

# Electronic Design 20

VOL. 20 NO.

FOR ENGINEERS AND ENGINEERING MANAGERS

SEPT. 28, 1972

**Tiniest 4-1/2-digit DMM** costs less than any other and, in fact, less than most 3-1/2-digit units. Rechargeable batteries provide six-hour operation and freedom from power-line interference. But even line operation offers better than 100 dB of common-mode rejection at 60 Hz. For a look at this small meter, see p. 87.



Do you face  
a make or buy decision  
on power supplies?

## How to use power hybrid voltage regulators to build your own power supplies.

There's another choice now in power-supply design. You're no longer restricted to a supply designed by others, nor to one you have to design from scratch. You can buy the heart of the supply—the voltage regulator—in a hybrid form that offers much more power output than monolithic regulators. Then you can design the rest of the supply and the heat sink, if necessary, using a straightforward procedure.

Hybrid regulators are now available in many models with outputs to 28 V dc and to 5 A. Dissipation at 25°C can reach 85 W—a far cry from the watt or so available in monolithic regulators.

Though there are differences in circuitry, specifications and packaging among regulators available from companies like Lambda, Melville, N. Y.; Micropac, Garland, Tex.; Fairchild, San Jose, Calif.; and Tecnetics, Boulder, Colo., the basic principles of designing with them are the same.

A typical circuit

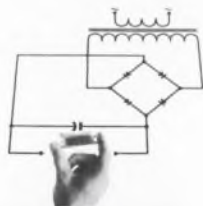
This article in Lambda's new hybrid regulator brochure tells you how to use these devices to build your own power supplies. . . . Send for your free copy.

**Announcing:  
NEW POWER HYBRID  
VOLTAGE REGULATORS**  
62W 5V 3A

**\$25 ea.**  
(in quantity  
of 1)

**\$14 ea.**  
(in quantity  
of 100)

**\$11 ea.**  
(in quantity  
of 1000)



**WHETHER  
YOU MAKE  
OR BUY...**

**△ LAMBDA  
ELECTRONICS CORP.**  
A Velleco Company

**NEW  
LOW PRICES ON  
85W 5V 5A**


**\$30 ea.**  
(in quantity  
of 1)

**\$18 ea.**  
(in quantity  
of 100)

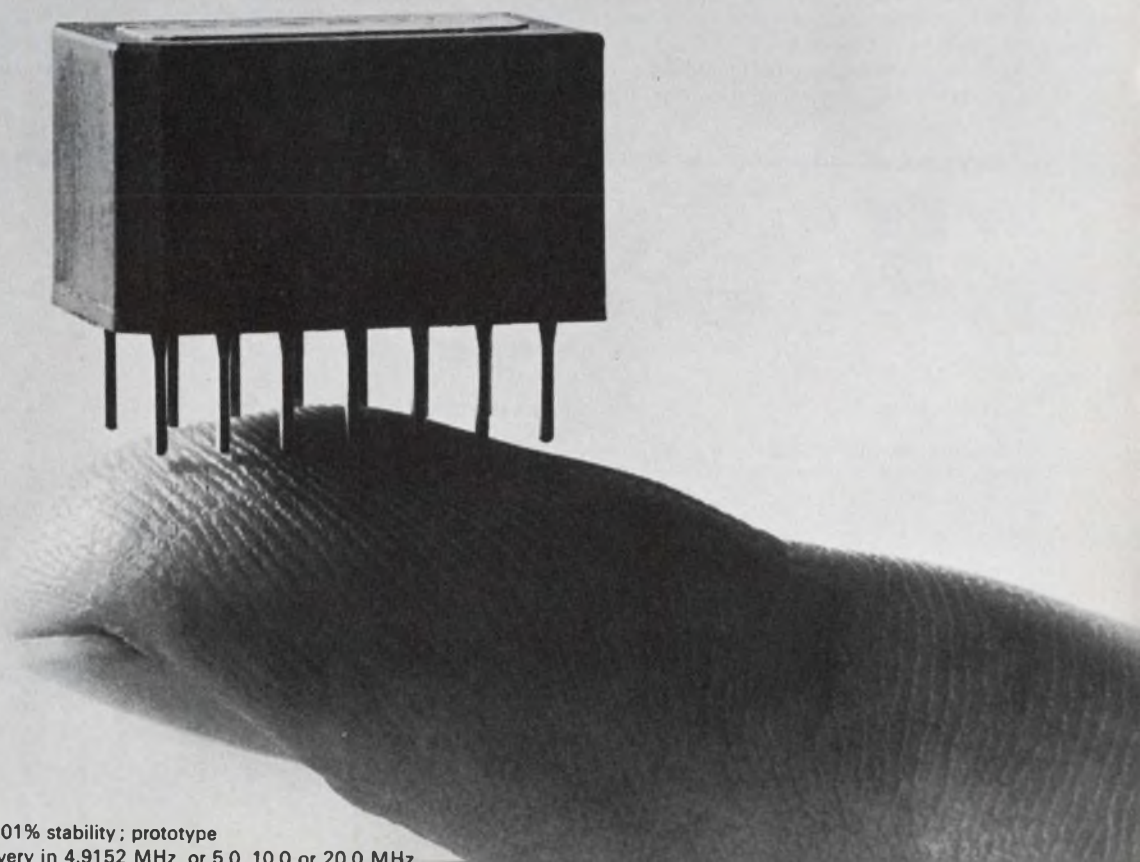
**\$15 ea.**  
(in quantity  
of 1000)

**100,000 hours MTBF  
demonstrated**



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

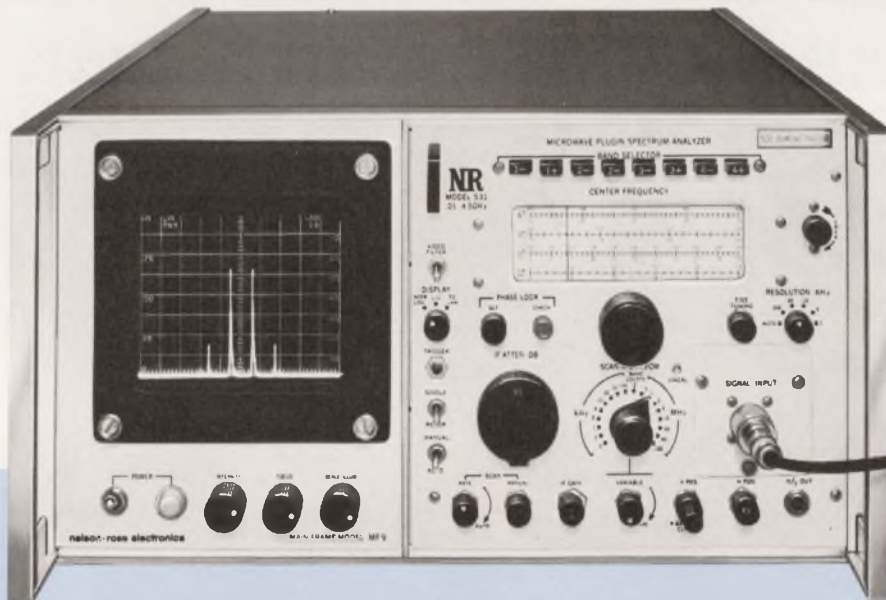
INFORMATION RETRIEVAL NUMBER 2



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

# 14 NEW Lowest Cost Spectrum Analyzers

From Sub-Audio to Microwave



## Nelson Ross Spectrum Analyzer Model 531

10 MHz to 4.5 GHz  
Dispersion 0-1 GHz  
Phase locked 1 KHz resolution  
Price: \$3,050

Nelson Ross, the specialist in Spectrum Analyzers, has the **Biggest Selection, Most Versatile Specifications and Proven Reliability . . . All This For The Lowest Prices.**

Now you can select a Spectrum Analyzer from 0.5 Hz to 6.5 GHz which is just right for your application. And, with Nelson Ross you'll save 50% or more by not paying for unnecessary extras that you'll probably never use.

The versatile Spectrum Analyzers illustrated here are typical of 14 complete analyzers and more than 30 plug-in analyzers available from Nelson Ross.

The complete instruments include the new MF-9 Calibrated Display Main Frame which provides bright, long persistence

8x10cm readouts, adjustable scale illumination and camera mount facility.

Our plug-in analyzers come in 3 complete series: • for the Tektronix "540/550 letter" series scopes • for the Tektronix 560 series scopes • for the HP 140/141 series scopes and the Nelson Ross MF-9 Display Main Frame.

Compare specifications, quality, ease of use and price. We're sure you'll join the thousands who have been selecting Nelson Ross Spectrum Analyzers for more than a decade.

Call, write or circle the Reader Service Number to get your new Nelson Ross Spectrum Analyzer Catalog. Then **you** can compare and save.

## Typical Plug-In Spectrum Analyzers for Nelson Ross MF-9 Display Main Frame or HP 140/141 series scopes.



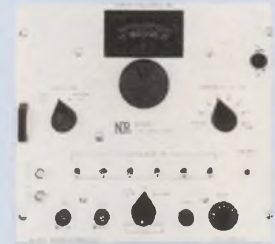
**Sub-Audio: Model PSA-036**  
0.5 Hz - 2 KHz  
0.5 Hz Resolution  
Plug-In: \$1,200  
With MF-9: \$2,200



**Broadband: Model PSA-235**  
1 KHz - 25 MHz  
200 Hz Resolution  
Plug-In: \$1,700  
With MF-9: \$2,700



**Audio: Model PSA-031**  
10 Hz - 20 KHz  
10 Hz Resolution  
Plug-In: \$ 850  
With MF-9: \$1,850



**RF-TV: Model CATV**  
1 MHz - 300 MHz  
Plug-In: \$1,500  
With MF-9: \$2,500

## Typical of more than 25 Plug-In Analyzers for use with Tektronix scopes.



**For "540/550 letter" series**  
**SSB Narrow-Band RF**  
**Model PSA-201**  
0.6 - 36 MHz  
10 Hz Resolution  
\$1,675



**For 560 Series**  
**Ultrasonic**  
**Model PSA-023**  
0.15 - 500 KHz  
150 Hz Resolution  
\$850

**nelson • ross electronics**

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Lake Success, New York 11040  
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INFORMATION RETRIEVAL NUMBER 3



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- 30 **How good are the new watches?** Liquid-crystal displays and claims of minute-a-year accuracy are causing controversy.
- 34 **The 'smart' bombing technique is about to become smarter.** Multisensor system for spotting military targets going on Navy attack aircraft.
- 38 **Electronic whiz kids** from Pratt Institute show off their ideas for building a better car.
- 44 **The Felix, a fast liquid crystal,** is easy on power and easy on the eye.
- 46 **Technology Abroad**
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## TECHNOLOGY

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- 57 **Try it on the calculator.** If the design is too troublesome for manual analysis but not complex enough to justify use of a computer, try a programmable calculator.
- 62 **Cut synchro-to-digital conversion costs** and improve performance with this simple converter. Extensive use of digital ICs simplifies quantity production.
- 70 **Switch to digital-filter design** and let numbers replace voltages, and stable shift registers, adders and gates replace drift-prone capacitors and inductors.
- 76 **Use the wired-AND and implied-OR configurations** to simplify logic circuitry. They require fewer gates and inputs than a conventional Boolean implementation.
- 80 **Ideas for Design:** Triangle-wave generator keeps slopes constant as amplitude changes . . . Ac reference achieves 0.01% accuracy with ROM-d/a converter combination . . . Clock oscillator for telemetry systems uses CMOS chip to minimize power drain.

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## PRODUCTS

- 87 **Instrumentation:** 4-1/2-digit pocket multimeter slashes size, price and power consumption.
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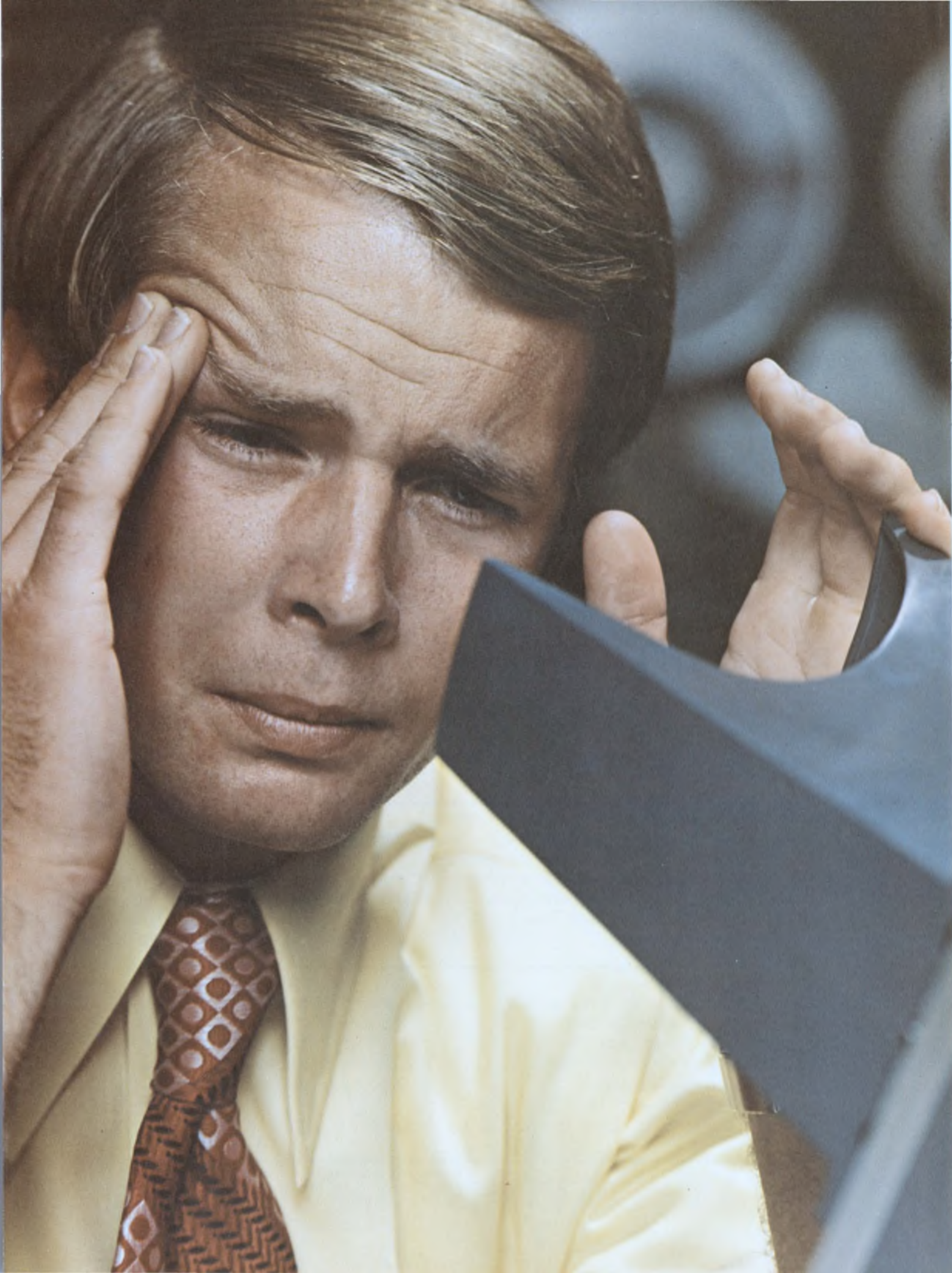
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**Cover:** Photo by Lew Colson. Courtesy of Data Precision Corp.







# Think Twice:

## What's one of the biggest measurement problems in the computer industry today?

### Low Duty-Cycle Measurements—

Making timing-pulse adjustments, and finding noise pulses in, or locating missing bits from low duty-cycle digital signals. Countless lost hours and eye-strain have resulted from this problem—trying to view low rep-rate signals like those found in disc, tape, or drum peripheral units. But with your refresh cycle occurring at such long intervals, coupled with short phosphor persistence, it's no wonder that you've spent an inordinate amount of time making such measurements. And it's no wonder that you often came out from under your scope hood rubbing your eyes. Well, no more!

**Storage CRT With Unmatched 400 cm/ $\mu$ s Writing Speed.** Hewlett-Packard just made it possible for you to throw away your scope hood by developing a new bright, burn-resistant, high-speed, variable-persistence CRT—available in either 100 cm/ $\mu$ s or 400 cm/ $\mu$ s writing speeds. Placing these new CRT's into an all new mainframe that's optimized for high-writing-speed storage measurements, HP now gives you a new dimension in storage scopes—the HP 184A. This unique combination offers the highest writing speed available, and a display with brightness as great as you can find anywhere. For the first time you can find those elusive transients that before were too fast for your storage scope to follow—like nanosecond noise pulses.

**Display True Replicas of Your Waveforms.** You'll appreciate being able to adjust persistence down to 0.2 seconds; that's 75 times lower than a major competitive unit. For those measurements that require faster sweep times, you'll know you are displaying true replicas of your waveforms when you're using an HP 184A. Capture low duty-cycle pulse trains, through repetitive sweeps, simply by adjusting the persistence to

"maximum," to build up the intensity of dim traces. This feature in the new 184A oscilloscope lets you do many jobs you previously allocated to expensive, single-shot scope/camera systems.

**Variable-Persistence Storage and Standard in One Scope.** Further, you'll find that your 184A is a true general purpose scope that offers you the capability to choose, by way of plug-ins, all the functional features of the HP 180 Series of oscilloscopes, including such items as selectable-input impedance, and sampling to 18 GHz. And for simplicity of operation, we think you're in for a pleasant surprise when you compare the 184A against the competitive unit.

**Superior Technology.** HP believes the most important part of a scope system is the CRT—the interface between you and your measurement. As the pioneer in practical applications of dome-mesh magnification, HP was first to expand the size of high-frequency CRT's to 6 x 10 cm; first to 8 x 10 cm; and first to 10.4 x 13 cm—all in high-frequency mainframes. HP was also the first to use dome-mesh technology to substantially lower power requirements for CRT deflection (making possible the only line of 35 and 75 MHz portable scopes with built-in battery packs—scopes that really are portable).

**From The Storage Leader.** HP was first with variable-persistence mesh storage for commercial applications—to give you a stored trace many times brighter than bi-stable tubes, and without annoying flicker. Variable-persistence, with its ability to build up waveform brightness, was the first CRT innovation that gave you a trace bright enough to let you tackle most single-shot or low rep-rate measurements problems. All you do is adjust persistence until the integrating storage effect brings your waveform up to a bright, clear display.

**Burn-Resistant CRT's.** HP placed variable-persistence in many of its scopes including the 181A, 1702A, and 1703A storage units. And now HP has developed, for its current line of storage instruments, carefree CRT's so highly burn resistant they require little more care than conventional CRT's. The new 184A high-writing-speed scope also has unprecedented inherent resistance to burns.

**Yes, Scopes Are Changing.** How many times have you wished for a scope that could display a low rep-rate digital signal brightly and clearly, and one that could also be used for a variety of general purpose measurements. That scope is here now in HP's 184A storage mainframe, \$2200 (for only \$500 more, you can boost your 184A's writing speed to 400 cm/ $\mu$ s), with plug-in capability to 100 MHz real time, or 18 GHz sampling. Think twice; put away your scope viewing hood and call your local HP field engineer for a demo today. Or write for our "No Nonsense Guide to Oscilloscope Selection." It covers the other members of HP's variable-persistence storage scopes. Hewlett-Packard, Palo Alto, California 94304. In Europe: P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: YHP, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

**Scopes Are Changing;  
Think Twice.**

HEWLETT  PACKARD

OSCILLOSCOPE SYSTEMS

# Our Bill Stuart doesn't work for Power/Mate.



**He works only for you...  
and that's the way the new Power/Mate  
wants it.**

Bill is the Power/Mate Quality Assurance Manager and he has 34 supervisors and perfectionists under him.

They also work for you.

The result is unexcelled and consistent quality that we at Power/Mate are genuinely proud of.

Bill does a lot more than making sure our products are produced in accordance with his high standards of workmanship. (He wrote the book on that too.)

Bill has developed a series of courses for all our employees on soldering techniques and workmanship standards.

□ He has developed a computer failure analysis program to insure that our vendors also maintain the consistent high quality you should expect when you use our power supply in your product.

□ He oversees the continuing MTBF studies (by computer of course) and worst case calculations on all our power supplies to insure the long life and trouble free performance you should expect.

□ He has developed a thermally cycled burn-in rack in which we subject *all* of our power supplies for 24 hours before shipment to insure there are no premature field failures.

□ He oversees the random sampling of all production-run power supplies. These are subject to a continuous night and day life test . . . for your continued assurance of a long-lived trouble free product.

We could go on . . . but we at Power/Mate are glad he works for you. That's why we can give a five year no-holds warranty.



THE NEW

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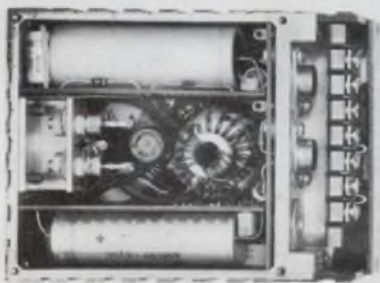
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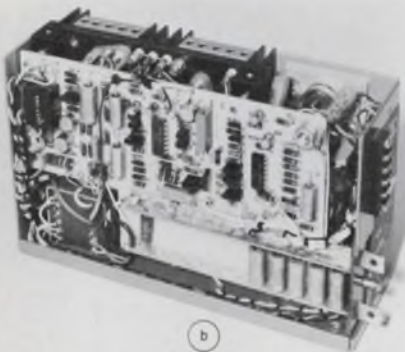
## across the desk

### Wrong picture and . . .

ELECTRONIC DESIGN apologizes for using the wrong photograph in the article, "Small, low-cost modular power supplies woo light-minded users," ED 15, July 20, 1972, p. 83. The article compared seven competing power supplies with a new 5-V, 12-A unit from Trio Labs. The photo, unfortunately, was not a shot of the Trio supply, but rather, one of a recent version of the RO Associates Model 210. The Trio supply (A) is shown here with the newest version of the RO unit (B), which now uses "throw-away" PC cards.



(a)



(b)

Two other points in the article were wrong or, at least, subject to dispute. The weight, taken from RO data, was given as 2.5 lb, but that's shipping weight. The actual weight is 2.1 lb.

Further, RO takes issue with

ED's published current rating at 5 V, of 8.7 A at 40-C ambient (derived from RO's derating data for no air or conductive cooling), insisting that the supply should be rated at 10 A with a heat sink. At 10 A and 2.1 lb, the unit has a power density of 24 W/lb, which is more dense than Trio's 18.5 W/lb (5 V, 12 A, 3.25 lb).

For more information:

From RO

CIRCLE NO. 356

From Trio

CIRCLE NO. 357

### Speedy technique stalled by errors

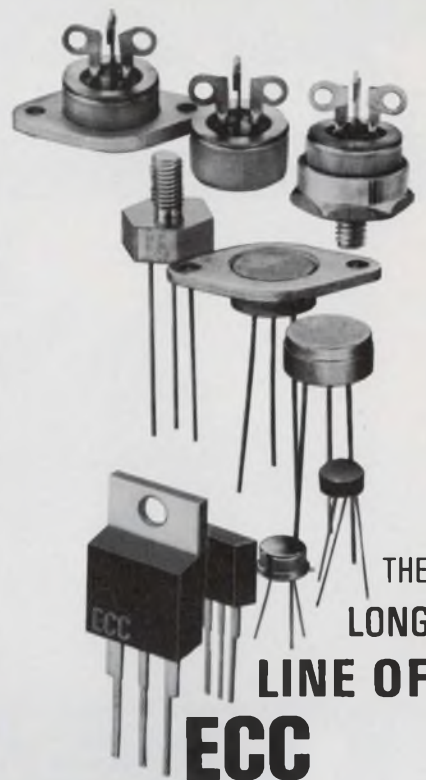
The article "Speed Computer-Aided Circuit Design," by R. D. Taylor, (ED 11, May 25, 1972, p. 54) proposes a computer technique as a design tool, but the references to the computer and computer program have completely obscured the proposed technique. I hope you will publish corrections to the article to clarify what appears to be a useful technique for minimizing a function.

What is an IBM S/360 501 computer? If it is a custom model perhaps the computer time could be compared with that of a more familiar model—such as the IBM 360 models 30, 50, or 65—to give some estimate of the time required on another computer.

Although the article states that little or no debugging would be required for such a program, the program listing in Fig. 3 contains at least two "bugs"—aside from being incomplete and evidently not the program to optimize the active-filter values, as claimed. The first WRITE statement will write com-

(continued on p. 10)

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.



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LONG  
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LOW AND HIGH CURRENT

**TRIACS**

World's leading  
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fast delivery,  
electrical isolation and  
a variety of packages.

#### LOW CURRENT TRIACS

THERMOTAB® and THERMOPAK\*; Swedge and TO-3; 3/8" Hex Stud, and TO-5 Metal and Plastic Packages

\*trademark of ECC

$I_{T(RMS)}$  0.8 - 16 amps

$I_{GT}$  1, 111 3, 10, 25, 50 ma max;  
with or w/o internal trigger

$I_{TSM}$  20 - 150 amps

$V_{DROM}$  200 - 800 volts

For more information, circle No. 238

#### HIGH CURRENT TRIACS

3/4" Press-Fit, Stud and TO-3 Packages

$I_{T(RMS)}$  25 - 40 amps

$I_{GT}$  1, 111 50 - 100 ma max

$I_{TSM}$  230 - 300 amps

$V_{DROM}$  200 - 800 volts min

For more information, circle No. 239

All packages are electrically isolated except TO-5 Metal Can. ECC triacs feature heavily glass passivated junctions for high reliability.

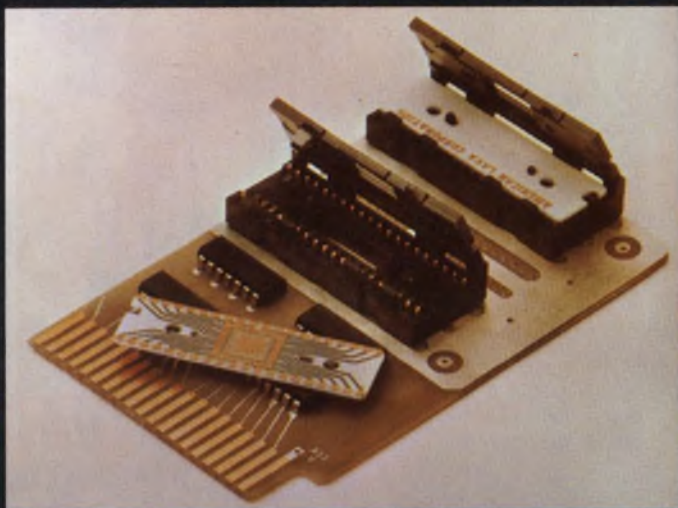
Contact your nearest ECC Sales Representative or Authorized Distributor for pricing and technical information.

**ECC**  
CORPORATION

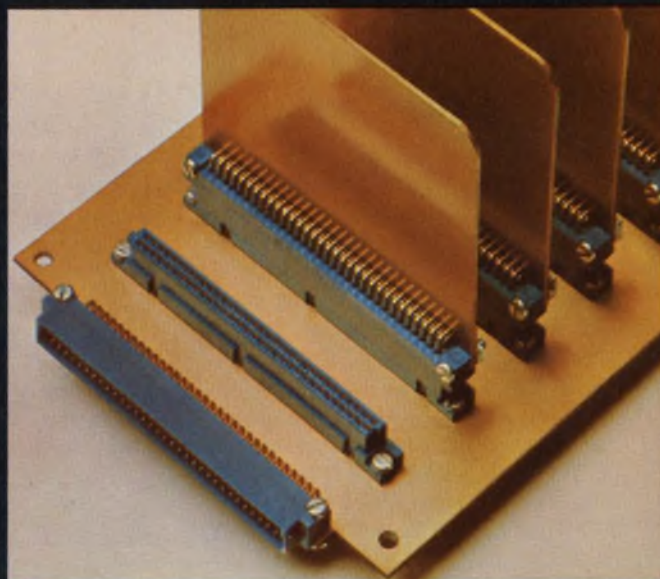
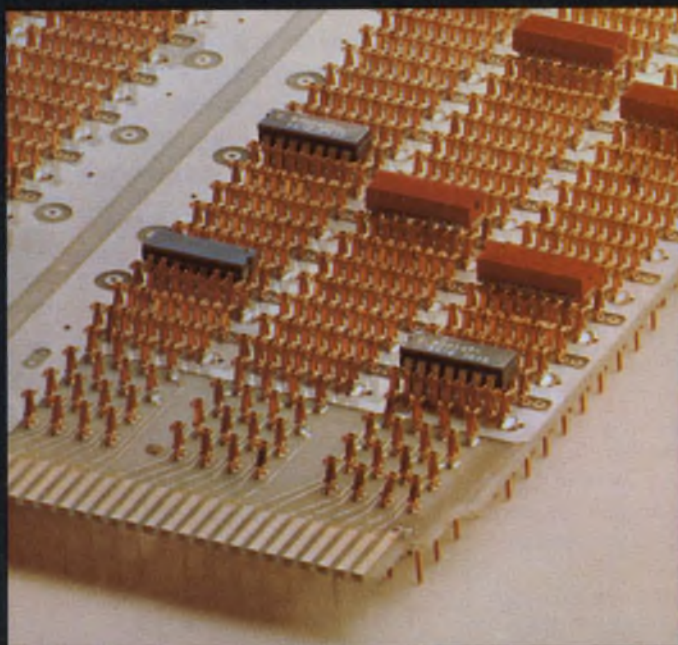
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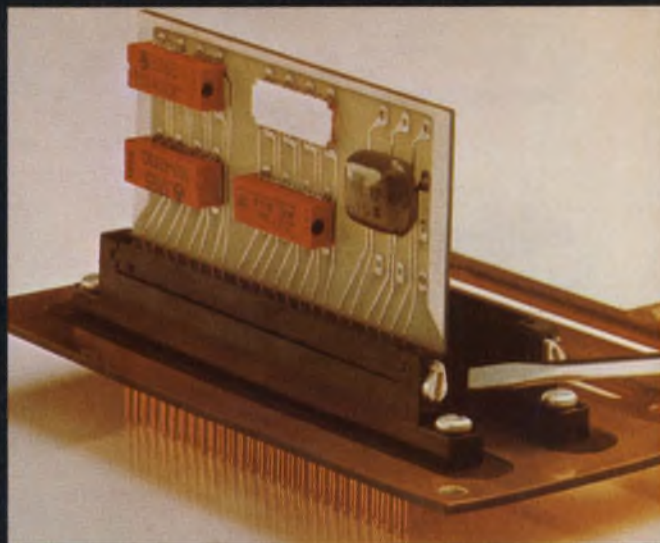
# New from Amphenol's Spectrum



**level 1** MOS/LSI Planar Plug-In connectors (above) for leadless, flat mount ceramic substrates. Permits fast, easy replacement of IC package, no screws, has snap-down lid. ■ Free-standing terminal (below) terminates IC's to PC boards for lowest total systems cost.



**level 2** Box contact connectors (above) intermate with .025" square or round contacts. Low insertion force. Terminations for crimp, wire wrapping or wave solder. ■ Zero insertion force connectors (below) improve PC board and connector life by eliminating strain and wear.



Above are seven new ideas from Amphenol Industrial Division's Spectrum of interconnection capability.

Amphenol's SPECTRUM offers you *all four* levels of interconnections from our unmatched breadth of product line:

**Level 1 . . . DEVICE TO BOARD OR CHASSIS.** We offer interconnections for components such as tubes, relays, transistors, IC packages, trimmers, resistors or capacitors to a PC board or chassis.

**Level 2 . . . BOARD TO MOTHERBOARD OR BACK PLANE.** We offer interconnections for PC boards or

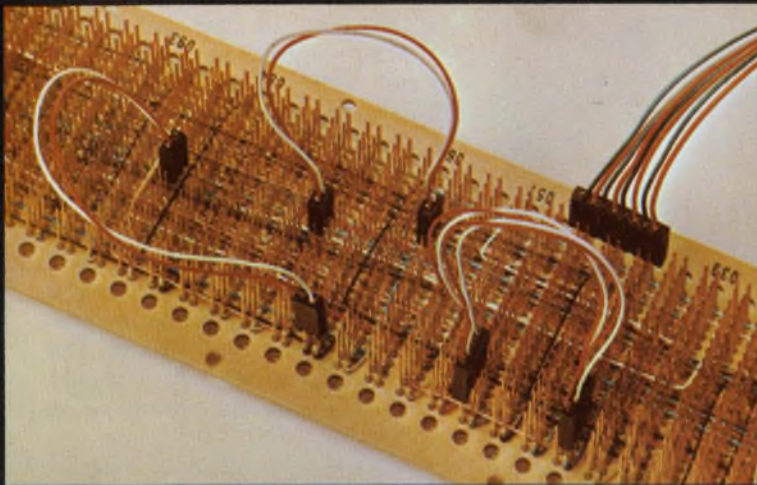
other sub-circuit modules to a motherboard or to a back plane.

**Level 3 . . . MOTHERBOARD OR BACK PLANE WIRING.** We offer interconnections for levels to each other and to other sub-circuits with multi-layer circuit boards, wire wrapping, clip terminations, jumper techniques and dip-soldering.

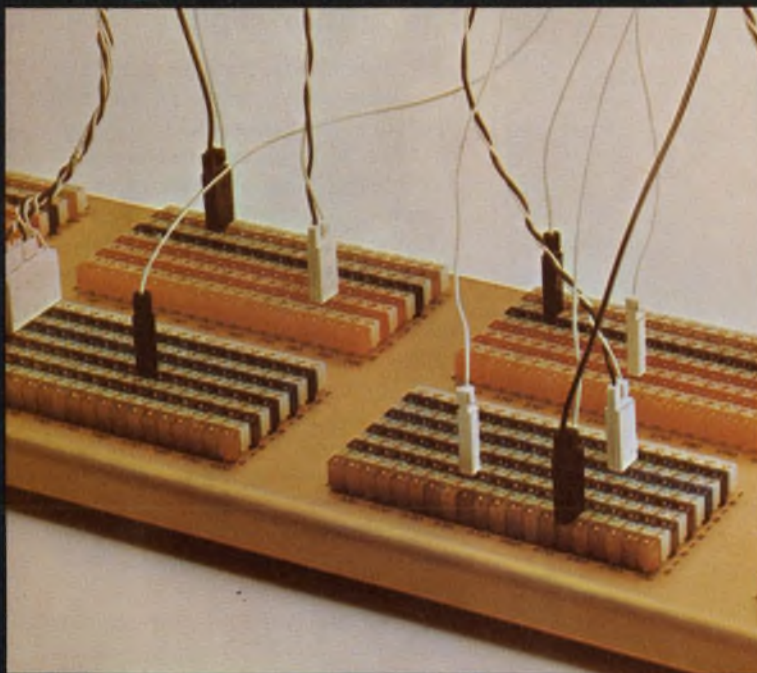
**Level 4 . . . INPUT/OUTPUT CONNECTIONS.** We offer interconnections for power and signals to and from a system. This interface may be between sub-assemblies within the same enclosure or between individual units.



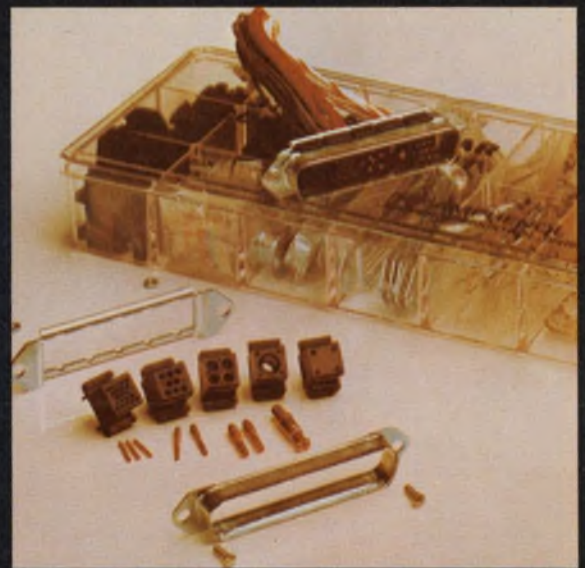
# of interconnections.



**level 3** Low cost strip connectors (above) are used as jumpers in back plane wiring. Interconnects with .025" square or round posts. ■ Circuit Concentration Bay (below) consists of wire wrappable panels that are five times as compact as the telephone distribution frames they replace.



**level 4** Modular Integral Connector concept lets you make your own pin & socket connector to fit your needs. Five contact sizes, thousands of combinations. Sufficient components for six connectors in handy MIC-KIT. Design and assemble your own prototypes.



From the simple tube socket—to a myriad of electrical/electronic connectors—to complete and complex termination systems . . . SPECTRUM.

But SPECTRUM is far more than products. It is a depth of capability in engineering, manufacturing and quality control. Amphenol's SPECTRUM is a new height of service, availability and distribution backed by seven Amphenol interconnection-oriented divisions.

Amphenol can fulfill your total interconnection requirements because we are not limited to specifics such as one or two product lines, one or two levels.

Therefore we approach your interconnection needs with complete open-mindedness.

For more new ideas and specific information, write for your copy of "SPECTRUM." Amphenol Industrial Division, Bunker Ramo Corp., 1830 South 54th Ave., Chicago, Illinois 60650.

**BUNKER  
RAMO**

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INFORMATION RETRIEVAL NUMBER 7



# The Word.

## On A/D and D/A Converters



**Yours FREE with this coupon.**

DDC—today's established leader in the field of advanced, high speed, analog-digital and digital-analog conversion—now brings you the latest word on the subject: our new 1973 *Selection and Evaluation Guide on A/D and D/A Converters*.

It covers not only state-of-the-art conversion devices that operate well up into the video frequency range, but also such supplementary modules as multiplexers, sample-and-hold units and signal conditioning devices. All are suitable for use in critical industrial, commercial, shipboard, aerospace and military ground support systems.

Your 1973 Guide comes with detailed technical application notes on Video Conversion Techniques, Fast Settling Amplifiers and Multiplying D-A converters, all prepared by recognized authorities in this field.



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CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_

ACROSS THE DESK  
(continued from p. 7)

puter garbage when executed the first time, for it is in the wrong place. Should it replace the CONTINUE of statement 1 perhaps? The "31E18" of the referenced FORMAT statement should be "3E18."

The program references to RANDU should be explained, since this is not a standard FORTRAN subroutine. I would assume that it is the program by that name in IBM publication H20-0205, "System/360 Scientific Subroutine Package." The listed computer program will not run without the RANDU subroutine, which should be defined for an understanding of variables IX, IY, AND A.

Dale L. Schafer  
Systems Analyst

Texas A & M University  
Texas Transportation Institute  
College Station, Tex. 77843

## The author replies

In response to Dale L. Schafer's letter and to the earlier letter from Kittredge D. Seely (ED 17, Aug. 17, 1972, p. 7) concerning my article "Speed Computer-Aided Circuit Design":

1. Because of a printer's error, the model number of the computer appeared as S/360-501 instead of S/360 501. But the comparative time estimates between the random-number method and Fletcher-Powell are still valid, no matter what machine is used.

2. Schafer is correct in saying that a format of 31E18.8 won't work. This was a typographical error on my part. The correct format is 3E18.8.

3. The first WRITE statement is incorrectly placed. It can precede statement 8, to prevent writing garbage the first time through the routine.

4. Statement 7 is the function to be minimized. This is not the sensitivity function of the active filter. Also, the two statements preceding statement 7 may or may not be desired, depending on how one wishes the minimization to proceed. Statement 7 is the location in this example of the function to be minimized. I

(continued on p. 13)



# If you think that one line of variable vacuum capacitors is just about the same as the next— you're right...

## ...except for three things.

1. *Amperex uses short duty cycle LONG LIFE BELLOWS—practically doubles the cycle-life of the capacitor.*
2. *Amperex SHOCK SUPPRESSING BRACE permits capacitor to withstand shock level of 150 G's at a pulse width of 11 milliseconds.*
3. *Amperex can supply EVERY CAPACITOR IN ITS LINE with a CERAMIC envelope, increasing the capacitor's temperature-handling range from 85°C to 125°C.*



Outside of longer cycle life, greater ability to withstand shock, and increased temperature-handling capacity, Amperex variable vacuum capacitors are probably no better and no worse than the competition's. They are competitively-priced and directly interchangeable with existing types, both electrically and physically. They are tested to exceed MIL standard 23183B specifications. And every capacitor shown in the Amperex catalog with a glass envelope is available on request in a ceramic version.

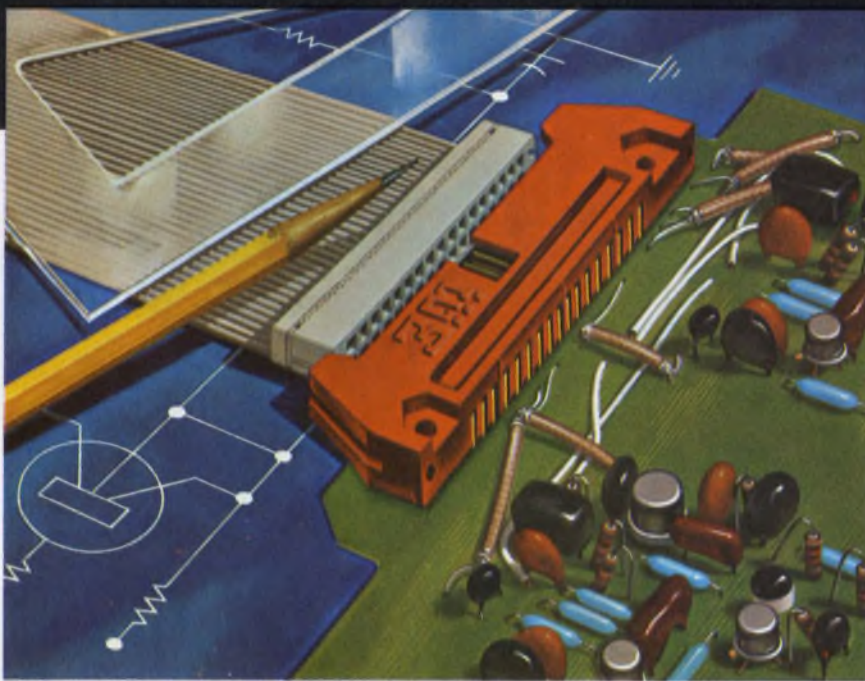
Application assistance on new or existing designs is available. For data, including complete replacement guide with prices, write: Amperex Electronic Corporation, Professional Tube Division, Hicksville, N.Y. 11802.

## Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS

Sold through  
North American Philips Electronic Component Corporation

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



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

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

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

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

costly assembly equipment is needed.

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

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

**3M**  
COMPANY

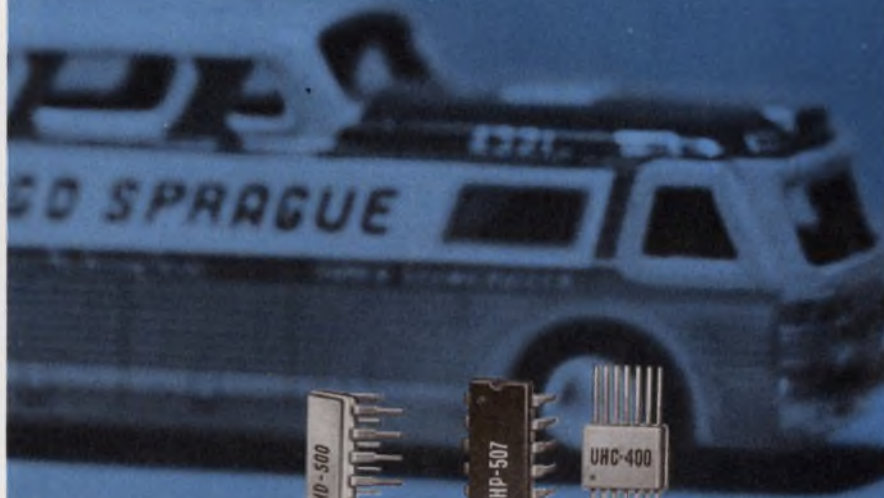


have used the program with the apparent corrections of Schafer and with various sensitivity functions to investigate cases for minimum sensitivity. The sensitivity function was not given in the article because of assumptions made to obtain it and because of its complexity. I did not feel this would have added to the article, which was trying to present an idea for general usage, not one particular example.

5. RANDU is a subroutine in the IBM Scientific Subroutine package. (The article stated that an IBM 360/50 was used.) IX and IY are used to generate a real number between 0 and 1 that is returned as A. The specifics of this routine or alternates must be explored for systems where the minimization routine is being programmed.

The program of Fig. 3 is intended to show that, for a minimum, one can set a function B3 to a very large number ( $B3 = 10^{**6}$ ), which would be much larger than the expected minimum. Then the random-number generator for the particular computer system employed is set up by initializing the routine ( $IX = 75773$ ). Following this, 500 passes are set up to choose variables ( $DO\ 8\ J = 1,500$ ). The next correct statement can be the format statement for three variables. Following this the random number is generated and set to A (CALL RANDU (IX, IY, A)). RANDU is re-initiated for the next use ( $IX = IY$ ). A variable of the function to be evaluated is set ( $A1 = 10*A$ ) to scaled random number. A similar process is used for A ( $A2 = 10*A$ ). Now the function is evaluated by an average of 10 passes of the function ( $X = X + 0.1$ ,  $B = f(X) + B$ .) The next step is to determine if the new value of B is less than the old one (previously  $B3 = 10^{**6}$ ); if it is, save this B and the variables of the function and write out these values. If this value of the function is not smaller, then continue and choose a new set. After the number of guesses is exhausted (in this case 500 passes), write the minimum of the function and the variables that yielded the minimum. Then stop the program. ■■

# Leave the driving to us!



## QUAD POWER DRIVERS

Quad power drivers from Sprague Electric, with more power dissipation than ever before; with breakdown voltages to 100 volts; and new low prices.

Unmatched reliability. Unique monolithic circuits incorporate both gates and high-current switching transistors. Available in plastic dual in-line packages as well as in hermetically-sealed DIPs and flat-packs. Compatible with DTL/TTL circuits.

**VERSATILE BUILDING BLOCKS.** For driving lamps, relays, solenoids, and other interfacing requirements, up to 1 Amp output current per package.

These drivers are now in quantity production, and are priced accordingly.

Series	Minimum Breakdown Voltage	Max. Output Current Sink Capability
500	100V	500 mA/output
400	40V	500 mA/output

48P-2109


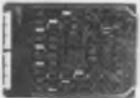
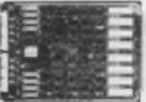








For Engineering Bulletin 29300, write or call the Semiconductor Division, Sprague Electric Co. Worcester, Mass. 01606. Tel. 617/853-5000.



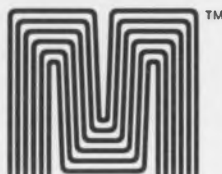
**DIGITAL INTERFACE PRODUCTS**

# Microdata moves into systems

Microdata, the company that made microprogramming irresistible, has moved into systems. We now offer all the modules, peripherals, software and application firmware you'll need to configure a high-performance system at a low price. Pick the items you need and add up their costs. Then compare the total with anything you get from our competition. You'll see what we mean.

<b>System Computers</b> 	<p><b>Series 1600 Computers</b>—CPU with power fail/auto restart, ROM control memory, real time clock, tele-type controller, power supply, card cage and system control panel. Typically, \$4,000</p> <p><b>Model 2208 Magnetic Core Memory</b>—8,192 byte, 8-bit module (up to 8 modules per computer) \$1,600</p>	
<b>Utility Interfaces</b> 	<p><b>Model 2510 Byte I/O Controller</b>—provides independent input and output controllers each with 8-bit data transfers. \$800</p> <p><b>Model 2511 Full Word I/O Interface</b>—provides 32 input lines and 32 output lines with data transfers under program control. \$700</p> <p><b>Model 2512 Priority Interrupt Board</b>—provides 8 levels of priority interrupt with individual arm/disarm. \$550</p> <p><b>Model 2513 Selector Channel</b>—operates by way of direct memory access, accommodates up to four I/O devices. \$850</p>	
<b>Communications Interfaces</b> 	<p><b>Model 2601 Synchronous Modem Interface</b>—has auto call/answer unit, accommodates standard rates up to 9600 baud. \$1,200</p> <p><b>Model 2610 Asynchronous Communications Controller</b>—single channel, full duplex, programmable baud rates to 9600 baud. \$500</p> <p><b>Model 2612 Asynchronous Communications Controller</b>—provides simultaneous operation of 8 full duplex asynchronous channels. \$1,600</p> <p><b>Model 2613 Asynchronous Modem Interface</b>—provides simultaneous operation of 8 full duplex 103 and 202 type data sets. \$2,000</p> <p><b>Model 2620 Modem/Communications Control</b>—provides 16 discrete inputs and 16 discrete outputs. \$800</p> <p><b>Model 2630 Automatic Call Unit Controller</b>—provides control function for four Bell Model 801 automatic call units. \$950</p>	
<b>Peripheral Systems</b>        	<p><b>Model 2710 Paper Tape System</b>—300 cps fanfold 8-channel reader, 75 cps fanfold 8-channel punch. \$3,955</p> <p><b>Model 2720 Card Reader</b>—300 cpm, 80 column cards. \$3,750</p> <p><b>Model 2731 Line Printer</b>—80 column, 64 character set, 358 lpm. \$9,750</p> <p><b>Model 2732 Line Printer</b>—132 column, 64 character set, 245 lpm. \$12,500</p> <p><b>Model 2810 Magnetic Tape System</b>—with one 7", 9 track, 800 bpi, 10,000 bytes/second transport and controller for up to four transports. \$4,830</p> <p><b>Model 2811 Magnetic Tape System</b>—with one 7", 9 track, 800 bpi, 20,000 bytes/second transport and controller for up to four transports. \$4,760</p> <p><b>Model 2820 Magnetic Tape Transport</b>—7" reel, 12.5 ips, 9 track, 800 bpi. \$2,830</p> <p><b>Model 2821 Magnetic Tape Transport</b>—7" reel, 25 ips, 9 track, 800 bpi. \$2,960</p> <p><b>Model 2822 Magnetic Tape Transport</b>—8½" reel, 12.5 ips, 9 track, 800 bpi. \$2,690</p> <p><b>Model 2823 Magnetic Tape Transport</b>—8½" reel, 25 ips, 9 track, 800 bpi. \$3,020</p> <p><b>Model 2851 Disc System</b>—includes disc drive with moving head removable cartridge, 2.4 million bytes, 75 ms random access, 200 kb transfer rate. \$11,730</p> <p><b>Model 2852 Disc System</b>—includes disc drive with moving head (one fixed and one removable), 4.9 million bytes, 95 ms random access, 200 kb transfer rate. \$12,750</p>	
		<b>TOTAL \$</b>

**with top performance and the right price**



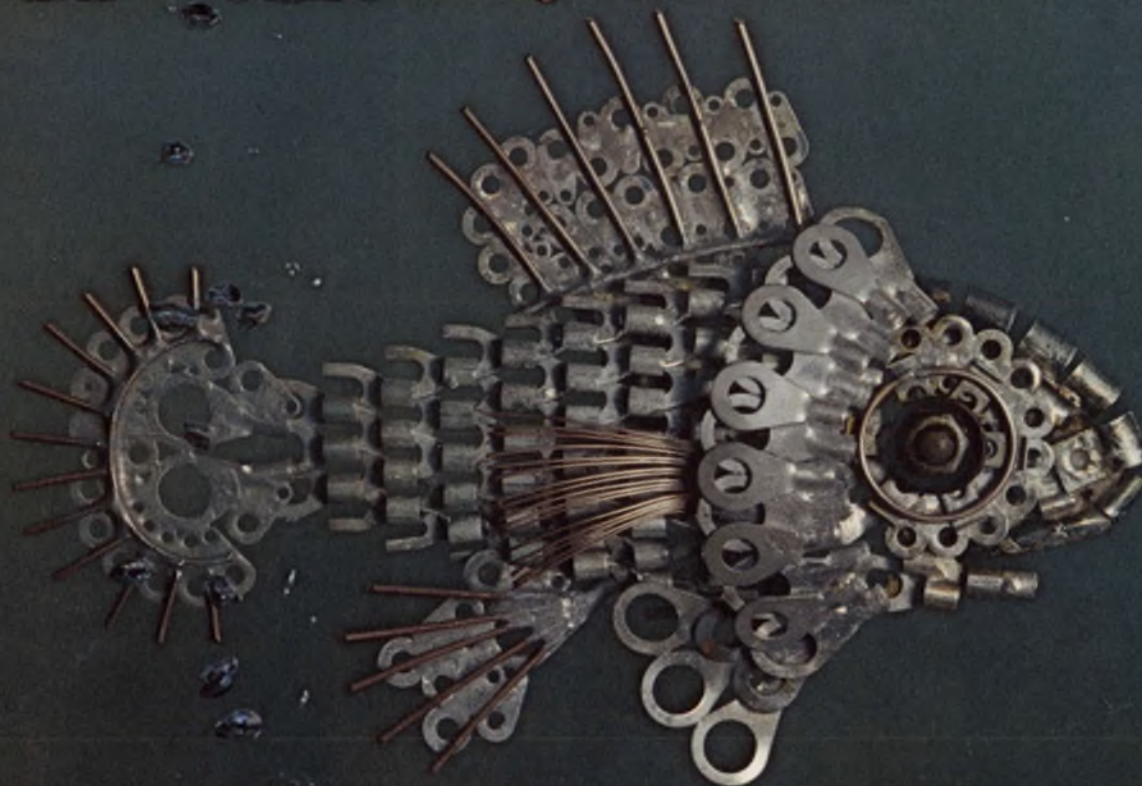
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# Rust. Corrosion. Galvanic coupling. Why tolerate them? Eliminate corrosion indefinitely with Dow Corning silicone dielectrics.

The fish, shown here in a tank of water, has since spent over 312 hours in a salt-fog chamber under accelerated aging test ASTM B117-64. Parts coated with Dow Corning® 6 Compound show no signs of corrosion.



Now you can inhibit corrosion for up to 20 or 30 years or more with Dow Corning® dielectric compounds. We offer a wide range to solve virtually all corrosion and moisture problems found in electrical and electronic equipment.

For example, Dow Corning 2 compound is especially formulated to protect copper conductors and device leads. Our 6 compound inhibits rusting of iron and steel. Number

19 compound prevents galvanic corrosion of electrical connectors, particularly aluminum-to-copper and steel-to-aluminum. All three greaselike compounds have excellent dielectric properties, are water repellent, resist drying out in service, retain protective properties from -40 to 400 F.

For tougher moisture and water problems, our dielectric sealing compounds protect better, longer, than any other sealing materials. Our 4 compound is particularly effective

on ignition systems, disconnects, electronic assemblies, electrical terminals. Number 11 compound seals vacuum and pressure systems, transformers, sonar systems.

Take your first step now, to the prevention of corrosion. Write for full product information. Dow Corning Corporation, Dept. A-2308, Midland, Michigan 48640.

*Dielectric compounds from*

**DOW CORNING**

DOW CORNING

# Sometimes magnet specs are pushed to the limit. Here's a new limit.

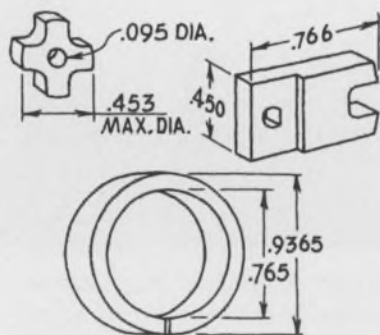
## Sintered Alnico

When your magnet requirements include high coercive force, intricate shapes, and close tolerances, sintered Alnico 8HE and 8H now provide a wider range of parameters to choose from. Coercive force 1800 Oersted and higher. Tolerances within 0.005 in.

The powdered metal process has been expanded through new manufacturing technology at Indiana General to give you the advantages of all six sintered Alnico materials in a wider range of sizes and configurations. You can now get high resistance to demagnetization and the lowest temperature coefficient of any magnet material in magnets to one-fourth pound.

## Intricate shapes

Higher consistency and homogeneity of the sintered process result in finished magnets with extremely close tolerances, smooth surfaces and high physical strength.

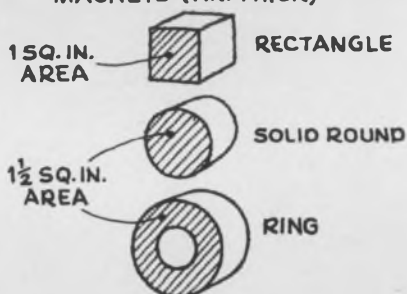


Intricate configurations such as these are typical of the many shapes produced through Indiana General's sintering facility. Precise tolerance and superior finish can eliminate grinding operations to lower your magnet cost in many applications.

## Now—larger sizes

Our expanded sintering capability now offers you production magnets in the size ranges shown below.

### MAXIMUM SIZES FOR PRODUCTION MAGNETS (1 IN. THICK)



A wide variety of configurations within these parameters of area and length are available to meet your production requirements.

For applications involving larger sizes, special manufacturing processes are employed. Sintered magnets up to *four inches* in surface area are being produced at Indiana General. Please contact us for specific recommendation.

## High residual induction— high coercive force

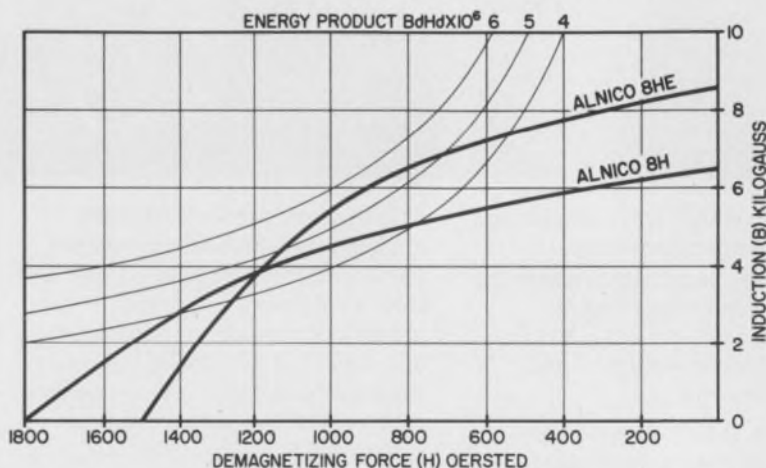
Alnico 8HE gives you highest residual induction (8,600 Gauss) and should be selected when the magnet material operates at the knee of the B/H curve (maximum energy) or above.

Alnico 8H has the highest coercive force (typically 1800 Oersted) and should be selected when the magnet material operates below the knee or near the coercive force of the material.

## Get complete specs

Our new *Magnet Materials Manual* number 34 covers the complete family of sintered Alnico materials — 2, 4, 5, 6, 8HE and 8H. Magnetic and material characteristics, demagnetization curves and tolerances are shown for each Alnico grade.

For your copy of this comprehensive guide to the latest in metal magnet technology, just contact: Indiana General, Magnet Products, Valparaiso, Indiana 46383. Phone (219) 462-3131.



**indiana general** 

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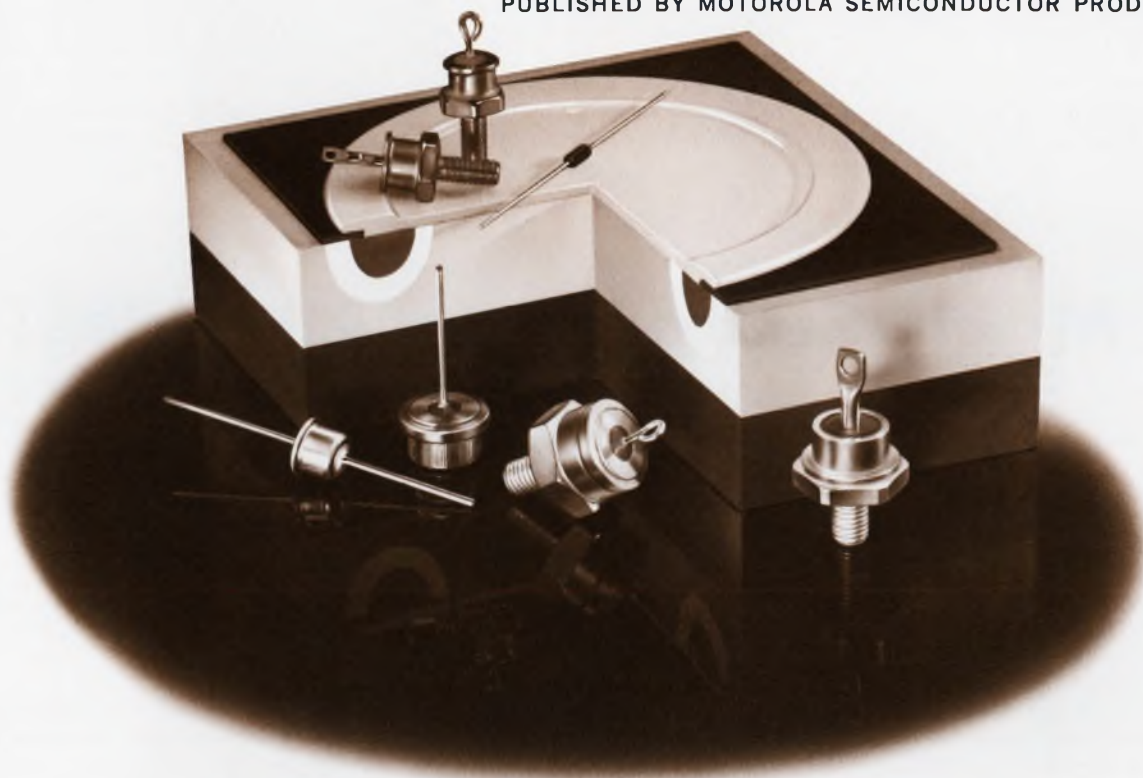
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3014



# SEMICONDUCTOR NEWSBRIEFS

PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.



## Schottky Barrier Rectifiers Break Through To 40 V, 40 A

In 1970, Motorola technology brought you the first Schottky barrier rectifiers — with a peak inverse voltage rating of 20. In 1972, Motorola technology breaks through again — with the first 40 volt devices in the industry. Now you can get 12 new Schottkys ranging from 5 to 40 amperes in 20 V, 30 V, or 40 V PIV. And they're all JEDEC registered!!

Motorola Schottky technology uses majority carrier operation to do away with stored charge resulting in reverse recovery times that are virtually unmeasurable. Operation continues well up into the megahertz range.

Motorola Schottky technology uses epitaxial construction, oxide passivation

and very closely controlled metal overlay contacts to produce surge capacity 3 to 5 times greater and forward voltage less than half that of conventional silicon power rectifiers.

When you use Motorola Schottky technology, you get:

- Rectification efficiency flat to beyond 100 kHz — perfect for high-efficiency switching power supplies.
- Power loss 50% less than with conventional power rectifier diodes. You use smaller heatsinks and transformers. Save space, weight.

Even when compared with existing Schottkys, Motorola technology comes through. The new Schottkys feature

much lower leakage and transient voltage sensitivity, greater temperature stability and a higher operating junction temperature range to +125°C.

The new Schottkys are supplied in 4 current ratings, each in the 3 voltages — 20 V, 30 V, and 40 V. 1N5823, 4, 5 are 5 A versions in a metal axial lead case; 1N5826, 7, 8 are 15 A, DO-4 stud devices; 1N5829, 30, 31 are 25A, DO-4 stud cased devices; and 1N5832, 3, 4 are 40 A, DO-5 versions. And Motorola Schottkys will soon be available in plastic.

Let Motorola Schottky technology rectify your situation. See your Motorola salesman for evaluation samples and information.

*For details, circle 211*





## Where Op Amps Go, $\pm 15$ V Regulator Follows

Mary had her little lamb, and now linear system designers have the MC-1568. For, everywhere their op amps go this dual  $\pm 15$  V tracking regulator is sure to follow.

Both the MC1468 version and the full MIL temperature range MC1568 represent the best value/price-performance combination available in dual polarity tracking regulators. In addition to the standard metal and dual in-line ceramics, Motorola offers the "R" metal power

package. Its 2.4 W power dissipation permits full use of the MC1568's 100 mA load current capability when running at higher voltages. And the MC1568 can handle input voltages up to  $\pm 30$  V.

Other important features of the MC-1568 regulator are excellent tracking with output voltages balanced to  $\pm 1\%$ , and output voltage temperature stability assured to a maximum 1%.

Outputs are pre-set internally to  $\pm 15$  V with initial tolerance of 0.2 V (max)

at currents up to 100 mA. When desired, a simple external adjustment is all that's needed to change them. Line and load regulation are 0.6%.

Prices are amazingly low for devices of this sophistication. The MC1468G is a mere \$2.80, the L version only \$2.90, and the R a modest \$3.75. MC1568G, L, and R range from \$6.25 to only \$7.00. Give a little lamb a place to go. Contact your Motorola distributor or sales office.

For details, circle 212

## McMOS Grows On All Sides!

McMOS is the name, growth is the game. We've regularly recited the complementary MOS litany for more than a year: CMOS is the new logic for low power systems . . . CMOS is the new logic for noisy control systems . . . CMOS is the new logic for battery operated and battery back-up remote systems . . . And it's true. McMOS is the low power logic of the seventies.

And before you can say "Leading Edge Of Digital Technology," CMOS will present to designers like you a full range of system optimized functions on a broad scale providing a combination of benefits other digital technologies can't. No complementary MOS line has met this need completely. But McMOS is stretching . . . maturing . . . growing fast! And growth has already led to new lower pricing, too.

Twenty-nine new MSI and simpler functions were introduced from the first of the year through September. The result is an effective combination of the most popular second-source devices with carefully-designed, original Motorola functions filling in the gaps.

Benefits are as great as they have been from the beginning! And prices are even better.

- Lowest quiescent power dissipation . . . 10 nW per gate.
- Top noise immunity — 45% of  $V_{DD}$  (typ).
- Single supply operation — plus or minus — over a 3 to 18 V power supply range.

- Simple digital interfacing.
- Choice of standard mil operating temperature range:  $-55^\circ$  to  $+125^\circ\text{C}$  or unusually wide commercial temperature range:  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ .
- And more!

All types listed are available now.

### EXPANDING McMOS FAMILY

These recent introductions have been added to the 20 devices previously available in the continuously expanding McMOS low power logic family. New low prices are available on McMOS logic, too, with some devices reduced more than one third.

Motorola Device #	Function	Replaces Pin-for-Pin	Price (100-999)
MC14000AL/CL	Dual 3-Input NOR Plus Inverter	CD4000AD/AE	3.10/0.78
MC14006AL/CL	18-Bit Shift Register	CD4006AD/AE	9.10/3.89
MC14007AL/CL	Dual Pair and Inverter	CD4007AD/AE	2.65/0.78
MC14008AL/CL	4-Bit Full Adder	CD4008AD/AE	10.15/4.02
MC14009AL/CL	Hex Inverter/Buffer	CD4009AD/AE	5.25/1.69
MC14010AL/CL	Hex Inverter	CD4010AD/AE	5.25/1.69
MC14016AL/CL	Quad Analog Switch/Quad Multiplexer	CD4016AD/AE	5.15/1.62
MC14023AL/CL	Triple-3 NAND Gate	CD4023AD/AE	3.40/0.78
MC14028AL/CL	BCD Decimal Decoder	CD4028AD/AE	7.92/3.67
MC14032AL/CL	Triple Full Adder (pos)	CD4032AD/AE	6.91/4.24
MC14038AL/CL	Triple Full Adder (neg)	CD4038AD/AE	6.91/4.24
MC14040AL/CL	12 Stage Binary Counter	CD4040AD/AE	10.20/5.40
MC14506AL/CL	Expandable A.O.I.	—	4.64/2.24
MC14516AL/CL	Binary Up/Down Counter	—	11.47/6.35
MC14522AL/CL	Programmable BCD Divide-by-N 4-Bit Counter	—	11.85/6.60
MC14526AL/CL	Programmable Binary Divide-by-N 4-Bit Counter	—	11.85/6.60
MC14527AL/CL	BCD Rate Multiplier	—	11.85/6.60

For details, circle 213

SEMICONDUCTOR  
newsbriefs

No. 15-72

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# Twelve MTTL Complex Functions Increase Your Design Options

Reduce package count, increase logic per function with 12 new MTTL building blocks — four data selectors, three counters, two shift registers, a bus transfer switch, encoder, and decoder.

Ideal for data-routing and multiplexing, the MC54150/74150 16-channel data selector generates any five-variable Boolean function. And for multiple data in and/or multiple data out jobs use the MC54460/74460 bus transfer switch.

Looking for 4-bit storage? The MC8280/7280 4-bit shift registers can divide decade or binary (MC8281/7281) or act as storage registers. The MC8280/7280 is sectioned into divide-by-two and divide-by-five functions (decade) while the MC8281/7281 is sectioned into divide-by-two and divide-by-eight functions (binary).

Decoding is simple with the MC9307/8307 BCD-to-seven segment decoder. It accepts a 4-bit BCD 8421 code input producing outputs for seven-segment displays. The MC9318/8318 8-input priority encoder converts a one-of-eight code to a 3-bit binary code in order of priority, with  $\bar{D}$  assigned the highest priority.

Input/output conversions are prime applications for the MC8270/7270 and

MC8271/7271 4-bit shift registers. And the MC9306/8306 presettable decade up/down counter offers four synchronously driven master-slave J-K flip-flops.

All are exact replacements — pin and function — for older designs and are available in limited and full temperature ranges. Call for evaluation units today.

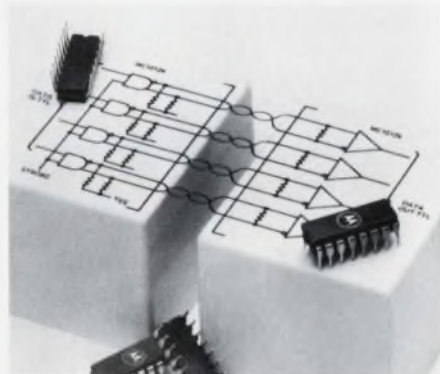
TYPE NO.	FUNCTION	PRICES (100-UP)
MC54150L MC74150L,P	16-Channel Data Selector	\$9.70 6.45(L)/4.30(P)
MC54151L MC74151L,P	8-Channel Data Selector	\$9.00 6.00(L)/3.45(P)
MC54460F,L MC74460F,L,P	Bus Transfer Switch	\$8.05(F,L) 4.10(F,L)/3.15(P)
MC8266F,L MC7266F,L,P	2-Input, 4-Bit Data Selector	\$6.08(F,L) 4.05(F,L)/2.70(P)
MC8267F,L MC7267F,L,P	2-Input, 4-Bit Data Selector (Open Collector)	\$6.08(F,L) 4.05(F,L)/2.70(P)
MC8270F,L MC7270F,L,P	4-Bit Shift Register	\$6.42(F,L) 4.28(F,L)/2.85(P)
MC8271F,L MC7271F,L,P	4-Bit Shift Register	\$6.42(F,L) 4.28(F,L)/2.85(P)
MC8280F,L MC7280F,L,P	Presettable Decade Counter	\$5.40(F,L) 3.60(F,L)/2.40(P)
MC8281F,L MC7281F,L,P	Presettable Binary Counter	\$5.40(F,L) 3.60(F,L)/2.40(P)
MC9306L MC8306L,P	Presettable Decade Up/Down Counter	\$11.55 7.70(L)/5.15(P)
MC9307F,L MC8307F,L,P	BCD To Seven Segment Decoder	\$7.88(F,L) 5.25(F,L)/3.50(P)
MC9318F,L MC8318F,L,P	8-Input Priority Encoder	\$12.00(F,L) 6.00(F,L)/4.20(P)

F Suffix = Ceramic Flat Pack  
L Suffix = Ceramic Dual In-Line Pkg.  
P Suffix = Plastic Dual In-Line Pkg.

For details, circle 214

## MECL 10,000 Translators And Multiplexer/Latches Now Available

Mate low speed TTL sections with high speed ECL systems easier with the MC10124 MTTL to MECL translator



MECL 10,000 translators can materially improve data transmission within a TTL system.

and the MC10125 MECL to MTTL translator.

The MC10124 is a quad translator having TTL compatible inputs and

MECL complementary open-emitter outputs that allow its use as an inverting/non-inverting translator or as a differential line driver. Typical prop delay is 5.0 ns. MC10124 can drive 50 ohm lines with high fanout capability.

MC10125 is a quad translator incorporating differential inputs and Schottky TTL "Totem Pole" outputs. Differential inputs allow its use as an inverting/non-inverting translator or as a differential line receiver. And a  $V_{IH}$  reference voltage is available for Schmitt trigger applications.

The translators can also improve data transmission between TTL equipments. In the illustration, the complementary outputs of the MC10124 drive a twisted pair data line connected to the differential receiver inputs of the 10125. This application provides a toggle rate typically in excess of 75 MHz, excellent noise rejection, and the quad translators offer minimum package count over conven-

tional duals.

Two new multiplexer/latches are ideal for application in high speed central processors, register files, instrumentation, and high speed digital communication systems. The MC10132 dual multiplexer with latch and common reset provides a common select input for both latches. Information selected at the input is latched on the rising edge of the clock pulse. The common reset input is used to reset the latches.

The MC10134 offers two latches with separate select inputs for each of the two pairs of data inputs. Each select input determines the information that will be provided to the appropriate latch.

All four devices are available in the 16-pin dual in-line ceramic package (L). 100-up prices are: MC10124L — \$4.50; MC10125L — \$4.50; MC10132L — \$5.02; MC10134L — \$5.02.

Evaluate these new additions to the expanding MECL 10,000 line.

For details, circle 215





## First Plastic Power Darlington's Registered

Here they are! — the first 2N-registered plastic power Darlington's with super-high gain, voltage and current for those super-low-priced series regulators, hammer drivers and general-purpose amplifiers.

They're the 2N6040 series of 5 and 8 A THERMOPAD devices in two optimum plastic packages. And they're complementary, too, for your transformerless, direct-coupled designs.

Gain? Much! 2,500  $h_{FE}$  typically at 4 amperes with 1,000 minimum spec'd. Lets you go from milliamperes to amperes directly, compatibly and easily with T<sup>2</sup>L-to-Darlington hookups. No bother with interface componentry.

Voltage? High! Up to 100 V sustaining capability for your more demanding

designs. Safe operating area is excellent with all types providing 1.5 A @ 40 V SOA. On the other end of the scale, a low, low, 2V maximum saturation voltage ensures minimum power loss.

Packaging? Optional! Your choice of the ever-popular, THERMOPAD case 90 with all the traditional, high-efficiency, compact mounting advantages or the newer, easy-mounting THERMOPAD case 199 offering more power-handling, more lead forms, more chip sizes, and more technology than TO-220 parts.

Other advantages include 60 and 80 V ratings, monolithic construction with emitter-base resistors on the one chip, and low price tags. To prove the last, the 2N6043 is only \$1.64, 100-up. Not only

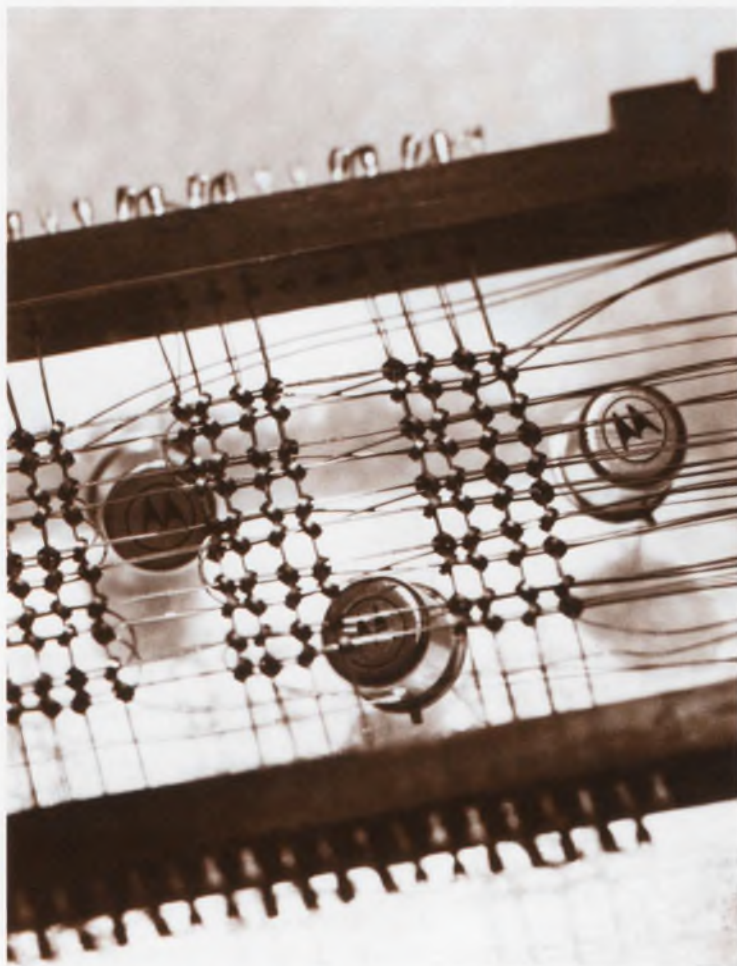
better-than-discrete performance, but better in price, too!

Check the specs . . . then see your distributor about evaluation units.

		1-99	100-999
Case 90/199	2N6040/MJE6040	\$3.05	\$2.31
	2N6041/MJE6041	3.33	2.52
	8 A 2N6042/MJE6042	3.83	2.90
	60-100 V 2N6043/MJE6043	2.14	1.64
	NPN/PNP 2N6044/MJE6044	2.37	1.83
	2N6045/MJE6045	2.77	2.14
Case 90/199	MJE1090/2090	2.70	2.05
	MJE1091/2091	2.90	2.23
	5 A MJE1092/2092	3.10	2.40
	60-80 V MJE1093/2093	3.50	2.65
	NPN/PNP MJE1100/2100	1.82	1.40
	MJE1101/2101	1.99	1.53
	MJE1102/2102	2.21	1.70
	MJE1103/2103	2.44	1.88

For details, circle 216

## 2N3725 Joins The Motorola Core Corps



Whether your frames are large or small, Motorola's 2N3725 gets to the core of the induction problem by providing a 50 volt  $BV_{CEO}$ .

Here's a new recruit to help you restore core to its rightful place in the store war. After a short campaign as a house quad in the dual in-line ceramic case, the NPN silicon Annular memory driver transistor that offers the best trade-off between high breakdown voltage and fast switching is here fully armed and JEDEC registered as the 2N3725.

The high  $f_T$  and low  $C_{ob}$  of the 2N3725 assure fast switching (at 500 mA,  $t_r$  is typically 18 ns,  $t_f$  is 15 ns) yet  $BV_{CEO}$  is a high 50 V minimum to prevent problems from the "kickback voltages" induced by switching highly inductive lines. And Motorola's 2N3725 is the first to offer the JEDEC-required 500 mA  $V_{BE(sat)}$  of 0.8 to 1.1 V.

Whether your application is voltage or current driving or both, 2N3725 has the gain,  $h_{FE}$  is 35 (min) at 500 mA. And the popular driver is supplied in the TO-39 outline package with untwisted 1/2" leads for quick, easy assembly into your systems.

Look for the core corps to grow into a driving army. 2N3725 is just the latest recruit. More enlistments announced this fall.

See your nearest Motorola salesman for more information on the 2N3725. And don't let its 100-up price of 75¢ change your battle plans — we're competitive.

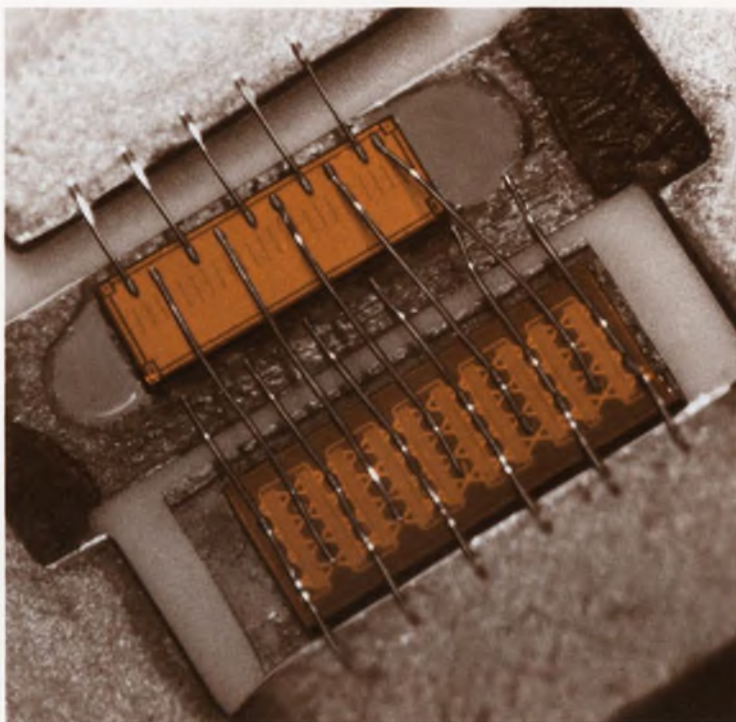
Up your esprit de core. Think 2N3725!!

For details, circle 217





Controlled-Q RF transistors employ MOS capacitor chips to transform base impedance and improve broadband performance.



## RF Technology Controls Q For Broadband Performance

Brilliant new lights in the RF spectrum — the new MRF618 and MRF620 NPN silicon RF power transistors for large signal applications to 520 MHz in frequency-modulated industrial/commercial equipment. They're operated by 12.5 V supplies.

And, they have Controlled-Q! Latest evolutionary highlight in the Motorola-developed Stripline-Opposed-Emitter configuration, Controlled-Q devices employ internal impedance-transforming techniques to lower Q at the base aiding broadband designs. An MOS

*For details, circle 218*

capacitor chip is connected in a T-network with internal and external lead inductances to transform the typical 0.5 ohm input impedance to 4 ohms at 470 MHz. Broadband performance is improved, input matching network problems reduced. And the flange-mounted, Controlled-Q package permits easy, one-sided assembly into your amplifiers.

Characterization provides series-equivalent, large signal parameters. Major specs are: With a 12.5 V supply, MRF620 offers 40 W at 470 MHz, 4.3 dB minimum common-emitter gain. Collector efficiency is 55%. Under the same conditions, MRF618 provides 15 W, 6.0 dB minimum gain and collector efficiency of 60%.

Rugged? . . . MR620 and MR618's Isothermal chips utilize nichrome-resistor emitter ballasting techniques for load mis-match protection. Isothermal design decreases emitter current under load mismatch conditions and compensates for variations in local temperatures over the chip. They're tested for a 20:1 VSWR at all phase angles at rated output power. So you know they'll last and *last!*

To focus on the potential performance of an amplifier built using MRF618, we did just that, built a broadband amplifier using 2N5944/MRF618. Testing showed that with 120 mW in, the 11 W output was flat from 410 to 510 MHz. VSWR was less than 1.5:1 across that band.

Try MRF620 or 618 in your amplifier. They're on your distributor's shelf today at the 25-99 price of \$40.00 (620) and \$21.00 (618). But wear your sunglasses.

## Hybrid IC Line Fattened By Five Fet Analog Switches

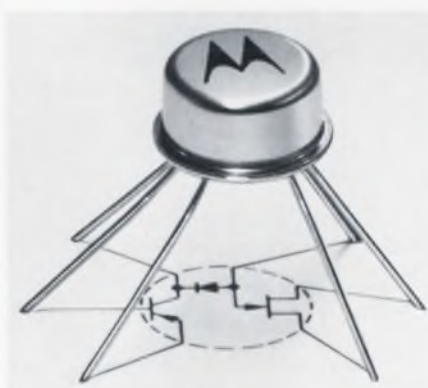
Five new analog switches — the MCH2222-1,2 and MCH2223,1,2,3 — are now offered as standard off-the-shelf functions.

The hybrid ICs feature as low as 10 ohms (max) drain-source "ON" resistance at 1.0 mA and a signal handling capacity up to 20 volts peak-to-peak.

Minimum signal error is assured by zero intrinsic offset voltage and outstanding logic noise isolation.

They're designed for switching applications in A/D and D/A converters, sample and hold circuits, and track and hold circuits for instrumentation and in modulators and demodulators for communications equipment.

Both the MCH2222 and MCH2223



Separate FET, transistor and diode chips on a common substrate are wire-bond connected in the MCH2222/23 series of Fet Analog Switches.

*For details, circle 219*

series have other important applications in solid state relays, commutators, gain changers and in general-purpose low-level switching. Their low static drain-source "ON" resistance capability offers designers minimum voltage loss and they have a nimble 300 ns typical turn-on and turn-off switching time.

Available in 6-leaded TO-5 metal cans, and are mechanical pin-for-pin replacements for competitive devices.

Warehouse shelves are now well-stocked with devices carrying the following 100-up price tags:

MCH2222-1: \$5.60 and MCH2222-2: \$6.00; MCH2223-1: \$10.00; MCH2223-2: \$15.00 and MCH2223-3: \$21.50.





## MLM 101A OP AMP SERIES

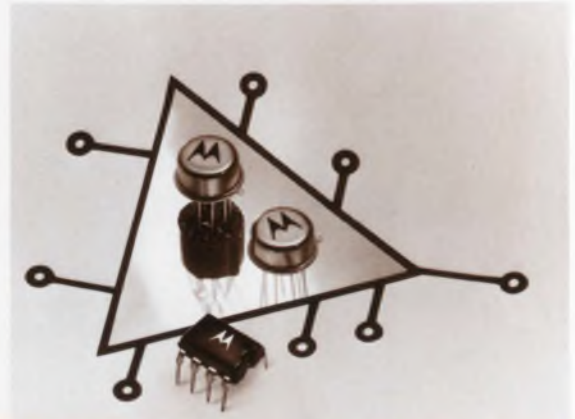
### — Leads Growing Linear Second Source Availability

Two op amps and a negative voltage regulator expand Motorola's linear second source offerings. Heading the new intros are the MLM101A series, pin-for-pin equivalents to the popular general purpose LM101A series op amps.

MLM210G and MLM310G are direct replacements for the LM210 and LM310 op amp/voltage followers, and the MLM104G series negative regulators directly replace the LM104 types. These three introductions join the MLM105G series positive regulators, MLM107G series internally-compensated op amps, and the fixed 5.0 V MLM109K regulators, bringing to six the number of LM device series made available by Motorola in recent months. All are supplied in standard metal packages, and the MLM301A is also available in plastic.

Prices (100-999) range from \$7.95 for the MLM101A down to \$0.60 for the MLM301AP and from \$8.00, MLM104, down to \$2.50, MLM304. MLM210s sell for \$6.00 and MLM310s for \$3.25 in 100-999 quantities. All are available off-the-shelf.

For details, circle 220

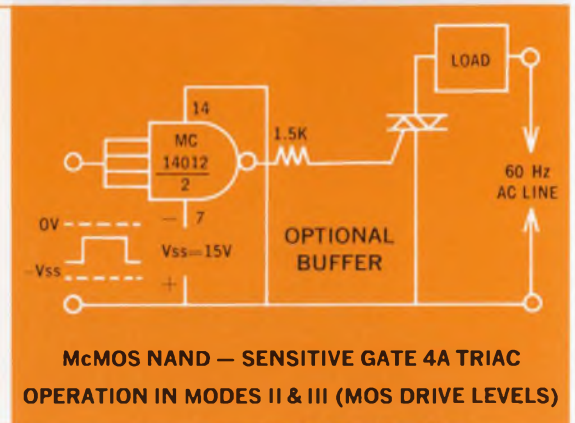


## SENSITIVE GATE TRIACS FORM IC ALLIANCE

### — Operates Loads To 4 A-600 V

Hooking T<sup>L</sup>, HTL, CMOS and op amp drives to full-wave Triacs is a snap — all you need in one hand is your own IC drive . . . and the new 2N6068A/B series sensitive gate plastic Triacs in the other. Put them together and presto: simple, economical control logic functioning for most any design. The 2N6068A/B series will trigger in various quadrants to match input drive requirements — II and III for HTL, I and IV for CMOS buffers and op amps and II and III for CMOS NAND gates and T<sup>L</sup>. Trigger levels for this series in the 4 quadrants vary from 3 mA (for CMOS) to 60 mA for higher-level drives. Voltage ratings range from 25 to 600 V and surge current protection reaches to 30 A. You can also get control completely free of electromagnetic interference by combining a Triac, MFC8070 zero voltage switch and an MOC series opto coupler. With 100-up prices low as 59¢ you ought to try the 2N6068A/B series. You'll like it!

For details, circle 221



CMOS NAND — SENSITIVE GATE 4A TRIAC  
OPERATION IN MODES II & III (MOS DRIVE LEVELS)

## MECL II QUAD TRANSLATORS

### — Speak System Savings Language

Now your high speed MECL II systems TTL sections of digital equipment can "talk" through the MC1067P/1267L MECL II/TTL and MC1068P/1268L TTL/MECL II translators. Both devices are quad translators; i.e., four translating circuits on one chip in a single package — thereby reducing board space and package cost.

The MC1067/1267 features complementary open emitter outputs from all gates and a strobe input to facilitate bussing and wired-OR capability. Complementary outputs permit balanced transmission on twisted pair cable. The MC1068/1268 provides the quad NOR logic function with standard MECL II inputs and Schottky TTL "Totem Pole" outputs. Typical propagation delay for both devices is 5 ns.

MC1067P and 1068P (0° to +75°C versions) are available in 16-pin plastic dual in-line packages at a unit cost of \$4.33 (100-up). For wide temperature versions (−55°C to +125°C) specify MC1267L or 1268L in ceramic dual in-line. Unit price is \$5.42 (100-up).

For details, circle 222



## MHTL 4-BIT SHIFT REGISTER

### — First In 30-Device High-Noise Immunity Line

The MC686 is Motorola's first high-threshold logic shift register. It consists of four J-K flip-flops connected in serial fashion and offers designers the shift register function for applications in high-noise industrial environments. The new device brings the total number of noise-immune MHTL ICs to 30.

MC686's flip-flop change state on the negative transition of the clock pulse. Q outputs are available from all four stages, and  $\bar{Q}$  from the last register stage. A clock-independent asynchronous master reset (MR) clears all flip-flops simultaneously. Individual set inputs ( $\bar{S}$ ) enable any flip-flop to be set regardless of the state of the clock.

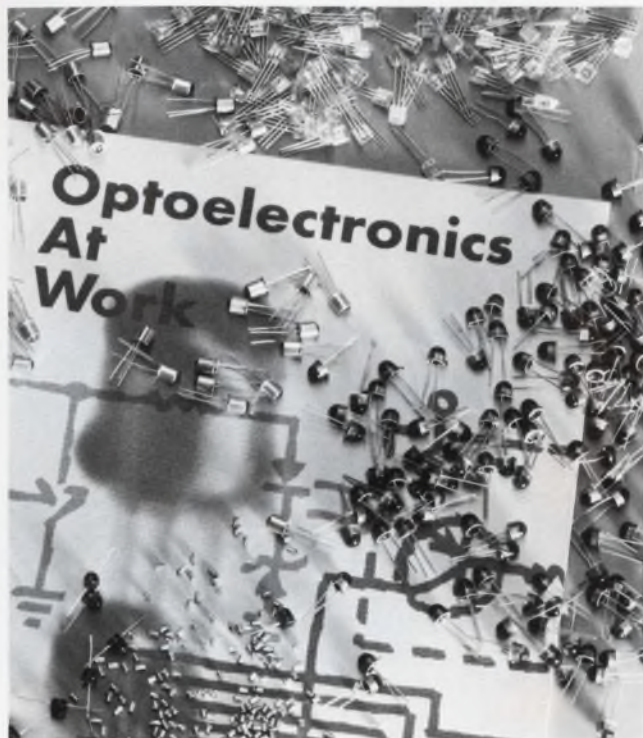
This new MHTL 4-Bit shift register operates across the −30°C to +75°C temperature range and is also available for use over the −55°C to +125°C range and/or with hi-rel processing on special order. 100-up prices, in the dual-in-line 16-pin plastic or ceramic package are \$3.25 and \$4.25, respectively.

For details, circle 223

COUNT	D	Q3	Q2	Q1	Q0
0	1	0	0	0	0
1	1	0	0	0	1
2	1	0	0	1	1
3	1	0	1	1	1
4	1	1	1	1	1
0	0	1	1	1	1
1	0	1	1	1	0
2	0	1	1	0	0
3	0	1	0	0	0
4	0	0	0	0	0







## Put Opto To Work With New "Opto At Work" Book

Suddenly, optoelectronics has become a hot topic in the electronics industry, with many designers looking to it for the answers to long-standing problems. Like reliable, top-performing solid-state relays . . . simple, line-voltage indicators . . . solid-state displays . . . TTL-to-MOS interfacing . . . computer/peripheral interconnects . . . and on and on.

You'll find many of the basic answers to these and other design problems in this new "Optoelectronics At Work" book. Compiled with the express purpose of furnishing an all-around look at what optoelectronic devices can do in a variety of circumstances, the contents include more than 40 complete circuits, the industry's most comprehensive compilation of opto terminology, a selection guide to Motorola devices and the latest cross-referencing of those devices with other industry types.

All in all, up-to-date info on a fast-moving technology.

Write on your company letterhead for your copy. Put "Optoelectronics At Work" to work in your circuit designs!

## Initial MECL 10,000 Reliability Report Available

A report summarizing reliability levels achieved by Motorola's MECL 10,000 family of Emitter Coupled Logic integrated circuits over an 8-month period has been prepared. The report presents results determined from operating and storage life tests as well as thermal and mechanical tests. Failure rates are estimated and discussed.

The report has been prepared in the form of an Application Note. When you write for your copy, ask for AN572.

Meanwhile, testing goes on. We'll report periodically.



## LITERATURE ORDER FORM

NOTICE: Requests for literature on items described in this publication cannot be honored after **December 1, 1972**.

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## Four New Dielectrically Isolated IC's For Radiation Environment Applications

Need to specify radiation-hard devices to satisfy computer and peripheral applications in radiation environments? If so, be sure to check out these four new D.I.C.s:

Designated the MCE7003 (7-Diode Array), MCE7005 (Diode-Resistor Network), MCE7006 (16-Diode Array), and MCE7007 (12-Resistor Network), the new devices all use a dielectric isolation instead of the usual junction isolation to combat the effects of gamma radiation. Each component is isolated by a high-resistance ( $10^{10}$  ohms) layer of  $\text{SiO}_2$ . Dielectric isolation also lowers inter-component capacitance and improves efficiency.

These DICs utilize nichrome resistors, post-metalization passivation, monometallic interconnections, and very small, high-frequency transistor structures. Their circuit designs feature the isolation of individual components in high-resistance islands, preventing metal interconnection burnout or power failure due to destructive photo currents.

*For details, circle 224*

D.I.C. DEVICE TYPE NO.	FUNCTION	PACKAGE	100-UP PRICE UNIT
MCE7003	7-Diode Array	(Case 607) TO-86 14-pin ceramic flat pack	\$14.00
MCE7005	Diode-Resistor Network	(Case 606) TO-91 10-pin ceramic flat pack	11.00
MCE7006	16-Diode Array	Case 606	16.00
MCE7007	12-Resistor Network	Case 607	8.00

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## NEWS BREAKS

### LocaLogic...A New Concept In LSI Circuit Design

With the opening of the first LocaLogic Design Center, Motorola has brought complete LSI design capability into the field under the direct control of customer engineers. The design center utilizes the Polycell system . . . industry's most practical approach for designing custom LSI. In this system, Polycells (proven, completely characterized logic cells, each comprised of several interconnected components) are handled on the computer as standard building block units.



LocaLogic design — a look into "do it yourself" LSI.

Upon arrival at the center you are assigned an office as a base of operation during the course of your program. If you are new to the Polycell system, the Motorola design staff conducts a training program and once a design is started, the staff can help with any step in the sequence. Experience proves that, after brief on-site training, a logician or circuit designer with no prior background in semiconductor design or processing can very effectively use the system.

The LocaLogic Design Center is a completely self-contained operation and covers the stages of design between original logic definition and mask artwork generations. For most design programs, the center has two outputs:

1. A verified data base for generating production mask artwork.
2. A completely graded program for computer testing of the final product.



In Motorola's new LocaLogic Design Center, two designers use an X-Y plotter to visualize cell placement.

Custom LSI approaches are the answer to increased system performance and lower costs. Now these designs can be accomplished by designers working close to their own facilities; quickly, easily and economically designing their own custom LSI. Investigate this new tool and make LocaLogic a part of your design team. Write for details.



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(Please use tape — do not staple)

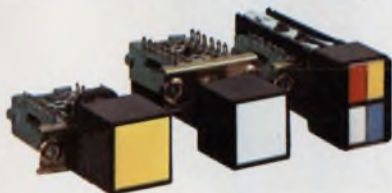


# Press here to save on lighted pushbutton switches.



**buys all  
the switch  
you need.**

Oak's Series 300 gives you good looks and a small price-tag in lighted pushbutton switches. Plenty of switching performance for most jobs, without paying a premium. Even the Series 300 Split-Legend/4 Lamp Switch is less than \$1.60 (normal latch, 2P2T, glass alkyd insulation, no engraving, less lamps.)



## **Three versions with switching up to 4P2T.**

Choose from single, dual, or four lamp display as well as non-lighted type. One to twelve station, momentary, interlock, alternate action, or any combination available on the same switch bank. Lockout feature available for all types. Power Module 3A125VAC. Lighted indicators are identical in size and appearance, but without switching.



## **Built to take it.**

Series 300 is built for reliable performance and long life. Applications galore—bank terminals, calculators, and copy equipment.

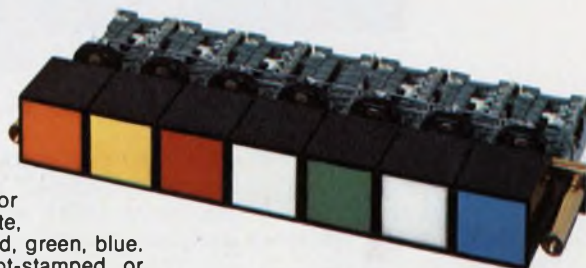


## **Modular design.**

Single-legend/single-lamp, split-legend/4-lamp, and single-legend/redundant lamp switches have snap-on lamp holders. Plus replaceable legend plates, lens caps, and button assemblies. Front-panel relamping, too, without special tools on all types.

## **Gang them up by the dozen.**

Order up to 12 switching stations on a single channel, any switching mix, with convenient panel-mounting studs. Color selection: white, lunar white, yellow, amber, orange, red, green, blue. Choose silk-screened, hot-stamped, or engraved-and-filled legends. Split-legend switches can be specified with any two, three, or four colors on insertable legend plates.



**Write for our Series 300 Brochure**

# **OAK** Industries Inc.

**SWITCH DIVISION**/CRYSTAL LAKE, ILLINOIS 60014  
TELEPHONE: 815 • 459 • 5000 ■ TWX: 910 • 634-3353 ■ TELEX: 72 • 2447

INFORMATION RETRIEVAL NUMBER 15

# World's Smallest High-Performance Tape Drive.



## **25-125 ips, auto-threading, vacuum tape handling.**

The Ampex TMA Tape Drive gives you top performance in the most compact package on the market. Only 19x24x18", it designs itself into your OEM system. Bargain priced, too, for more computer power.

Performance: 25 to 125 ips, 10½" reels, ANSI/ECMA 7 or 9 track standards, NRZI with 200, 556, 800 bpi or 9 track 1600 bpi. Diode and triac switching for all control circuits. Option of auto-threading or manual. Single capstan. Linear reel servo system with vacuum columns for tender loving care of your tape. A series of drives and electronics to meet your needs.

Reliable all the way. A compact performance giant.

And a super-charged buy — the best price/performance computer tape drive you can find. Special bargains

when you buy in quantity. All this backed by Ampex worldwide service, 95% interchangeable parts. Get more details on better tape drives, plus Ampex disk drives and core memories, with a call to your Ampex computer specialist.

# AMPEX

**AMPEX COMPUTER PRODUCTS DIVISION**  
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## Red Chinese are turning out computers with 'modest' ICs

In a recent trip to mainland China, six American computer experts were amazed to find the Chinese producing their own third-generation computers. So reports Severo Ornstein, computer systems designer for Bolt, Beranek & Newman, Inc., of Cambridge, Mass., and the organizer of the trip.

Ornstein has told *ELECTRONIC DESIGN* in an interview that the integrated circuits used in the third-generation Chinese machines are "modest" compared with American ICs, containing a maximum of only a few gates per chip. "They seem to favor a five-input NAND gate with an extender on it," he says. Although they have only smaller quantities of emitter-coupled logic, the Chinese have some that are fairly fast. Ornstein reports.

The group's tour in China included a visit to a computer manufacturing plant. Ornstein differs, however, with a production estimate made by another member of the visiting group, Prof. Thomas E. Cheatham Jr., director of Harvard's Center for Research in Computing Technology. Cheatham, an expert on computer languages and programming, estimated the Chinese factory's output at between 100 and 300 computers a year. Ornstein believes the factory is capable of producing only about 20 to 30 computers a year.

Ornstein reports that one of the great voids in the Chinese computer systems is a lack of "sensible" peripheral equipment.

"The typical machine we saw," he says, "had on it a reasonably high-speed paper-tape reader for inputting data, and a printer, generally of the teletypewriter variety, for outputting data. There were some home-brew xerographic printers and high-speed impact printers, but they were only capable of printing about 80 columns, and

they were certainly not the clean type of printing that we are used to."

As for other peripherals, Ornstein says that the group saw no sign of any card equipment or high-speed paper-tape punches.

In addition the Chinese have no time-sharing of computers or disc memory systems, he says. They do, however, have small drum memories, reasonably advanced core memories and primitive magnetic tape systems, Ornstein says.

The development of the Chinese computers appears to have been strictly by "brute force," Ornstein says, without foreign assistance. Each manufacturing plant, he observes, makes the machinery to make a tool, which in turn makes more machinery to make another tool, which makes the equipment needed to build the computer.

A good example of this, Ornstein continues, can be found in the universities where the students go through the whole process of building equipment to make ICs, then make the ICs and finally use the ICs to build computers.

The use of computers in China is generally limited to scientific and engineering calculations, such as those needed for building dams and bridges, Ornstein says. The Chinese do virtually no process control with computers, he notes, because most things in China are done by hand.

"You've got to have factories before you can have process control," he observes.

While in China the visiting group saw about a dozen computers. "My guess," says Ornstein, "is that we saw most of the computers in China."

Does this mean that U.S. computer manufacturers have a new, large potential market to exploit? For the immediate future, Ornstein thinks not.

"They're not ready for a great number of computers," he believes. "If someone were to suddenly give them 30 computers, they wouldn't know what to do with them. Most of the technology there is very primitive. They need trucks much more than they need computers."

## Color TV disc player is shown by Philips

N. V. Philips of the Netherlands has demonstrated in New York its Video Long Play television disc system, which—by way of a record-player attachment—plays color programs through an ordinary television set. The company says the system will be marketed in the U.S. "within a few" years by the North American Philips Corp.

Unlike other video tape systems, the VLP uses a new type of record that closely resembles an ordinary long-playing disc but that has an additional reflective coating. Both records are pressed in essentially the same way.

The playback unit of the TV disc system employs a low-powered helium-neon laser, in place of a stylus, and an electro-optical pickup, thereby completely eliminating record wear.

The VLP disc provides color programs that run up to 45 minutes on each side. The cost will be slightly more than that for conventional records, according to a Philips spokesman. But the playback unit, he adds, is expected to cost as much as a color TV set does.

The system permits random access, image speedup, slowdown, stills, reverse or picture-by-picture display. It is being designed for the American broadcast standard (NTSC), from the Philips version that was developed for the European broadcast standard (PAL). Record speed is 1800 rpm for the NTSC system.

## Machine Tool Show lures Soviet buyers

Two years ago the main attraction at the Machine Tool Show in Chicago was direct numerical control. DNC was where the action was going to be. The money. But



that hope fizzled.

This year the big attraction was not equipment—least of all DNC, which seems almost to have withered on the vine. It was the Russians. The 116-man team of Soviet engineers was watched with warmth, hope and open order books by exhibitors and visitors alike.

The gigantic show filled Chicago's International Amphitheatre and McCormick Place, playing to an audience estimated at 75,000 from Sept. 5 to 15. As always, the show was sponsored by the National Machine Tool Builders Association of Washington, D.C.

Were the Russians there to learn or to buy? Both, it seems. There was a lot of note-taking and picture-snapping.

"They had a good system worked out," one American electronics manufacturer observed. "Always operating in a group, they would pass by an exhibit, take the literature and leave. A few hours later, or the following day, they would come back. The literature had obviously been thoroughly assimilated, and they had a lot of good questions to ask."

But there were also orders. By the second day, the Russians were actively negotiating with several companies.

How much would they spend? "It could reach \$20-million, but to say specifically could be in error by a factor of 10," says G. G. Ignatyev, Deputy Chairman of Stankoimport of the Soviet Ministry of Foreign Trade.

The Russians planned to visit 25 to 30 machine-tool plants in the U.S. and if "the technology and price" were right, they would buy, according to the Soviet Minister of Machine-Tool Industry, Anatoliy I. Kostousov.

Much equipment will eventually have to be bought. The Soviet Union's five-year-plan, Ignatyev pointed out, calls for an 89% increase in productivity. To do this, he added, the Russians will place great emphasis on "automated tools, NC machines and all the new, advanced machinery."

Other foreign countries visiting and exhibiting at the show included Belgium, Canada, Czechoslovakia, Denmark, France, Great Britain, Hungary, Italy, Japan, the Netherlands, Portugal, Spain, Swe-

den, Switzerland and West Germany.

## Better crystals seen with new furnace

Materials of higher purity and crystals with improved characteristics are promised with a new furnace that uses mirrors to focus the heat of a xenon arc lamp. Temperatures of 3500 C are reported readily obtainable.

The furnace, designed at the Cambridge Air Force Research Laboratories in Bedford, Mass., is the first to be designed from scratch with the objective of controlled crystal growth in mind, according to William Field, staff physicist at the installation.

The mirrors, he says, are specially coated so they match the radiation of the xenon lamp. The radiation from the lamp is maintained constant by a servo system that uses a new type of optical pyrometer—one that is highly sensitive to the arc's temperature.

## New ILS overcomes rf reflection effects

A new instrument landing system (ILS) antenna array recently tested at Boeing Field, Seattle, demonstrated that it can keep the pilot lined up with the runway centerline despite severe rf reflections from the terrain and airport environment. In addition the system is substantially less costly to install than present ones.

The test was made at Boeing, says James L. Ramsey, a member of the FAA's Research and Development Section, Washington, D.C., because reflections of ILS localizer signals from jetliner hangars, surrounding power and tele-

phone lines and fences, as well as from nearby hills, give a "worst case" situation.

These reflections, he points out, ordinarily interfere with the pilot's vertical on-course indicator needle (when centered, it indicates he's lined up with the runway centerline). The needle may drift to one side or the other, or fluctuate so badly it can't be used.

The reflection problem arises, Ramsey says, because in ILS localizer systems two signal patterns—both aligned with the runway centerline and of the same frequency—are radiated. The first pattern is that of a  $\pm 5^\circ$  on-course signal, while the second is a broader one extending to  $\pm 35^\circ$  on either side of the centerline. This helps the pilot "capture" the precision localizer beam. It is this second, broader beam that is reflected and that interferes with the sharp beam.

The ILS antenna system tested at Boeing Field consists of two arrays—one for the precision pattern, the other for the  $\pm 35^\circ$  "clearance" pattern. It works on the "capture effect" principle invented by Andrew Alford of Andrew Alford Consulting Engineers, Winchester, Mass., designer of the new system.

"The tests turned out to be very favorable, Ramsey reports.

An important factor that Ramsey points out is that these arrays cost less than conventional ones. They are modular—"like an erector set," he notes. They are broadband devices that have no mutual coupling. As a result, the cables are all cut at the factory, and the field installation does not require hand-tuning of stubs.

Installation of the new system takes only two or three days, Ramsey notes, in contrast with nine to 10 weeks for the tuned-waveguide systems now in use.

## News Briefs

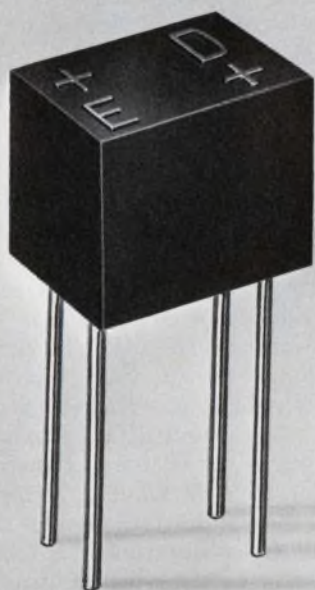
NASA has selected Hughes Aircraft, El Segundo, Calif., and Avco, Wilmington, Mass., to conduct parallel studies for system design for a series of proposed missions to carry out scientific investigations of the planet Venus and its environment with Pioneer-class spacecraft beginning in January, 1977.

Laser-beam communications are being flight-tested at high altitudes by NASA to determine the effects of the atmosphere on vertical transmission of the beams. The space agency is experimenting with a helium-neon laser transceiver in an aircraft and an argon-laser ground-acquisition and tracking station.



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# How good are the new watches?

## Electronic claims split industry

*... Minute-a-year timekeeping accuracy with a quartz-crystal wristwatch.*

Is that fact or fiction?

*... A watch with an advanced all-solid-state design—the watch with the liquid-crystal display.*

Is it an effective display or merely a gimmicky sales device?

There is sharp division in the American watchmaking industry over these two claims, inquiries by ELECTRONIC DESIGN show.

On the question of timing accuracy, one manufacturer—Bulova—says flatly that no one can live up to the minute-a-year guarantee with a mass-produced electronic wristwatch. Another—Hamilton—is inclined to agree, and three manufacturers—Gruen, Waltham and Microma Universal—say they stand by the claim, though they decline to elaborate technically.

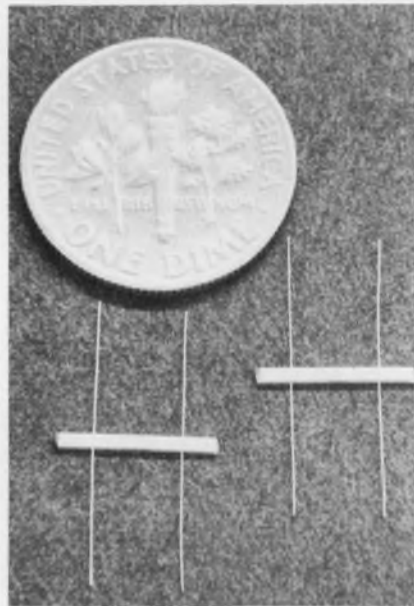
As for the liquid-crystal display, even boosters of it concede it has flaws. But solutions are envisioned.

The timing-accuracy issue was propelled into the spotlight at a jewelers' convention in New York City in July when the Bulova Watch Co. of New York cautioned delegates in an official statement:

"The present state of the technology makes it unrealistic to make claim to or to offer a specific guarantee for minute-a-year timekeeping for any quartz-crystal watch, including the Bulova Accuquartz."

Dr. Dale Koehler, manager of Bulova's Advanced Research Laboratory in Flushing, New York City, has told ELECTRONIC DESIGN that changes in the frequency of low-frequency crystals that are being used can produce a substantially higher error than a minute a year.

The quartz-crystal frequency is



**These tiny bars of quartz are the 32,786 kHz frequency standards that drive the Bulova Accuquartz watch. The leads shown are shortened and attached to a sealed can assembly.**



**A four-digit dynamic-scattering liquid crystal display gives the time on this Microma Universal watch.**

affected by three principal factors, he explains: aging, shock and temperature change. As an example, he gives Motorola's guaranteed maximum aging specification of 5 ppm per year, which is equivalent to a loss in timing accuracy of

about 0.4 second a day. From this error alone, he notes, there is a potential loss of about two minutes a year.

Koehler points out that future developments in crystals will bring an improvement in aging.

David Bingham, manager of micro-power products for Intersil, Inc., Cupertino, Calif.—a maker of electronic watch parts—agrees with Bulova. The low-frequency crystals now in use are in the 32-kHz range, he notes, and they have a built-in error in their aging rate.

Bingham sees this problem solved by eventual development of crystals operating anywhere from 0.25 to 4 MHz. The aging rates of these higher-frequency crystals will be substantially less, he says, as will be their temperature sensitivity. But the adverse influence that high-frequency crystals will not be able to be guaranteed against, he points out, is shock.

Bulova's Koehler explains that when the present quartz-crystal wristwatches are dropped, the shock introduces a strain in the wire supports (see photo). Crystal manufacturers equate the change in frequency caused by shock in terms of a deceleration-time profile, he says. This profile is for a drop from a one-meter height with a deceleration of 3000 G for a 0.25-ms-wide half-sine deceleration pulse.

Bulova's experience, Koehler says, is that the frequency can change from 0.6 to 10 ppm after such a shock. If the watch is dropped halfway through the year, he explains, and if it develops a 2-ppm change in frequency, there will be a 31-second time error for that year as a result of one shock alone.

On temperature effects on crystal operation, Koehler says that the change in frequency is a para-



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bolic curve with the zero-error point on the crystal set at about 28 C. Since temperature varies from day to day, it is reasonable to take one-third of the maximum temperature error and assume that it accumulates for a half year at 2 ppm, Koehler says. This is equal to another 31-second-a-year error in timing.

Adding the potential errors caused by aging, shock and temperature drift, Koehler comes up with a total error of 141 seconds for the first year of watch use. With this potential, he asserts, it is not possible to guarantee a mass-produced watch for minute-a-year accuracy.

### Hamilton inclined to agree

John M. Bergey, president of Hamilton's Pulsar Time Computer Center in Lancaster, Pa., manufacturer of the first all-solid-state watch using LEDs for a display, told *ELECTRONIC DESIGN* that Bulova's statement to the jewelers' convention was "reasonably accurate" and "put things in perspective."

But minute-a-year accuracy is possible, Bergey says.

"We have been producing the Pulsar for over a year now," he reports, "and we find that a large distribution of the watches fall within the minute-a-year category. In fact, some of the watches show a zero-second error rate per month."

Spokesmen for Gruen Watch, Inc., New York City, and the Waltham Watch Co., Chicago, said without elaboration that their companies stood by earlier statements indicating minute-a-year accuracy for their quartz-crystal wristwatches.

Donald Rogers, director of marketing for Microma Universal, Inc., of Mountain View, Calif., asserted: "We guarantee five-seconds-per-month accuracy for our all-solid-state watch."

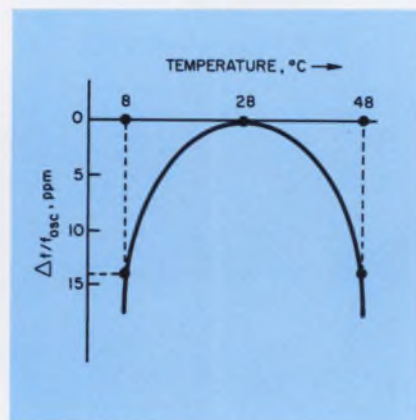
### Liquid crystals stir debate

The liquid-crystal displays being introduced in some all-solid-state versions of electronic watches have their champions and detractors. Criticism of the present generation of dynamic-scattering displays centers on three points:

They're hard to see at certain angles and under certain lighting conditions; they have a large number of leads, making them difficult to replace or repair; and the life of the devices has not yet been demonstrated over extended periods of time.

Because the dynamic-scattering display requires a mirror that reflects the ambient, scattered light when the digits are energized, the display tends to wash out at certain angles.

"I'll admit that the watch has to be angled right in order to view it properly," says Ian McCrae, marketing manager for Texas Instruments' optoelectronics products. "But a simple movement of the wrist is ordinarily enough to bring the display into the proper viewing angle. The only real limi-



**Wristwatch crystal operating temperature limits** are typically established between 8 C and 48 C, with the normal wrist temperature (zero-error point) at 28 C.

tation of this type display is that you can't see it in the dark."

TI is supplying liquid-crystal displays to Swiss watchmakers.

A newer type of display, called the field-effect liquid crystal (Felix), operates on somewhat different principles that give it better optical and electrical characteristics see "The Felix, a Fast Liquid Crystal, Is Easy on Power, Easy on Eye, (p. 44 this issue).

McCrae admits the field-effect unit is better in several respects. However, he points out that it has a narrower viewing angle and is more expensive.

Rogers of Microma Universal, which is introducing its own watch

with a dynamic-scattering liquid crystal display (see photo), says:

"There's no question, at the present state of the art, that a lot of things could be better. But we've optimized our display so it's salable. We didn't want to spend five more years engineering it.

"We've been doing work with polarizing filters and with colors in an effort to improve our display. Another important factor in the quality of the display is the fact that we make our own crystals. The commercially available materials are not very good."

As far as life and servicing of the liquid-crystal display is concerned, Bulova says that at the present state of the art replacement within 12 months is not unrealistic. Bulova has been investigating the use of the liquid crystals for the past few years.

Dr. Zolton J. Kiss, president of the Optel Corp., Princeton, N.J., supplier of liquid-crystal displays to Waltham and others, notes that while the history of these devices has not been long, displays have been run as long as five years in some company's laboratories. He expects this figure to be realistic for watches.

### Replacing display a problem

Bulova contends that replacing a liquid-crystal display is a far more complex operation than replacing a conventional watch dial. Kiss counters that the displays can be designed as snap-in or plug-in units.

Intersil's Bingham believes that liquid crystals for watches will be successful when they are designed to allow multiplexing to reduce the number of leads. As an example, he points to the current four-seven-segment digits on a watch. They require 28 leads for the segments plus at least one more for the ground.

With a multiplexing—or strobing—system, Bingham says, there are four rows and seven columns. The number of connections is reduced, depending on the scheme used. However, he says, the real problem here is that this method can be expensive.

Microma Universal's Don Rogers is convinced that whatever type of liquid crystal display wins out, this will be the ultimate choice. ■■



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This is not to say that no one else builds good circuit breakers. But at their stage of the game, a five-year warranty could be a bit risky. It takes a while to find out how well a product will stand up under the unpredictable conditions of

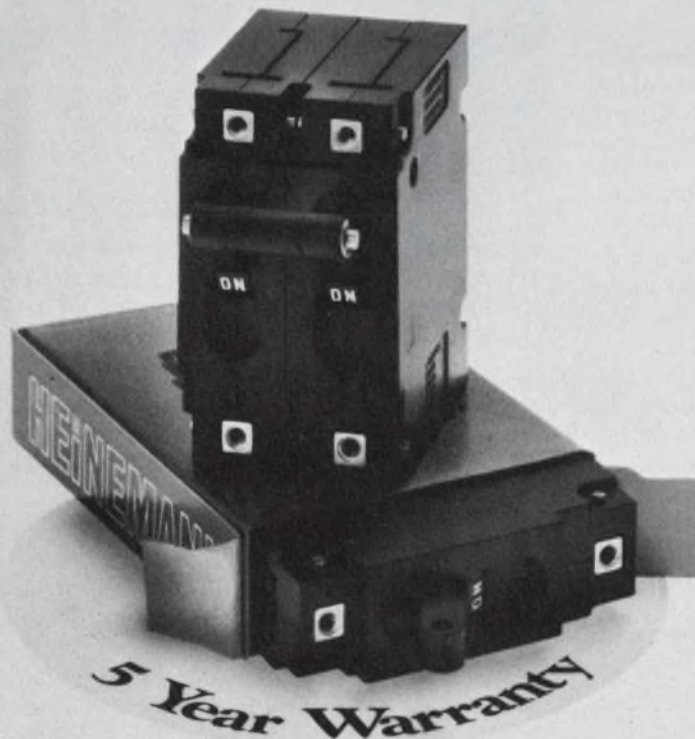
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5302

# The 'smart' bombing technique is about to become smarter

A multisensor system for finding military targets from the air and guiding "smart" bombs and missiles to them is being designed into the Navy's A-6E attack aircraft by a team of engineers at Grumman Aerospace in Bethpage, N.Y.

So-called smart weapons, which have been used so successfully in Vietnam, are maneuverable after release from an aircraft and can be guided toward a target illuminated by laser light. Usually the target must be found and identified visually by the pilot before the laser is turned on.

The new system, called Tram (for Target Recognition Attack Multisensor), will spot targets day and night with a forward-looking infrared detector (Flir) that is bore-sighted with a laser range-finder to illuminate the target. Tram is being developed for Grumman by Hughes Aircraft in Culver City, Calif.

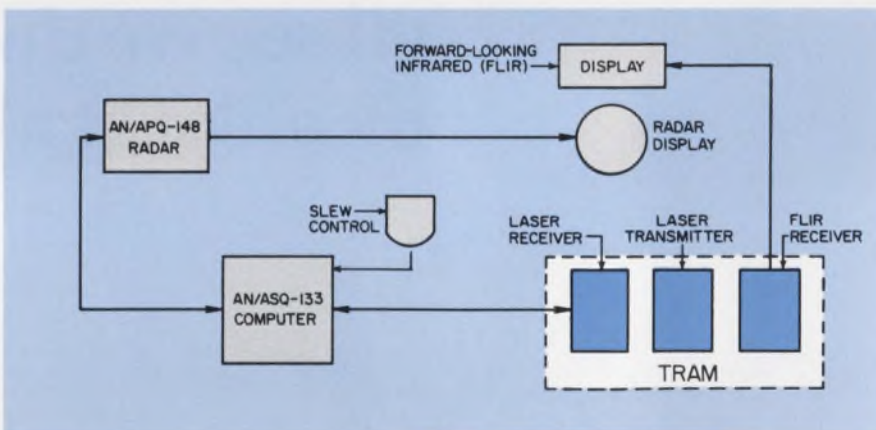
The operation begins when the bombardier-navigator picks up a target on the aircraft's relatively long-range radar, Norden's AN/APQ-148. He then waits for the target to appear on his Flir display, a TV-like screen sitting on top of the radar scope. Flir does not have the long range that radar does, but it has much better resolution.

When the operator sees the target on Flir, he manually lines it up with a Flir reticle and flips on the laser rangefinder. The laser and the infrared detector then remain pointed toward the target on instruction from the radar's computer, an IBM AN/ASQ-133.

The computer knows where the target is because the inertial system tells it the aircraft's ground-



A small bulge had to be built into the A-6E attack plane to accommodate the new infrared-laser sensor system called Tram.



Tram will work with the aircraft's radar and computer system. The slew control realigns the infrared detector when the target drifts off center.

speed and track. If the target begins to drift off center, it's because the inertial system is drifting. The operator corrects this manually—by slewing a control stick—a correction that goes through the computer, telling it not only the target's true position but also how much it can expect the inertial system to continue to drift.

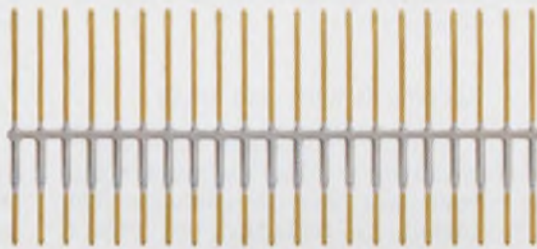
When the moment is right, the bombardier drops the smart bomb, which homes in on the spot the laser is illuminating.

To play back the entire mission on the ground later, a video tape recorder is trained on both the radar and Flir scopes during the significant portions of the mission. The video display is capable of recording for approximately 40 minutes.

"Integrating Tram equipment with the aircraft's radar, with the radar's computer, which Tram also uses, and with the inertial navigation and bombing system is our job," says Grumman's Vernon



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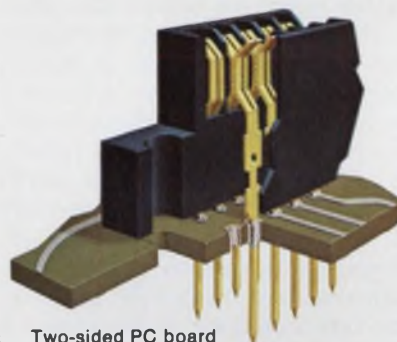


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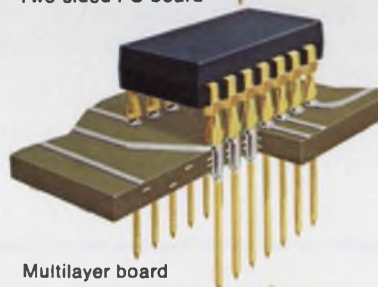
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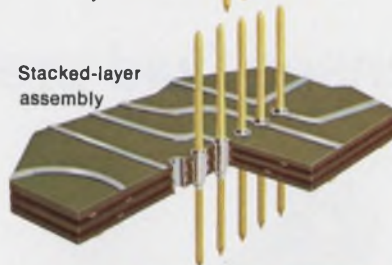
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INFORMATION RETRIEVAL NUMBER 20

Kramer, who heads up the program management team for installing an R&D Tram system in an A-6E under a \$23-million contract.

"We've broken the design problems down into five categories," explains Dan Collins, Grumman's deputy director for the A-6 program. "Electromagnetic interference, weight and space, temperature, software and interface.

"If you set up your EMI philosophy correctly, you won't have any EMI problems."

Grumman achieved this in two steps. "First of all," Collins says, "we decided not to be influenced by the traditional airframe designer's preoccupation with weight." Airframe designers generally use the airframe as a ground instead of designing a radio with a central grounding system of its own.

Using the airframe "sounds good," Collins says, "but it doesn't work."

"The airframe is not continuous," he explains. "It's got spaces along the way, and you really don't bond to it properly."

The result, he says, is an undefined grounding system with significant resistances. When the signal has to come back through the low-impedance circuitry, the grounds aren't at 0 V. They are at 0.5 to 1 V—"which is like having a signal 0.5 to 1 V below what it should be," Collins says.

Grumman designed a separate grounding system for Tram, providing separate copper wires to bring the current back—wires big enough to carry the current without getting induced transients down the line.

"We've also taken care of the re-

sistance path, the inductance path, and we have eliminated the ground loop problems," Collins says. "The airframe ties into the signal circuit in only one place."

The main three-phase power distribution from the generator system does go back through a ground return, which ties into the airframe, but this all goes through transformers that isolate it, so the power supply separates the ground return from the main power return.

"The second thing we did," Collins says, "was to shield the wires heavily. You have to do this in an aircraft because there isn't room to isolate wires."

### Keeping it light and small

Though weight was not a highly critical problem, Collins says, the team was able to eliminate 300 pounds by replacing two radars with one. The new one, Norden's AN/APQ-148, presents a normal plan-position-indicator picture, or map; it tracks and it provides elevation range for terrain clearance.

The radar does what two radars did previously, because it has an interferometer on its gimbaled search antenna. The interferometer receives the search radar's reflected signals and generates a profile of the terrain ahead of the aircraft at every azimuth angle. This information is used to create a terrain-clearance display. In addition, the interferometer is interrogated at the azimuth angle and at the slant range to develop the elevation angle to the target.

Space is more crucial than weight, and Grumman had to create a small pod below the radar un-

der the nose of the A-6E to house Tram. But this is the only aerodynamic change planned.

### Keeping it cool

Tram alone pulls 4 kW of power. Keeping heat-vulnerable components cool was a prime requirement. Overheating could easily damage the laser and the power supply, Collins says, adding: "We had to provide a totally separate cooling system for the additional equipment; we had more electrical energy going in than we could have taken out. We pump cool air through the equipment, and we have a general cold plate that transfers heat out of the equipment.

"Some software problems are inevitable, but we're starting early. We've already sized the software job. We know the number of bits required in the computer, and we have already recognized that for our program the computer has a basic iteration rate of about 10 per second.

"This has to be increased for some specific Tram applications. For this we have developed a high-speed subroutine to be used when needed.

"When we deliver the aircraft, there may be a few software errors, but there will not be any goofs."

The largest problem Collins expects is the man-machine interface. "And this can't be checked out," he concedes, "until the plane flies and the operators come back and tell us what's wrong. Other than this, we only foresee the usual interface problems that occur in assembly and are easily rectified." ■■

---

## Silicon crystal senses fluid pressure

A piezoresistive strain-gauge bridge diffused into the surface of a 1-cm<sup>2</sup> silicon crystal is the sensing element of two new solid-state fluid pressure transmitters. Developed by the Honeywell Industrial Div., Fort Washington, Pa., for process control, the silicon gauge has no bonds or creep joints and consequently is stable with time and temperature.



The silicon element—used in differential pressure and direct pressure transmitters—is sealed in a silicon fluid through which the fluid pressure is transmitted.

Integrated circuits, mounted on the main substrate, convert changes in pressure, ranging from 30 to 10,000 psig, to current outputs of 4 to 20 mA with 24 V dc excitation. ■■



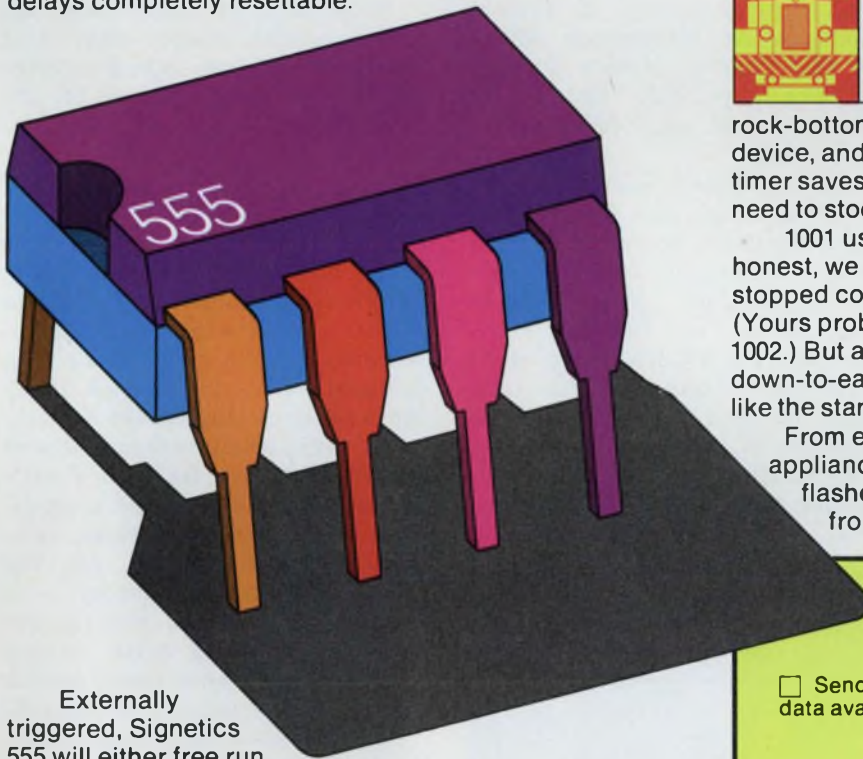
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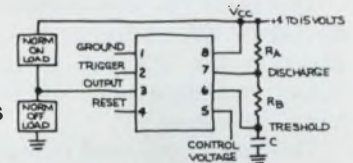
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INFORMATION RETRIEVAL NUMBER 21

# Electronics whiz kids display better ideas for building cars

Can a group of undergraduates, led by a 20-year-old electrical engineering student in his junior or senior year, make design improvements in cars that are significant enough to influence the pros in Detroit?

To find out, 65 such groups, representing more than 2000 students from universities and schools throughout the United States and Canada, last month sent 65 newly designed or modified vehicles to the General Motors Proving Grounds at Milford, Mich., for a competition.

The goals: to demonstrate ways to reduce the emission of noxious gases in the exhaust, to improve safety, to reduce noise and to make handling easier.

The techniques used relied heavily on electronics. Besides sensors and catalysts in the engine, closed-

circuit television replaced rear-view mirrors, pushbuttons called up data on displays when needed, a variety of electronic tricks awaited drunken drivers and thieves, and one car had an electronic diagnostic system.

Successes and failures were mixed. And their influence on Detroit's car makers is at present unknown. An information official at the General Motors Proving Grounds says only that "there were a lot of good ideas at the competition."

General Motors contributed between \$250,000 and \$500,000 for the competition, according to Dean John H. Sununu of Tufts University in Medford, Mass. Student Competitions on Relevant Engineering, Inc., a Tufts group, sponsored the competition. The tests were certified by the National Academy of Engineers.

In an effort to avoid noxious effluents, some of the groups steered clear of the conventional internal-

combustion engine and went to other sources of power: steam, pressurized propane gas, hydrogen, CNG (compressed natural gas), electricity and hybrids—one, a combination of electric battery with internal combustion and another, hydraulics and internal combustion.

Some, however, stayed with the liquid gasoline engine—either lead sterile or lead free—which is, after all, still the most practical for the near future.

## Pratt buys second-hand car

Pratt Institute in Brooklyn, New York, with a small budget of \$5200, bought a secondhand 1971 Subaru FF-1G station wagon with its inherently dirty engine—as all 1971 engines were—and cleaned it up sufficiently to surpass the Government's 1974 pollution standards and nearly meet those for 1975. Pratt's car won the clean-engine competition in the gasoline-burning category, and the award for the quietest car in any category.

Pratt spent \$1500 for the car and the remaining \$3700 to convert it into a cleaner, safer, quieter vehicle with a number of sophisticated features. Pratt's team leader, Richard Doherty, is particularly proud that his was the only car that was driven to and from the competition. All the others were taken by truck or train—"some because their fuel was too dangerous to be used on highways and in tunnels."

To tackle nitric oxide, the constituent in the exhaust that is the most difficult to control, Doherty's team added capacitor discharge ignition to make burning more complete, and this also lowered hydrocarbon emission.

A second step was to add an air pump to the engine that feeds

**John F. Mason**  
Associate Editor



A television camera looks out the rear window in place of a mirror. It covers 90 degrees, operating well in moonlight and in rain.



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compressed air into the exhaust to reignite unburned fuel. A provocative by-product of this, Doherty says, is the 1200-F heat produced by burning the unused fuel. Eventually he hopes to come up with a use for this wasted energy—possibly to power a sealed evaporative type of air-conditioner.

Besides extra structural support, several modifications were made to improve the car's safety. Doherty is particularly pleased with his device for keeping drunkards off the highway. Three seconds after the ignition is turned on, a red light of the car's dashboard goes on. If the driver doesn't hit the brake with his foot in 3/4 second, the car doesn't start. If after 12 attempts the driver still hasn't made it, the ignition locks for five minutes.

The red light-brake device required simple, straightforward designing, Doherty says. It uses four relays, one relay time-delay tube and two unit function-transistor timing circuits.

Doherty sees at least one major advantage to his system over General Motors' drunken driver's test, which requires the driver to remember a series of numbers that flash on a dashboard display and then "type" the correct series back.

Some people just don't have good memory retention for numbers, he says—a faculty that has nothing to do with good driving, whereas reacting quickly with the brake does.

The safety panel at the General Motors competition, however, maintained that a clever drunkard could probably get Pratt's car started by standing outside the car and keeping his hand on the brake, pushing it down when the light came on.

MIT won the drunken-driver tester competition with a red-light reaction tester that went a step further than Pratt's. Instead of allowing the driver a fixed 3/4 second to respond to the red light, the MIT system contains a memory that knows the normal reaction time for every member of the family and allows him his particular time. It distinguishes each by a signature card—like a credit card—that is inserted into a slot. It has learned each driver's reaction time by measuring it for the first 20 times he drives the car. This device, of course, costs more than Pratt's.

#### A device to foil thieves

The University of British Columbia also entered a device that doubles to foil drunkards and thieves. To unlock the door, a correct three-digit combination must be pushed on a nine-button panel on the door. Then, before the car will start, another three-digit combination must be pushed on another nine-button panel on the dashboard.

To see well to the rear of the car, two alternatives to mirrors

were tried: periscopes and closed-loop television. Six cars had periscopes rising from their roofs, and Pratt used a television. Doherty's team discarded the periscope for several reasons.

"It only displays the tops of nearby cars in the rear," Doherty says. "Its visibility would be impaired by dirt, rain, snow and ice."

A television camera inside the car—pointed through the back window, with a small display on the dashboard—works beautifully, Doherty says. "Oddly enough, though," he notes, "we had to reverse the perfectly normal picture you get with the TV to a mirror image, because that's the way drivers are conditioned to see behind them as they drive."

The TV camera is a standard unit made by the GBC Corp. in New York City. Using a 2/3-inch vidicon tube that covers a 90-degree angle, it is sensitive enough to see the highway markings by moonlight. The display is a five-inch, 110-V TV receiver made by Sony. Parts not needed were removed—the i-f stages, tuner and audio amplifier.

The set has a 450-line resolution, and its contrast can be adjusted during rain. And, Doherty says, it is more effective than a mirror at night and during rain. The whole system cost \$300, but if mass-produced, Doherty estimates that it could be sold for about \$100.

Conventional dashboard gauges have been replaced in Pratt's car with a single three-digit Nixie tube display that time-shares voltage, fuel and temperature readings. Each reading is called up on demand when a button is pushed. The only other displays on the dashboard are the rearview TV screen and speedometer.

Other features in Pratt's car include a crash-resistant battery containing acid-neutralizing chemicals housed in a semi-foam, impact-absorbing material. The car also has an automatic burglar alarm that activates if a key other than a coded electronic one is used. And for fire control, an automatic fire-extinguishing system is activated by heat sensors in the engine compartment.

Pratt's vehicle could retail, Doherty says, for \$2435 if 100,000 were produced. ■■



The dashboard instruments (from left to right) are the speedometer, the rear-view TV display and the digital Nixie tube display.



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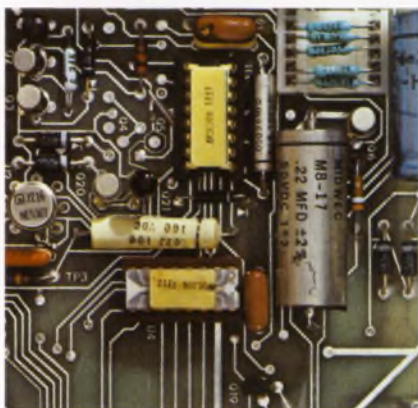
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INFORMATION RETRIEVAL NUMBER 23

# The Felix, a fast liquid crystal, is easy on power, easy on the eye

Field-effect liquid crystals are joining gas-discharge, light-emitting diode and dynamic-scattering liquid-crystal displays in the marketplace, and designers are gaining in flexibility as a result. The new display—called a Felix—offers significant improvements in performance and visibility.

Dr. James L. Fergason of the International Liquid Xtal Corp., Cleveland, which began initial production of displays with field-effect liquid crystals earlier this month, contrasts them with dynamic-scattering types.

Compared with the dynamic-scattering display, he says, the field effect device:

- Requires about one-tenth the current to operate.
- Has substantially higher con-

trast ratio—on the order of 40:1 for both reflective and transmissive displays.

- Is about four times faster—typical turn-off time is 50 ms compared with 200 ms, and it can be energized by 60-Hz to 10-kHz voltages.

- Can operate over a wider temperature range of 0 to 70 C.

- Can be operated at lower voltages.

## Less current with Felix

As an example of comparative current drains, Fergason cites a four-digit display. The dynamic-scattering unit, operating at 15 V, requires about 35  $\mu$ A. A comparable Felix display, operating at 7 V, draws but 35 nA, he says.

The differences in performance, Fergason explains, are caused by the different methods of cell operation. The basic dynamic-scatter-

ing unit has a thin layer of transparent liquid crystal sandwiched between two conductive sheets of glass. The front electrode is transparent. The rear electrodes are shaped in the form of segments of alphanumeric characters. The rear panel is transparent in transmissive displays and is an opaque, mirror-like element in reflective displays.

When the voltage is applied between the front and rear electrodes of either type, the current flow between them causes turbulence in the areas between the electrodes. This turbulence scatters the ambient light in the form of the rear electrode pattern.

With Felix displays, the construction of the cells is somewhat different in that the liquid crystal material is sandwiched between two polarizers, Fergason says. The liquid-crystal material is dielectrically anisotropic—that is, in the unenergized state, the crystal molecules are aligned parallel to the front of the display glass. In this case light is absorbed by the polarizers. Upon applying a voltage, the dielectric anisotropism causes the crystals to rotate under the influence of the electrostatic field, so they are at 90° to the face of the display. This rotates the plane of polarization and allows either ambient or transmitted light to pass through, depending on the display.

Exceptionally high-purity liquid-crystal material is required for the Felix display, Fergason points out. For this reason Ilixco prepares its own proprietary crystals.

The lifetime of liquid-crystal displays is, in general, limited by contamination of the material through the seals, Fergason notes. Based on accelerated life tests, he predicts a life of 18 months for present Felix displays. ■■

Jim McDermott  
Eastern Editor



The field-effect, liquid-crystal reflective type display (above) provides better all-angle viewing in diffuse light than does the standard dynamic scattering display. The segments use 7 V from a 60 Hz to 10 kHz source.



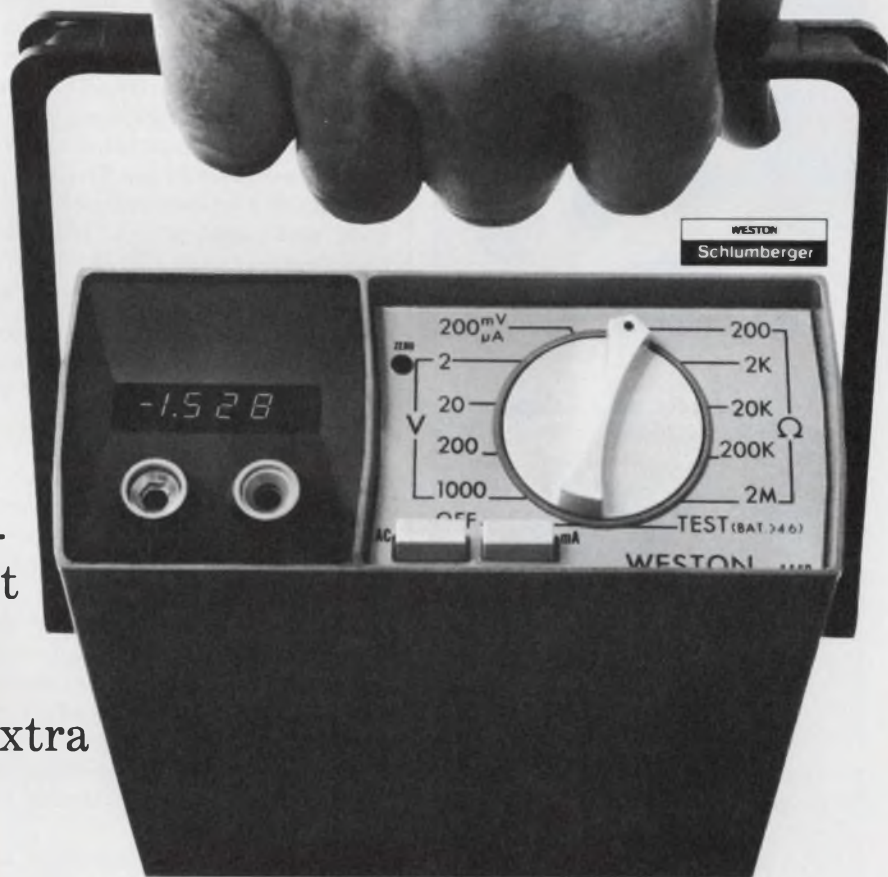
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INFORMATION RETRIEVAL NUMBER 25

## technology abroad

A MOS chip to replace pushbuttons in television tuners uses low threshold p-MOS technology. A six-channel sense circuit is driven directly from a two-terminal touch plate that replaces the conventional mechanical push-button selection. Neon lamps indicate the channel selected. The circuit drives a varicap tuner through a bias-selection network. The company—Emihaus Microcomponents, Ltd., Surrey, England—claims that this circuit is the first single-chip MOS for use in touch selection and control in television receivers.

CIRCLE NO. 441

An improved method of etching integrated circuit masks has been developed by Philips at its research laboratory in Hamburg. Research has shown that a low mask etching rate can be achieved with sputter etching, provided a target with strong gettering power is used as a substrate holder. A titanium target has been used with success, and the technique insures that the reactive gases are adequately removed, thus reducing their effect on the mask. Further research is being carried out to determine effectiveness of other materials for the target.

CIRCLE NO. 442

Advanced techniques for measuring air pollution are being developed by the Federal German Research Association's Observation Network, to analyze elements with atomic numbers from 9 (fluorine) to 92 (uranium). The monitoring system, which has a sequential X-ray spectrometer with tabulator control, uses secondary X-ray emission methods to measure aerosol specimens deposited on a filter paper. Nine spectral lines can be automatically scanned and measured, although the tabulator control can be extended to operate on a maximum of 36 spectral lines. The measured results are recorded as pulse counts and then transferred

to punched cards for subsequent evaluation at the University of Darmstadt's computer center.

CIRCLE NO. 443

A new antiaircraft missile guidance head using semiactive radar techniques has been developed by Marconi Space and Defense Systems, Ltd., under a contract from the British Government. The semiactive radar techniques to give the missile all-weather performance. Microstrip circuits are used exclusively to eliminate bulky and costly waveguide assemblies. The result is a unit that can be tailored to fit into a wide variety of missile types. The complete unit is 330 mm long and 190 mm in diameter.

CIRCLE NO. 444

Two experimental optical glass fiber transmission routes for studying the transmission of videotelephone and speech signals have been assembled in the Siemens research laboratories in Munich. With present glass fiber materials, the transmission rate is expected to be more than 50 Mb/s—sufficient for a least one television picture channel. The signals are converted to amplitude modulated pulses with a repetition frequency of 2 MHz, prior to being fed to a gallium-arsenide laser diode attached to one end of the glass fiber. Repeater amplifiers of laser diodes and photodiodes boost the signal.

CIRCLE NO. 445

A system for transmitting color pictures from transparencies over an international wire network was used for coverage of the recent Olympic Games in Munich. The colors were separated into magenta, cyan and yellow, and these signals were processed by dc and logarithmic amplifiers. The signals were then fed through nonlinear color-boost amplifiers and finally through antilog amplifiers, so that the transmitted signal was compatible with existing picture transmission systems.

CIRCLE NO. 446





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The ADC-12QZ has all the good features of the ADC-10Z at 12-bit resolution. It's monotonic from 0°C to +50°C, has a temperature coefficient of  $\pm 30$ ppm/°C, converts in 40 $\mu$ sec (max.), and is priced at \$92 for one hundred or more.

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# Washington report

## **Export controls to loosen**

The Secretary of Commerce has been ordered by Congress to report in six months on his actions in loosening export controls on U.S.-produced items as a result of the enactment into law of the Equal Export Opportunity Act. The law calls for a study to determine which goods and technology should no longer be restricted on grounds of national security. Electronics industry representatives had complained of inability to sell items already marketed freely abroad by foreign sources.

## **Electronics industry antitrust hearings looming**

Hearings on a Congressional bill that eventually could have considerable impact on competition in the electronics industry may yet be started this year, say sources on Sen. Philip A. Hart's Senate Judiciary Antitrust Subcommittee. Hart (D-Mich.) is looking at some seven industrial areas, including electronics and electrical machinery, to determine the extent, if any, of monopoly practices. His proposed bill (S3832) would create a Federal Industrial Reorganization Commission to develop and administer a plan to make competition more effective within each industry.

## **Review of Army helicopter program asked**

A review of the Army's new heavy-duty helicopter program, known as the Uttas, has been asked by Rep. Aspin. The Army awarded two competitive prototype contracts—to Boeing Vertol and Sikorsky—for a total of \$153.2-million. Each is to build seven models for evaluation. The estimated cost of the total program including production, Aspin charges, already has jumped from \$2-billion to \$2.344-billion.

## **FCC remains firm on TV-tuner accuracy requirements**

Electronics companies are waiting anxiously to see if the single producer of 70-position TV tuners can meet Federal Communications Commission standards for accuracy. The FCC is making it clear that it will frown on any further manufacturer requests for extensions past Jan. 1, 1973. By that date, it says, all TV receivers must meet a tuning accuracy



of  $\pm 3$  MHz. The FCC recently permitted RCA to use Sarkes-Tarzian tuners with an accuracy of  $\pm 6$  MHz till the end of the year. But Sarkes-Tarzian, supplier to all U.S. television manufacturers, must improve the accuracy of all its tuners by next Jan. 1, or sets made after that time cannot be sold.

## **Litton challenged on helicopter ship costs**

Litton Industries has been sent back to the drawing board by the Navy to rejustify its claim on the trouble-plagued landing helicopter assault program. Litton is asking \$270-million extra for "changes" and "excusable delays." The Navy agreed to keep paying the company's cost for six more months while the claims were reworked and negotiated.

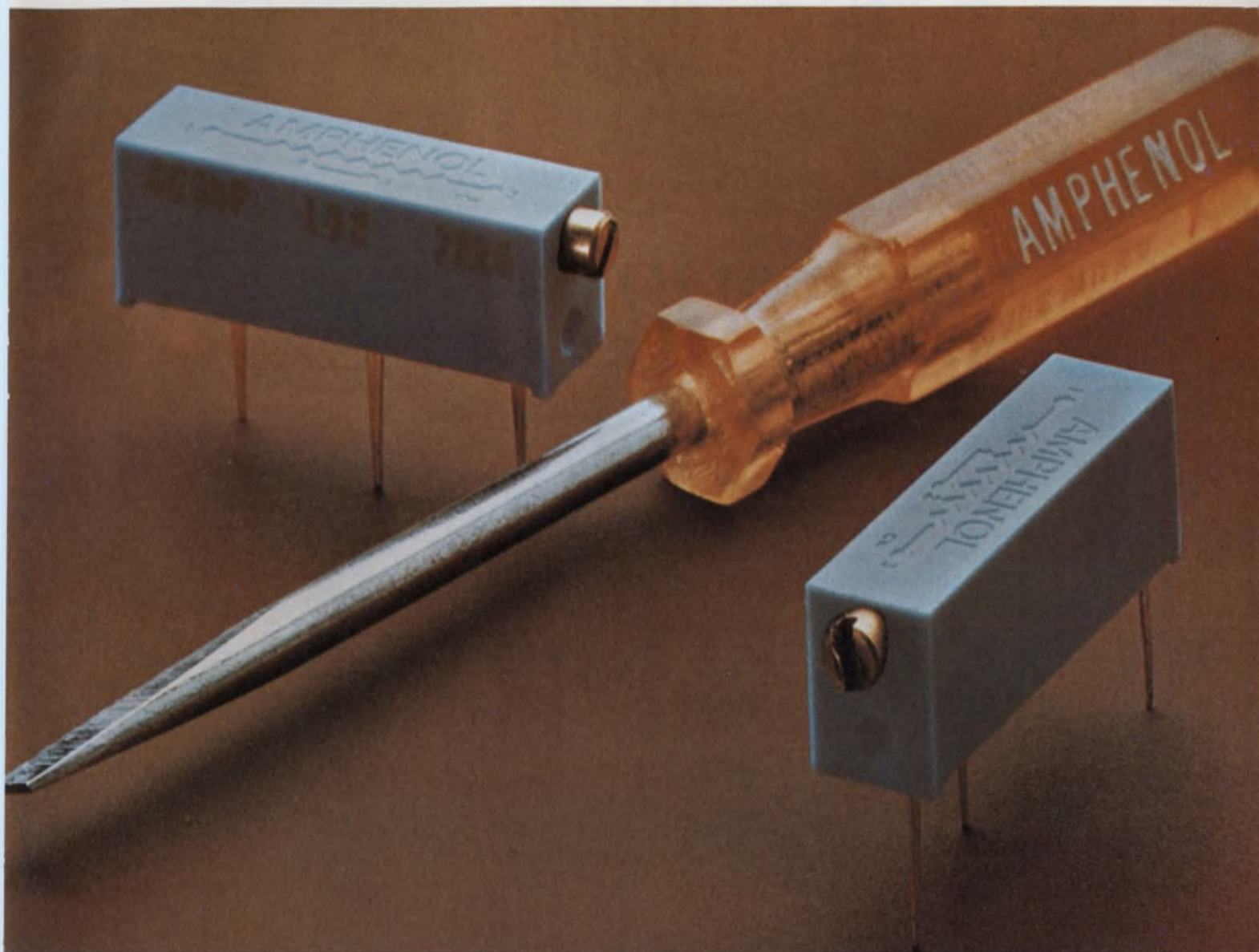
The action prompted Rep. Les Aspin (D-Wis.) to call for a General Accounting Office investigation of the Navy's decision to keep paying costs. Aspin also charged that the Navy was hiding overruns on a Government-furnished sonar system to be put on another Litton ship program, the DD-963 destroyer. Litton meanwhile says that despite Congressional concern, the DD-963 program is in good shape and is meeting both its budget and production schedules.

## **FCC to unsnarl communications satellite tangle**

The Federal Communications Commission is expected to rule soon on the complicated question of domestic communications satellites in the wake of a new alignment by the Comsat Corp. and the MCI Lockheed Satellite Corp. The two companies, both of which were applying for domestic satellite systems, have agreed on a proposed jointly owned system. Comsat, which also is applying to lease satellite service to AT&T through a separate system, says now it would withdraw another earlier application for a system to serve all customers other than AT&T. All the would-be communications-satellite operations, including Western Union which already has ordered satellites for an as-yet unapproved system of its own, are anxiously awaiting the FCC's ruling on their applications.

**Capital Capsules:** The Engineering Dept. of the Electronic Industries Association has issued the **first recommended standard for thyristors**. The 192-page document is available from EIA, 2001 Eye St. N.W., Washington, D.C. 20006. . . . The Government Printing Office has published a **Handy Metric-Conversion wallet card**. . . . NASA has selected the **Hughes Aircraft Co., TRW Systems and Avco** to study system design for a **Pioneer-class spacecraft to probe Venus**. . . . ITT Gilfillan has won a NASA contract to develop a **visible laser communications experiment for the Applications Technology Satellite**. . . . The **International Voluntary Standards Cooperation Act (S1798)**, which would provide Federal participation in setting international electronics standards and thus help U.S. industry abroad, has **passed the Senate but is stalled in the House Commerce Committee**. . . . The new **Transit navigational satellite** that went into a near-polar orbit earlier this month is transmitting experimental data at 400 and at 150 MHz. After **experiments lasting until early spring**, the satellite will be available to all Transit users, Navy and commercial. The new satellite updates the Transit that went up in 1964.

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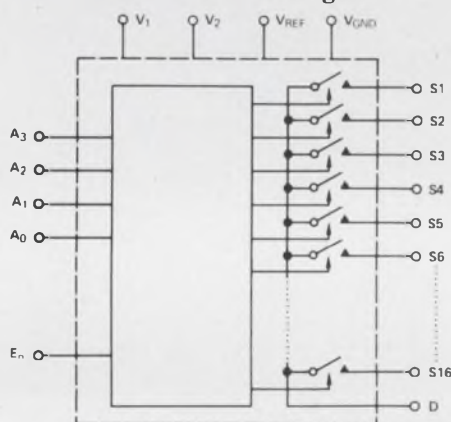
# Switch 16 channels with CMOS DG506.

Here is a single-pole 16-channel multiplexer using paired CMOS FETs, with drivers controlled by a 4-bit binary word input plus an Enable-Inhibit input — all on one chip! Check the functional diagram and then refer to the decode truth table to see what binary word input selects which switch.

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- $\pm 15$  V Analog signal range
- Break-before-make switches
- ON resistance  $< 500$  ohms
- TTL, DTL, and CMOS direct control interface
- 36 mW standby power

DG506 Function Diagram



Decode Truth Table

A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>	E <sub>n</sub>	ON SWITCH
X	X	X	X	0	NONE
0	0	0	0	1	1
0	0	0	1	1	2
0	0	1	0	1	3
0	0	1	1	1	4
0	1	0	0	1	5
0	1	0	1	1	6
0	1	1	0	1	7
0	1	1	1	1	8
1	0	0	0	1	9
1	0	0	1	1	10
1	0	1	0	1	11
1	0	1	1	1	12
1	1	0	0	1	13
1	1	0	1	1	14
1	1	1	0	1	15
1	1	1	1	1	16

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INFORMATION RETRIEVAL NUMBER 29

# Some questions for rivals in the Presidential race

It is difficult to recall a Presidential election campaign in which the two candidates held such divergent views on so many issues—defense spending, Vietnam, the economy, national priorities and so on.

On defense, Senator McGovern believes that the military budget can be reduced substantially with no weakening of national security. President Nixon categorically rejects the slash-now, beg-later approach to defense policy. He views such programs as the B-1 bomber, F-14 and F-15 fighters, along with the Trident submarine, as necessary to this nation's defense in the decade ahead. The Senator from South Dakota, on the other hand, calls for a \$30-billion cut in defense spending over the next three years and cancellation of the B-1, F-14, F-15 and Safeguard ABM programs.



These and other important issues will be discussed and scrutinized by the electorate in the weeks ahead. However, there are other questions that remain to be answered—questions that have an important bearing on engineering. For example:

What steps will the candidates take to stabilize once and for all, the cyclical unemployment in major sectors of the electronics industry?

What can be done with the thousands of unemployed and underemployed electronics engineers as a result of the recent recession?

What can be done to make the electronics industry less dependent upon fluctuations in defense spending?

Since research is the key to maintenance of technical superiority, what plans do the candidates have to keep the U.S. on top through consistent government support of research and development?

What steps will the Administration take to make the public aware that more technology—not less—is needed to solve the problems of shrinking resources, urban blight, transportation decay and increasing pollution?

What plans do the challenger and President have to modify the winner-take-all method of awarding Government contracts, with its crippling effects upon both the losing company and the latter's geographic region?

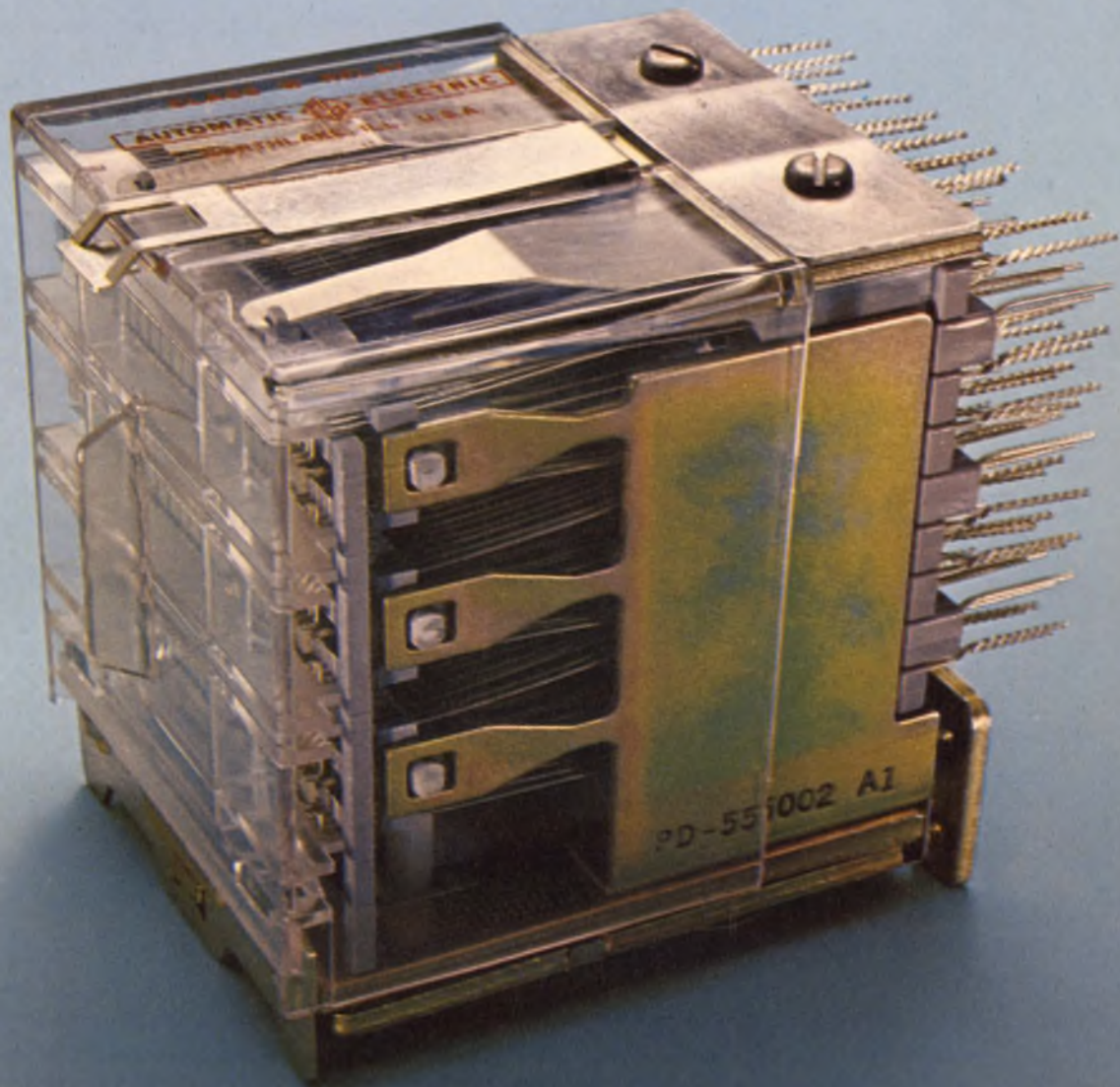
We hope that in the remaining weeks of this campaign the two candidates will address themselves to these questions. They affect the welfare and professional status of the engineer.

A handwritten signature in cursive script that reads "Ralph Dobriner". The ink is dark and the signature is fluid.

RALPH DOBRINER  
Managing Editor



# Reliability is staggered steps and a hunk of DAP.





### **Expect over a billion operations.**

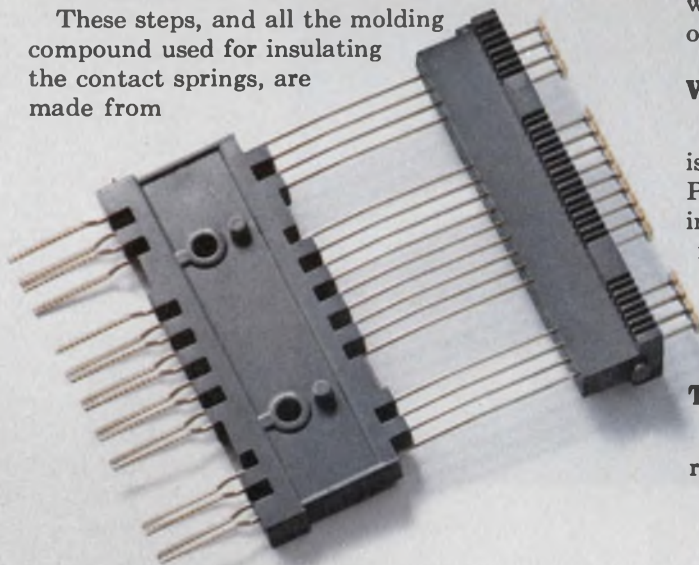
Our Class W wire-spring relay is different. In fact, there's nothing like it in the entire industry. Where else can you find a relay with lots of contacts and a mechanical life of more than a billion operations! That's about two and a half times the life of the best conventional relay around.

Another nice thing about our Class W is that it takes up a lot less space and costs less than using a bunch of other relays. That's because we build our Class W relay with one, two or three levels of contact assemblies, with 17 form C combinations per level. By the way, they're available with gold contacts for low-level switching.

### **Making it tough on creepage.**

All those staggered steps you see on the side were put in to raise the breakdown voltage between terminals. These molded steps add extra creepage distance between the terminals. This really counts for high voltage testing, or when using our Class W in unfavorable ambient conditions.

These steps, and all the molding compound used for insulating the contact springs, are made from



diallyl phthalate. (They call it DAP for short.) It has great insulating properties and it wears like iron. Even if the humidity is high, you have excellent protection.

### **Redundancy—two springs are better than one.**

Each of our long wire-spring contacts has an independent twin with the same function. One tiny particle of dust could prevent contact on other relays. Not with our Class W. You can be sure one of the twins will function. That's back-up reliability.

The twin contacts are twisted together at the terminal end. Then we give them a spanking (you might call it swedging) to provide solderless wrap.

### **We're for independence.**

Our springs are longer, because the longer the spring, the more independent they get. And the better contact they make. Don't forget, the wire-spring relay is the most reliable way to get a permissive make or break contact. You can rely on it.

The middle contact springs have to be stationary. To make sure they stay that way forever, we actually mold them between two thick pieces of DAP on both ends. Just try to move one.

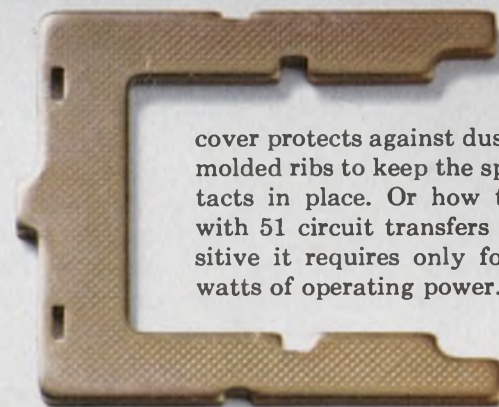
### **When we say flat, it's flat.**

Each frame, banged out by a gigantic machine is extra thick and extra flat. Then they're planished. Planishing is another step we go through in forming the frame to add strength and stability by relieving surface strain.

We've made our spring-loaded pile-up clamp extra thick, too. Once it's tightened down, the whole pile-up is nice and tight, and stays tight.

### **There's more.**

We could tell you a lot more about our Class W relays. Like how the tough high-temp molded



cover protects against dust and has molded ribs to keep the spring contacts in place. Or how this relay with 51 circuit transfers is so sensitive it requires only four to six watts of operating power.

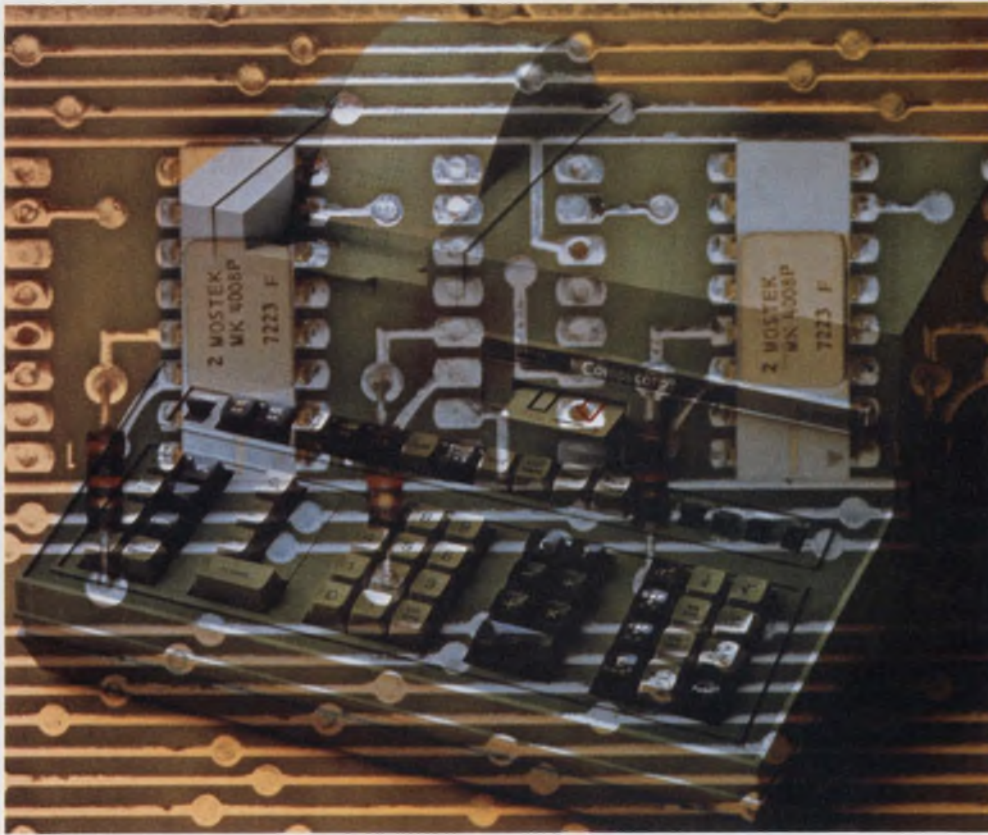
But why don't you let us prove how much reliability we put into our Class W? We'll be waiting to hear from you. GTE Automatic Electric, Industrial Sales Division, Northlake, Ill. 60164.

# **GTE AUTOMATIC ELECTRIC**

INFORMATION RETRIEVAL NUMBER 30



# The calculator and the engineer



Programmable calculators, once rarely used in engineering, are rapidly becoming one of the most valuable tools that a design engineer or engineering manager has.

These calculators serve the engineer both at his desk and in the laboratory. At his desk, the machine provides rapid, easy solution of problems that otherwise wouldn't be attempted or that would require a small computer to solve. In the laboratory, the calculator can make speedy calculations between measurements or even acts as a central processing unit and controls an automated test system.

Programmable calculators are getting both smaller and larger. Hand-held machines are starting to intrude on the realm of the slide rule. Larger programmable calculators—with a full array of peripherals, such as printers, plotters,

**David N. Kaye**  
Senior Western Editor

digitizers, expandable memory and the like—are beginning to fuzz the boundary line between calculators and minicomputers. The larger calculators have several hundred storage registers and can handle programs with several hundred steps.

Prices for programmable calculators range from less than \$1000 to nearly \$10,000. When you add peripherals, the costs can go much higher.

Engineers sometimes ask: "For my job, do I need a programmable calculator, a minicomputer or a time-shared terminal?" The answer comes from a thorough understanding of the capabilities and limitations of each. Many articles

have been written about the capabilities and limitations of minicomputers and time-sharing. Not much has been said about programmable calculators.

ELECTRONIC DESIGN has put together three articles on the capabilities of the programmable calculator and possible applications. The first article gives a broad overview, explaining functional capability, programming and calculator structure in a general way. There is also a discussion of the use of a calculator as a system component.

The second article will consider the programming features of the calculators and their limitations. And the third article will discuss the expansion of a calculator system with peripherals.

*Starting in this issue with the first article, the series will be continued in the next two issues of ELECTRONIC DESIGN.*



# The Calculator and the Engineer -- Part 1

**Try it on the calculator.** If the design is too troublesome for manual analysis but not complex enough to justify use of a computer, try a programmable calculator.

Once mere adding machines, sometimes improved with a few special keys, calculators are now available as powerful, flexible, interactive systems that rival small computers. Still, today's programmable calculators—as machines with such expanded capability are called—are just as easy to use as their predecessors. They fill the gap between the slide rule and the computer, doing hundreds of odd jobs that don't quite fit the computer and simply would never get done by hand.

Consider these facts if you are a designer who has yet to investigate the value of these machines and how they operate.

- Programmable calculators come in two

Paul L. Asmus, Hewlett-Packard, Calculator Products Div., P.O. Box 301, Loveland, Colo. 80537

languages, keyboard and algebraic, and each has a wide choice of capabilities.

- Most of the peripherals available to computers can be used, including card readers, tape readers and punches, X-Y plotters, output printers, digitizing devices and general-purpose interfaces.

- Keyboards are used not only for entering data for on-the-spot calculations but also for entering programs, and separate keyboard sections are available for special functions. Most of the program language appears right on the keyboard.

- Displays show calculated results, input data and programs, and they range from a simple numerical presentation to a complete alphanumeric, real-time output. Often there's a built-in hard-copy printer, and usually there is a magnetic-card or cassette unit for storing and read-



1. A programmable keyboard-language calculator is almost as easy to operate as the old adding machines.

Built-in card readers, displays, printers and a program mode make it a powerful problem solver.



ing back data and programs.

- Editing, syntax-checking and error-detecting features are often built in.

### Shipped ready for instant use

Programmable calculators are ready to use right out of the shipping carton. On keyboard-language calculators (Fig. 1) complete operation—such as add, subtract or multiply—is normally defined by a single key. When the key is pressed in the operate mode the operation takes place immediately. Many functions that need several operations—such as storage, search, printing and many user-defined specials—can often be done with at most two key strokes.

Programming a keyboard-language calculator is done by switching it to its learn-program mode and pressing the keys in the same sequence that you would to make calculations directly. Thereafter the calculator can repeat a complex sequence automatically, stopping only to wait for new data at selected points or to take prestored data from the memory or registers.

Keyboard-language calculators are easy to master. With almost no experience in programming, you can operate a unit with fair efficiency almost immediately and program effectively in days.

The keyboard calculator is powerful. The simpler unit can execute sequentially about 500 programmed steps, and more advanced machines can handle several thousand steps. Each step is represented by a single-key operation. Most keyboard calculators can store about a hundred floating-point numbers, and they can easily solve 10 simultaneous linear equations. Almost all units operate internally with at least 12-digit precision, although the output may be rounded off to any lesser precision the user selects.



2. A programmable algebraic-language calculator accepts and displays equations almost as you would write them.

But a limitation of the keyboard calculator is that it is cumbersome to use to solve really long and complex problems. Although it has all the instructions to do the job, the long sequence becomes tedious.

### Algebraic units solve complex equations

The algebraic programmable calculator (Fig. 2) is a better choice for solving complex equations. Its language and displays are very similar to a computer's. An engineer familiar with FORTRAN, BASIC or any other well-known programming language can use an algebraic calculator almost immediately. He enters the expression in the calculator with almost the same symbols he uses to write it on paper.

Each key represents the code of one function

## Calculators offer more than just answers

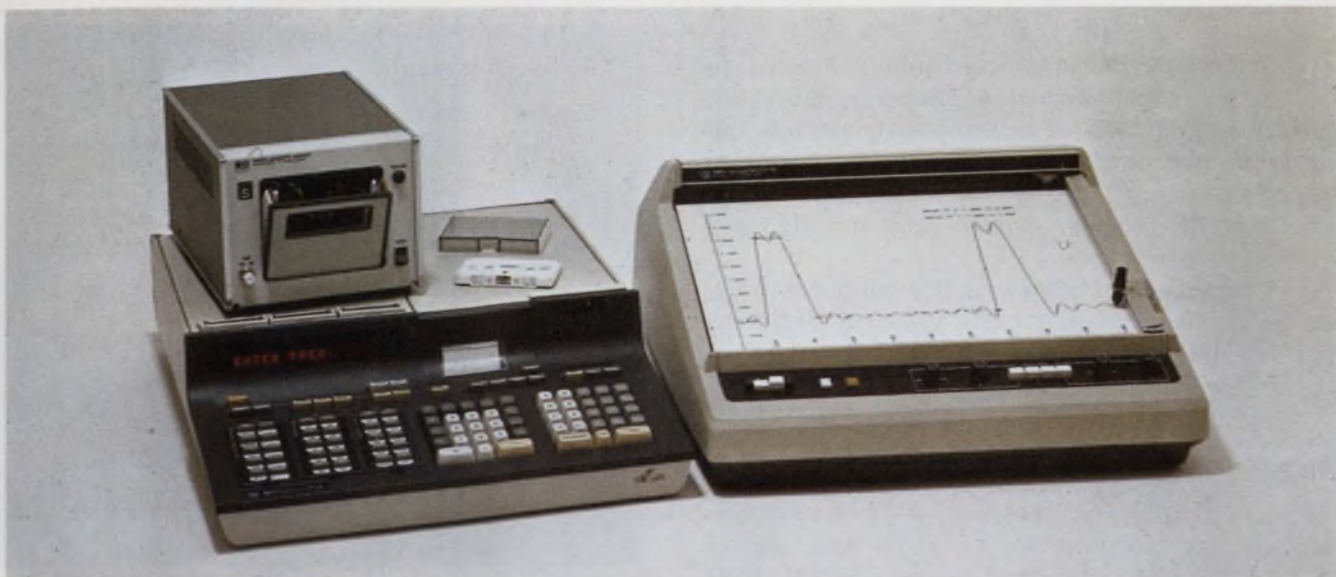
Programmable calculators encourage engineers to try things they might not otherwise do. "I haven't time to mess with that" becomes, "Let's try that on the calculator."

A simple RC trigger circuit, for example, often gets designed by rule of thumb. Solving the few exponentials is conceptually simple, but it requires tables or a slide rule. In the time it takes to find the right set of tables, an engineer can punch a two or three-line program on a calculator and accomplish a lot more—find out how resistor tolerance affects delay time or what the linearity of the charge rate is.

Or consider the engineer making a field-

strength plot for an antenna. The calculations involved aren't too complex, but they are time-consuming—there are sines and cosines to look up, lots of data to jot down. He can "write" a complete program on an algebraic calculator in the time it takes to calculate one point with a slide rule. With time to spare, he can make several plots—or change the length of the stub or the number of turns of the coupling coil and watch the results. Soon he sees that the back lobe widens or narrows, or that directivity increases. He's learning something about antennas—something important, something he might not have time to learn without his calculator.





3. **Programmable calculators that use a bus architecture** are easy to interface with almost all the peripherals

available to minicomputers such as X-Y plotters and magnetic-tape cassette units.

of a program, even though in the display it may appear as a two or three-character mnemonic. A program statement like `IF A > C; GTO 16` takes eight characters, since `IF` and `GTO` are only one character each. The expression appears on an alphanumeric display as it is entered.

At any time during the entry the expression may be backed up and edited. An error causes the calculator to display an error message. Errors in a line, such as failure to include a terminal parenthesis, prevent the calculator from executing or storing the line; instead the machine displays a diagnostic code. When the program is running, performance errors, such as an attempt to divide by zero or to take logs of a negative number, stop the calculator, and an error code is displayed along with an indication of the line in which the error occurred.

Once the expression is properly entered, pressing an "execute" key produces the calculated result. If a "store" key is pressed instead, the calculator assigns a number to the entered line of algebraic figures (as the user sees it on the display), and the machine stores both the line number and expression in its memory.

### Calculators do have their limits

However, there is a limit to the size of problems that even an algebraic calculator can handle. Available memory capacity is the main limiting factor. Although peripherals like tape cassettes can substantially expand the memory, use of a calculator beyond a certain point is inefficient. A computer may be better here.

Unfortunately there is little agreement among

calculator manufacturers and users on how best to measure capability. Some use the number of registers, others the number of program steps that can be handled. But different calculators may use different percentages of their memory for a particular step, and not all registers are the same size or can do the same things. Comparison is difficult, but not impossible. Let's examine some helpful guides.

### Measuring capability

To use the number of registers as a measure of calculator capability, the engineer must first understand their purpose and the sizes they come in. In general, a register is a memory circuit that is big enough to store a 12-digit or longer floating-point number, its sign and a two-digit exponent with its sign. This is equivalent to four, 16-bit words. Therefore a common calculator with 100 registers has the equivalent of about 400, 16-bit words of memory.

In some calculators all registers can be used interchangeably for either program or data storage. Other calculators have registers set aside for data only, while different registers hold program information only. When used for program storage, a register holds from eight to 16 steps in keyboard machines, and about eight characters of program in an algebraic machine.

Thus, in judging calculator capability the number of registers alone is insufficient information. The size and allowed flexibility in using the registers must also be considered.

To use total program steps as an effective measure of calculator capability, you must know



how much calculating is done with each step. In most keyboard machines, arithmetic operations use one or at most two steps. Storage and recall operations and indirect arithmetic operations call for from two to six steps. Conditional transfer operations require two to five steps. And special functions, like trig or square root, usually need only one step.

A comparison of step-capacity numbers only, can be quite misleading. The types of problems that the user will be solving have a great effect on the meaning of this capacity number.

### The calculator is easily interfaced

Programmable calculators with a bus architecture are easy to interface (Fig. 3) with digital devices that use standard codes. Digital voltmeters, counters, X-Y plotters and tape-cassette units are only a few of the peripherals that may be used. In fact, a variety of standard packages are available for interfacing calculators with peripherals that use BCD and ASCII codes. A calculator, an interface card set and a DVM make an inexpensive measuring, data-processing and logging system. The voltages measured automatically by the DVM are fed into the calculator, and they can be converted to other units of measurement, if desired. A complete statistical analysis can be done. And a printer, usually part of the calculator, makes the system a data logger.

Further, while serving in such dedicated systems, the calculator can still be used for its basic purpose—calculating. Built into its language is the ability to disconnect from the interface; there is no need to physically reconfigure the system in any way.

There are two main approaches to calculator interfacing: the dedicated interface and the general-purpose coupler. The dedicated interface connects a single peripheral device directly to the calculator's internal bus. As many as four interface cards are used. The calculator has full control over the bus, directing and routing data between itself and the peripheral.

The general-purpose coupler, however, provides its own external bus system, and couplers with as many as eight interface channels are available. Thus up to eight different devices can be simultaneously connected to a calculator.

By using a general-purpose coupler, with an ASCII input-output card, and a programmable power supply, you can make an automatic stimulus source for testing. Combine this with a DVM and a data scanner (often part of the DVM), and you have an automatic test system for circuit boards. The different functions of DVMs—such as ac or dc, volts or milliamperes, or ohms—and



4. Automatic testing, data analysis and logging can be done by coupling a programmable calculator to programmable signal sources and measuring instruments. A programmable frequency sweeper and tracking detector, when added to a calculator, becomes a versatile network analyzer that is simple to program.

their ranges are also controlled by the calculator. The program for the tester is written in the same language used for normal calculator work.

By combining a programmable frequency sweeper and tracking detector with a calculator via a general-purpose interface card, you get a very versatile network analyzer (Fig. 4). The calculator controls the measurement cycle and then analyzes the results. Hi-go-lo testing, statistical analysis and even self-calibration can be done. And with a tape cassette added, the calculator can maintain a history of the test data for the quality-assurance department.

Such systems are nearly as powerful, but much less expensive, than minicomputer configurations. At the same time calculator testers are very easy to use, and they can be readily reconfigured for other jobs.

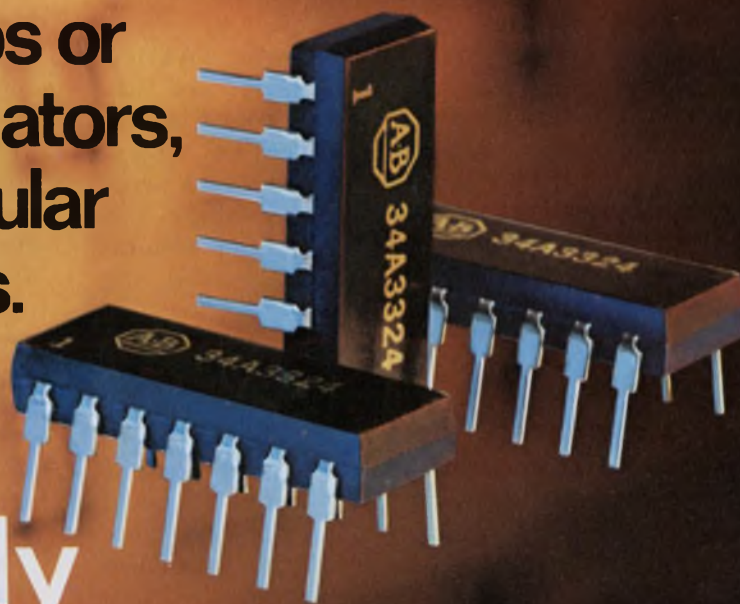
Speed, however, is an important limitation with calculators. A calculator-DVM combination can operate at 40 to 50 readings a second. A comparable minicomputer system can operate several magnitudes faster.

Another limitation is the relatively small on-line storage capability of calculators—generally only several hundred storage locations. This can be improved by using the usual 12-digit calculator register to hold two numbers of five digits each. However, this results in a sacrifice of speed. A further way of improving storage capacity, if speed is not important, is to store the data on a magnetic-tape, cassette or cartridge unit, or a magnetic disc. In this manner, very large amounts of data and programs can be handled. ■■



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Actual Size



**Allen-Bradley**  
Milwaukee, Wisconsin 53204



# Cut synchro-to-digital conversion costs

and improve performance with this simple converter. Extensive use of digital ICs simplifies its quantity production.

In spite of increasing synchro-to-digital conversion needs, present conversion techniques are complex and frequently shrouded with proprietary labels. The common approaches—using nonlinear function generators or interpolation techniques<sup>1</sup>—result in hardware that is difficult to mass-produce. Calibration, production-testing and repair are problems.

The arc synchro-to-digital converter (ASDC) avoids these shortcomings. (The term "arc" underscores the fact that the device converts arc-sine or arc-cosine functions). An ASDC with a peak error of  $\pm 5.4$  arc minutes, or 12-bit accuracy, can be built for \$130 in parts (single-unit prices). Since neither nonlinear function generation nor interpolation techniques are used, the ASDC can be mass-produced easily.

## ASDC operation is simple

The basic ASDC encoding technique for converting a synchro input into a  $0^\circ$ -to- $360^\circ$  output is very simple, since it uses the best known waveshape—a sine function. This sinewave function is readily available in the form of synchro excitation voltage. The standard three-wire, 120-degree-spaced synchro input is converted into a sine and a cosine function with a Scott-T transformer (see box for brief explanation).

To understand the basic ASDC operation, suppose that we have two inputs: a dc signal  $R \times \sin \theta$ , varying in amplitude as a function of a shaft angle,  $\theta$ , with the maximum possible positive value of  $R$  volts, and a sinewave  $R \times \sin \omega t$ , varying as a function of  $\omega t$ , also with the maximum possible positive value of  $R$  volts. In addition suppose that we have available a square-wave,  $\text{Ref}_{\text{so}}$ , varying between 0 and +5 V, whose positive portion coincides in time with the positive half cycle of  $R \times \sin \omega t$ .

If we connect these signals (Fig. 1a), we obtain an output pulse train, with the pulsewidths proportional to  $\theta$ . Mathematically,

$$R \times \sin \theta = R \times \sin \omega t, \quad (1)$$

or, canceling terms,

$$\theta = 2\pi \text{ ft.} \quad (2)$$

The comparator of Fig. 1a, ideally, can swing instantaneously between 0 and +5 V. In practice, however, as  $R \times \sin \theta$  approaches the peak of  $R \times \sin \omega t$ , the finite gain of a "live" comparator will begin to show as jitter in the encoded pulsewidths. To solve this problem, the other output of the Scott-T transformer ( $R \times \cos \theta$ ) is used. To understand how, assume that  $\theta$  is in the first quadrant. As  $\theta$  approaches  $90^\circ$ ,  $R \times \sin \theta$  will approach the peak value of  $R \times \sin \omega t$  ( $R$  volts). Simultaneously  $R \times \cos \theta$  will approach zero volts. At  $\theta = 45^\circ$ ,  $R \times \sin \theta$  equals  $R \times \cos \theta$ . By detection of this equality, pulsewidths are generated, with  $R \times \sin \theta$  used for angles of less than  $45^\circ$ . For angles of greater than  $45^\circ$ ,  $R \times \cos \theta$  is used as the input to the comparator of Fig. 1a. For effective encoding, dual comparators are required for detecting  $\theta$  as it passes through all four quadrants.

This dual-mode comparison is summarized graphically in Fig. 2. It should be noted that the IC comparators must have these minimum characteristics to achieve the accuracy of  $\pm 5.4$  arc minutes:

- Minimum gain of 200 V/mV.
- Response time of 100 ns or less.

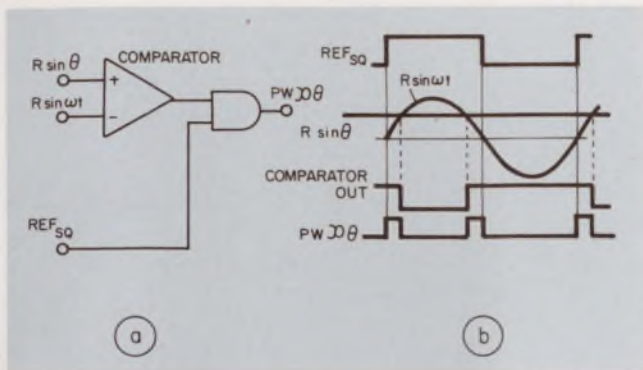
## Understand ASDC timing

Basic to the operation of the ASDC is the use of a complete cycle of  $R \times \sin \omega t$  for the peak detection (or sampling) process. This is done to avoid comparison of negative  $R \times \sin \omega t$  voltages, thus reducing component count and logic complexity. Referring to Fig. 3, we see that the complete conversion cycle is:

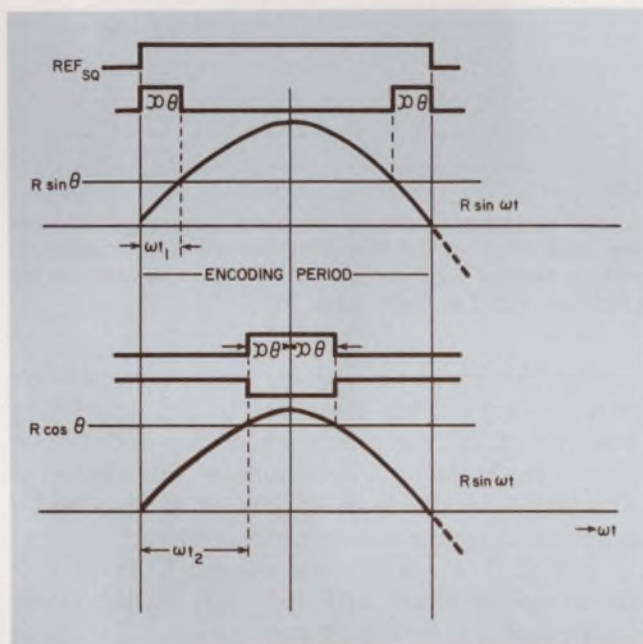
1. Peak and quadrant detection.
2. Encoding.
3. Reset function.

The presence of the  $R \times \sin \theta < R \times \cos \theta$  comparator output throughout the encoding period provides the switching reference for the dual-mode comparison.

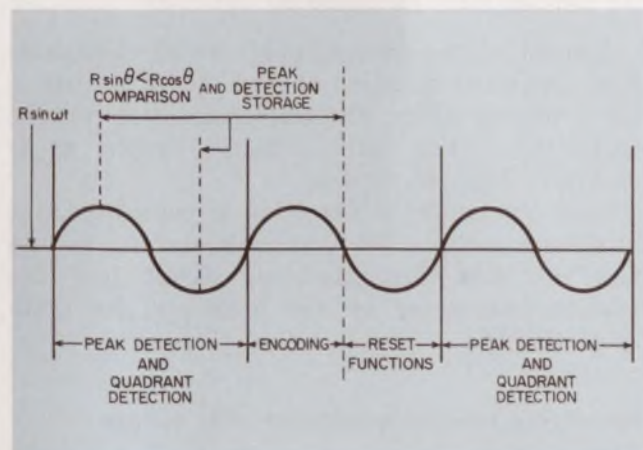
Before proceeding with octant-by-octant operation of the ASDC, note that the  $R \times \sin \theta < R \times \cos \theta$  comparator need not be very accurate, since the pulsewidth jitter does not become significant until  $\theta$  becomes about  $70^\circ$ . Furthermore the octant selection itself does not have to be



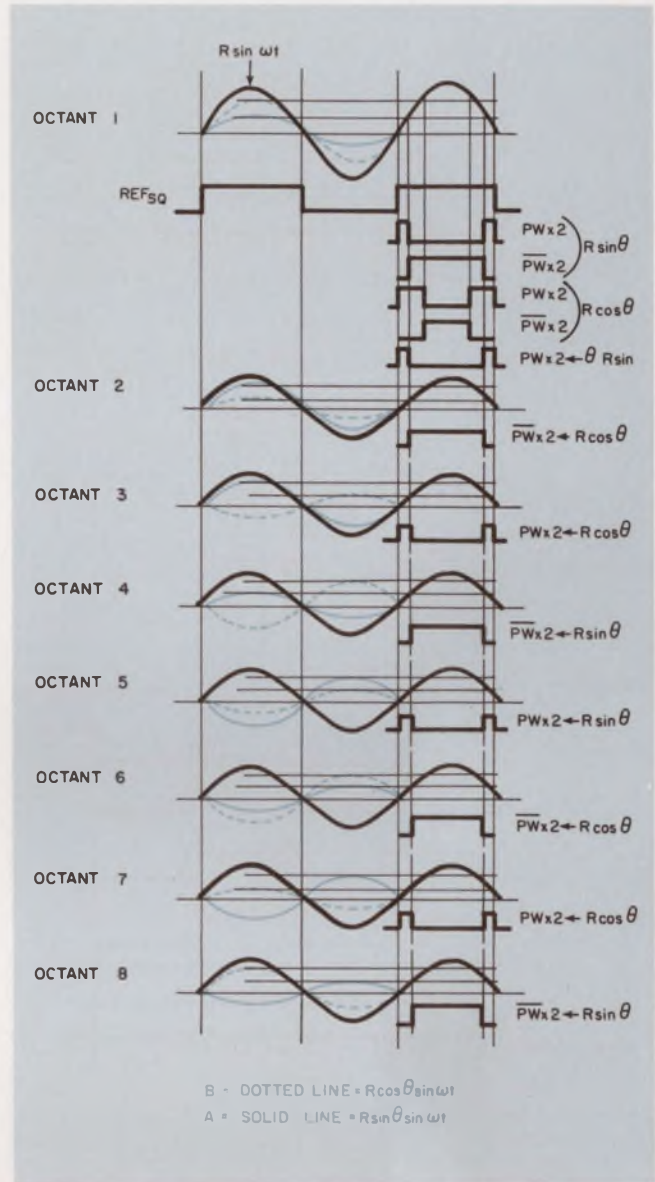
1. Synchro-to-digital conversion is based on generating pulsewidths (PW) proportional to the angle  $\theta$ . The principle is illustrated in a simple circuit (a) and its waveshapes (b).



2. To eliminate pulsewidth jitter at large angles, both outputs of the Scott-T transformer ( $R \times \sin \theta$  and  $R \times \cos \theta$ ) are used. The  $R \times \sin \theta$  is used for angles of less than  $45^\circ$ , and  $R \times \cos \theta$  is used for angles of more than  $45^\circ$ .



3. Use of a complete cycle of the reference signal ( $R \times \sin t$ ) results in fewer components and simpler logic for timing various encoding events.



4. Selection of the encoded angle's octant is done after determining the corresponding quadrant (see Table 1) and then "looking" at the waveshapes shown above.

precise. Thus this comparator can have a sizable hysteresis without effect on ASDC accuracy. This is a significant advantage over existing synchro-to-digital converters that rely on octant selection for generating the third most significant bit in the digital angle output.

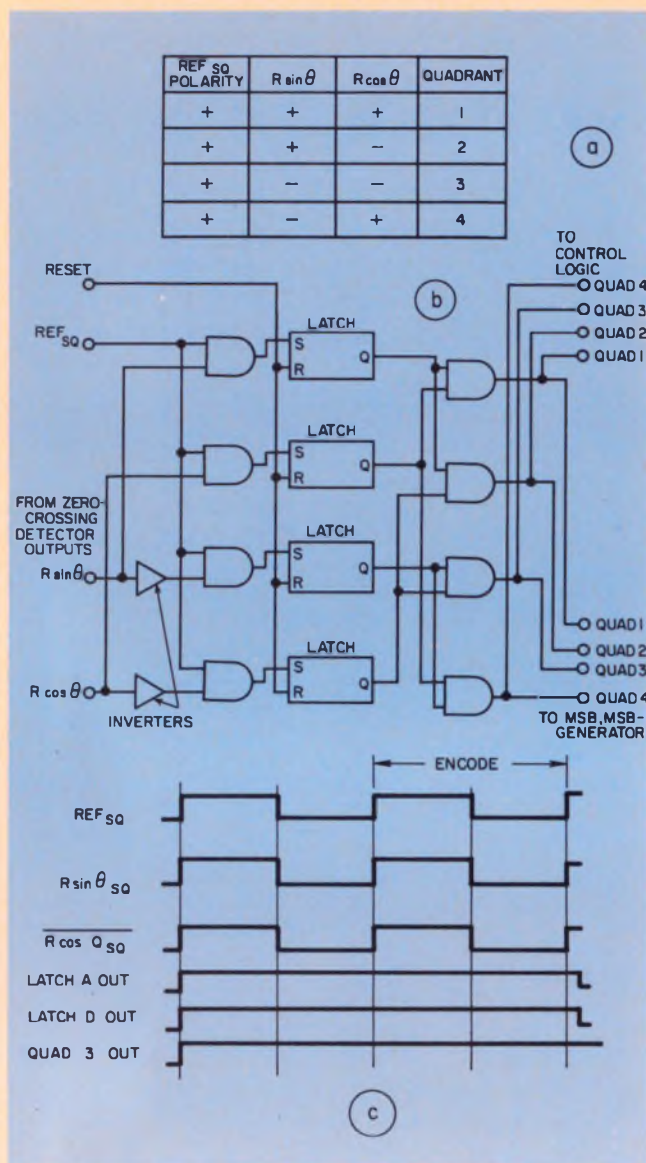
#### Selecting the octants

Octant selection is summarized in Table 1, with octant-by-octant waveforms sketched in Fig. 4.

Octant I is characterized by the fact that both  $R \times \sin \theta \times \sin \omega t$  and  $R \times \cos \theta \times \sin \omega t$  prior to peak detection are in phase with  $R \times \sin \omega t$ . The reference squarewave,  $\text{Ref}_{SQ}$ , is obtained by squaring  $R \times \sin \omega t$ , and it provides the master timing reference for the ASDC operation.

Note that a total of four pulse trains (marked  $\text{PW} \times 2$  or  $\text{PW} \times 2$  in Fig. 4) are provided

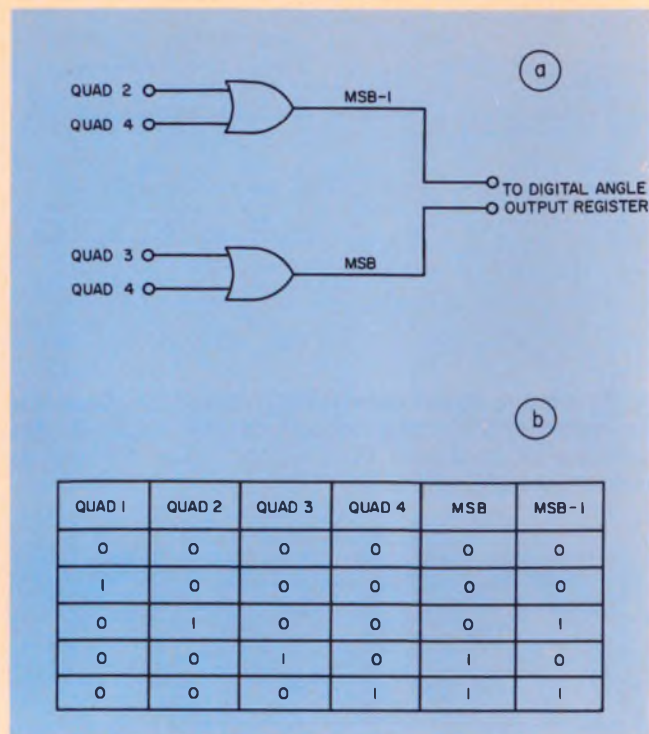




5. Instead of conventional demodulators, quadrant selection is essentially digital, in accordance with the truth table (a) and its implementation (b). The operation is detailed in "c."

## Dual-mode comparison and encoding

$R \sin \theta$ $\times R \sin \omega t$ POLARITY	$R \cos \theta$ $\times R \sin \omega t$ POLARITY	QUAD- RANT	$R \sin \theta <$ $R \cos \theta$	OCTANT	CHOOSE $R \sin \theta$ IN FORM OF		CHOOSE $R \sin \theta$ IN FORM OF	
					PWx2	PWx2	PWx2	PWx2
+	+	1	YES	1	x			
			NO	2				x
+	-	2	NO	3			x	
			YES	4		x		
-	-	3	YES	5	x			
			NO	6				x
-	+	4	NO	7			x	
			YES	8		x		



6. The most significant bit and next most significant bit are generated on the basis of the detected quadrants with a simple logic circuit (a), which operates in accordance with the truth table (b).

during the encoding period, two corresponding to  $R \times \sin \theta$  and the other two to  $R \times \cos \theta$ . The selection of the right pulse train for encoding is shown in Table 1. For example, the choice of  $R \times \sin \theta$  in the form of  $PW \times 2$  in octant 1 is preceded by the following conclusion:

1. Both  $R \times \sin \theta \times \sin \omega t$  and  $R \times \cos \theta \times \sin \omega t$  are in phase with  $R \times \sin \omega t$ , thus indicating that  $\theta$  is in the first quadrant.

2. The peak-detected value of  $R \times \sin \theta$  is less than the peak-detected value of  $R \times \cos \theta$ .

The ASDC operation in other octants can be followed from Table 1 and Fig. 4.

## No demodulators for quadrant detection

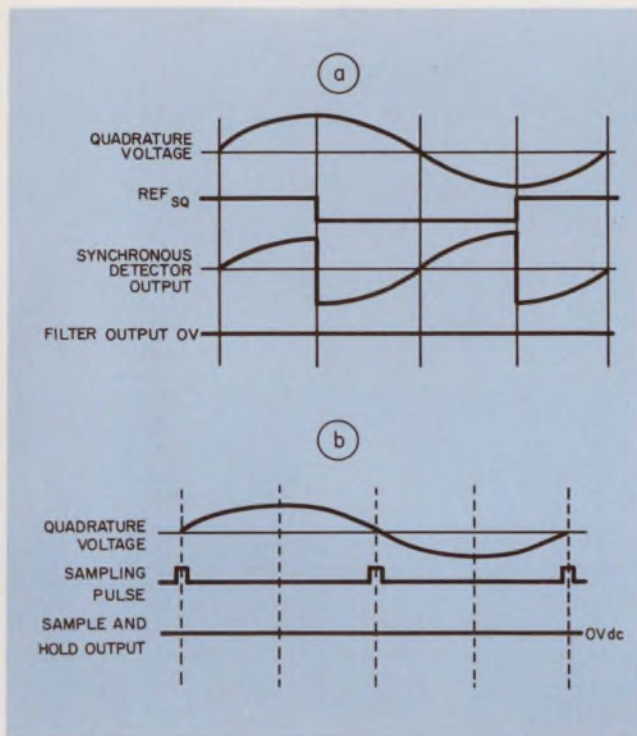
Instead of the conventional use of demodulators, quadrant selection in the ASDC is essentially digital (Fig. 5). Implementation of the truth table (Fig. 5a) is fairly simple, as is shown in Figs. 5b, and 5c.

Once the quadrant detection is completed, the bits representing  $180^\circ$  (the most significant bit) and  $90^\circ$  (the next most significant bit) are readily determined by the logic and its truth table (Fig. 6).

## Minimizing synchro quadrature null voltage

One of the most important features of the ASDC is its ability to reject the synchro quadrature voltage. To appreciate this, let's review very





7. To improve the conventional quadrature voltage rejection technique (a), the ASDC uses a specially designed peak sampler that rejects the quadrature voltage in accordance with "b."

briefly the errors produced by the quadrature voltage and an existing technique for their elimination.

All synchros (and resolvers) exhibit a fundamental null voltage, along with harmonics (predominantly the third) when the synchro is positioned at its electrical zero. The harmonics can be filtered out, but the fundamental null voltage cannot, being of the same frequency as the synchro excitation voltage but with a quadrature ( $90^\circ$ ) phase shift.

The error caused by the quadrature null voltage can be substantial. For example, suppose that a quadrature voltage of  $20 \text{ mV dc} = R \times \sin \theta$  exists after detection and filtering. If ratioing is used and the maximum value of  $R \times \cos \theta$  is  $10 \text{ Vdc}$ ,

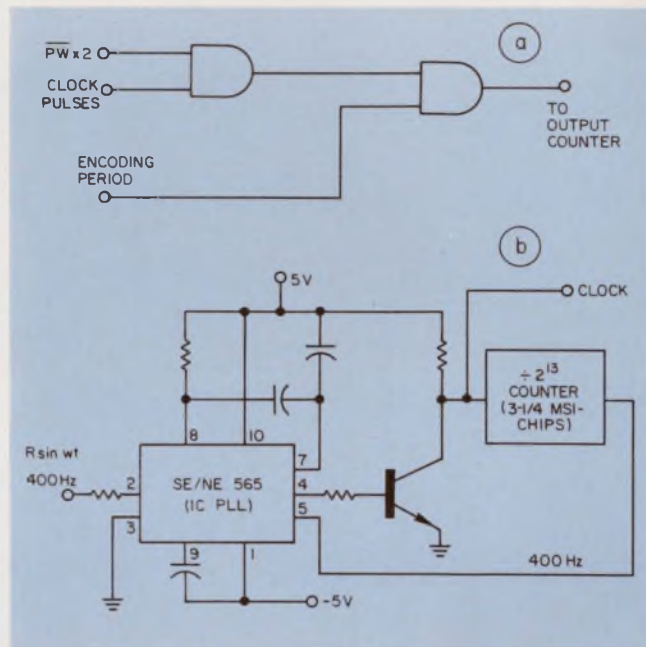
$$\frac{(R \times \sin \theta) / (R \times \cos \theta)}{(0.02) / (10.0)} = \tan \theta,$$

so that

$$\theta = 7 \text{ arc minutes of error.}$$

Among the previously available techniques for rejecting quadrature voltage, there is only one worth mentioning. Referring to Fig. 7a, we see that synchronous detection of  $\sin \theta$  and  $\cos \theta$  (or synchronous detection of ac error voltages generated within the conversion process) is used to eliminate quadrature voltages. This technique is widely used in high-accuracy, closed-loop tracking converters<sup>1</sup>.

The method used in the ASDC consists of sampling the  $R \times \sin \theta$  and  $R \times \cos \theta$  voltages



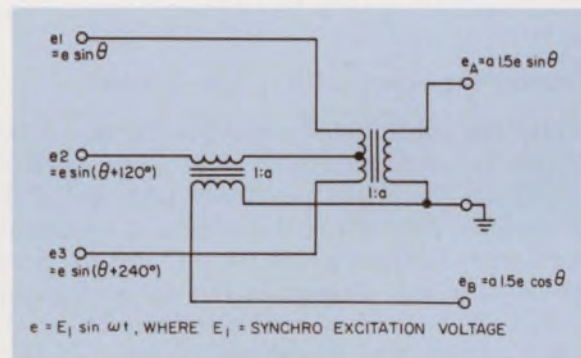
8. Pulsewidths are converted into digital data by a single AND gate (a) that puts out the clock pulses during the pulsewidth ( $PW \times 2$ ). The second AND gate stops the output pulses to the output counter at the end of an encoding period. To eliminate the effects of the drift in the reference signal (synchro excitation voltage,  $R \times \sin t$ ), the clock is slaved to the reference (b).

## What is a Scott-T transformer?

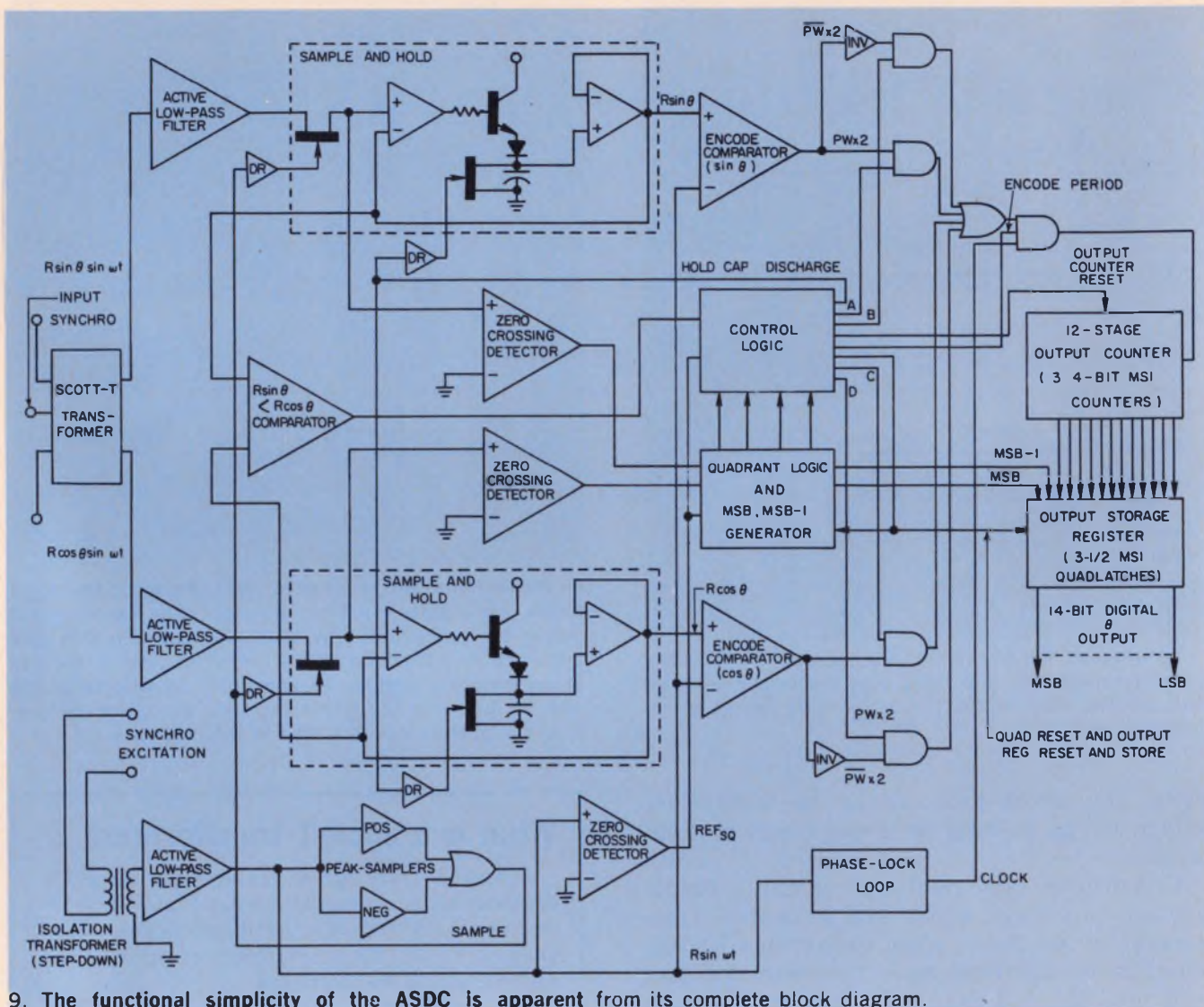
A Scott-T transformer converts the three 120 degree-spaced sinusoidal signals into two 90-degree-spaced sinusoids. As shown in the accompanying sketch, the transformer consists of two interconnected transformers.

The information in the output and input signals of the transformer is in the form of amplitude modulation of the carrier,  $e = E_1 \sin \omega t$ , whose magnitude varies as a function of the synchro shaft angle. A step-down ratio,  $1:a$ , is required to accommodate solid-state conversion circuits. Typical maximum outputs of a Scott-T transformer are  $20 \text{ V peak-to-peak}$ .

Highly accurate and compact transformers— $2 \times 1 \times 1/2$  inches, with errors as low as 45 arc sec—are commercially available at prices from \$5 to \$35.







9. The functional simplicity of the ASDC is apparent from its complete block diagram.

at the peaks of the reference carrier  $R \times \sin \omega t$  to avoid quadrature (Fig. 7b). Since the sampling accuracy in Fig. 7b depends almost entirely on how narrow the sampling pulse is, a special peak sampler<sup>2</sup> was designed for the ASDC. It permits generation of pulses as narrow as  $100 \mu s$  with a 400-Hz carrier. (The type of sample-and-hold circuit used to store the peak values of  $R \times \sin \theta$  and  $R \times \cos \theta$  is shown in the over-all functional schematic of the ASDC.)

#### Minimizing the effects of $R \times \sin \omega t$ drift

While the amplitude variations in the reference synchro excitation voltage,  $R \times \sin \omega t$ , have no effect on the ASDC accuracy because of the peak-sampler properties, the effects of commonly encountered frequency drifts of up to  $\pm 5\%$  must be canceled. This calls for an explanation of counting technique used for converting the encoded pulsewidths into digital angle values.

Assume that we are encoding a synchro shaft

angle of  $90^\circ$  and that the frequency of the reference,  $R \times \sin \omega t$ , is exactly 400 Hz. At  $90^\circ$  the selected encoded pulsewidth is  $PW \times 2$  (Fig. 4). This turns out to be a squarewave that is exactly coincident with  $Ref_{sq}$ . Since the ASDC is a 14-bit device and the most significant bit and next most significant bit are generated as a result of quadrant detection, the remaining 12 bits must be derived from the  $PW \times 2$  product corresponding to  $90^\circ$ . This is done by counting clock pulses that occur during the pulsewidth,  $PW \times 2$ , with

Clock frequency =  $2 \times 400 \times 2^n$  Hz/sec, where  $n$  is the number of least significant bits (LSB) remaining. Since in this case  $n = 12$ , the clock frequency becomes 3,276,800 Hz.

And since  $90^\circ$  is represented by 12 binary bits, this means that

$$LSB = 90^\circ / 2^{12} = 90^\circ / 4096 = 1.3 \text{ arc minutes.}$$

Thus, for the output digital angle to represent  $90^\circ$ , a counter must count a total of 4096 clock pulses in  $1/800^{\text{th}}$  of a second. The conversion of the  $PW \times 2$  pulsewidth into a digital output is



carried out by two AND gates (Fig. 8a).

In this scheme if the synchro-excitation-voltage frequency changes and the clock period remains the same, there will be an error in the digital output that is proportional to the frequency change.

To prevent this error, the clock is slaved to the synchro-excitation frequency by a phase-locked loop (Fig. 8b). While the phase-locked-loop circuit is designed with higher-than-usual gain (to keep the phase-locked loop error contribution below  $\pm 1\text{LSB}$  ( $\pm 1.3$  arc minutes), the circuit will be stable, since it has to track over frequency deviations of only  $\pm 5\%$ .

### How to encode an angle

Having covered the major design points of the ASDC, we can now go over its operation. Referring to Fig. 9, a complete functional schematic of the ASDC, let's follow the encoding of, say, a  $30^\circ$  angle.

The active low-pass filters attenuate harmonics and any high-frequency pickup is also filtered out.

The filter outputs are sampled at the positive and negative peaks of the reference sinewave,  $R \times \sin \omega t$ . Quadrant selection takes place as soon as the sampled peak voltages are available to the zero-crossing detectors. The stored peak voltages correspond to  $R \times \sin 30^\circ$  and  $R \times \cos 30^\circ$  in dc form. The  $R \times \sin \theta < R \times \cos \theta$  comparator decides that  $R \times \sin 30^\circ$  is less than  $R \times \cos 30^\circ$ , so that  $PW \times 2$  output of the encoding comparator is selected from the  $\sin \theta$  channel. The  $PW \times 2$  pulses are gated with the clock pulses, which are derived from the phase-locked loop. The gated clock pulses are counted by a 12-stage binary counter, with the maximum count of 4096 for a  $90^\circ$  angle. Since our angle is only  $30^\circ$ , the output of the counter is

$$(30^\circ/90^\circ) \times 4096 = 1365.333,$$

or, since the counter cannot count fractions, 1365.

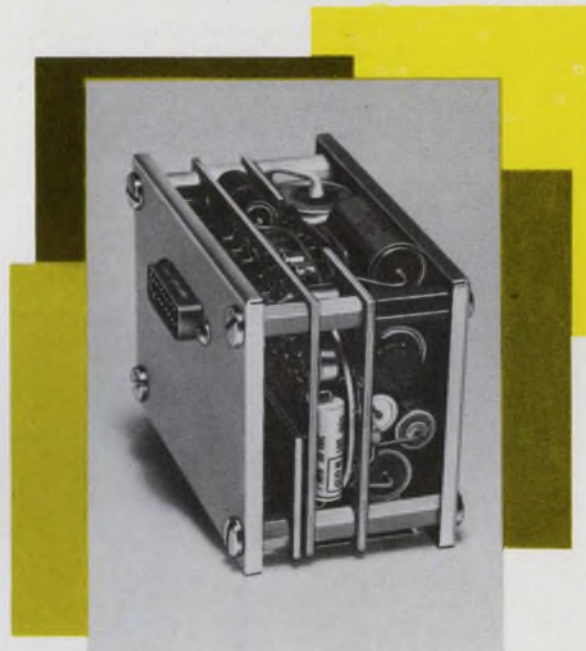
As soon as the encoding period ends, the leading edge of the QUAD RESET & OUTPUT REG. RESET & STORE pulse resets the quadrant storage latches and the output register, while the trailing edge transfers the counter contents into the output register. The transfer takes place in parallel in only 100 ns. This completes the operation of the ASDC.

The ASDC, because of its sampling nature, has an inherent time-division multiplexing capability. It also can be used in conjunction with absolute-shaft-angle encoders that use resolvers. ■■

### References

1. Hermann Schmid, "An ELECTRONIC DESIGN Practical Guide for Synchro-to-Digital Converters," first part appearing in ED 6, March 15, 1970, p. 178.
2. George S. Oshiro, "Generate Noise-Free Timing Pulses," ED 10, May 11, 1972, p. 56.

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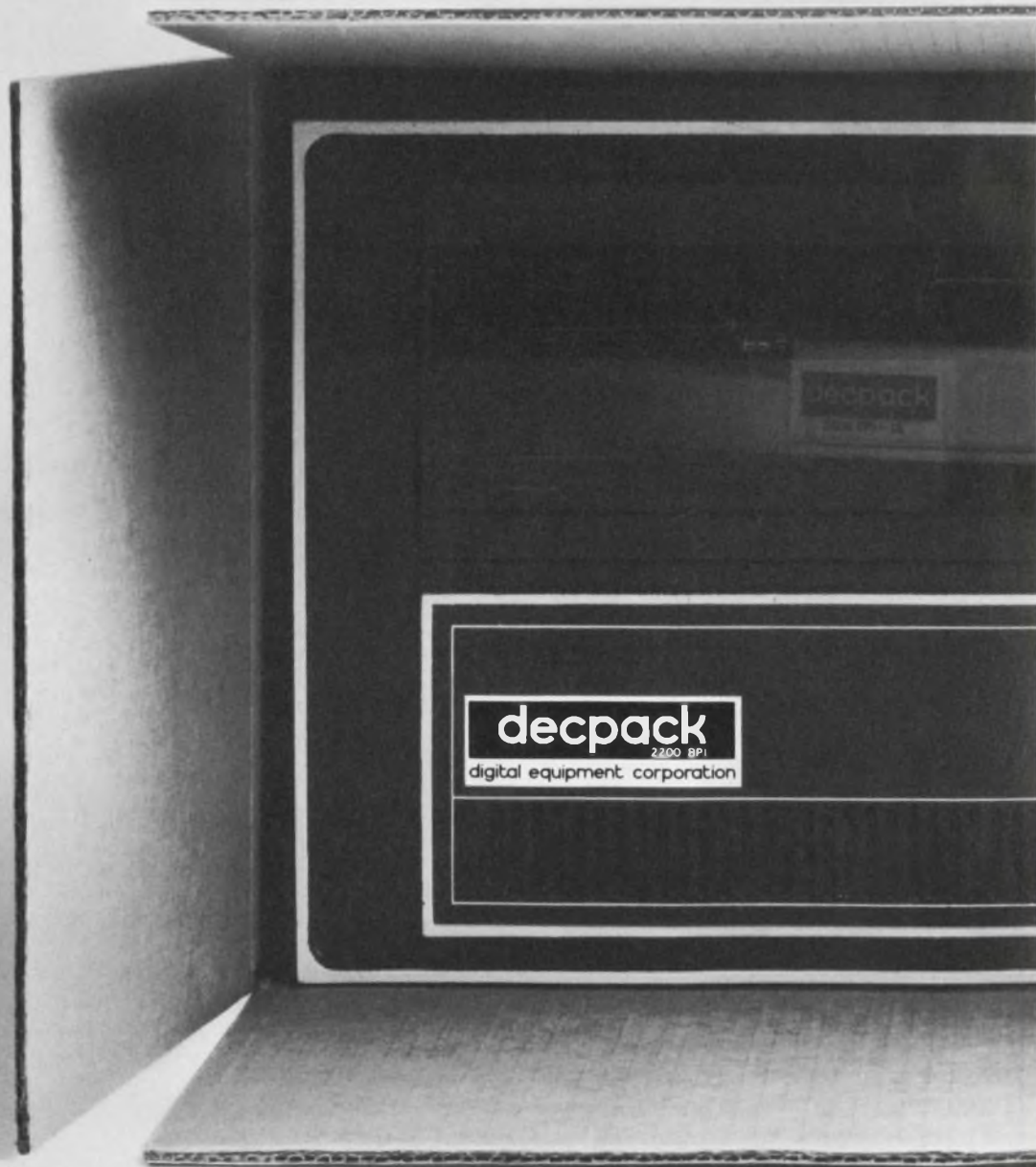
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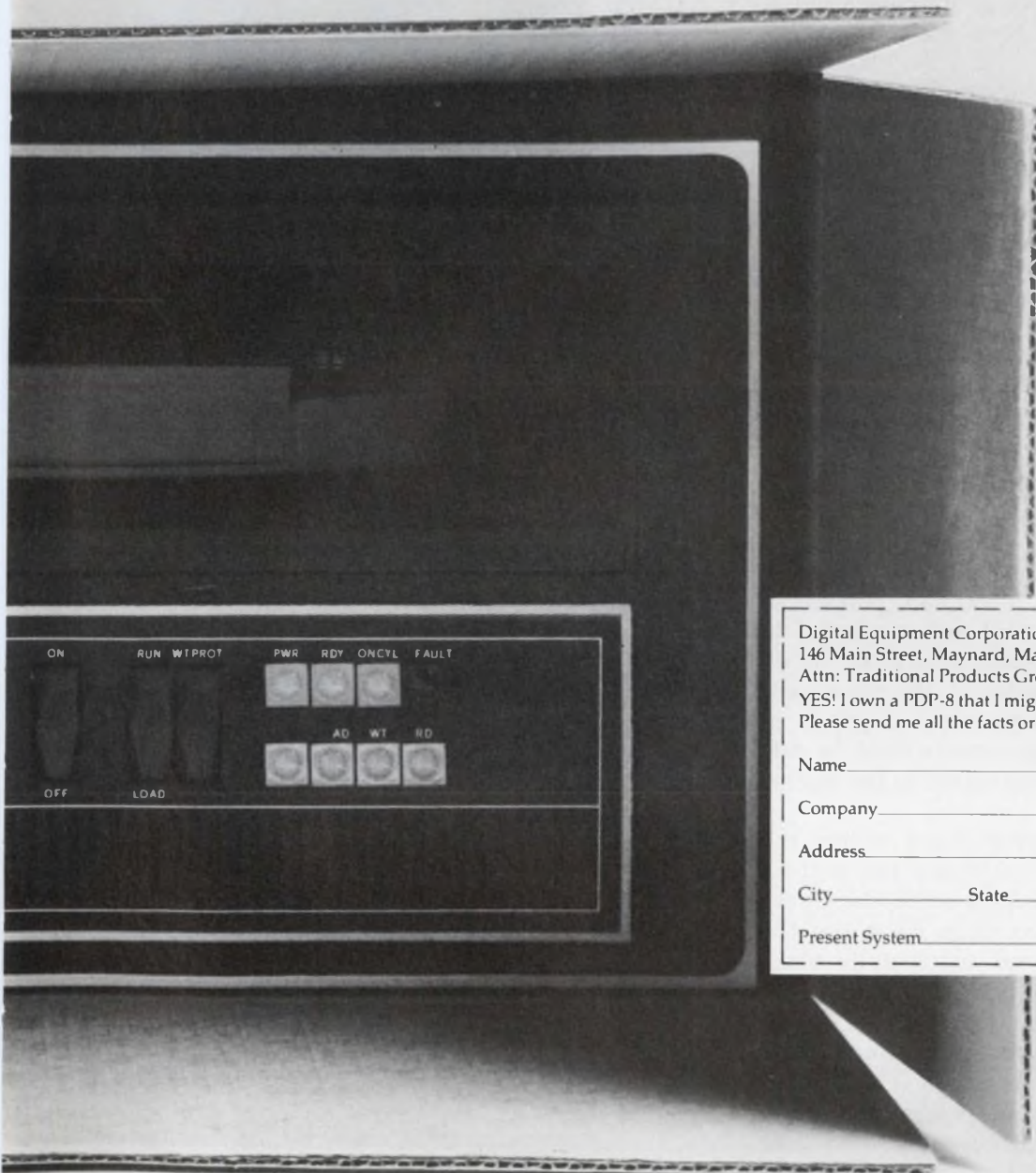
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# Switch to digital-filter design and let numbers replace voltages. Stable shift registers, adders and gates eliminate drift-prone capacitors and inductors.

The design of analog filters has reached the point where further improvement is limited by available capacitor and inductor stability and tolerances. But digital filters have their future before them.

The only ultimate limits on digital filters are the word lengths and the speed with which analog-to-digital converters (a/d) can handle them. And since both speeds and word lengths of a/d converters have been improving rapidly at economical prices, the way is wide open for great advances.

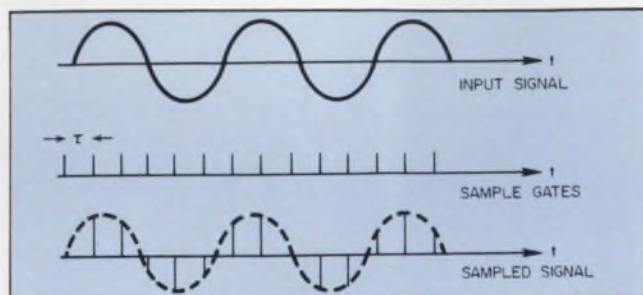
But how do you design a digital filter? Even though the theory of digital filters can be derived from classical analog theory<sup>1,2</sup>, the terminology and techniques used in the digital and analog disciplines are radically different. To ease the transition to digital-filter technology<sup>3,4,5</sup>, let's examine some simple digital filters.

## First, the signal is sampled

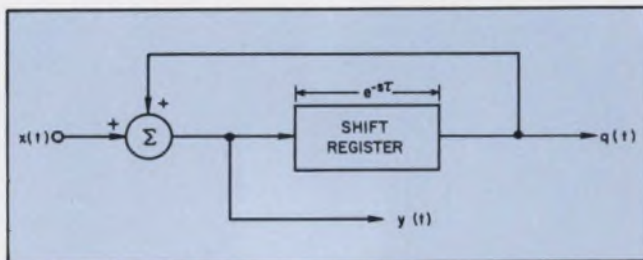
A conventional digital filter can process a signal only after it is sampled and converted to a digital format by an analog-to-digital (a/d) converter. To do this, samples of the signal are taken at discrete, uniformly separated points in time (Fig. 1). Sampling increments must be sufficiently small to describe the signal to the degree required.

A rule of thumb for digital filters is that the sampling rate be at least 10 times the highest frequency—generally at the 3-dB point. But filters with sampling rates of less than six times the highest frequency have been successfully used. Theoretically the lower limit is the Nyquist rate (twice the highest frequency).

The analog-to-digital function converts these samples to a digital form, usually a binary code, which describes their sign and magnitude. Then these digital samples are processed in real time by a digital filter. These filters can perform all the functions of analog types. After processing, the signals may be left in digital form or con-



1. Sampling and converting to digital signals is the first step in implementing a digital filter.



2. A digital integrator is formed by combining a shift register with an adding circuit.

verted back to analog, as required.

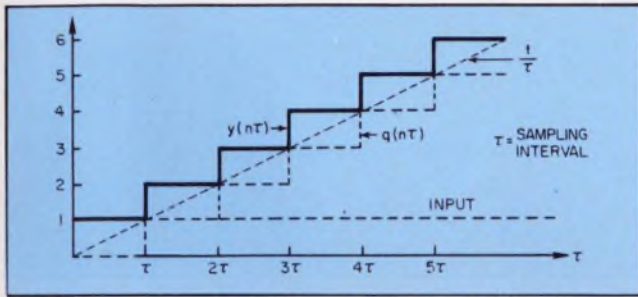
The shift register (Fig. 2) is the heart of the digital filter. It functions as a delay element to compare data sampled at a particular instant of time with data sampled at prior instants of time. Thus an output  $q(t)$  is equal to the input  $x(t)$  present  $\tau$  seconds before;  $q(t) = x(t - \tau)$ . In

most digital filters  $\tau = \frac{1}{f_s}$ , where  $f_s$  is a constant sampling rate.

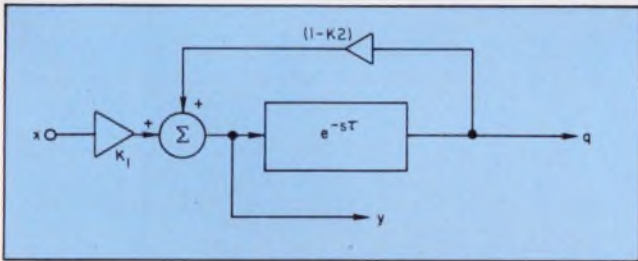
Even though the data are only significant at instants  $t = \tau$ , we may nevertheless represent this delay process in the S domain by the Laplace delay operator  $e^{-s\tau}$ , which can be approximated as follows:

$$\begin{aligned} e^{-s\tau} &= 1 + s\tau \frac{(s\tau)^2}{2!} + \frac{(s\tau)^3}{3!} + \dots \\ &\approx 1 + s\tau \text{ where } s\tau \ll 1, \text{ thus } e^{-s\tau} \approx \frac{1}{1 + s\tau} \end{aligned}$$

This approximation increases in accuracy as the sampling rate,  $f_s$ , becomes much greater than the highest frequency of interest.



3. The response of the circuit in Fig. 2 to a step input shows that it behaves as an integrator.



4. By digitally including the scaling factor, the integrator becomes a digital low-pass filter.

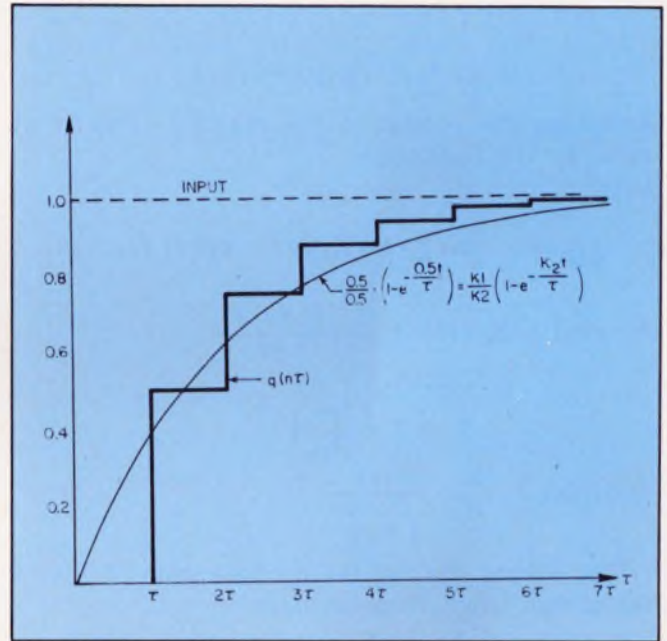
Figure 2 is used to explain the application of this S-domain approximation to digital filters. The delay element is connected to an adder circuit. At any sampling instant ( $n\tau$ ), the input to the register is the data at that instant plus all previous sampled data:

$$y(n\tau) = \sum_{k=0}^n x(k\tau) = x(0) + x(\tau) + x(2\tau) + \dots + x(n\tau).$$

The resulting output for a unit-step input is a stepped approximation to a ramp function as shown in Fig. 3. For simplicity, it's assumed that both the input and output are constant in the interval between samples. The inputs may in fact be continuous or pulsed, but this simplification does not affect the final conclusions.

#### A delay and an adder make an integrator

To show that the configuration of Fig. 2 is an integrator, let  $q(s) = y(s) e^{-s\tau} = \frac{y(s)}{1 + s\tau}$



5. A good comparison is obtained between the unit-step input response of a low-pass filter and the approximation derived from the S-domain calculation.

where  $y(s) = x(s) + q(s) = x(s) + \frac{y(s)}{1 + s\tau}$

solving for  $y(s)$  results in

$$y(s) = \frac{(1 + s\tau)x(s)}{s\tau}.$$

Since  $s\tau \ll 1$ ,  $y(s) \approx \frac{x(s)}{s\tau}$ . Applying the Laplace transform for  $x(s)$ , which is a unit step, then

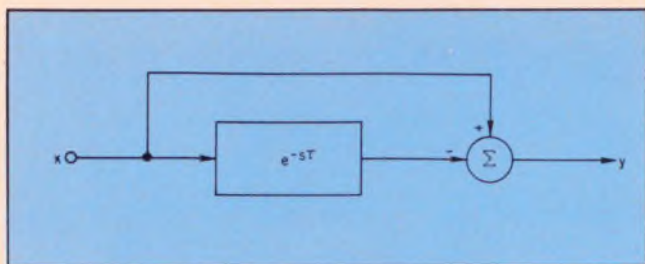
$y(t) = \frac{t}{\tau}$ , a ramp represented by the dotted line of Fig. 3. This is the behavior of an integrator to a step input.

#### Adding scaling factors forms a low-pass filter

The integrator configuration of Fig. 2 becomes a low-pass filter with the addition of the scaler  $K_1$  to the input and the scaler  $(1 - K_2)$  to the feedback connection (Fig. 4). In that case,

$$y(n\tau) = K_1 x(n\tau) + (1 - K_2) y[(n-1)\tau] \\ = K_1 x(n\tau) + (1 - K_2) K_1 x[(n-1)\tau] +$$





6. A digital differentiator is formed by using a subtractor with a shift register.

$$(1-K_2)^2 K_1 x[(n-2)\tau] \\ + (1-K_2)^3 K_1 x[(n-3)\tau] \\ + \dots$$

$$= K_1 \sum_{k=0}^n (1-K_2)^{(n-k)} x(k\tau)$$

assuming the output of the register initially at zero. In the S-domain, and

$$q(n\tau) = \begin{cases} K_1 \sum_{k=0}^n (1-K_2)^{(n-k-1)} x(k\tau) & \text{for } n \geq 1 \\ 0 & \text{for } n = 0 \end{cases}$$

$$y(s) \simeq K_1 x(s) + \frac{(1-K_2)y(s)}{1+s\tau} \\ = \frac{K_1 x(s)(1+s\tau)}{K_2 \left(1 + \frac{s\tau}{K_2}\right)}$$

$$\text{and } q(s) = \frac{K_1}{K_2} \frac{x(s)}{1 + \frac{s\tau}{K_2}}$$

The output  $q(s)$  of the configuration of Fig. 4 for a step input then becomes:

$$q(s) = \frac{1}{s} \frac{K_1}{K_2} \frac{1}{1 + \frac{s\tau}{K_2}}$$

Let's check the accuracy of response  $q(s)$  by transforming it to the time domain:

$$q(t) = \frac{K_1}{K_2} (1 - e^{-K_2 \frac{t}{\tau}})$$

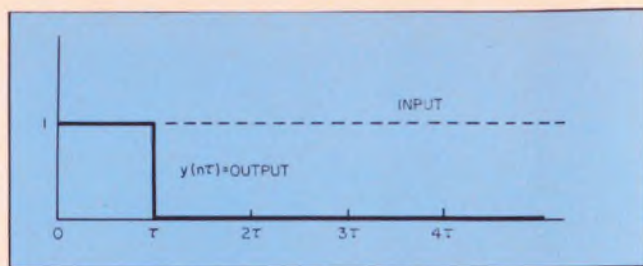
The actual time response  $q(n\tau)$  is

$$q(n\tau) = \begin{cases} \sum_{k=0}^{n-1} (1-K_2)^{(n-k-1)} & \text{for } n \geq 1 \\ 0 & \text{for } n = 0 \end{cases}$$

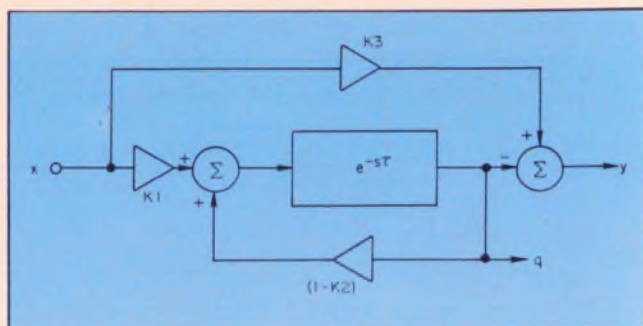
These two functions are compared in Fig. 5 for  $K_1=K_2=0.5$ . The curve of  $q(n\tau)$  is characteristic of the response of a low-pass filter (to a step function input) whose passband gain is  $K_1/K_2$  and cutoff frequency (in radians) at the 3 dB point is  $K_2/\tau$ . The output at "y" is that of "q" but ahead in time by  $\tau$ . The ratio of the sampling frequency to the cutoff frequency for  $K_2 = 0.5$  is

$$\frac{f_s}{f_{3dB}} = \frac{f_s}{K_2/2\pi\tau} = \frac{2\pi}{0.5} = 4\pi.$$

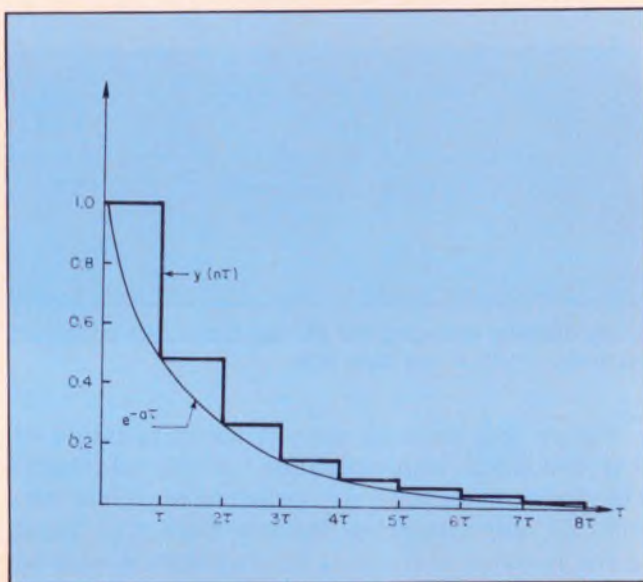
With  $K_2 = 0.2$ , the S-domain approximation is more accurate near the 3 dB cutoff frequency and a time response plot as in Fig. 5 would show a closer approximation to the exponential



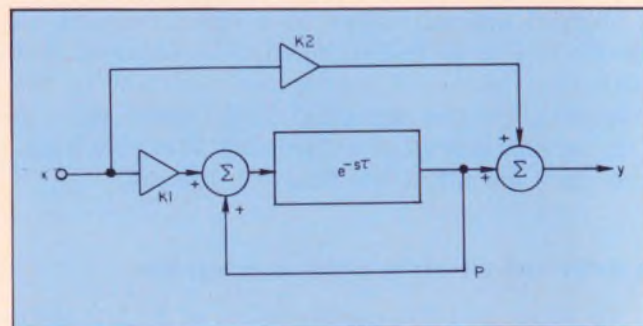
7. The response of the circuit in Fig. 6 to a step input shows that it behaves as a differentiator.



8. Digitally including the scaling factors,  $K_1$ ,  $K_2$  and  $K_3$  converts the differentiator to a digital high-pass filter.



9. The step response of the digital high-pass filter as derived by the S-domain approximation is compared to its theoretical value.



10. The response of a feedback system is digitally synthesized using a combination low-pass-high-pass circuit.

function. This is because the sampling rate would be 2.5 greater.

To build a high-pass filter, a differentiator instead of an integrator is used (Fig. 6). The delayed information in this case is subtracted from the current information, so that

$$y(n\tau) = x(n\tau) - x(n\tau - \tau).$$

This is plotted in Fig. 7 for a step input.

In the S domain,

$$y(s) \simeq x(s) \left(1 - \frac{1}{1 + s\tau}\right) = \frac{s\tau}{1 + s\tau} x(s)$$

when  $s\tau \ll 1$ ,  $y(s) \simeq s\tau \cdot x(s)$ , and a differentiator is obtained.

### A differentiator becomes a high-pass filter

The differentiator becomes a high-pass filter with the addition of scaling factors and another adder (Fig. 8). Then

$$q(n\tau) = 0, \text{ for } n = 0$$

$$q(n\tau) = K_1 \sum_{k=0}^{n-1} (1 - K_2)^{(n-k-1)} x(k\tau), \text{ for } n \geq 1$$

$$y(n\tau) = \begin{cases} K_3 x(n\tau) - K_1 \sum_{k=0}^{n-1} (1 - K_2)^{(n-k-1)} x(k\tau), & \text{for } n \geq 1 \\ x(n\tau), & n = 0 \end{cases}$$

The response to a step function is shown in Fig. 9.

In the S-plane,

$$q(s) = \frac{K_1}{K_2} \frac{x(s)}{1 + \frac{s\tau}{K_2}}$$

$$y(s) = \frac{x(s) \left[ K_3 \left(1 + \frac{s\tau}{K_2}\right) - \frac{K_1}{K_2} \right]}{1 + \frac{s\tau}{K_2}}$$

$$\text{Setting } K_3 = \frac{K_1}{K_2}$$

$$y(s) = x(s) \frac{1}{K_2} \frac{s\tau}{1 + \frac{s\tau}{K_2}} \frac{K_1}{K_2}$$

This is the response of a high-pass filter of pass-band gain  $\frac{K_1}{K_2}$  and a cutoff frequency at  $\omega_{3dB} = K_2/\tau$ .

### Feedback control is a practical example

It is possible to synthesize a variety of filter structures by combining low-pass and high-pass configurations. The general procedure is to calculate the constants and sampling rates needed to obtain the response and gain. As an example, consider the problem of digitally synthesizing the response

$$G(s) = 2 \frac{\left(1 + \frac{s}{1.5}\right)}{s} = \frac{KV \left(1 + \frac{s}{\omega_1}\right)}{s}$$

This form of response occurs frequently in

feedback control work and may be synthesized by a configuration similar to Fig. 8 but with  $K_2 = 0$ , and noting that  $y = K_2 x + q$  as shown in Fig. 10.

Accordingly,  $y(s) = K_2 x(s) + P(s)$ , and

$$P(s) = \frac{K_1 x(s)}{1 + s\tau}.$$

Solving for  $P(s)$  gives

$$P(s) = \frac{K_1 x(s)}{s\tau},$$

Since  $y(s) = x(s) (K_2 + K_1/s\tau)$ .

Rearranging terms results in

$$\frac{y(s)}{x(s)} = \frac{(K_1/\tau) (1 + s K_2 \tau/K_1)}{s}$$

The desired response can then be synthesized by setting

$$\frac{K_1}{\tau} = K_v = 2, \frac{K_1}{K_2/\tau} = \omega_1 = 1.5 \text{ radians.}$$

For a frequency range up to two octaves, above  $\omega_1$ , use  $s\tau(\text{max}) = 0.1$  and

$$f_s (\text{sampling frequency}) = \frac{1}{\tau} \\ = 10 \times 4 \times 1.5 = 60 \text{ Hz.}$$

Choosing instead  $f_s = 66.6 \text{ Hz}$ , for numerical convenience, you get  $\tau = 15 \text{ ms}$  and  $s\tau = 6 \times .015 = 0.090$  at 6 radians—two octaves above 1.5 radians. Solving for the remaining constants results in

$$K_1 = K_v \tau = 2 \times 15 \times 10^{-3} = 0.03$$

$$K_2 = \frac{K_1}{\omega_1 \tau} = \frac{0.03}{15 \times 10^{-3} \times 1.5} = 1.33.$$

### Implementing the scalars

The scalars (such as  $K_1$  and  $K_2$ ) can often be implemented by means of simple binary shift and add operations. Scalars equal to numbers that are powers of 2 or  $1/2$ —like 2, 4, 8; or  $1/2$ ,  $1/4$ ,  $1/8$ —can be obtained by simply shifting the binary input to the left (which multiplies by two) or right (divides by two).

When these shifts do not adequately approximate the required scalar, it can be more closely approximated by a combination of shifting and adding. For example:

$$K_2 = 1.33 \simeq 1.25 = 1 + 1/4 \text{ and}$$

$$K_1 = .03 \simeq .0313 = 1/32$$

Then  $K_1$  can be obtained with a five place shift to the right, and  $K_2$ , with a two place shift to the right and summation with the original input as in Fig. 11.

### There are shortcomings too

The mixing (or beating as in a superheterodyne receiver) of the input signal with the sampling frequency,  $f_s$ , results in not only the desired spectral line,  $f_m$ , falling within the filter's pass-band, but also an undesired or "aliased" line at



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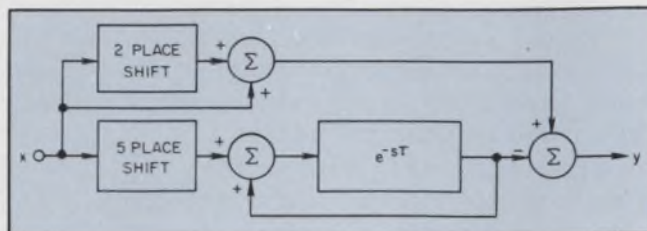
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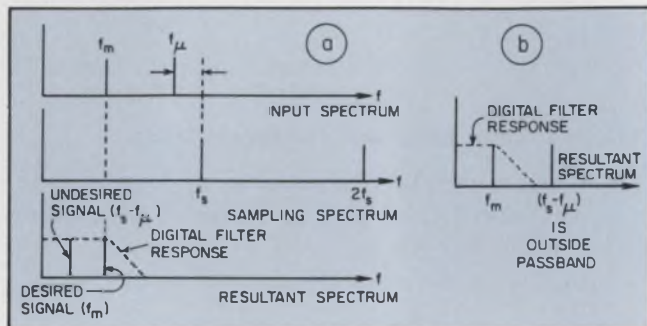


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11. The scalars are implemented digitally.



12. Aliasing of undesired signals into the passband is a serious problem in digital filters. Raising the sampling frequency helps reduce this problem.

frequency  $f_u$ , is mixed into the passband at  $(f_s - f_u)$ , as in Fig. 12a. In general, frequencies near a spectral line of the sampling frequency will "beat" down to the pass region of the filter.

As in Fig. 12b, this undesired energy, can be removed by increasing the sampling frequency so that  $(f_s - f_u)$  lies above the cutoff frequency of the digital filter. When a broad band of unwanted frequencies (such as noise) exists, though, this is not possible, and an analog low-pass filter may have to be placed ahead of the a/d converter.

In the particular case where the input signal is in pulse form, it is most efficient when the sampling signal's frequency and phase coincide with the input signal. This eliminates the need to place sampling points so close that no pulse is missed. Signal information is lost by missing a pulse. ■■

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INFORMATION RETRIEVAL NUMBER 35



# Use the wired-AND and implied-OR configurations to simplify logic circuitry. They require fewer gates and inputs than a conventional Boolean implementation.

If you want to realize logic functions that will reduce circuitry, the wired-AND or implied-OR configurations have a lot going for them:

- They tend to minimize the conventional logic required.
- They call for algorithmic methods to obtain functions, thereby lending themselves to straightforward implementation by computer program.
- They can eliminate static hazards, or glitches.

In the wired-AND configuration, gate outputs are tied together to obtain the AND function (Fig. 1a); in the implied-OR, gates are tied together to obtain the OR function (Fig. 1b). Note that it is the common connection that yields the logical function at the outputs.

With gate drivers connected as shown in Fig. 2a, the output is high (positive level) when transistors  $Q_1$  and  $Q_2$  are off, giving the AND condition. With emitter-follower drivers as shown in Fig. 2b, the output is high if either transistor  $Q_1$  or  $Q_2$  is on, giving the OR condition.

In other words, if the gates that are wired together have an emitter-follower driver, then the common connection forms an OR. This is generally the case for emitter-coupled logic. Note that for the AND case, the gates are usually connected at the output of an amplifying stage.

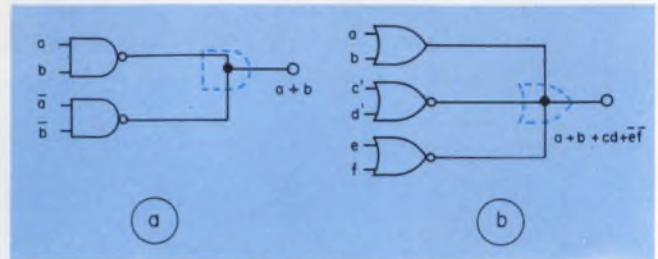
## Synthesis is easy

The implied-OR can easily be synthesized with the aid of a Karnaugh map. The map yields a sum-of-products expression, which is then modified for implied-OR realization with DeMorgan's Theorem. The terms of the expression may then be implemented with individual NOR gates and OR-gates, for the single-product terms. For example, consider the logic function of Fig. 3a. A minimum sum-of-products expression for this function is:

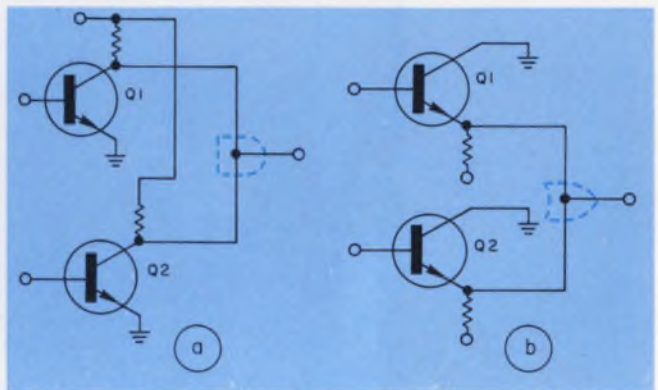
$$f = a + b + \bar{c}\bar{d}$$

Using DeMorgan's Theorem, we get an equivalent expression:

$$f = a + b + (c + d).$$



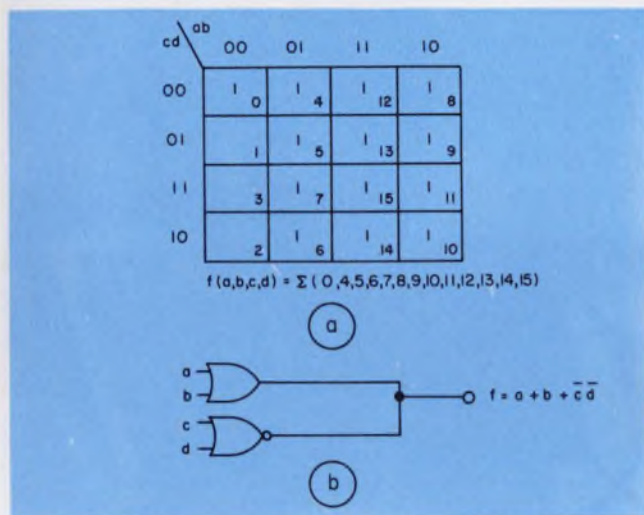
1. The wired-AND is formed by connecting the outputs of individual gates (a). The implied-OR is similarly obtained (b).



2. Actual wired-AND (a) and implied-OR (b). Output is high or the wired-AND when both transistors are cut off. Output is high for the implied-OR when either transistor is conducting.

The implied-OR realization for this function is shown in Fig. 3b.

While the implied-OR configuration is easy to implement directly from the Karnaugh map, this is not true for the wired-AND. For example, though TTL provides the AND function when hard-wire connected, the totem-pole output structure of the TTL gates can cause problems. This is because, with a totem-pole arrangement, a single output stage may be required to sink current from the active pull-up transistors of the other gates. In addition to degradation of the logic-ZERO voltage level, there exists the possibility of high-current damage to the output-stage transistors. This is because the totem-pole structure can source as much as 55 mA, while a typical gate output is usually guaranteed to sink only 16 mA.



3. Function plotted on Karnaugh map (a) is realized in implied-OR form (b). DeMorgan's theorem is used to re-arrange the function to the implied-OR form.

The problem is avoided by use of open-collector gates, of which up to 10 can be wired together with no adverse effects.

The algorithm for obtaining the logic expression for the wired-AND consists of three steps:

Step 1: Obtain a sum-of-products expression for the function.

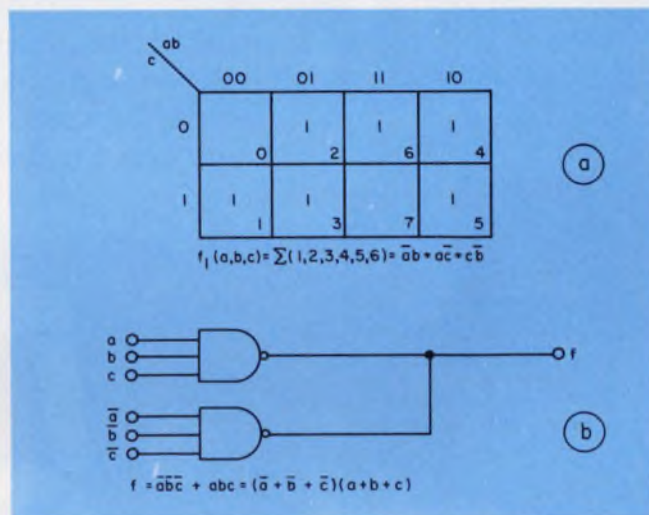
Step 2: Complement the expression obtained in Step 1.

Step 3: Take the dual of the expression obtained in Step 2.

For example, consider the logic function shown in Fig. 4a. To realize this function, you would need four gates with nine inputs. However, by complementing the expression and then taking the dual, you can reduce it to a form that requires only two gates with a total of six inputs (Fig. 4b).

This technique can be more easily implemented, of course, by reading the ZEROES of the Karnaugh map and then taking the dual of the resulting expression. Further, as the number of variables in the function increases, the savings in logic for the wired-AND configuration increases.

A rule of thumb: If a large number of ONES are contained in the function, then the wired-



4. Three-variable function derived from Karnaugh map (a) is realized by wired-AND circuit shown in (b). Only two gates are required.

AND will generally be the simplest solution. If a large number of ZEROES are present, the implied-OR often yields the best realization.

#### Solution is glitch-free

Both the wired-AND and implied-OR solutions are free of static hazards, if the original sum-of-products expression, obtained from the Karnaugh map is hazard-free.

A static hazard is the momentary output change that occurs when an input switches between two states that, individually, produce the same output state. These glitches, as they are often called, may or may not be tolerable in a given logic circuit.

If a sum-of-products expression contains no static hazards, then the final expression, obtained with the algorithmic methods given here, will also be free of hazards. For example, the function of Fig. 4b must be rearranged to the following form to be hazard free:

$$f = \bar{a}\bar{c} + \bar{a}\bar{b} + \bar{b}\bar{c} + \bar{a}\bar{c} + \bar{a}\bar{b} + \bar{b}\bar{c}.$$

To realize this function, you would need seven gates with 18 inputs. However, the wired-AND realization is also hazard free, and it requires only six gate inputs—a significant savings. ■■



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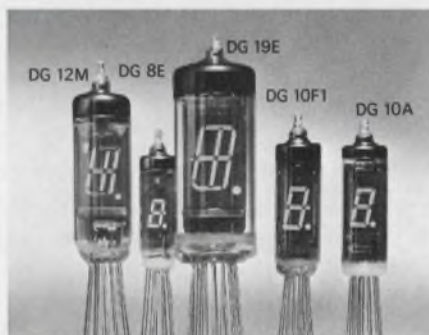
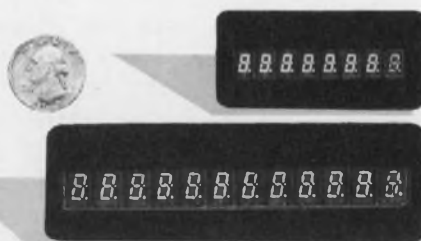
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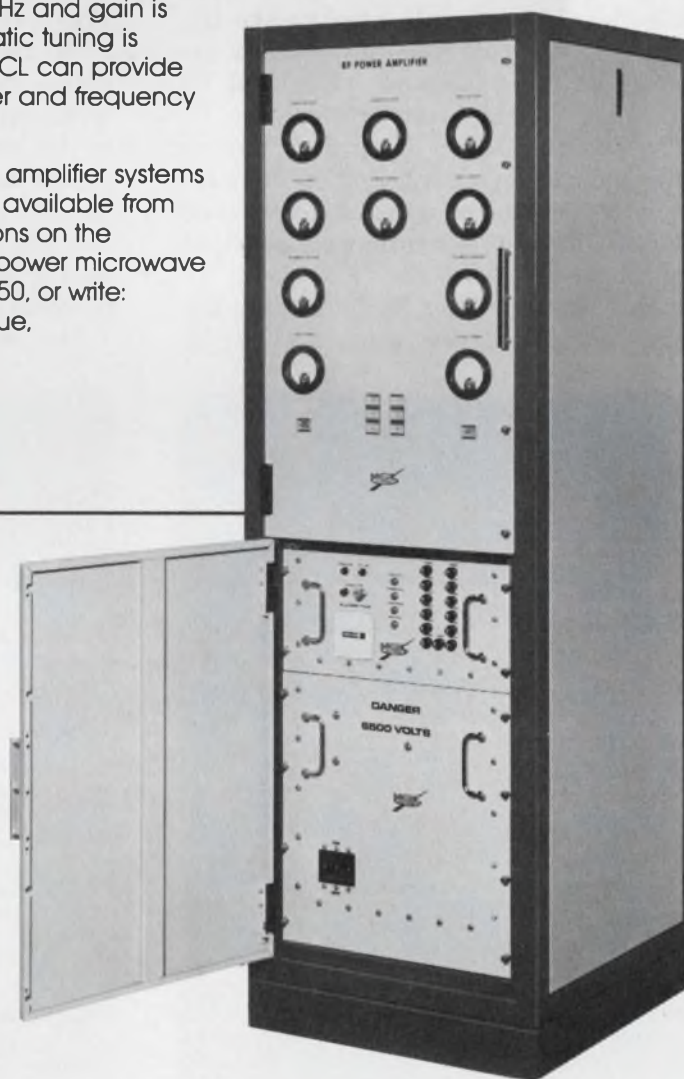
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INFORMATION RETRIEVAL NUMBER 86



## Triangle-wave generator keeps slopes constant as amplitude changes

A function generator maintains constant positive and negative slopes of a triangular-wave output during amplitude variations. In addition the slopes may be independently controlled. And the triangle-wave output may be offset from circuit common without changing the shape of the waveform.

Two op amps (Fig. 1) generate a square-wave output that is then integrated to produce the triangular output. The square wave always has the same frequency as the triangular wave, and its amplitude is symmetrical about ground.

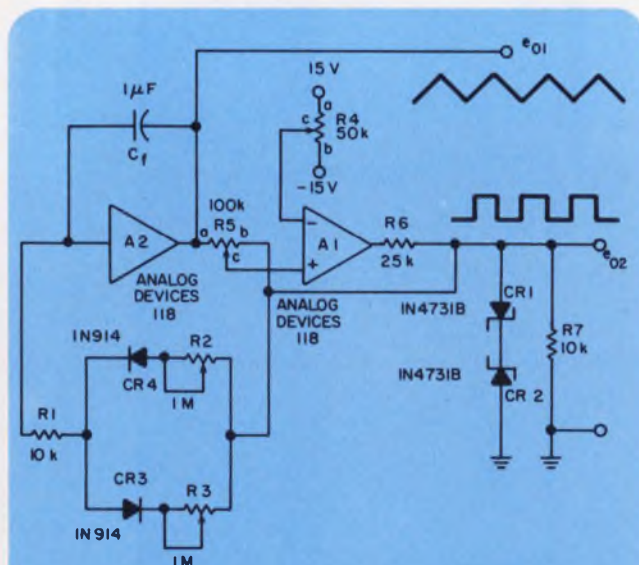
Op amp  $A_2$  operates as an integrator that is driven by the square-wave output of op amp  $A_1$ . The amplitude of the square wave is determined by zener diodes  $CR_1$  and  $CR_2$  to have a constant amplitude of  $\pm 5$  V.

The setting of potentiometer  $R_3$  determines the positive slope (Fig. 2) of the triangle wave;  $R_2$

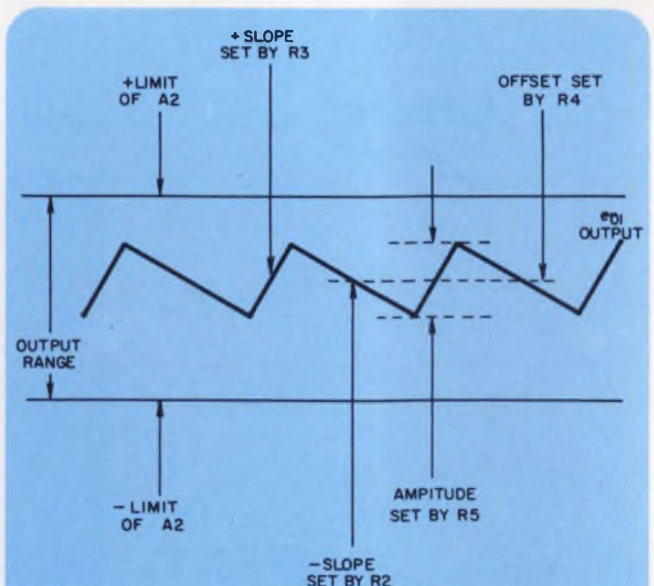
governs the negative slope. Amplitude of the triangle is determined by the setting of  $R_5$ . If only equal positive and negative slopes are desired,  $CR_3$ ,  $CR_4$  and  $R_2$  may be omitted. Diode  $CR_3$  switches resistor  $R_3$  out of the circuit during the negative slope, and  $CR_4$  switches  $R_2$  out during the positive slope. Of course, resistors  $R_2$  and  $R_3$  vary the output frequency when they vary the slopes, but they have no effect on the amplitude.

Op amp  $A_1$  operates as a comparator. The reference voltage provided by the setting of  $R_1$  determines the offset of the output but has no effect on its amplitude or slope. The amplitude is adjusted by  $R_5$ , which acts as a variable voltage divider between the output of the comparator and the varying output of the integrator. The setting of  $R_5$  has no interaction with any circuit function except amplitude.

The maximum positive or negative slope is



1. Integrator  $A_2$  generates a triangular wave from the square-wave output of comparator  $A_1$ . Resistor  $R_5$  controls amplitude, but has no effect on slope.



2. Triangular-wave output has positive and negative slopes, which may be varied independently of amplitude by potentiometers  $R_3$  and  $R_2$ .

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## Design Equations

$$\text{Triangle-wave Amplitude } E_{o1} = E_{o2} \left( \frac{R5_{ac}}{R5_{cb}} \right)$$

$$\text{Square-wave Amplitude } E_{o2} = \pm 5 \text{ V as determined by limit diodes CR}_1 \text{ and CR}_2$$

$$\text{Positive Slope (V/s)} = -E_{o2} \left( \frac{-C_r}{R1 + R2} \right)$$

$$\text{Negative Slope (V/s)} = +E_{o2} \left( \frac{-C_r}{R1 + R3} \right)$$

$$\text{Output Voltage Offset} = (-30) \left( \frac{R4_{ac}}{R4_{ab}} \right)$$

500 V/s; the minimum is  $\pm 5$  V/s, with the  $\pm$  rates adjustable independently. Offset is variable over a  $\pm 10$ -V range, but the output is also limited to  $\pm 10$  V and clipping may occur when either the output amplitude or the offset is large.

Limiting factors include slew rate and current capability of the op amps and switching speeds of the diodes. For other rates, use integrating components that allow  $A_2$  to integrate faster or slower, depending on need. The use of only one set of integrating components also restricts the integration rate.

*David G. Larsen, Instructor, Virginia Polytechnic Institute and State University, Dept. of Chemistry, Blacksburg, Va. 24061*

CIRCLE NO. 311

## Ac reference achieves 0.01% accuracy with ROM-d/a converter combination

By adding a 1024-bit ROM to an eight-bit d/a converter, you can build an ac reference source that has an amplitude error of less than 0.01%. The circuit's frequency stability is determined by the stability of the clocked input.

In the circuit shown, two 5493 counters act as a seven-bit counter that drives the 1024-bit (128  $\times$  8) ROM. In conjunction with the d/a converter, the ROM generates 128 voltage segments in the shape of a sine wave, with a pk-pk voltage of twice the dc reference voltage.

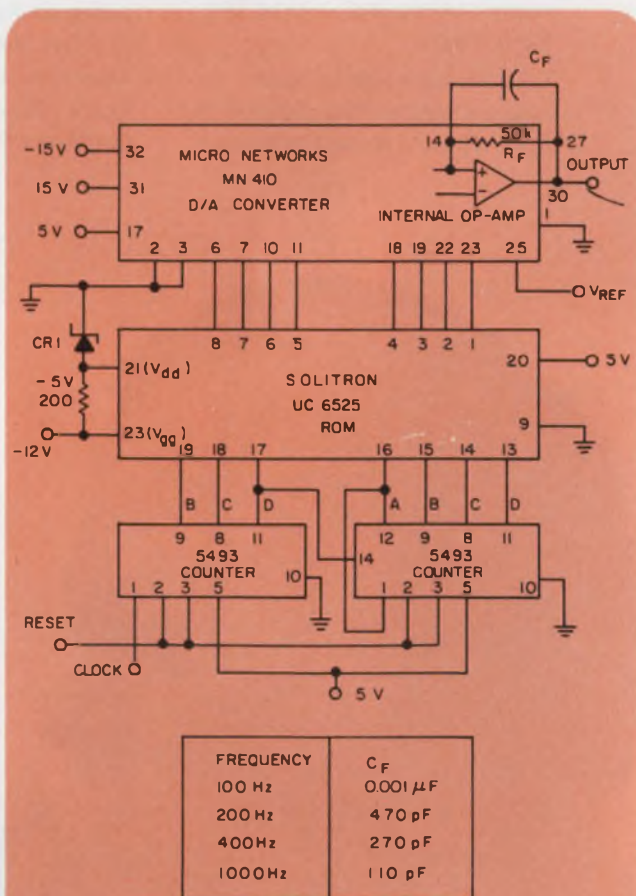
Capacitor  $C_F$  smooths out the incremental steps, producing an undistorted ac signal. The value of  $C_F$  depends upon the desired output frequency, as shown in the accompanying table. Large values of  $C_F$  will slightly attenuate the output signal. To correct for this, an increase in the reference voltage can increase the rms value of the output.

If better than 0.01% accuracy is desired, use a 4096 ROM and a nine-bit d/a converter. This combination increases the number of steps for a given period and reduces the size of  $C_F$ .

The circuit shown is designed for operation over the full MIL temperature range of  $-55$  to  $125$  C. For other combinations of ROMs and d/a converters, temperature variations must be considered. Absolute accuracy and linearity drift of the d/a converter must be compensated, and the ROM circuit must be completely operational over the entire temperature span.

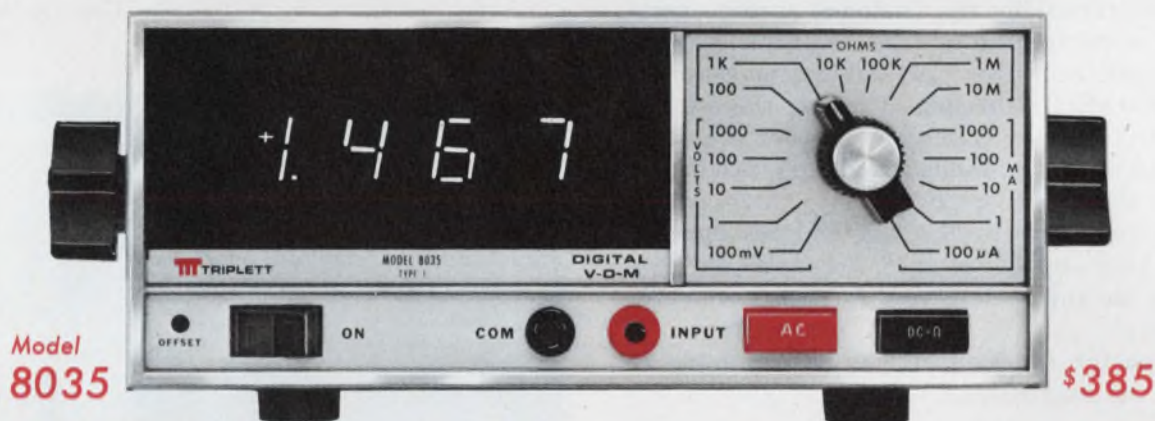
*Tim Hickey, Micro Networks Corp., 5 Barbara Lane, Worcester, Mass. 01604.*

CIRCLE NO. 312



Capacitor  $C_F$  smooths the output waveform of the MN 410 d/a converter in this ac reference circuit. Optimum values for the capacitor are indicated in the table.

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# Clock oscillator for telemetry systems uses CMOS chip to minimize power drain

An inexpensive and stable oscillator built around a CMOS IC chip and a piezoelectric resonator has a total power consumption of less than 100  $\mu$ W. Frequency stability is better than 0.0015%/C over a 0 to 50 C temperature range.

The stability is sufficient for telemetry systems, which often require a master clock oscillator to control various operations, such as channel sampling and bit synchronization. The low power drain is particularly important in battery-powered systems, since the master oscillator usually remains on continuously.

Oscillations are generated by an adjustable piezoelectric resonator (VBA1-R in the diagram) and are sustained by the feedback system, composed of a differentiator (the feedback resistor  $R_2$  and input capacitor  $C_3$ ) and the inverter on the CD4000AE CMOS chip. The two three-input gates on the chip are connected as inverters, with the unused inputs grounded, and they produce a buffered square-wave signal at the output. Power-supply network  $R_1$ - $C_1$ - $C_2$  reduces current drain at high supply voltages, decouples the circuit from the supply line and provides automatic gain control.

The transfer function of the differentiator is given by the expression:

$$\frac{V_m}{V_o} = -j\omega R_2 C_3 \frac{A}{1 + A + j\omega R_2 C_3},$$

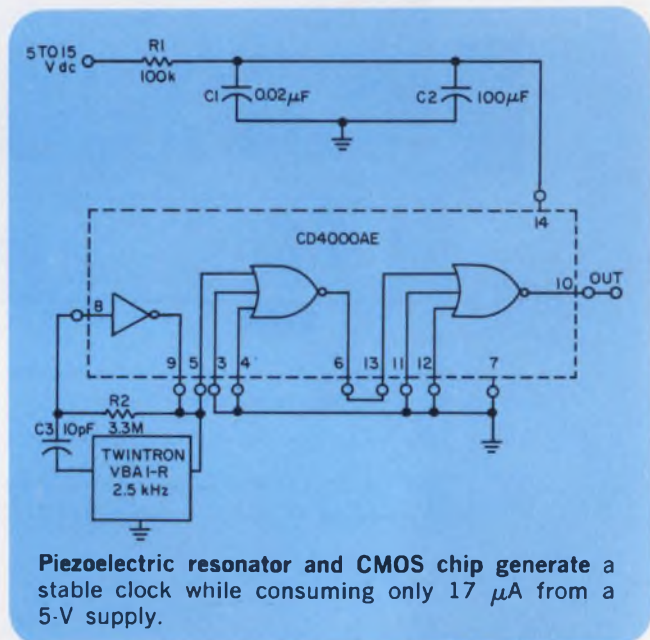
where  $A$  is the gain of the inverter (approximately 10). At resonance, the phase shift of the resonator is approximately 90 degrees, and the losses are negligible. The circuit will thus oscillate at the resonant frequency of the crystal, provided the  $R_2$ - $C_3$  time constant is chosen to obtain a greater than unity open-loop gain. Capacitor  $C_3$  should be kept as small as possible—

but larger than the 5-pF input capacitance of the inverter—because this type of resonator operates best with a high impedance load.

Circuit operation has been optimized with the component values shown for 2.5-kHz operation. The power-supply voltage may range from 4.2 to 15 V without deterioration in circuit performance, and the total current drain then varies between 17  $\mu$ A at 5 V to 106  $\mu$ A at 15 V. With a 5-V supply, the output signals are 3.3-V pk-pk, with rise-time of 1.5  $\mu$ s.

*Dr. Sam Ben-Yaakov, Associate Research Engineer, and P. Greene, Dept. of Geology, UCLA, Los Angeles, Calif. 90024*

CIRCLE No. 313



## IFD Winner of May 25, 1972

**T. J. Steen**, Pres. Kennedylaan 36, Roosendaal, The Netherlands. His idea "Three-LED circuit indicates ac or dc and polarity" has been voted the Most Valuable of Issue award.

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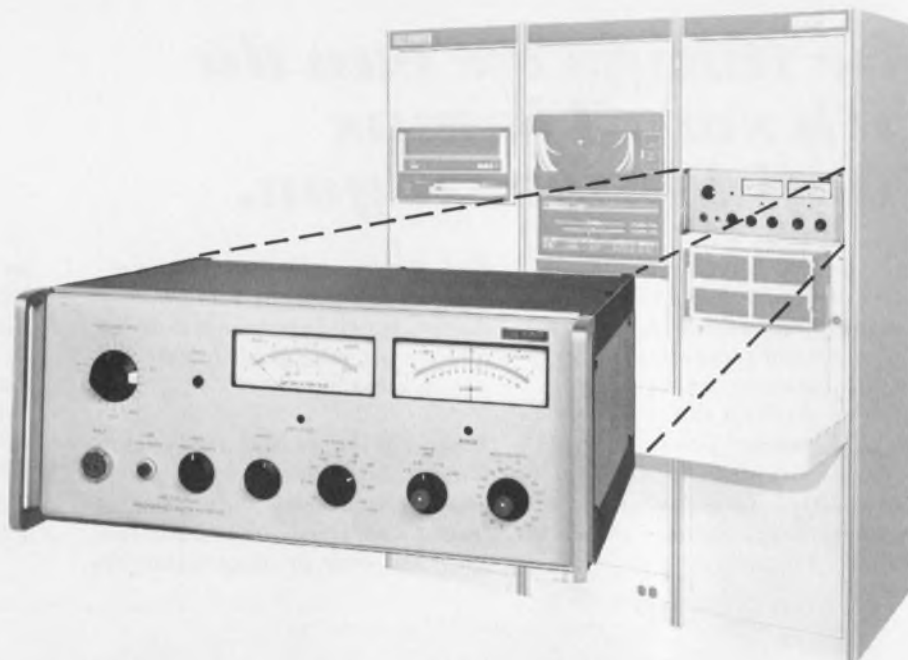
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PRD ELECTRONICS DIVISION, Harris-Intertype Corp.  
1200 Prospect Avenue, Westbury, L. I., N. Y. 11590  
Telephone: 516-334-7810

## new products

# 4-1/2-digit pocket multimeter slashes size, price and power consumption



Data Precision Corp., Audubon Rd., Wakefield, Mass. 01880. (617) 246-1600. \$295; stock.

The smallest 4-1/2-digit multimeter is also the least expensive. At \$295, Data Precision's Model 245 is priced with many 3-1/2-digit meters and far below all but one 4-1/2-digit unit—the \$329.95 Anaconic Model 390.

With a volume of 468 cubic inches (5 H × 8-1/2 W × 11 D), Anaconic's unit is a bit bigger than Data Precision's, with 31 cubic inches (1-3/4 × 5 × 3-1/2). The Anaconic is for line operation only, while the Data Precision (which weighs only 14 oz. and can fit in a jacket pocket) works from internal, rechargeable batteries or from the line.

Anaconic's unit has 29 ranges against Data Precision's 21, but the Anaconic is not always characterized as thoroughly as one might wish and some ranges may be less than convenient to use.

For example, to measure 1, 10 or 100 mA dc, you apply the leads (not furnished) to the terminals marked "VOLTS-MA," which is what you'd expect, though "the 1-mA range is extremely influenced by external ac fields and is provided as a convenience only," according to the manufacturer.

Measuring dc microamperes,

however, is less straightforward. For the 100-μA range, you apply the leads to the "LOW" jacks of the terminals marked "VOLTS-MA" and "OHMS-CAP." Then you turn the range and function switches to 100 V dc. For the 10-μA range, you switch to 10 V dc, keep the leads where they were and short the "VOLTS-MA" jacks.

Despite such inconveniences, the Anaconic's versatility is impressive. It offers measurements of capacitance and frequency (to 2 MHz) as well as the usual resistance, dc and ac voltage, and dc current (though frequency measurements may require application of some arithmetic). The instrument counts events and provides four time-base signals (1 to 1000 ms).

For some measurements, the meter's accuracy could have been provided by a 3 or even 2-digit instrument. The basic accuracy of the two ac ranges, for example, is 5% f.s. ±200 mV or "typically" 5% rdg ±300 mV, depending on whether you read the data sheet or some accompanying notes.

In contrast, Data Precision's unit is designed for simplicity of operation and is rather thoroughly characterized in terms of accuracy for each range and (unlike the Anaconic) short- and long-term

drift and temperature coefficient. On the ac-current (which the Anaconic lacks) and dc-current ranges, Data Precision blanks out the least-significant digit, admitting that it can't get good enough shunts.

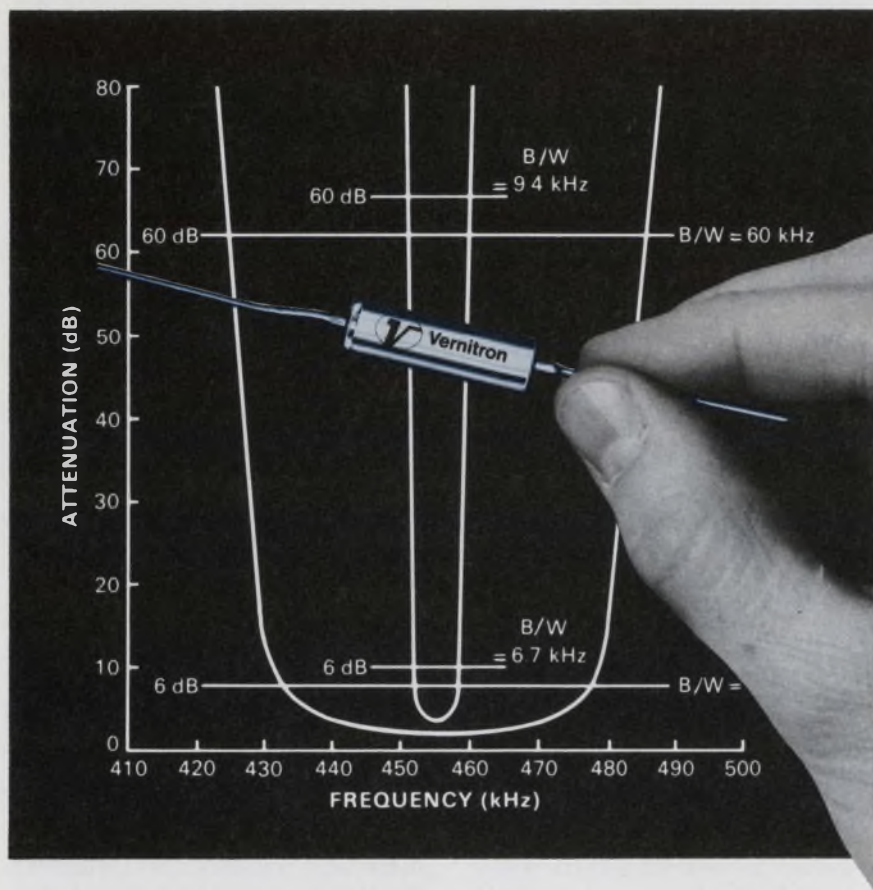
The Data Precision includes ranges from 1 to 1000 V dc and ac (though the 1000 V ac range, like that in the Anaconic, is limited to 500 V ac), 1 to 1000 mA dc and ac, and 1 to 10,000 kΩ. All Data Precision functions permit 100% overrange, while the Anaconic has only 20% except for the frequency and count, which go to 19999.

For ac operation and simultaneous battery charging, the Data Precision works with a small, plastic-cased charger at the far end of the line cord (to keep raw ac out of the instrument) or with an optional bench stand with charger (at about \$50). Internal batteries are included in the price of the instrument, as are the line-cord charger, the carrying strap, probes and carrying case.

Both meters use gas-ionization displays. The Anaconic uses conventional tube types and the Data Precision uses the Sperry planar display to conserve power. The entire unit consumes only 0.75 W. For more information:

From Anaconic CIRCLE NO. 250  
From Data Precision CIRCLE NO. 251





## MIL-Quality At A Commercial Price! from Vernitron (the filters people)

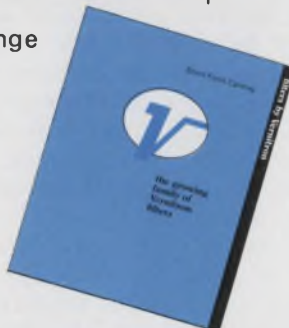
MIL-quality miniature ceramic ladder filters at about half the price of typical MIL quality — yet with everything MIL specs call for: ruggedness, stability, selectivity, shock-resistance, hermetic sealing, immunity to magnetic fields — and *fixed-tuned*, so there's no "touching-up" during production.

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INFORMATION RETRIEVAL NUMBER 41

## INSTRUMENTATION

### 8-digit frequency counter operates to 120 MHz



Heath Company, Hilltop Avenue, St. Joseph, Mich. 49085. (616) 983-3961. \$349.95 (mail order).

The IB-1102 Frequency Counter Kit features eight cold-cathode display tubes, an overrange lamp, gate lamp, and two range-indicator lamps. Over-all accuracy is assured by the use of a pre-built, temperature-compensated, crystal-oscillator (TCXO) clock. The unit has a sensitivity of 50 mV to 100 MHz and 125 mV to 120 MHz. It accepts inputs up to 120 V rms from 1 Hz to 150 Hz, 50 V at 40 MHz, and 3 V at 120 MHz without damage to the instrument. The IB-1102 uses ECL plug-in ICs and circuit boards to speed and simplify assembly and service. The counter can be wired for either 120 or 240 V ac operation.

CIRCLE NO. 252

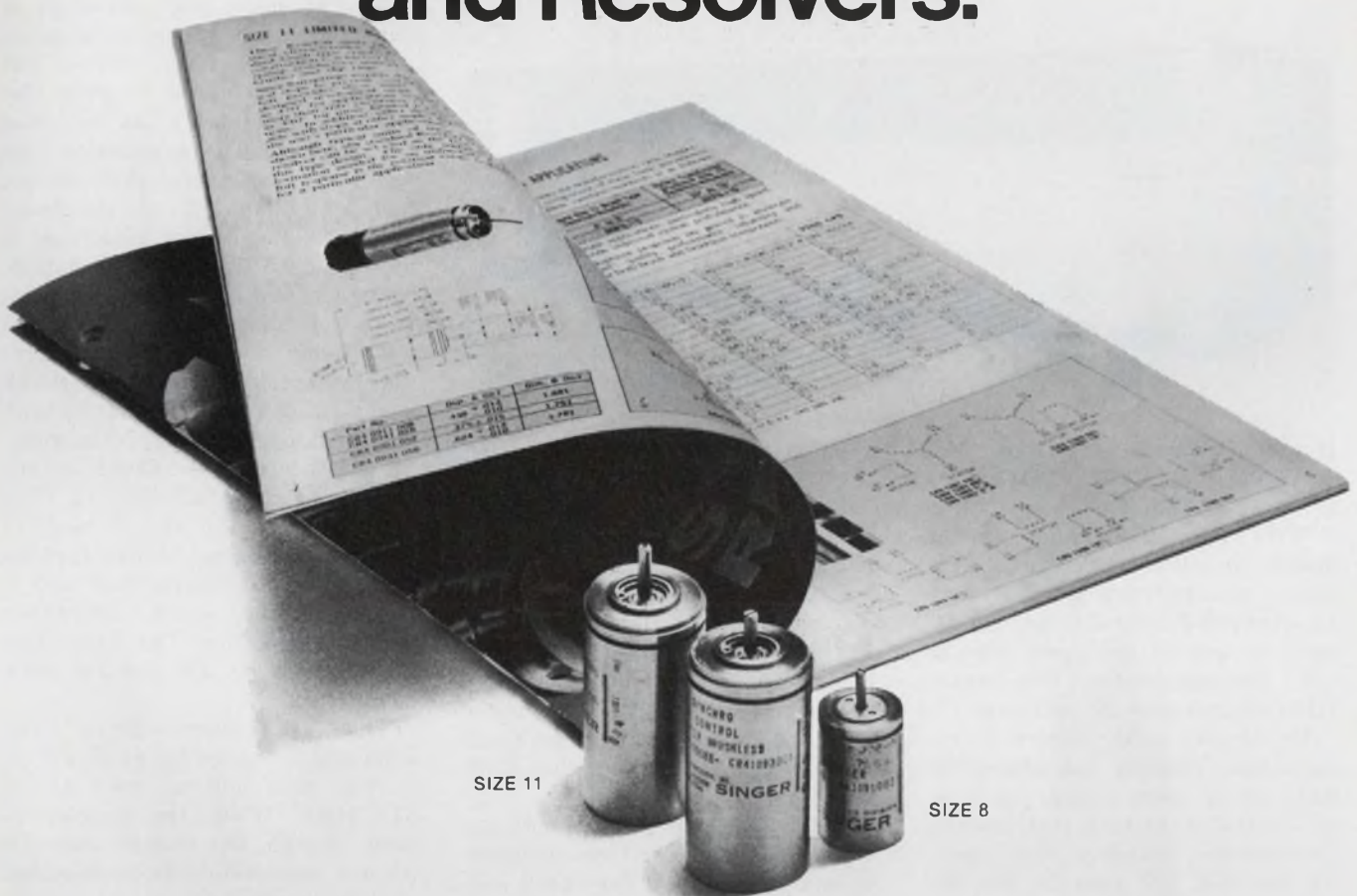
### Drop-proofed VOM costs just \$132.50

Weston Instruments Div., 614 Frelinghuysen Ave., Newark, N.J. 07114. (201) 243-4700. \$132.50; stock.

The Model 666 is the latest addition to the company's line of "drop-proofed" VOMs. For current measurements, the Model 666 offers twelve ranges with a lowest full-scale range of 1  $\mu$ A; eighteen voltage ranges, from 100 mV full scale through 1000 V and fourteen ohms ranges, featuring seven low-power-ohms ranges for "in circuit" measurements of semiconductors. Other features include a differential FET-input circuit providing 10 M $\Omega$  impedance. This design eliminates frequent battery replacement, assuring 400 continuous hours of operation.

CIRCLE NO. 253

# Send for our brushup course on Brushless Synchros and Resolvers.



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limited and continuous rotation applications—plus our full line of Synchros and Resolvers. The Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, New Jersey 07424.

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# Phase-locked signal generators yield ultra-stable frequencies



*Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (213) 877-1282. \$4450; 90 days.*

With the introduction of the 8640B, an ultra-stable signal generator with extreme spectral purity, Hewlett-Packard joins the attack on one of the most popular vhf generators—the 608—which HP fathered over 20 years ago.

Its closest rival, Singer Instrumentation, recently introduced the 6201—with specs similar to those of the 8640B. In both instruments, the extreme stability—0.05 ppm/hr for HP, 1.0 ppm/24 hrs for Singer—is obtained by phase-locking the output to a crystal reference.

Temperature drift for the 8640B is a low 0.05 ppm/°C—at room temperature—and less than 1 ppm/°C over the 15-30 C range. The 6201's drift is listed as less than 0.5 ppm/°C.

Spectral purity is where the solid-state HP unit really shines: It delivers low-noise signals that, till now, could be attained only with vacuum-tube generators. Non-harmonic and sub-harmonic outputs are more than 100-dB down. Close-in noise, important for adjacent-channel selectivity tests, is spec'd at 130-dB below the carrier.

Though it's difficult to compare noise specs—since they are measured and presented differently—the Singer generator appears to run neck-and-neck with HP's, with

a listed broadband noise of better than 130-dB below the carrier.

Harmonics of both units are better than 30-dB down across the entire frequency range.

Both units have a six-digit LED display of output frequency which, in the HP, covers the range of 450 kHz to 550 MHz and, in the Singer, covers 7.75 to 512 MHz. However, the Singer 6201 can go down to 61 kHz with the optional 6202 plug-in.

Both units also offer an optional frequency doubler; the doublers extend the range of the 8640B and the 6201 to 1100 and 1024 MHz, respectively. But, when using the doubler option with the Singer instrument, the frequency output is twice the indicated frequency. In contrast, the HP always displays the actual output frequency.

Additionally, both generators can measure external frequencies with their built-in counters. In this mode, the 8640B handles frequencies to 550 MHz, while the 6201 measures to 10 MHz.

Modulating characteristics of both the 8640B and the 6201 match their precision CW performance. Both units provide AM, FM and pulse modulation. AM, in both units, can be varied from zero to 100%. Distortion, in the HP, (at 1-kHz rate) is less than 1.5% to 50% AM, and less than 2% to 90% AM. For the Singer, distortion is less than 2% for 30% AM.

In FM mode, peak deviation of both units can be set to a minimum of 0.5% of the carrier. But FM distortion seems to differ for the two units: HP's has less than 1% up to 25-kHz modulation rate and to 1/4 of maximum deviation, and less than 3% at maximum deviation. For Singer, distortion is less than 0.5% at 0.1% deviation.

In contrast with the HP unit, in which deviation is calibrated and remains constant with frequency, the user must go through a calibration process to set the peak deviation on the Singer sig gen.

Output level of the 8640B ranges from +19 to -145 dBm (2 V to 0.01  $\mu$ V into 50  $\Omega$ ), leveled to  $\pm 0.5$  dB. The level is displayed on both a direct-reading dial and a built-in meter, which autoranges for best resolution. The meter also displays percent AM and FM peak deviation.

The 6201 delivers +20 to -146 dBm and is leveled to  $\pm 0.25$  dB up to 125 MHz and to  $\pm 0.5$  dB to 512 MHz. When the doubler is used, though, the output drops 16 dB and the leveling is downgraded slightly to  $\pm 0.8$  dB.

Finally, the HP 8640B offers a number of operating conveniences and options which complement its fine performance. An optional, built-in 20 Hz-to-600 kHz oscillator can be used as the modulating source, or independently to provide calibrated output levels. This \$150 option extends the usable cw frequency of the 8640B down to 20 Hz.

Other features include: lighted annunciators that indicate when output levels or modulation limits have been exceeded; a flashing of the LED display to indicate that the phase-lock has been broken; and a vernier that allows fine tuning of the rf in the locked mode of at least  $\pm 20$  ppm.

For more information from:

Hewlett-Packard:	CIRCLE NO. 254
Singer:	CIRCLE NO. 255



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### Typical Capacity Ranges Available MCL — 500

	NPO			K2000			K6500		
Cap.	25V	50V	100V	25V	50V	100V	25V	50V	100V
Min.	20pf	20pf	20pf	1000pf	1000pf	1000pf	5000pf	5000pf	5000pf
Max.	3300pf	2000pf	1200pf	.15uf	.08uf	.05uf	.33uf	.18uf	.10uf

### Capacity Values Available MLC — 510

	NPO			K2000			K6500		
Cap.	25V	50V	100V	25V	50V	100V	25V	50V	100V
Min.	100pf	100pf	100pf	5000pf	5000pf	5000pf	.015uf	.015uf	.015uf
Max.	.015uf	.01uf	.008uf	.5uf	.44uf	.33uf	1uf	.68uf	.5uf

#### Specifications

	NPO	K2000	K6500
Temperature Coefficient:	NPO	Y5P	Z5U
Minimum Capacitance Tolerances:	± 5%	± 10%	± 20%
Minimum Q 1 MHz:	1000		
Maximum DF 1 KHz:		2.5	2.5
Temperature Range:	-55°C - +125°C		
Working Voltage:	25 VDC, 50 VDC and 100VDC		
Life Test:	Per EIA RS-198B		
Flash Test:	2.5 X Rated Voltage for 1 Second		

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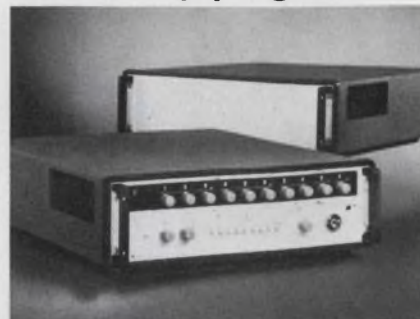


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## INSTRUMENTATION

### Frequency synthesizer is remotely programmed



General Radio, 300 Baker Ave., Concord, Mass. 01742. (617) 369-4400. \$4700.

General Radio's new 160-MHz Model 1061 Frequency Synthesizer is characterized by an 80-dB signal-to-spurious ratio and 100-μs switching speed. The synthesizer is structured so the user can select options for a level of performance and degree of frequency resolution commensurate with his needs. The basic unit provides a leveled output of 0 dBm to +20 dBm into 50 Ω from 400 kHz to 160 MHz with 10-kHz (5-digit) resolution. Both frequency and output level can be remotely programmed and a search-sweep mode provides additional resolution to 100 Hz. A separate output covers a frequency range of dc to 10 MHz and is standard on all units. The search-sweep mode allows any decade, with 1-MHz steps or less, to be varied by a continuous control with overlapping coverage.

CIRCLE NO. 256

### Autoranging DPMs offer 100 MΩ input

Digitan Systems Co., 5001 16th Ave., Brooklyn, N.Y. 11204. (212) 853-2793. \$99 (200); 4-6 wks.

A new line of digital panel meters offer an auto-expand feature: when the reading gets to 10% of full scale, a scale expansion by a factor of 10 takes place. Thus the meter, when used to replace a conventional 3-1/2-digit panel meter, enhances the overall system capability. The DPMs feature seven-segment fluorescent readouts, 100 MΩ input impedance, 5 V power supply, 100% over-range, and input readings up to 20 V.

CIRCLE NO. 257



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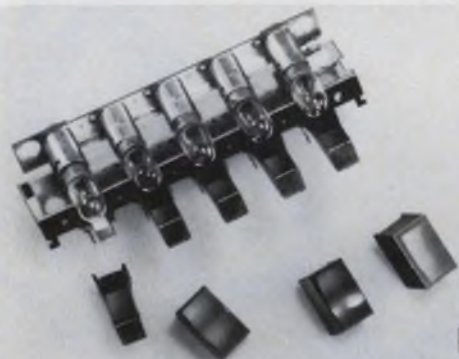
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INFORMATION RETRIEVAL NUMBER 47

## INSTRUMENTATION

### Angle indicator resolves 0.1 degrees

*Transmagetics, Inc., 210 Adams Blvd., Farmingdale, N.Y. 11735.  
(516) 293-3100. \$645; stock.*

The Model 2623EC2 is a compact, solid-state angle indicator having a digital readout. The unit will accept the full range of synchro or resolver inputs and will display the mechanical input angle from 0 to 359.9 degrees on a four-digit, seven-segment display. The instrument will display a 180-degree change in input angle within 2.5 ms. The four-decade unit has 14-bit resolution with an absolute accuracy and resolution of 0.1 degrees. The incandescent digital character height is 3/8 inches. Size is 4-1/2 x 1-3/4 x 5 inches. Power supply requirements are +5 V dc and ±15 V dc.

CIRCLE NO. 258

### Waveform generator lets user set exact shape



*Princeton Applied Research Corp., Box 2565, Princeton, N.J. 08540.  
(609) 452-2111. \$1650; 60 days.*

The Model 175 waveform generator/programmer permits the user to independently select all the individual parameters whose values determine the exact shape of the final waveform. Instead of providing the usual frequency, amplitude and offset controls, the Universal Programmer allows the independent selection of up to four inflection points and two values of either time (in pulse mode) or slope (in sweep mode) so that complex waveforms of up to four variable-length segments can be generated either singly or repetitively. Front panel and parallel external controls permit instant reset, hold and reverse of the generated waveform at any point.

CIRCLE NO. 259



## Photometer/Radiometer has digital readout



Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005. (503) 644-0161. \$600 w/o probe; 6 wks.

The J16 Digital Photometer/Radiometer is a portable unit capable of making a wide variety of light measurements. It measures only  $2.4 \times 4.6 \times 8$  inches, and weighs 3-1/4 lb, including the internal rechargeable batteries. The 2-1/2-digit LED display can be easily read in low-ambient light conditions. All probes use silicon sensors ( $1 \text{ cm}^2$ ) for maximum stability. The J6501 Probe measures illuminance in footcandles. The J6502 Probe measures irradiance in  $\mu\text{W}/\text{cm}^2$  within the spectral range of 450 to 1000 nanometers. The J6503 Probe measures luminance in foot Lamberts. The J6504 Probe has no correction filter so that the spectral response characteristics of the silicon detector may be used directly. The J6505 Probe measures illuminance of sources having spectral outputs in the red region (LEDs).

CIRCLE NO. 260

## Rb frequency standard is inexpensive

Tracor, Inc., 6500 Tracor Lane, Austin, Tex. 78721. (512) 926-2800. \$5900.

The Model 308-A rubidium frequency standard has been introduced by Tracor, Inc. Designed for applications in astronomy, navigation, metrology, communications and other situations where a precise and stable time base is required, the 308-A has all the advantages of atomic stability at near-crystal prices. Standard output is 5 MHz with others optional.

CIRCLE NO. 261

## Another Sprague Breakthrough!

### PRODUCTION-ORIENTED SOLID TANTALUM CAPACITORS

Solid flame-retardant epoxy with precise dimensions for automatic insertion. Completely shock and vibration resistant.

Flat surface permits clear easy-to-read marking.

No rundown to interfere with seating of capacitors on printed wiring board.

Rugged 0.025" dia. tinned leads maintain alignment. 0.100" lead spacing for standard PWB grids.

Top flat for easy identification of positive lead either visually or by touch.

Standoff feet on base to eliminate moisture entrapment and facilitate cleaning of wiring boards.

Formed leads with either 0.200" or 0.250" spacing to permit interchangeability with dipped capacitors.

ACTUAL SIZE

## Type 198D Low-cost Econoline\* Tantalum Capacitors Lead in Performance!

When it comes to low-cost solid tantalum capacitors, the new Sprague Type 198D Econoline Capacitors outperform all other designs. Here are some additional advantages:

- Low d-c leakage
- Low dissipation factor
- Wide voltage range, 4 to 50 VDC
- Capacitance range from 0.1 to 100  $\mu\text{F}$
- Withstand severe temperature cycling and temperature shock over  $-55^\circ\text{C}$  to  $+85^\circ\text{C}$
- Speedier handling for insertion
- Easier-to-read markings

The new Sprague Type 198D epoxy-encased Econoline Capacitor is tooled for mass production and priced competitively with imported dipped units. Investigate this new Sprague breakthrough without delay.

Call your nearest Sprague district office or sales representative, or write for Engineering Bulletin 3546 to: Technical Literature Service, Sprague Electric Co., 347 Marshall Street, North Adams, Mass. 01247.

\*Trademark

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THE MARK OF RELIABILITY



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Inductor coils made with a jeweler's touch. At mass-production prices. Elegant answers to applications that demand exacting performance. Like solenoid control valves. And coils for computer disc drives. With custom bobbins, windings and transfer-mold encapsulation executed under a single roof. So turnaround is fast — even when you want sample or pilot quantities.

At U.S. Electronics, you'll find all the precision and finesse you expect from an EAI component company. Look to EAI also for transformer kits. For thick-film audio and servo amps. For capacitors. Active filters. Analog/digital converters and other special-function modules. Plus a growing list of other elegantly crafted etceteras.



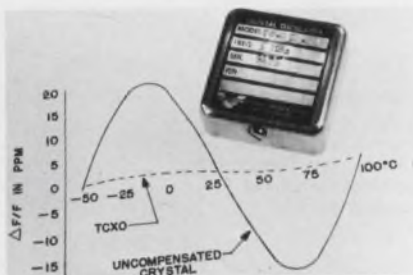
## USEC

U.S. Electronics Corporation  
Orient Way and New Jersey Avenue  
Lyndhurst, New Jersey 07071  
Tel. (201) 438-2400

A Subsidiary of Electronic Associates, Inc.  
INFORMATION RETRIEVAL NUMBER 49

## MODULES & SUBASSEMBLIES

### Crystal oscillator offers $\pm 10^{-7}$ stability



Vectron Laboratories, Inc., 121 Water St., Norwalk, Conn. 06854. (203) 853-4433. Stock.

The Model CO-252-3A TCXO (temperature-compensated crystal oscillator) uses computer compensation techniques to achieve a stability of  $\pm 1 \times 10^{-7}$  over the 0 to 50°C temperature range. This stability is achieved without the use of an oven, resulting in low (5-10 mA) power drain, small size and instantaneous "on-frequency" operation. Long term stability (aging) is better than  $1 \times 10^{-8}$  per day and  $1 \times 10^{-6}$  per year. A broad temperature range unit, Model CO-252-4A, provides  $\pm 1 \times 10^{-6}$  stability over the -55 to +85°C temperature range. These oscillators provide sine, TTL or CMOS output in the 1 to 20-MHz range; models are available covering frequencies from 60 Hz through 80 MHz.

CIRCLE NO. 262

### Power modules feature automatic crossover

Kepco, Inc., 131-38 Sanford Ave., Flushing, N.Y. 11352. (212) 461-7000. \$225.

Kepco, Inc. introduces the PTR power supply module, an automatic-crossover voltage/current stabilizer in modular form for the OEM. PTRs feature integrated front ends in both the voltage and current-control channels. They function in OEM environments from -20 to +71°C (with no need to derate the output) and can be programmed digitally (with the Kepco "SN Programmer") or with analog instructions. A built-in overvoltage crowbar, available as an option, protects sensitive loads. PTR modules offer the OEM a selection of six power units ranging from 0-7 V at 5.5 A to 0-100 V at 0.6 A.

CIRCLE NO. 263

### DPM uses external scaling resistors to set FS



Analogic, Audubon Rd., Wakefield, Mass. 01880. (617) 246-0300. \$47.00 (100s).

Analogic's AN 2530 is a 3-decimal digital panel meter that can be inventoried as a single basic measurement block for almost any system measuring and display application. All that is necessary is to select an appropriate feedback resistor and to pin select the desired display increment. The universal DPM is available in two mechanical configurations.

The unit measures positive or negative inputs in the presence of up to  $\pm 300$  V common mode (dc or ac peak) with respect to digital logic ground. The isolated input is powered from a floating analog source developed by a built-in dc/dc converter. The analog count circuit is transformer-coupled to the counter-display circuit.

Externally-selected input scaling is accomplished with simple resistor connections. Full scale voltage is  $\pm 20$  mV to  $\pm 2.0$  V with current ranges from 2  $\mu$ A upwards as determined by a selected shunt. External jumper connections of counter-circuit terminals provide a least-count resolution of 1, 2, 5 or 10 units.

Other specs include: 0.2% resolution; guaranteed monotonicity; independent decimal point selection; linearity and relative accuracy of  $\pm 0.2\%$  FS  $\pm 1$  count; input bias current of 10 nA (nominal); tempco of Zero: 1 count per 20°C or 20  $\mu$ V/°C (whichever is greater); tempco of F.S. range: 1 count per 20°C or 250 ppm/°C (whichever is greater); a conversion rate of 1.5 per second (nominal); a CMRR of 120 dB for dc (nominal) and 100 dB for ac (nominal at 60 Hz) input. Input power is 3.0 W, and size is 3.187  $\times$  1.375  $\times$  1.800 inches (behind bezel).

CIRCLE NO. 264



Meet our growing family of  
amorphous

# RMM<sup>S</sup>

## NON-VOLATILE/ELECTRICALLY ALTERABLE SEMICONDUCTOR MEMORIES

We started with a 256-bit silicon/amorphous memory—the very first of its kind. And we've been adding to the line ever since. All the way from 8 to 16-bit integrated chips used as register saves and in preset counters, plus a host of logic control applications. On up to 2048-bit arrays for microprogramming, communications processing and a broad range of machine tool and industrial process controls.

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Besides being the only truly non-volatile and fully electrically alterable semiconductor memories on the market, these Ovonic RMMs

also feature high noise immunity, low power storage, in-system write, rapid random access, and non-destructive readout.

We've made them easy to use, too. They come in standard packages. They're TTL/DTL compatible and compatible with each other. And they can be applied for direct interfacing with any logic form. All of which means you can mix or intermix them any way you want to create flexible, expandable memory systems to meet present and future needs—*exactly!*

Availability? Here and now! In *any* quantity. Call or write for complete information today.

**Energy Conversion Devices, Inc.**

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INFORMATION RETRIEVAL NUMBER 68

## THE MINNESOTA TWINs

46 of these . . . 0.125 ctrs.



46 of these . . . 0.100 ctrs.

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

Write for free information today:

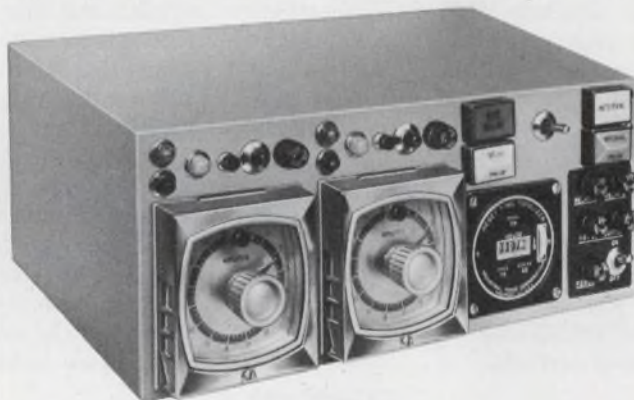
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DIVISION OF  **FABRI-TEK INC.**

INFORMATION RETRIEVAL NUMBER 69

ELECTRONIC DESIGN 20, September 28, 1972



## If you need Custom-Built Timing Controls, it will pay you to let us build them.

That's because we design and build them better — faster at less cost. It is our 28 years of experience that makes it possible . . . years in which we have filled 5,124 orders for customer timing controls.

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Industrial Timer Corp., U.S. Hwy 287, Parsippany, N.J. 07054 201/887-2200

INFORMATION RETRIEVAL NUMBER 70



## Panel display features eight 0.7-inch digits



Burroughs Electronic Components Div., Box 1226, Plainfield, N.J. 07061. (201) 757-5000. Approx. \$2/digit (quantity); 1st quarter of 1973.

The BR08751 PANAPLEX II panel display with eight 0.7-inch characters (compared to previously announced 0.25 and 0.4-inch characters) can be comfortably viewed from distances of up to 35 feet. The character format is seven-segment, 0.37 inches wide, and is displayed against a black, non-reflective background. The BR08751 panel contains eight digits of display interconnected within a common envelope. Only 24 connections are required to address the eight character positions and decimal point. The connection scheme permits a wide variety of vertical, horizontal, and angled mounting configurations. The unit is 5.4 inches wide, 1.6 inches high, and only 0.25 inches thick (not including tubulation). The BR08751 operates at low power and is compatible with standard TTL and DTL integrated circuits.

CIRCLE NO. 265

## Crystal oscillator gives 12 frequencies

Connor-Winfield Corp., Winfield, Ill. 60190. (312) 231-5270. 2-3 wks.

A crystal, multiple-frequency clock oscillator provides up to 12 fixed, square-wave frequencies that are multiples of up to 2 different frequencies from 1 Hz to 30 MHz ( $\pm 0.001\%$ , 0 to  $+50^\circ\text{C}$ , or  $\pm 0.005\%$ ,  $-25$  to  $+75^\circ\text{C}$ ). Each frequency can drive 10 TTL gates. Supply voltage is 5 V dc  $\pm 5\%$ . Case size is  $0.78 \times 0.49 \times 0.57$  inch.

CIRCLE NO. 310

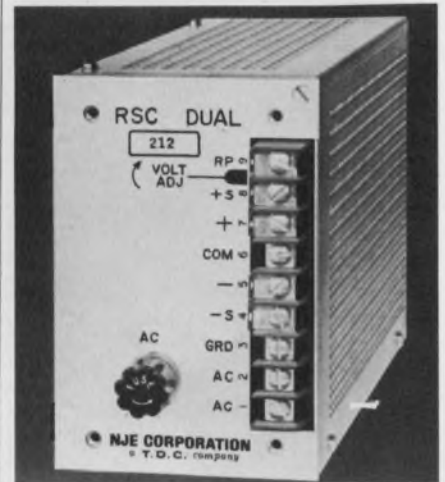
## Narrow-band rf amp has 3-dB NF, weighs 2.5 oz.

Optimax Inc., P.O. Box 105, Advance Lane, Colmar, Pa. 18915 (215) 822-1311. AL-1007: \$305; AL-1005: \$345; AL-1006: \$285.

The Model AL-1007 narrow-band rf amplifier weighs only 2.5 ounces, has a noise figure of 3 dB, maximum and a frequency range of 10 to 110 MHz. Hybrid thick-film techniques are used to reduce weight and size, which is  $2.5 \times 1 \times 0.6$  inches. The amplifier has a nominal gain of 35 dB and a gain-control range of  $\pm 5$  dB. The VSWR in/out is 1.5:1, maximum and the IM product-intercept point is +15 dBm. Two other narrow-band rf amplifiers are available in this series: Model AL-1005 with a 380 to 500-MHz BW; and Model AL-1006 with a 40 to 80-MHz BW. Both of these units have the same noise figure as the Model AL-1007.

CIRCLE NO. 266

## Power supply offers $\pm 15$ V at 2.4 A



NJE Corp., Culver Rd., Dayton, N.J. 08810. (201) 329-4616. \$145; stock.

NJE now offers a high-current op amp OEM modular power supply, Model RSB-212, with a dual output adjustable from  $\pm 12$  to  $\pm 15$  V at 2.4 A (at  $40^\circ\text{C}$ ). Physical size is  $3.17 \times 4.45 \times 9.37$  inches. The unit is fourth in a new series of op-amp type supplies by NJE. Input on all models in the series is 105-132 V, 47-440 Hz. Load regulation for all models in the series is 0.1% for a no-load to full-load change in output current within rating of the supply. Ripple and noise do not exceed 3 mV pk-pk, 1.0 mV rms (dc to 10 MHz). Stability is less than 0.1% total drift for eight hours. Transient recovery time is less than 50  $\mu\text{s}$  within  $\pm 1.0\%$  for line changes of  $\pm 10\%$  around nominal, or  $\pm 50\%$  load changes around nominal.

CIRCLE NO. 267



ANALOG  
ANA'S BOYS TURN OUT CUSTOM ANALOG CIRCUITS FASTER THAN POOR OLD NORM ANY DAY. TO BUILD YOUR OWN, IT TAKES DESIGN, PARTS INVENTORY, PRODUCTION, TESTING, TRAINED PEOPLE, MONEY AND TIME. AND WHILE YOU'RE STILL DESIGNING SOMEONE ELSE UP AND INTRODUCES A BETTER SYSTEM. START SWINGING WITH ANA'S BOYS... CALL INTECH FOR FAST, FAST TURNAROUND ON CUSTOM ANALOG CIRCUITS. FREE ESTIMATES.

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## 10-bit d/a converter has 0.01 $\Omega$ output impedance

Sprague Electric Co., 87 Marshall Street, N. Adams, Mass. 01247. (413) 664-4411.

The Series UHM-500 consists of complete 8 and 10-bit d/a converters in DIP-compatible plastic cases for operation over the temperature range of  $-55$  to  $+125$  C. Conversion accuracy is specified as better than  $\pm 1/2$  LSB between  $-25$  and  $+85$  C. The type UHM-503 is a 10-bit converter with an absolute accuracy of better than  $\pm 0.048\%$  and a conversion time of, typically,  $2.5 \mu\text{s}$ . The Type UHM-506 is similar but includes an operational amplifier with feedback resistors for an output impedance of only  $0.01 \Omega$ . The Type UHM-523 is an eight-bit converter with an absolute accuracy of better than  $\pm 0.195\%$  and a conversion time of, typically,  $2.0 \mu\text{s}$ .

CIRCLE NO. 268

## Hexadecimal display has integral TTL chip



Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237. (212) 497-7600. \$10 ea. (1000) 4-6 wks.

Dialight announces its new 0.27-inch LED hexadecimal readout with integral TTL circuit that accepts, stores and displays four-bit binary data. The display and TTL MSI chip are mounted on a lead-frame assembly that is then cast within a red, electrically nonconductive, transparent plastic compound. Multiple displays may be mounted on 0.450-inch centers. The display also has left and right decimals, single-plane wide-angle visibility, and high brightness due to the gallium arsenide phosphide used for the LEDs. These readouts can be used with separate LED and logic 5-and-6-V power supplies.

CIRCLE NO. 269

# What's new in frequency control?



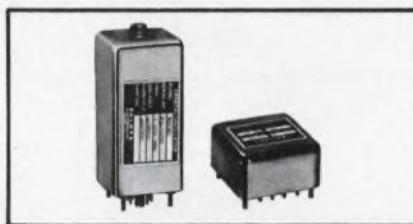
A new series of *highly miniaturized coldwelds* having a broader frequency output is now available. The units — developed by Bulova — feature tolerances as close as 3 ppm of nominal on initial adjustment, and aging rates up to 3 pp  $10^8$  per week. In the TO-5 can, for example, with a frequency range of 500 KHz to 160 MHz, Bulova coldwelds have a tolerance of  $\pm 0.015\%$  (from  $-55^\circ\text{C}$  to  $+105^\circ\text{C}$ , or to specs.) Aging is  $1 \times 10^{-7}$ /week after 4 weeks.

CIRCLE NO. 51



Group delay crystal filters offering perfect phase linearity for optimum data transmission are also available from Bulova. Overshoot is kept to 40 db (1%) below the steady state value. The filters provide distortion-free selectivity, at a maximum speed, and have a reduced error rate. Bulova's complete line of crystal filters meet all transmission specifications from 4 KHz to 150 MHz.

CIRCLE NO. 53



In crystal oscillators, the *temperature compensated TCXO-18* offers a frequency stability of  $\pm 2$  ppm over a temperature range of  $-55^\circ\text{C}$  to  $+105^\circ\text{C}$ . A voltage variable capacitance diode and thermistor network maintain stability without an oven. The *high stability PCOXO-5* — also by Bulova — has an aging of 5 pp  $10^{10}$ /day. It's a commercial, plug-in package with frequency stability of 2 pp  $10^{10}/^\circ\text{C}$  over a range of  $0^\circ$  to  $+60^\circ\text{C}$ , and short term stability of 11 pp  $10^{10}$  per second.

CIRCLE NO. 52



The news in *subminiature fork oscillators* is a unit which uses less than 5 ma. The oscillator, developed by Bulova and designated the FS-11-1, takes up about  $\frac{1}{2}$  cu. in. of space and weighs one ounce. Their units have accuracies up to  $\pm 0.0005\%$ , 90% reliability for 200,000 hrs. and logic circuit compatibility.

CIRCLE NO. 54

Bulova has been making frequency control news since 1937. For information on Bulova's complete range of frequency control products, call 212-335-6000, see EEM Section 2300, or write: Bulova Watch Company, Inc., Electronics Division, 61-20 Woodside Ave., Woodside, N. Y. 11377.





## Augat enclosures. You can do a lot with 3 1/2 inches.

Example: Augat's 3 1/2-inch-high drawer assembly will package up to 720 DIP's. That's a lot. What's more DIP's are always in easy reach. Panel frames have unique two-way hinges for accessibility or removal.

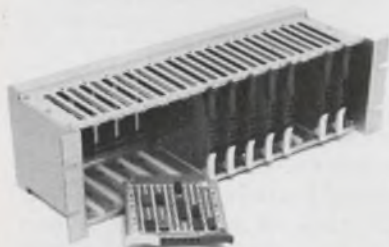
Augat rack assemblies also give you plenty of packaging density. Plus flip-up access to panels for fast repairs or design changes.

Smallest of all, our new mini-rack assembly—with small racks and plug-in panels—lets you subdivide logic more flexibly than before.

Whichever way you want to go, you can count on Augat for all your enclosure needs. And probably pay less money than you're paying now, thanks to our off-the-shelf supply.

Augat. The ones who pioneered the plug-in panel. Call us for panels (with automatic wire wrapping available), enclosures, sockets, accessories. Or write for our catalog.

Augat Inc., 30 Perry Avenue, Attleboro, Mass. 02703. (617) 222-2202. Our representation and distribution is nationwide and international.

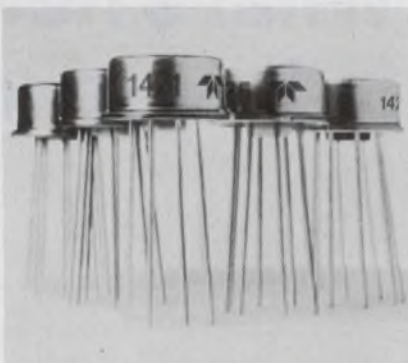


**Plug into Augat®**

INFORMATION RETRIEVAL NUMBER 56

## ICs & SEMICONDUCTORS

### FET op amp line extended



*Teledyne Philbrick, Allied Dr. at Route 128, Dedham, Mass. 02026. (617) 329-1600. Stock.*

Six devices are added to the company's 1400 series, a line of FET op amps. The new units include the following: the 1422—a 5-MHz GBW amp with 8 V/ $\mu$ s minimum slew rate; 1424—a low-cost version; 1425—an internally trimmed device with 1 mV max initial offset voltage and 5 pA maximum bias current; 1426—a low-drift unit with 1 mV max initial  $E_{os}$  and 5  $\mu$ V/ $^{\circ}$ C drift; 1428—a low-cost replacement, and the 1429, with bias currents under 0.25 pA and internal trimming to 1-mV max initial offset voltage.

CIRCLE NO. 270

### Hybrid op amp boosts slew rate to 2000 V/ $\mu$ s

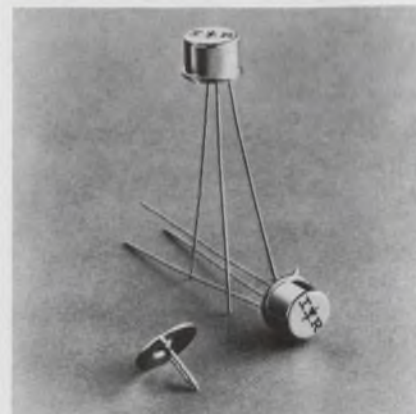


*M. S. Kennedy Corp., 168 Pickard Bldg., E. Molloy Rd., Syracuse, N.Y. 13211. (315) 437-5616. \$89 (10-24); stock.*

The Model 780 hybrid op amp boasts a slew rate of 2000 V/ $\mu$ s with an output current rating of 80 mA. Bandwidth is 120 MHz. The 780 comes in an 8-pin TO-3 package and operates over the full MIL temperature range.

CIRCLE NO. 271

### Low power SCR line extended



*International Rectifier Corp., 233 Kansas St., El Segundo, Calif. 90245. (213) 678-6281.*

Six series of SCRs in TO-5 cans provide an alternate source of these units while further expanding the company's line of low-power SCRs. The new series are the 2N2322, 2N4212, IR5 and IR6. All are available in versions with rated voltages of 25 to 400 V; and the 2N1595 and 2N1595A, with rated voltages of 50 to 400 V.

CIRCLE NO. 272

### SCRs and diodes rated at 1000 V plus



*Westcode Semiconductors, 282 Bel-field Rd., Rexdale 605 Ontario, Canada. (416) 677-5881.*

A series of SCRs and diodes operate from voltages above 1000 V. Transient voltage ratings are up to 5.5 kV, and repetitive voltage ratings go to 3750 V. The average current range is from 200 A to 625 A, with double-sided cooling.

CIRCLE NO. 273

# Quick Fastening Devices for the Electronics Field.

Dzus Fastener Co. Inc., who invented the ¼-turn fastener in 1932 for use in the aircraft field, also produces a wide variety of specialized fastening devices for the electronics field which carry through the original Dzus concept of quality fastening at low installed cost.

## Panel Line



### Spiral Cam ¼-Turn Self Locking Fasteners

Ideal for securing instruments, modules and chassis to racks. Panel strips are available in various lengths and configurations to conform to any application.

## Standard Line



### The Original and Most Versatile ¼-Turn Fastener

For use on any structural material in a wide variety of applications. Available in a variety of lengths and head styles.

## Adjustable Pawl Latches



### Standard and Miniature Sizes for Doors, Drawers and Panels

For compartment doors, sliding drawers or instrument covers. Wide, variable grip adjusts to fit varying metal thicknesses.

## Toggle Latches



### Low Cost, Low Profile Models with Choice of Strikes

For container fastening, control boxes, instrument cases and other uses where pull-up is required

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## Dzus Fastener Co. Inc.

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INFORMATION RETRIEVAL NUMBER 57

FAST, ACCURATE

## computer plotted printed circuit conversion

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digitizing

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film processing

prototype fabrication

production

Com-Cir-Tek system converts basic electric logic into highly accurate artwork, prototypes and production run circuit boards in a matter of days. Minimizes time and expense. Accuracies to  $\pm 0.0005$  are routine. Laborious manual designs, changes and corrections are eliminated. Flexible Com-Cir-Tek capability easily adapts to your requirements. Free bulletin gives full details. Write:

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PHONE 716 675-3800

INFORMATION RETRIEVAL NUMBER 58

ELECTRONIC DESIGN 20, September 28, 1972

**TEST CLIPS**  
After 100,000 wire insertions and removals contact resistance registered less than .001 ohms.



**BI-PIN LAMP SOCKETS**  
Features 4 point PC mount for stability.



**TRANSISTOR SOCKETS**  
Minimum insulation resistance of 500,000 meg-ohms at 100 VDC.



**BINDING POSTS**  
Caps won't melt at soldering temperature.

## Even hardware can be different

Grayhill is in termination hardware because our customers wanted something different.

And products and features shown above reveal only part of the picture.

Grayhill makes 100 other items of termination hardware—developed for superior insulation, dielectric strength, minimum contact resistance. And if what you need isn't in our line now, we can design and make it for you.

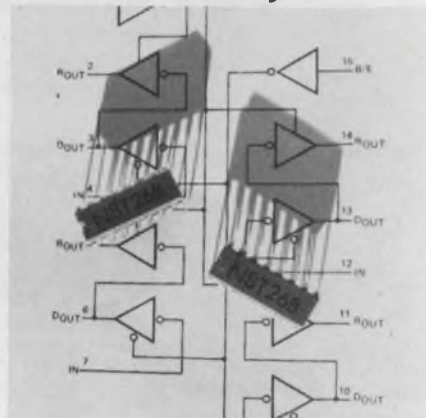
For our latest Engineering Catalog write or phone:  
Grayhill, Inc., 565 Hillgrove Ave.,  
La Grange, Illinois 60525.  
(312) 354-1040.



INFORMATION RETRIEVAL NUMBER 59



## Quad bus drv'r/rcvr lists 17-ns delay



Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700. N8T26B: \$3.90 (100 up); stock.

The 8T26, Schottky-TTL IC consisting of four driver/receivers, features a propagation delay of less than 17 ns and a power consumption of 250 mW. Each driver can sink 40 mA, while a receiver can handle 16 mA. The quad transceiver is suitable for routing data in bus-oriented systems, including small minicomputers and memory systems.

CIRCLE NO. 274

## Having P/C repro problems? Maybe your artwork is too fat.

What you see here is a clay model representing art made with die-cut symbols. To your eye your artwork doesn't look like that. But the lens of the repro camera picks up the buildup of those die-cut symbols and tape.

Mecanorma symbols, on the other hand, are printed on an ultra-thin transparent carrier film just 20 microns thick! The tape lies flat. There is no buildup, hence there is no distortion, no parallax.

You can apply Mecanorma symbols with pinpoint accuracy, too. Unlike die-cut symbols, Mecanorma comes in handy transparent strips which give you rapid and precise positioning. No sticky situations, either. The symbols and the carrier sheet can actually come in contact with your work surface without the symbol sticking before you want it to.

And if you change your mind, you can quickly correct it with tape or rubber cement pick-up (it's 40% or 50% quicker than other methods). Mecanorma symbols come in a flat box so they're easy to store (they have a 7-year shelf life). And if you think variety is the spice of life, we have over 800 different symbols to keep you happy.

To prove Mecanorma symbols are all we say, we'll send you some samples and one of our catalogues. Free. Just write Keuffel & Esser Co., 20 Whippany Road, Morristown, N.J. 07960.



KEUFFEL & ESSER CO.



## Dual op amps, comparators introduced

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. (408) 732-5000. LH2301AD: \$6.95; LH2308-D: \$8.95; LH2310D: \$10; LH-24250CD: \$8.95; LH2311D: \$8 (100 up); stock.

A series of dual op amps and dual voltage comparators are offered. These include the LH2101A/LH2301A high performance amps, LH2108/LH2308 precision amps, LH2110/LH2310 high-speed voltage followers, LH24250/LH24250C programmable op amps and the LH2111/LH2311 voltage comparators. These ICs embody all of the features and specifications of the popular single LM101A, LM108, LM110, LM4250 and LM111, respectively. The new circuits offer lower weight, reduced insertion cost, reduced space requirements and closer thermal tracking.

CIRCLE NO. 275

# The Answer Fan. Low-profile installation? It's a mere 3<sup>5</sup>/<sub>8</sub>" sq., 1<sup>1</sup>/<sub>2</sub>" deep. High output vs back pressure? It packs a 46 cfm cooling wallop. We call it, "The Mini Boxer."

MiniBoxer fights the damaging effects of heat in rack panels, tape decks, main frames and similar space-critical applications.

10 high performance models, ball or new Grand Prix sleeve bearing types, provide 10 or more years normal operating life. Also available in rugged Mil Spec versions.

Other airmovers? Of course!

Send for our full-line catalog No. ND4r. It's free, and contains performance data, electrical and mechanical specifications on more than 100 units.

And valuable application information too.



For immediate service, contact us at **IMC Magnetics Corp., New Hampshire Division**, Route 16B, Rochester, N.H. 03867, tel. 603-332-5300. Or the IMC stocking distributor in your area. There are more than 50 nationwide and overseas.



**IMC New Hampshire Division Airmovers** are available at the following locations:

**Colo., Denver**/Denver-Walker Electronics, 300 Bryant St. 80219/(303) 935-2406  
**Colo., Denver**/Newark-Denver Elec., 2170 S. Grape St. 80222/(303) 757-3351  
**Conn., Norwalk**/Harvey-Conn., 112 Main St. 06852/(203) 853-1515  
**Ga., Atlanta**/Ack Radio Supply Co., 554 Deering Rd., N.W. 30309/(404) 351-6340  
**Mass., Boston**/Demambro Electronics, 1095 Commonwealth Av. 02215/(617) 787-1200  
**Mass., Dedham**/Gerber Electronics, 852 Providence Hwy. 02026/(617) 329-2400  
**Mo., St. Louis**/Olive Industrial Elec., 6662 Olive Blvd. 63130/(314) 863-7800  
**N.C., Greensboro**/Hammond Electronics, 838 Huffman St. 27405/(919) 275-6391  
**N.J., Haddonfield**/Mid-Atlantic Electronics, 140 Haddon Ave. 08033/(609) 428-8286  
**N.Y., Binghamton**/Stack Industrial Elec., 45 Washington St. 13901/(607) 723-6326  
**N.Y., Schenectady**/Adirondack Electronics, 2469 Albany St. 12304/(518) 316-4717  
**Penn., Scranton**/Consolidated Distributing, 115 Capouse Ave 18500/(717) 346-3831  
**Tex., Houston**/Texas Inst. Supply, 3939 Ann Arbor Dr. 77042/(713) 785-4800  
**Utah, Salt Lake City**/Standard Supply, 225 East 6th St. So. 84110/(801) 355-3971  
**W. Va., Beckley**/Halley Electronics Co., 713 S. Oakwood Ave. 25801/(304) 253-2151

Send for the complete **IMC Distributor Directory**.

INFORMATION RETRIEVAL NUMBER 61

## Versatile lighted pushbuttons.

Our Series 3 answers your need for a versatile medium-priced line of lighted pushbuttons.

□ There's a choice of matrix, individual or strip mounting. Each with uniform panel appearance. □ As well as a choice of momentary or two-level alternate actions. □

There's even a choice of 5 amp power switches with Form X, Y and Z or electronic

duty Form A reed switches. Matching

indicators are available for both. □ Typ-

ical applications include transporta-

tion control systems, reproduction equip-

ment, data processing and business machines, numeric control panels and

communications gear. □ Call your

MICRO SWITCH Branch Office or Author-

ized Distributor (Yellow Pages, "Switches, Electric"). Or write for our Series 3

product sheet.



## MICRO SWITCH

FREEMONT, ILLINOIS 61032

A DIVISION OF HONEYWELL

## Now we have two sides to our Pin Bar story.

Now you can pick up every pin with a single new Lear Siegler Pin Bar™. The new design utilizes both sides of the bar to pick up adjacent pins. Your installation time and production costs therefore are significantly reduced. Unlike most common connection methods, no soldering is required so making

terminal connections has never been easier or less expensive.

So if you'd like to simplify your bussing operation for as low as 2 or 3 cents per terminal, pin us down for details and a free sample.

**LEAR SIEGLER INC. ELECTRONIC INSTRUMENTATION DIVISION**  
214 NORTH BROOKHURST ST.  
ANAHEIM, CALIFORNIA 92803  
PHONE (714) 716-1010

INFORMATION RETRIEVAL NUMBER 62

ELECTRONIC DESIGN 20, September 28, 1972

INFORMATION RETRIEVAL NUMBER 63



# Look close or you may miss the world's smallest shielded inductor.



## New Pee-Wee Ductor 66% smaller than the previous smallest

Nytronics' new Pee-Wee Ductor for microminiature hybrid circuits is about an 1/8th of an inch from stem to stern . . . or about 1/3rd the size of the previous world's smallest magnetically shielded inductor. Yet its electrical performance is big time. It offers higher L and Q (MIL-C-15305) in ratio to volume than its famous predecessors Wee-Wee and Super Wee-Wee. Values run from .10 to 1000 uH  $\pm 10\%$ , a low of .025 to a high of 10,000 uH on special order. Minimum Q ranges from 34 to 55 at RF frequencies, and current capability from 43 mA to a whopping 1.5 amps.

Write for additional specs and temperature curves.  
Write small.



## Nytronics, Inc.

THE QUALITY LINE OF STANDARD COMPONENTS

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INFORMATION RETRIEVAL NUMBER 64

## ICs & SEMICONDUCTORS

### 2048-bit dynamic RAM offers 300 ns access

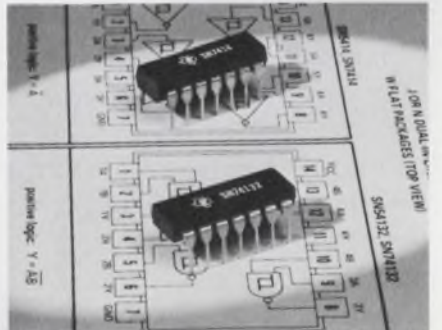


Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700.

A  $2048 \times 1$  dynamic RAM, termed the 2548, uses enhancement-mode p-channel devices on a single chip to obtain a read access time of 300 ns (max) and cycle time of 615 ns (max). Power dissipation is only  $80 \mu\text{W/bit}$ . The memory is fully decoded and contains built-in refresh amplifiers. All input data and control lines are directly TTL compatible.

CIRCLE NO. 276

### Schmitt trigger ICs ease interface woes



Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. SN7414N: \$4.19, 3 wks.; SN74132N: \$3.02, stock.

A TTL hex and TTL quad Schmitt-trigger interface ICs offer a solution to unsuitable input waveforms and TTL inputs. The hex circuit, termed SN54/7414, and the quad IC, termed the SN54/74132, feature over 800 mV hysteresis typically and are guaranteed to provide a total of 800 mV additional noise margin. That's 300 mV for logic ZERO and 500 mV for logic ONE inputs.

CIRCLE NO. 277

## DATA PROCESSING

### Binary data converted to five-digit angle display



Computer Conversions Corp., 6 Duntion Court, E. Northport, N.Y. 11731. (516) 261-3300. \$395 up; 4 wks.

The BAC 100 series of low-cost, 5-digit angle indicators operate on 16 bits of binary input data. The indicators have an accuracy of  $\pm 0.01^\circ$ . Their BCD readouts and digital displays can also be scaled to indicate other inputs such as range data, weight, pressure, temperature, etc. The units are available in a 9-1/2 x 1-3/4 x 12-in. case or on a 4.5 x 6.5-in. PC card.

CIRCLE NO. 278

### Cassette runs 3 hours; claimed to be a first



TDK Electronics Corp., 23-73 48th St., Long Island City, N.Y. 11103. (212) 721-6881. \$6.75 (unit qty).

A three-hour low-noise cassette, the TDK C-180LN claims a first in the audio cassette industry; it is 50% longer than any other. It uses an ultra-thin tape with a thickness of 0.025 mils. TDK says that it has solved thin-tape problems with its high-density magnetic coating, special tape backing material and binder system. TDK recommends using the cassette on its "jam-proof" cassette mechanism.

CIRCLE NO. 279

### Bell offers 4800 b/s self-equalizing modem

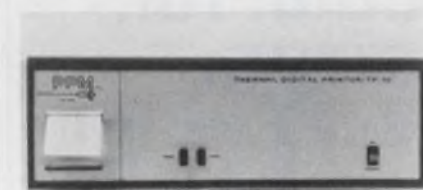


American Telephone & Telegraph Co., 680 Fifth Ave., New York, N.Y. 10019. (212) 393-2101.

Data-Phone 4800 is the Bell System's new high-speed (4800 b/s) phase shift keyed data modem. The solid state unit features a 50-ms turnaround time. Automatic equalization corrects for delay or amplitude variations that may occur on the recommended four-wire, private-line, type-3002 telephone channel. A three-position test switch and status lamps on the front panel aid the analysis of the set's operation.

CIRCLE NO. 280

### Quiet thermal printer stores input data

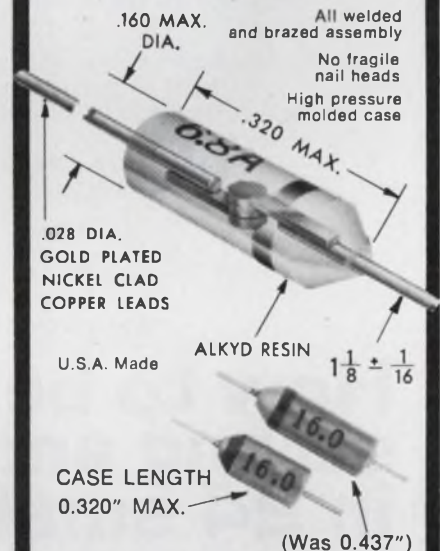


PPM, Inc., Subsidiary of Torq Engineered Products, Inc., 32 W. Monroe St., Bedford, Ohio 44146. (216) 232-1880.

Quiet in operation, the Model TP-10 prints on thermal paper using a thermal print head. The printer is available with 4, 8 or 12-column capacity. Print speed is 5 lines/sec continuous, or 10 lines/sec in bursts of 1000 lines. The TP-10 accepts parallel BCD codes for numeric characters at DTL/TTL levels. Data storage is provided, thus the data source need hold data for only the duration of the print command (5  $\mu$ sec min), plus the previous print cycle, (100 msec).

CIRCLE NO. 281

## NEW SHORTER CASE! SCHAUER 1-WATT ZENERS



**SAME LOW PRICES FOR 1% TOLERANCE ZENERS**

**ANY VOLTAGE FROM 2.0 TO 18.0**

Quantity	Price Each
1-99	\$1.07
100-499	.97
500-999	.91
1000-4999	.86
5000 up	.82

### IMMEDIATE SHIPMENT

Send for rating data and 20%, 10%, 5% and 2% tolerance prices.

Semiconductor Division

**SCHAUER**

MANUFACTURING CORP.

4511 Alpine Ave., Cincinnati, Ohio 45242  
Telephone 513/791-3030



# New RCA Picoammeter



**Measures DC from 1 picoampere to 30 mA** in 18 overlapping ranges. WV-511A also serves as a high input-resistance voltmeter, megohmmeter and amplifier.

Features solid-state components, battery or AC operation. Price: \$250.\* For further information, see your RCA Distributor.

Write RCA Test Equipment Headquarters, Harrison, N.J. 07029. Quantity prices on request.

\*Optional Distributor Resale Price

# RCA

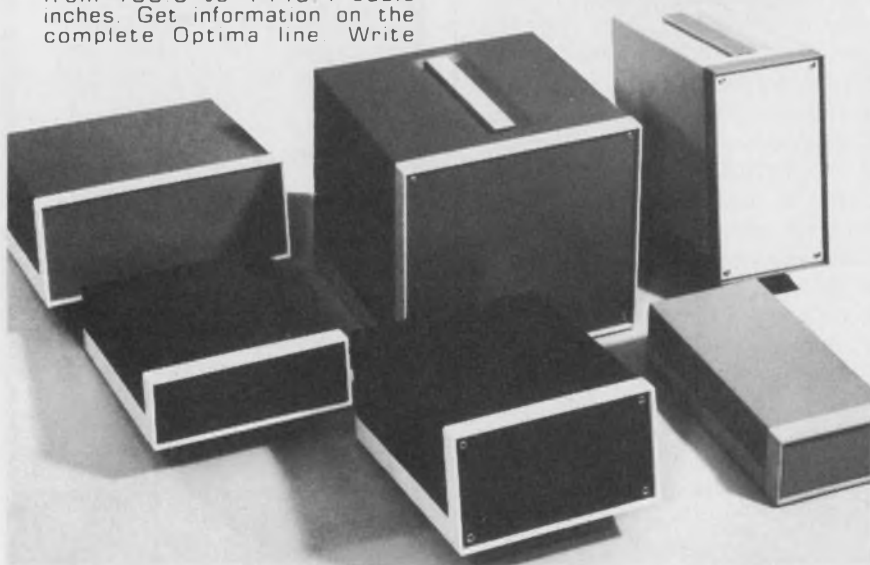
INFORMATION RETRIEVAL NUMBER 66

## How to be beautiful, strong and colorful, in 24 small sizes.

Bold design and quality construction are hallmarks of Optima Small Case enclosures. Mobile, versatile and rugged, these cases offer hundreds of two-color combinations in durable vinyl finishes, with useable inside space ranging from 133.6 to 1445.4 cubic inches. Get information on the complete Optima line. Write

Optima Enclosures, division of Scientific-Atlanta, Inc., 2166 Mountain Industrial Blvd., Tucker, Ga. 30084. Or call (404) 939-6340.

# OPTIMA



INFORMATION RETRIEVAL NUMBER 67

## design aids

### Alumina package chart

A 24-in. by 33-in. wall chart features documented test data, suggested use data and specifications as well as a broad representation of alumina/glass package dimensional outline drawings. Packages covered in the chart range from 14 to 40-leads and offer all standard varieties of lead spacing, row centers, dielectric or F-15 alloy base materials. Thermal resistance case to ambient in °C/Watt is specified. Plessey Veritron, Inc.

CIRCLE NO. 300

### Microwave transistors

Power vs frequency rating charts are available for molded and hermetic-sealed Power Tower microwave transistor packages. The charts (Bulletins 205 and 206) present, in graphic form, the power capabilities of National Beryllia Corp.'s Cermetrol Div. discrete device packages at various frequencies from 100 MHz to 3 GHz. With the inherent thermal conductivity characteristics of Berlox, the fundamental substrate of all Power Tower packages, higher power semiconductors can be electrically isolated and packaged in smaller sizes. National Beryllia Corp., Cermetrol Div.

CIRCLE NO. 301

### ABS resins chart

A simplified, handy chart compares the cost—in cents per cubic inch regardless of price fluctuations—of Cycolac ABS resins and Cycoloy alloys with other engineering thermoplastics and metals. The revised chart—"Marbon Quick Reference File 9A"—gives an easily applied formula utilizing the specific gravity and pounds/cubic inch values of light and dense materials for computing and comparing the cents/cubic inch and cents/pound costs of Cycolac ABS resins and Cycoloy alloys versus those of 11 other plastics and five metals. Borg-Warner Corp., Marbon Div.

CIRCLE NO. 302

## evaluation samples

### Temperature templates

A modular approach to temperature monitor systems is highlighted in a template which features full-size photographs of Thermo's self-contained Mini Monitor and Six Point Indicator. It is designed so that the user may cut out the component pictures in order to prepare his own full-size panel layout. In contrast to scanning monitors, the modular approach of the Mini Monitor System provides continuous monitoring of each critical thermocouple point. Operation is simple. The user simply sets the high (or low) temperature limit of his process. When the setpoint is reached, an alarm lamp lights while rear connections can activate an audible alarm, shut down his process, and/or trigger peripheral equipment. Alarm sensitivity is to 1 F, with 1/4% repeatability and 1% setpoint accuracy. Thermo Electric.

CIRCLE NO. 303

### Solder sleeves

A solder sleeve termination system for attaching coaxial cables to printed circuit cards is designed to prevent center conductor breakage while allowing closer spacing for more wires attached to the card. The Paddlecard Solder Sleeve contains a prefluxed solder preform and ground connecting device in a transparent, heat-shrinkable sleeve. Raychem, Devices Div.

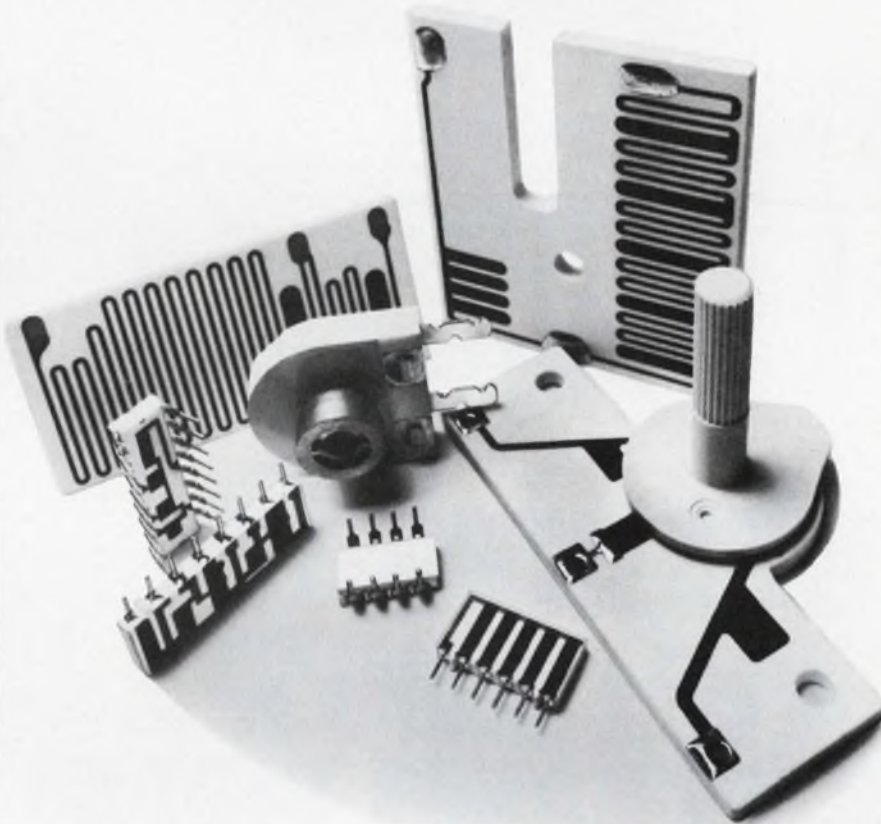
CIRCLE NO. 304

### Fuse clips

Fuse clip #798 features easy-mount legs and reduced costs. Two legs are the innovating feature of the new fuse clip design—they insert quickly into a printed circuit board for easy mounting. Since need for a separate fuse block is eliminated, the new fuse clip also effects a reduction in over-all user cost. Zierick Manufacturing Corp.

CIRCLE NO. 305

# Your custom resistor network is only an idea away!



CTS CORPORATION, a pioneer in cermet network packaging, HAS WHAT YOU NEED TO SOLVE "CUSTOM" RESISTOR REQUIREMENTS! Complete thick film facilities save in-house investments: existing tools speed production—cut costs...capabilities you can't afford to overlook. Resistors and resistor networks are our business...not just a sideline.

Whatever your needs, from standard in-line and DIP networks to custom high power/high voltage packages, you can rely on CTS experience and know-how.

Unmatched field reliability, high volume mechanization, and over a decade of cermet thick film-technology make CTS resistors "the engineers' choice". We have what it takes for both standard and custom resistor packages. Call on CTS EXPERIENCE...today! CTS CORPORATION, 905 N. West Boulevard, Elkhart, Indiana 46514, Phone: (219) 293-7511.

**CTS CORPORATION**

Elkhart, Indiana



A world leader in cermet and variable resistor technology.

INFORMATION RETRIEVAL NUMBER 79



# think woven



## for flexibility

It rolls, bends and folds for turns, tight spots and small spaces, without lead damage or signal distortion. Woven goes from "Point A" to "Point B" like no other cable can!

## WOVEN ELECTRONICS

A DIVISION OF SOUTHERN WEAVING COMPANY

P.O. Box 189, Mauldin, S.C. 29662. (803) 288-4411  
INFORMATION RETRIEVAL NUMBER 71

# ENGINEERS WHO KNOW REFERENCE DIODES SPEC DICKSON

For voltage reference (TC Zener) diodes, knowledgeable engineers look to Dickson first because Dickson has been a specialist in reference diodes since 1960. This specialization just naturally means more quality built into every device. The standard line includes voltages from 6.2 to 200V and test currents from 0.5mA to 10mA. Try us! Write, today, for new 6-page Zener selection guide.

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P.O. BOX 1390 • SCOTTSDALE, ARIZONA 85252

INFORMATION RETRIEVAL NUMBER 72

## EVALUATION SAMPLES

### Pushbutton switches

A multi-function pushbutton switch features immediate, continuous recognition of "in" and "out" positions without lamps or indicators. Non-illuminated DVR (dual visual recognition) switches visually present a black color band behind a color recognition cap to indicate the "out" position. When pushbutton is depressed ("in" position) black band disappears, leaving only the bright colored Recognition Cap showing, which readily signals that switch is set to "in" position. There is no possibility of a false identification caused by a malfunctioning lamp. Prices for the new components range from \$1.50 (1-C) to \$2.50 (4-C). Recognition Cap Kits (25 Caps per kit) are \$2.50. Switchcraft Inc.

CIRCLE NO. 338

### Molded plastic plugs

A line of molded plastic slides, buttons, plugs and bumpers provides hundreds of configurations and sizes. These molded plastic components need no lubrication and work in absorbing shock, in sealing, in reducing vibration and noise, and in providing a low friction bearing surface. All are electrical insulating, low in heat conduction, have good mechanical properties, and easy to install. Materials to choose from include nylon, polyethylene and cellulose acetate butyrate. Product Components Corp.

CIRCLE NO. 339

### Cable ties

WRAP-IT cable ties are available in standard designs to meet military specifications and in screw mounted designs. Standard ties are offered in nine lengths from 3-3/4 to 21-1/4 in. for tying bundles from 1/16 to 6 inch in diameter. Screw-mounted ties come in six lengths from 5-13/16 to 15-5/8 in. for tying bundles with diameters from 1/16 to 4 in. A free LOCK N' SNIP tension-fastening gun accompanies initial orders for 25,000 ties. Richlok Corp.

CIRCLE NO. 340

## PC card guides

Electro-Flex nylon guides for 1/16-inch PC boards have an exclusive bow feature which exerts tension, top and bottom, for improved card retention. A unique slot mounting pattern permits sufficient movement of the bowed guide to compensate for tolerance variations from card to card and thus control rack "spreading." Molded of UL-approved, Type 6/6 nylon, the guides come in 3, 4, 6 and 8-1/2-inch lengths. Electro-Space Fabricators, Inc.

CIRCLE NO. 306

## DIP sockets

Dual-in-line sockets feature positive closed-entry insulators which prevent damage to socket contacts during IC insertion. Specifications of the 14 and 16-pin sockets include insulation resistance of  $10^6$  M $\Omega$ , breakdown voltage between adjacent contacts of 1150 V, contact resistance average—initial 8.3 M $\Omega$  and after 100 insertions 10 M $\Omega$  (with electrotin contact finish). JOLO Industries.

CIRCLE NO. 307

## Syntactic-foam epoxy

A syntactic-foam epoxy system is designed for honeycomb edge-fill, radome repair, and other electronic and aerospace applications requiring low density and high strength. Tra-Bond 2125 is a completely unicellular material composed of micron-sized glass spheres in a high-performance epoxy binder. It cures at room temperature, has a dielectric strength of 375 V/mil and a compressive strength of 13,000 psi. Tra-Con, Inc.

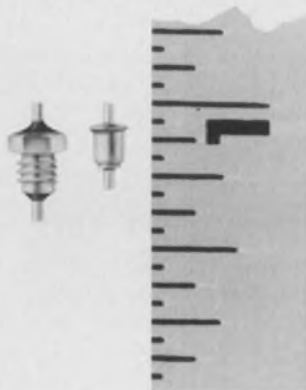
CIRCLE NO. 308

## Plastic toggles

The Tinnerman wallboard toggle offers all-plastic, one-piece design providing positive retention in a front-mounting, re-usable assembly. The Tinnerman toggle can be used on standard wallboard thicknesses, from 3/8 in. to 1/2 in. No special tools are needed for assembly. The toggle is simply folded and inserted into a 5/16-in. panel hole. Eaton Corp., Engineered Fasteners Div.

CIRCLE NO. 309

# Now, get more insertion loss from a smaller-volume filter.



You can get it from these RFI/EMI low-pass feedthrough filters from AMP. Because of their unique ferrite-titanate composition, they provide suppression and environmental

characteristics never before available in miniature-sized filters at an economic cost.

It's all made possible by single-piece construction which distributes inductance, capacitance and resistance over the filter, making it act like a lossy transmission line. And provides superior mechanical strength, in the bargain.

These filters are free of the usual resonance effects of conventional lumped-element filters. And, through the use of special solders, can be joined safely to bulkheads at temperatures to 260°C, without damage or change in performance. Their operating range is -55°C to +125°C. No voltage derating is required at the higher temperature.

A variety of center-conductor, terminal-type and solder- or bolt-in mounting-type filters is available in two families of filters: "55" Series—the standard maximum suppression line—and the "25" Series—miniature and subminiature filters.

For more information on AMP low-pass feedthrough filters, write to **Capitron Division, AMP Incorporated, 1595 S. Mount Joy Street, Elizabethtown, Pa. 17022.**

Capitron is a trademark of AMP Incorporated.

# AMP

INCORPORATED

Manufacturing and direct sales facilities worldwide: Barcelona, Brussels, Buenos Aires, Frankfurt, London, Mexico City, Paris, Puerto Rico, Sao Paulo, s'Hertogenbosch (Holland), Sydney, Stockholm, Tokyo, Toronto, Turin, Vienna.

INFORMATION RETRIEVAL NUMBER 73



# new literature



## Switches

Engineering drawings, specifications terms and operating characteristics are part of a catalog of switches. Over 200 standard types of snap-action switches, matrix selector switches, thumbwheel switches and keyboard switches plus everything you need to know in order to specify or order them are contained in this literature. Cherry Electrical Products Corp., Waukegan, Ill.

CIRCLE NO. 320

## '72 Wescon papers

The 1972 Wescon technical session preprint can be ordered at nominal cost—most for about \$2.00 per session (average: four papers for each of the 28 sessions) plus \$1 mailing charge per complete order. The offer is good until December 1, 1972. For order form,

CIRCLE NO. 321

## Microwave tubes

Characteristics of 136 microwave tubes and devices are presented in a catalog. New developments of traveling wave tubes, magnetrons, circulators, isolators, filters and mixers are listed together with a comprehensive equivalents list and a translation of terms into French, German, Italian and Spanish. The M-O Valve Co. Ltd. London, England.

CIRCLE NO. 322

## Industrial controls

A 154-page Catalog No. 0200 contains description, application information and specifications for over 70 varied industrial event control products. Precision analog indicating and control tachometers, digital process monitors, speed-sensing transducers (magnetic pickups), instrumentation amplifiers, switches, relays, transmitters, dc transducers, meters, converters, SCR power controllers and temperature controls and alarms are included. Airpax Electronics/Controls Div., Fort Lauderdale, Fla.

CIRCLE NO. 323

## Fast-switching thyristors

Full-frequency rating information for six different designs of the fast switching di/namic gate family of silicon-controlled rectifiers used in high-frequency applications and in inverter and dc chopper equipment is presented in a 130-page booklet. The booklet explains the difference between conventional thyristors and the dynamic gate device, whose lower switching losses and higher allowable peak currents make possible higher frequency ratings. It also explains the concurrent testing method used to verify high-frequency thyristor ratings. A special section tells how to use the high-frequency rating data matrices supplied for the six different device designs. Westinghouse Electric Corp., Semiconductor Div., Youngwood, Pa.

CIRCLE NO. 324

## Modems

A brochure describes a complete line of low-speed, Bell-compatible data modems. Designated the 4080 series, the modems are available in a variety of configurations, featuring TTY, EIA or TLT interfacing; loop-back testing and visual diagnostics; and dedicated or dial-line operation. Pulsecor, Falls Church, Va.

CIRCLE NO. 325

## Limit switches

A super-sensitive limit switch for rotary and oscillating applications is the subject of a two-page data sheet. The fully illustrated data sheet furnishes complete product information on the Series EA150, a limit switch sensitive to torques as low as 1.5 oz. in. Namco Controls, Cleveland, Ohio.

CIRCLE NO. 326

## Trimmer, counter catalog

A 160-page T-100 line catalog covers all the in-production time, count, program and step controls and accessories. The catalog includes a selection guide, a glossary of timer and counter terms used in the catalog and an index for quickly locating all models by number. Automatic Timing & Controls, Inc., King of Prussia, Pa.

CIRCLE NO. 327

## Components

A 20-page condensed catalog details a complete line of components. Product categories covered are: ceramic capacitors, potentiometers and trimmer resistors, push-button and rotary switches, technical ceramics, thick-film circuits, EMI/RFI filters, semiconductor devices and optoelectronic products. Globe-Union, Inc., Centralab Electronics Div., Milwaukee, Wis.

CIRCLE NO. 328

## Resistors

A two-color, eight page catalog pictures and describes capabilities of 56 types of cermet, carbon and wirewound trimmers, potentiometers, cermet DIP resistor networks and Series 212 rotary selector switches. Distributor quantity prices are also included. CTS Corp., Elkhart, Ind.

CIRCLE NO. 329

## Infrared data links

The economic and performance benefits of using infrared data links for direct transmission of data over short distances, without wires, are discussed in a four-page brochure. Computer Transmission Corp., Los Angeles, Calif.

CIRCLE NO. 330



## Rotary switches

In addition to engineering specifications on eighteen series of rotary switches, this 28-page handbook includes inch/decimal/millimeter conversion charts, technical information on the patented design "Spider," engineering details, plus complete information on nine series of commercial switches. Technical information is also included for switches with PC terminals and switches preset for "divide by 'N' counter." A section of the handbook is devoted to homing switches, specifically developed for portable communications equipment. RCL Electronics, Inc., Irvington, N.J.

CIRCLE NO. 331

## Miniature lamps

A broad line of miniature lamps is described in a brochure. The brochure provides dimensions and operating characteristics of lamps used in telephones, computers, control panels, automobiles, aircraft and radio panels. It also contains information on housing, lenses and strip and standard sockets for slide base pilot lamps. GTE Sylvania, Inc., Seneca, N.Y.

CIRCLE NO. 332

## Cradle relays

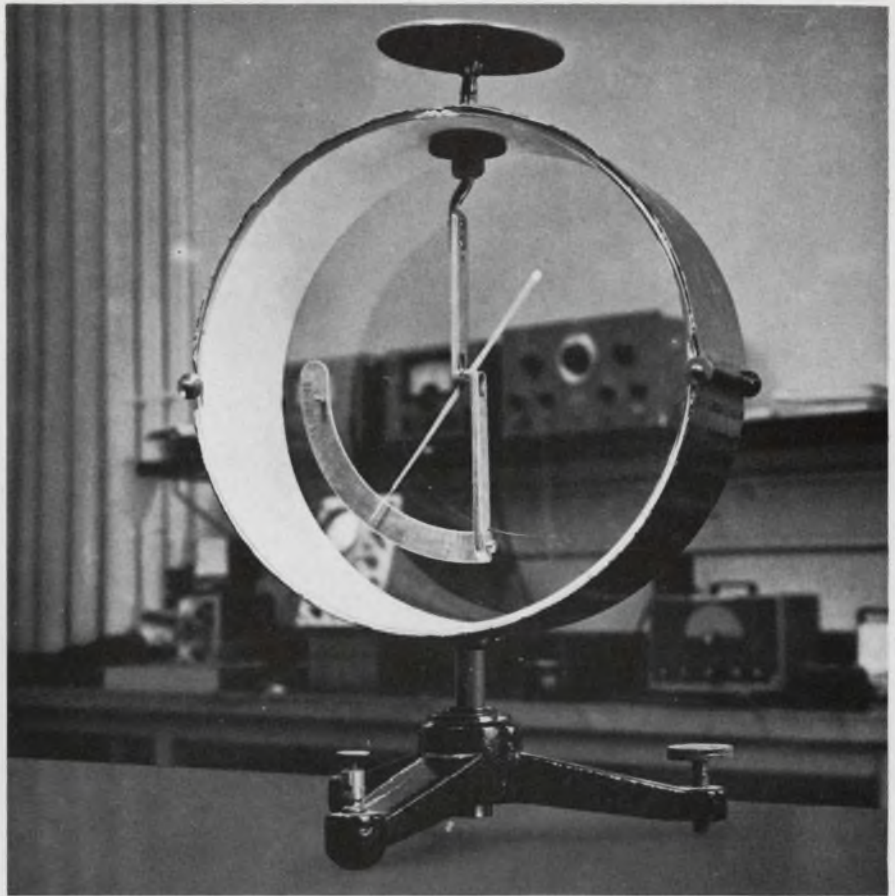
A complete line of general-purpose cradle relays is described in a four-page bulletin. The brochure offers complete specifications for both plug-in and PC board types. Information includes coil and contact data, wiring diagrams, socket information and physical dimension drawings. Siemens Corp., Iselin, N.J.

CIRCLE NO. 333

## Resistor packages

Two dual-in-line resistor networks in standard 14 and 16-pin DIP packages are featured in a brochure. This four-page catalog sheet provides specifications, outline drawings, and applications data on the company's full line of dual-in-line resistor networks. Beckman Instruments, Inc., Helipot Div., Fullerton, Calif.

CIRCLE NO. 334



# How would you get a measurable signal from only 6,000 electrons per second?

**Most people do it Victoreen's way**

With just 6,000 electrons, our  $10^{12}$  RX-1 will give you a good clean one millivolt signal . . .

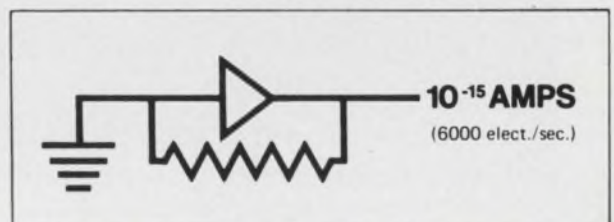
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## When a 3½ digit DPM is more than you need... Faratron has a 2¾ answer

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\*in OEM quantities with AC or +5V power

Actual size

INFORMATION RETRIEVAL NUMBER 81

## NEW LITERATURE



### Microprogramming handbook

The revised Microprogramming Handbook contains descriptions of the latest peripheral systems and communications interfaces offered by the company as well as an update of the Micro 1600 reference manual. The first section is a primer with the glossary of data processing terms. It is followed by application examples of microprogrammed computers, a Micro 800 user's manual with dozens of microprogrammed subroutines, the Micro 1600 reference manual, a firmware manual showing the architecture of a general-purpose computer implemented by microprogramming and a section of tutorial text on system design procedures. The final section is the expanded version of the product catalog. Microdata Corp., Santa Ana, Calif.

CIRCLE NO. 335

### Crystals

Single crystals, including a complete line of metal crystals, are presented in a crystals catalog. Ultra-high purity crystals, grown from 73 types of metals, alloys and non-metallic materials are listed. And, for each crystal, the catalog provides method of growth, typical purity, available diameters and current prices. Materials Research Corp., Orangeburg, N.Y.

CIRCLE NO. 336

### Filters

Bandpass, band-reject, high-pass and low-pass filters are described in a specification sheet. T T Electronics, Los Angeles, Calif.

CIRCLE NO. 337

## bulletin board

IBM will provide normal CPU maintenance on Fabri-Tek, Inc. core memory expansions of 360/30 to 96 and 128 k-bytes. Fabri-Tek will offer these 360/30 add-on systems under a separate MOD 30 "c" model number to distinguish them from previous models which were acceptable to IBM under the "best efforts" maintenance. To date, this latest expanded memory for the Model 30 is the only independent Model 30 memory to earn the "normal maintenance" acceptance by IBM.

CIRCLE NO. 343

ITT Semiconductors has added seven original circuits to its 54/7400 series. The seven circuits constitute the first group of ITT original TTL circuits to be offered in the market. They include a universal pulse generator, quad two-input AND and OR power drivers, and quad/hex NAND Schmitt triggers.

CIRCLE NO. 344

## Price reductions

Monsanto Commercial Products Co. has reduced prices of a number of its discrete light emitting diode products up to 34%. The products affected by changes include the MV54, MV5010 series, MV5030 series, and MV5080 series LEDs. All are red GaAsP diodes which have been commercially available from Monsanto for some time.

CIRCLE NO. 345

Interdata, Inc., has announced a new schedule of peripheral pricing that will reduce the cost of a typical 24 k-byte minicomputer system by about 10%. The pricing schedule offers a 24KB Series Model 70 system for \$39,150, as compared with the old price of \$43,400. The system includes 24 k-byte of core memory.

CIRCLE NO. 346

## vendors report

Annual and interim reports can provide much more than financial-position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

**Microwave Semiconductor Corp.** Transistors, IC amplifiers and diodes.

CIRCLE NO. 347

**Computer Products.** Power modules, a/d interface units and software.

CIRCLE NO. 348

**General Instrument Corp.** Cable TV, entertainment-electronics, components, data-processing systems, semiconductors, aerospace, electromechanical products and electro-optics.

CIRCLE NO. 349

**Computer Equipment Corp.** Computer terminals, marine electronics and communications.

CIRCLE NO. 350

**Digital Computer Controls Inc.** Computers, minicomputers and data systems.

CIRCLE NO. 351

**Alpha Industries, Inc.** Microwave components and equipment.

CIRCLE NO. 352

**Ametek, Inc.** Pressure and temperature-measuring instruments, recorders, process controllers.

CIRCLE NO. 353

**ITT.** Avionics, communications, semiconductors, microwave devices, optoelectronics, consumer products, data equipment, medical electronics, aerospace, office and business equipment.

CIRCLE NO. 354

**Eldorado Electrodata Corp.** Test equipment, calculators, computers.

CIRCLE NO. 355

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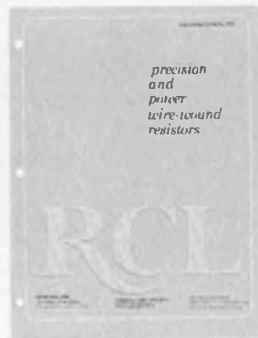
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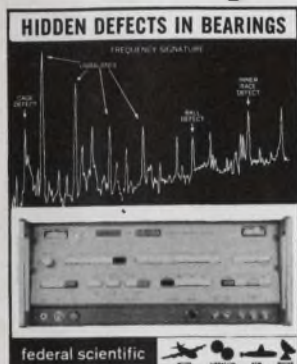
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CIRCLE NO. 174

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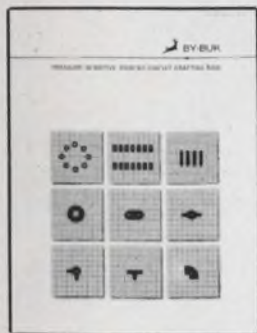
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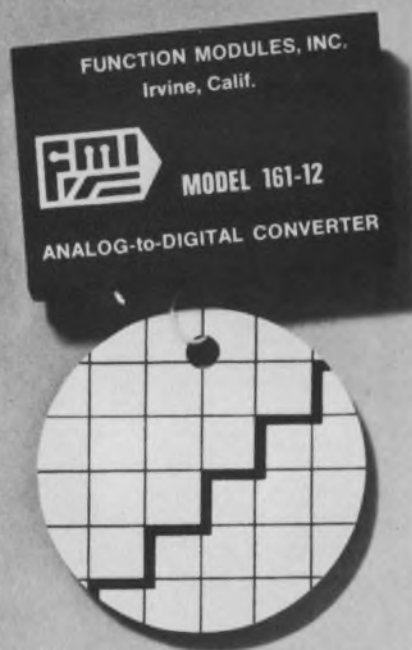
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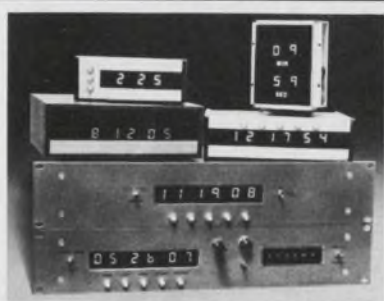
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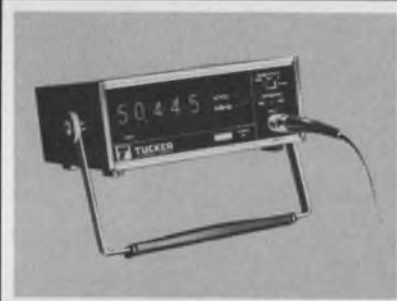
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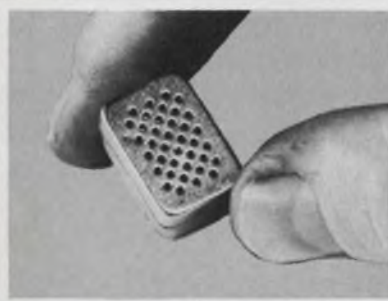
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# product index

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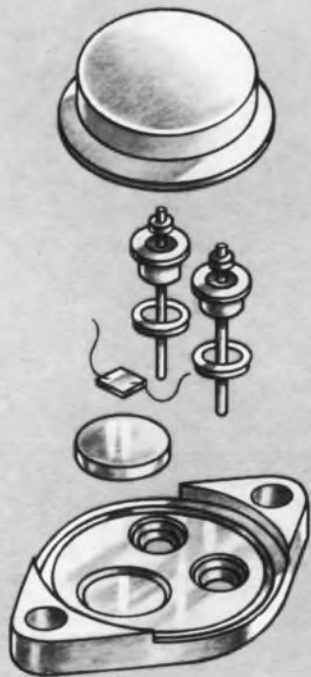
INFORMATION RETRIEVAL NUMBER 233





# If your aluminum packages leak, you didn't buy RCA hermeticity—in steel.

**Aluminum Package—TO-3, soldered, preformed eyelets**  
**Thermal Cycling Test Conditions—16 W,  $\Delta T$  case = 90°C**  
**(40°C to 130°C)**  
**Typical Performance (cycles to failure)—3 K**  
**Typical Requirements (cycles)—25K**



**Steel package—TO-3, glass-to-stem, compression seal**  
**Thermal Cycling Test Conditions—16 W,  $\Delta T$  case = 90°C**  
**(40°C to 130°C)**  
**Typical Performance (cycles)—50 K (Test terminated; no failures.)**  
**Typical Requirements (cycles)—25K**



The case for RCA in popular TO-3 transistors is steel...rated from -65°C to +200°C.

The aluminum package can have an inherent weakness in the solder bond between the eyelets and the aluminum header. Under temperature cycling, fractures develop at this interface, destroying the device's hermeticity.

The RCA steel package, with

its glass-to-stem high compression seal, welded cap, and controlled solder process, offers you at least an order of magnitude improvement over aluminum in terms of hermeticity, reliability, and long-term, trouble-free performance.

Ask for RCA's Reliability Report ST6071, or conduct your own tests. Write: RCA Solid State, Section 571-28 UTL31, P. O. Box 3200,

Somerville, N.J. 08876. International: RCA, Sunbury-on-Thames, U. K., or Fuji Building, 7-4 Kasumigaseki, 3-Chome, Chiyoda-Ku, Tokyo, Japan. In Canada: RCA Limited, Ste. Anne de Bellevue 810, Quebec.

**RCA Solid State**  
 products that make products pay off