconnection packaging method that allows components to be plugged directly into printed wiring boards without the need for soldering has been introduced by Augat Interconnection Products, Attleboro, MA.

Called Holtite, the interconnection system is based on precision-machined contacts that are press-fitted into a printed wiring board, plated-through hole.

Until recently, plated-through holes for socket applications have been used as soldered receptacles to mount standard style sockets, according to Richard Holt, Augat product manager. These sockets are mounted above the top surface of the board with an average profile height of 0.16 in.

The Holtite system is the first solderless method to use the existing space within the board as the contact receptacle, says Holt. As a result, the socket offers a very low profile that permits card rack spacing as close as 0.4 in.—equal to that of boards with soldered components.

The tapered entry contact is recessed into the board to provide a large contact target area (0.044 in. diameter), which makes it ideal for automatic component insertion, Holt observes.

Holtite contacts can be installed in boards at a rate of 30,000 per hour by means of a specially designed, mass-loading machine that features a vibratory feed and vacuum system.

CIRCLE NO. 319

Undersea communicator sharpens speech clarity

An underwater voice communicator that uses enhanced speech-processing techniques to improve the intelligibility of subsurface communication has been developed by Sound Wave Systems, Costa Mesa, CA. Called the "WetPhone," the device also features specially developed transducer encapsulating material and a 31-kHz, amplitude-modulated carrier signal.

"Reverberations caused by speaking into a small face mask as well as breathing and gurgling noises have been the main problems with previous undersea voice systems," observes Dennis Johnson, president of Sound Wave Systems. The WetPhone filters out these noises along with those components of human speech below 650 Hz—including breathing sounds.

Because 65% of voice intelligibility is contained in speech components above 1000 Hz, the unit employs two high-pass filters and a very sensitive receiver. The receiver is equipped with an automatic gain control whose dynamic range covers 85 dB.

The WetPhone communicator delivers 1 W of acoustic power into the water and has a range of a quarter mile. Its operating cycle runs six to seven hours with replaceable alkaline batteries or an optional, rechargeable battery pack.

Two other options are available. One is an alarm, called Auto-Alarm, that is activated automatically when the WetPhone detects that the diver isn't breathing. This alarm can alert any underwater companions as well as a surface rescue unit. It can also be used as a tracer signal for search and rescue operations. A separate acoustic direction finder is also available for use in such an emergency.

The other option, called VOX, is a voice detector that can be placed against the larynx to automatically switch the WetPhone from "receive" to "transmit" without manual intervention.

Solar μ wave repeater saves power and money

A solar-powered microwave communications repeater that uses only 4 W of power and can operate at temperatures as high as 140 F has been developed by GTE Lenkurt Inc., San Carlos, CA. The repeater, called the 700F1 can be installed at about one-fourth the cost of existing repeater systems.

The first commercial installation of the solid-state repeater begins operation this month to provide telephone service to a remote Navajo Indian outpost near the community of Mexican Hat in southeastern Utah.

Currently, the 700F1 can transmit 36 simultaneous telephone conversations, but a system with "much greater capacity" is planned for next year, according to Herbert Krengel, GTE Lenkurt's president.

Power is supplied to the repeater as well as to a bank of four storage batteries by 36 silicon solar cells mounted on two panels. The batteries allow the system to operate for up to 10 days of total darkness.

Ability to operate at high temperatures (over a range nearly three times higher than repeaters currently in use) eliminates the need for costly, high-power air conditioning to cool the electronics.

'Recombination' laser readied for space use

A recombination argon-gas laser that should be useful to communications and power transmission in space has been proved feasible at Princeton University in NJ. The laser produces energy in the 4700-to-5100-Å ultraviolet spectrum. But ultimately, this use of doubly ionized helium may result in a laser operating in the soft X-ray region around 1500 Å, according to Dr. Edward M. Campbell, the first to demonstrate the argon plasma-dynamic recombination lasing.

Short-wavelength lasers of this nature can be useful in space communications because unlike the radiation from the sun in the infrared spectrum, the radiation in the ultraviolet is relatively low, according to Campbell. For this reason, background noise that may interfere with UV receivers is lowered substantially. Consequently, the system design of such a receiver will be simpler and laser-power requirements minimized.

Minicomputer system to be the first OEM for IBM

A general-purpose computing system with both communications and sensor-based capabilities represents IBM's first venture into the OEM minicomputer business.

Developed and being manufactured at IBM's General Systems Div., Boca Raton, FL, the Series/1 will enable users to attach many different input and output devices, including custom-made equipment for special applications.

Formerly known by the code name "Peachtree," the Series/1 is expected to replace some large computer systems in organizations that wish to decentralize their operations. IBM's first two sales are to Citibank in New York and to an automobile parts distributor, Middleton, Delaware, which will use three units for inventory control, accounts receivable and automatic ordering.

Offered for sale—not for leasing—Series/1 models will range in price from $10,000 to $100,000. The 19-in., rack-mounted units are available in 16,384-byte increments of memory, from 16,384 to 65,536 bytes, in Model 3 and from 16,384 to 131,072 bytes in Model 5. Model 3 has a storage cycle-time of 800 ns, and Model 5 660 ns.

Not only are the IBM minicomputers competition for DEC, Data General and Hewlett-Packard, but for IBM itself. The firm's 370 sales force is reportedly concerned.

News Briefs

The first family of **CMOS programmable ROMs requiring one hundredth the power of their bipolar counterparts** has been introduced by Harris Semiconductor. The power cut will keep systems running cooler and make them more power efficient. However, since the PROMs are CMOS, they will not operate at bipolar speeds—access times will be about 200 ns instead of 60 to 100 ns. . . . Users of **specialized digital communications circuits**, called ASTRO (asynchronous transmitter/receiver), developed by financially-troubled Western Digital, will soon have a second source. **A pin-compatible replacement** is due from SMC Microsystems, Hauppauge, NY, in the first quarter of 1977. . . . A **Motorola single-bit controller circuit**, built with CMOS technology and scheduled for introduction early in 1977, will find its way into a number of control applications in industrial processes and in such appliances as blenders and washing machines. The circuit will reduce both manufacturing cost and the size of the finished product by eliminating large numbers of discrete components—transistors, small-scale integrated logic and (possibly) medium-scale ICs. . . . The Defense Dept.'s Autodin communications system in Europe will soon acquire **a new switching system capable of handling both analog and digital** transmissions. Specifications will be published in 1977. A full digital system won't be installed before 1985, according to a EOD spokesman.

Intro-ducing the amaz-ing EECO

machine: in one end
you put your raw,
un-annotated logic diagram,
and out of the other comes
your fully wire wrapped
socket board/frame/drawer/system—
your choice.
Together with
a Final Exception Report,
a Final String List,
an IC Location List,
lists for IC Type and Socket Size,
a Wire Loop List,
a Pin Assignment List,
an Unused Circuit Elements and Pins List,
a Pin by Pin Wire List,
and your diagram back, fully annotated.

This machine uses
a computer,
and people,
and hardware
all under the same roof,
and gives you a chance
to correct or change
your circuitry
before we go to hardware.
We deliver in as little as two weeks,
including time for you
to review.
We've been doing this
for more than five years,
almost in secret.
Now we're telling you
and the world because
it's about time.
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the keeper of the EECO machine,
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CIRCLE NUMBER 14

ATTENTION *ALL* ENGINEERS!

Design yourself a free vacation for two!

Yes, you can win an all-expense-paid Caribbean vacation plus $1,000 cash — or one of 99 other valuable prizes!

There's nothing to buy, nothing to write, no slogans or gimmicks.

All you have to do is pick the ten advertisements that our readers will best recall having seen in the January 4 issue.

It's *Electronic Design's* popular TOP TEN CONTEST — the contest that can pay off handsomely for you *and* for your company.

Win a free vacation for yourself

Think of it! Clear sky... warm sun... expanses of blue water. The Caribbean is at its best when viewed from the deck of a sailing ship.

Top prize is a fabulous week's Windjammer Cruise for two. You can choose trips among the Bahama Out Islands, the U.S. and British Virgin Islands, or the exotic Windwards and Leewards.

Visit colorful ports with their old world charm and duty-free shops. Swim, fish, snorkel, relax, or lend a hand with the ship.

And it's all free! The prepaid cruise is worth many hundreds of dollars — not to mention the $1,000 cash for travel and incidentals.

Win for your company

More and more companies are urging their engineers to enter this contest. Why? Because a large sample of *Electronic Design* subscribers will determine the top-scoring ads. The ten best will be rerun free of charge. Your company can win one of these reruns, worth up to several thousand dollars! (To receive this prize, your company must have an ad in the contest issue.)

Separate contest for advertisers and their agencies

The TOP TEN CONTEST is actually two contests with separate sets of prizes (1) for engineers and engineering managers (readers) and (2) for company executives, marketing and advertising personnel and their advertising agencies. Urge your top brass to enter. Xerox this page and pass it on to them. Maybe they can pick the top ten ads and walk off with one of the separate prizes.

Here's all you have to do to enter

First, read the rules contained in the January 4 issue. Then:

(1) Examine the contest issue with extra care.

(2) Pick the ten ads that you think *Electronic Design* subscribers will best recall having seen. List these ten ads by company name and reader service number on the entry card. Mail before February 15, 1977.

Your selections will be checked against Reader Recall, *Electronic Design's* method of measuring readership.

100 reader prizes in all

Watch for the January 4 Top Ten issue, then try your skill. This year, maybe *you* can sail away with the top prize.

PRIZES
READER CONTEST

1st PRIZE
A WINDJAMMER CRUISE (FOR TWO) IN THE CARIBBEAN
(Choice of itineraries and dates)
PLUS
$1,000 CASH FOR TRANSPORTATION AND INCIDENTALS

2nd PRIZE
GTE SYLVANIA PORTABLE COLOR TV SET
($325 value)

3rd, 4th & 5th PRIZES
DIGITAL WRISTWATCH
($100 value)

6th through 100th PRIZES
TECHNICAL BOOKS
(title to be announced)

PRIZES
ADVERTISER CONTEST

1st PRIZE
WINDJAMMER CRUISE (FOR TWO) IN THE CARIBBEAN
(Choice of itineraries and dates)
PLUS
$1,000 CASH FOR TRANSPORTATION AND INCIDENTALS

2nd PRIZE
GTE SYLVANIA PORTABLE COLOR TV SET
($325 value)

3rd PRIZE
DIGITAL WRISTWATCH
($100 value)


NOTE TO ENGINEERING MANAGERS
Urge your staff to enter. The winning ads will receive free reruns worth $ thousands for your company.
WATCH FOR THE
TOP TEN CONTEST (JAN. 4 ISSUE)

Army communications—A special report

The switch to digital accelerates in radios, phones and satellites

Never before has the Army communicator or the design engineer who develops his equipment known in such detail what battlefield communications would be like 20 years hence and the steps their evolution would take.

Hybrid capability, both analog and digital, which has been part of the Army's tactical communications since 1972, will accelerate.

By 1982, the balance will start leaning toward the digital side. By 1992, everything that can be digital will be—even telephones, if one can be built cheaply enough.

Electronic switching equipment will be found even in the forward combat areas.

Voice communications probably won't go out of style, but more and more data will be transmitted: maps, handwritten messages and photographs shot back and forth by facsimile—even to the fronts. High-speed facsimile will be transmitted on a new vhf family of radios on a time-shared basis with voice users. The facsimile device will transmit an 8 × 10-in. page of 240 words in approximately 30 seconds. Today's teletypewriter takes four minutes.

Conventional hf-radio teletypewriter assemblages may be eliminated in favor of high-speed, automatic teletypewriter terminals that print out at 12 s/page. These machines will be smart and will enable the operator to type, store, edit and display before transmitting over satellite and uhf radios.

At the brigade and division levels, the conventional multichannel radio system will be replaced by a fully automatic radiotelephone switching system known as the Mobile Subscriber Equipment (MSE) subsystem.

John F. Mason
Associate Editor

The Army version of the Marine Corps SB-3614 switchboard provides fully automatic queuing, ring and disconnect. It is built by Sylvania.

Multichannel tactical satellite terminals and automatic voice and teletypewriter switching will improve the grade and speed of service even further.

High-frequency radio will retreat from the field as the satellite communications advance—even for short-haul links.

Equipment will be secure or securable. If it isn't built secure, it will be designed to accommodate a secure module, or adapter, later.

And all systems will be as interoperable and standard throughout the Defense Dept. as possible. To ensure this conformity, a special Defense Dept. office called Tri-Tac (Joint Tactical Communications) has been established to pass on every tactical-communications development proposed by any service.

The future is known for the Army because of a study called Intacs (Integrated Tactical Communications Systems), carried out in its early stages by the Army Signal School at Fort Gordon, GA, and completed by the Aerospace Division of Martin Marietta Corp., Baltimore, MD. The input for the study includes some 46,000 communications-support requirements turned in by combat arms and other tactical Army users of communications equipment.

When Intacs is implemented, it is hoped that 30,000 less signal personnel and 5000 fewer vehicles will be needed to support the 24-division Army projected for 1980. "This is the first time in the history of the Signal Corps that we have been able to cover the gamut of tactical communications in a single study," says Colonel William E. Wilson, director of the U.S. Army Signal School Combat Development Directorate at Fort Gordon.

Much of the equipment required to implement the concept is either being developed or planned for development by such Defense agencies as Tri-Tac and the Army's Tactical Satellite Communications and Single-Channel Ground and Airborne Radio Subsystem (Sincgars) programs.

A new family of radios

The Sincgars family of vhf/FM radios, which will probably go into the battalion level and below, will be smaller and lighter than the currently used VRC-12 family as well as securable and hardened against electromagnetic pulse.

All Sincgars radios—manpack, vehicular and airborne—will be essentially identical, with special modules for different applications.

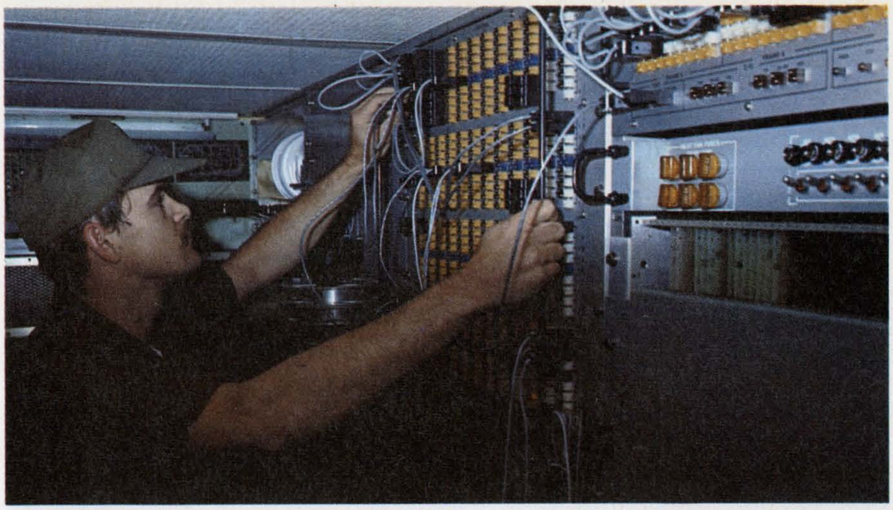
The radios will be optimized for 16-kbs digital data: They will have to perform with the same functions and interoperate with the current Army inventory of vhf/FM equipment in both the secure and nonsecure modes, and they will have to provide at least 920—and preferably more—usable channels. At least four of these will be preset frequency/crypto-net channels.

A lightweight family of antennas is required that are simple to operate, need no physical tuning adjustment, and minimize the targeting of the operator.

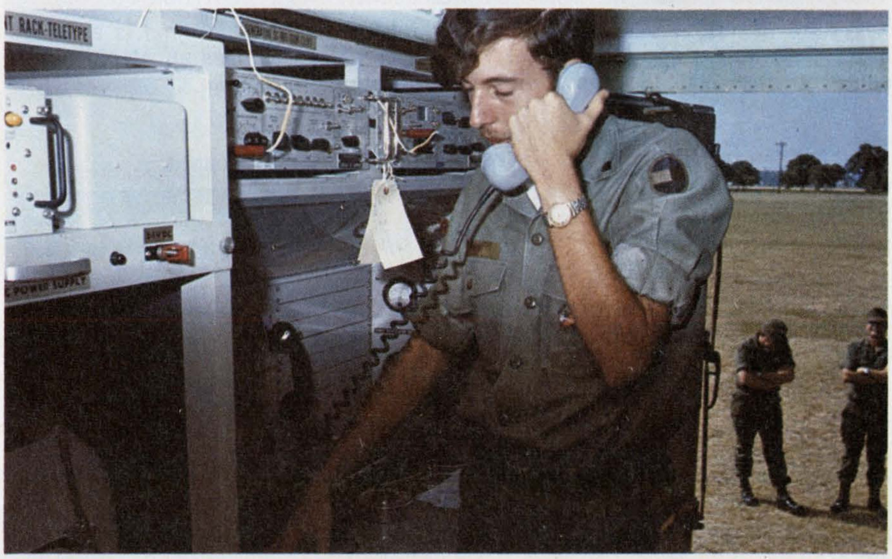
The secure manpack radio will not exceed 20 lb, including batteries. The batteries, some of which will be lithium organic, will provide power for 24 hours of continuous operation for normal duty cycles.

The minimum acceptable MTBF will be 1250 hours, with the best operational capability set at 3300 hours for the manpack and 1500 for the vehicular and airborne units. The scheduled organizational maintenance time will be no more than 30 min/week.

Improved filter technology will be required—"more than likely in the active filters rather than in the passive," says Theodore A. Pfeiffer, chief, Communications



The AN/TTC-38 tactical-automatic-telephone central office, built by Sylvania, switches up to 300 analog, nonsecure voice circuits.



Technical Control Facility, AN/TSQ-84A, built by the Army, interconnects, monitors and tests up to 432 full duplex channels.

Electronics Systems Integration Office, Army Electronics Command at Fort Monmouth, NJ. "And we're probably going to a higher level of microprocessor technology where practical. This will reduce power consumption, physical size and weight, as well as other phenomena such as transient problems."

Switching for the future

Designed to tie the present to the future the AN/TTC-39 is an automatic communications central office switch—a telephone switchboard that accommodates both analog and digital transmissions. Actually, the TTC-39 has two switches: a circuit switch for voice and data, and a message switch for data exclusively. Both switches can operate with a wide range of transmission systems, such as satellite communications, tropospheric scatter and microwave, cable, data terminals and voice telephones.

The circuit switch can be equipped with a mix of both analog (space-division) and digital (time-division) matrices controlled by the same central processor. This combination provides a hybrid switch that can interface with both current and future analog and digital systems.

Both the circuit switch's hardware and software are modular to provide a family of compatible switching combinations.

Circuit-switching modularity is provided by a basic switching mod-

The 82nd Airborne Div.'s AN/VSC-2 radio-teletypewriter terminal is air-droppable, lightweight and long-range. Mounted in a jeep, it uses an AN/GRC-106 single-channel, hf, SSB radio with a frequency-shift modem.

ule that is expandable in increments of 150 terminations and may be expanded in the field to 3000 terminations.

A continuously variable-slope-delta (CVSD) technique is used to convert the analog input into digital signals.

The message switch is a means for data-terminal equipment with dissimilar characteristics to communicate with each other. Its hardware and software permit it to understand, and be understood by, any military data terminal.

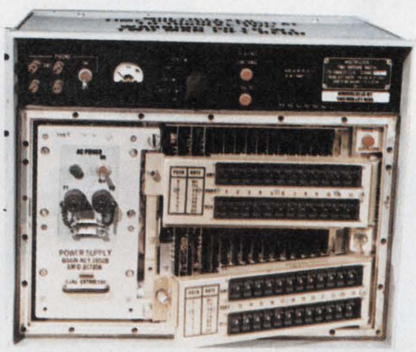
The switch can process up to 81-million characters per day, with a one-second peak throughput up to 9000 characters. Single messages may be as long as 44,000 characters.

In the TTC-39, LSI is used as much as possible along with multilayer PC cards. CMOS is used primarily to keep power consumption down, but where necessary, low-power Schottky TTL medium-scale integration is used.

The TTC-39 system is being built by GTE Sylvania's Electronic Systems Group's eastern division, Needham Heights, MA.

Telephone network on the move

Probably the most advanced equipment under development for Intacs is a mobile radio-telephone subscriber system, known as the Mobile Subscriber Equipment



The TD-1069 Time Division Multiplexer (TDDM) multiplexes and demultiplexes up to 24 separate digital and teletypewriter dc signals into a bit stream of 32 Kbp/s.

(MSE), which will provide secure automatic radio telephone service to subscribers who require access while in transit.

The Army wants to get away from the multichannel line-of-sight equipment now used. It takes too long to set up; and it requires large antennas, retransmission stations, and too much cable. And its limited mobility is no longer acceptable. "The multichannel equipment takes too long to wire up our command posts," Colonel Wilson says. "It's just not good enough for the future battlefield."

With the MSE, each subscriber has a unique address that can be reached at distances up to 45 km with the help of one or more relay centrals. Direct calls without a central should be possible up to 10 km.

Switching will be automatic. If a call doesn't get through by direct link, it switches over to a central. The concept is a significant emulation of the old, now defunct, Random Access Discrete Address system under development in the 1960s.

The MSE subsystem will be operational some time in 1987.

Tactical satellites step forward

The Tactical Satellite Communication System is being upgraded, says Colonel Fred M. Knipp, commanding officer of the Army Satellite Communications Agency, Fort Monmouth, NJ. "We're putting in new digital terminals and converting existing terminals. The first one went in earlier this year, and by 1980 we'll be all digital."

Satellite communications can be used over a wide range of point-to-point distances. "You can use them from one valley to the next or for distances up to 9000 miles," Col. Knipp says.

The satellite network has three satellites operating at shf that are shared by the Strategic Satellite system: one for the Atlantic, one for the Pacific, and one for NATO forces. A second NATO satellite is soon to be launched. The tactical system also uses several classified satellites operating in the uhf region plus two Marisat relay craft, also uhf.

Uhf is used for vehicular and manpack terminals. Shf is used with 8-foot antennas installed on trucks. Collins is manufacturing the uhf equipment, and RCA, the shf. The manpacks, which will use whip antennas, are being built by Cincinnati Electronics.

The satellite-communications system is moving to Time Division Multiple Access modulation, Col. Knipp says, because the spectrum is so tight. With TDMA, each channel is divided into a number of discrete time slots, with 30 ns the lowest practical limit.

Each terminal in the communication system will be assigned a time slot on a given channel and will transmit in a burst mode. With burst transmissions, each channel will be able to accommodate many more subscribers with no loss in communications capability per terminal.

Uninterrupted voice communica-

tions can be expected in this mode, just as with a straight-through channel, since the time slots are so small and so frequent that no loss of communication can be perceived.

Millimeter waves are in the future, according to Col. Knipp: 30 GHz up to the satellite, and 20 GHz down.

Technology leads the way

The Army wants fundamental technology change in *all* future communications inventory. For example:

"We're trying to get away from punched paper tape as a recording medium," says Pfeiffer at Fort Monmouth. The goal is to cut what is considered the biggest time waster at the communications center, message handling.

To get away from the problems inherent in electromechanical devices keyboard technology will be as solid-state as possible. Fort Monmouth is looking at a number of possibilities including piezoelectric technology.

For video display, CRT is being considered, of course, because it's the most prevalent. But the field is open. Liquid crystals (LCD) and plasma are both possible.

Many battlefield transmitters that all send data may one day be combined: sensors, IFF, wideband data links from aircraft to ground terminals and position beacons, says Pfeiffer "Maybe someday we'll be small enough to build modular transceivers that can do all these things."

For possible answers, Pfeiffer's group is looking at Time Division Multiple Access techniques, which have already been selected for the satellite program.

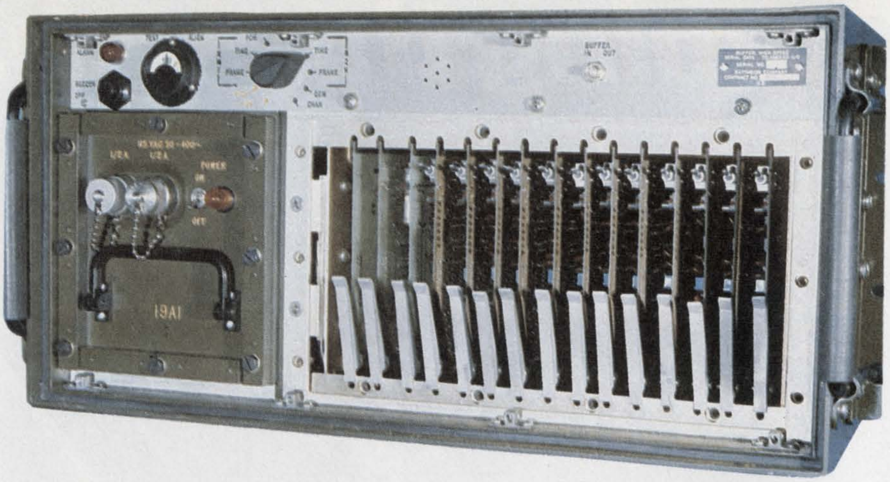
The Army currently uses PCM to multiplex, which, of course, is digital: "The Army is probably more digital today than any other service," Pfeiffer observes.

TDMA *will* eventually join the Army in the field via the Joint Tactical Information Distribution System, which the Air Force is handling for all the services. An outgrowth of the basic communication system proposed for the Air Force's airborne warning and command system aircraft, AWACS, the system can be applied to a communications network serving a large community of users who share the same general data interests and can share the same transmission, explains Grady Banister, Deputy Project Manager of Army Tactical Data Systems at Fort Monmouth.

For example, an air-defense sensor can send out a message describing an enemy position via the TDMA system to all system members. Also, each participant has a time slot for transmitting his own data, which can be received only by the addressees.

"I believe TDMA will dramatically change the way we communicate," says Banister. "It has a high bit rate and serves a large number of data subscribers."

A digital multiplexer joining the Army's inventory will permit the digital access of high-speed data and wideband, secure voice traffic with rates of 32 k and 16 kbits/s to be fed into the Army's tactical communication transmission system. The 1065 will sense analog or digital signals and process them accordingly. Digital telephones are now under development. In such an instrument the a/d converter will be right in the telephone.



High-Speed Data Buffer TD-1065 is being developed for digital access of high-speed data and wideband, secure voice traffic at rates of 32,000 and 16,000 bits/s into the Army's tactical trunking system.

The AN/PRC-77 manpack radio, which still uses some germanium transistors, will be used until Sincgars radios come into inventory.

"Perhaps the continuously variable slope delta modulated (CVSDM) chips being used in the satellite program, the TTC-39 and in other Defense Dept. programs could be used in the digital telephone," Pfeiffer suggests.

A problem with digital telephones is that of loop length. "We're told now that the digital telephones are limited to 3.2 km over a pair of field wires," according to Col. Wilson at Fort Gordon. "And since we don't want repeaters that have to be powered by an outside source, we've got to have one that can operate on a couple of flashlight batteries for an extended period of time."

Fort Monmouth recognizes the benefits of multilayer printed-circuit boards. Some of the security equipment now being built contains cards 14 layers thick. "A 14-layer PC card has such high density that it can't be repaired easily, so they've got to be reliable," Pfeiffer observes.

For memory technology, the Army will use whatever is available—bubbles, if they are ready, because they save power; but definitely solid-state memories, cassette tapes and discs. ■■

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Smart industrial robot sees whatever it's supposed to do

The robot's video camera, similar to the TN-2200, can inspect and measure piece parts, recognize printed material and collect data in real time.

Industrial robots are well known for grabbing small parts as they ease down an assembly line, whirling around and screwing them on to another part a few feet away—all without being able to see.

But now a robot from Auto-Place Inc., Troy, MI, has been given "eyes," an automatic camera, and even a "brain," a microprocessor. Opto-Sense, a small black box with an air-powered arm that can lift up to 30 lb, can watch products move down the line, much like a shepherd watching sheep file through a mountain pass. It can also pick up all the round ones—if that's what it's been told to do—and throw out the rest.

If, say, five different-sized products have to be grouped into one package, the brainy, sighted robot can be instructed to do so. For more complicated tasks, two robots can be used, each handling as many decisions as it can.

Opto-Sense's possibilities are infinite, as demonstrated at the recent North American Industrial Robot Conference in Chicago. With a GE TN-2000, an automated standard TV camera modified for sequential scanning, Opto-Sense picked up playing cards, inspected them and sorted them according to suit.

The camera was developed by GE originally for the Air Force to guide "smart" bombs.

"Using conventional analytical circuitry, we gave the TN-2000 camera the ability to make a number of decisions," says Frederick A. Sachs, marketing manager for GE's Optoelectronic Systems operation, Syracuse, NY. "If the robot presented the wrong side of the card to the camera, the circuitry told the robot arm, to turn it over."

The camera then focused on the small number and suit symbol in the corner of the card, determined the suit by area analysis and told the robot which pile to put it in.

"End of the game" was the final decision for which the camera was programmed. If there were no more cards, the camera waited until a new game began.

The GE camera's charge-injection area sensor, which consists of 244 rows with 188 elements per row, produces 46,000 pixels (picture elements). The output signal conforms to the EIA RS 170 signal-structure standard—which means the camera can interface with any monitor built to U.S. standards. ■■

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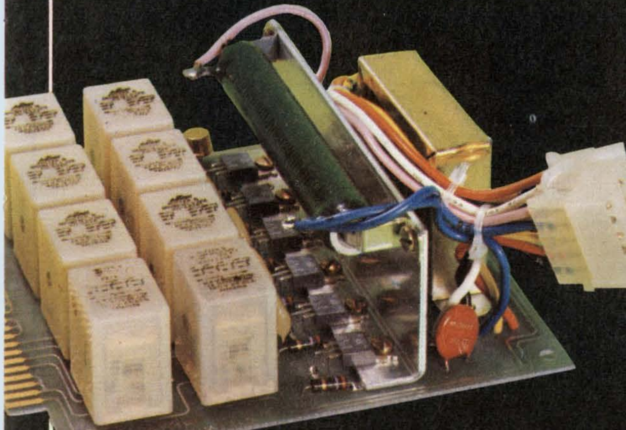

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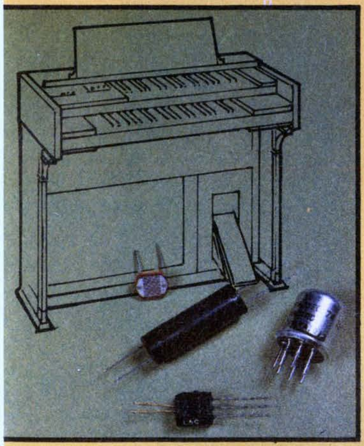
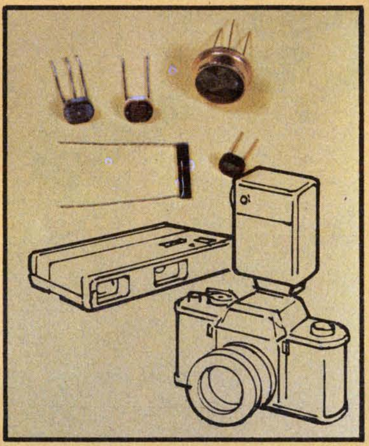


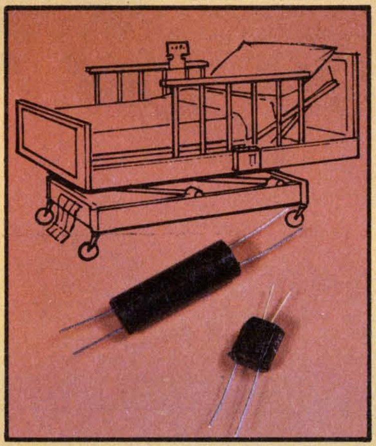
Electronic Organs

LED or lamp/LDR Vactrols for audio, and CdS cells for swell pedal controls.



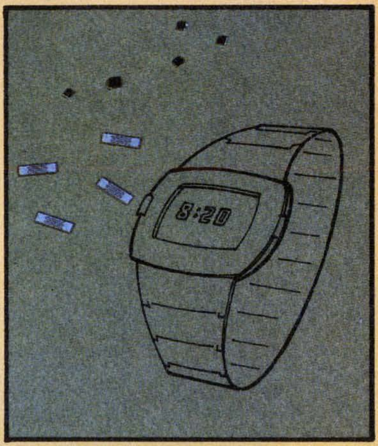
Cameras and Projectors

CdS or blue enhanced silicon photodiodes for automatic shutter timing; aperture servo systems for automatic projector focus; and slave flash controls.



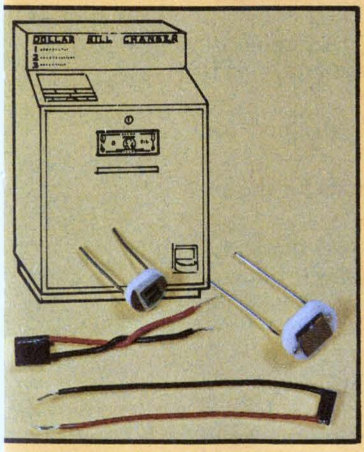
Triac Motor Controls

A special Vactrol gates a triac for forward and reverse motor operation as in hospital beds.



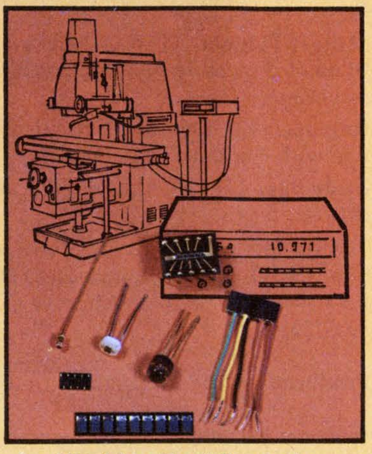
LED Watches

Photoconductive or phototransistor chip controls LED brightness.



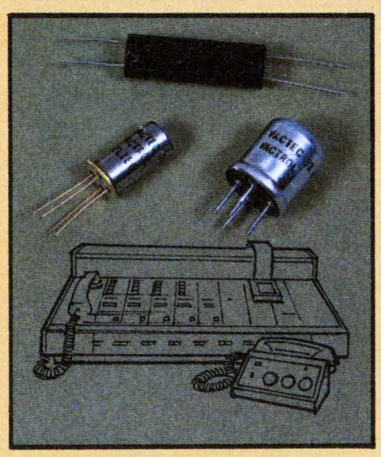
Dollar Bill Changers

Silicon photovoltaic cells analyze optical characteristics.



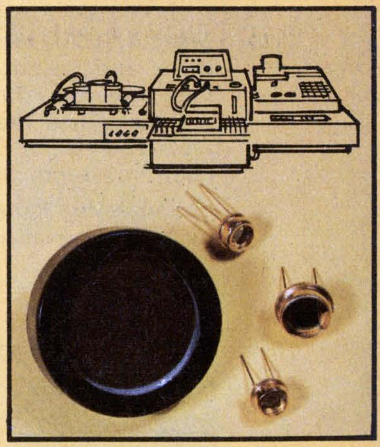
Machine Tool Controls

High-speed photovoltaic cells or transistor arrays help computer control repetitive operations, non-contact sensing, and counting and weighing.



Telephone Equipment

Neon/LDR Vactrols sense ringing. Direct a-c coupling, slow LDR response isolates electronics from noise.



Scientific Instruments

Blue enhanced silicon or selenium photovoltaic cells detect solutions densitometrically for precise blood chemistry and other analyses.

CIRCLE NUMBER 20

Air Force, Canada seek new air-warning system

The Air Force, in a joint program with Canada, is asking for industry proposals by January 7 on a network of seven military air-traffic control centers to be known as the Joint Surveillance System (JSS). The system will replace the existing Semi-Automatic Ground Environment (SAGE) and Back Up Intercept Computer (BUIC) systems installed in the late 1950s and early 1960s, which have become too expensive to operate.

The JSS, which is expected to cost $300-million, will be managed by the Air Force's Electronic Systems Div., Bedford, MA. Canada is putting up about $45-million of the total cost, and Canadian subcontractors are expected to receive a comparable share of the business.

The Air Force expects to award parallel-development contracts to two firms in September and then choose a single prime contractor to produce the entire system around January, 1979.

Boeing, Hughes Aircraft and Burroughs are the likely contenders for the prime contract. Boeing has teamed with IBM (builder of the original SAGE system) to propose a land-based version of its Airborne Warning and Control System (AWACS). Hughes and Burroughs (builder of the BUIC) are bidding alone. Ford Aerospace & Communications (formerly Aeronutronic Ford) and GTE Sylvania, which had indicated an interest in the prime contract, are no longer expected to bid.

Navy seeks ion implantation, electron-beam ideas

The Navy is interested in pushing the state of the art of IC fabrication by seeking ideas from industry on new ion-implantation and electron-beam imaging systems to be operated in an IC process line.

The ion-implantation system should be capable of processing at least 100 wafers per hour. Other requirements include high beam currents of more than 1 milliamp for most encountered dopants, low-energy implants of 5 to 30 KEV and reproducibility to within 1% accuracy across a 3-in.-diameter silicon wafer.

The electron-beam imaging system should be fully automated and capable of producing at least 60 wafers per hour with sub-micron resolution and alignment accuracy. Current single-beam, pattern-generation systems that serially scan each pattern are too slow for production applications, according to the Navy.

Interest has not reached the request-for-proposals stage yet, but if the Navy sees something it likes it might award hardware contracts later. The project is being handled by the Naval Regional Procurement Office at Long Beach, CA.

DOD criticized for keeping R&D from industry

The Defense Dept. continues to keep development work within its own research establishment that should be contracted out to industry, according to a declassified study prepared for Congress by the General Accounting Office (GAO). The study focuses on Mitre Corp. of Bedford, MA, and its relationship with the Air Force's Electronic Systems Division. Mitre is one of nine federal contract research centers, commonly called "think tanks."

The GAO investigators reviewed three Air Force programs, managed by Mitre—the Pave Paws phased-array radar, the AN/GPN-XX air-traffic-control radar and the Tactical Loran C/D navigation system—and found that industry would have bid on the same technical management tasks if they'd had the opportunity. In the case of Pave Paws, for example, 10 radar producers were asked if they would have bid on the technical management contract even if it involved a hardware-exclusion clause. All 10 firms said they could have done all or part of the work, and five would have signed a hardware exclusion clause to get the job, according to GAO.

Defense Dept. regulations prohibit the federally sponsored centers from doing such work unless they can prove that private industry cannot do it. Mitre and the Air Force failed to provide such evidence for the three programs reviewed, according to the GAO study.

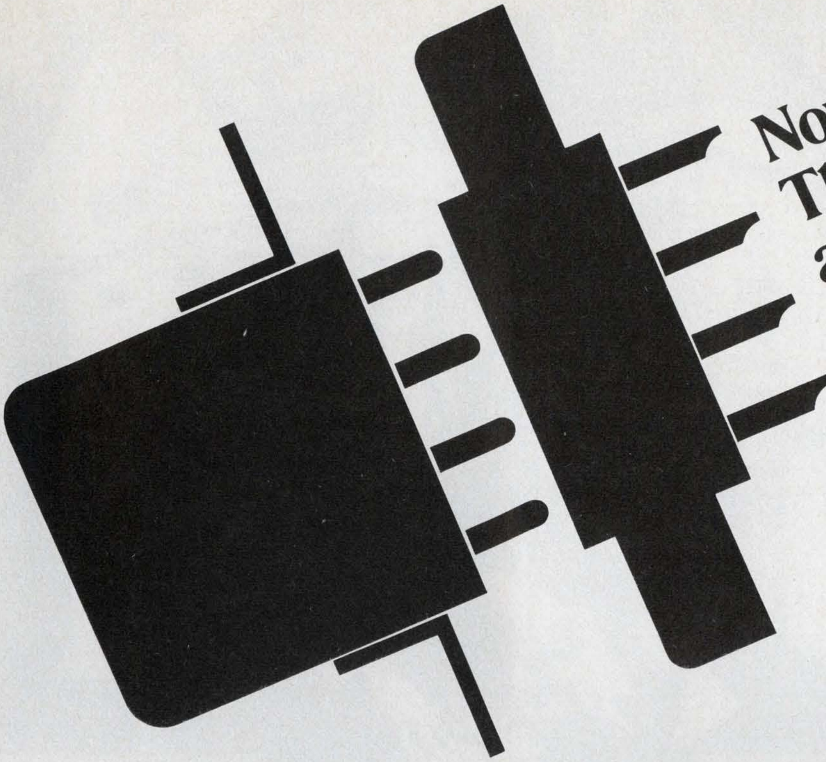
NBS to calibrate diagnostic X-ray units

A calibration service for high-voltage dividers used with diagnostic X-ray units has been established by the National Bureau of Standards as part of an effort to reduce unnecessary exposure to X-rays.

Diagnostic dividers, consisting of a number of resistors, are hooked into the high-voltage points of X-ray units to divide the voltage and reduce it to a point low enough to be measured. By ensuring that the peak voltage is consistent from one X-ray unit to another and from day to day within the same unit, a calibrated divider enables patient dosage to be reduced. Consistency also reduces the number of retakes required by cutting the number of nonuniform film exposures.

The calibration service, which has been tested for the past year by the Dept. of Health, Education and Welfare's Bureau of Radiological Health, is now being made available to the X-ray industry on a cost-reimbursable basis.

Capital Capsules: The Federal Aviation Administration is considering **making it mandatory for all commercial aircraft to carry FAA approved equipment for transmitting and receiving information about adverse weather.** . . . The Defense Dept. plans to increase its funding to industry to apply **new manufacturing-technology methods to increase productivity.** This year's funding level of $114-million is due to rise to $132-million in the new budget to be submitted to Congress in January. The eventual goal is $200-million a year to support more automation and other productivity-related investment. . . . The Army Mobility Equipment R&D Command, Fort Belvoir, VA, is **seeking a new infrared aiming device with a laser diode for rifles** to illuminate targets at night. The system should be effective at 100 meters and work with current Army night-vision goggles. Average power output of the diode should be 150 microwatts in the near-IR spectrum of about 850 nanometers.



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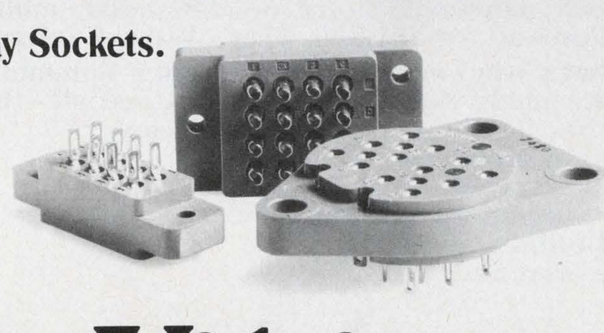

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CIRCLE NUMBER 22

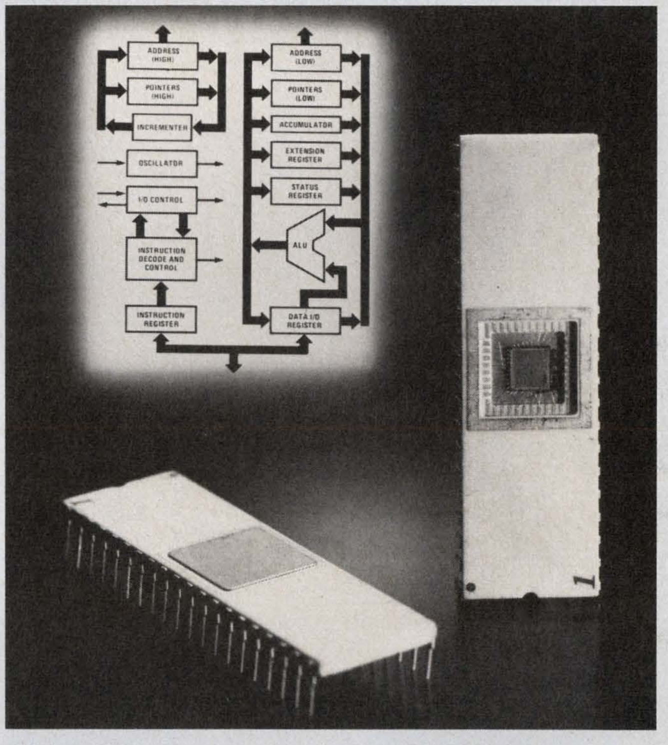
N-channel SC/MP-II doubles speed but cuts power by four times

By going to n-channel processing, designers at National Semiconductor have boosted performance, slashed power and cut costs to come up with a "super" version of the already popular SC/MP 8-bit microprocessor. The SC/MP-II requires only a +5-V power supply, not the +5 and −7 required by the original SC/MP.

With the power requirement cut to only 225 mW—one-quarter that of the p-channel version—the SC/MP-II can be housed in an inexpensive plastic package. And, being an NMOS device, the super μP can operate at clock frequencies as high as 4 MHz—double that of the PMOS version. Thus, low-cost, 3.58-MHz timing crystals can be used for the clock source.

The SC/MP-II can slip into the same socket as the SC/MP if the negative supply is eliminated and the pin is grounded. However, there are three minor software changes: The bus-request, enable-in and enable-out lines, which are active-high in the SC/MP, are

(continued on page 40)



Satellite-borne μP system can repair itself

A powerful μP-based system designed to operate reliably in space for seven years is being developed by Hawker Siddeley Dynamics of Stevenage, England. A custom μP will be used in communication satellites from 1980 on and will have two unique features: direct, high-level language programming and sophisticated self-repair facilities.

Normal μP design procedure has been reversed to design the space microprocessor around its own real-time, high-level programming language, which provides a one-to-one compilation into assembly language instructions.

To improve reliability, two μPs, with specially developed firmware to detect failures, will be used in the satellite system. Although it will have seven types of NMOS LSI devices, the complete Siddeley system will contain about 20 chips, some of which will be doubly redundant.

The μP is currently in the chip-fabrication stage and, following successful simulation trials, is scheduled for flight trials in 1978. The device is being produced with a low-power NMOS process that features "semi-dynamic" techniques. For example, the memories will need no refresh cycle but will be powered up briefly during access and write cycles.

(continued from page 39)

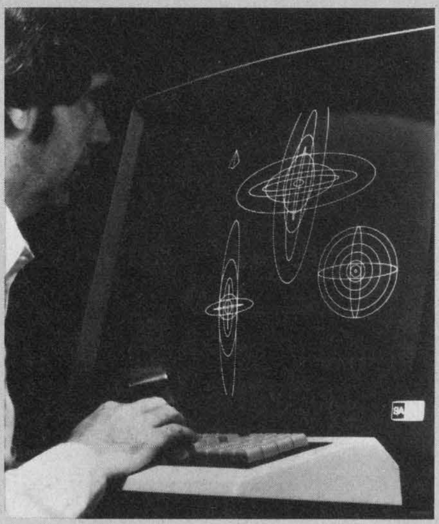
active low in the SC/MP-II. And minor hardware adjustments must be made.

Like its predecessor, the super μP has a three-state data bus, separate serial-data input and output ports, full TTL compatibility on all lines and an addressing capability of 65 kwords. And, by use of their special delay instruction, either microprocessor can interface with memories or peripherals operating at any speed.

Available from stock, the SC/MP-II sells for less than $10 in quantities of 1000 or more. *National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. H. Patel, (408) 737-5000.*

CIRCLE NO. 508

Dual μPs simplify interactive terminal operation



The first interactive graphic display system to incorporate two programmable microprocessors—the Sanders Associates Graphic 7—can either independently operate or be interfaced with most 16-bit computers. The dual intelligence of the Nashua, NH, firm's system provides a "universal" interface and minimizes the cost of special interface hardware and programming.

The basic system has terminal control circuitry, a 21-in. CRT display, such input devices as a keyboard, and such optional features as a light pen and a trackball.

The terminal controller includes two "μPs," one a display processor the other a graphic controller. Both are actually built from 6700-series bipolar bit slices from Monolithic Memories.

The display processor, a general-purpose unit, operates with 8 and 16-bit words. It has eight general-purpose registers and an 8-k read-write memory, expandable in 8-k increments.

The graphic controller is a 16-bit parallel μP with 40 display instructions, 13 display registers and four general registers, and provides the refresh functions. A 4-k × 16 ROM contains the graphic control program, which handles communications between the terminal and a host computer, controls and data-entry devices, manages the display-image refresh and performs other functions usually done in a host computer.

The CRT screen has 2048 × 2048 addressable locations with 1024 × 1024 reserved for viewing.

The standard character set is 96 ASCII elements. Up to 32 user-defined characters are optionally available, and each can be rotated 90 degrees counterclockwise and presented in four different sizes. However, 2.4 μs are required to present a typical character. Eight brightness levels are available.

The firmware-committed, graphic control program makes terminal operation transparent and minimizes host-computer involvement in display functions. It also frees the system programmer from having to support the graphics terminal and allows him to concentrate on the application software.

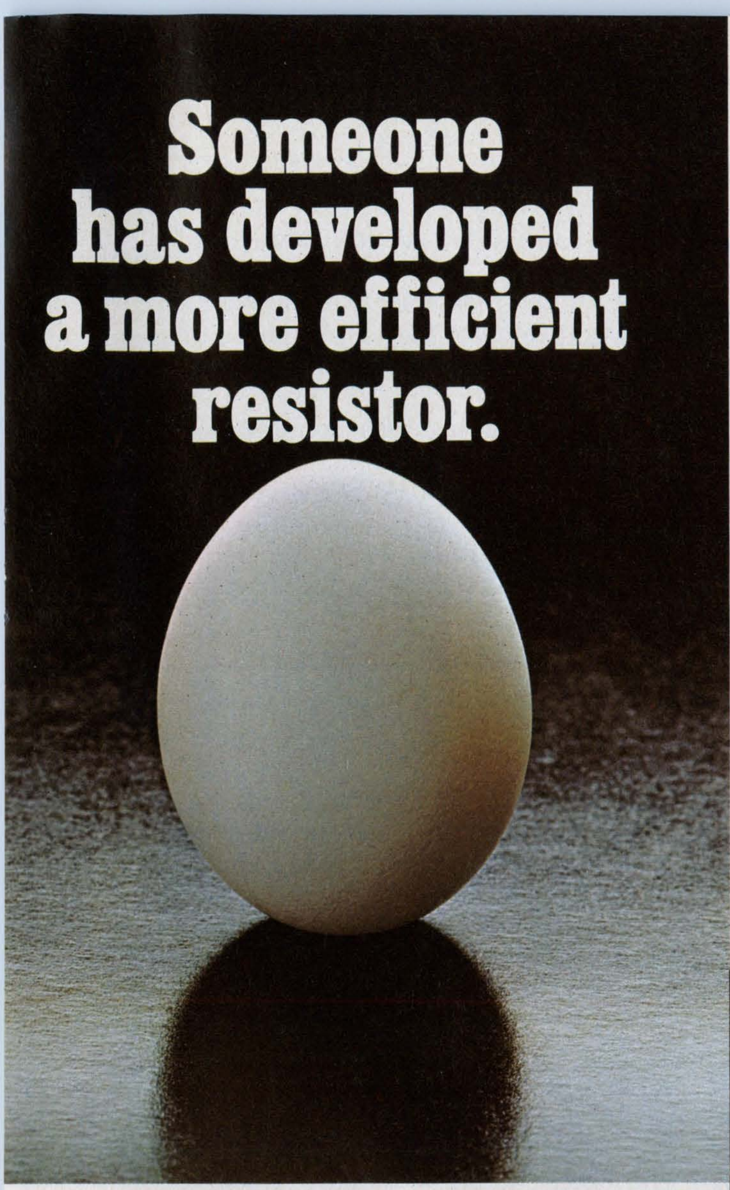
Software development package plugs into a microcomputer

By plugging four EPROMs, the RDP2 package, into Intel's SBC 80/10 single board computer, and adding power supplies and a teletypewriter, it is possible to give a system program editing, assembly, and debugging capabilities.

The programs are subsets of Intel's versions supplied for the MDS development system.

(continued on page 42)

Someone has developed a more efficient resistor.



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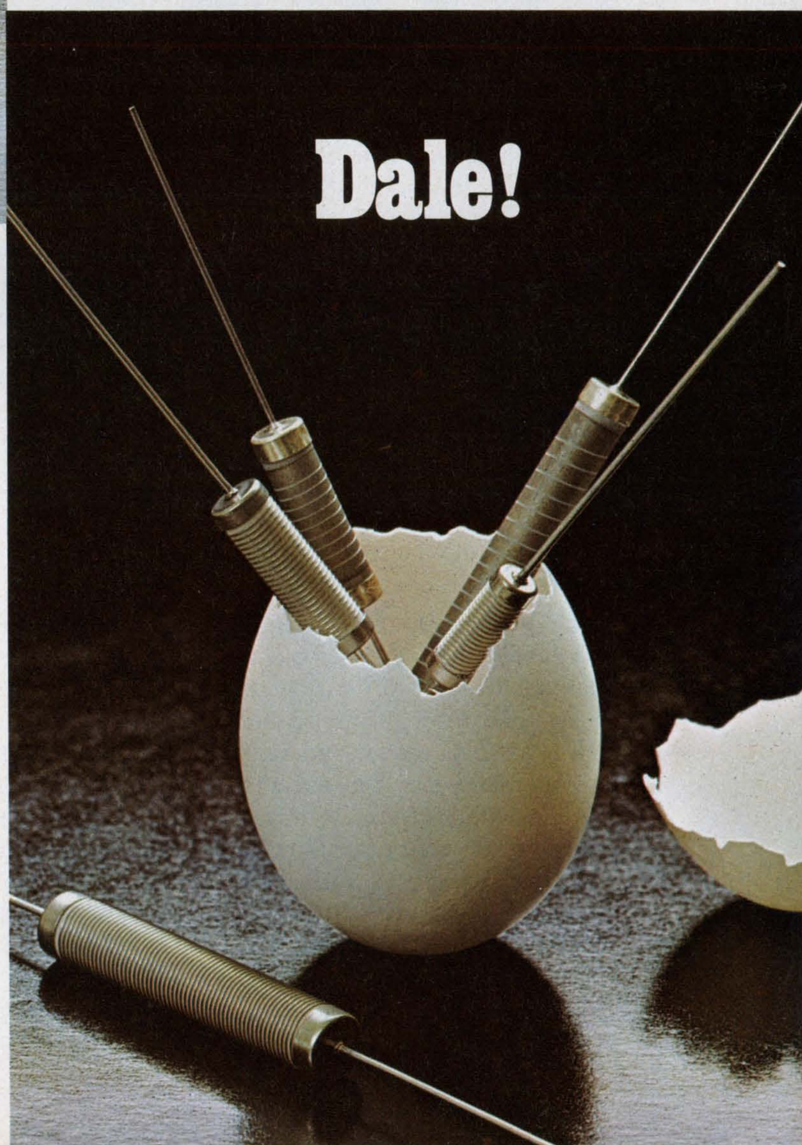
CIRCLE NUMBER 24

Dale!



(continued from page 40)
The assembler, for example, will not create macros—user generated subprograms—or use operand expressions.

The editor prepares assembly-language paper tapes for the assembler. In one pass the assembler generates up to 500 lines of code and puts it into the SBC 80/10 memory. Because source code only has to be read once, the RDP2 is two to three times faster than other multipass assemblers.

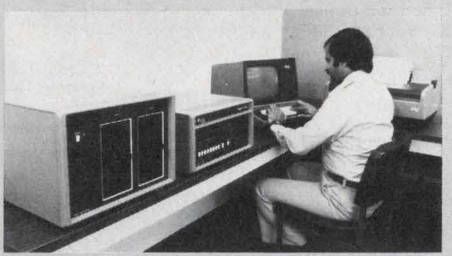
The monitor contains functions for software debugging, including tape dumping and loading, storage and register modifications, and selective program execution.

The package price of $995 includes complete documentation, periodic software updates, and a warranty. RDP2 is available for immediate delivery.

Extensys Corp., 592 Weddell Dr., Suite 3, Sunnyvale, CA 94086. (408) 734-1525.

CIRCLE NO. 509

Microprocessor development system has resident compiler



A combined resident-compiler and modular-programming system from Intel can support the 8080, the SBC80 single-board computers and other 8080-based products.

Residing in the Intellec microcomputer, the software system consists of an advanced version of the PLM-80 compiler for the 8080A, and a new diskette operating system, the ISIS-II. The compiler is supplied on diskettes and costs $975.

The PL/M compiler supports modular software designs and generates linkable and relocatable object code modules. These modules can be automatically connected not only to each other, but also to object-code modules produced by a new relocating micro-assembler contained in the ISIS-II package.

Since the Intellec resident compiler does away with having to access large, expensive computer or time-sharing systems, development costs come down.

ISIS-II includes all other subsystems required for modular programming: macro-assembler, linker, locater and library manager. A text editor with string search, substitution, insertion and deletion commands is also included.

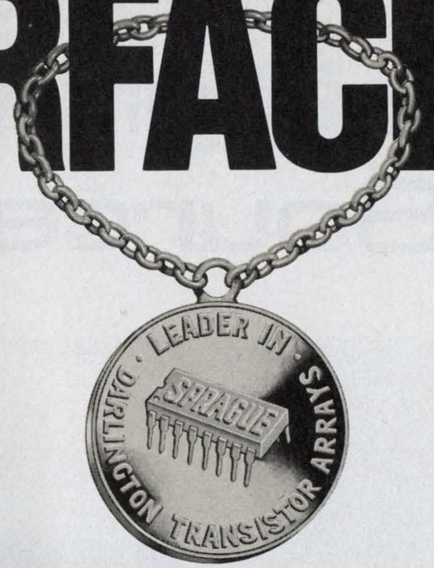
Intel, 3065 Bowers Ave., Santa Clara, CA 95051. (408) 246-7501.

CIRCLE NO. 510

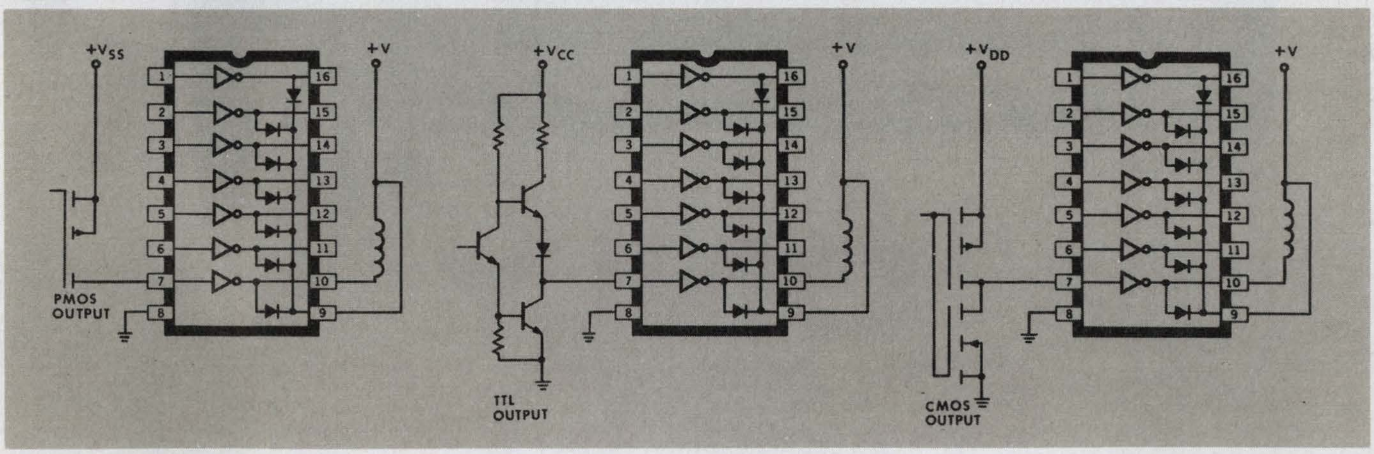
Micro Capsules

Both a commercial temperature-range series and a **plastic-encased series of microprocessors have been added,** with related support circuits, to the 6800 family by Motorola, Austin, TX. Identified by a "C" suffix, the commercial circuits have a temp range of −40 to +85 C and cost 60 to 80% more than standard 6800 parts. The plastic units are intended for operation over the 0-to-70-C range and will probably cost 15 to 20% less than the ceramic-cased models. . . . In a few years, **one 300-mil-square chip should contain not only the CPU, but all the ROM, RAM and interface circuitry.** Volume production of the large chips should be economically feasible by 1981, predicts National Semiconductor's William Baker, Group Director for Microprocessors. . . . **MicroForth, a high-level language** developed by Forth Inc. of Manhattan Beach, CA, **permits the user to work on a resident or direct basis** to develop programs on the RCA 1802 μP. The new language executes 10 to 100 times faster than Basic and requires only 8 kbytes of memory, including a 2-k work space . . . A small, **hand-held terminal** will be introduced soon by the microprocessor-development group at RCA, Somerville, NJ. **With a built-in keyboard and LED display,** the terminal is expected to cost about $300.

INTERFACE ACE



For High-Voltage, High-Current Interface with PMOS, CMOS, TTL, DTL . . . Sprague Darlington Transistor Arrays Have No Equal



A new exclusive Sprague development, Series 2000 Transistor Arrays are high-voltage, high-current integrated circuits comprised of seven silicon NPN Darlington pairs on a common monolithic substrate. They feature open collector outputs and integral suppression diodes for inductive loads.

Supplied in 16-pin dual in-line plastic, these devices greatly reduce the number of discrete components used to interface between digital logic and high-voltage and/or high-current loads. In some applications, all discrete components can be replaced by a single DIP, resulting in substantial space and cost reduction.

With broad commercial/industrial application, these unique arrays are an excellent choice for interfacing to LEDs, solenoids, relays, lamps, and small stepping motors in printing calculators, cash registers, and control equipment.

Type ULN-2001A is a general-purpose array, pinned with inputs opposite outputs to facilitate circuit board layout. Type ULN-2002A is designed for use with 14 to 25 V PMOS inputs. Type ULN-2003A and ULN-2005A interface with TTL, low-power Schottky TTL, DTL, or CMOS operating at a 5V supply voltage. ULN-2004A has series input resistor to allow operation directly from CMOS and PMOS outputs utilizing 6V to 15V supplies.

For more information, write or call George Tully, Semiconductor Division, Sprague Electric Co., 115 Northeast Cutoff, Worcester, Mass. 01606. Tel. 617/853-5000.

For Engineering Bulletin 29304, write to Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247.

For the name of your nearest Sprague Semiconductor Distributor, write or call Roger Lemere, Sprague Products Company, North Adams, Mass. 01247. Tel. 413/664-4481.

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CIRCLE NUMBER 25

Editorial

The importance of being important

Joe's new X-21 was a winner. Every day he'd get a dozen calls about it from potential customers who seemed almost as excited about it as he was. Then one day the calls stopped coming. Abruptly.

Joe began to sweat. He had expected the calls to taper off eventually, after the novelty of the product wore off. But this was too sudden. So he spent lots of time worrying about the product. Had a competitor suddenly introduced a more exciting unit? Did customers see flaws that he had missed? Had marketing priced his product too high? He checked with the fellows in marketing, but they were stymied, too. Something very strange had happened.

Well, because the situation seemed hopeless anyway, Joe began to forget about it. Trying to help him forget, Charlie one day told Joe to size up Sally, the new switchboard operator—"a real knockout."

"Sally?" Joe gulped. "What happened to Mary?"

"Not to worry," Charlie calmed him. "Mary just has a mild case of pregnancy. She'll be all right in a few months. Before she left she broke in Sally thoroughly. Told her everything about the switchboard and the company."

Well, not quite everything, Joe discovered. Mary had prepared a chart listing everybody's extension number. And she'd told Sally that Joe was the chief engineer, Charlie the sales manager, Jack the president, and Ted the company wolf. But she had neglected to tell Sally that if a caller wanted information on the X-21 (or almost anything else), then Joe was to get the call. So, very courteously, Sally told such callers that she didn't know what they were talking about. She needed a person's name.

That was unfortunate because the X-21 was important. All the *important* people in the company knew about it. Had Sally been important, she would have known about it, too.

George Rostky
Editor-in-Chief

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CIRCLE NUMBER 28

FOCUS on Solid-State Relays

Question a solid-state relay manufacturer about his specs, and he is likely to come back with several questions that you must answer first—a sure sign that the spec sheet shouldn't be taken simply at face value.

For example an SSR's output-current capability appears simple to specify. Not so! Although the "maximum" current is boldly flaunted, contingent conditions, such as temperature and the need for a heat sink hide in footnotes and derating curves.

Designers more accustomed to working with electromechanical relays (EMRs) tend to forget about temperature—the SSR's greatest enemy—because EMRs are hardly affected by heat.

Heat can sink an SSR

Up front, the spec list may simply say, "Maximum load current: 15 A rms." But buried at the bottom is a typical fine-print footnote: "Above 5 A rms, the relay must be mounted on a 6 × 6 × 1/8-in. aluminum plate held in a vertical position. Use silicone grease to seal the relay tightly to the plate."

The relay itself may occupy a surface of only 1-3/4 × 2-1/4 in., so you may find yourself squeezing in a much larger heat sink after your layout has been completed. Worse, a burnout may be the first indication that you have forgotten the heat sink. And that's not all.

Not only will the SSR usually not handle the listed maximum current without a sizable heat sink, but many specs state (and some make you guess) that the ambient must be at room temperature—about 25 C. Sound reasonable? No, it isn't. Rarely do you find air at room temperature in the immediate vicinity of power-handling electronic components. Temperatures over the range of 40 to 80 C are more realistic.

Even with the recommended heat sink, that "15-A" relay can probably carry only 10 A safely, because the ambient is 60 C, not 25 C. But you find this out only after you carefully study the derating curves, which aren't always supplied with the spec sheet.

The typical 15-A relay's derating curve might be flat to 25 C, then rapidly slope to 10 A at 60 C. But be careful: When you operate on the slope, a slight increase in ambient temperature or load can often lead to regenerative behavior, and to the SSR's destruction.

Some derating curves can fool you even further, so examine them very closely. Are the curves plotted for ambient temperature? Often, manufacturers plot allowable load current against the SSR's case temperature, not the ambient, even though the curve's title boldly states, "Permissible Load Current vs Ambient Temperature." Sometimes there's no label: You are left to guess. Case temperatures can run 20 to 40 C higher than the corresponding allowable ambient, and so make the spec look better than it is.

Another point: Thermal derating curves of SSRs designed for use without heat sinks can define the general derating conditions, but curves that call for a specific type of heat sink can't. Those for the rather frequently cited 6 × 6-in. aluminum plate are of limited value, because you can use such a plate only rarely. Moreover, even if a standard heat sink is specified, the specific unit listed may not fit your packaging concept. Then the heat-sink curves are at best useful only as guidelines.

Some manufacturers specify an allowed thermal resistance between the SSR's case and am-

Morris Grossman
Associate Editor

bient. With a thermal resistance, you can easily select a heat sink to fit your specific application. This is the preferred method.

A case of high heat

If thermal resistance is not provided, you can use a rough relationship to obtain the temperature rise of the SSR's case above the ambient under free convection conditions. The relation is

$$T \simeq 133\ (W/A),$$

where W/A is the dissipated watts per square inch. So, for a 15-A load, an ON-state forward-voltage drop of 0.7 V and 6 × 6-in. heat sink, the case temperature of an SSR reaches almost 40 C above the ambient temperature.

With a PC-mounted SSR, only the sink's top side is exposed to the free flow of air. Thus, the value of 36 in.^{2} is used in the example—only one side of the plate.

Of course, a heat sink can't extend an SSR's rating beyond the maximum allowed ambient operating temperature. A typical spec might list an operating ambient range of −30 to 100 C. But take note: The relay is useless at or near 100 C because it is derated to carry zero current as 100 C is approached. Also, the −30-C end of the range limits operation, though not as severely as the high end. Minimum allowed load current rises sharply near the low limit.

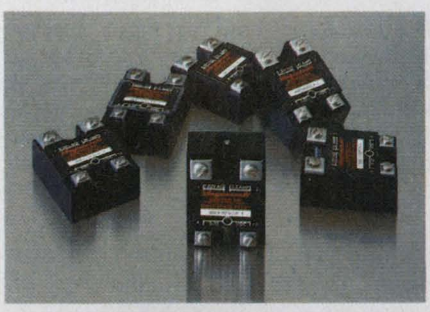
At the low end of an SSR's "operating" temperature range, the relay can fail to turn on reliably, especially if the load current is low. At normal operating temperatures, SSRs with SCRs or triacs as output devices require a minimum load current—typically about 5% of the rating. Between −20 and 80 C, the minimum-current requirement rises only slightly as the temperature drops. But at temperatures colder than −20 C, the minimum-current requirement increases very rapidly; at −30 C, the current can rise to about 30% of rated.

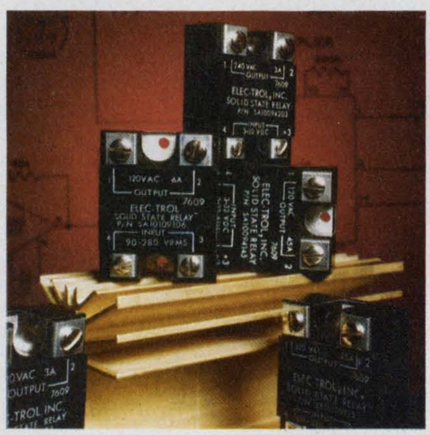
SSR leaks can sink a design

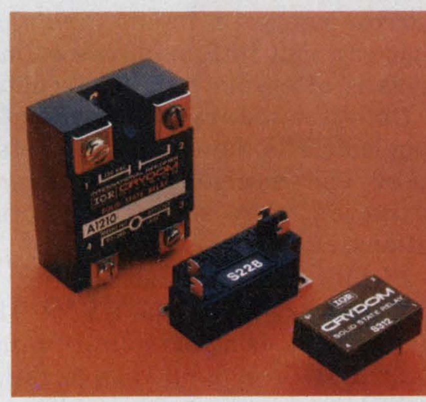
Besides being temperature-dependent, SSRs can leak in the OFF state—seldom a problem with EMRs.

Although leakage in SSRs is not important in most power circuits, occasionally it can be troublesome, such as when a null is required in a servo-motor drive or when lightly loaded solenoids must drop out. And even when low, leakage does add substantially to the power the relay must dissipate, since in the OFF state, the full voltage is across the SSR.

The SSR's ON-to-leakage current ratio is







The four-screw terminal-block style of housing has become a widely used package for solid-state power relays. The same sized package (about 1-3/4 W × 2-1/2 L × 1 H in.) serves loads from 2 to 40 A rms. But be very careful: Above about a 2-A load, the relays must be mounted on a sizable heat sink for safe operation. Many manufacturers such as Grigsby-Barton, Magnecraft, Electrol, Crydom and North American Philips (from lower left, clockwise) package their SSRs in these block-style plastic cases.

generally over 1000:1. A 10-A SSR typically exhibits a 5-to-10-mA leakage proportional to the load voltage—5 mA at 120 V and 10 mA at 240 V.

Not all the leakage comes from the SSR's semiconductor output device: An RC snubber network—used to limit the rate of output voltage rise—as well as internal control and biasing circuits, can easily contribute at least half.

Broad turn-on voltage range featured

Interestingly, although specifying the load of an SSR leads to many complications, an SSR's input presents few difficulties. EMRs generally operate over a relatively narrow input-voltage range with a single coil. Coil changes or even different relay styles may be needed to cover the same range handled by one SSR. Typical SSRs easily turn on positively and safely over a range as wide as 3 to 32 V dc, and in some cases as wide as 3 to 300 V dc—and even ac over the same voltage range. Furthermore, SSR inputs are no more temperature-sensitive than EMRs.

The more sophisticated SSR designs incorporate a current regulator to maintain a relatively constant input current over most of the rated ON input-voltage range.

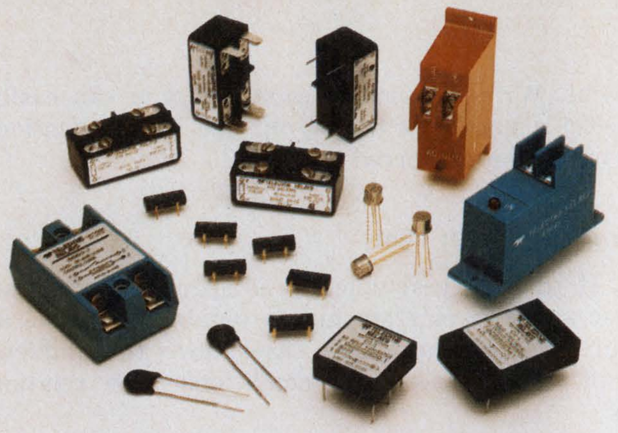
Hybrid SSRs have reed-relay inputs and are probably the most limited in input-voltage range—determined by the reed's pick-up and drop-out characteristics and the coil's resistance. But a reed input is simple, low-cost, and effective in many applications. Most applications need only a narrow range of inputs, and the life of a reed that can run into hundreds of millions of operations is often more than adequate.

Opto-isolated-input and transformer/oscillator coupled SSRs, however, are preferable where the speed and mechanical life of a reed may be a limitation; they allow wide, versatile input conditions.

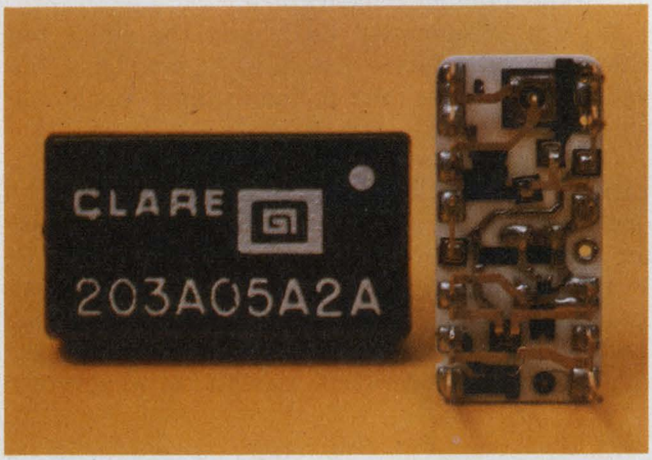
Pickup and dropout ratings for SSRs are handled very much like EMRs. The low end of an SSR's input-control voltage range is analogous to an EMR's pick-up voltage rating and often referred to confusingly as "maximum pick-up" voltage. A less ambiguous name is "must-operate" voltage. Of course, the high-end, must-operate voltage should not be exceeded, or the relay may be damaged.

Similarly, turn-off voltage—the highest input voltage at which the relay in the ON state can return dependably to the OFF state—is often called "minimum drop-out" voltage. The term, "must-release" voltage, is less confusing. Must-release voltage is generally less than half the must-operate voltage.

The difference between the must-operate and must-release voltages gives the SSR a control hysteresis—a desirable (usually) characteristic that promotes clean switching. Uncertain, or fuzzy, ON/OFF action can be caused by control-voltage fluctuations, noise pick-up in the control circuit and transients coupled from the power line, among other things.



Some companies use a wide range of packaging styles. Teledyne's SSRs come in all sizes from DIPs and TO-5 cans to the terminal-block style for power-sized loads.



Compatible with TTL/DTL logic both in input control voltage and in its DIP packaging, C.P. Clare's 203 series of SSRs handles 750 mA for voltages to 240 V rms at 45-C ambient temperature in free air. Although the package is tiny, thick-film circuitry allows even zero-crossover switching to be squeezed into this opto-isolated unit.

A relay is a four-terminal device

Since a relay, by definition, is a four-terminal device, the degree of input/output isolation is important. The three specs that define input/output isolation—insulation resistance, dielectric strength, input-output capacitance—are usually unambiguous.

The insulation resistance between input and output (and to a metal case, if any), usually measured at 500 V dc, is typically in the neighborhood of 10^9 Ω.

The dielectric strength, typically about 1500 V rms, can be as high as 5000 V rms in some special designs. And the input-to-output capacitance, though not always given, can range from 5 to 10 pF in small units, though 10 to 20 pF is usually low enough to ensure little noise coupling from load back to the input.

Hybrid SSRs have input/output isolation characteristics determined mostly by the properties of the input reed relay. Hybrids probably have the most rugged inputs—more tolerant of input transients than all-solid-state designs, because the input relays require a substantial amount of energy to operate.

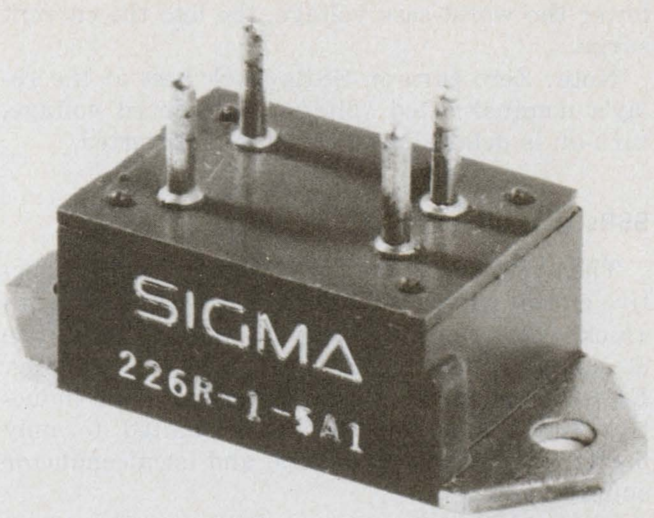
The solid-state-input SSR needs little input energy. But when the SSR operates on short pulses, the pulses must contain a minimum amount of energy for reliable turn-on. The pulse height may exceed the SSR's trigger level, but the width must last long enough to supply the needed energy.

Such a minimum-energy spec is hardly ever provided. You must ask for it.

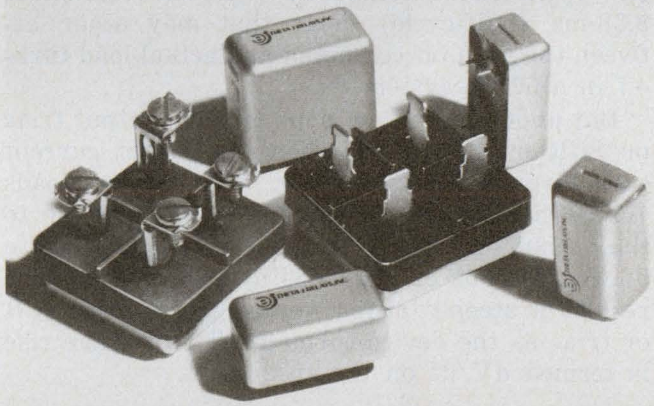
Of course, maximum input-voltage specs (almost always provided) should never be exceeded. Solid-state input circuits can be damaged by high, narrow spikes even though they don't last long enough to turn the SSR on.

Many SSR designs have built-in input protection circuits. Units for dc input are often protected against accidental reversal of the input polarity. Where necessary, external circuits—low-pass filters, clippers and special signal conditioners can remove most transients without materially affecting the desired performance.

Also, special input circuits can be provided to match impedances, shift levels and accept balanced signals with high, common-mode voltages. Naturally, inputs compatible with TTL, CMOS and other popular logic families are a common feature of SSRs.



Many companies concentrate on a single package for their SSRs. Sigma's Series 226 units handle 50 mA to 7 A in one housing. However, the unit needs a heat sink above 1.5 A and above 30 C. The unit fits TO-3 transistor heat sinks. This low-cost relay provides only random turn-on operation.



This family group of SSRs manufactured by Theta-J Relays covers a range of load capabilities from 0.75 to 25 A at up to 280 V rms. As with most SSR ratings, the ambient temperature must be carefully considered. To its credit, Theta-J has chosen 40-C ambient as its rating criterion vs 25 to 30 C for most other vendors.

Let the dynamic response fit the load

Between its input and output, the SSR allows a wide choice of dynamic responses, many not possible with EMRs. Compared with EMRs, the SSR can turn on almost instantaneously—1 μs in some fast units vs 1 to 50 ms for EMRs.

Random turn-on SSRs are generally recommended for resistive loads only, because there are no current surges or inductive kickbacks to worry about.

Of course, if you want fast turn-on, choose a transformer or optically coupled unit. The hybrid is slower, limited by the reed relay to about 1 ms, but still 10 times faster than any EMR of comparable load rating.

Zero-voltage turn-on—closure of the output circuit synchronized with a zero crossing of the ac line voltage—is highly desirable for high input-current surge loads like lamps and capacitors. In addition to protecting the SSR against huge current surges, zero-voltage turn-on keeps electromagnetic interference to a minimum. Note that zero turn-on response has an inherent delay, which may be as much as a half cycle, or 8.33 ms on 60-Hz power.

Be aware that an SSR doesn't necessarily have zero turn-on, merely because the manufacturer claims "internal transient protection" for an SSR. He may be referring only to an internal snubber network that, though helpful (especially for inductive loads) can't do the job of zero turn-on.

If you decide you need zero-crossover turn-on, ask about the worst-case, zero-switching voltage. Very few spec sheets include this information. The lower the worst-case voltage, the less the current surge.

Note: Zero turn-on SSRs work best at the relay's nominal rated voltage; at reduced voltage, turn-on is delayed, and the output distorted.

SSRs turn off softly

The abrupt interruption of current in an inductive circuit can cause very high transient voltages (kickbacks) reaching several thousand volts. The attendant arcing and EMI can be very damaging. EMRs must be particularly rugged with inductive loads, since protection is limited to only partially effective snubbers and semiconductor suppressors.

With SSRs on ac systems, SCR or triac output devices inherently turn-off only when the circuit current falls close to zero, regardless of when the OFF command occurs. The result: no current, no kickback and no EMI. The inherent 2-to-5-μs delay that the SCR or triac introduces at turn-off has little effect compared with the maximum 8.33-ms (half-cycle) delay that may occur between the turn-off command and actual load turn-off in a 60-Hz system.

But another problem pops up. The output triac or SCR may turn off when the output current goes through zero; however, with reactive loads (capacitive or inductive), the supply voltage to the output device may be near its peak (close to 90 degrees out of phase with the current). The result: a steeply rising voltage across the SCR or triac as the device turns off. This voltage rise is termed dV/dt on the spec sheet.

Turned off by turn-off specs?

Here is where the output-to-input capacity spec becomes important. The dV/dt generated across the SSR uses the I/O capacitive path—along with any stray wiring capacitance—to find its way back to the triac's or SCR's input control gate. The result is a commutation failure—the circuit refires (false fires) repeatedly and hangs up the circuit in an ON condition.

Transients originating in remote sources can enter the load wiring to the SSR and also cause false firing, but last usually only half a cycle. Such random false triggering may not be detected when you switch lamps or heater loads, and usually can be tolerated with such loads. However, with inductive loads, fast and repetitive false triggering can degrade and eventually destroy the SSR.

Thus, an SSR's dV/dt rating is an important output characteristic. Many manufacturers list a maximum dV/dt. Some don't. Of course, it's better to have a high maximum dV/dt.

But be careful: dV/dt ratings come in two categories, commutating and OFF-state, with the latter much higher in value than the former. An OFF-state dV/dt of 100 V/μs minimum is usually considered satisfactory for most applications. The corresponding commutating dV/dt value generally is only about 5 V/μs.

Sometimes a spec sheet lists only one value without identification: If the value is 100 V/μs or more, it's the OFF-state value.

Another problem: dV/dt ratings should be determined under realistic test conditions. Both the load and source impedance must be defined. A 50-Ω resistance has been proposed as an industry standard to be included in the NARM (National Association of Relay Manufacturers) SSR specifications. Clearly, this resistance can be set arbitrarily high to produce a seemingly better (higher), but unrealistic, dV/dt rating. Spec sheets rarely mention the test conditions for the given values: It's better to ask than be surprised.

Finally, if an SSR's built-in transient tolerance and dV/dt rating are insufficient you can add an external snubber circuit across the load to help suppress the transients.

High on/off rates can hurt

When an SSR is fully ON, its load-switching element may carry a high current, but the voltage

What's a solid-state relay?

A relay is defined as a four-terminal device whose input can control—but is dc-isolated from—its output. A solid-state relay, in addition to passive components, contains mostly semiconductor active devices. Unlike electromagnetic relays, most solid-state units are specifically designed to carry either ac or dc loads; the same SSR usually can't switch both.

Popular SSR load voltages include such ranges as 6 to 48 V and 90 to 150 V dc, or 80 to 140 V, 90 to 280 V and 200 to 480 V ac (rms). Higher voltages to the limits of modern semiconductors—about 1000-V peak—are also obtainable. The low limit is established by the minimum voltage needed for reliable turn-on of the load-switching semiconductor. Most manufacturers specify a range of 47 to 63 Hz for ac SSRs; 400-Hz units are available on special order.

Both SCRs and triacs are used for ac switching—SCRs tend to be more resistant to false turn-on than triacs. Power transistors are usually used for dc. However, some manufacturers make a back-to-back transistor bidirectional unit that can handle either dc or ac loads.

Isolation of the input from the output is usually done at the input circuit. Three methods are commonly used: optical, transformer/oscillator and reed relay.

drop across the element is low (typically 0.7 to 1.7 V). When the SSR is fully OFF, the current is low (milliamps of leakage), even though the voltage is high. In both cases, consequently, the power dissipated by the switching device is modest—between, say, 2 and 15 W for medium-sized SSRs. Generally, this power dissipation is included in published SSR specs, if not always adequately.

However, during the interval the SSR switches on or off (the breakover state), both high current and high voltage are present, and substantial power peaks are generated, peaks that must be dissipated.

Some SSR-design experts advise that the power-switching semiconductor should be built with glassivated junctions. Properly glassivated junctions produce devices with sharp breakover "knees." The "softer" the knee the longer the high-leakage interval during switching and the greater the heating, especially at chip edges where surface impurities can cause hot spots.

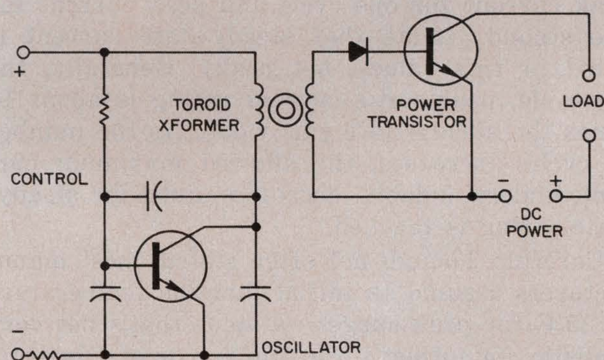
Switching time is short (microseconds), so when switching rates of the SSR are low—or even moderately high—the heat generated during switching contributes little above that of the static ON/OFF states. However, when switching occurs very rapidly, the heat generated during switching can become substantial. A marginal

Transformer isolation is fast

SSRs for dc often use a modulated-oscillator input and a small toroid transformer for isolation. This approach, used by Theta-J and Teledyne in some models, can have a very fast turn-on time—as fast as 1 μs—and low contact offsets—as low as 150 μV.

The transformer should have electrostatic shielding against capacitive coupling of transients from the load to the input, which can damage the input gate. Another caveat: Since the switched output current depends on the input current, any attempt to switch more load current than the input circuit can make available may damage the output semiconductor.

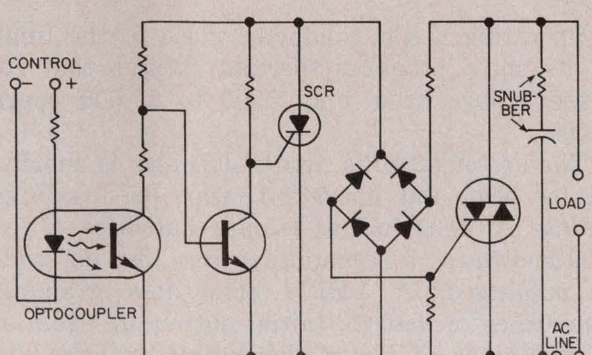
Also, the oscillator can produce rf noise in the load—from a few microvolts to as much as 200 mV at 3 to 9 MHz. This noise, of course, can be bypassed.



Optical isolation is all solid state

Some manufacturers, like C.P. Clare, use LEDs optically coupled to a phototransistor or photo-SCR. This approach is said to provide a fast or snap-action transfer characteristic desirable for triggering a triac or SCR. Other manufacturers, like Theta-J and Sigma, prefer a photocell or photoresistor sensor for greater light sensitivity, increased immunity to noise, higher voltage rating and lower cost.

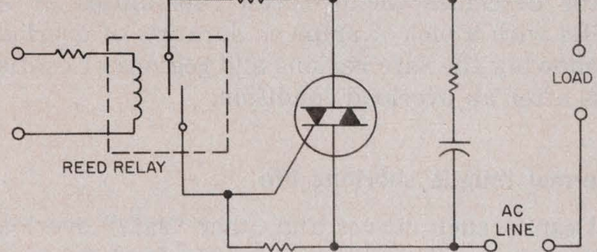
However, the photocell is slow and produces a "soft" trigger for the output semiconductor, which may shorten the semiconductor's life. Photocoupled SSRs have a high parts count when compared with reed-relay inputs, and especially with zero turn-on characteristics. Therefore photo SSRs are relatively high in cost.



Reed-relay isolation is low cost

Many SSR users have balked at using a reed-relay-input hybrid SSR, because it's a departure from the use of all-solid-state components. But low-cost, reliable performance and good trigger action, especially for triacs, have won over many users to reed-relay isolated types, such as Gordos' Reedac series. The over-100-million operation life is adequate for many applications.

Some disadvantages include sensitivity to shock, vibration and magnetic fields. Furthermore, a reed relay can stick when closed—not a fail-safe condition. Optocouplers generally fail in the open condition.



heat-sink design can then cause a unit to be short-lived. An SSR must be derated for such duty.

Then why are almost all SSR specs silent on this subject? For applications involving high switching rates (for which SSRs are superior to EMRs), you are practically forced to consult the SSR manufacturer.

Curb that surge

One series of specs that is almost never missing from even the most abbreviated spec sheet is the current-overload, or surge, maximums.

Exceeding those surge-current ratings can permanently damage an SSR. The rapid rise of the output semiconductor's junction temperature on a current surge ultimately limits the current rating. Most semiconductor junction temperatures should not exceed about 100 C maximum.

Overload ratings often appear in two ways: peak current for one cycle and peak current for one second. (Note that steady-state current is rated in rms values, not peak). Generally, the one-cycle, peak-surge current rating is about 10 times the steady-state rms value. As the number of cycles increases, the allowed maximum current, understandably, decreases, until the steady-state rating is reached.

Careful: Though not often stated, most manufacturers assume an initial junction temperature of 25 C for peak surges—a value that's not very realistic for either surge ratings or steady-state loads.

Some manufacturers supply a plot of allowable surge data in the form of a derating curve. Typically, a 10-A, steady-state-rated relay can have a one-cycle, 90-A rating. For one second (or for 60 cycles on 60 Hz), the allowed current can drop to 20 A. And at 120 cycles, the curve can approach the steady-state value.

A disturbing phenomenon frequently observed but seldom reported by manufacturers occurs when the overload exceeds certain levels of current and time. The SSR can lose its ON/OFF control for several seconds and lock into the ON state until the junction cools. Recommendation: Use slow blow fuses or circuit breakers, since this lock-ON condition can damage both controlled equipment and the SSR. At least one manufacturer describes the overload capabilities of its SSRs with a plot of amps vs duration of overload —showing the safe regions and regions of control loss after an overload condition.

Thermal fatigue shortens life

Despite such curves and other "safe" overload criteria, avoid operation near specified extremes and near overloads. Working at maximum load or repeated overload produces a cumulatively destructive effect on an SSR.

Thermal fatigue of SCRs and triacs is a subject dealt with gingerly by manufacturers of power semiconductors—and totally avoided by SSR makers.

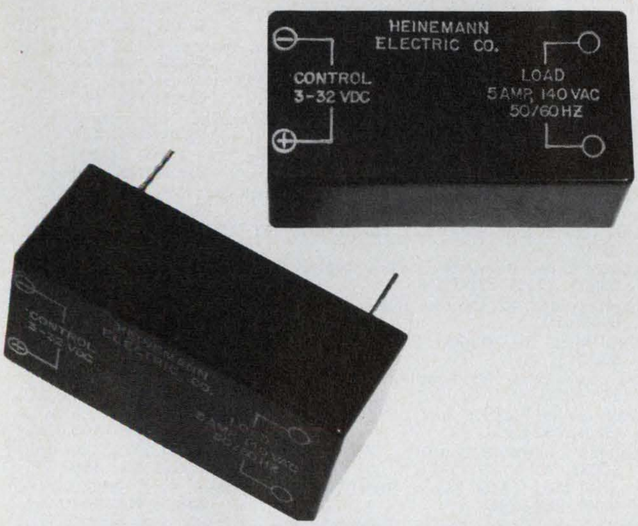
Virtually all SSRs use SCRs and triacs made with soft-soldered chips. Solderable chips switched at maximum ratings undergo substantial temperature excursions that stress the solder interface.

Operating a semiconductor close to the limits of its specs produces thermal fatigue that can cause failure after only 5000 to 10,000 operations.

The life of a SSR's input LED also is shortened by heat and operation near its maximum rating. A LED has a definite half-life—a fact well known to LED manufacturers, but not widely publicized. A LED's brightness gradually diminishes to half its initial output in hundreds of thousands of hours, depending on how hard it's driven. A well designed SSR with optocou-

A nylon case covers the innards of this SSR. The relay is mounted on an isolated metal base to provide good heat conduction to an external heat sink. Guardian Electric rates these units for loads of 7 to 10 A and up to 280 V rms.

SSR current ratings are based upon the maximum junction temperature of the output semiconductor device. Opto-22 recommends a safe value of 100 C for its units.



A choice of PC-mounting, quick-on or screw connectors is available for Heinemann's line of SSRs. The units feature fail-safe fusible links to prevent short-circuit damage.

pling operates the LED conservatively—say, at 20% of maximum brightness—to achieve long life in a generally hot (60 to 80 C) environment.

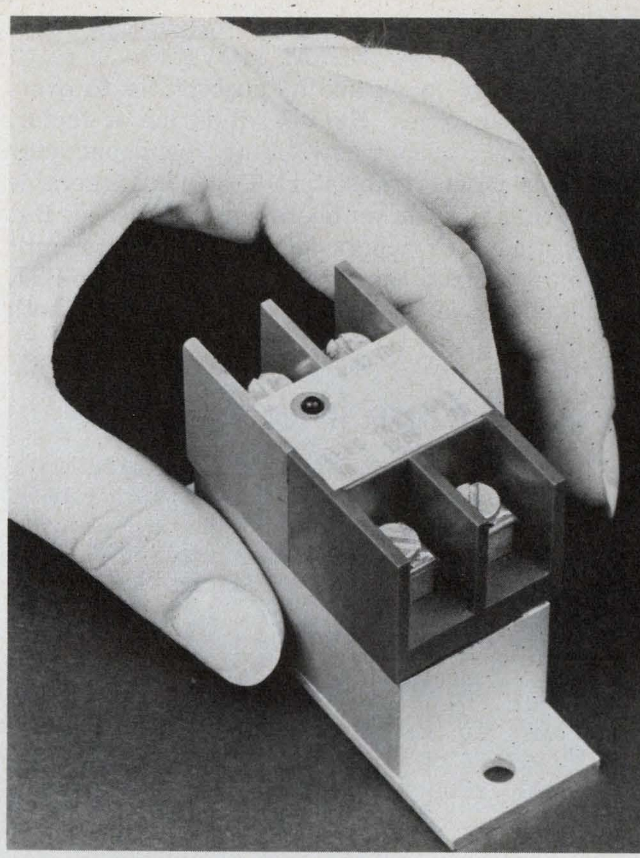
Don't snub the snubber

Many manufacturers build snubbers into their SSRs; some units don't have the room. Don't overlook the need for an external snubber when driving inductive loads.

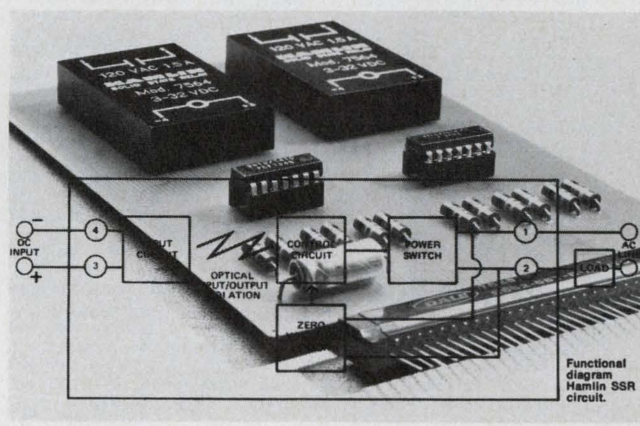
While a snubber can ensure that an SSR's dV/dt ratings are not exceeded, it can have some undesirable side effects as well. Its capacitor can resonate with the load inductance and in some cases develop voltages that exceed the line voltage and the SSR's voltage rating.

A similar phenomenon occurs when switching load capacitors. For example, when switching the capacitor in a reversing motor, the voltage across the SSR can rise as much as 100 V above a 120-V line.

One way to protect the SSR against overvoltage is to install a metal-oxide varistor (MOV)



Here's one SSR that comes with a "built-on" heat sink. Made by Electronic Instrument and Specialty Co., this relay can therefore handle the load specified; however, the spec sheet still warns, "electrical specs at 25 C, unless otherwise specified."



Printed-circuit-board mounted SSRs, such as these Hamlin units, provide a convenient and logic-circuit compatible way to control ac-power loads to about 1.5 A.

across the output terminals. But be careful: The MOV should be not only in a fully conductive state at a voltage less than the peak voltage rating of the SSR, but also in a high-impedance state below the maximum line voltage.

Therefore, to allow "room" for the MOV to operate properly, the SSR's rating should be well above the maximum line voltage. If a 200-V-peak SSR is used for a 120-V rms line without an

MOV, choose the next highest rated SSR—possibly a 400-V unit—with an MOV.

SSRs for dc loads are as susceptible to overvoltage as ac types. But dV/dt is not a factor, because the output switching semiconductor (usually a power transistor) is a nontriggerable device; thus, dV/dt snubbers are not needed. But MOVs, diodes or zeners should be used to limit overvoltages. And the constraint of using an SSR rated well above the line voltage applies for both ac and dc units. In some cases, it may be necessary to use transient suppression across both SSR and load.

Another way to suppress transients in dc switching circuits is to employ a controlled-response circuit. Controlling the rise and fall rates of the switched load current can substantially reduce the kickback in inductive loads. But, of course, external transients must still be controlled by voltage-limiting devices. ■■

Need more information?

For further information on solid-state relays, readers may consult the manufacturers listed here by circling the appropriate numbers on the reader service card. More vendors and information may be found in ELECTRONIC DESIGN's GOLD BOOK.

Action Instruments Inc., 8601 Aero Dr., San Diego, CA 92123. (714) 279-5726. **Circle No. 421**

Adams & Westlake Co., 1000 N. Michigan St., Elkhart, IN 46514. (219) 264-1141. **Circle No. 422**

Aerolite Electronics Corp., 2207 Summit Ave., Union City, NJ 07087. (201) 863-2955. **Circle No. 423**

Allen-Bradley Co., 1201 S. 2nd St., Milwaukee, WI 53204. (414) 671-2000. **Circle No. 424**

American Zettler Inc., 16881 Hale Ave., Irvine, CA 92714. (714) 540-4190. **Circle No. 425**

Applied Electro Tech, Inc., 2220 S. Anne St., Santa Ana, CA 92704. (714) 556-6570. **Circle No. 426**

Automatic Switch Co., 50-56 Hanover Rd., Florham Park, NJ 07932. (201) 966-2000. **Circle No. 427**

Autronics Corp., 180 N. Vinedo Ave., Pasadena, CA 91107. (213) 681-3545. **Circle No. 428**

Barber-Colman Co., Industrial Instrus. Div., 1317 Rock St., Rockford, IL 61101. (815) 877-0241. **Circle No. 429**

Basler Electric Co., Box 269, Highland, IL 62249. (618) 654-2341. **Circle No. 430**

Branson Corp., Vanderhoff Ave., Denville, NJ 07860. (201) 625-0600. **Circle No. 431**

B-W Controls Inc., 2200 E. Maple, Birmingham, MI 48012. (313) 643-8800. **Circle No. 432**

Cardinal Control Co., Inc., 32 Kensington Rd., Kensington, CT 06037. (203) 828-6379. **Circle No. 433**

C. P. Clare & Co., a subsidiary of General Instruments Corp., 3101 W. Pratt Ave., Chicago, IL 60645. (312) 262-7700. **Circle No. 434**

Computer Components, 88-06 Van Wyck Expressway, Jamaica, NY 11419. (212) 291-3500. **Circle No. 435**

Cutler-Hammer, 4201 N. 27th St., Milwaukee, WI 53216. (414) 442-7800. **Circle No. 436**

Delaval/Gems Sensors Div., Spring Lane, Farmington, CT 06032. (203) 677-1311. **Circle No. 437**

Deltrol Controls Corp., 2745 S. 19th St., Milwaukee, WI 53219. (414) 671-6800. **Circle No. 438**

Elec-Trol Inc., 26477 N. Golden Valley Rd., Saugus, CA 91350. (805) 252-8330. **Circle No. 439**

Electronic Instruments & Specialty Corp., 42C Pleasant St., Stoneham, MA 02180. (617) 438-5300. **Circle No. 440**

Electronic Relays, Inc., 7106-08 W. Touhy Ave., Niles, IL 60648. (312) 647-7727. **Circle No. 493**

Electronic Specialty Div., Datron Systems Inc., 18900 NE Sandby Blvd., Portland, OR 97220. (503) 665-0121. **Circle No. 441**

Essex Controls Div., 121 Godfrey, Logansport, IN 46947. (219) 753-7521. **Circle No. 442**

Essex International Inc., 1601 Wall St., Fort Wayne, IN 46804. (219) 743-0311. **Circle No. 443**

General Automatic Corp., 235 W. 1st St., Bayonne, NJ 07002. (201) 437-7500. **Circle No. 444**

General Electric Co., Electronic Components Sales, Electronics Pk., Building 1, Rm 3, Liverpool, NY 13088. (315) 956-0123. **Circle No. 445**

Gordos/Grigsby-Barton Inc., 1000 N. 2nd St., Rogers, AR 72756. (501) 636-5000. **Circle No. 446**

Gould Inc., Allied Control Div., 100 Relay Rd., Plantsville, CT 06479. (203) 628-9654. **Circle No. 447**

Grayhill Inc., 565 Hillgrove Ave., La Grange, IL 60525. (312) 354-1040. **Circle No. 448**

Guardian Electric Manufacturing Co., 4030 W. Spencer St., Torrance, CA 90503. (213) 542-8651. **Circle No. 449**

Hamlin Inc., Lake & Grove Sts., Lake Mills, WI 53551. (414) 648-2361. **Circle No. 450**

Hartman Electrical Mfg Div., A-T-O Inc., 175 N. Diamond St., Mansfield, OH 44902. (419) 524-1411. **Circle No. 451**

H-B Instruments Co., 4316 N. American St., Philadelphia, PA 19140. (215) 329-9125. **Circle No. 452**

Heinemann Electric Co., Brunswick Pike, Route 1, Trenton, NJ 08602. (609) 882-4800. **Circle No. 453**

Hi-G Inc., 580 Spring St., Windsor Locks, CT 05096. (203) 623-2481. **Circle No. 454**

Hope Elecs, 20 Newark Pompton Turnpike, Wayne, NJ 07470. (201) 777-3522. **Circle No. 455**

International Rectifier, Crydom Div., 1521 Grand Ave., El Segundo, CA 90245. (213) 322-4987. **Circle No. 456**

Walter Kidde, Douglas Randall Div., 6 Pawcatuck Ave., Pawcatuck, CT 02891. (203) 599-1750. **Circle No. 457**

Kratos, 403 S. Raymond Ave., Pasadena, CA 91109. (213) 449-3090. **Circle No. 458**

LaMarche Manufacturing Co., 106 Bradrock Dr., Des Plaines, IL 60018. (312) 299-1188. **Circle No. 459**

Lark Elecs Inc., Box 390, New York, NY 10040. (212) 925-9060. **Circle No. 460**

Leach Corp., Relay Div., 5915 Avalon Blvd., Los Angeles, CA 90003. (213) 232-8221. **Circle No. 461**

Logitek Inc., 42 Central Ave., Farmingdale, NY 11735. (516) 694-3080. **Circle No. 462**

LRC Inc., 101 Digital Dr., Hudson, NH 03051. (603) 883-8001. **Circle No. 463**

Madison Labs, 83 Bradley Rd., Madison, CT 06443. (203) 245-4280. **Circle No. 464**

Magnecraft Electric Co., 5575 N. Lynch, Chicago, IL 60630. (312) 282-5500. **Circle No. 465**

Master Electronic Controls, 1651 19th St., Santa Monica, CA 90025. (213) 393-3177. **Circle No. 466**

Midtex Inc., 1650 Tower Blvd., North Mankato, MN 56001. (507) 388-6286. **Circle No. 467**

MKC Elecs Corp., 454 E. Donavan, Kansas City, KS 66115. (913) 371-1351. **Circle No. 468**

Monsanto Electronics Div., 3400 Hillview Ave., Palo Alto, CA 94304. (415) 493-3300. **Circle No. 469**

North American Philips Controls Corp., Frederick Div., Husky Pk., Frederick, MD 21701. (301) 663-5141. **Circle No. 470**

Ohmite Manufacturing, 3601 Howard, Skokie, IL 60076. (312) 675-2600. **Circle No. 471**

Opto 22, 5842 Research Dr., Huntington Beach, CA 92649. (714) 892-3313. **Circle No. 492**

Potter & Brumfield Inc., 1200 E. Broadway, Princeton, IN 47671. (812) 386-1000. **Circle No. 472**

Regent Controls Inc., 169 Harvard Ave., Stamford, CT 06902. (203) 348-7734. **Circle No. 473**

Ripley Co., Inc., 46 Nooks Hill Rd., Cromwell, CT 06416. (203) 346-6677. **Circle No. 474**

R K Electric Co., Inc., 11315 Williamson, Cincinnati, OH 45241. (513) 793-4060. **Circle No. 475**

Sensor Corp., 303 Scottdale Ave., Scottdale, PA 15683. (412) 887-4080. **Circle No. 476**

Shigoto Ind. Ltd., 350 5th Ave., New York, NY 10001. (212) 695-0200. **Circle No. 477**

Sigma Instruments Inc., 170 Pearl St., Braintree, MA 02184. (617) 843-5000. **Circle No. 478**

Solid State Electronics, 15321 Rayen St., Sepulveda, CA 91343. (213) 894-2271. **Circle No. 479**

Square D Co., Executive Plaza, Park Ridge, IL 60068. (312) 774-9200. **Circle No. 480**

Sterer Engraving & Manufacturing Co., 4690 Colorado Blvd., Los Angeles, CA 90039. (213) 245-7161. **Circle No. 481**

Struthers-Dunn Inc., Lambs Rd., Pitman, NJ 08071. (609) 589-7500. **Circle No. 482**

TDR Electronics, Foot of John St., Lowell, MA 01852. (617) 459-0151. **Circle No. 483**

Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, CA 90250. (213) 973-4545. **Circle No. 484**

Texas Instruments Inc., P.O. Box 5012, Mail Station 84, Dallas, TX 75222. (214) 238-3333. **Circle No. 485**

Theta-J Relays, Inc., 2 Linden St., Reading, MA 01867. (617) 942-0390. **Circle No. 486**

Utec Corp., 871 Allwood Rd., Clifton, NJ 07012. (201) 779-0430. **Circle No. 487**

Vectrol Inc., 1010 Westmore Ave., Rockville, MD 20853. (301) 424-6900. **Circle No. 488**

Versitron, 6310 Chillum Pl. NW, Washington, DC 20011. (202) 882-8464. **Circle No. 490**

Wabash Relay & Electronics, First & Webster St., Wabash, IN 46992. (219) 563-2191. **Circle No. 491**

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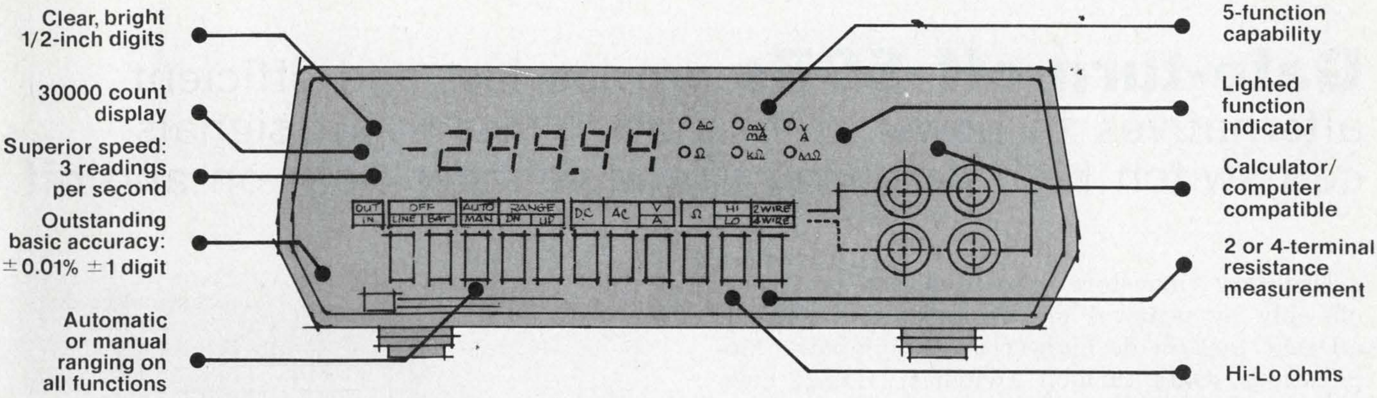

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Technology

Gate-turn-off SCRs provide fast and efficient alternatives to power transistors. Pulse input signals can switch high dc currents and voltages both on and off.

Ordinary thyristors once fired, can be turned off only by removal of the anode voltage—not an easy task in dc high-voltage, high-power applications. Gate turn-off switches (GTS), however, have the advantage that they can be turned off with relatively little effort by a negative pulse to the gate.

GTS thyristors can be used where only transistors (and sometimes electromechanical devices) could do the job before—in solid-state relays for the control of high-voltage and high-current dc; in the control of dc traction motors, stepping motors and powerful dc solenoids; and in power inverters and many other applications.

Further, GTS thyristors can do a better job than transistors. They are more efficient (especially for high power), operate with low-control power (need only pulses to turn ON or OFF) and can act faster and provide higher blocking voltage (to 800 V) and higher current switching (to 30 A average) for a given size.

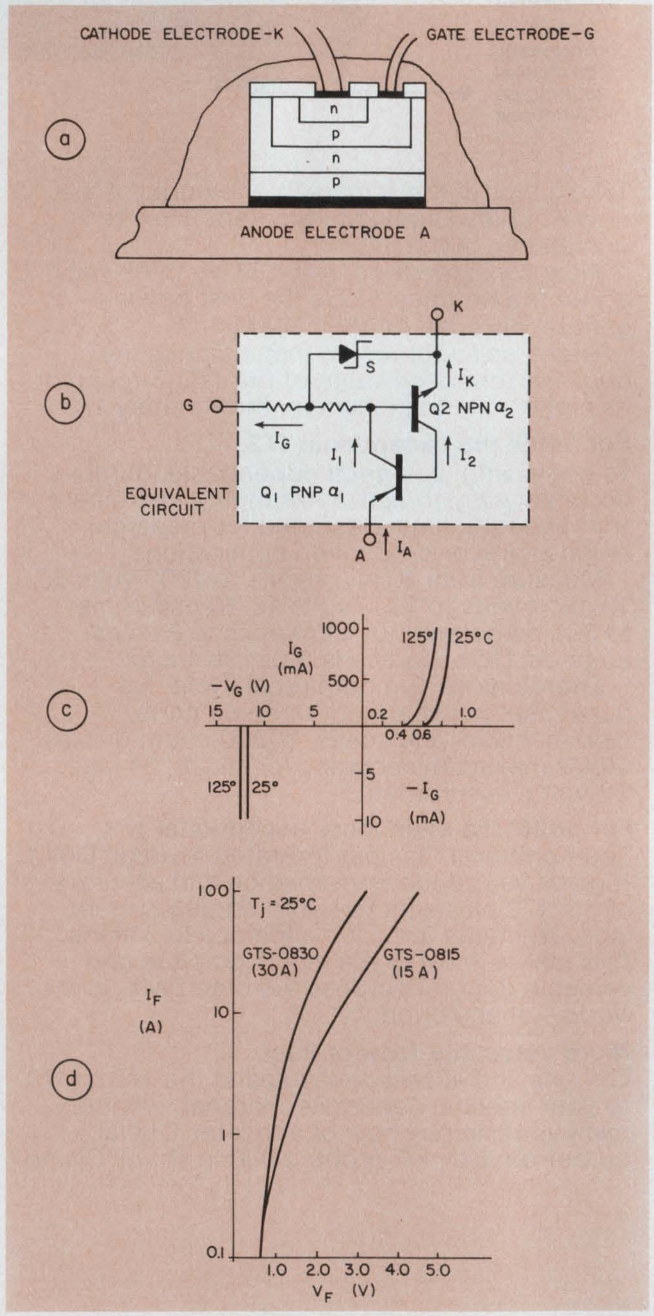
GTS construction similar to ordinary SCR

The GTS thyristor is a four-layer pnpn device constructed similarly to a conventional thyristor (Fig. 1a). However, a new factor, turn-off gain (G_{off}), is introduced, and defined as equal to the anode current, I_A, divided by the amount of reverse gate current, I_G, required to turn off the anode current,

$$G_{off} = \frac{I_A}{I_G}.$$

Fig. 1b shows an approximate equivalent circuit of a GTS. The device acts as if it contained two transistors and one zener diode and the gate (G) to cathode (K) path presents a voltage/current characteristic similar to a zener diode (Fig. 1c).

A positive pulse to gate, G, turns Q_2 ON, which then turns Q_1 ON. The regenerative feedback via paths I_1 and I_2 keeps the Q_1/Q_2 combination con-

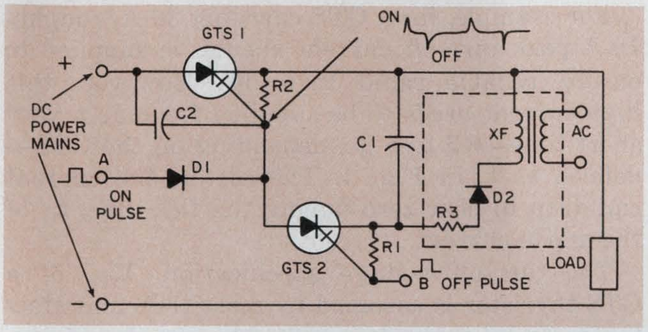


1. A gate turn-off thyristor is very similar in construction (a) to an ordinary SCR and has a similar equivalent representation (b). Between the control gate and cathode terminals, the GTS exhibits the properties of a zener (c). And the forward drop from anode to cathode (d), when the GTS conducts, is low and varies little—between 0.7 and 2 V—over a large current range.

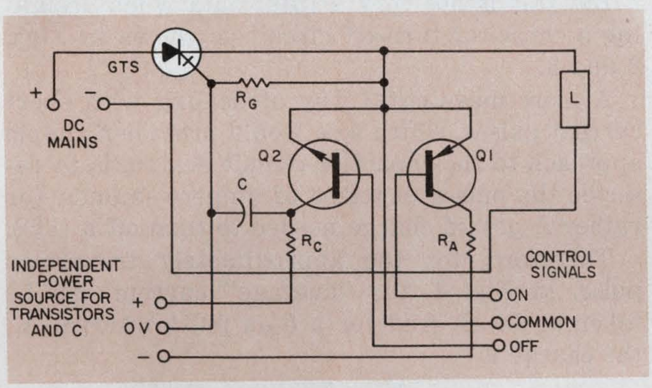
K. P. Ohka, Vice President of Engineering, and **E. D. Lucas Jr.,** Consultant, Sabor Corp., 12597 Crenshaw Blvd., Hawthorne, CA 90250.

ducting after removal of the pulse, provided the current gains a_1 and a_2 of Q_1 and Q_2, respectively, are adequate. This behavior is exactly as for ordinary SCRs. But because of design compromises to achieve a fast gate turn-off capability in GTS thyristors, the high regenerative gain inherent in conventional SCRs is reduced in GTS design.

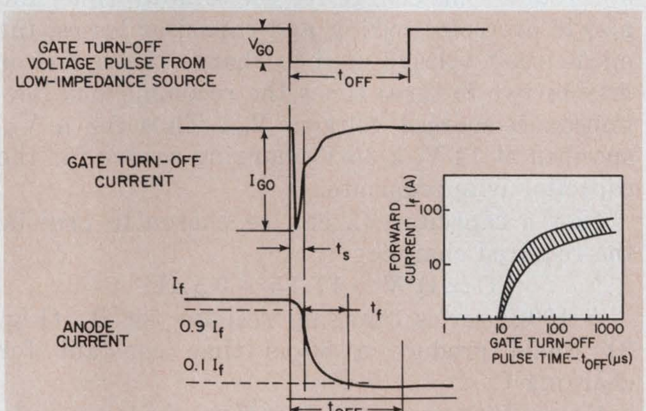
GTSs are specially configured so that a negative current flow to G can turn off the device by drawing off current from I_a sufficiently to "break" the regenerative loop. Although a large G_{off} would make turning off the GTS easier, a limit is reached for a G_{off} between 15 and 20. Above this gain range, GTS fabrication requirements produce an increase in forward-voltage drop, V_f (see Fig. 1d for typical values), and a decrease in reverse blocking voltage. Therefore, especially for high-power devices, G_{off} must be traded at the expense of providing a higher turn-off current, I_G, from the external control circuit.



2. **One of the first successful turn-off circuits** uses a separate small power supply to charge a capacitor that supplies the extinguishing-current surge to the GTS's gate. With only milliamps of input, amperes of dc current can be turned on and off.



3. **Medium-sized transistors can be used to control** high-volt, high-current GTS units.



4. **The gate turn-off peak pulse,** I_{GO}, lasts only a short period, t_s—roughly 10% of the total turn-off time, t_{off}.

Dc can turn off a GTS, but a sharp pulse is best, especially in rapidly repeated on/off application. The reasons for this conclusion can be understood by referring to the equivalent circuit, Fig. 1b.

- If the reverse gate current is gradually increased, then near the turn-off point, transistors Q_1 and Q_2 only slowly release from saturated states, as I_A decreases. During this interval, the voltage rises between the anode (A) and cathode (K) and the relatively high current and voltage will produce high power consumption, and hence, loss of efficiency.
- Further, with the negative voltage still applied to the gate after the gate has turned OFF, the zener can conduct, and the loss of power into the gate can also be very high.

Fig. 2 is the first of several successful circuits used for controlling a GTS thyristor. With only 20 mA, about 30-A-dc current can be turned on, but a sizable, 10-to-15-A, 5-μs pulse is needed to turn it off. Thyristor GTS_1 is the main power-control unit and GTS_2 acts as a turn-off trigger for GTS_1.

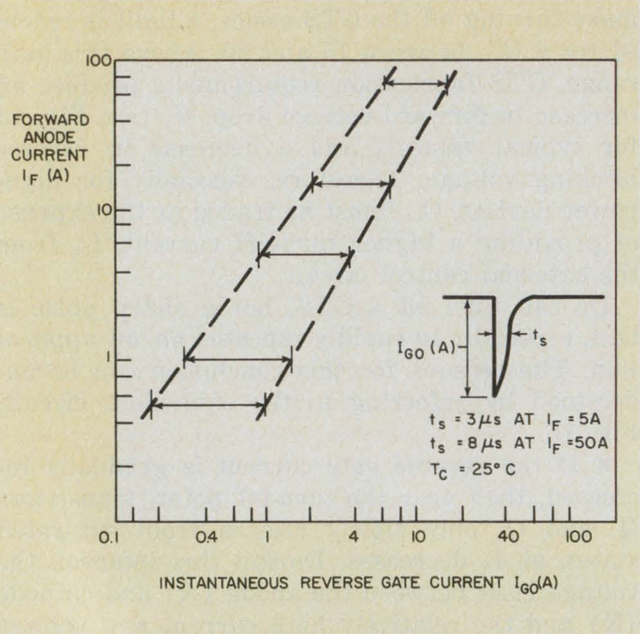
A capacitor supplies the turn-off pulse

A positive pulse to terminal A turns GTS_1 on. Capacitor C_1 is charged by an independent power supply, shown in the dotted box enclosing R_3, D_2 and a small transformer, XF.

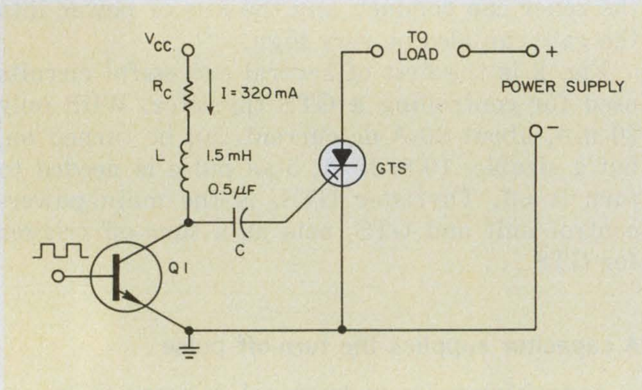
To turn off GTS_1, a positive pulse is applied to terminal B. GTS_2 fires and discharges a current pulse from C_2 through resistor R_2. This pulse applies a negative voltage to the gate of GTS_1 for a period sufficiently long to turn off GTS_1. GTS_2 also turns off automatically when the current from C_1 drops below GTS_2's hold-on current—R_3 limits C_1 charging current below the hold-on current. With GTS_2 OFF, C_1 recharges.

A similar control circuit (Fig. 3) uses transistor, Q_1, to turn on the GTS and another, Q_2, to discharge a capacitor, C, to turn off the device. Note that again, separate power sources are needed. They supply the transistor voltages and charge C.

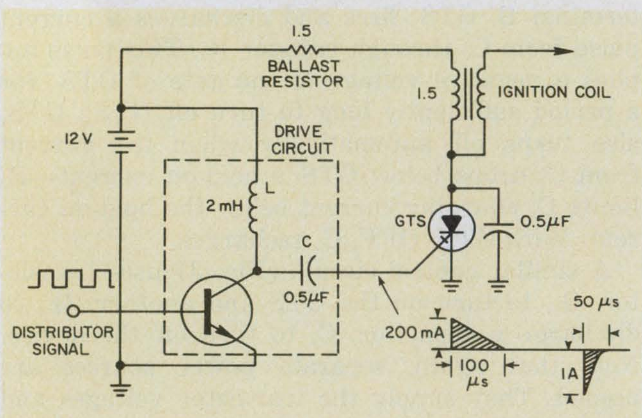
Resistor R_A controls the forward gate turn-on current of the GTS, and R_C the charging current of C. And, acting in series, resistors R_A and R_C determine the amount of power drawn from the separate power supplies.



5. **The peak current needed to turn off a GTS** depends upon the forward anode current.



6. **An inductor in the turn-off circuit** allows the use of a reduced voltage source, V_{cc}, to charge the turn-off capacitor, C, sufficiently to extinguish the GTS.



7. **Ignition signals from an automobile distributor** control the on/off timing of a GTS thyristor. High-voltage developed in the ignition-coil secondary, when the GTS turns off, produces a spark across the gap of a spark plug. The GTS turns on within 100 μs and off in about 50 μs and needs about 1-A peak to extinguish.

Clearly, turning off the GTS requires a bit more ingenuity than turning it on. The turn-off pulse must be applied for several tens of microseconds, t_{off}, but fortunately the amperes of peak current that may be required need persist for only a few microseconds, t_s, of the interval, t_{off} (Fig. 4). A very rough rule of thumb calls for an instantaneous peak pulse current, I_{GO}, of about one-half the anode current at the time of turn off. Fig. 5 provides a more accurate range of peak-current values for a typical GTS, than this rule of thumb. New GTS developments may strongly reduce the peak-current requirement.

For example, for a GTS carrying 20 A, roughly 10-A peak turn-off current should be supplied to ensure reliable rapid turn off. However, this high current needs to be supplied for only a very short time—0.5 to 5 μs, depending on the GTS—defined as t_s in Fig. 4. Thereafter, the current can drop to near zero during the fall time, t_f, of the anode current.

The turn-off voltage specification, V_{GO}, of a GTS thyristor is assumed by most GTS manufacturers to be derived from a low-impedance constant-voltage source. The V_{GO} for the device of Figs. 4 and 5 is specified as 14 V.

Amp-μs: A better way to spec turn off

But this is not very helpful data when designing a capacitor turn-off circuit as shown in Figs. 2 and 3.

A more meaningful way of dealing with short current pulses, which also would provide a simple approach to the capacitor-circuit design, is to describe the pulses in terms of ampere-seconds (or rather A-μs) of charge needed to turn off a GTS.

Therefore, for the approximately triangular pulse, in Fig. 4, the "average" current can be taken as $I_{GO}/3$. And for a 5-μs pulse interval, t_s, the charge is

$$Q \simeq \frac{10 \times 5}{3} \simeq 17 \text{ A-}\mu\text{s}.$$

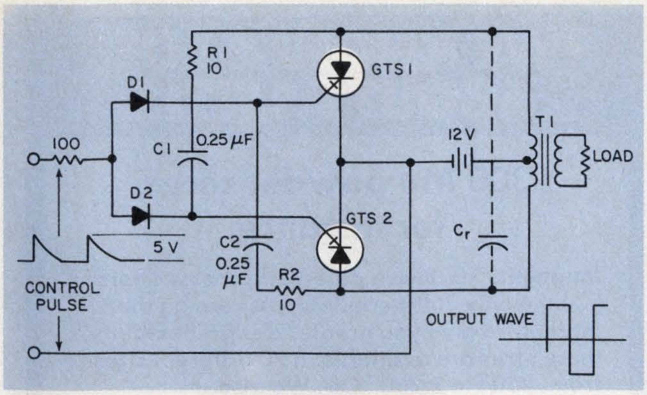
To assure the required high initial current and still retain some charge for the total t_{off} time, and also to overcome wiring and capacitor losses, the open-circuit voltage used to charge the capacitor may be two to three times the recommended low-impedance-sourced voltage, V_{GO}. Thus for a V_{GO} specified at 14 V, a 35-V charging source for the capacitor is appropriate.

Now a capacitor, C, can be chosen to provide the required charge:

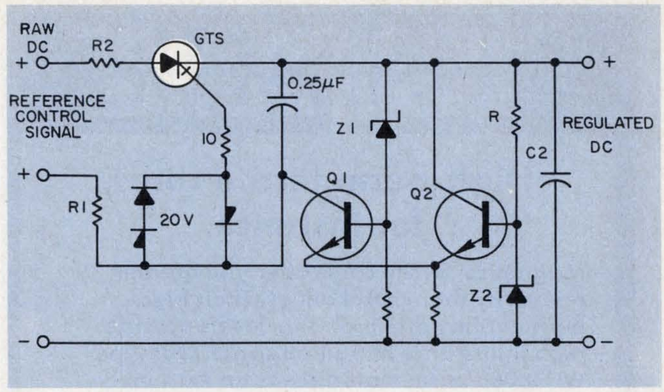
$$C = Q/V \simeq 17/35 \simeq 0.5\ \mu\text{F}.$$

A 100-Ω series charging resistor for R_c (Fig. 3) would produce a 50-μs time constant for charging C.

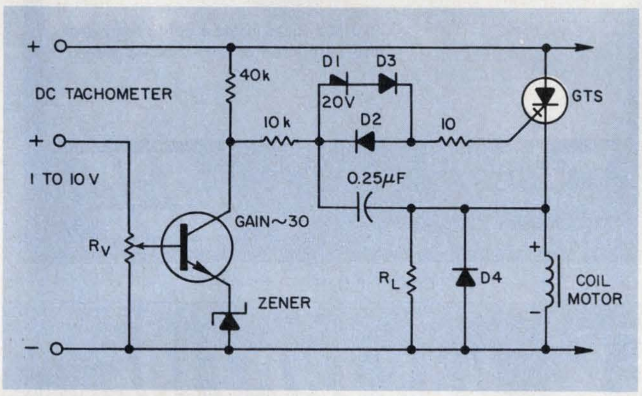
Note: With capacitor C sufficiently large, only part of its charge is drained off during the initial t_s surge, because the impedance of the GTS gate



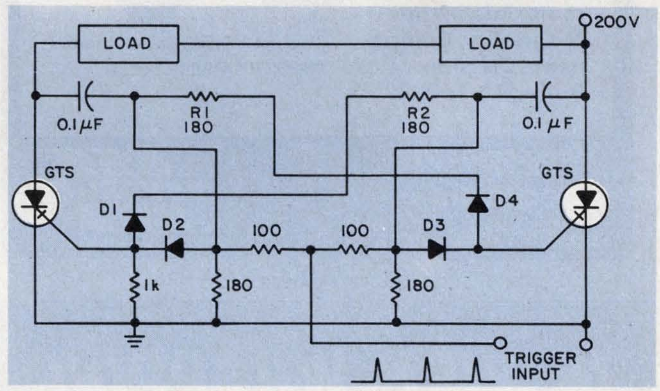
8. **In this dc-to-ac converter,** input-controi pulses turn the two GTS thyristors on alternately. When one GTS goes on, the other is automatically turned off by the charge stored in C_1 or C_2. Thus, alternate half-cycle pulses in the primary of the transformer become ac in the secondary. Low-loss and high-current capabilities of GTSs provide efficient power conversion.



10. **In this voltage regulator,** a positive reference control level turns the GTS on. When the regulated voltage stabilizes, transistor Q_2 stays on, which keeps Q_1 off, to allow GTS to conduct and supply power to the regulated-voltage load. A rise in regulated voltage above the level established by the reference turns Q_1 on, which extinguishes the GTS temporarily, until the output voltage falls to the controlled level.



9. **For use as a dc-motor speed control,** a dc tachometer turns transistor Q on or off as the motor speed and tachometer voltage rises above or drops below a reference level set by resistor R_V and the zener diode. At low speeds, Q turns off and its collector voltage rises to turn the GTS on via a 20-V Shockley diode. When the speed, and thus, the tachometer's voltage rises above the reference level, Q turns on and the GTS gate becomes negative with respect to its cathode, turning the GTS off. The Shockley diode produces a sharp turn-on point when it "breaks" into conduction, and also, it introduces some desirable hysteresis into the circuit. The circuit can also be used as a solid-state relay operating from a wide variety of input sources for driving motors, solenoids, mechanical counters and many other devices.



11. **To switch high voltage and current between two loads** under the control of low-voltage trigger pulses, two GTS devices serve as power switches in this flip-flop.

becomes high once the OFF state is achieved in the first 0.5 to 5 μs.

An interesting variation of GTS control combines an inductor with the capacitor and allows the use of a lower source voltage (Fig. 6). Energy stored in the inductor, when the transistor is conducting, is converted to voltage to increase the voltage on the capacitor, when the transistor opens. The voltage, V_L, that is added to V_{cc} to make a total voltage V_c across the capacitor can be determined approximately by assuming that all of the coil energy eventually is stored in the capacitor; therefore,

$$\text{(energy in coil) } 1/2\ LI^2 \simeq 1/2\ CV_L^2 \text{ (energy in capacitor)}$$

$$V_L = I\sqrt{\frac{L}{C}}$$

$$V_c = V_{cc} + V_L$$

In Fig. 6, with the values of L and C shown, for a current of 320 mA, limited by R_c, V_L when taken together with about 18 V on V_{cc} can charge C to about 35 V.

The A-μs approach is, admittedly, very "rough," but it gets practical results.

As is so often the case with other solid-state nonlinear devices, design engineers can often best learn to use the GTS by studying the circuits of some representative application examples. A drive for an ignition circuit (Fig. 7), a dc-to-ac converter circuit (Fig. 8), a dc motor-speed control (Fig. 9), a dc voltage regulator (Fig. 10) and a high-voltage flip-flop (Fig. 11) show the diversity of possible uses for GTS. Each circuit is explained by its caption. ■■

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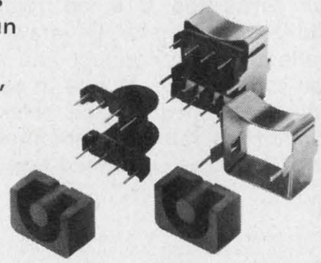

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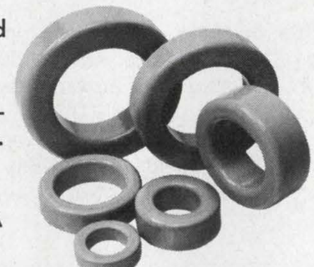

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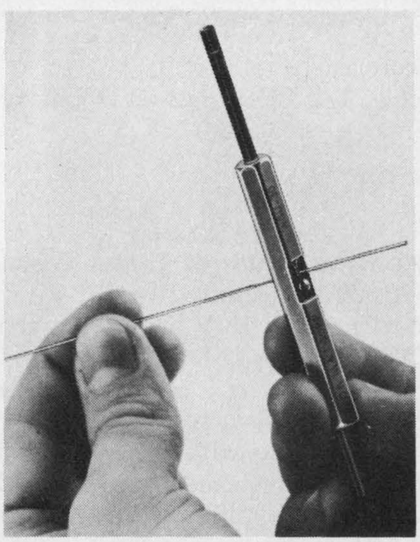

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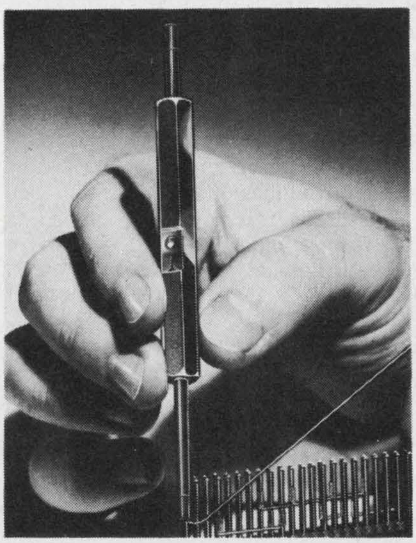

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Design flyback converters for best performance. Analyzing the two basic operating modes gives the relationships between the important parameters.

Knowing how the output parameters of a flyback converter vary with voltage and load, you can optimize the converter for various requirements, such as maximum current limits or minimum transformer volume.

To analyze what happens in the choke, assume an ideal switch and linear operation for the inductance. The power stage and the time variation of currents and voltages at the transformer input and output are shown in Fig. 1.

The principle behind flyback converters is based on the storage of energy in a choke during a time period, t_1, and the discharging of the energy to a load during a second period, t_2. If isolation is necessary between the battery—the primary source of power—and the load, the primary of a transformer can play the part of the storage choke in addition to its normal role.

Analysis boils down to two modes

Although there are many different flyback-converter designs, just two basic modes of operation exist. In one mode (A), the energy stored in the choke is yielded totally to the load before the next cycle begins. In the other mode (B), the choke begins to recharge before discharge is completed.

In mode A, during t_1, the input current increases linearly until it reaches a maximum value, I_{pM}, given by:

$$I_{pM} = \frac{E}{L_p} t_1, \qquad (1)$$

where E is the battery voltage, and L_p the primary inductance. During t_2, the current in the secondary decreases from a maximum of I_{sM} given by:

$$I_{sM} = \frac{V_s\ (\text{off})}{L_s} t_2, \qquad (2)$$

where V_s is the voltage across the secondary, and L_s the secondary inductance.

The energy stored in the primary during t_1, expressed by $1/2 L_p I^2_{pM}$, is transferred to the secondary with efficiency η_{tr}, a number that indicates the quality of the transformer. From the relationship, $1/2\ L_s I^2_{sM} = \eta_{tr} 1/2 L_p I^2_{pM}$, comes:

$$I_{sM} = \sqrt{\eta_{tr}}\ \frac{n_p}{n_s} I_{pM}, \qquad (3)$$

where n_p is the primary turns and n_s the secondary turns. Find the load current by integrating the secondary current for the period T and getting this result:

$$I_L = \frac{1}{2} I_{sM} \frac{t_2}{T}. \qquad (4)$$

Since the rectifier loses power, a rectifying efficiency, η_R (significant for low output voltages) must be introduced. Thus:

$$\eta_R = \frac{V_L}{V_s\ (\text{off})}. \qquad (5)$$

Using the notation, $\tau = t_1/T$, and introducing the over-all efficiency, $\eta = \eta_{tr}\eta_R$, the power delivered to the load can be deduced from Equations 1 through 5:

$$P_L = \left(\frac{1}{2}\eta\tau^2\right)\frac{E^2}{fL_p}. \qquad (6)$$

The value of t_2 as a function of the load can also be found:

$$t_2 = \sqrt{\frac{2\,\eta_R\,L_s}{f\,R_L}}. \qquad (7)$$

Expressions 4 and 5 can be reshaped for easier use in design. Thus:

$$I_L = \frac{1}{2}\left(\frac{n_p}{n_s}\sqrt{\eta_{tr}}\right)\frac{\tau\,(1-\tau)\,E}{f\,L_p}; \qquad (8a)$$

$$V_L = \eta_R\sqrt{\eta_{tr}}\left(\frac{n_s}{n_p}\right)\left(\frac{\tau}{1-\tau}\right)E. \qquad (8b)$$

What the equations show

Analyzing the equations reveals a number of things about converters working in mode A:

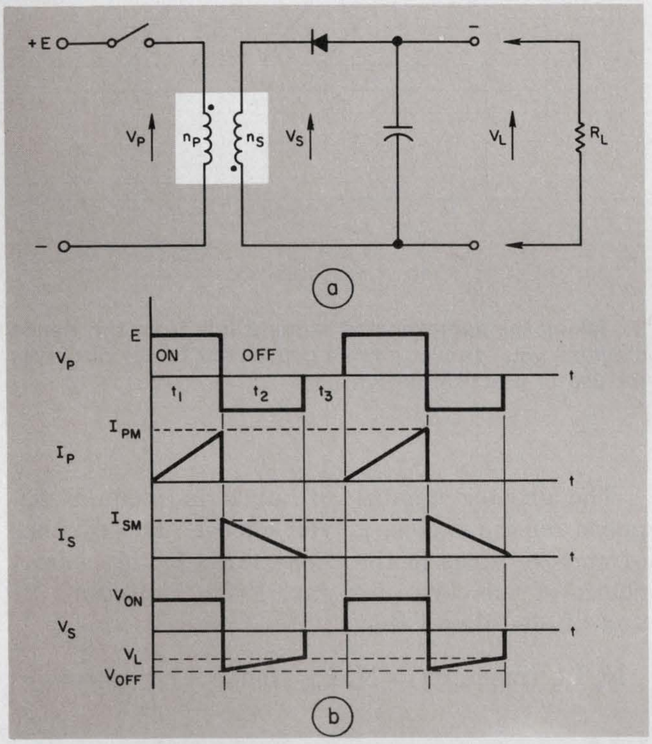
1. The maximum input current I_{pM} does not depend on load variations.

2. The power delivered to the load does not depend on the load value R_L. The converter provides a constant power, and the battery is isolated from the load for any output conditions, including no-load. For the no-load condition, the output voltage increases until the dissipation of the leakage resistances equals the constant power of the converter. At that point, t_2 is very short.

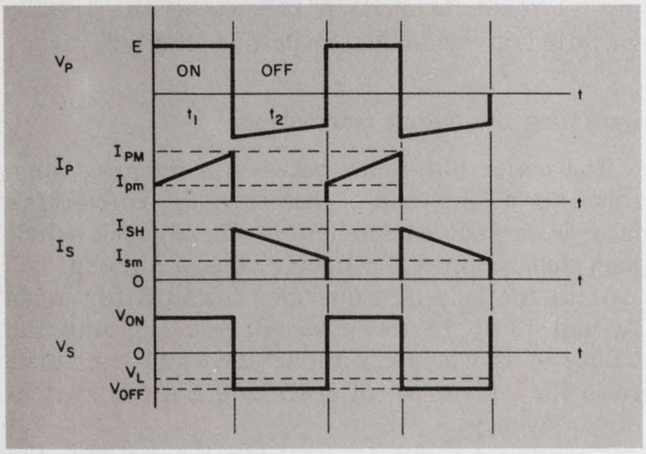
3. The power delivered by the converter de-

Vladimir Brunstein, Design Engineer, Nova Electric, 263 Hillside Ave., Nutley, NJ 07110.

pends on the product, fL_p, for a given duty cycle and battery voltage, E. In other words, for a given power, an increase in the frequency decreases the inductance, L_p, and, hence, the size of the ferrite core.



1. **The power stage of a flyback converter** can be idealized into an ideal switch and a linear transformer for analysis (a). The primary and secondary voltages and currents of the ideal converter (if all energy is discharged at each cycle) are shown in (b).



2. **If all energy isn't discharged** before the next cycle begins, then the flyback currents and voltages are somewhat different from those for complete discharge. Energy is stored during interval t_1.

4. The values of τ or f, or both, can be modified through a feedback loop (usually the frequency is kept constant and only τ is the varied) to stabilize values I_L or V_L with load variations.

In mode B, the primary and secondary currents and voltages are similar to mode A (Fig. 2). During t_1, energy is stored by a linear growth of the current in the winding from a minimum value, I_{pm} (residual from the previous cycle), to a maximum, I_{pM}, where:

$$I_{pM} - I_{pm} = \frac{E}{L_p} t_1 . \qquad (9)$$

During t_2, current appears only in the secondary and decreases linearly from a maximum of I_{sM} to a minimum of I_{sm} as follows:

$$I_{sM} - I_{sm} = \frac{V_s\ (\text{off})}{L_S} t_2 . \qquad (10)$$

Since switching occurs before the secondary current drops to zero, energy remains stored in the choke and is transferred back to the primary through the current I_{pm}. The relationship between the currents—similar to the one in mode A—is given by:

$$I_{sM} - I_{sm} = \frac{n_p}{n_s} (I_{pM} - I_{pm}) , \qquad (11)$$

and the load current is:

$$I_L = \frac{I_{sM} + I_{sm}}{2} \left(\frac{t_2}{T}\right). \qquad (12)$$

Using the same notations as in mode A results in the following:

$$I_L = \frac{1}{2}\left(\sqrt{\eta_{tr}}\, \frac{n_p}{n_s}\right) \tau\ (1 - \tau)\ \frac{E}{f\, L_p} + \sqrt{\eta_{tr}}\, \frac{n_p}{n_s}\ (1 - \tau)\ I_{pm} . \qquad (13)$$

$$V_L = \eta_R \sqrt{\eta_{tr}}\, \frac{n_s}{n_p} \left(E \frac{\tau}{1 - \tau} \right). \qquad (14)$$

$$P_L = \frac{1}{2}\, \eta\, \tau^2\, \frac{E^2}{f\, L_p} + \eta\, \tau\, E\, I_{pm} . \qquad (15)$$

The values of I_{pm} and I_{pM} are given by:

$$I_{pm} = I_{pM} - \frac{1}{2} \frac{E\, \tau}{f\, L_p} ; \qquad (16)$$

$$I_{pM} = \frac{\eta_R}{\tau} \left(\frac{\tau}{1 - \tau}\right)^2 \left(\frac{n_s}{n_p}\right)^2 \frac{E}{R_L} . \qquad (17)$$

In mode B, therefore;

1. The output voltage is not dependent on the load or the frequency. However, a weak dependency exists between V_L and the load through the efficiency, which depends on R_L.

2. The power delivered by the converter is a function of R_L, so protection against overload is necessary.

3. Voltage V_L can be stabilized against variations in E only by varying τ.

4. Eq. 16 shows that I_{pm} varies with the load

and, at a certain moment, can be zeroed. At that moment, a change in the working mode occurs since the increase of resistance R_L leads to mode-A operation.

5. For the condition, $I_{pm} = 0$, the equations for mode B become the same as those for A, where $t_3 = 0$, and $t_1 + t_2 = 1/f$. This case corresponds to a blocking-oscillator mode (self-oscillating flyback). The limiting value for R_L can be obtained from any of the cited conditions.

For R_L in the blocking-oscillator mode, the frequency and the duty cycle vary according to:

$$R_L = \eta_R \frac{n_s^2}{n_p} \left[\frac{2 f L_p}{(1-\tau)^2} \right]. \qquad (18)$$

To illustrate the advantages and disadvantages of both modes, compare two converters with the same load, the same τ, and the same power delivered from a battery E.

How the modes stack up

Begin by comparing the regulation of the output parameters (voltage or current). Notice that the load current is inversely proportional to $\sqrt{R_L}$ in mode A and inversely proportional to R_L in mode B.

Consequently mode A is advisable for those converters with constant output current (for instance, remotely supplied amplifiers in cable-communication equipment), because the current variation to be stabilized for a given R_L is small. On the other hand, mode B is better for a converter of constant output voltage, because V_L is only mildly dependent on load variations (Eq. 14).

Comparing the maximum currents is important when the restricting element is the current limit of the semiconductor being used as the switch. From Equations 6 and 15, the output powers are:

$$P = \frac{1}{2} \tau E \eta I_{pM}, \text{ for mode A}; \qquad (19)$$

$$P = \frac{1}{2} \tau E \eta (I_{pM} + I_{pm}), \text{ for mode B}. \qquad (20)$$

Equating Eq. 19 to Eq. 20:

$$I_{pM} \text{ (mode A)} = I_{pM} \text{ (mode B)} [1 + k], \qquad (21)$$

$$\text{where } k = \frac{I_{pm}}{I_{pM} \text{ (mode B)}}, \text{ and } 0 < k < 1.$$

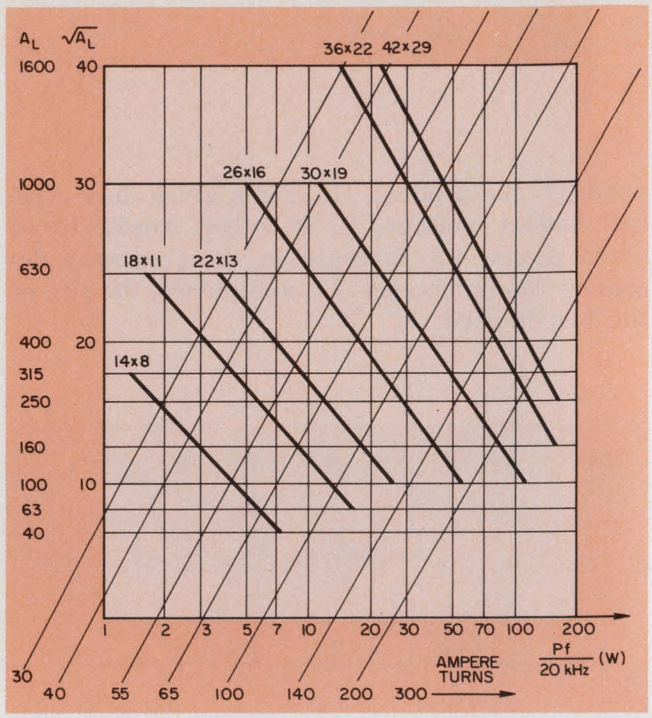
So to obtain the same output power in mode B, the maximum current should be smaller and approach a limit that is half the value required in mode A. Specifically, k ranges between 1/2 and 2/3.

The primary inductance for both cases follows from Equations 1, 9 and 21:

$$L_{pB} = L_{pA} \frac{1+k}{1-k}.$$

Hence, for the same core, the turns ratio is:

$$\frac{N_B}{N_A} = \sqrt{\frac{1+k}{1-k}}. \qquad (22)$$



3. **Taking the approximated straight line from the Hanna diagram,** you can plot a more convenient family of curves for use in practical designs.

The greater number of turns in mode B depends on the factor, k, you choose. The number of ampere turns in the choke leads to the correct choice of the core's air gap. From Equations 21 and 22, it follows that:

$$N_B I_{pM} \text{ (mode B)} = N_A I_{pM} \text{ (mode A)} \left[\frac{1}{\sqrt{1-k^2}} \right] \qquad (23)$$

Hence, for the same core in mode A, ferrite saturation occurs later and additional power can be supplied.

A continued comparison shows that diminishing the number of turns in mode A decreases copper losses and that the ripple induced in the supply is greater in mode A because of the greater variation in mode A's switching current.

Designing the output transformer

The major difference between a flyback transformer's design and a feedthrough converter's is a dc-current component in the flyback windings that requires a properly chosen air gap.

With the help of Equations 6 and 8 for mode A, and 13 to 15 for mode B, you can find the values of the primary inductance and the turns ratio for a given set of specs and a given switching frequency.

Knowing L_p and L_s, you must then find the optimum core for the required power. That is, you can opt for either minimum volume or maximum efficiency (resulting in a lower temperature increase in the core). The conventional procedure uses the well known Hanna curves, a family of core curves using the air gap or the A_L (inductance) factor as a parameter for each type of core.

Some data books provide a single Hanna diagram for all types of cores, but the values on the X or Y axis are normalized to volume or weight. In either case, using the diagrams is difficult when the starting point is the value of the output power. However, the curves can be redrawn.

Bear in mind that the Y axis on the Hanna curves represents the energy stored in the choke for a given ampere-turn product. In a flyback converter, this energy is transferred to the load at a rate of f times a second. Knowing that the product, $1/2LI^2f$, gives the output power of the converter (without the losses), and taking as a reference f = 20 kHz, you can compute the power values for each significant point on the Hanna curves.

Knowing that the saturation points for each A_L lie along an approximately straight line, you can plot a new family of curves for each group of cores (for instance, pot cores). The new family represents the saturation points, with A_L as a parameter and the output power and ampere turns, respectively, on the X and Y axes.

Replot the Hanna curves

A convenient diagram is shown in Fig. 3, in which $\sqrt{A_L}$ is plotted on the Y axis and Pf/20 is on the X axis (f is in kHz).

The diagram in Fig. 3 stems from Hanna curves found in the 1975 MBLE ferrite catalog (available from Philips, Eindhoven, the Netherlands). The straight lines represent only the core's nonsaturable mode. The relationships that govern the characteristics are as follows:

$$\frac{1}{2}LI^2 = k_1 NI + k_2,$$

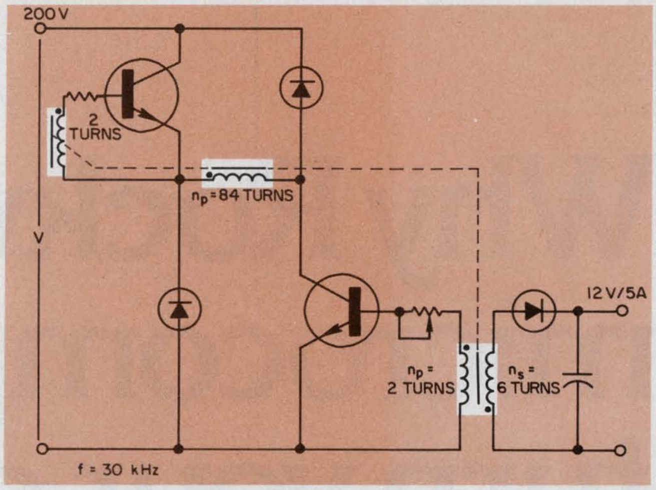
which approximates linearly the nonsaturating portions of the Hanna curves, and

$$P = \frac{1}{2}LI^2f,$$

$$A_L = \frac{L}{N^2}.$$

To design a transformer, start with the value of the output power. Divide it by the estimated efficiency to get the power the transformer should handle. Then choose the switching frequency and locate that point on the X axis. A vertical line from the X point intersects the curves at the values of A_L at which the cores will saturate. Since the inductance factor, A_L, has standard values, choose either the value below the intersecting point or a higher value on a larger pot core.

For the best transformer design, the copper and ferrite losses should be equal. This happens for A_L values between 160 and 250.



4. **Practical flyback-transformer design** starts with the values of the output power, frequency, and input and output voltages. Cores are selected from the modified Hanna curves, and the number of turns from the given equations. The switching transistor is selected to handle the calculated maximum current and the peak voltage.

The skin effect shouldn't be overlooked in evaluating the transformer's efficiency. At 20 kHz, efficiency can be increased with stranded wire. If you use solid wire, the diameter should not exceed double the penetration depth, or approximately 0.5 mm at 20 kHz.

Suppose you want a flyback, self-oscillating converter with the following values: V_{in} = 200 V; V_{out} = 12 V; P_{out} = 60 W; f = 30 kHz. With an assumed efficiency of 0.8, the input power equals 75 W.

From the diagram in Fig. 3, the 50-W point (for 20 kHz) corresponds to 75 W at f = 30 kHz. Following the vertical line from this point, you can see that this power can be handled by a couple of cores: $\phi 26 \times 16$, with $A_L = 100$; $\phi 30 \times 19$, with $A_L = 250$; and $\phi 36 \times 22$, with $A_L = 630$.

The optimum core is $\phi 30 \times 19$ since for the $\phi 26 \times 16$ core the copper losses exceed the core losses; for the $\phi 36 \times 22$ core, the core losses exceed the copper losses.

For a self-oscillating converter, the formulas for mode A are identical with those for mode B ($t_1 + t_2 = T$ for A, and $I_{pm} = 0$ for B). From Eq. 6 or Eq. 15, determine the value of L_p, assuming a maximum duty cycle (for $\tau = 1/2$, we obtain the value $L_p = 1.77$ mH). With $A_L = 250$, the number of primary turns is found from $N_p^2 = A_L/L_p = 84$. The number of secondary turns (six) is found from Eq. 8 or 14. To choose the switching transistor, calculate the maximum current for the inductance L_p. From Eq. 1 or Eq. 9, with $I_{pm} = 0$ and $t_1 = T/2$, $I_{pM} = 1.88$ A.

The feedback windings are designed conventionally, with the feedback voltage double the V_{BE} (Fig. 4). You can provide the converter with additional feedback control circuits for a regulated output. ■■

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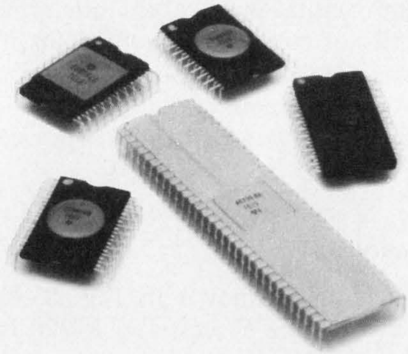

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Rockwell International

Stabilize optical-sensing systems

with automatic light-intensity control. Negative feedback via the light path maintains the switching threshold accurately.

Anyone familiar with optical control and sensing systems knows how difficult it is to adjust and maintain light intensity and the alignment of the light path. And, adjusting multiple electro-optical channels is particularly difficult, especially when a system is called upon to sense less-than-perfect marks on colored or soiled documents.

If the documents are fully opaque and no dust accumulation occurs on the optical devices, choosing a safe, fixed switching level to differentiate "white" from "black" will not be a problem.

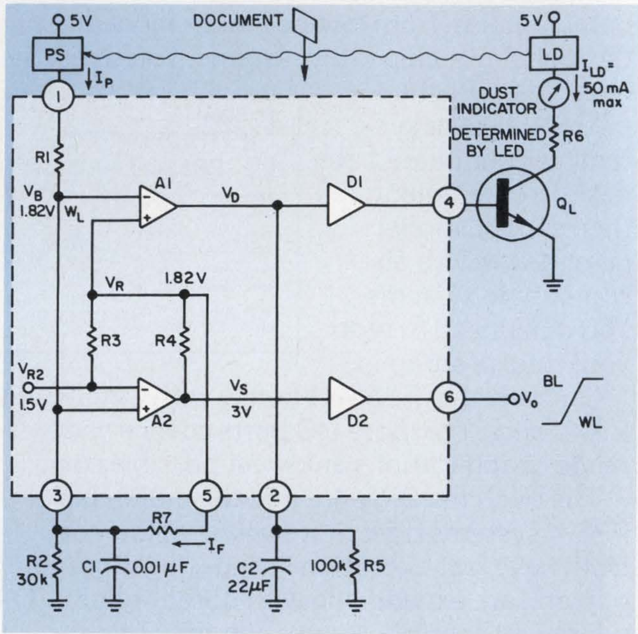
However, relatively thin documents may easily transmit 20% of the incident light, and a grease spot may let up to 30% of the light pass through. Even a small amount of dust on the light source or sensor window can cut the light transmission substantially. These problems, taken together with unavoidable tolerances, can make unattended reliable sensing for long periods almost impossible with the use of fixed switching levels.

Automatic light-intensity control (ALIC), however, has proven itself on both see-through and reflective systems, such as for sensing through translucent documents in a dusty environment and low-contrast marks on documents of varying reflectivity.

A servo-loop serves the system

A typical (but simplified) two-level ALIC system (Fig. 1), shows a closed-loop feedback system consisting of a differential control amplifier, A_1, and driver circuit, D_1 and Q_L. A LED light source, LD, and phototransistor, PS, close the loop via the sensing path. A second differential amplifier, A_2, with its driver, D_2, produces a black/white logic-level output, V_0.

A white-light level on the document (maximum light), transmitted from the LED to PS, produces an input voltage of $V_B = 1.82$ V to the two differential amplifiers. With R_2 equal to 30 kΩ, I_p is about 62 μA and automatically kept there by the negative feedback loop.



1. **In this simplified diagram of an automatic light-intensity control,** the differential control amplifier, A_1, with its drivers, D_1 and Q_L, controls the LED light source; the differential switching amplifier, A_2, with its output driver, D_2, provides a logic output. The logic switching point is determined by the internal reference voltage V_{R2}, which—together with R_3, R_4 and the voltage swing at V_S—establishes the reference voltage, V_R, for the differential amplifier, A_1.

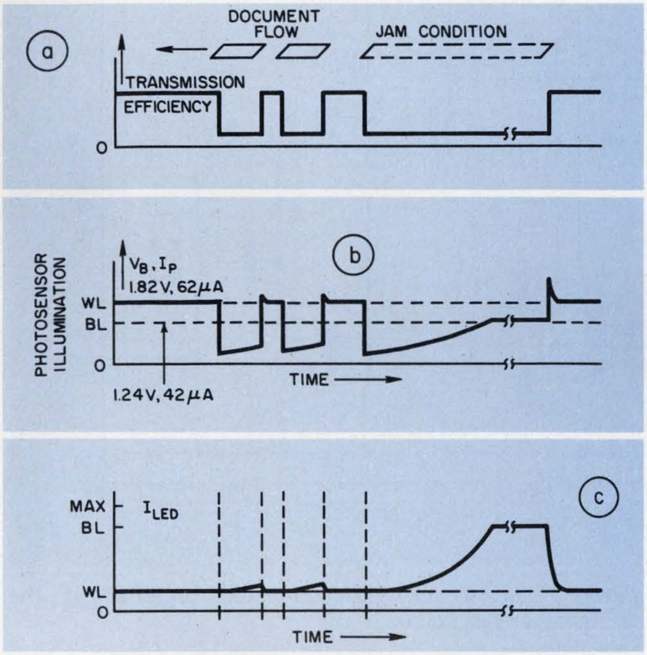
Capacitor C_2 (22 μF) provides heavy damping to prevent oscillations or overshoot and also slows the loop's response. Therefore, only slowly changing light intensities are compensated. The C_2 and R_5 combination limits the LED-current rate of change to about 6 dB in 50 to 100 ms—much too slow to respond to small marks on a document. Rapid response to obtain the logic level outputs is provided by a separate path via A_2 and D_2.

If V_B rapidly drops to, or below, A_2's reference-voltage level of 1.5 V, when a black mark is sensed, V_0 switches to the black level. At the same time, the A_1 reference voltage, V_R, drops from 1.82 V (WL) to 1.24 V, but the rapid change doesn't affect the LED current.

However, note that for extended black periods V_B stabilizes at a level equal to 1.24 V (BL) and

Roland J. Braun, Advisory Engineer, IBM Corp., System Products Div., P.O. Box 6, Endicott, NY 13760.

I_p at 42 μA (Fig. 2). Thus the ALIC has a two-level threshold reference—BL after the input signal has been "black" for an extended period and WL after the signal has been at the "white" level. Also, note the fast compensation of overshoot in the white directions when compared with the slow response to a black excursion. Both the two-level threshold and a special discharge-path circuit for capacitor C_2 under "high" input-current conditions, which produces this black/white response discrimination, is discussed in detail for a single-chip implementation of the circuit (Fig. 3).



2. **In a typical see-through, document-sense application,** the transmission efficiency, I_P/I_{LD}, shown in curve A, is a measure of the light reaching the photosensor, if I_{LD} is constant. Curve B represents the actual I_P in an ALIC system, if translucent documents let about 20% of the impinging light pass through. In curve C, note particularly that the LED current rises slowly to the BL level when the illumination is low, and falls quickly to the WL level from a fully illuminated condition.

A single-chip implementation of the ALIC

Although the ALIC circuit can be built with discrete components and IC differential amplifiers and drivers, integrating most of the circuit into a single IC package (Fig. 3) provides money and space-saving ways to handle multiple-channel optical systems. Two such circuits have been built on an 82-mil-square silicon chip.

Transistors 1 through 8 and an external damping network (the equivalent of R_5 and C_2 in Fig. 1) form the automatic LED control circuit and provide a minimum open-loop gain of 126 dB. The reference voltage, V_R, is either 1.82 or 1.24 V, depending on the state of switching transistor 23. Transistors 9, 10, 11, 16 and 23 provide the output logic function equivalent to A_2 (Fig. 1), and transistors 17, 18, 19 and 20, equivalent to D_2, act as the output driver. Transistor-diodes 12 through 15 establish voltage-reference levels, with diode 15 serving in the constant-current circuits of transistors 4, 8, 11, 16 and 18.

As in Fig. 1, with the so-called full white condition ($I_p = 62$ μA and $V_B = 1.82$ V), transistors 9 and 23 are fully ON and holding the output V_o at its down-level state and V_R at 1.82 V.

Switching occurs when a signal causes the input current to drop at least 20%—from 62 to 50 μA or less—which decreases the input voltage, V_B, below the switching reference voltage, V_{R2}. Transistors 9 and 23 turn OFF, which switches the output to HIGH and the V_R to the black value —nominally 1.24 V. Current I_p is now regulated toward 42 μA for this new V_B of 1.24 V through control of the LED current.

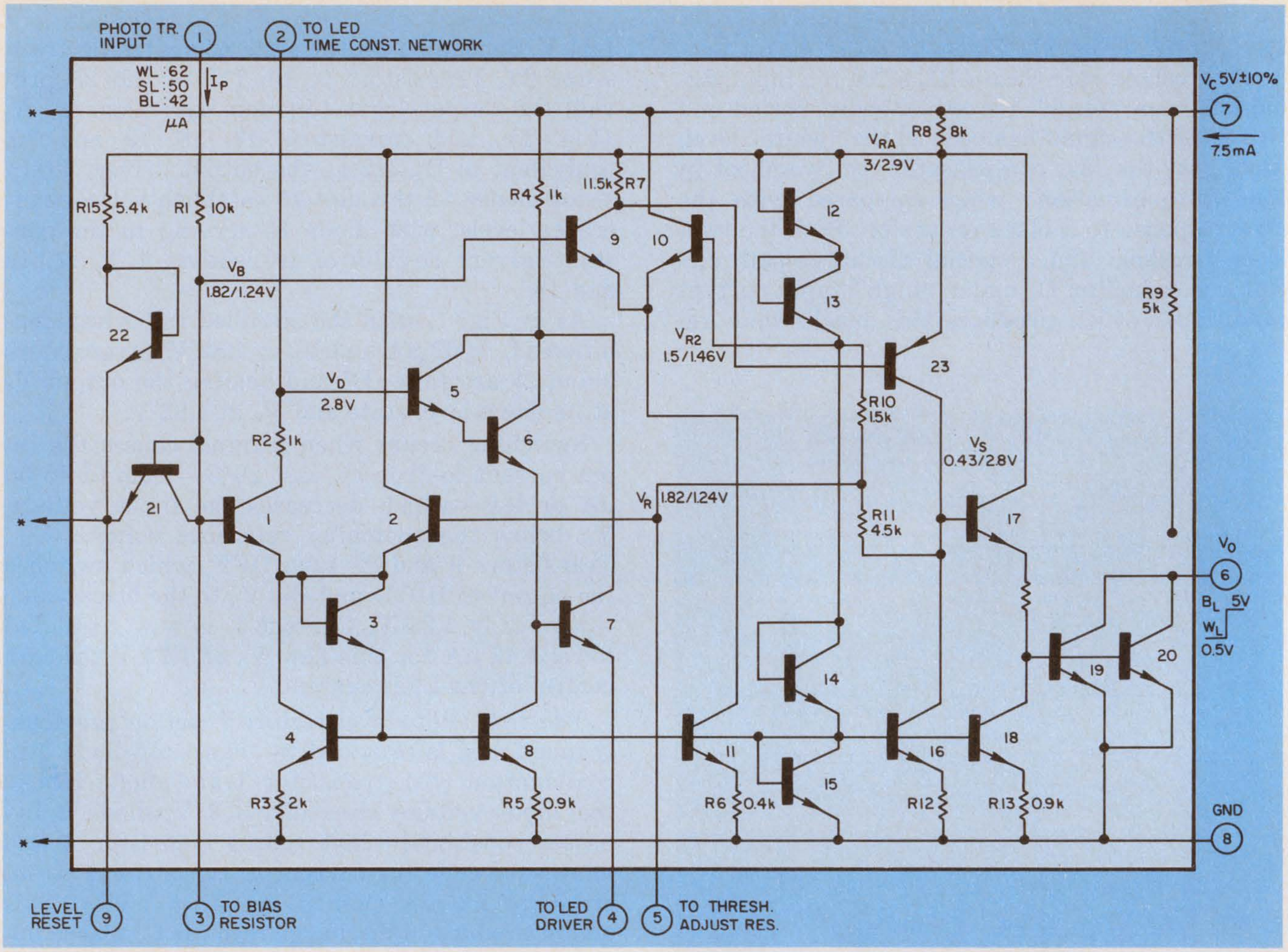
The fast white-level restore function previously mentioned is provided by transistor-diode 3 in combination with transistor 1 and diode 15. As the input voltage rises above 2 V, diode 3 bypasses constant-current source transistor 4 and allows the collector current to transistor 1 to increase to 1.2 mA (limited by $R_2 = 1$ kΩ). This action produces a discharge rate for C_2 that is 50-times faster than the 24-μA, black-level charge current (limited by $R_5 = 100$ kΩ).

Threshold and hysteresis are adjustable

The circuit's built-in switching level and threshold values are determined by resistors R_{10} and R_{11} (equivalent to R_3 and R_4 in Fig. 1). These resistors can be chosen to provide almost any desired combination of values for the WL and BL thresholds. And for fast, reliable snap-action, a small switching hysteresis—about 3%—is built into the circuit of Fig. 3.

When transistors 17 and 23 turn off, current through diode chain 12 to 15 increases. Consequently, the switching reference voltage, V_{R2}, rises from 1.46 V to about 1.50 V to produce the built-in hysteresis with terminals 5 and 6 open.

As much as a 40% hysteresis can be achieved with a resistor (30 kΩ minimum) between terminals 3 and 5 (equivalent to R_7 in Fig. 1). However, because resistor R_7 provides positive feedback from the reference voltage V_R to the input V_B, not only the hysteresis, but also the switching thresholds are affected by a change in R_7. This interaction is normally desirable, because both hysteresis and switching levels increase together, providing higher noise immunity for lower sensitivity setting.



3. **Two ALIC circuits** can be integrated on an 82-mil-square IC chip. Only one of the two circuits per chip is shown. The circuits are connected together at the asterisk-marked points.

The IC version includes a reset feature provided by a diode network that connects reset terminal 9 to the positive voltage source, V_c. The reset feature is used for both testing and initializing the circuit to the WL state.

Initialization is the reset feature's main function. When the power to the circuit is first turned on, the circuit normally assumes the BL state, because capacitor C_2 charges slowly. The circuit, however, changes to the correct state—BL or WL—automatically only after the first signal transition. Some cases, however, require an initial WL condition—for example, to correctly identify the leading edge of the first document.

A voltage less than 0.6 V applied to terminal 9 forward-biases diode 21 and forces V_B below its BL reference voltage of 1.24 V. This applied voltage simulates an extreme black signal; thus, all currents and voltages assume their BL values, and I_p, V_D and I_{LD} rise toward their maximum saturation levels. When terminal 9 opens, or a voltage above 1.2 V is applied, at the end of this down signal, the circuit automatically assumes the WL state, provided a white optical condition exists. The downward reset signal should be at least 50 ms wide.

The ALIC circuit design allows loose component tolerances as well as a large range of input conditions. Even the black and white threshold levels, which are normally the only critical values, depend only on resistance ratios—R_3/R_4 in Fig. 1, and R_{10}/R_{11} in Fig. 3—rather than absolute values. For different applications, these ratios and the components that determine the maximum LED current, input current, time-constant, high-frequency response and the adjustable portion of the switching threshold and switching hysteresis can all be changed over a wide range.

Both parts and temperature are uncritical

Temperature influences the threshold levels less than ±5% between 10 and 60 C, and a ±10% power-supply variation has negligible influence because of built-in voltage regulation (Fig. 3). A total threshold tolerance of ±10% can easily be achieved with ordinary IC-component tolerances and low-tolerance discrete components.

Exposure to high-frequency noise is not a serious problem, despite the low current and high impedance of the circuit's input, even with the photosensor at a large distance from the amplifier. The signal frequency is low; thus, a filter capacitor, C_1, as large as 0.01 μF can be used across the amplifier input to suppress noise above 20 kHz without affecting signals with rise times of 0.1 ms or greater. For faster rise times, C_1 may be reduced; for extremely high-speed applications, photodiodes should be used with a preamplifier mounted near the sensor.

Dust indicator: a circuit feature

In many applications, an early warning of the system's dust-accumulation status minimizes the need for frequent routine cleaning. Also, early warning can be a valuable diagnostic tool for identifying deteriorated or nonaligned components.

Normally, the LED current increases with dust accumulation and other degrading influences, which cause the collector voltage of the LED driver, Q_L (Fig. 1), to decrease proportionally. Once saturation of Q_L occurs, the circuit has reached its operational limit. To the point of saturation, the collector voltage of Q_L directly indicates the system's remaining safety margin, and indirectly indicates the amount of dust accumulated in the optical path.

The ALIC's ability to overcome the dust problem in optical sensing is of equal importance with the circuit's insensitivity both to loose tolerances and a wide range of input conditions. Consequently, the ALIC principle can work with fluorescent, neon or incandescent lamps and almost any optical sensor, and, the principle can even extend to work with ultrasonic and magnetic sensing, among others.

The need for only low average light intensity is an important side benefit of the ALIC concept: Decreased power dissipation allows a long life for the light source.

Unfortunately, since each sensor in the ALIC system must have its own light source, sensor arrays with a common light source can use the ALIC principle only in a compromised form. But this problem should be readily solvable with the wide variety of available small LEDs that allow the use of closely spaced arrays of individual light sources to replace single sources. Also, the IC design of the ALIC circuit allows low-cost use of many circuits.

However, large arrays may suffer from optical crosstalk. Optical crosstalk between the LEDs and sensors in an array can become troublesome, especially where a common glass covers the LEDs and sensors. Internal reflections in the glass can mix the signals. Such reflections increase rapidly with even a thin layer of dust on the outside surface. But crosstalk is easily avoided with care in design of the optical paths. ■■

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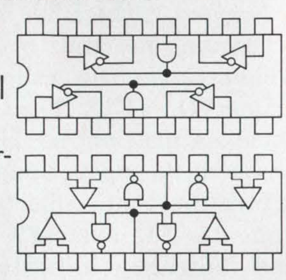

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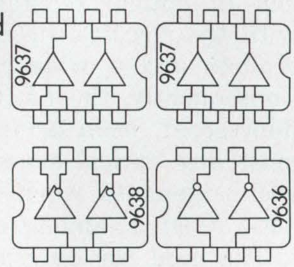

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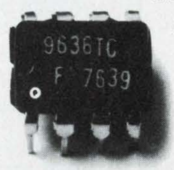

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9644	9648/A*	55/7538/39	55/75232/233	55/75326
9645*	55/7524/25	55/75207	55/75234/235	55/75327
9646*	55/7528/29	55/75208	55/75238/239	
Peripheral Drivers				
9665	55/75430	55/75450A/B	55/75460	55/75471
9666	55/75431	55/75451A/B	55/75461	55/75472
9667	55/75432	55/75452A/B	55/75462	55/75473
9668	55/75433	55/75453A/B	55/75463	55/75474
	55/75434	55/75454A/B	55/75464	
Line Drivers/Receivers				
9612	9621	9634*	55/75107A	55/75121/8T13
9613	9622	9636	55/75107B	55/75122/8T14
9614	9626*	9637	55/75108A	55/75123/8T23
9615	9627	9638	55/75108B	55/75124/8T24
9616	9628*	9640*	55/75109	75150
9617	9629*	9641*	55/75110	55/75154
9620	9630*	9642*	55/75112*	1488*
				1489/A*
Display Drivers/Other				
9624	9664A	55/75491	55/75491B	55/75492A
9625	9664B	55/75491A	55/75492	55/75492B
9664				

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CIRCLE NUMBER 35

Ideas for Design

Transient-free pulsed acoustic sinusoids generated with phased-array speakers

When testing an acoustical-to-electrical transducer such as a microphone, it is often necessary to drive it with bursts of acoustic sinusoidal signals. But speakers are notorious for their poor transient responses. Thus, difficulties occur in deciding whether questionable characteristics of the test data result from the unit under test or from a poor acoustical-input signal.

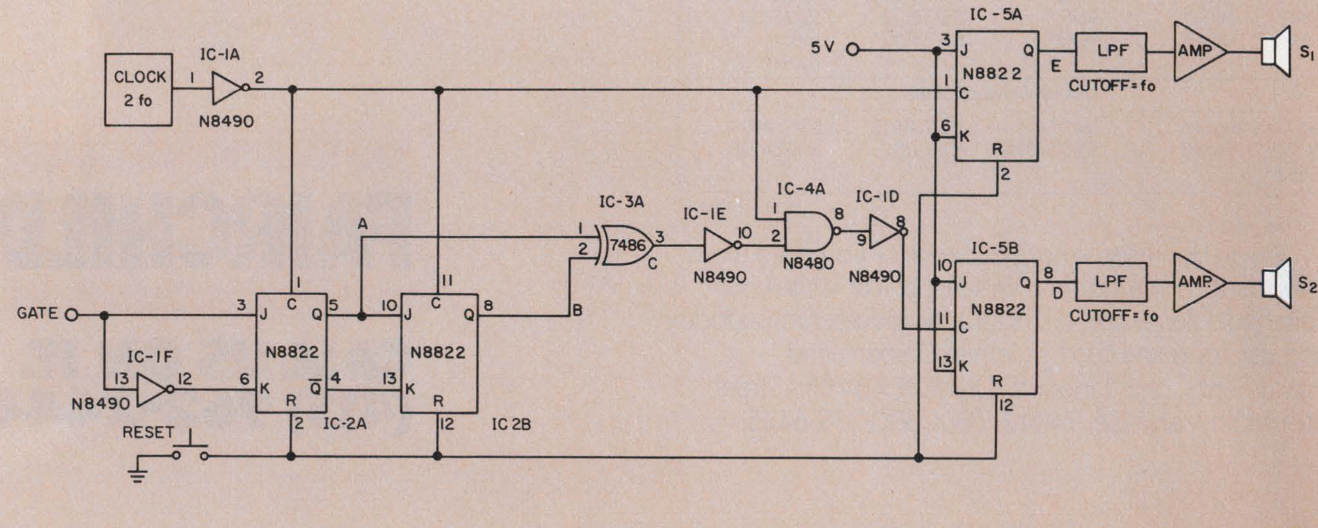
The circuit (Fig. 1), with the use of principles known for years by rf-antenna designers, can provide a microphone with a distortion-free burst of acoustic sinusoids in free space. The circuit doesn't use the obvious approach of driving a speaker with a gated sinusoidal signal. Instead, two speakers in a phased-array configuration (Fig. 2) provide the bursts. Both are fed an identical, continuous sinusoidal signal. Almost any two speakers will do.

The microphone is placed, as shown, between the two speakers. The circuit sequentially changes the phase of the signal to one of the two speakers by 180 degrees (Fig. 3). The signal "seen" by the microphone is then either a sum or a cancellation of the two speakers' outputs. Moving the test microphone around allows you to obtain virtually any ratio of high-to-low amplitude for pulse testing.

The secret of the circuit lies in ensuring that the phase of the one speaker changes at the right time. Otherwise, the original transient-distortion problem will be still there. The phase should only change when the sinusoid is at a positive or negative peak, when the speaker diaphragm travels at zero velocity. At this point, a phase change merely causes the speaker to remain stationary a little longer.

In the circuit, the clock signal starts at twice the desired output frequency and is divided in half by IC_{5A}. Then, after passage through a low-pass filter, it is amplified and drives one of the speakers, S_1. The low-pass filter suppresses the higher harmonics of the digital signal, E. Of course, the better the filter, the more sinusoidal the signal out of speaker S_1. For most applications, a simple two-pole active or passive filter is sufficient.

The TTL-level input labeled Gate controls the phase relationship between the two speakers. This signal can be provided by a switch, pulse generator or any TTL-logic source. Signal A (Fig. 3), a retimed version of the gate signal, is converted to pulses, C, which cause IC_{5B} to "skip"



1. The phase of the signal to speaker S_2 is switched 180 degrees, sequentially, at the peak signal amplitudes to produce ON/OFF bursts of transient-free pulsed acoustical signals.

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Get them all—connectors, reeled contacts, crimpers. And get them now. Five basic contact configurations in 17 Series connectors are now available. So is all termination equipment, backshells, and accessories. For more details, contact: Bob Ashley, Amphenol Connector Systems, Bunker Ramo Corporation, 900 Commerce Drive, Oak Brook, Illinois 60521.
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BUNKER RAMO ®
CIRCLE NUMBER 36

(continued from page 78)

a clock pulse corresponding to the beginning and end of each gate signal.

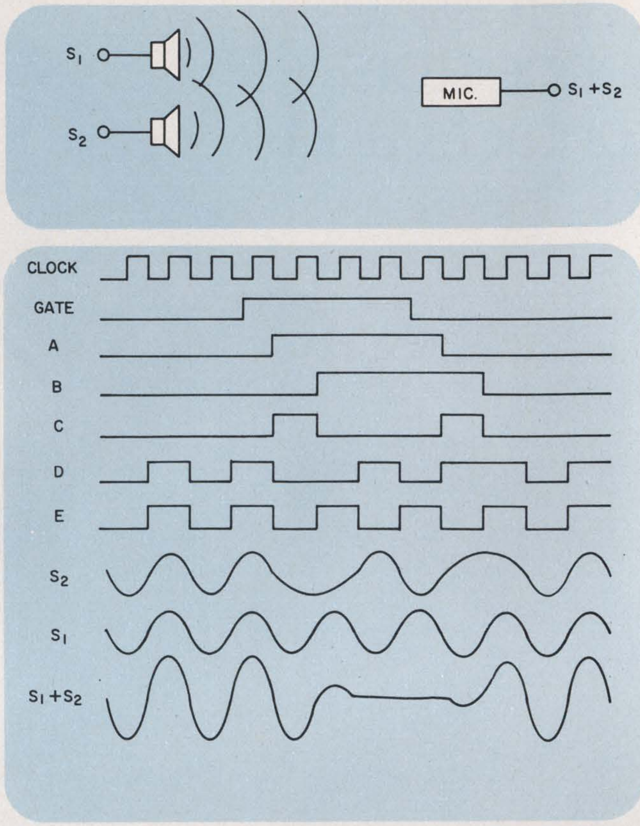
Whenever IC_{5B} misses a clock pulse, signal D remains in its previous state until the next clock pulse. The result is a 180-degree phase change with respect to signal E.

Signal D is low-pass filtered and amplified, as in the case of signal E, and then fed to the speaker, S_2. A reset switch ensures that both speakers start out in phase. The sum of signals from the two speakers ($S_1 + S_2$) is "seen" by the microphone in the median plane between the two speakers.

Of course, an anechoic chamber is the ideal environment in which to use this system. However, good results are easy to get with two small speakers separated about a foot, with the test microphone only a few feet away between them. On-to-off amplitude ratios of 30 dB can be obtained in almost any room. The relative positions of the speakers and microphone are not critical. With reasonable care, experimental repeatability is no problem.

William F. Lawrence, Electronic Engineer, 707 Kingston Rd., Towson, MD 21212.

CIRCLE NO. 311



Diodes act as temperature sensor in remote temperature-measuring circuit

A remote temperature probe can be built from ordinary diodes. The probe senses temperature by the change of voltage drop across several forward-biased silicon diodes. With such a probe outside temperature can be measured from inside a building. Even the water temperature at the bottom of a lake can be remotely measured with the sensor.

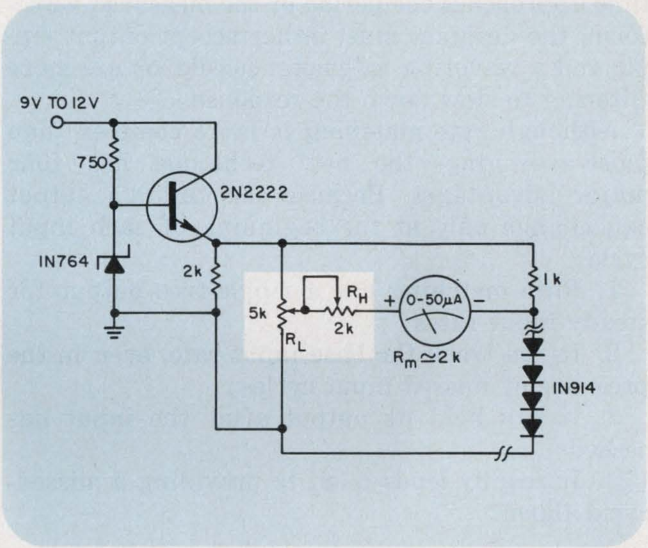
The circuit (Fig. 1) compares the voltage across the diode sensor with a voltage set with potentiometer R_L. As the temperature increases, the voltage across the sensor decreases at the rate of 2 mV/°C for each diode in the probe.

The circuit shown uses four diodes. Over a 25-C temperature range, the voltage change across the diodes is 200 mV. This voltage change causes a 50-μA current change into a 4-kΩ impedance.

With the probe exposed to the lowest temperature of interest, the meter is set to zero with the 5-kΩ potentiometer, R_L. The meter is adjusted to full scale with R_H, the series 2-kΩ resistance, when the probe is exposed to the highest temperature of interest. The zener diode and transistor regulate the voltage to the probe, so that readings are relatively independent of battery-voltage fluctuations.

Donald C. Elmore, Principal Engineer, Electronic Communications, Inc., P.O. Box 12248, M/S 22, St. Petersburg, FL 33733.

CIRCLE NO. 312



Heart-beat monitoring circuit provides steady output and a missed-beat alarm

A new technique[1] called rate matching neatly circumvents the problems of pulse-averaging methods commonly used in frequency-meter circuits for applications like heart-rate monitoring. With pulse averaging, since the desired response time approaches the period of the measured waveform, the designer must either accept output ripple and a wavering ratemeter needle, or use more filtering to slow down the response.

Although rate matching is more complex than pulse-averaging, the new technique has four major advantages. Because the circuit's output can change only at the beginning of each input cycle:

1. Rate matching has a ripple-free output for steady input rates;
2. It can track the base input rate, even in the presence of missed input cycles;
3. It can hold its output after the input has ceased;
4. It readily lends itself to providing a missed-cycle alarm.

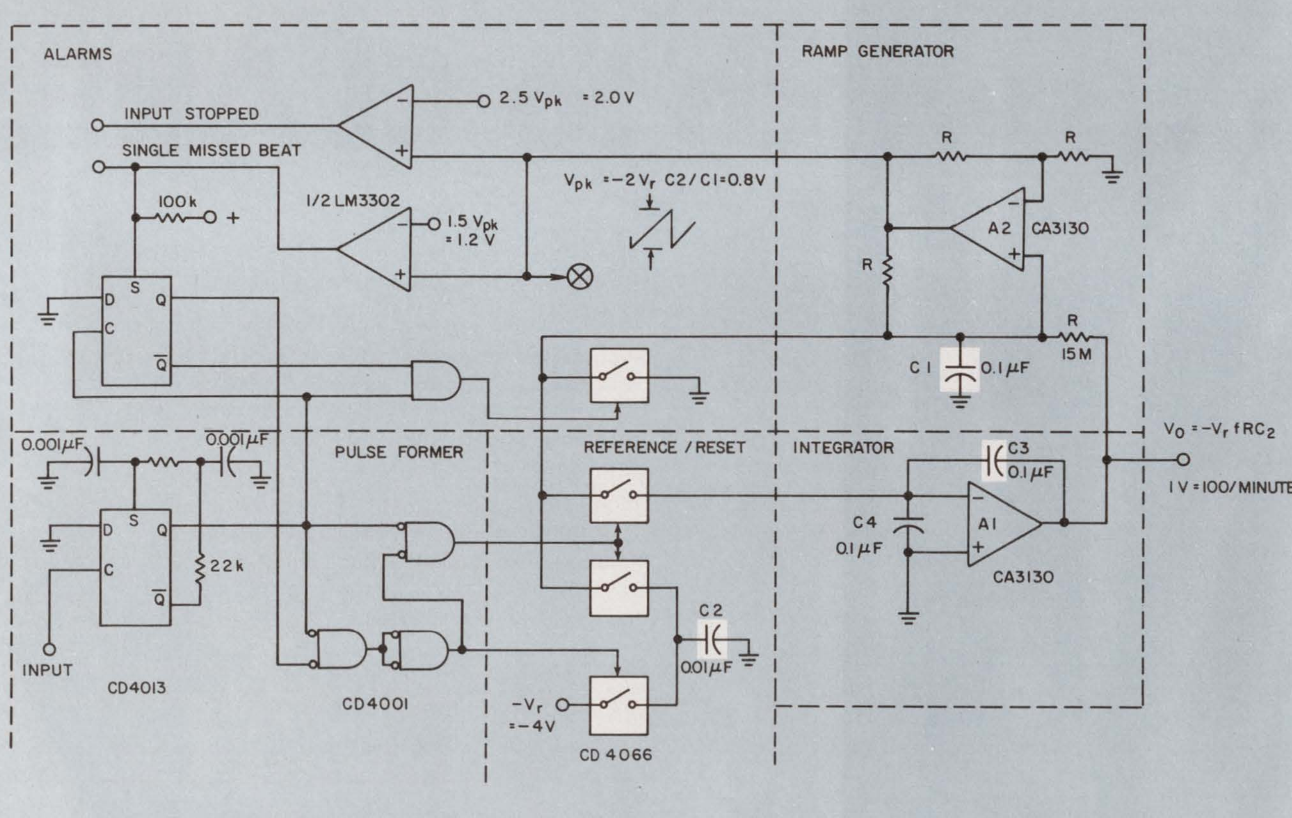
The rate-matching circuit (Fig. 1) uses negative feedback to match a ramp rate to the input rate. The input signal passes through a pulse former that generates a short pulse at the beginning of each input cycle. The pulses then drive an analog switch labelled reference/reset.

An integrator, A_1, with no input resistor, presents a virtual ground that fully discharges capacitors C_1 and C_2 transferring the algebraic sum of their charges to C_3 each time an input cycle causes the analog switch to "operate." Capacitor C_4 merely absorbs switching transients; its value is not critical.

After each discharge, a new ramp voltage starting from zero builds up across C_1 at a rate proportional to V_o, the output of A_1.

If reference voltage V_r charges C_2 to be equal and opposite to the charge on C_1, then their combined discharge into the integrator has no effect on V_o. However if the rate of ramp build-up across C_1 is slow, the C_1 charge doesn't balance

(continued on page 84)



1. A heart-beat monitoring circuit uses a CMOS quad 4066 analog switch to control transference of charge from C_1 and C_2 into the integrator-circuit's storage capacitor, C_3.

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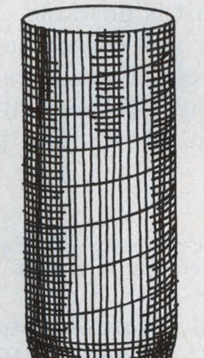

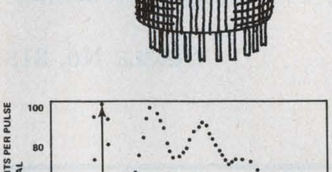

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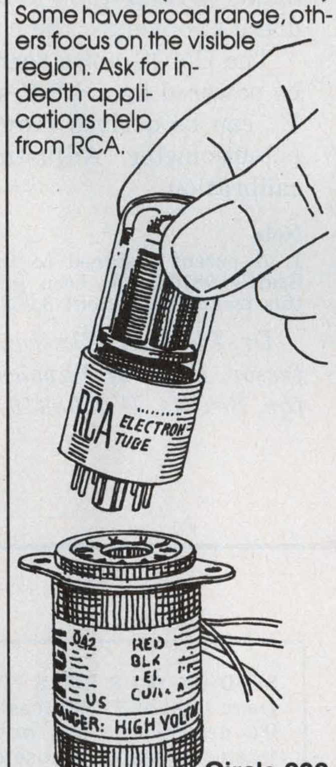
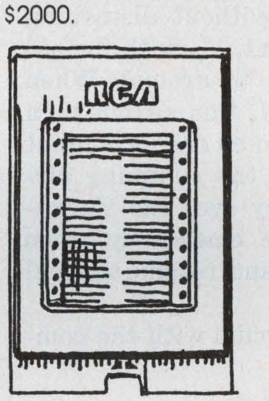
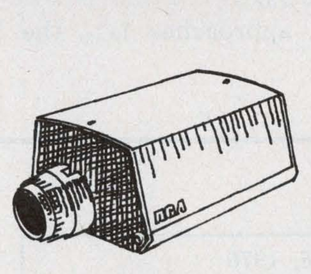


Circle 202

RCA announces a new Si Imaging Device. Better performance, lower price.

Using buried channel techniques, we've improved horizontal resolution in our new Silicon Imaging Device (SID). And we're subjecting units to more stringent blemish criteria. RCA's "Big SID" is a 512 x 320 array, 163,840 pixel, charge-coupled device that produces a standard interlaced 525-line TV picture with ultra low blooming and no lag or microphonics. SID52501, priced under $1000 is available with 30-day delivery. Or get Big SID in our TC1160 camera for less than $2000.

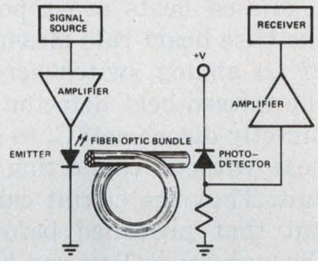


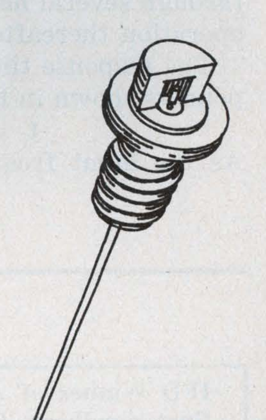


Circle 203

Hi-speed IR emitters for fiber-optic communications.

The speeds are right: 100 MHz min. analog bandwidth (C30119) or 40 MHz min. (C30123). And so is the size: A 6-mil edge emitter in an OP-18 package with removable cap that assures good collection efficiency with single fibers or bundles. (Also available in hermetically sealed package.) These IR emitters are rated at up to 200 mA forward current for continuous operation and 1.5 A peak forward current for pulse operation. Competitively priced, they're available from stock.





Circle 204

If electro optics can solve your problem, remember: EO and RCA are practically synonymous. No one offers a broader product spectrum. Or more success in meeting special needs. Call on us for design help or product information. RCA Electro Optics, Lancaster, PA 17604. Phone 717-397-7661. Sunbury-on-Thames, Middlesex TW16 7HW, England; Ste. Anne de Bellevue H9X 3L3, Canada; Belo Horizonte, Brazil; Hong Kong.

RCA

(continued from page 82)

the C_2 charge and the difference causes an increase in the output of V_0. An increase in V_0 then increases the ramp rate. Conversely, V_0 is decreased if the ramp rate is too high to match C_2 at the time of the input signal causes the analog switch to operate.

Thus, the circuit's negative feedback forces the ramp rate to match the rate of the input signal. And output V_o is kept proportional to the input signal's rate—a responsive measure of the input frequency. V_o is ripple free once it has adjusted to reflect the input rate.

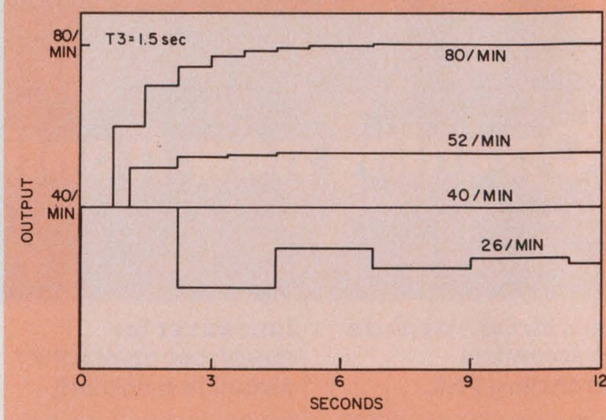
The ramp voltage at point X in Fig. 1 is used to trigger a missed-beat alarm. During normal operation, the signal at X is a sawtooth with a peak amplitude, V_{pk}, equal to $-2V_rC_2/C_1$ independent of input rate. However, if one beat is missing from the input stream, the ramp voltage continues to rise to approximately twice the normal peak voltage; two missed beats result in a triple-height peak, and so on. Thus, the comparator set to trigger at 1.5 times the nominal peak height will detect a single miss; another set to 2.5 times the nominal peak height will detect more serious interruptions.

Missed beats are reported without disturbing the base heart-rate measurement, V_o, with the aid of an analog switch across C_1 to ground. When the missed-beat detector is ON, this switch then directly discharges C_1 to ground on the next input beat without connecting it to the summing circuit. Thus the circuit can carry over the V_o output that prevailed before the emergency, even through several missed beats, and resume normal operation thereafter.

The response time of the circuit with the components shown in Fig. 2 is

$$t_3 = RC_3 = 1.5 \text{ s.}$$

As the input frequency, f, approaches $1/t_3$, the circuit's response at first improves. When f exactly equals $1/t_3$ (40 pulses/min), the first correction fed back within the circuit is exact and the output is steady and correct thereafter; below frequencies of $1/t_3$, corrections increasingly overshoot. Nevertheless, convergence to the correct output value eventually occurs as long as f remains greater than $1/2t_3$. Below $1/2t_3$, the error doesn't converge; the circuit is unstable.



2. **The monitoring circuit works best above a frequency equal to $1/RC_3$.** Below $1/(2RC_3)$ the circuit becomes unstable.

The CMOS pulse former and control logic may be powered by a ±5-V supply. The 4-V reference, V_r, can be derived from the −5-V supply with a potentiometer. Adjustment of V_r also provides calibration.

Note

1. A patent assigned to the University of Washington, Seattle 98195, has been granted for a circuit based on this technique, Patent 3,968,431.

Dr. Philip A. Ekstrom, Affiliate Assistant Professor, Dept. of Physics, University of Washington, Seattle, WA 98915.

CIRCLE NO. 313

IFD Winner of August 16, 1976
Burt Sandberg, Engineer, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510. His idea "State Diagrams for a 555 Timer Aid Development of New Applications" has been voted the Most Valuable of Issue Award.
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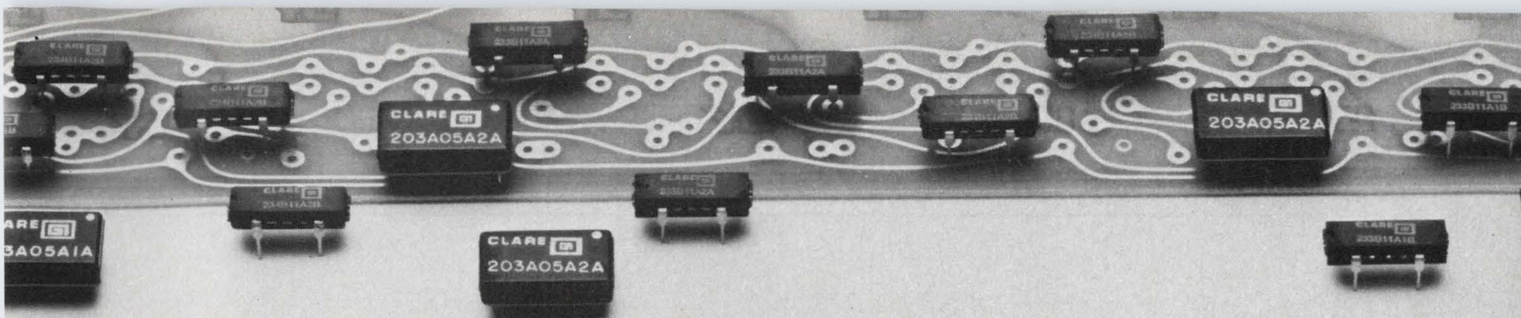
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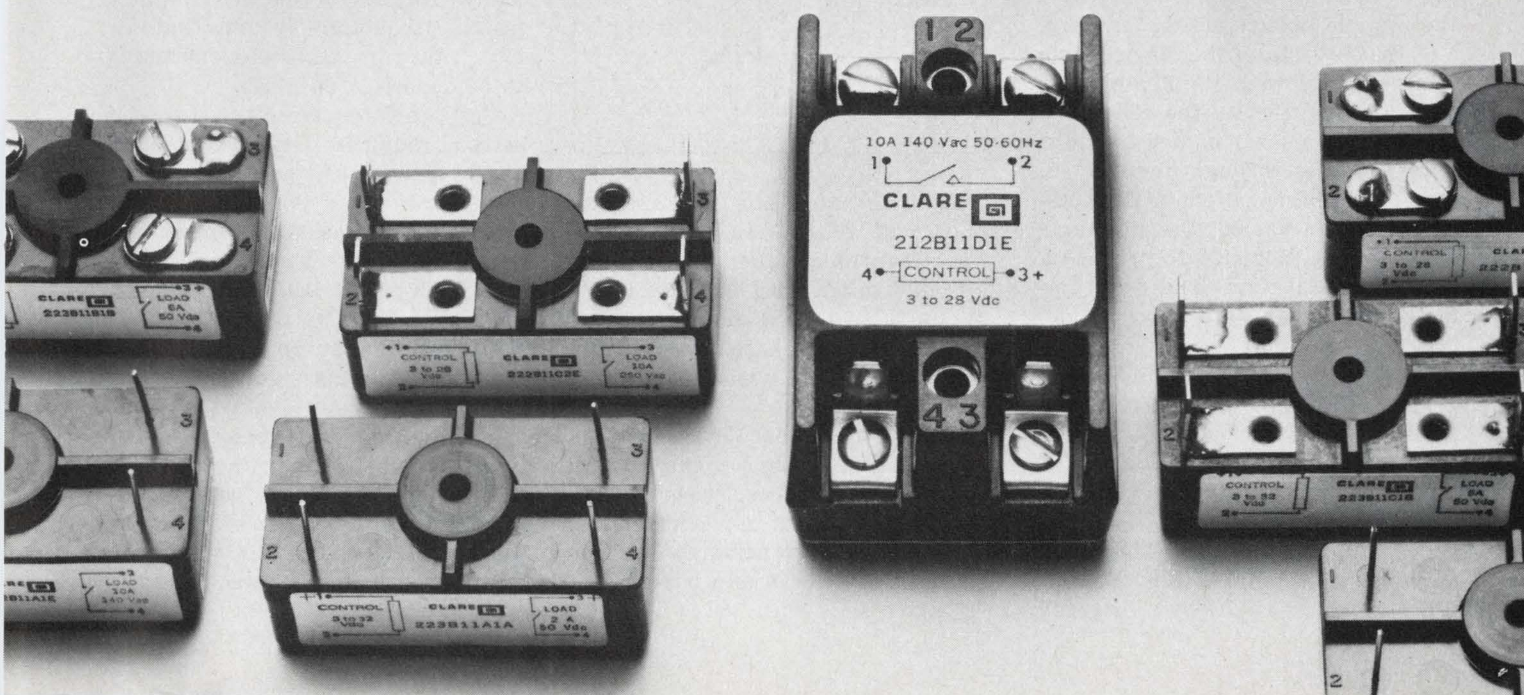
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Liquid crystals increase laser-beam deflection

An electrically controlled optical beam bender that uses liquid crystals to deflect a laser beam substantially has been developed at the Royal Radar Establishment in Malvern, England. Angular deflections to ±20° have been obtained with a liquid-crystal layer 1 mm thick. The Kerr cell, the Malvern device's potential major competitor, deflects laser beams only a fraction of a degree, and competing acousto-optic methods less than 1°.

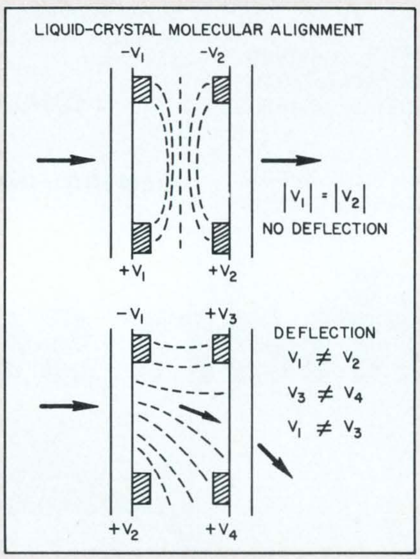
The molecular orientation of liquid crystals is modified electrically to produce a spatially varying refractive index that causes light to follow a curved path through the liquid crystal. The Malvern device, which deflects light in a single plane, consists of a cell, 1 to 2 mm thick and 3 to 4 mm wide, that contains a positive nematic liquid crystal and electrodes at the top and bottom of the front and rear cell walls.

The crystal molecules are aligned parallel to the cell walls by applying equal and opposite voltages to the top and bottom electrodes (Fig. 1). In this state the device acts like a crystal with its straight optical axis parallel to the cell walls. A polarized beam, applied at right angles, passes through undeflected.

If the electrode-potential relationships are varied, the molecular alignment is modified to produce a curved optical axis. The light follows the curved path through the cell.

The angle through which the beam is deflected depends on the dimensions of the cell, the optical anisotropy of the liquid crystal, and the ratios of the electrode potentials. The absolute values of the electrode voltages determine the speed of deflection only. Since the optical-path length does not vary linearly across the cell, the angle of deflection varies with the location at which the beam is applied.

Although the device may be used for beam scanning, the region that produces maximum deflection is one in which switching produces turbulence in the crystals. So continuous scanning is not compatible with maximum deflection. Continuous scanning can be achieved, however, if the beam is focused outside the turbid region.



At 1 kV, the beam deflects full-scale and returns in less than 1 ms. At present, the transmission loss due to absorption and scattering is typically greater than 50%. Scattering is combated by specially treating the cell walls and by operating the device at high fields.

An eight-electrode device, capable of deflecting a beam in two dimensions, has also been constructed. With this device, x-y addressing, such as for use in holographic storage systems, becomes a possibility.

Japanese keyboard lowers mechanical parts

A thin, light-action electronic keyboard with a piezoelectric sheet has been produced at the Musashino Electrical Communication Laboratory in Tokyo.

The 0.3-mm thick piezoelectric sheet lies on top of a PC board, which detects key depression and carries out the first stage of key encoding. This arrangement minimizes the number of mechanical parts and permits the use of low-profile keys. The sheet is formed by blending a base material of polyfluoric vinylidene resin with particles of zirconate-titanate lead.

The keyboard also consists of a key mechanism, a MOSFET wave-shaping circuit and final-encoding circuitry.

Thin-film matrix on glass will lead to flat TV

A low-cost, flat TV screen with either electroluminescent or liquid-crystal display elements may be commercially feasible in three years, says Dr. A. Fischer of the University of Dortmund, West Germany. He has developed an automated production system that allows thin-film transistor matrices to be deposited on glass.

Shift-register circuitry for the screen requires five components per stage. Depositing the register matrix on glass is a seven-mask process. The masks and their support frames are housed in a bell jar. Each mask can be drawn out or pushed back by means of magnetic drives that operate through the walls. The glass substrates can also be raised or lowered so that the masks can be properly mated with the substrates in the bell jar.

Films are deposited from vapors generated by electron-beam heating. Film growth rate is monitored by preprogrammed controllers.

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CIRCLE NUMBER 37

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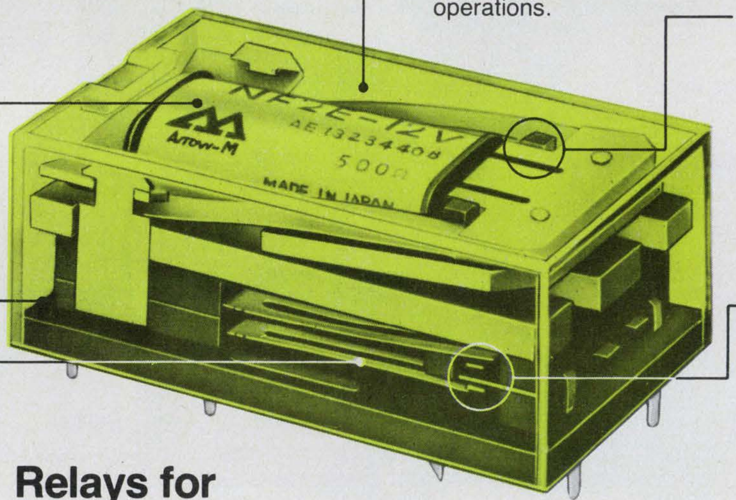

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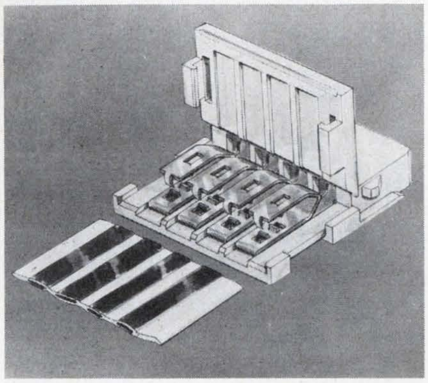
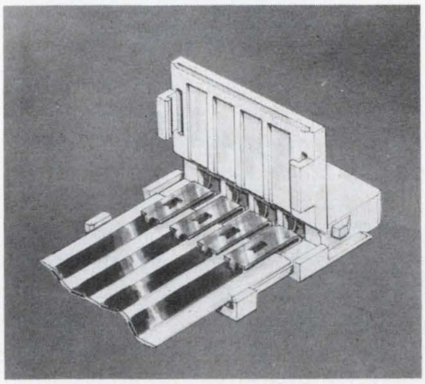
CIRCLE NUMBER 43

New Products

Connector mass terminates flat-conductor, flat cable





Berg Electronics, Div. of E. I. DuPont De Nemours & Co., New Cumberland, PA 17070. (717) 938-6711. See text.

Housing five to 33 contacts, a new connector, the Clincher, simultaneously terminates all conductors in a flat-conductor, flat cable. Crimping the connector to the cable is done faster and with less expensive tooling than is possible with the only other flat-conductor connector, one from AMP, Harrisburg, PA.

In production, Berg's crimping machine simultaneously presses down on all the contacts, forces them to pierce the plastic surrounding each conductor, then squeezes around the copper to hold it securely. Additional ridges in the contacts pierce the copper to make a low-resistance connection, said to be a maximum of 10 mΩ.

The Clincher system cuts total assembly time for an 18-conductor connector to under 10 seconds—more than 20 seconds faster than the AMP system, whose crimping machine does one contact at a time at a rate of two per second. Then, the operator must snap the assembly into a separate housing. The AMP crimping machine must be rented for \$300 a month, while Berg's machine sells for \$800.

However, AMP does make a variety of contact types and housings, while Berg makes only a single-row, 5-to-33 contact female connector series with 30 μin. of gold, or solder plating that mates with 0.025-in-square posts. AMP offers male, female, or solder-tab contacts and eight kinds of plating. Housings hold 9 to 33 contacts in single rows, or 18 to 70 in double rows.

Both connectors accept cable having conductor spacings of 0.1 in. The width of the conductor can measure from 0.04 to 0.062 in. The connectors can be installed on a cable end or in the middle to produce a daisy-chained connection. Both connectors carry about 3 A; the maximum for the copper conductors.

The Clincher's housing comes with an opened lid so that the cable can be slipped into place between the contacts. The lid flips down after the contacts are crimped, which insulates the connection and provides strain relief for the cable.

The contacts are made of two different metals, one supplying spring retention and the other supplying high conductivity. The spring material is made of a beryllium-copper alloy, which provides high forces to the opposing contact. A copper-nickel alloy provides high conductivity. The housing material is made of polyester, rated up to 105 C.

The over-all height of the housing allows stacked connectors to be spaced in increments of 0.1 in.

Whether one method is cheaper than the other is unclear. The Clincher costs 7 to 9¢ per contact, with either 30 μin. of gold plating or solder-plated contacts 10-K quantities. AMP's cost per contact —including housing and the same gold plating as the Clincher's—is 4 to 10¢ in quantities of 5-K to 100-K.

Berg Electronics **CIRCLE NO. 301**
AMP, Inc. **CIRCLE NO. 302**

Operator station solders and desolders

Cooper Group Deutschland GmbH, 7122 Besigheim/Wurtt, West Germany. 07143 7063.

The Weller DS100P station solders and desolders components on PC boards. The unit consists of two solder pencils and stands, and a vacuum pump. The pencils are transformer-powered, low-voltage temperature-controlled types. One pencil has a standard soldering tip. The other pencil is fitted with a solder-suction nozzle and a transparent solder collector. Air vacuum or pressure is supplied from the built-in pump, a factory air line or a compressed air cylinder. When employed with air systems other than the vacuum pump, a transducer must be used to convert the compressed air into a vacuum. Solder is removed when a foot switch is depressed. The system will operate on air pressures between 30 and 120 lb/in^2.

CIRCLE NO. 303

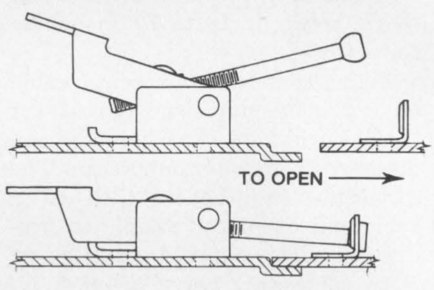
Double-walled bushing insulates wires

Heyman Manufacturing Co., North Michigan Ave., Kenilworth, NJ 07033. (201) 376-7300. $3.05 (500-2000); stock.

A panel bushing, Model S-87, provides a double wall of insulation for wires going through its center. The bushing's outside surface is rounded to minimize sharp bends in the wire. The S-87 mounts using fingertip pressure, into a hole with a diameter of 0.875 in. It locks into panel thicknesses up to 0.062 in. The inside diameter is 0.5 in.

CIRCLE NO. 304

Adjustable latch allows wide closure tolerances



Southco Inc., Brinton Lake Rd., Concordville, PA 19331. (215) 459-4000. $2.63 (1-50); stock.

An adjustable latch, Model A1-10-501-10, allows gaskets of differing thicknesses to fit between a case and a lid. The thickness may vary 0.342 in. The unit comes in two parts, a latch and a keeper, both of zinc-plated steel with a chromate dip. It has an over-all length of 2.5 in. There are four mounting holes: two in the case and two on the lid. Rivets, bolts, or screws can be used to fasten the latch body to the case and the keeper to the lid.

CIRCLE NO. 305

Breadboard has contacts of conductive elastomer

Lareine Microelectronique, 53 Rue N.D. de Nazareth, 75003 Paris, France.

The Wonderboard solderless breadboard has electrical contacts made of conductive-elastomer slugs molded into an insulating substrate. The board measures 3.19 × 1.4 × 0.16 in. It has six rows of contacts, with spacings between row pairs of 0.3 in. On each row, contact-to-contact spacing is 0.1 in. The contacts accept wire diameters from 19 to 31 AWG and contact resistance is 1 mΩ. Insertion force is 750 grams.

CIRCLE NO. 306

Silicone grease conducts heat well

Emerson & Cuming, Inc., Canton, MA 02021. (617) 828-3300. $6 (12 oz-up); stock.

A thermally conductive, electrically insulating, silicone grease, Eccotherm TC-5, is filled with inert metal oxides. The material features a thermal conductivity of 0.0062 (cal)(cm)/(s)(cm^2)(C), a volume resistivity of 10^{14} ohm-cm and a dielectric strength of 500 V/mil. Eccotherm TC-5 does not harden or run on prolonged exposure to temperatures up to 200 C.

CIRCLE NO. 307

Conductive paints spray on, shield

Tecknit, 129 Dermody St., Cranford, NJ 07016. (201) 272-5500. 1 lb, 1-up prices: $55 (Acrylic 1), $44 (Acrylic 10).

Two acrylic conductive paints, Acrylic 1 and 10, have surface resistivities, after application, of 1 Ω/sq. and 10 Ω/sq. The paints provide a minimum of 25-dB insertion-loss shielding to electric and plane-wave fields. Both have the consistency of regular paint and can be applied in one operation with industrial sprayers. The paints stick to structural foam and molded plastics. They are colored silvered gray (Acrylic 1) or gray (Acrylic 10) and come in 1 and 7-lb containers. The operating temperature ranges from −65 F to +180 F.

CIRCLE NO. 308

Generator delivers 3-kV pulses

Monroe Electronics, 100 Housel Ave., Lyndonville, NY 14098. (716) 765-2254. $995; stock.

Model 241 ±3-kV reference supply/pulse generator is designed as a calibration supply for high input-resistance instruments. It can be used as a high-voltage dc supply, 0.05% accuracy, or as a high-voltage pulse generator providing an output pulse of up to 3 kV with less than 1-ms rise time. Output pulse may be set for single-shot or repetitive operation at a 2-Hz rate. Pulse width and slope are variable by a front-panel control.

CIRCLE NO. 309

Unit takes test results and provides reports

Fairchild Systems Technology, 1725 Technology Dr., San Jose, CA 95110. (415) 962-3816. $125,000 to $250,000; 60 days.

A new concept in semiconductor test-system architecture correlates total test results into a meaningful management information system. The system, called the Integrator, is aimed at both manufacturers and volume users of complex LSI circuits. The system integrates raw data from on-line test systems to tell managers at every level what is happening in various process stages from silicon to finished product to the end system. The Integrator separates the data processing and software support functions from the product testing function. Essentially, the system consists of test locations, a communications network, and a centralized data storage and data processing system. Data are collected through the network into a disc file to create a central data base.

CIRCLE NO. 310

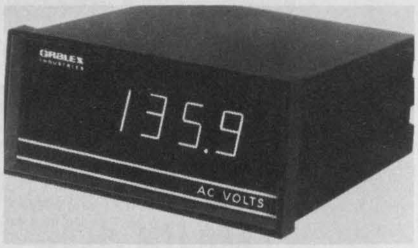
Standard interface bus boosts test speed

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. 5390A, $22,500; 8950A, $58,500; 14 weeks, either system.

Two test systems owe their performance to the HPIB (HP's implementation of IEEE-488). The first, the 5390A frequency-stability analyzer, makes fast phase-noise measurements to within 0.01 Hz of a carrier. The second, the 8950A transceiver test system, needs just three minutes to check out a typical 2-channel mobile FM transceiver, CB radio, handi-talkie or AM transceiver. Both test systems are calculator controlled, and both are built up of mostly off-the-shelf instruments interconnected via the standard bus.

Transceiver tester **CIRCLE NO. 320**
Stability analyzer **CIRCLE NO. 321**

DPM monitors ac power lines

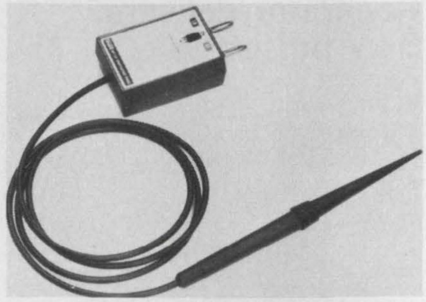


Gralex Industries, 155 Marine St., Farmingdale, NY 11735. (516) 694-3607. $164; 90 days.

Series 37DLM DPM measures voltages associated with ac power lines or systems. Capable of replacing large 4-1/4-in. switchboard meters, the series offers 1/2% accuracy and readability at distances up to 20 ft. Other features include gas-discharge display, NEMA standard case and universal ac line powering. Standard units are available in ranges of 200 or 400 V with 0.1-V resolution or 600 V with 1-V resolution. The meters are accurate at frequencies from 45 to 2000 Hz and usable with reduced accuracy to 20 kHz.

CIRCLE NO. 322

Probe makes any DVM a digital thermometer

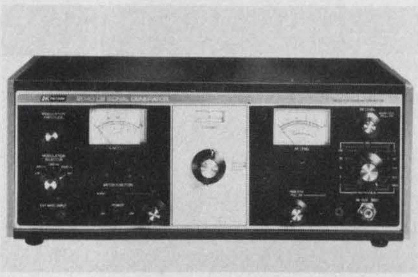


John Fluke, P.O. Box 43210, Mountlake Terrace, WA 98043. (206) 774-2211. $125.

The 80T-series is a small, self-powered temperature probe. Intended to be a universal accessory to DMMs, the probes are available in both Celsius (−50 to +150 C) and Fahrenheit (−58 to +302 F) versions. Probe output is in mV/degree and basic accuracy is ±2 C or F. Battery life is rated in 1000 h of continuous use. DMM compatibility is not critical, and any instrument with ±0.25% accuracy, minimum 1-MΩ input resistance and adequate sensitivity will do.

CIRCLE NO. 323

CB signal generator covers 50 channels



B&K Precision, 6460 W. Cortland Ave., Chicago, IL 60635. (312) 889-9087. $475; stock.

Model 2040 CB signal generator covers 50 channels, including all 40 authorized channels. Frequency calibration and stability are accurate to ±5 ppm (0.0005%) after a 15-min warmup. Phase-locked loop circuitry, referenced to a high-accuracy crystal, and powered by a well-regulated power supply, maintains performance standards under all normal operating conditions. A microvolt output meter and calibrated attenuators combine to provide accurate generator output measurements, down to 0.1 μV.

CIRCLE NO. 324

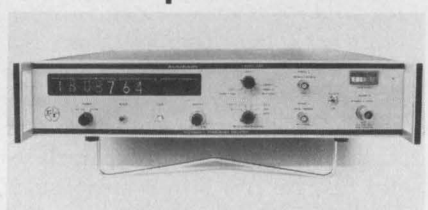
Distortion meter works automatically

Marconi Instruments, 100 Stonehurst Ct., Northvale, NJ 07647. (201) 767-7250. $850; 30 days.

Model 2337A automatic distortion meter enables rapid measurements to be made of both level and distortion of audio-frequency test signals. There's no need to set a reference level or to precisely tune a fundamental rejection filter. The only controls are pushbutton switches for selection of input voltage range, distortion range and fundamental frequency. Distortion down to 0.01% can be measured with an input signal of 100 mV.

CIRCLE NO. 325

Microwave counters measure pulsed carriers



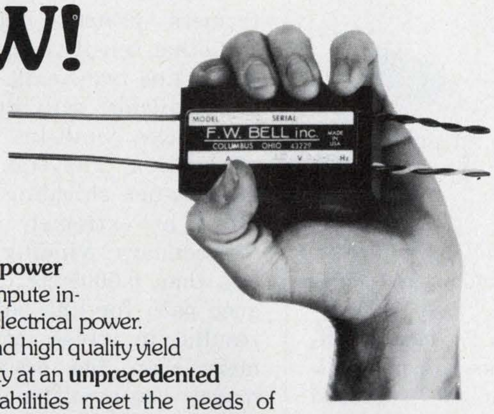
Eldorado, 2495 Estand Way, Pleasant Hill, CA 94523. (415) 682-2100. 988G, $5500; 989G: $6500; 17 wks.

A new 18-GHz pulsed microwave counter, Model 989G, and a similar 12.4-GHz instrument (Model 988G) measure carrier frequencies during pulse-modulation conditions. Frequency measurements to a resolution of 10 kHz (7 digits) are automatically provided, and rf pulses as narrow as 100 ns can be measured. Models 989G/988G also offer a CW mode providing resolution to 1 Hz (11 digits). Complete systems compatability is available, including remote programming and data output in BCD or IEEE GPIB format.

CIRCLE NO. 326

New Transducer modules measure electric power

NEW!



These **new power transducers** compute instantaneous ac electrical power. Simple design and high quality yield excellent reliability at an **unprecedented price.** New capabilities meet the needs of hundreds of previously difficult or uneconomical applications. These include, ±0.50% accuracy, **50 Hz to 10 kHz** frequency range, one and three phase operation, accurate operation with non-sinusoidal waveforms, better than ±0.25% power factor influence and a 100μs response time.

Each transducer is encased in a small, tough nylon case for easy installation. **Use the inquiry card** to get complete technical data.

4949 Freeway Drive E
Columbus, Oh 43229
614/888-7501
TWX: 810-337-2851

F.W. BELL INC.

A subsidiary of The Arnold Engineering Company

CIRCLE NUMBER 42

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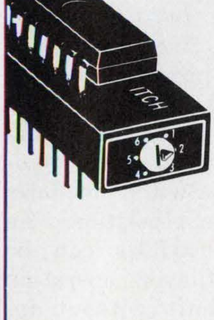
4 SWITCHED ON ADVANTAGES!

DIPSWITCH was the industry's first rotary switch for DIP sockets. It offers the designer the versatility and reliability only experience can bring. Here are four reasons you should consider **DIPSWITCH** for your switching needs.



1. if savings board space is important, you can piggyback an IC right onto **DIPSWITCH**.
2. if you need additional switch closures, **DIPSWITCH** can be tandem coupled using extended shafts.
3. if multilayered boards are part of your design, **DIPSWITCH**'s .230" profile is about half anybody else's. You can stack as close as ¼".
4. if you need special switch closure programming, **DIPSWITCH**'s six independent cams can be factory assembled to perform your programming.

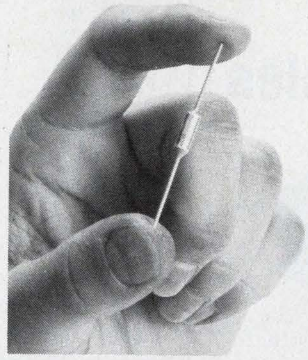
DIPSWITCH® is a Registered Trademark of the McGraw-Edison Company. Pat. No. 3621157

EDISON ELECTRONICS
a McGraw-Edison Company Division
Grenier Field Municipal Airport, Manchester, New Hampshire 03103 (603) 669-0940

CIRCLE NUMBER 41

Want A Safer Product And Lower Manufacturing Costs Too?

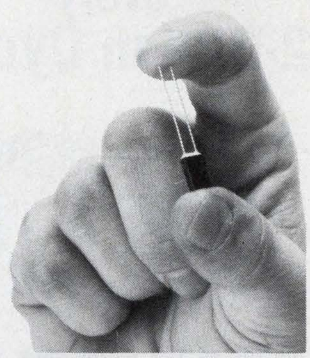
On the one hand choose the MICROTEMP® thermal cutoff



A reliable, accurate easy to install, "one shot" thermal limiter.

- temperature tolerance—±1.7°C.
- temperature ratings—58° to 242°C. (136° to 468°F.)
- current capacity—up to 30 amps at 240 VAC.
- compact—diameter, .157"; length, .457" (exclusive of leads).
- economical
- easy to install—assorted terminations, mounting packages and insulations available.
- Recognized under the Component Program of Underwriters' Laboratories, Inc. UL File #E40667A. CSA approved. BSI Certificate #5041 approved. Recognized by MITI and VDE. Military approval.

On the other hand, don't overlook the new PICOTEMP thermal cutoff



Used where installation or space restrictions rule out MICROTEMP® thermal cutoffs.

- temperature tolerance—+0°C.— –3.3°C.
- temperature ratings—63° to 150°C. (146° to 300°F.)
- current capacity—to 5 amps. at 120 VAC. Will hold this rating up to and including 240 VAC.
- compact—.236" x .389" x .087/.104" (exclusive of leads).
- economical
- Package is completely insulated, leads are 26 gauge silver plated wire.
- Recognized under the Component Program of Underwriters' Laboratories, Inc. UL File #40667A. MITI approved. CSA approved.

Both devices are completely sealed against the atmosphere. Because of their unique design and construction, they won't derate. And they're unaffected by age or extended use. You not only get positive, yet low cost protection against malfunctions in circuits and components caused by equipment failure or user abuse, but you eliminate costly and unnecessary service calls caused by nuisance tripping.

PICOTEMP or MICROTEMP? Which is best? Depends on your needs. Tell us about them.

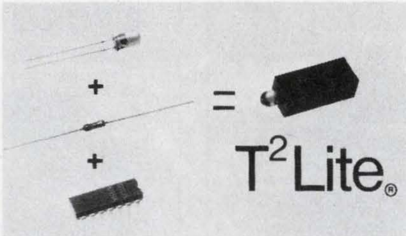
MICRO DEVICES

EMERSON

DIVISION OF EMERSON ELECTRIC CO.
1881 SOUTHTOWN BLVD.
DAYTON OH 45439 513-294-0581

CIRCLE NUMBER 49

DIP combines LED with TTL circuit



Data Display Products, Box 91072, Los Angeles, CA 90009. (213) 641-1232. $1.50 (100 up); 3 to 5 wks.

A new concept in PC-board indicator lights combines a visual indicator, using super or standard brightness LEDs and a TTL IC in a standard DIP package, thus saving the unnecessary cost and space of connecting separate components. This T² Lite is available with most 74-series ICs and either a super-bright or standard-bright LED in four colors. Current limiting resistors are built-in for 10, 20 or 30-mA LED current. LEDs are available either with tinted or clear encapsulation for narrow-beam, high-intensity units, or tinted or diffused encapsulation for wide-angle units.

CIRCLE NO. 327

New piezoceramic builds into stable filters

Channel Products Inc., 16722 Park Circle Drive W., Chagrin Falls, OH 44022. (216) 543-8137.

A new piezoceramic filter material, FGH, is said to have time and temperature stability that is greatly improved over currently available materials. The material has a frequency stability with time of +0.1% for 5 yr. Temperature stability is better than 0.1% from 0 to 50 C and 0.2% from −40 to 85 C. Present uses of the new material include filter resonators for AM radios and transceivers. For example, an FGH-01 filter resonator built with the material can be used for emitter bypass applications to improve selectivity and markedly simplify i-f alignment. The FGH-01 can also be used as a basic building-block resonator for complex bandpass-filter designs at 455 kHz.

CIRCLE NO. 328

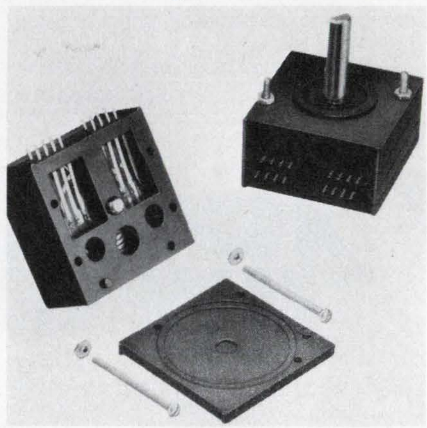
Power transformers suppress line noise

Topaz Electronics, 3855 Ruffin Rd., San Diego, CA 92123. (714) 279-0831. From $95 (unit qty).

A line of noise-suppression transformers protects data-processing and other sensitive equipment from power-line transients. Some models are available with line cords and receptacles built-in for ease of installation. The transformers use a triple-box shielding technique to attain an extremely low primary-to-secondary winding coupling of less than 0.0005 pF. A low-impedance path for line noise to ground results in noise attenuation of more than 146 dB. Single-phase models are available in power ratings from 125 VA to 20 kVA. Three-phase models are rated from 3 kVA to 130 kVA.

CIRCLE NO. 329

Rotary switch provides coded outputs

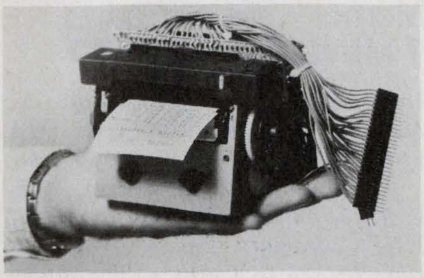


AMP Inc., Harrisburg, PA 17105. (717) 564-0100.

AMP 3500 Series rotary switches use bidirectional rotating coded PC boards with fixed cantilever brush contacts to provide a variety of output codes that include BCD, a direct seven-segment numerical code and a number of special synthesizing codes. Switch modules have 18-to-50 detent positions. As many as seven modules can be ganged for multilayer operation from a single shaft without increasing mounting surface dimensions. Rated for 2.5-A nonswitching and 125-mA switching, the units have a dielectric withstanding voltage of 250 V dc min. Life expectancy is over 25,000 bidirectional rotations at rated load.

CIRCLE NO. 330

21-column head prints in two colors



Master Digital Corp., 1308-F Logan Ave., Costa Mesa, CA 92626. (714) 751-8271. $102 (100 up); stock.

Two-color printing is achieved in Model 308-21, a 21-column numeric print head, by using an ink-ribbon cassette that features no-mess ribbon replacement. The print head can be operated with a 100% duty cycle at a print rate of 3 line/s. Life is 5-million printed lines. The print head can be mounted so the paper exits from either the top or front to allow flexibility in packaging. Dimensions of the head are 3.5 H × 5 W × 4.1 D in. and the unit weighs 3 lb.

CIRCLE NO. 331

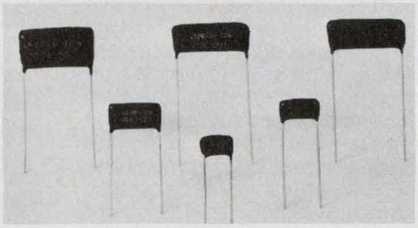
EM transducer replaces precision potentiometers

Astrosystems Inc., 6 Nevada Dr., Lake Success, NY 11040. (516) 328-1600. $295 (1-9); stock to 2 wks.

A wiperless high-accuracy electromagnetic position transducer provides a replacement for precision potentiometers. Proven rotational life is in excess of 100,000,000 rotations. An electromagnetic rotary transducer with solid-state excitation and conditioning electronics provides a smooth continuous dc-voltage output proportional to shaft rotation. The shaft is capable of continuous rotation. The transducer has infinite resolution with a dead band of less than 0.02°, a starting torque of less than 0.1 oz-in, and an accuracy and linearity of 0.05%. Available output voltages are 0 to +10 V dc, −5 to +5 V dc or 0 to +10 V dc from an internal or external reference. Ripple voltage is less than 3 mV rms. The unit is approximately 1.5 in. in diameter by 1.3 in. long.

CIRCLE NO. 332

Polyester-film caps offer high cap/volume



Cornell-Dubilier, 150 Avenue L, Newark, NJ 07101. (201) 589-7500.

Type DMT polyester-film dipped capacitors provide very high volumetric efficiency and moisture resistance (95 to 100% relative humidity at 40 C for 240 h). A combination plastic coating with a firm bonding of epoxy around the leads prevent the entrance of moisture. The capacitors operate to 125 C without derating and with good stability, and at up to twice the rated voltage at 85 C.

CIRCLE NO. 362

DATA PROCESSING

Memory system adds 1 Mbyte to IBM's 370

Intel Memory Systems, 1302 N. Mathilda Ave., Sunnyvale, CA 94086. (408) 734-8102. $4567/mo.

An add-on memory system, Model 7125, expands the 96 kbytes of IBM's standard memory size for the 370/125 to 1 Mbyte. The Model 7125 semiconductor memory system uses 16 kbit RAMs for data storage. When parts of the memory fail, backup memory is automatically switched in. System access time runs 280 ns, and the cycle period is 480 ns.

CIRCLE NO. 333

Color-TV display accepts computer data

Comtal Corp., 169 N. Halstead St., Pasadena, CA 91107. (213) 793-2134. See text: 90 days.

The Model 2000 computer-output memory and buffer produces a full-color continuously refreshed, flicker-free display. The unit operates on-line with a host processor such as a 16-bit minicomputer ($17,950 with interface controller). Or the 2000 takes data from a magnetic-tape drive ($19,950 including 9-track drive). The unit displays 480 lines with 512 picture elements per line. The display is refreshed 30 times per second.

CIRCLE NO. 334

16-k × 20 RAM board accesses in 280 ns

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 737-5000. $1050 (large qty).

The Model NS3000-1 RAM board holds 16-k × 16, 18 or 20 bits, according to user requirements. The timing specifications are: access, 280 ns; read or write cycle, 430 ns; and read-modify-write cycle, 610 ns. Options include parity generation and check and data-available reset. The latter option permits the NS3000-1 to control a shared-data bus. The card measures 11.75 × 15.40 in. The NS3000-1 is rated for operation between 0 and 50 C.

CIRCLE NO. 335

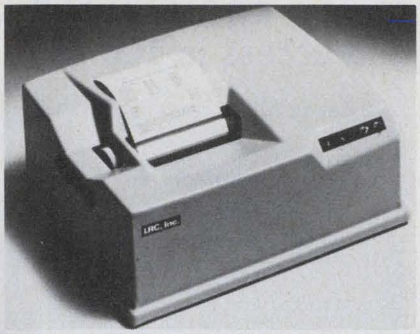
Keyboard terminal drives a video monitor

Computer Conversor Corp., 1961 Old Middlefield Way, Mountain View, CA 94043. (415) 969-3213. $695.

The Conversor-8000 terminal has a keyboard and generates composite-video output for an 80-character by 24-line TV display. The terminal talks to a computer over RS232 lines at a 110 or 300 baud rate. The 8000 has automatic display scrolling. It weighs 6.5 lb, and measures 6 × 11 × 14 in. Options include an integral acoustic coupler ($110), video monitor ($120) and software-controlled beeper ($30).

CIRCLE NO. 336

Printer includes control electronics



LRC, Inc., Technical Research Park, Riverton, WY 82501. (307) 856-6524. $495 (single qty).

A 40-column printer comes with control electronics. Designated the Model 140, it uses a dot-matrix printer. The system contains a MOS chip that has a 48-character buffer, a character generator, and control logic. Software commands alter character width, height and density. Extra-cost options include RS-232C or current-loop lines, a pin-feed platen, a high-speed paper feed, label printing and front-feed document printing.

CIRCLE NO. 337

Floppy-disc terminal searches for data

Techtran Industries, 530 Jefferson Rd., Rochester, NY 14623. (716) 271-7953. $2595 (single qty); 60 days.

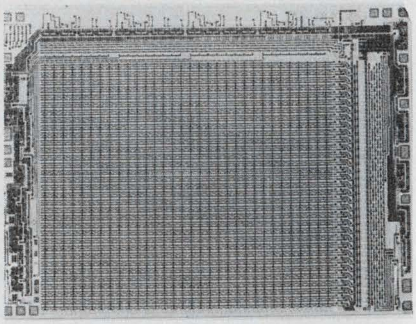
The 9512 floppy-disc drive and terminal can search its disc for a 14-character sequence and alter or read out the associated data. Other disc-based terminals require the track and sector location of the data be entered to alter it; the 9512 will also do that. The unit stores data on the disc in an IBM-compatible format. The 9512 has two 110-9600 baud serial lines. One line could connect to a keyboard, the other to a computer.

CIRCLE NO. 338

CIRCLE NUMBER 52

INTEGRATED CIRCUITS

Bipolar PROMs hold 8 k and access in 100 ns



Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. (408) 739-7700. $31 (100-up); stock.

Developed with either open collector or three-state outputs, the 82S184 and 82S185 field-programmable bipolar ROMs are available in a 2048 × 4 organization. The ROMs have an address access time of 100 ns maximum and a typical power dissipation of 50 μW/bit. Both devices are available in 18-pin ceramic DIPs with performance guaranteed over the commercial temperature range. Military temp range devices will be available in the near future.

CIRCLE NO. 339

JFET-input amplifiers come in many models

Texas Instruments, P.O. Box 5012, Dallas, TX 75222. (214) 238-2011. From $1.60 (100-up); stock.

The LF155 series of JFET input op amps offers input-bias currents of under 50 pA (LF156A). There are three basic model groupings available: the LF155, 155A, 255, 355 and 355A are intended for low current drain applications; the LF-156, 156A, 256, 356 and 356A are designed for wideband uses; the last group, the LF157, 157A, 257, 357, 357A are intended for wideband decompensated uses. The 155 series units are rated over the full military temperature range, the 255 series over a −25 to +85-C range and the 355 series over the 0 to 70-C range. The op amps are available in 8-pin ceramic or plastic DIPs and in TO-99, 8-pin metal cans. All units are pin-compatible with the LF155 series of op amps from National Semiconductor.

CIRCLE NO. 340

HiNIL counters deliver decimal or hexadecimal

Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, CA 94043. (415) 968-9241. From $3.06 (1000-up); stock.

Two up-down (reversible) counters, the HiNIL 373 and 374, offer a choice of decimal or hexadecimal outputs. Each unit has two clock inputs; pulsing one clock input causes the device to count up; pulsing the other causes it to count down. Other features include a noise immunity of 3.5 V, minimum, carry and borrow outputs for N-bit cascading, a clear input independent of count and load, individual presets to each flip-flop, and synchronous operation. The circuits operate at maximum counting frequencies of 1 MHz.

CIRCLE NO. 341

Speedy shift register handles ECL and TTL

TRW Defense and Space Systems, One Space Park, Redondo Beach, CA 90278. (213) 536-1500. $80 (1 to 99); 30 days.

A 128-bit bipolar shift register, the SR128, has both ECL and TTL compatible inputs and outputs. Its 60-MHz operating speed is guaranteed when the ECL connections are used. ECL outputs are complementary open-emitter, thus permitting hard-wire OR connections. In the 60-MHz ECL configuration, the SR128 can source 20 mA. The TTL mode operates at a guaranteed 40 MHz, and its output is single-ended with a 6-mA sink capability. TTL and ECL inputs are either single ended or differential and can be multiplexed with an ECL level control. The inputs and outputs can be interfaced with single-ended inputs by connecting the complementary input to one of the two on-chip reference voltages. In the differential mode, inputs can be used as analog comparators with the ECL inputs for high level signals and the TTL for lower level signals. The SR128 operates from a single power supply of 5 V for TTL or −5.2 V for ECL. Open-emitter ECL outputs may terminate in 50 Ω by connecting load resistors to a −2.2-V supply.

CIRCLE NO. 342

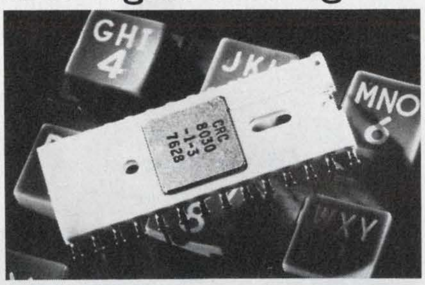
μP support circuits do control or bus driving

AMD, 901 Thompson Pl., Sunnyvale, CA 94086. (408) 732-2400. From $6.50 (100-up); stock.

A pair of system controllers and bus drivers, the Am8228 and Am-8238, are designed for operation with 9080A/8080A microprocessor systems. They provide eight-bit, bidirectional bus drive and are controlled by signals from a gating array. These circuits, pin-compatible with like-numbered devices from Intel, provide multibyte instruction interrupt acknowledge and a selectable single level vectored interrupt. The Am8238 has an extended memory write pulse width enhancing its application in large system timing controls. Both devices are available in molded and hermetic DIPs and are specified for operation over the commercial or military temperature ranges.

CIRCLE NO. 343

Telephone-tone decoder uses digital filtering

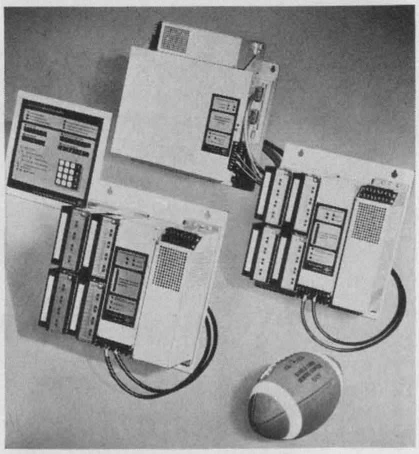


Collins Commercial Telecommunications, Division of Rockwell International, Newport Beach, CA 92663. (714) 833-4638. See text; stock.

Using a unique digital filtering technique, the CRC-8030 provides a low-cost solution for DTMF decoding. The circuit, which costs only $29 in hundreds, when used in conjunction with a front-end band-split filter/limiter, forms a complete telephone-tone receiver. Valid tones are detected and converted to binary or 2-of-8 coded outputs within 22 to 39 ms, depending upon the front-end filter. The CRC-8030 is an ion-implanted depletion-mode, p-channel MOS/LSI device. It can operate from a +5-V supply and requires only a standard external 3.579545-MHz crystal for clock generation. It is housed in a 28-pin ceramic DIP.

CIRCLE NO. 344

Industrial multiplexer cuts the wire-mire

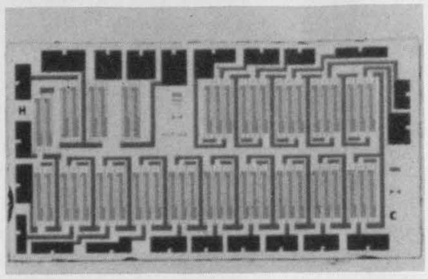


Cutler-Hammer, 4201 N. 27th St., Milwaukee, WI 53216. (414) 442-7800. From $6000; 20 wk.

Directrol is a multiplex system that permits industrial control devices to communicate over a two-wire loop. The manufacturer estimates that multiplexing can save up to 50% in wiring costs when compared with conventional point-to-point wiring networks. A system can handle up to 4096 input and/or output devices. Up to 4096 individual digital or 2048 analog signals, or a combination of the two, can be transmitted from as many as 128 separate locations via time-division-multiplexing at a throughput rate of 3 ms. The system transmits analog measurements between terminal stations and to the communications station, where they can be displayed on an optional monitoring panel or made available for a computer. This stand-alone system does not need a computer. However, it is compatible with many computers. A standard feature automatically bypasses a malfunctioning station without disturbing continuous-flow processes. A redundancy option, using two pairs of wires, reconfigures a new communications loop when wires break. Bipolar 12-V, non-return-to-zero pulses at a 500 kHz rate, bi-phase modulated (Manchester code) give the system a data rate of 190 k bits per s. Each 8-bit data word is redundant and undergoes a geometric parity-check. The systems meets or exceeds NEMA ICS 2-230 for noise.

CIRCLE NO. 345

Stable ladders resolve 15 bits

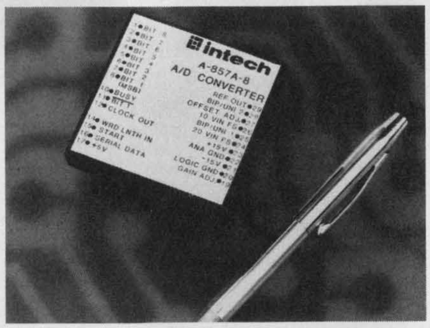


HyComp, 146 Main St., Box 250, Maynard, MA 01754. (617) 897-4578. $47 (100 qty).

The series HC 1500 is a family of six R-2R ladder networks, each with 15-bit resolution. These nichrome thin-film devices have tracking tempcos of 1 ppm typical, 2 ppm maximum, and absolute tempcos of ±50 ppm. Standard impedance level is 25 kΩ ±5%, but laser-trimmed ladders with ±1% tolerances are available. Ratio accuracies range from 0.005% to 0.05%. Maximum accumulated positive and negative deviation error is less than the specified ratio-accuracy. The networks are available in a 24-pin DIP or flatpack; the passivated chip itself is 0.19 × 0.1 in.

CIRCLE NO. 346

8-bit a/d settles in 800 ns or less

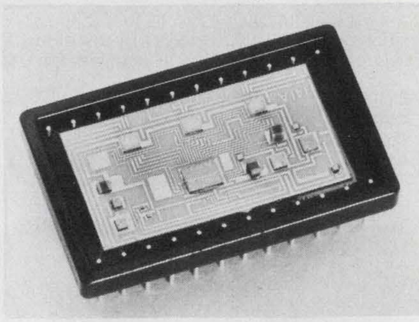


Intech Inc., 282 Brokaw Rd., Santa Clara, CA 95050. (408) 244-0500. $199 (1-24); stock to 4 wks.

The A-857A-8 features an 800-ns conversion time, and can be short-cycled for 2-to-7-bit operation with proportionately shorter conversion times. At its input, the A-857A-8 accommodates ±10 V, ±5 V, and 0 to +10 V; digital outputs are provided in both parallel and serial formats. A low temperature coefficient guarantees no missing codes over the rated 0-to-70-C temperature range.

CIRCLE NO. 347

D/a converters get MIL-883 testing

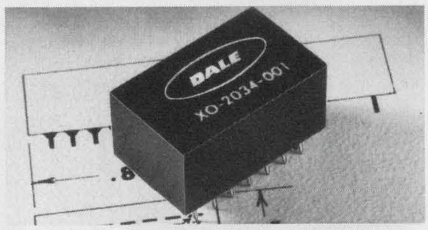


Micro Networks Corp., 324 Clark St., Worcester, MA 10606. (617) 852-5400. From $69 (1-24).

DAC-85 series 12-bit d/a converters are routinely tested to MIL-883 Class C specs, at no extra cost. In quantities of 1 to 24, the Model DAC-85-C (0 to 70 C) starts at $69, while the DAC-85-CBI and CCD (−25 to +85 C) are priced at $89. These, as well as BCD and binary versions, come in sealed 24-pin DIPs, and offer guaranteed monotonicity within the −25 to +85 C range. Both voltage and current output models provide programmable ranges, TTL-compatible inputs, and work from standard +5 and ±15-V supplies.

CIRCLE NO. 348

Low-cost oscillators span 20-MHz range

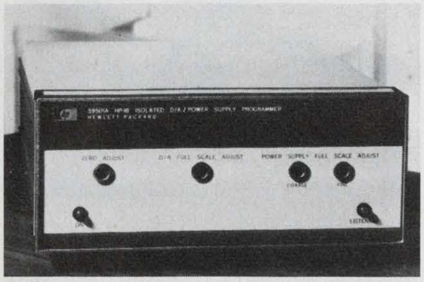


Dale Electronics, 930 W. 23 St., Tempe, AZ 85282. (602) 967-7874. See text.

For $5.50 (1000 qty.) the XO-2000 series of crystal-controlled oscillators gives you an output frequency in the 3.7-to-25-MHz range. The frequency's stability is ±1000 ppm from 0 to 60 C. Stabilities of ±50, ±100 and ±500 ppm are available at higher costs. Fan-out is ten TTL inputs from the 14-pin DIP-type, 0.8 × 0.5 × 0.4 in., encapsulated unit. As an option, the height can be shrunk from 0.4 to 0.3 in.

CIRCLE NO. 349

Programmer ties supplies to HP-IB



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $500; 2 wk.

With this power-supply programmer you can control more than 80 models of HP unipolar and bipolar power supplies via the Hewlett-Packard Interface Bus (HP-IB). The Model 59501A controls a wide range of dc voltages and currents at power levels up to 10 kW. Output voltage (or current) of HP remotely programmable power-supplies is controlled by voltage programming from the unit, with gain provided by the power-supply control circuits. The programmer contains an adjustable resistance network that matches its output to various HP power-supply programming coefficients and full-scale output ratings. The device offers isolation rated at 600 V dc between bus input lines and the output terminals. The instrument also can be used as a low-level dc voltage source with two manually selected output modes. One mode is unipolar, from 0 to 9.99 V in 10-mV steps with an accuracy of 0.1% of output plus 5 mV. The other mode is bipolar, from −10 to +9.98 V in 20 mV steps with an accuracy of 0.1% of output plus 10 mV. Resolution for both modes is 0.1%. A bus-programmable 0.1-times range provides increased resolution and accuracy over the lower 10% of both output modes. Output current up to 10 mA is available. Internal conversion circuitry enables the 59501A to produce a full-scale d/a voltage change in less than 150 μs from the time the digital data are received until the programmed analog voltage is reached.

CIRCLE NO. 350

POWER SOURCES

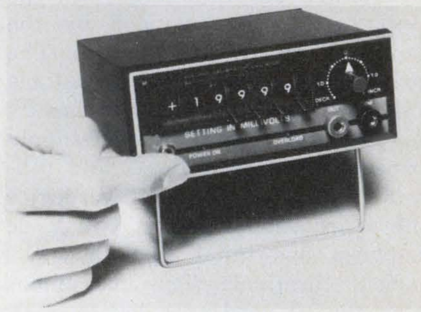
Supplies for boards offer high regulation

Standard Power, 1400 S. Village Way, Santa Ana, CA 92705. John Mittelbach, (714) 558-8512. $29-$115; stock.

Circuit-board mountable ESPD and ESPT dc power supplies provide either two or three outputs with no-load to full-load regulation of 0.02%. You can select any combination and polarity of 15, 12, or 5-V outputs, at total currents from 25 mA to 2 A.

CIRCLE NO. 351

Dial-a-voltage with 0.005% fs accuracy

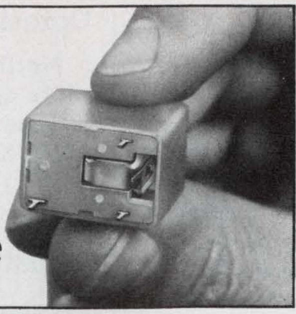


Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. (617) 828-8000. $295 (1-9 units); 4-6 wks.

The DVC-8500 low-cost miniature voltage generator supplies a bipolar output up to ±19.999 V at 25 mA, in 1-mV switch-selected steps, accurate to 0.005% full scale, or ±1 mV of setting. For precise zeroing, a vernier varies the output by 0 to 1.5 mV. The manufacturer claims a 90-day stability of 27-ppm fs drift, and 5-μV zero drift, with less than 1 mV absolute error over a 0-to-50-C operating range. Powered by 115 or 230 V ac ±10%, 47 to 440 Hz, the instrument has a short-circuit protected output accessible both in front and back. Panel mounting kit available.

CIRCLE NO. 352

Low cost, high performance 3A SPDT relay really saves PC board space



Mounts on .69" centers... satisfies thousands of application needs

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You'll find the Series 27 relay suitable for hundreds of control applications. For instance: timing controls; gas pilot light controls; anti-theft devices for CB radios; automotive controls; emergency lighting equipment; and medical equipment, to name a few.

The relay has a 450 mW pick-up sensitivity (180 mW available). Contact rating is 3A res @ 28V dc. 120V ac. Contact resistance is 0.10 ohm.

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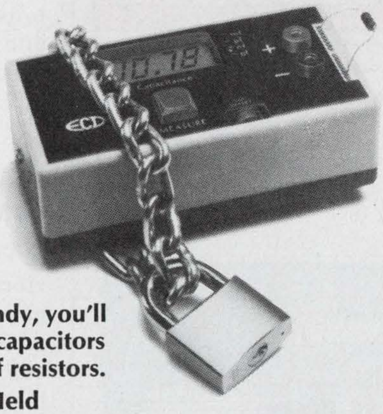

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CIRCLE NUMBER 67

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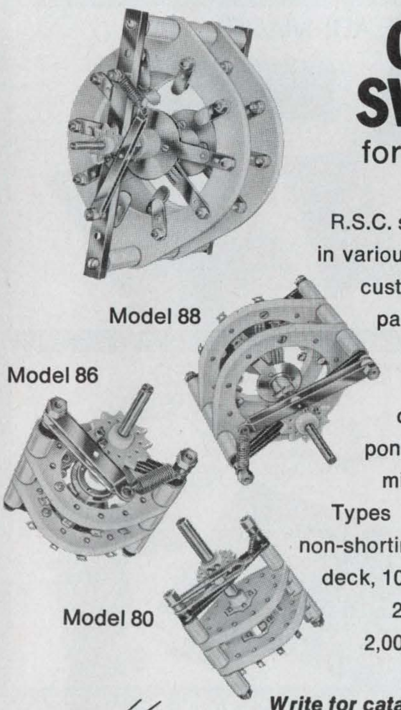

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Model 88

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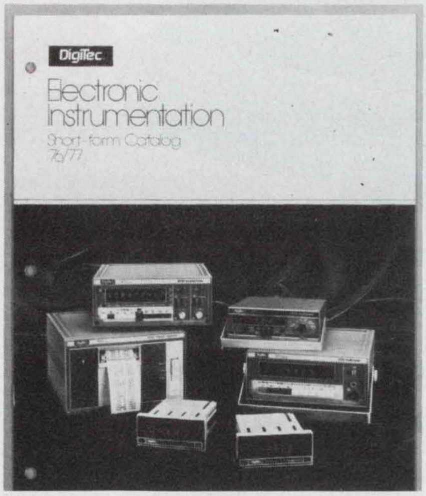
New Literature



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Specifications on over 150 digital instruments, such as DMMs, thermometers, calibrators, data-acquisition systems, are contained in a 20-page catalog. United Systems, Dayton, OH

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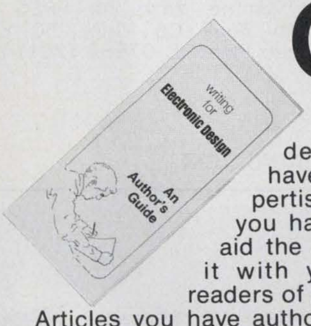
Display devices

Display devices for a variety of demanding industrial and military applications are covered in a 22-page catalog. The illustrated catalog is divided into the following product sections: CRTs, display storage tubes and a developmental electroluminescent (EL) flat-panel display. Westinghouse Electric, Industrial & Government Tube Div., Horseheads, NY

CIRCLE NO. 361

AUTHOR'S GUIDE



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quick ads

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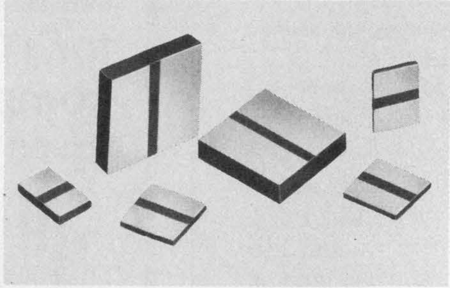

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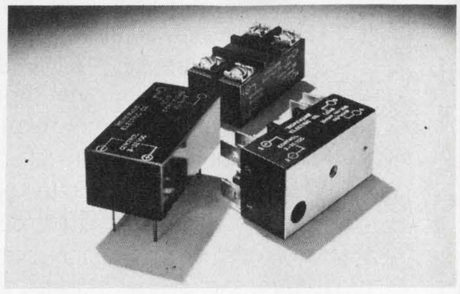
CERAMIC CHIP CAPACITORS 181



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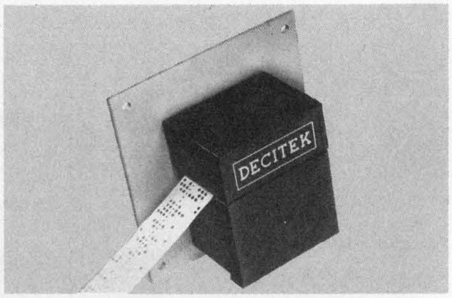

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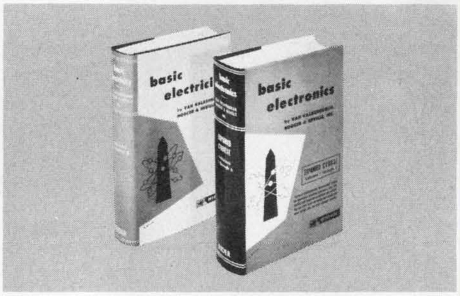

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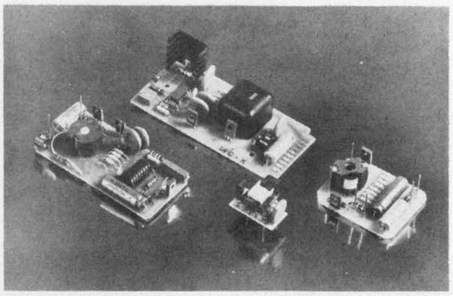

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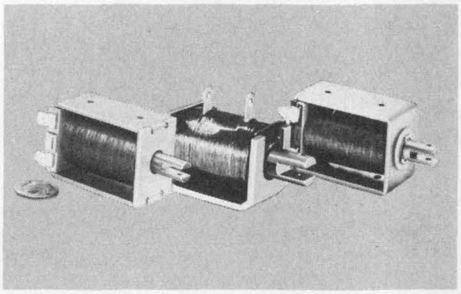

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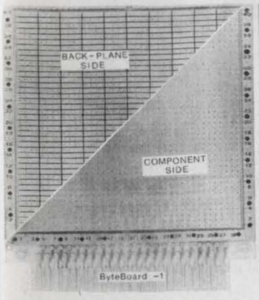
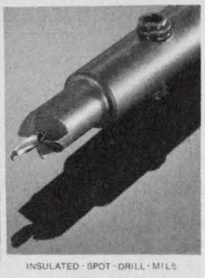
SOLENOIDS 186





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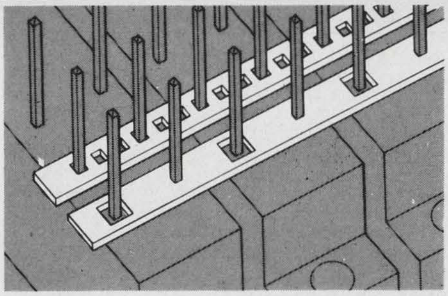

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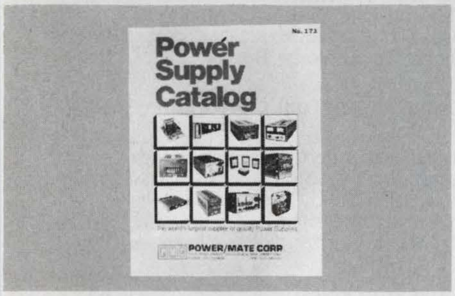

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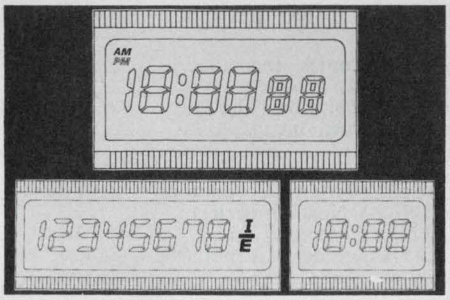

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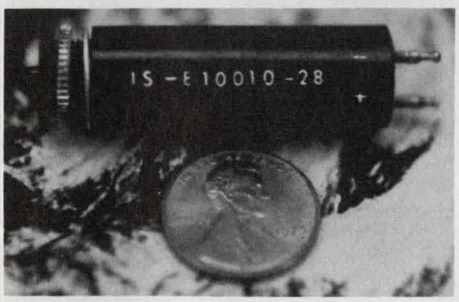

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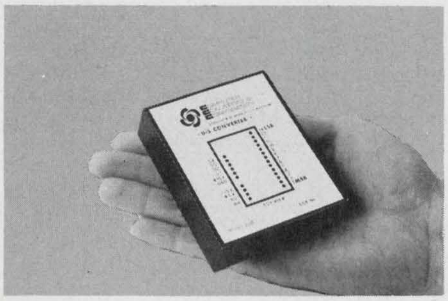

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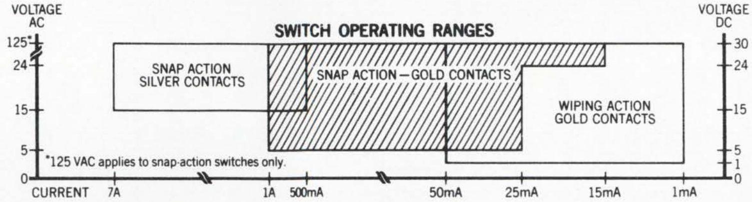
Product Index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

new literature

Dialight Switches

A switch for all reasons.



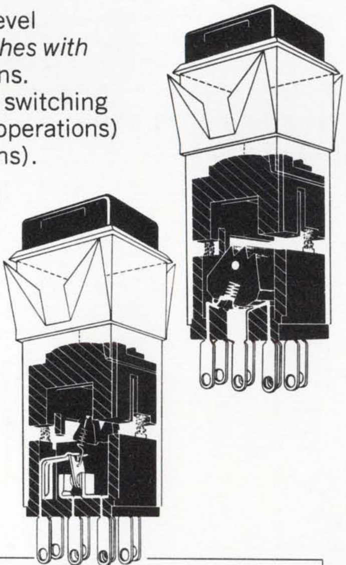
Reason 1: Dialight offers three switch configurations to meet all your needs—*snap-action switches with silver contacts* for moderate-level applications, *snap-action switches with gold contacts* for intermediate-level applications, and *wiping-action switches with gold contacts* for low-level applications. Each of these ranges is served by two switching actions—momentary (life: 750,000 operations) and alternate (life: 250,000 operations).

Reason 2: Dialight's snap-action and wiping-action switches come in a new modular design concept . . . a common switch body for either high or low current operation. All 554 series switches and matching indicators have the same rear-panel projection dimensions.

The snap-action switching mechanism guarantees a fast closing and opening rate. This insures that contact force and contact resistance are independent of the switch's actuation speed.

In the wiping-action switch, the contacts are under constant pressure (A unique Dialight design). This insures long life with a minimum build-up of contact resistance.

Both switch types are tease-proof.



PRODUCT SELECTOR GUIDE						
SWITCHING ACTIONS	Snap-Silver contacts SPDT	Snap-Silver contacts DPDT	Snap-Gold contacts SPDT	Snap-Gold contacts DPDT	Wiping-Gold contacts SPDT	Wiping-Gold contacts DPDT
MOMENTARY	○	○	○	○	○	○
ALTERNATE	○	○	○	○	○	○

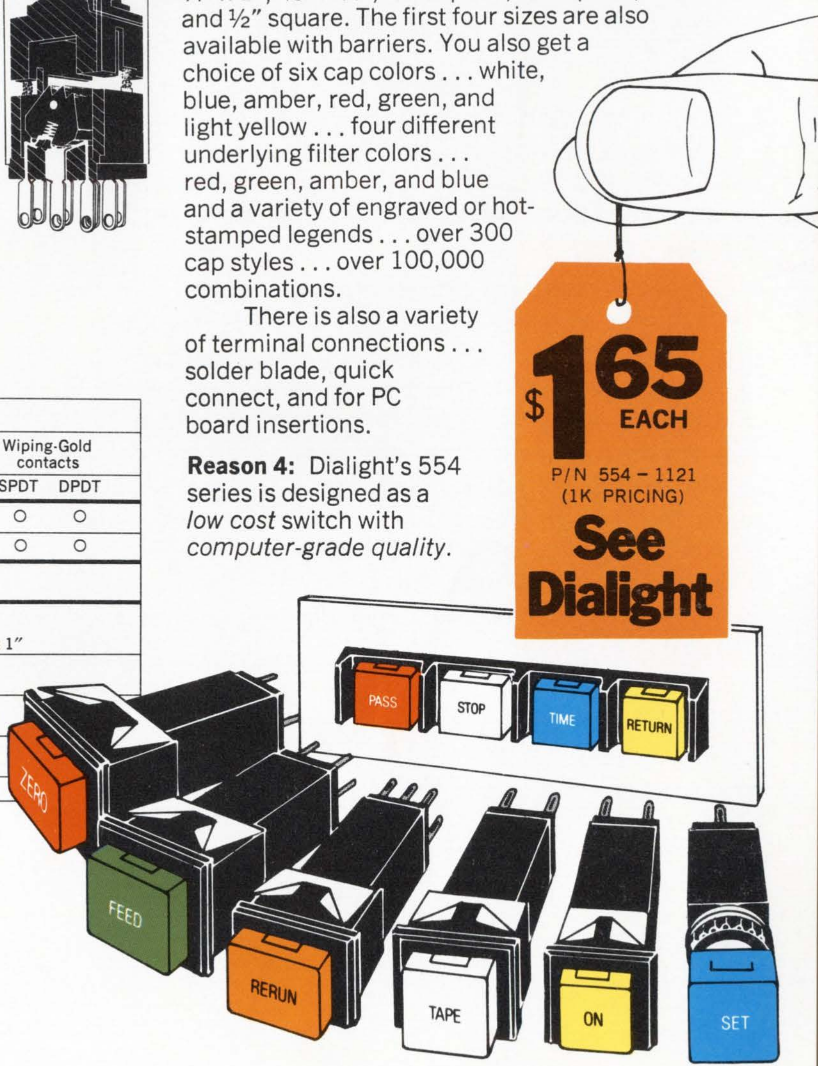
OPTIONS — PUSH BUTTON CAP SIZES	½″ Sq.	⅝″ Sq.	⅝″ x ¾″	¾″ Sq.	¾″ x 1″
BEZEL MOUNTING TO ACCOMMODATE	○	○	○	○	○
BEZEL MOUNTING WITH BARRIERS TO ACCOMMODATE		○	○	○	○
PANEL MOUNTING TO ACCOMMODATE	○	○	○	○	○
MATCHING INDICATORS	○	○	○	○	○

Reason 3: Dialight offers a wide variety of panel and snap-in bezel mounting switches with momentary and alternate action configurations in SPDT and DPDT types. There are over 240 switch variations to choose from.

The 554 illuminated switch, designed for front of panel lamp replacement, gives you a choice of five different bezel sizes . . . ¾″ x 1″, ⅝″ x ¾″, ¾″ square, ⅝″ square, and ½″ square. The first four sizes are also available with barriers. You also get a choice of six cap colors . . . white, blue, amber, red, green, and light yellow . . . four different underlying filter colors . . . red, green, amber, and blue and a variety of engraved or hot-stamped legends . . . over 300 cap styles . . . over 100,000 combinations.

There is also a variety of terminal connections . . . solder blade, quick connect, and for PC board insertions.

Reason 4: Dialight's 554 series is designed as a *low cost* switch with *computer-grade quality.*



DIALIGHT

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