APRIL 20, 1980

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EDN

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Offsetting, linearization up transducer performance

Electro/80— Close encounters with new electronics technology

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Modular temperature logger: PTI stacks up.

With today's tight budgets and spiraling costs, your instrument investments have to work hard for you. That's why we designed Portable Test Instruments (PTI) to work double time.

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This little system boasts accuracy specs that stand up to even laboratory standards. As a matter of fact, we designed the 2300A Scanner as a measurement match to our most accurate thermometers: the 2180A and 2190A series. Together they handle as many as 100 channels of temperature (20 channels maximum in mainframe) from five types of either RTD or thermocouple sensors.

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- ☐ Send literature on the 2300A logging system.
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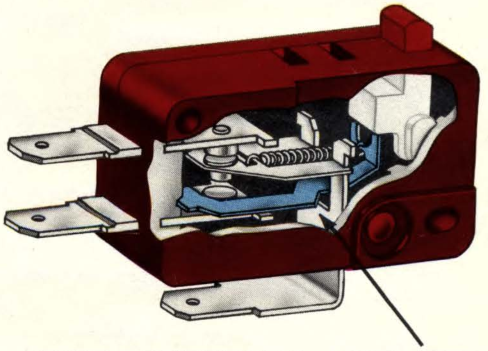
For technical data circle no. 1

Less than 2 grams of force actuates this Cherry snap-action miniature switch. Outside, a 2⅜″ long aluminum lever provides unusually low operating force. Inside, an extra internal actuator reduces operating force even more while maintaining solid contact pressure for reliable performance.

Our unique light force miniature design is available with other external levers offering operating forces ranging from 3.5 to 15 grams...rated 3 amps, 125VAC. Gold crosspoint contact versions bring this same, dependable switching to your low energy (0.1 amp) solid state circuits. Or, choose higher electrical ratings of 5, 10 or 15 amps with increased ...but still low...operating forces.



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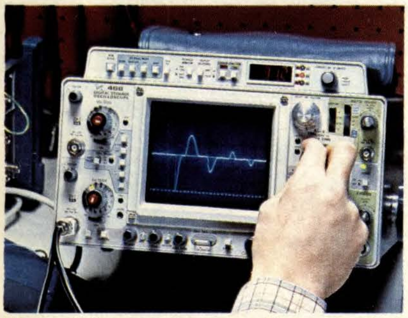
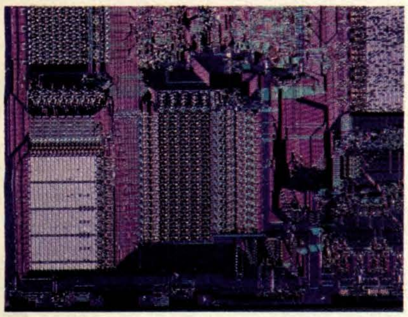
EDN

APRIL 20, 1980 • VOLUME 25, NUMBER 8 • EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



Newest lab scopes *provide expanded price, performance alternatives (pg 71).*



Electro/80 *focuses on gate arrays, μC peripherals and instrumentation (pg 116).*

On the cover: *Yesterday's blue-sky devices, such as the Am9512 1-chip floating-point processor, are today's down-to-earth designs. Turn to pg 116 for more information. (Photo courtesy Advanced Micro Devices)*

CP BPA ABP

DESIGN FEATURES

TECHNOLOGY NEWS

NEW PRODUCTS

DEPARTMENTS

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HP announces a way to accelerate microcomputer development...

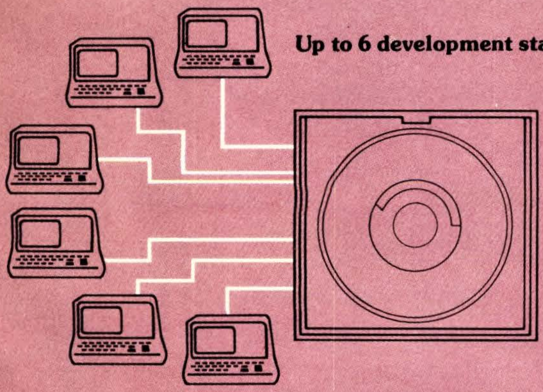
HP—When you depend on logic

and put the brakes on development costs.

The new HP 64000 Logic Development System helps you speed microcomputer development and cut costs several ways. First, it uses a universal, rather than a dedicated, approach to microcomputer development. So you can use the HP 64000 to develop an 8080-based system today, and then a 6800-based system tomorrow. Or you can use it for different types of microprocessors in the same product, without paying the price of separate development systems for each. What's more, HP's powerful 64000 architecture is independent of processor type, bus-width or speed. So you'll be able to use this same basic system with future developments such as 16- and 32-bit processors.

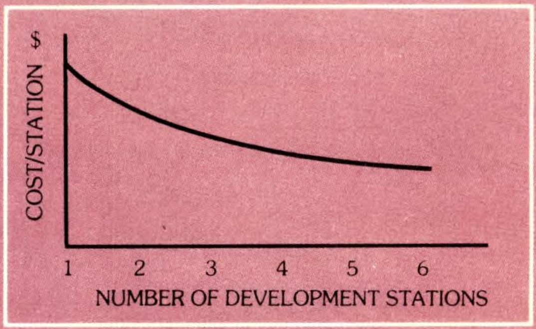
Teamwork means faster system development.
Second, the HP 64000 can help shorten development schedules through efficient teamwork. HP's shared peripherals approach means that a number of operators share a common disc. This common data base serves up to six development stations. A powerful file manager encourages teamwork. Each user can work with his own copies of files, while a master set is maintained separately. Now, several programmers can work at the same time. Or designers can perform emulation, while programmers debug software.

The disc's high speed means each user is independent of, and essentially transparent to, every other. And all users have immediate access to the latest software for more efficient operation.



Up to 6 development stations

This HP approach is superior to a single-station, dedicated system for two other important reasons: With today's growing emphasis on microprocessor-based products, it's unlikely that any single system will provide the flexibility and growth path you'll need in future years. What's more, the 64000 offers significant savings when multiple development stations are contemplated (see chart below), and provides a practical way for you to obtain high-performance peripherals.



An accelerated path to market.
Third, because the HP 64000 has a powerful user-oriented display editor, rather than a teletype editor, it becomes a user-oriented system that speeds editing and debugging. Its advanced real-time emulation shows you precisely how your system will perform at speed, to help eliminate potential production problems and product entry delays.

In short, the HP 64000 ($18,500* for a minimum operating system) provides a way for you to optimize the efficiency of your development team, plan for the future, and expand development capabilities. Because the system is backed by Hewlett-Packard, you also enjoy the benefit of on-site service during the initial 90-day warranty period. Then, if you wish, you can get a complete HP service contract tailored to your needs that can also include on-site service.

To get complete details, write to Hewlett-Packard, 1507 Page Mill Road, Palo Alto, CA 94304. Or call the HP regional office nearest you: East (201) 265-5000, West (213) 970-7500, Midwest (312) 255-9800, South (404) 955-1500, Canada (416) 678-9430.

*Domestic U.S.A. price only

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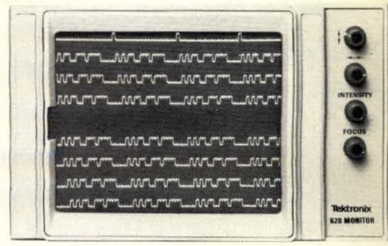
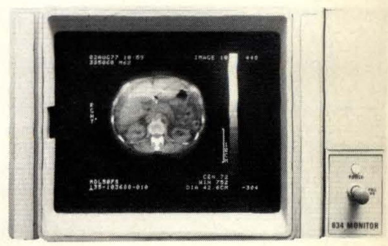
Tektronix OEM Products

No matte Tektronix

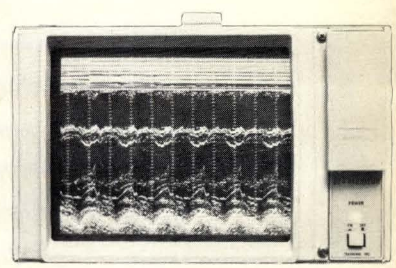
606B Very high resolution display for photographic recording applications in medical multi-imaging, for electron microscopy, radiation and thermal scanning systems, and for alphanumeric and graphic displays[1].



620 For logic analyzer, A-scan ultrasound, optical electronics, and mechanical measurement applications.



634 For ultrasound, computerized tomography, video multi-imaging, ECM and other high-performance raster-scan applications.



624 For electronic test and measurement applications and for A, B, M-mode and real time ultrasound use.

Look to the leader.

As the leader in quality OEM displays, we know your needs and we can meet them with the greatest variety of display products in the business. We know that you expect our displays and cameras to do the job they're specified for — day after day.

You expect us to offer you the most competitive price/performance packages. To work closely with you to help solve your interface requirements. To support you totally, before and after purchase. To grow as you grow, so we can both meet the new technologies, government regulations, and competitive pressures that impact our business. Meeting these expectations is what it's all about. And it's a commitment we honor. All the way.

[1]606A and 606B dot scans shown as accumulated on film.
[2]Image courtesy of Optical Electronics, Inc.

Methode's JAGUAR* offers more tooling options & lowest total cost!

Our Jaguar ***MULTIPLE TERMINATION SYSTEM** is a complete wire-to-post interconnect system on .100″ and .156″ centers that accomodates discrete wire or ribbon cable with solid, stranded or fused-stranded conductors.

This reliable insulation displacement system eliminates wire stripping, crimping and stuffing . . . and, features buy or lease application tooling for very small or very large runs up to 24,000 connections per hour. We'll even customize tooling to meet your exact needs.

Just circle the reader service number to receive our fully illustrated Jaguar system catalog.

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NEW JAGUAR IDC POWER CONNECTORS
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One shot from our new Jaguar JT-2 hand gun automatically terminates 2 to 24 wires for super-fast harness construction. The air tool locks easily into IDC connector fixtures arranged to the harness shape . . . then trims and terminates the pre-positioned wires.
This latest addition to our Jaguar interconnect system eliminates wire stripping, crimping and stuffing on small or large runs .
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JAGUAR
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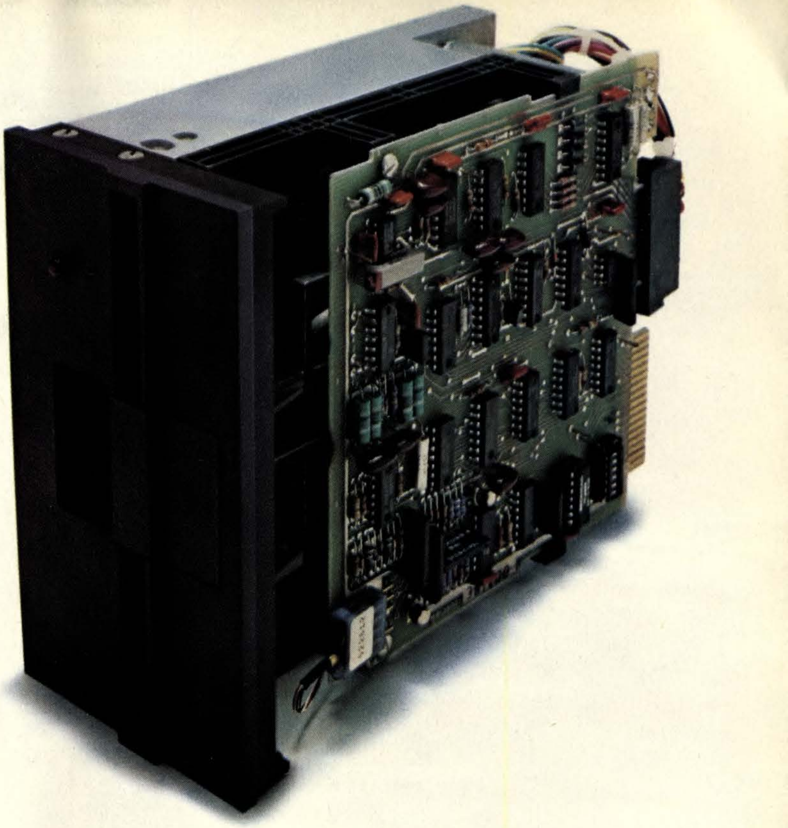

The original Minifloppy. The SA400 single-sided Minifloppy is the most popular 5¼-inch disk drive available. Since we invented the Minifloppy in 1976, over half a million have been delivered to builders of microprocessor-based systems, personal computers, and word processing systems. The Minifloppy offers the lowest unit cost of any Shugart drive, yet it stores up to 218.8 kilobytes (unformatted, double density) in a reliable, compact package. It uses the same proprietary head and recording technology as our single-sided 8-inch floppy drive. A servo-controlled DC drive motor eliminates AC power requirements and the simplified actuator with direct drive spiral cam provides more reliable track-to-track access. Low heat dissipation, positive media insertion, write protect, and an activity light are standard. And only Shugart has the production capability to meet your needs.

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Choose the Headstrong Minifloppy disk drives. No matter which of our Minifloppy disk drives you select, you get the competitive edge when you go with Shugart. We are Headstrong about helping to keep you competitive too, with high volume deliveries of drives that offer superior reliability, quality, and value. This Shugart commitment is also backed by all the support you need including helpful technical services, in-depth documentation, and design assistance. And when your product line grows, we'll be there with a complete family of floppy, Minifloppy, and fixed disk drives in a full range of capacities. Reliable products, volume delivery, superior quality, and value. That's what we're Headstrong about at Shugart. □ **Shugart Associates: 435 Oakmead Parkway, Sunnyvale, CA (408) 733-0100** *Sales & Service: Sunnyvale, CA; Costa Mesa, CA; Minneapolis, MN; Richardson, TX; Waltham, MA; Landing, NJ; Atlanta, GA; Toronto, Ontario; Paris, France; Munich, Germany.* □ *Shugart products are also available off the shelf from local Hamilton/Avnet outlets.*

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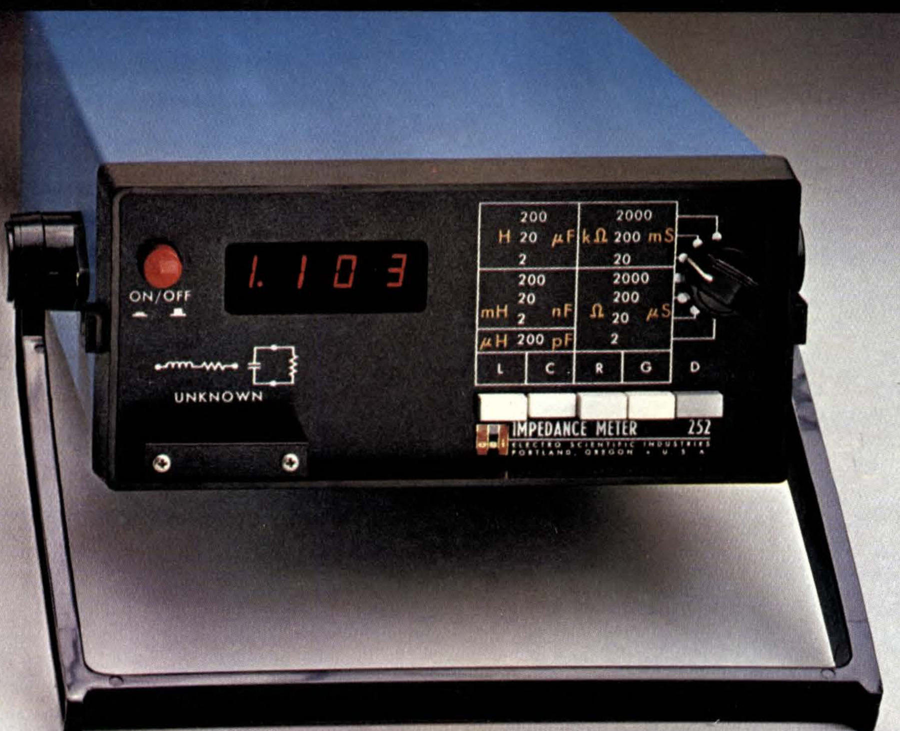
Your low cost way out of the impedance jungle.

Before they get on board,
fend off wild RCL components for $795 (usa).



Those untamed components. They swarm over your circuit boards, eat into your resources, trap you in the impedance jungle.

But there is a low cost, reliable way out. Armed with the Model 252, you breeze through a wide range of values for resistance (R), capacitance (C), inductance (L) and conductance (G) at ±0.25% accuracy. The push of a button gives you dissipation factor (D).

At $795, the 252 rivals instruments costing twice as much.

- 0.25% basic accuracy
- Wide ranges (0.1 pF resolution to 200 μF)
- 3½-digit display (no manual balance)
- Dual analog outputs (C or L with D)
- External bias (to 50 VDC)
- Four measurements / second
- 4-terminal Kelvin Klips® (guarded)
- Input protection
- Easy calibration, servicing
- 1 kHz test frequency (120 Hz option)
- Low power design
- Lightweight, tiltstand handle

For systematic GO / NO-GO sorting, there's an optional limits comparator and sorting fixture.

Want autoranging? Gear up with the Model 253. And if you test at low frequency, check out the 120 Hz Model 254.

For over 25 years we've tamed the ways of the impedance jungle. A detailed 252 brochure shows you how.

The sure way to innovation. esi® ELECTRO SCIENTIFIC

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Edited by Joan Morrow

News Breaks

SPEAKING OF VOICE I/O . . .

Talking in either a male or female voice, the MN6401 synthesizes as many as 63 words. Matsushita Electric's (Osaka, Japan) chip permits selection of either 10 sec of high-quality voice output or up to 30 sec of the device's lowest quality speech.

The synthesizer employs the partial autocorrelation technique (originally developed by Nippon Telephone and Telegraph Corp), which processes stored digital signals in a manner approximating the human voice. Matsushita's 28-pin device performs the same job as the 3-chip set previously introduced by other Japanese firms, but it requires +5V rather than −10V.

. . . A vocal warning conveys an urgency that a flashing light or LCD lacks. At least that's the rationale that will lead major car manufacturers to replace conventional warning indicators with synthesized voices sometime within the next 4 yrs. Top-of-the-line models will be the first to complain when the oil pressure gets too low or the brakes need adjustment, but lower cost models will quickly follow suit.

According to a Chrysler Corp spokesman, though, the language barrier must be bridged before such voice units become commonplace. Thus, first-generation cars will probably combine a vocal message with a flashing light bearing an international symbol picturing the difficulty or failure.

A similar problem — operator confusion — hampers military efforts to employ voice display in aircraft. The units might be too efficient: Airborne-equipment manufacturers are so quick to capitalize on voice-synthesis technology that crew members run the real risk of having an entire cockpit of instruments telling their stories at once. Therefore, current research is examining efficient ways to arbitrate the potential chaos.

. . . Far more has been written and said about synthesizing voice with a computer than recognizing human speech with a computer. Recognition is, however, the more difficult task. If you want to learn about the practical ramifications of talking to computers, study the theories underlying current recognizers and get hands-on experience with the latest equipment, attend a short course, "Computer Recognition of Speech," in Silver Spring, MD on May 1 and 2. You can get more information on the course by calling Speech Science Publications at (805) 683-1323.—ET

TOP-TO-BOTTOM μP INTROS INCLUDE DEVICE WITH ON-CHIP BASIC

Look for a low-end single-chip μC with ROM-resident BASIC (NIBL) interpreter from National Semiconductor (Santa Clara, CA) in about 2 months. Designated the INS8073, the device will be part of the firm's 8070 family and will incorporate 64 bytes of RAM and 2.5k bytes of ROM.

The introduction is part of the firm's top-to-bottom assault on the μP market, which will also include introduction of an advanced 8048-type single-chip μC and a dedicated low-end μP with a standard CPU "engine" configurable to specific application areas. Also expect to see an evaluation board for National's NSC800 CMOS 8-bit μP by early summer.—JB

LAMINATE UPS PRODUCTIVITY, REDUCES PC-BOARD PROCESSING COSTS

General Electric (Coshocton, OH) expects its Engineered FR 4 epoxy/glass laminate to cut pc-board costs by decreasing the number of reject parts. The product incorporates an epoxy adhesion promoter or "bridging agent" that improves epoxy-to-epoxy bonds. It also allows GE to reduce board glass content to 46% of its current value; the resulting 20%-extended drill-bit life, coupled with less heat generated during drilling with the new laminate, improves productivity by reducing rejected boards caused by delamination (from excessive heat), through-hole irregularities (from dull drills) and resin smear. For more on the subject of pc-board failures, turn to pg 63.—JT

μP DEVELOPMENT SOFTWARE RUNS ON DESKTOP COMPUTERS

Software-development packages for 8080/8085, 6800 and Z80 μPs have been added to Hewlett-Packard's (Palo Alto, CA) application-software library for its Series 9800 System 35 and 45 desktop computers. Each package costs $2500, with the combination of all three specially priced at $3000. Development software for each μP type, contained on one data cartridge, includes initialization, editors, assemblers and console programs, along with special-function-key overlays and instructions.—AS

DMOS FET FAMILY PICKS UP A SECOND SOURCE

Semi Processes Inc (Santa Clara, CA) has signed a second-source agreement with Signetics Corp (Sunnyvale, CA) to manufacture and sell high-speed DMOS FETs. The agreement covers the SD5000 quad and SD210 Series single-analog-switch families and the SD305 and 306 dual-gate RF amplifiers and mixers. Additionally, SPI will develop new DMOS products for the two companies under the direction of Dr Jean Hoerni, inventor of the planar process and member of SPI's board of directors.—WT

COMMON-SENSE SOFTWARE TOOLS OUTFIT THE 6809 FOR THE REAL WORLD

Completely position-independent code is just one of the functionality benefits offered by Motorola's (Phoenix, AZ) BASIC-M. The compiler combines the best features of all available software packages, such as user-definable multiline procedures from PASCAL, and provides powerful application-programming capabilities. And to make programming even easier, the firm has also introduced SUPERBUG, a heavily evolved version of MIKBUG that suits 6809 boards. This software package includes utility routines that link to BASIC-M programs.—ET

CONFERENCE WILL UPDATE OPTICAL-COMMUNICATIONS APPS, MARKETS

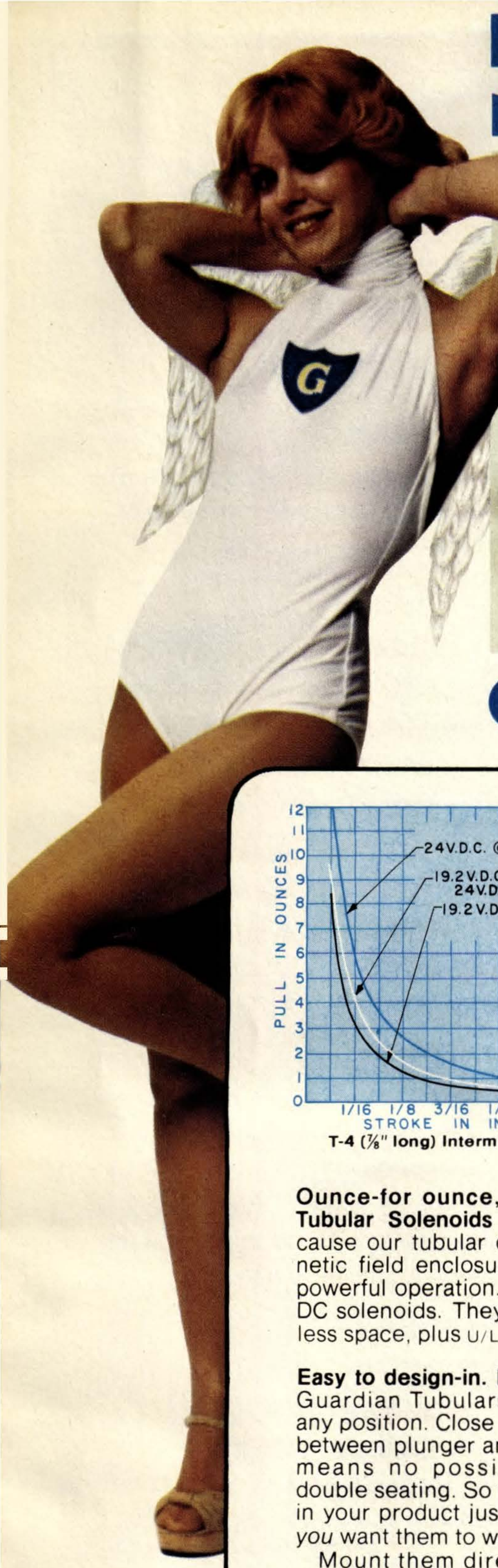
Hurry if you plan to attend the Outlook for Optical Communications conference in Andover, MA, scheduled for April 27 through 29. The convention will present and discuss the approaches required to design and market fiber-optic communications products and systems employing currently available components and will explore the status of rapidly evolving industrial-technology standards and applications. For registration information, contact Richard Murray at (617) 267-9425.—TO

FIBER-OPTIC-LINK KIT'S PRICE SLASHED BY MORE THAN 50%

To make it more attractive for design engineers to investigate the advantages of using fiber optics, Hewlett-Packard Co (Palo Alto, CA) will reduce the price of its HFBR-0010 simplex fiber-optic-link kit from $570 to $275. Ready to hook up, the kit consists of transmitter and receiver modules, a 10m cable/connector assembly and complete technical literature. The modules accommodate data in any format at rates from dc to 10M baud and offer TTL compatibility.—TO

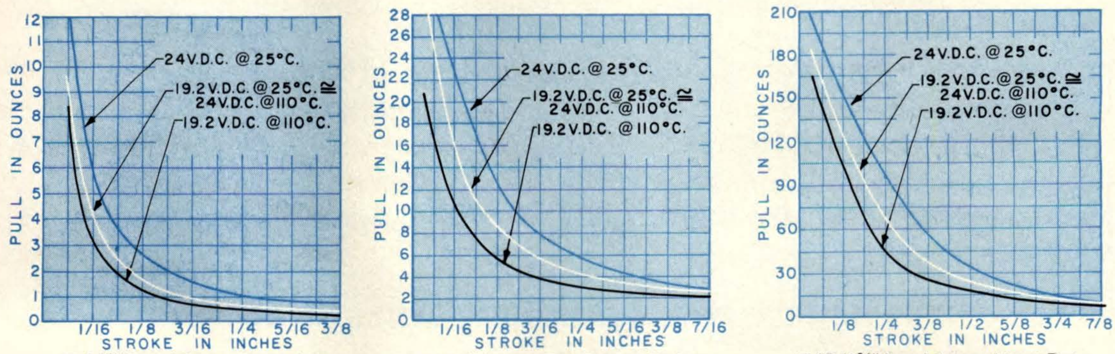
AT-HOME LEARNING COURSES PROVIDE HANDS-ON INSTRUCTION

Electronic Technology Series self-instructional courses from Heath/Zenith Educational Systems Div (Benton Harbor, MI) include text material (typically less than 300 pgs), programmed instruction sequences, audiovisual materials, self-checking quizzes, practical experiments (components supplied) and a money-back guarantee. Four study subjects are now available: operational amplifiers ($39.95), active filters ($29.95), IC timers ($39.95) and phase-locked loops ($49.95). For more information, phone (616) 982-3210.



MORE PULL in a smaller package?

Check these curves.



T-4 (⅞" long) Intermittent duty

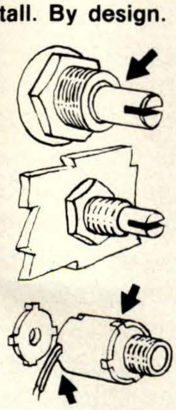
T-8 (1⅛" long) Continuous Duty

T-12 (1⅝" long) Intermittent Duty

Ounce-for ounce, inch-for-inch Guardian Tubular Solenoids pack more power... because our tubular designs assure total magnetic field enclosure and result in efficient, powerful operation. More efficient than other DC solenoids. They give you more power in less space, plus U/L and CSA recognition.

Easy to design-in. Easy to install. By design. Guardian Tubulars work in any position. Close tolerance between plunger and bobbin means no possibility of double seating. So they work in your product just the way *you* want them to work.

Mount them directly into panel by inserting threaded bushing thru installation hole and tightening nut on lock washer. Or, mount with standard bracket.



Either way, Guardian Tubulars install without damage to the solenoid. Look how the notched tube-steel shell mates with notched end plate. Result? A stronger assembly that takes more torque when installing...with no chance of damage. The leads emerge thru a notch in the steel shell, so they *will* not, *can* not be sheared by rotation during installation.

Once you put a Guardian Tubular in your product... forget it. Typical mechanical life is 20 million. That's probably longer than your product's life expectancy...due primarily to the unique Valox® 420 molded bobbin.

Variations and specials? Guardian's got 'em. Any DC voltage from 6 to 240. Push type or pull type operation. Return springs, silencers, termination variations, special mountings . . . you name it and we'll deliver it with the high quality craftsmanship and low prices that have made Guardian Number 1 in Solenoids—and that keeps us here on top.

Let the Guardian Angel reveal all the pull charts and curves in full size. Send for your free copy of our 72 page catalog.

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For more information, Circle No 7

Zilog (Cupertino, CA) also departs from traditional methods of customer education by offering a 5-part Z8000 study-at-home correspondence course. It's intended for designers with a good μP-technology background, with five lessons covering Z8000 architecture, memory-management techniques, interfacing memory and peripherals, handling of interrupts and traps, and use of the Z8000 instruction set. Each lesson contains a 10-question quiz that is graded and returned with a critique of your answers. The course and all required study material cost $39. To enroll, phone Kathy Trappen at (408) 446-4666.—WP, JM

PC-BOARD STANDARDS UPDATE INCLUDES DATA ON "MEASLES"

Recent discussion of pc-board failure modes (see pg 63) might make the IPC Guidelines For Acceptability of Printed Boards (IPC-A-600C) even more valuable — especially because this latest version contains new information on measles, an internal condition in boards' laminated base material in which the glass fibers separate from the resin at the weave intersection.

The document ($5 to members, $8 to nonmembers) contains photographs that visually standardize individual interpretations to specs on pc boards, plus acceptability criteria for single- and double-sided and multilayer printed boards, flexible circuits and flat cable. You also get descriptions of the various test methods the IPC recommends. For more information, contact the IPC at 3451 Church St, Evanston, IL 60203, or phone (312) 677-2850.—JB

50-MHz DELAYED-SWEEP SCOPE SELLS FOR $1745

The latest entrant into the lab-scope sales sweepstakes is Hitachi Denshi Ltd's (Woodbury, NY — phone (516) 921-7200) 50-MHz delayed-sweep unit, which includes probes. The rest of the Japanese-import line consists of 15- and 30-MHz single- and dual-trace units priced from $545 to $945. The 50-MHz instrument features 5-mV/div sensitivity, trigger view and automatic trigger.—AS

FIBER-OPTIC TRANSMITTER STRETCHES LINES TO 1000m

The HFBR-1002 fiber-optic transmitter can send signals 1000m — 10 times farther than Hewlett-Packard's previous MFBR-1001 unit equipped with the same -2001 receiver and -3000 Series cable/connector assemblies. The $235 (100) unit is pin compatible with the earlier device and can handle data rates from dc to 10M baud. The cables are available in any user-specified length, not in just five discrete lengths to 100m, as noted in the Palo Alto, CA company's current catalog.—AS

COMING ATTRACTIONS . . .

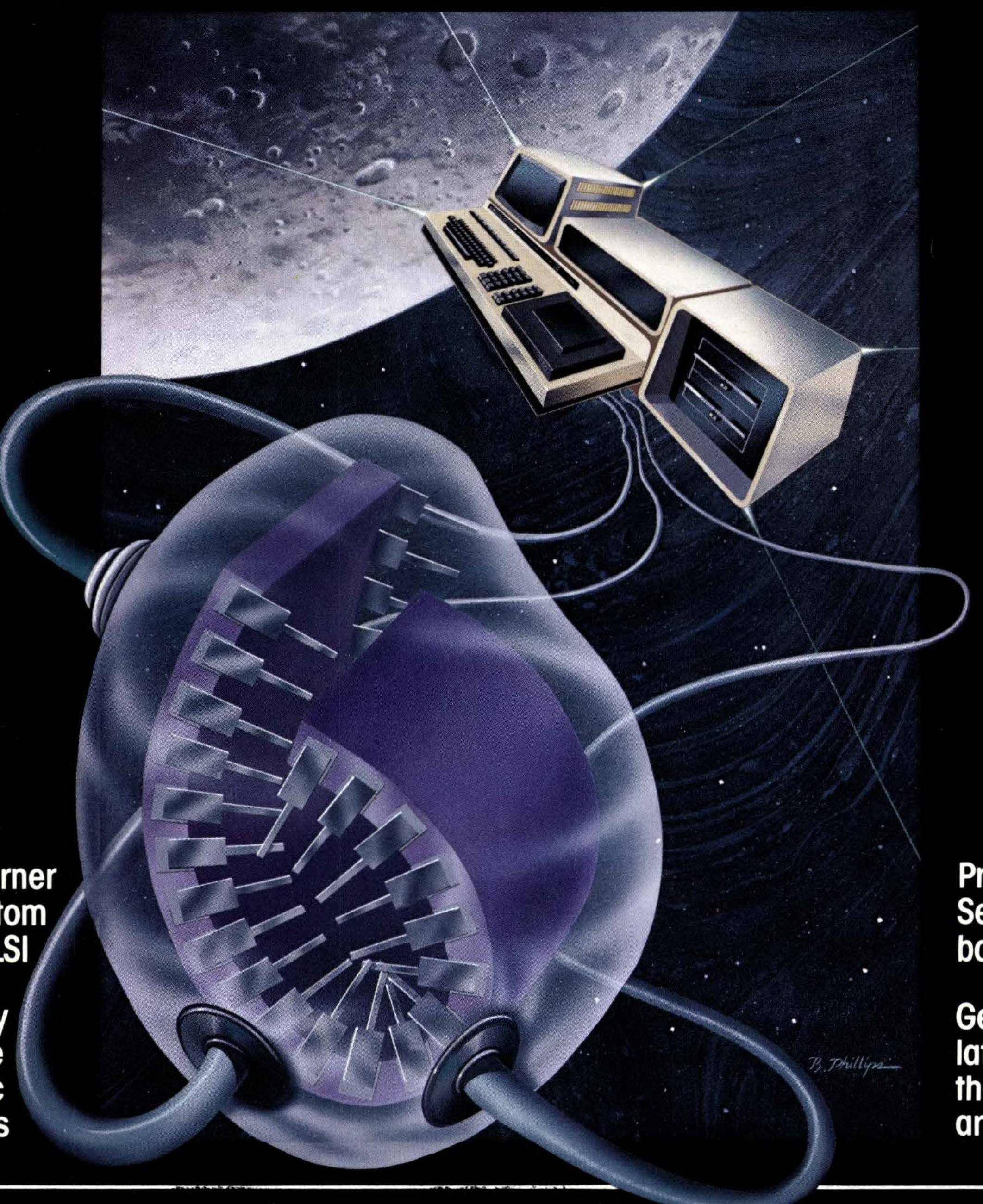
Attendance at the Microprocessor Design or Microprocessor Design Lab Operations workshops is a prerequisite for enrollment in Tektronix's Microprocessor Project Development course, to be held on April 21 through 25 in Santa Clara, CA and May 19 through 23 in Chicago, IL. The $600 hardware-oriented course focuses on the operation of devices commonly employed in μP hardware design and on the equipment and techniques available for fast and convenient software/hardware integration. Call (503) 644-0161 collect for more information . . . An intensive 4-day course on VLSI technology will be held at American University, Washington, DC, on June 3 through 6. Coverage will encompass both fabrication fundamentals and applications of VLSI circuits, with emphasis on digital signal processing for the '80s. Certificates of Completion and Continuing Education Units will be awarded to those participants who complete the $525 course. Phone Jennifer Murphy at (202) 686-2697 for all the details . . . A $750 seminar, entitled "PASCAL Programming for Mini and Microcomputers," covers a general approach to the use of high-level languages in small computers, including an intensive course in PASCAL programming, a preview of ADA (the evolving Department of Defense standard real-time language) and an introduction to

NATIONAL ANTHEM

SEMICONDUCTOR NEWS FROM THE PRACTICAL WIZARDS OF SILICON VALLEY.

Developing Microprocessors.

STARPLEX,™ WITH ISE,™ THE FULLY DEVELOPED DEVELOPMENT SYSTEM.



Mike Turner on Custom MOS/LSI

Truly reliable dynamic RAMs

Practical Series/80 boards

Get the latest from the National archives

cquisition Logic Transistors Hybrids Linear Interface Bubble Mem
RAMs/ROMs/PROMs Transducers Displays Custom Circuits Optoelectronics
Microprocessors Modules

NATIONAL ANTHEM

Nationally improved memories.

A unique combination of design and manufacturing techniques results in a truly reliable family of 16K dynamic RAMs.

With their exclusive combination of design and manufacturing procedures, National's MM5290 Family of 16K dynamic RAMs is setting new industry standards for reliability.

The readily available MM5290 Family is designed so that soft errors induced by stray alpha particles are virtually eliminated.

Furthermore, National has extensive component test procedures, which include pre-burn-in, monitored burn-in, final test, and Quality Assurance checks.

The combined effect, of course, is unsurpassed operational accuracy and dependability in every 16K dynamic RAM shipment.

The first and only MST.™

In addition to National's use of conventional final testing and QA component level processing, many customers request National's unique MST (Memory Systems Test). MST eliminates or greatly reduces the customer's own requirements for internal testing. So their incoming test, board test and system rework costs are substantially reduced.

The MST system duplicates the test flow of a sophisticated systems manufacturer. Using an actual nine-megabyte card level system to perform the testing, the dynamic RAMs are burned in at elevated ambient temperatures and at stress voltage levels.

The MST program then applies multiple test patterns, power supply margin tests, real-time error logging, and hours of continuous testing over the operating temperature range in the nine megabyte system.

All of which serve to screen out board and system level rejects. The kind of rejects that are impossible to detect using component level tests that only take seconds to perform.

For more detailed information about MST and the MM5290 Family – plus a Reliability News Brief on alpha particle test results – be sure to check the National archives coupon below.

Quality RAMs from a quality source.

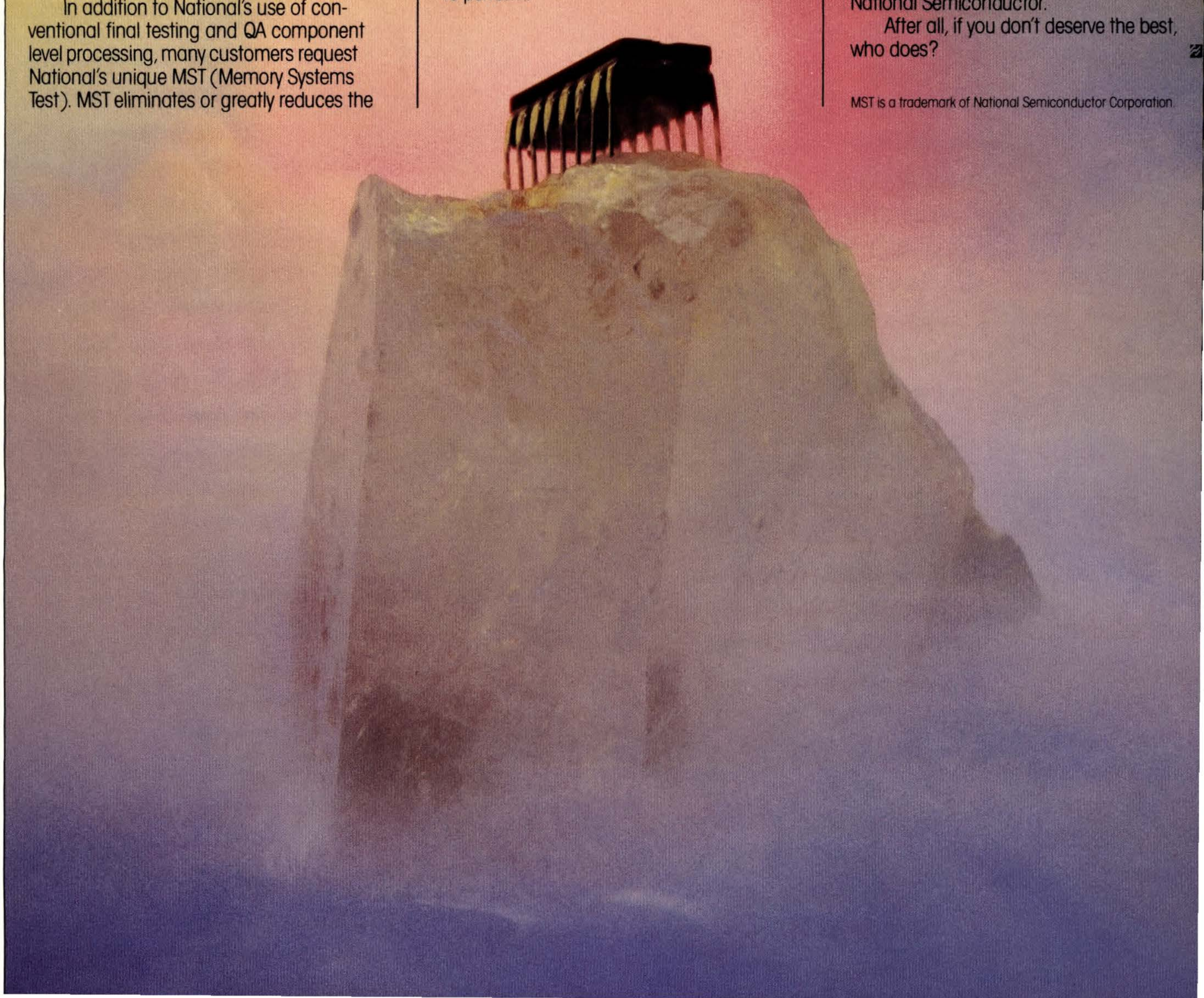
National has, of course, been known as a quality production house for a long time. MST now provides 16K RAMs that are first in quality and reliability.

And thanks to National's commitment to manufacturing excellence, MST quality in 16K RAMs is available now in production volumes. National has been preparing MST for three years and now offers it on-line to increase your level of quality and lower your overall costs.

So when your design calls for dynamic RAMs, think of the Practical Wizards at National Semiconductor.

After all, if you don't deserve the best, who does?

MST is a trademark of National Semiconductor Corporation.

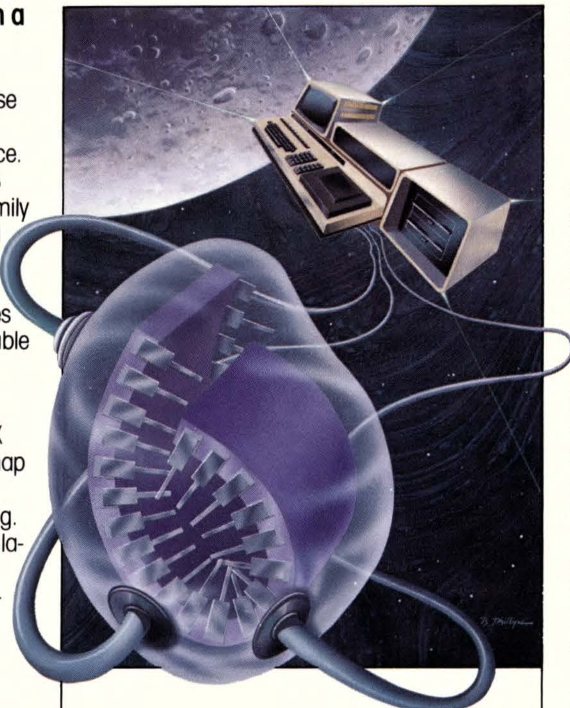


STARPLEX™ aids microprocessor development.

For the first time, real-time 8048 Family emulation and debugging in a multiprocessor environment.

With the STARPLEX system, National Semiconductor has created an easy-to-use development tool that helps design engineers complete their entire job in one place.

Using STARPLEX and National's 8048 Emulator Package, designers of 8048 Family systems get the kind of sophisticated tool needed for efficient microcomputer development. And with 8048 ISE™ (In-System Emulator), they get capabilities that up to now simply haven't been available in this type of instrument.



What is ISE?

National's ISE is a separate STARPLEX module housing 32K bytes of real-time map memory, plus all the necessary logic for breakpoints, tracing, and memory mapping. These resources are available for the emulation of any processor, since the individual emulation packages are the only components dedicated to particluar processors.

And since ISE doesn't share the STARPLEX BUS, the system doesn't have to compete for memory access with its STARPLEX host.

ROM display and disassembling.

The 8048 emulator package provides capabilities which zero in on the problems of designing with single-chip microcomputers. The target card has its own 4K of RAM dedicated to the real-time emulation of the processor's program ROM. So the designer has complete access to this memory throughout emulation.

He may examine and disassemble existing ROM contents, make changes, and execute the altered code. This gives him considerable flexibility in new product design, as well as in debugging existing systems containing a previously masked 8048.

There's more to STARPLEX beneath the ISE.

National's easily-learned software comes completely integrated into the STARPLEX system, including an automatic testing mode called "In-File" that will implement a predefined sequence of tests. And ISE can also record those results, so you can see exactly how each part of the system operates during testing.

STARPLEX's symbolic debugging capability provides not only the usual breakpoint conditions, but also a "coast" command which allows you to continue executing a program after the breakpoint combination has been satisfied.

STARPLEX can not only develop and debug software for National's 8048 Family, but also for 8080, 8070, NSC800, 8085 and Z-80® microprocessors plus BLC/SBC Series 80 boards.

When you get right down to it, National's STARPLEX with ISE offers features not available in any other development system on the market today. Yet it costs substantially less to own and operate than any system currently being sold.

Practical Wizardry strikes again.

Series/80 microcomputer products brought back down to earth.

National doesn't just make over seventy-five Series/80 computer products. They make them practical with test points, options, functional design and availability.

Some manufacturers build flashy boards loaded with far-out technology that you don't need and won't ever use. But not National. They make practical, reliable boards that do just what you buy them for.

And National makes more kinds of those practical, reliable Series/80 products than any other manufacturer.

The Series/80 Family is by no means just a second source supply. No other supplier beats National's reliability, functionality of design, user options, or variety of products.

The Series/80 Family includes CPUs, memories, controllers, analog and digital I/O, peripheral controllers, firmware, card cages, power supplies, cables and just about anything you need for just about any application.

Test procedures make them practically perfect.

National's boards are designed to be functional, easy to design in and totally consistent in operation. That's why test points have been designed into each board. So testing becomes an integral part of the design phase and continues throughout National's unique dynamic high temperature burn in.

To further ensure reliability, you also get a full one-year warranty with each Series/80 board that you buy from any of National's distributors worldwide. The longest warranty in the industry.

All from the Practical Wizards who finally brought space-age technology back down to earth.

"National is the only broad-based supplier of Custom MOS/LSI."

"There is only one supplier of Custom MOS/LSI components that has the design resources of a billion-dollar company behind it. National Semiconductor.

"With all that weight behind us, we've had considerable success in turning out the highest quality Custom components you can find.

"But depending on your applications, unit volume and several other considerations, we may find that standard microprocessors or discrete logic would be your best solution.

"This is where National stands alone among all Custom suppliers. Because if your needs don't actually justify the Custom approach, we won't try to sell you on it.

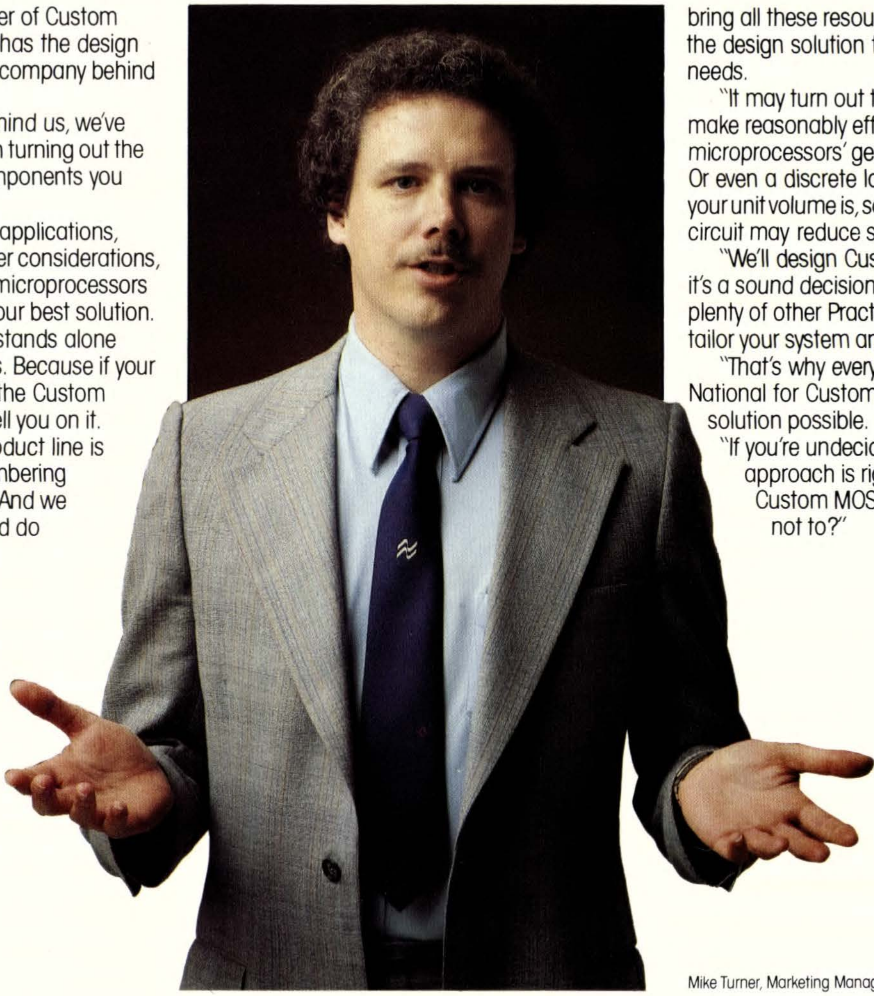
"National's standard product line is extremely broad-based, numbering literally into the thousands. And we in Custom MOS/LSI can and do bring all these resources to bear in finding the design solution that best fits your needs.

"It may turn out that your product could make reasonably efficient use of standard microprocessors' generalized instruction set. Or even a discrete logic design. But when your unit volume is, say, 40K or more, a Custom circuit may reduce systems costs.

"We'll design Custom circuits for you if it's a sound decision. But if not, National has plenty of other Practical Wizards that can tailor your system anyway.

"That's why everyone who comes to National for Custom MOS/LSI gets the best solution possible.

"If you're undecided as to which design approach is right, come to National Custom MOS/LSI. Can you afford not to?"



Mike Turner, Marketing Manager, Custom MOS/LSI

What's new from the National archives?

005 ☐ Additional Custom MOS/LSI Information
006 ☐ Special Functions Data Book ($6.00)
015 ☐ MST Program Brochure
035 ☐ Additional Series/80 Information
036 ☐ Optoelectronics Handbook ($3.00)
037 ☐ Additional STARPLEX and ISE Information
038 ☐ MM5290 Data Sheet and Additional Information

Enclose check or money order based upon appropriate currency. Make checks payable to National Semiconductor. Allow 4-6 weeks for delivery.

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The Practical Wizards of Silicon Valley

NA10

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structured-programming techniques. The seminar will be held in Lexington, MA on July 28 through August 1. Professor Donald D French can give you the scoop — call (617) 964-1412.—JM

VHSIC CONTRACTS WILL ENHANCE MILITARY ELECTRONIC SYSTEMS

Focusing on CMOS/SOS technology, Rockwell International's Electronic Systems Group (Anaheim, CA) and Sanders Associates (Nashua, NH) will undertake a $1.6 million 1-yr contract for the definition phase of a very high-speed-integrated-circuit (VHSIC) program. The team will address the signal-processing requirements of communications, imagery and electronic-warfare systems — with the aim of developing a broadly applicable architecture for these disciplines.

In a separate development, Westinghouse Electric Corp (Washington, DC), with team members National Semiconductor, Control Data Corp and the Mellon Institute, has also received a $1.2 million Phase 0 VHSIC contract from the US Navy. The group will select candidate systems for potential VHSIC applications and prepare a technical approach for subsequent phases.—WT, JM

SYMPOSIUM TO EMPHASIZE STEPPING-MOTOR APPLICATIONS

If requirements for accurate positioning leave you at a standstill, the ninth annual Incremental Motion Control Symposium will bring you up to speed. Most of the gathering's planned exhibits and 40 of 50 scheduled papers will center on stepping-motor applications, while the remaining presentations will treat dc-servo systems and other motion-control schemes. For more information on the conference, slated for June 2 through 5 in Champaign, IL, contact the Incremental Motion Control Systems Society, Box 2772, Station A, Champaign, IL 61820, or phone (217) 333-4341. And to pique your curiosity on the subject, turn to pg 37 in our April 5 issue for an update on stepper-motor technology.—RN

THE FOCUS IS ON COBOL FOR COMMERCIAL APPLICATIONS

Having discovered that 90% of the programming for the commercial and small-business market occurs in COBOL, Zilog will aim its next generation of computer systems at the multiterminal COBOL environment. To actively pursue this market, the Cupertino, CA-based manufacturer plans introductions, beginning in the second quarter, of a new family of computers that will offer increased floppy-disc storage, a multitasking operating system, faster processing and increased remote-data-communications capabilities. These systems will be based on the 4-MHz Z80A μP and will address the same applications as the firm's current MCZ-1 family.—ET

HOTLINE SERVES HANDICAPPED PERSONS' EQUIPMENT NEEDS

If you're physically handicapped (or know someone who is) and require information on communication equipment, call (503) 357-4354, a hotline set up by Tektronix's (Beaverton, OR) Special Interest Group on Computers and the Physically Handicapped. Monitored by an answering machine, the hotline answers questions and provides referrals regarding the special-equipment needs of the blind, motor impaired or deaf.—JB

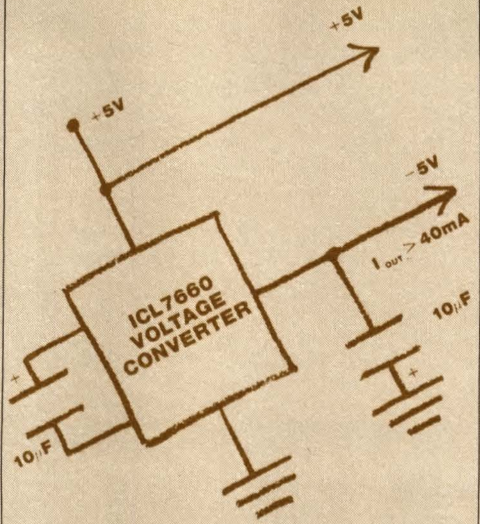
INSTRUMENT FIRM OFFERS CONSULTING SERVICE

The Nicolet Consulting Group (Northvale, NJ) provides a service for the solution of various structural problems — whether you're using Nicolet Instruments equipment or not. The group specializes in vibration and dynamics problem solving, computerized dynamic modeling, performance prediction and dynamic model verification. To discuss this service, contact Dot Hubner at (201) 767-7100.—JM

INTERSIL INSIGHT 2

"NOTHING SUCCEEDS LIKE SUCCESS"

That quotation from Alexandre Dumas certainly applies to INTERSIL INSIGHT. Our first issue brought a deluge of inquiries from engineers wanting to know more about the latest in our broad line of linears, RAMs, ROMs, data acquisition systems, power MOS, display drivers... you name it. And INTERSIL INSIGHT #2 is equally packed with timely information. So when an item catches your eye, just check the appropriate number on the coupon on the back page for more product data. We call it the You Got Me! coupon. Be sure to check it, clip it, and send it in. Additional information will be on its way to you fast. And in case you missed INSIGHT #1, you can check 17 for a reprint.

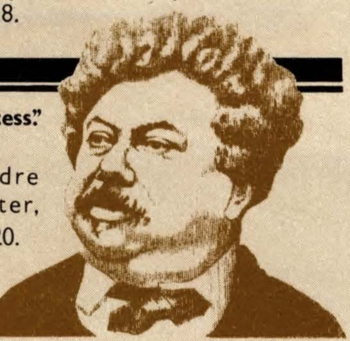


HOW TO GET -5V OUT FROM +5V IN.

Power your analog circuitry from your digital power supply with the new CMOS ICL7660. It's a unique monolithic chip which converts positive voltage to negative voltage with 99.9% voltage conversion accuracy ($R_L = \infty$). With 98% power conversion efficiency ($R_L = 5K\Omega$). And I_{OUT} is greater than 40mA ($R_{OUT} = 55\Omega$). So forget about that expensive second analog supply or those bipolar kluge circuits. Need −5V for a board full of dynamic RAMs? The ICL7660 is the inexpensive answer: only $1.95 each in 8-pin minidips, in 100 piece quantities. Need higher negative voltages? Just cascade multiple 7660's. Need more current? Hook 7660's in parallel. It's a very versatile device. Check 18.

"Nothing Succeeds Like Success."

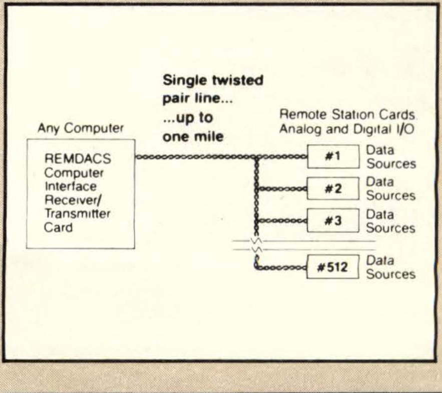
For our Alexandre Dumas poster, check 20.

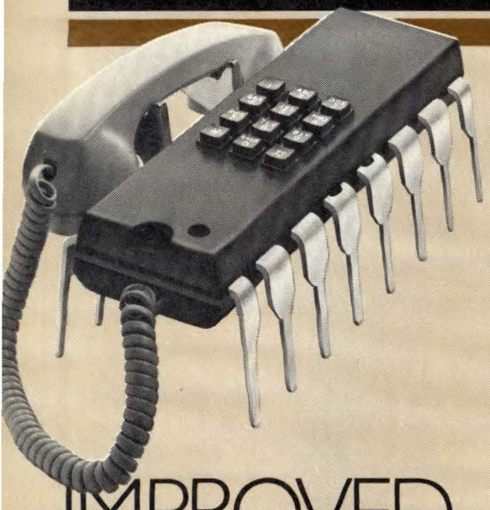


Acquire Data One Mile Away with REMDACS™

If you design data acquisition systems, our new REMDACS concept will light up your life at a cost of only $30 per channel. REMDACS is a remote data-acquisition and control system which permits analog sensors to be linked to a host computer up to one mile away... through a single twisted pair of wires. REMDACS consist of two basic cards. The 4 x 7-inch remote station board will accommodate either voltage or temperature measuring inputs. The other 4 x 7-inch receiver/transmitter card not only handles communications with the remote stations, but formats data to and from the host computer. Conversation between cards is in a serial party-line protocol. Need more stations? A single receiver/transmitter card can address up to 512 remote stations... 256 with 24-bit dual-word-length message formats and 256 with 44-bit message configurations. For quick evaluation, a third card is available which is compatible with the RS232 serial I/O port standard on most CPUs. For our brochure on this exciting new D/A system concept, check 19.

TM—REMDACS is a trademark of Intersil, Inc.





IMPROVED CMOS TOUCH-TONE ENCODER.

Here's a new version of Intersil's popular CMOS 7206 touch tone encoder. The new ICM7206C combines both oscillator mute and single contact keyboard functions on one chip—and avoids spurious side tones. The 2-of-8 sine wave touch tone encoder features fast oscillator start-up (5ms), extemely low distortion (<5%) and low voltage operation (down to 3V). The ICM7206C works with either 3x4 or 4x4 key formats for minimum cost keyboard design. It's intended for telephones, numeric data entry and the like. Check 21.

A Low Cost Alternative Micro for OEM PDP-8 Users.

If you're getting long delivery quotes on PDP-8® minicomputers, here's an attractive low-cost alternative: Intersil's new LSI-8 microcomputer. It's ideal for medium and high volume general-purpose applications requiring a powerful, reliable, easily serviced computer. It comes in four modules: CPU with dual serial I/O; 32K RAM memory board; 4K battery-backed-up CMOS RAM board; and DMA flexible-disk controller. And a large software base is available. The full system, with CPU, 32K memory and dual flexible disks, is $4145 in 25-unit quantities. Without dual flexible disks, systems start at $1525. Check 22.

® PDP-8 is a registered trademark of Digital Equipment Corporation.

A HIGH-SPEED LOW-POWER 2147.

It's called the IM7147. It features 55ns access time and consumes only 20mA in the standby mode. This new 4K static RAM has all of the good things associated with Intersil's expertise in CMOS, including lower power dissipation and higher system reliability. Not to mention the reduction in power supply and cooling requirements. The bottom line is superior performance with significant savings. The price: $36.80 in 100s. For more information, check 23.

	Operating Power	Standby Power	Access Power
IM7147	125mA	20mA	70ns
IM7147L	100mA	10mA	70ns
IM7147-3	**125mA**	**30mA**	**55ns**
IM7147L-3	**110mA**	**20mA**	**55ns**
(military) IM7147LM	125mA	20mA	85ns

TWO NEW CHIPS FOR VACUUM FLUORESCENT DISPLAYS.

4½ Digit Counter with VF Static Display Drivers.

The ICM7236/ICM7236A are new low-power up-counters with static drivers for vacuum fluorescent displays. They are high-performance CMOS devices including decoders, output latches, count inhibit, reset and leading-zero blanking circuitry on a single chip. For fast counting, 15MHz is guaranteed and 25MHz is typical. ICM7236 has a maximum count of 19999, ICM7236A has a maximum count of 15959. Power consumption is only 10μA typical. Store and Reset inputs permit use as a frequency or period counter. The price in plastic: $5.86 in 100s. Check 24.

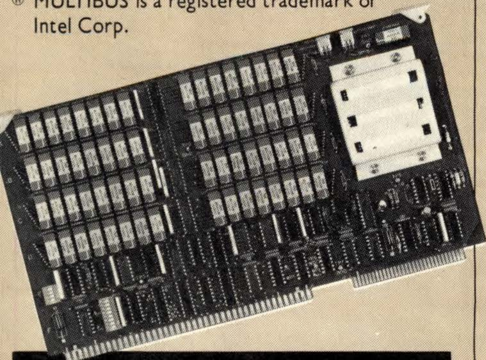
From µP to VF Display with One Chip.

The new ICM7235 is a single chip interface between microprocessors and non-multiplexed 7-segment vacuum fluorescent displays. It comes with multiplexed BCD input for digital logic interface, or with high-speed μP interface. You can get either hex (0-9, A-F) or code B (0-9, dash, E, H, L, P) outputs. The ICM7235 features display blanking, static discharge protection, brightness control and, most significantly, the saving of up to seven TTL or CMOS devices per display. It's great for digital instruments, automobile readouts and a wide range of other displays applications. For more data, check 25.

CMOS MEMORY BOARD FOR MULTIBUS® MICROS.

The new MCB-332 32K byte memory board features low-power CMOS static RAMs and total compatibility with SBC 80/10, 80/20, 80/30 and 86/12 microcomputers. Data can be either 8 bits or 16 bits wide, depending on MULTIBUS control inputs. Worst case memory access time is 350ns max. Memory cycle time is 500ns min. Fast response time requires no wait state injection when used with most microcomputers. All interface address, data and command signals are TTL-compatible, and battery back-up is on board for 21-day data retention. All this, plus immediate delivery from Intersil. Check 26 on the You Got Me coupon.

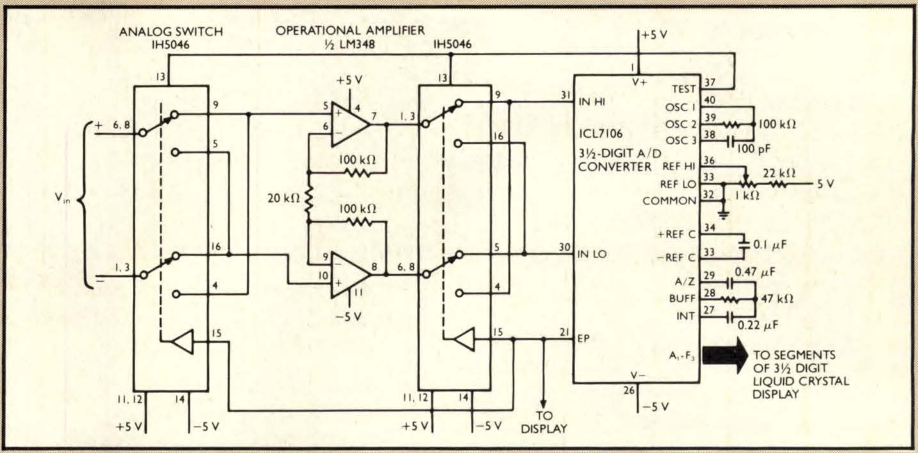
® MULTIBUS is a registered trademark of Intel Corp.



DESIGNER'S CORNER: (THE FIRST OF A CONTINUING SERIES)

Switching Pre-Amp Extends A/D Converter Sensitivity.*

The low-signal resolution of an A/D converter such as the Intersil ICL7106 is limited by the noise level at 100mV per count. Simple preamps can cause problems, and choppers can be expensive. But a differential preamplifier, phase-switched at 50% duty cycle, will virtually eliminate input offset error and allow a 10 times increase in converter sensitivity. The normal conversion process will not be affected ... the converter will see the average of V_{IN} over the switching period, multiplied by the gain. However, offset voltage at the input will be alternately fed to the converter with +Ve and − Ve polarity. The equivalent offset voltage over a cycle will be near zero. The LCD backplane drive of the ICL7106 is a perfect 50% duty cycle signal, synchronous with conversion, to drive the Intersil IH5046 analog switches at a nominal 60Hz rate. The TEST output (37) provides the low logic level to the switch drivers. Most dual op amps will be suitable, but devices with crossover distortion (viz, LM324) should not be used.



A SEMINAR FOR SERIOUS DATA ACQUISITIONERS ONLY.

From March 18 through May 2, Intersil will be presenting in-depth data acquisition seminars across the country. The focus is real-life applications. But no "overviews." No ABCs. In three information-packed hours, you'll get an armload of state-of-the-art techniques for designing data acquisition systems. You'll also see real systems that have been prototyped and tested: a high-speed successive-approximation multi-channel system, an auto-ranging 4½-digit DMM system, a complete frequency/period counter/timer system, an intelligent instrument system, a digital transmitter/transducer system, a remote data system with serial output. This seminar is a must for any serious data acquisitioner. For date and location in your area, call (408) 996-5403.

	CMOS UART	PMOS UART
Speed	up to 4 MHz	200 KHz
Power Consumption —Active	6.6 mW	385 mW
Power Consumption —Standby	4.4 mW	385 mW
Power Supplies	Single	Two or Three
Noise Immunity	50%	30% or less
Operating Temperature	−40 to +85°C*	0 to 70°C
Price	$3.80	$4.00-$7.50

*Military temperature unit also available.

CMOS UARTs 20x FASTER THAN PMOS.

The chart tells the story. Our IM6402/IM6403 CMOS UARTs beat PMOS UARTs hands down in speed and price. What's more, the CMOS technology offers lower power, better noise immunity, better reliability, and greater flexibility. For instance, you have two oscillator options: the IM6403's on-chip oscillator eliminates additional circuitry such as baud-rate generators; or use the IM6402 and add your own off-chip clock generator. Both devices are programmable for 5 to 8-bit word lengths and interface to most popular microprocessors, such as the Intersil IM6100 CMOS family. For full technical data, check 27.

INTERSIL

YOU GOT ME!

VOL. 2

Please send me data on the following:

- ☐ 17
- ☐ 18
- ☐ 19
- ☐ 20
- ☐ 21
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- ☐ 23
- ☐ 24
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EDN42080

Hot New Lit.

Commutating Design for IC Amplifiers Virtually Eliminates Offset Errors (#R010).

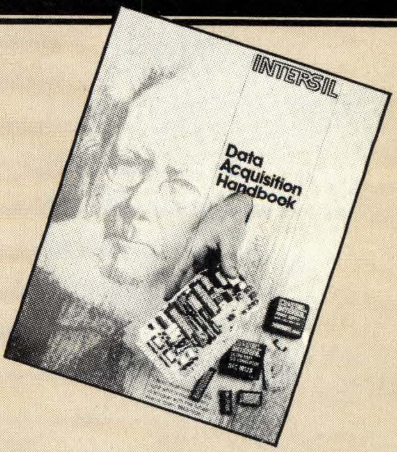
An article reprint from *Electronic Design* covering operation and application of our new ICL7600/ICL7605 Commutating Auto-Zeroing(CAZ)amplifiers. Check 28.

Dual Word Length Serial Protocol Improves Data Acquisition Network (#R007).

Detailed discussion of protocol considerations involved in revolutionary new REMDACs remote data acquisition concept. Reprint from *Computer Design*. Check 29.

Reduce CMOS Multiplexer Troubles Through Proper Device Selection (#R009).

Reprinted from *EDN*, this tells how to overcome output leakage current and overvoltage protection problems in CMOS analog multiplexers. Also, how to reduce component count and cost. Check 30.



Order our big, brand-new Data Acquisition Handbook: only $5. The last word on the whole spectrum of leading-edge data acquisition products, systems, design and debugging information. Send check or money order to the Intersil Marketing Services address on the coupon.

Signals & Noise

Designing takes a degree of imagination

Dear Editor:
For years I have been reading articles in trade magazines on how nondegreed people have been encroaching on the sacred domain of the graduate engineer. The feeling I get from these stories is this: Only if one sits through 4 yrs of college classes is one qualified to do design work.

I have been working in electronics for more than 10 yrs, the last five of which have been spent designing electronic equipment. I have achieved this record without the sanction of an accredited college or university, proving that formal education does not necessarily qualify a person for electronic design. Indeed, some might even be so bold as to say that a structured system smothers an individual's imagination and common sense.

Until it's recognized that the degree does not make the person, many good people and ideas will be wasted.

Sincerely,
John T Abrams
Society for the Prevention of the Glorification of Sheepskin
Bohemia, NY

" I WAS QUITE ELATED WHEN HE SAID THEY PLANNED TO SPEND MONEY LIKE WATER FOR RESEARCH.......... IT TURNED OUT TO BE A DROP AT A TIME."

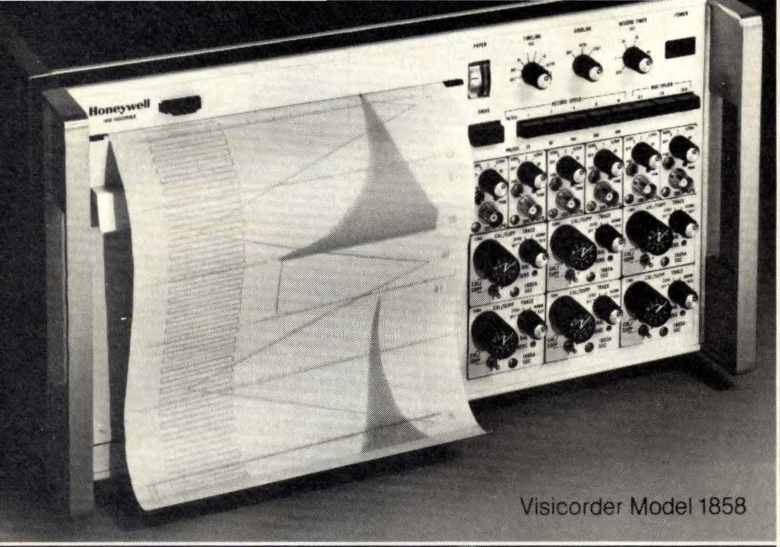
Even editors get the blues sometimes

We're embarrassed. In our writeup of Datel-Intersil's ADC-815 (Editor's Choice, February 20, pg 69), we omitted a basic parameter. The A/D converter is a 10-bit unit. We thank John D Fogarty of Columbia, MD, and other readers, for putting us in our place.

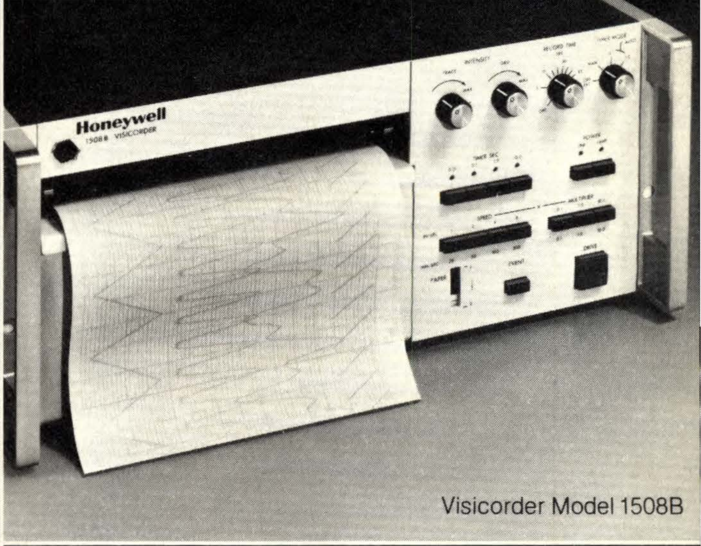
Obscure timer specs

Dear Editor:
The article on IC timers (EDN, January 20, pgs 111-117) prompts me to offer an observation regarding a 556 quirk: In Fairchild's and Signetics' 556s, at least, but *not* in National's, trigger LOW overrides threshold HIGH to maintain Q HIGH. I employed

Your turn...,
EDN welcomes your comments, pro or con, on any issues raised in the magazine's articles. Address letters to **Signals and Noise Editor, EDN, 221 Columbus Ave, Boston, MA 02116.** Names will be withheld upon request. We reserve the right to edit letters for space and clarity.

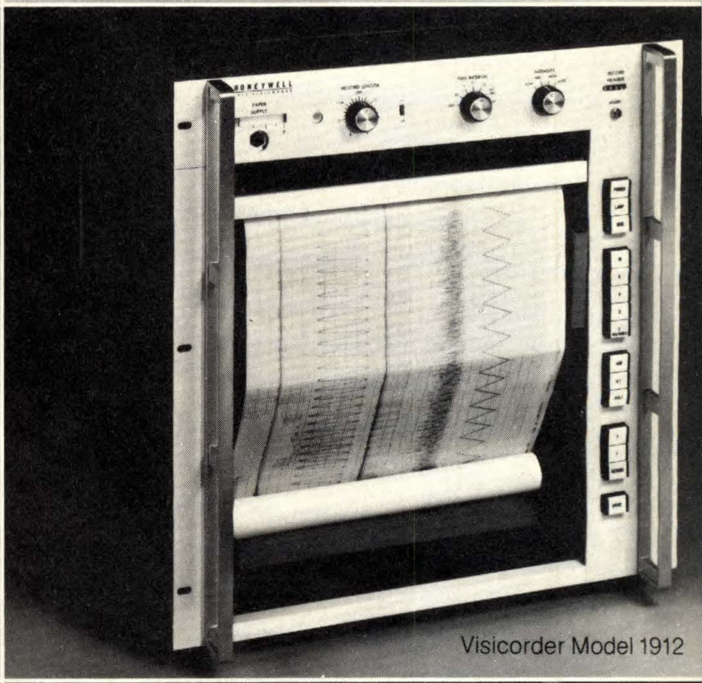


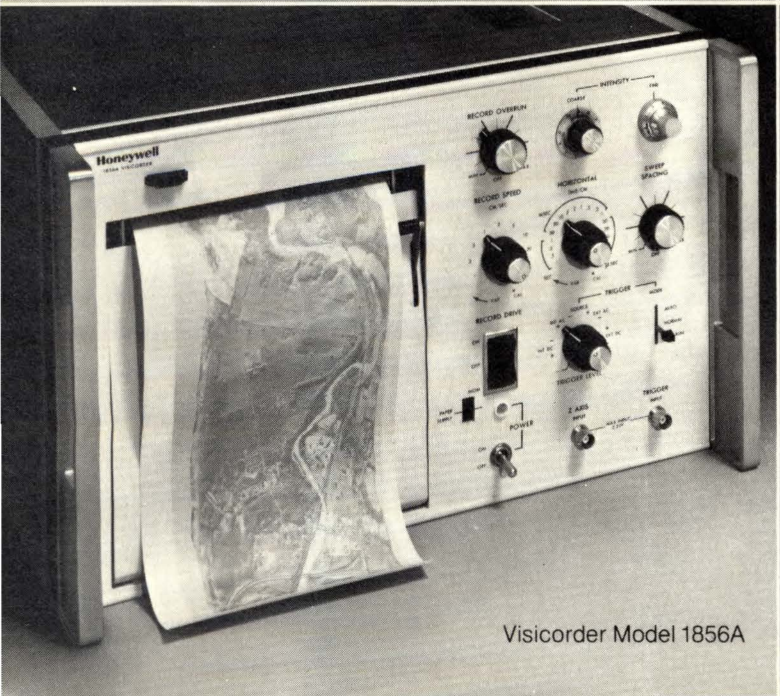
Visicorder Model 1858



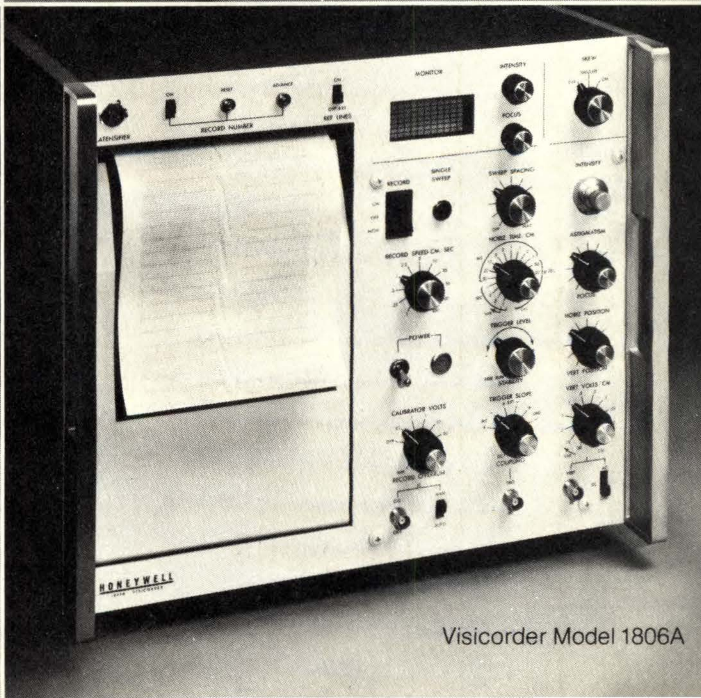
Visicorder Model 1508B

Visicorder Model 1508C


Visicorder Model 1912



Visicorder Model 1856A



Visicorder Model 1806A

MEET SIX TOP RECORD MAKERS.

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Visicorder Model 1858 is a completely self-contained system with up to 18 channels, yet it stands less than nine inches high. This unexcelled portability, enhanced by a wide selection of miniature, plug-in signal conditioners, makes the Model 1858 ideal for field or mobile use. And its dc to 5 kHz response, wide chart speed range, 100 μV-300V input sensitivity, and the ease with which it expands to 32 channels also make it a favorite in the lab. A fiber-optic CRT assures sharp traces of high resolution across the entire 8-inch record.

Visicorder Models 1508B and 1508C offer dc to 25 kHz response, wide chart speed range and writing speeds greater than 50,000 inch/sec. Both combine high-linearity optical systems with sensitive galvanometers to produce extremely accurate 8-inch-wide recordings. The Model 1508B has 24 data channels plus 4 for event recording; Model 1508C has 12 data channels plus 2 for event recording.

Visicorder Model 1912 offers the most data channels, widest recording paper, and widest transport speed range of all Honeywell galvanometer-type oscillographs. This versatile recorder can handle up to 36 channels of data, in addition to 6 channels of event recording. It accommodates 12-inch-wide paper at speeds from .005 to 200 inch/sec.

Do you need 4-axis recording capability? Our linescan image recorders give you the kind of record quality you can only get with a direct writing fiber-optic CRT.

Visicorder Model 1856A produces 6-inch-wide records that have exceptionally high resolution and wide gray scale. This makes the recorder particularly suited for such applications as facsimile, spectrum analyzer readouts, IR mapping and echocardiography. Z-axis response is dc to 8 MHz, Y-axis is dc to 75 kHz, and the X-axis is capable of scan rates to 18,000/sec. Accessories are available for film records.

Visicorder Model 1806A can record, on 6-inch-wide paper, high-frequency signals that would otherwise require magnetic tape or oscilloscope camera techniques. It offers Y-axis response from dc to 1 MHz, Z-axis to 10 MHz, X-axis to 1 MHz and writing speeds greater than 1,000,000 inch/sec. The Model 1806A also accommodates accessories for film records.

Honeywell's Accudata signal conditioning modules speed most recording and measurement tasks.

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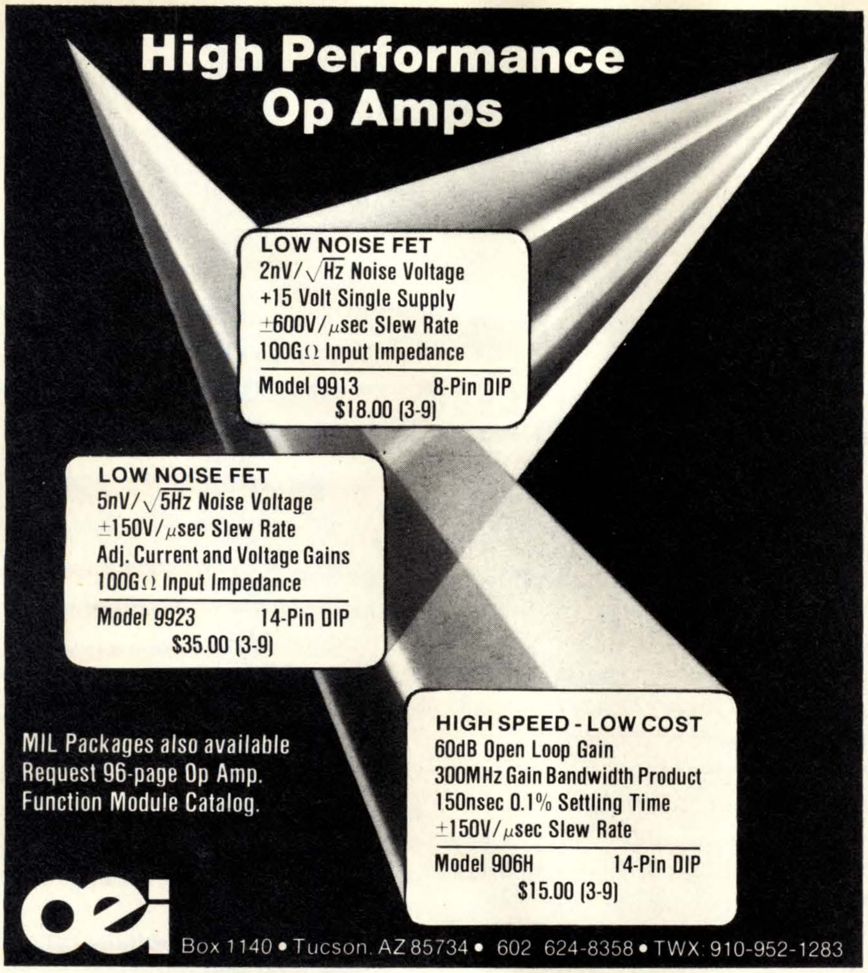

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Signals & Noise

this feature in a design and found it necessary to specify which firms' 556s could and could not be used.

My experience reminds me of the old rule that says "never depend on an unspecified characteristic." I grant, though, that 555-type products' data sheets have been among the more obscure I've encountered.

Sincerely,
K C Herrick
Chief Engineer
ESI Electronics Corp
San Francisco, CA

Memory refresh

Dear Editor:
EDN's article on programmable - memory choices (January 5, pgs 80-98) incorrectly referred to the Texas Instruments TMS 2508 as being the same device as the industry-standard 2758. The TMS 2508 is a true 8k 5V EPROM which operates at a maximum access time of 250 nsec. The 2758 (which TI also supplies) is a partial 16k 5V EPROM operating at 450 nsec.

Sincerely,
Frank Hrobak
MOS Memory Marketing
Texas Instruments Inc
Houston, TX

NEXT TIME

In EDN's May 5 issue, look for a preview of key sessions and product exhibits at NCC '80. This year's National Computer Conference promises to be bigger and better than ever, and EDN will be there. Also look for feature articles on

- The latest serial printers, complete with a handy clip-out chart
- The next step in EDN's hands-on μC Design Series exploration of analog μPs

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EDN: Everything Designers Need


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NEC Electron, Inc.
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EDN 4/20

Books

A comprehensive text on 6800-μP use

Basic microprocessors and the 6800, *by Ron Bishop. 262 pgs; $11.95 (paperback); Hayden Book Co, Rochelle Park, NJ, 1979.*

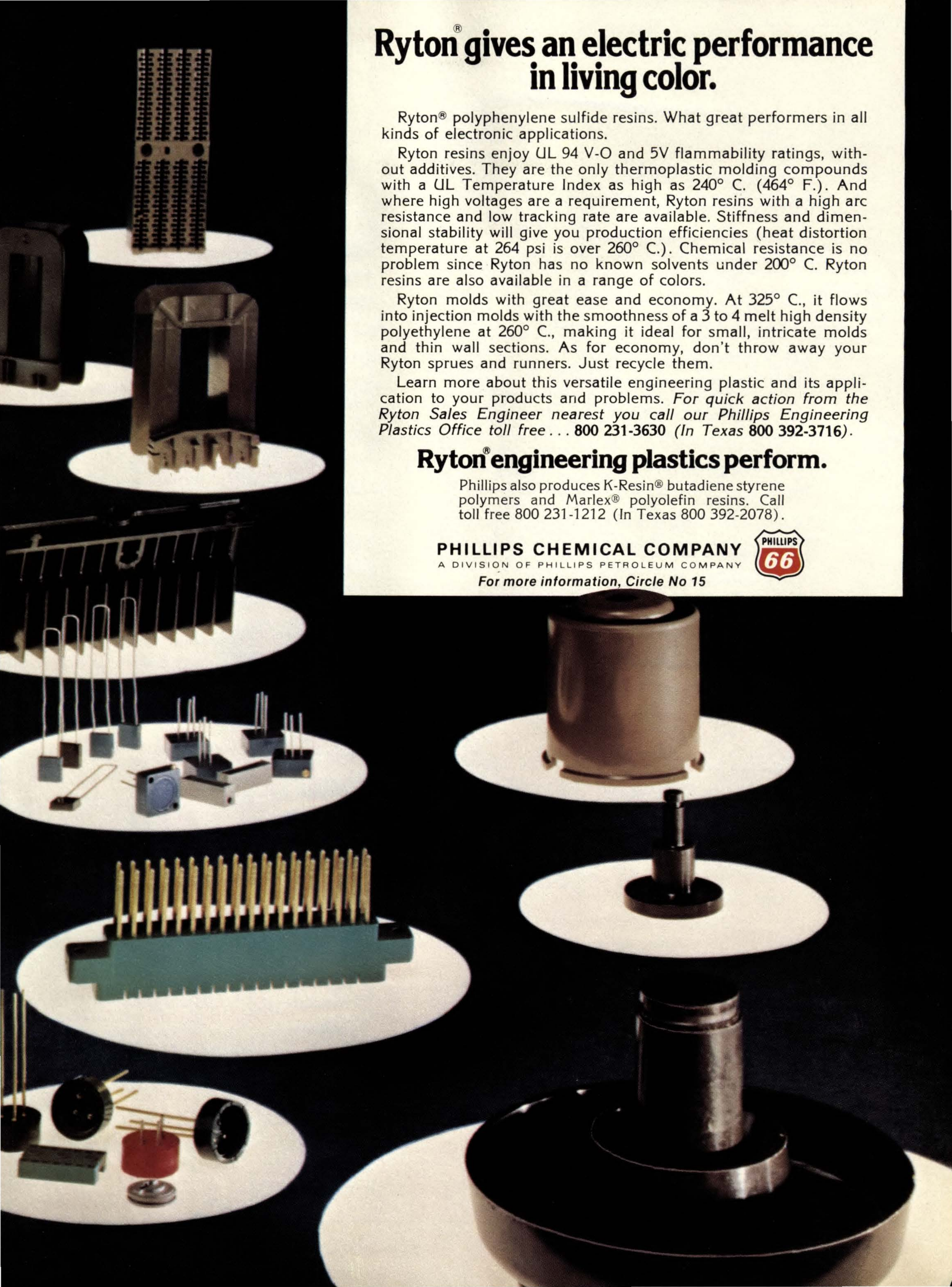
Even though volumes of information have appeared concerning the basics of microprocessors—and the 6800 in particular—very few books take readers through all levels of the μP learning experience.

But this deficiency has now been corrected by author Ron Bishop. He assumes that if you are completely unfamiliar with electronics and computers, you deserve some background material. Therefore, his book's first six chapters provide a clear and concise exposition of basic electronics, logic and micrcomputers in general.

Should you already understand the basics, however, you can skip immediately to Chapter 7, which begins an in-depth discussion of addressing modes.

Although two chapters on μP outboard chips read like data sheets (and indeed, they originated from these sources, according to the book's preface), two other chapters on software more than compensate for this shortcoming. Chapter 8, for example, fully describes each MC6800 instruction, presents examples of addressing-mode use and describes the effect of instructions on condition codes and execution times.

The book's final chapter, "Example Programs"—one of the best ever written in this genré—not only presents valuable working programs that summarize the concepts discussed earlier in the book, but also explains exactly what happens and why.—***Carl Warren***



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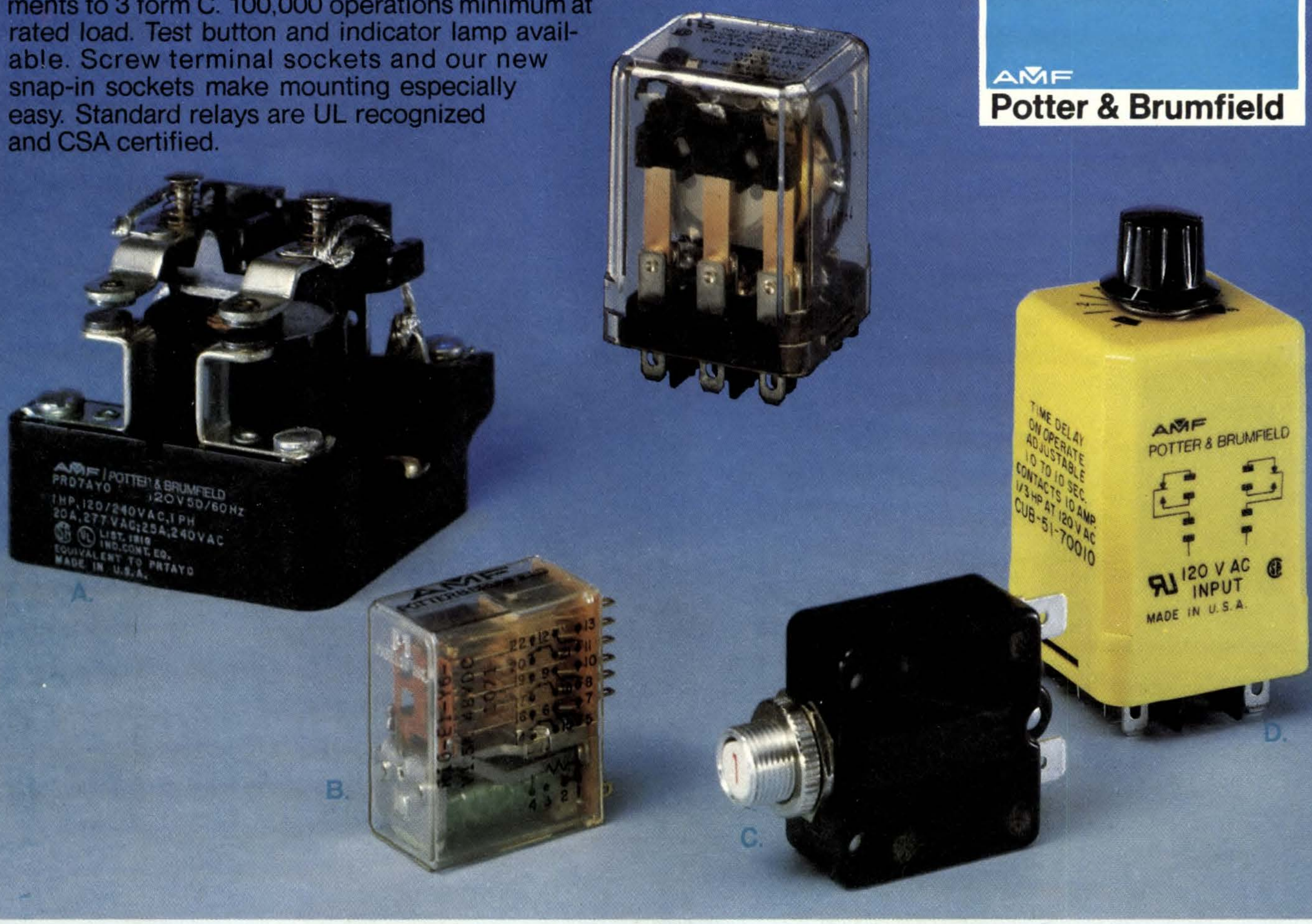

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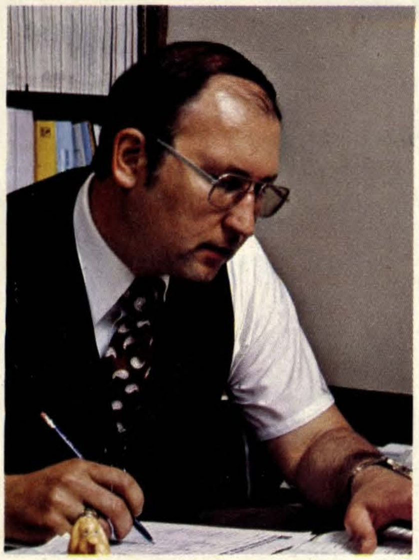
Editorial



Let's hear it for Silicon Circle

Route 128, the highway circling Boston and its suburbs, achieved fame in the '60s and early '70s because of the many high-technology companies abutting it. But its allure diminished in the mid-'70s, thanks to huge cutbacks in military/aerospace spending and the simultaneous growing dominance of high-technology semiconductor companies in California's Santa Clara Valley, also known as Silicon Valley.

One reason for Rte 128's prominence as a prime location for electronics firms was its closeness to great institutions such as MIT and Harvard, whose research labs have spawned many a high-technology company. Yet those labs have never focused on semiconductor technology as Stanford University has; hence the clustering of semiconductor companies in Silicon Valley—near Stanford.

Twenty years later, MIT is seeking to correct its oversight by establishing a $5 million advanced-IC fabrication facility on its Cambridge campus. Although this effort doesn't compare with the $16 million VLSI facility planned at Stanford, it's a start. It certainly will prove a boon for the many computer companies in the Boston area. And it should also be a stimulus for the region's few semiconductor companies, such as Analog Devices, Cherry Semiconductor, Sprague and Unitrode.

As a result of MIT's plans, will Rte 128 become Silicon Valley East—or better, Silicon Circle? Possibly, though on a smaller scale. When you view the current problems in Silicon Valley—including incredibly high living costs, shortages of skilled personnel and moratoriums on plant expansions—Silicon Circle offers an interesting alternative. The area not only will provide a significant semiconductor research facility at MIT, but it will also retain the other high-technology research labs and companies that made it famous two decades ago. Furthermore, Massachusetts is making valiant efforts to improve its business climate, thanks to the stimulus of the Massachusetts High Technology Council, headed by Analog Devices president Ray Stata.

EDN applauds MIT's move and hopes that the Golden Circle of Rte 128 will indeed become Silicon Circle. The resulting diversification can only have a beneficial effect on the electronics industry.

Roy W. Forsberg

Roy Forsberg
Editorial Director

An Award*-Winning Magazine
1978 Staff-Written Series — System Design Project
1978 Contributed Series — Designer's Guide to Fiber Optics
1977 Contributed Series — Software Design Course
1976 Special Issue — Microprocessor Reference Issue
1975 Staff-Written Series — Microprocessor Design Series

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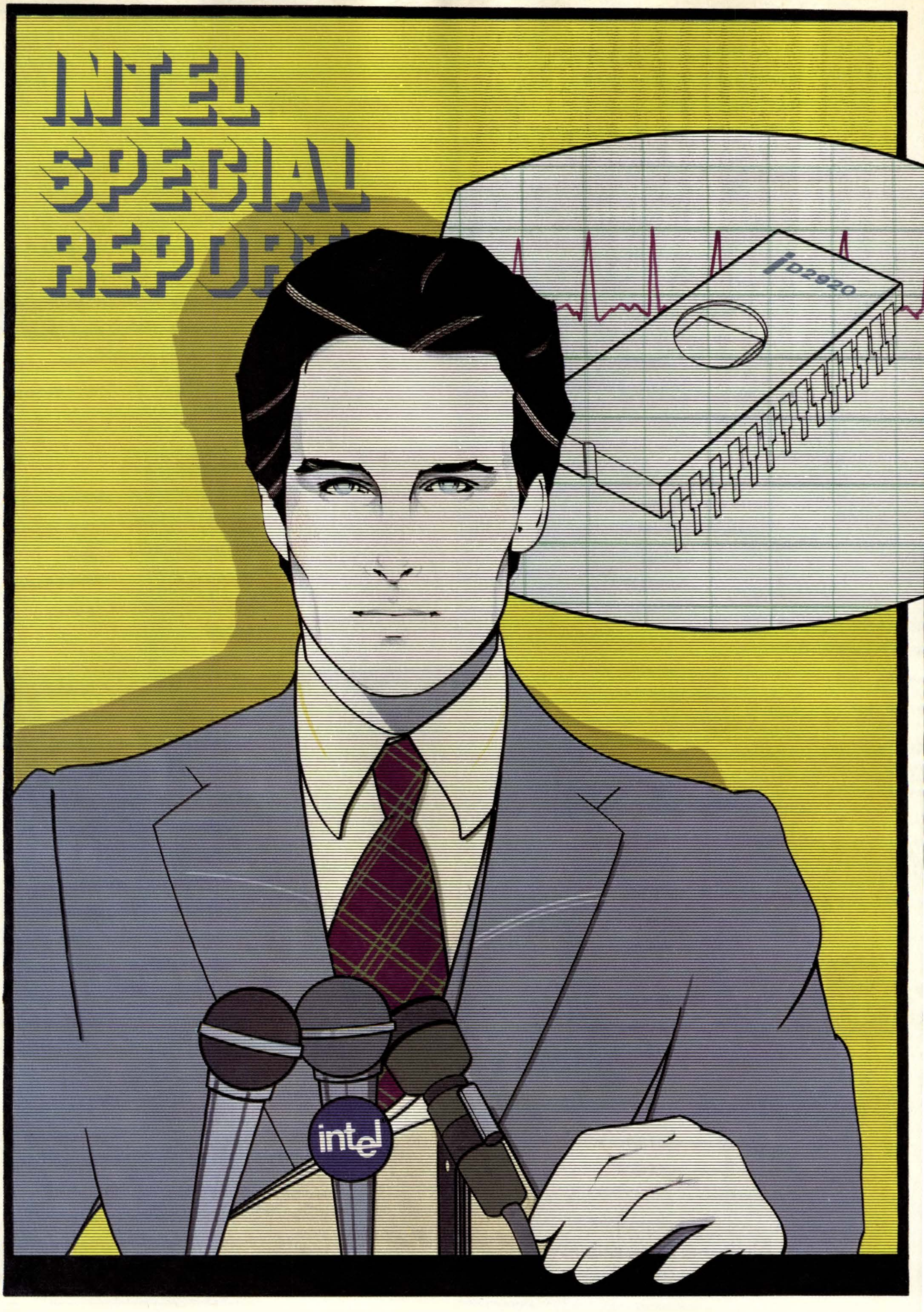
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LSI Breakthrough for Analog

Intel announces the 2920 Signal Processor, first general purpose, real-time system on a chip.

Good news for analog designers. Intel breaks a new barrier in microelectronics: The first intelligent chip powerful enough to process analog signals in real time. Plus a computer-aided development package to help speed your systems to market faster than ever before.

Intel's 2920 is a complete, micro-sized signal processing system that packs the equivalent of over 18,000 transistors on a single chip. It operates hundreds of times faster than current digital processors. And best of all, the 2920 allows designers to *program* system values quickly, instead of having to match and tweak components.

A revolution in analog design

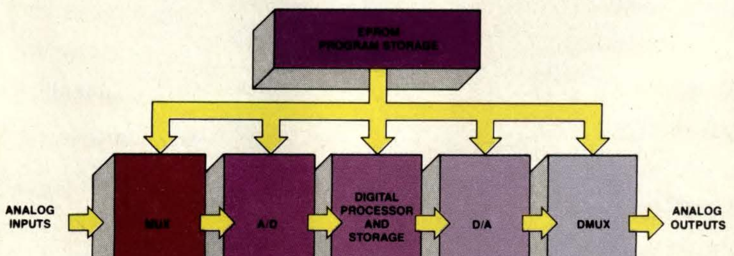
From the beginning, LSI technology has helped designers achieve dramatic improvements in product size, design cycles and manufacturing economics. But until now, the speed and complexity of analog processing has stood in the way of general purpose, single chip solutions for real-time applications.

Today, Intel's 2920 Signal Processor brings the power and flexibility of LSI to the analog world. Because of its size, the 2920 can fit in spaces too compact for traditional analog solutions. Because the 2920 is programmable, product development and time-to-market are speeded significantly. Finally, because the 2920 is a solid state device produced with Intel's proven NMOS process, reliability and manufacturing repeatability are assured to a degree not possible with previous methods.

Micro-processing for the real world

Applications for the 2920 are as broad as your imagination. Since analog designers can program the 2920 processor to perform a large number of standard building block functions, the chip can be used as an entire subsystem. Implement such functions as complex filtering, waveform generation, modulation/demodulation, adaptive processing, and even non-linear functions. This broad capability makes the 2920 an ideal single chip solution for virtually any application in the DC to 10 kHz range.

And like the digital microprocessor, the 2920 is destined to create entirely new classes of applications: products that are smaller, simpler, and less costly to produce. It gives a competitive advantage to companies in such areas as process control, test and instrumentation, guidance or control systems, telecommunications, speech processing, and seismic or sonar signal processing.



Functional Block Diagram of the 2920 Signal Processor

How the 2920 simplifies system development

Programming Intel's 2920 Signal Processor is fast and easy to learn—far less complex than the component matching it replaces. Most importantly, Intel provides the complete support tools and design workshops you need to start designing 2920 systems today.

Our SP20 Support Package and Intel's Intellec® Microcomputer Development System allow you to develop and debug by simulating your system in software. Just program functions according to your system schematic, then specify input and operating values. Together, Intel's development aids let you see how your system will work before you even build a prototype. Best of all, because you develop in digital code, your prototype system will be duplicated precisely in manufacturing.

Start making news with your product

Everything you need to begin designing a new generation of real-time analog processing systems is here today: Intel's 2920 Signal Processor, SP20 Support Package, and the Intellec Development System. For detailed information, including our new 2920 brochure, plus a schedule of Intel's nationwide 2920 Design Workshops and Seminars, contact your local Intel sales office or distributor. Or write Intel Corporation, Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051. Or call (408) 987-8080.

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H	Dual-input	125, 250, 375	+2 to +24
M	Triple-output	40, 70, 120	Combinations from −15 to +15
E	Single-input	25, 50, 100, 150	+5 to +24

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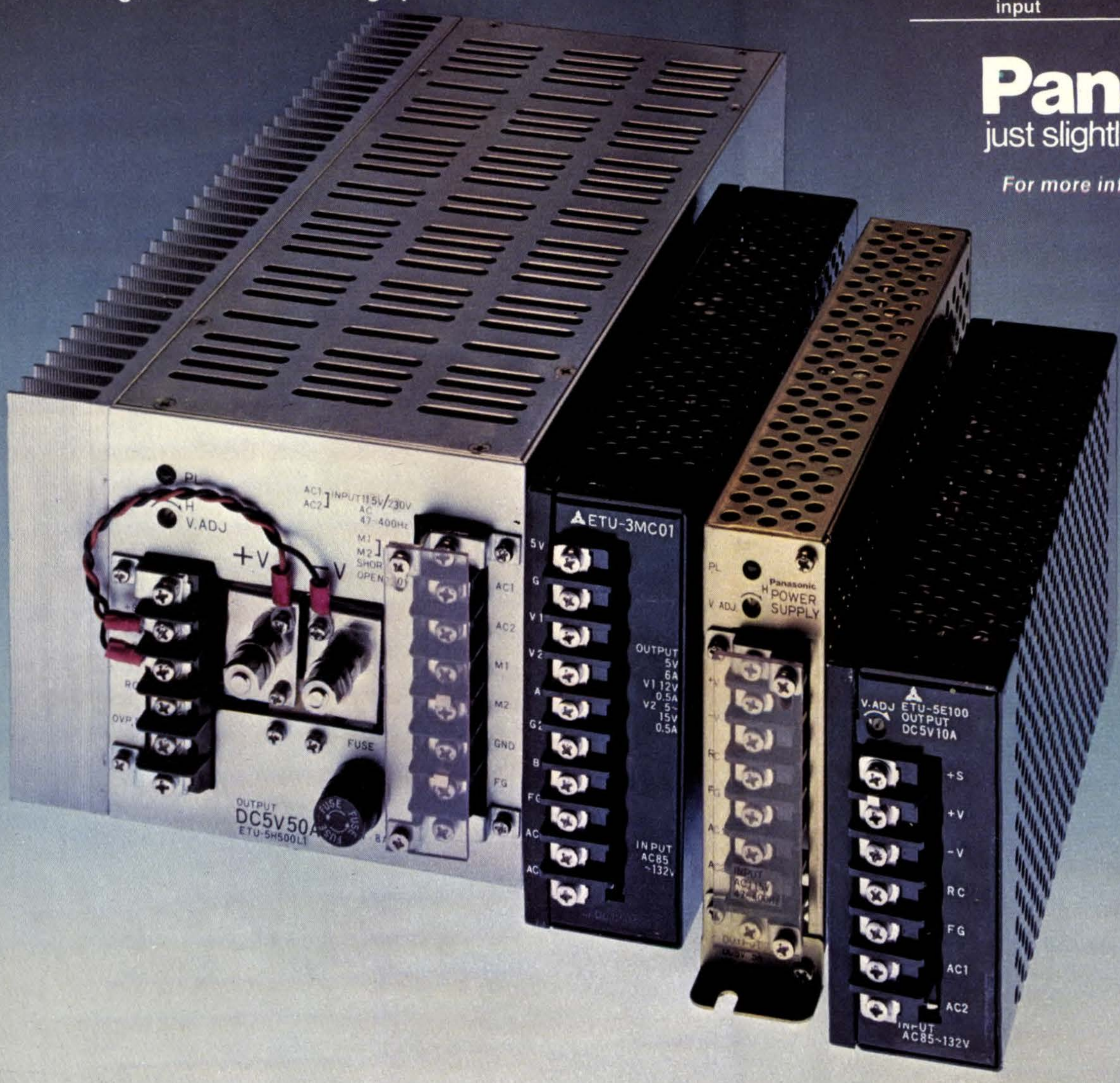


Technology News

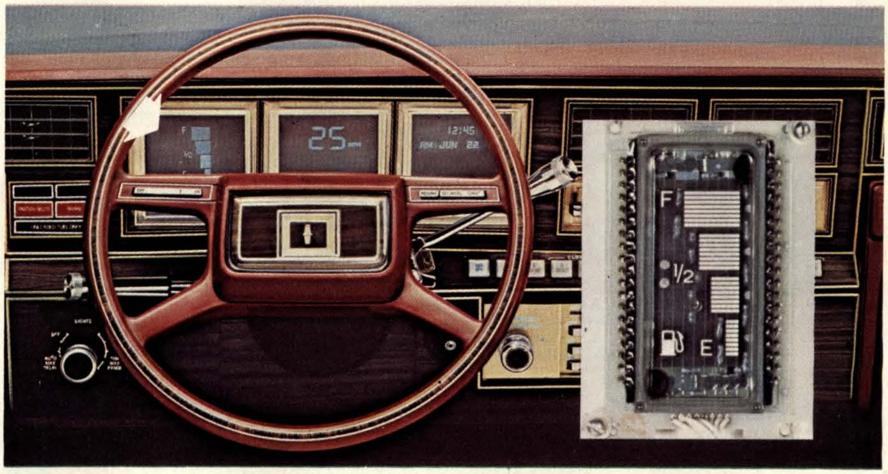
Dot/bar-display-driver ICs aid analog-meter replacement

Jim McDermott,
Special Features Editor

Recently developed LSI chips incorporate in a single package the complex sensing circuitry and elements required for driving light-bar and dot displays, which are rapidly supplanting analog meters in automotive, consumer and instrumentation applications. Such bar/dot displays represent the magnitude of an analog quantity as the length of a vertical or horizontal string of lighted LEDs or vacuum-fluorescent (VF) bars or dots. (In an alternative configuration, a single lighted dot travels along a graduated scale.)

In an analog meter, the current through a moving-coil element converts an input into a pointer movement that denotes a scale value. The new class of comparator/drivers perform the same function for the LED or VF displays—they convert an analog input into a quantity represented by a particular number of lighted elements (or the apparent location change of one such element). Some drivers have enough current capacity to light small incandescent bulbs.

Bar/dot displays find use in such applications as 32-bar VF fuel gauges in some of Ford's 1980-model autos, as well as in volume-unit (VU) meters on stereo receivers and amplifiers and instruments such as the audio spectrum analyzer manufactured by Audio Developments International. (The Palo Alto, CA firm's equipment incorporates 10 vertical-bar graphs consisting of 20 LEDs each.) And in the latest radio receivers, a traveling lighted red or green dot controlled by one of the driver chips



Analog-sensor and bar-element-driver ICs *control vacuum-fluorescent (VF) display devices like the 32-bar VF fuel gauge shown in the inset and used in several 1980 Ford car models (arrow). When the tank is full, all 32 elements glow a bright green, but as fuel is used, the bars darken sequentially, from the top down.*

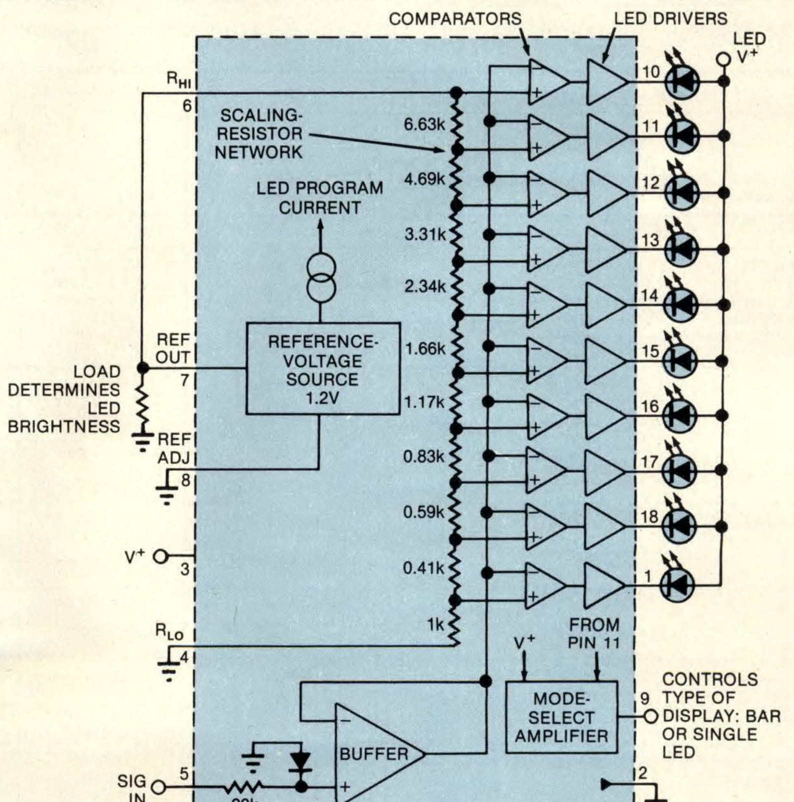


Fig 1—Basic functional elements *of National Semiconductor's LM3914/15/16 dot- or bar-display drivers allow the chips' outputs to drive 10 LEDs in a moving-dot mode (if pin 9 is open) or a rising-bar mode (if pin 9 is tied to V⁺). The ICs can also drive vacuum-fluorescent devices and LCDs.*

replaces a mechanical tuning pointer.

Comparators: key components

A bar/dot-driver chip is essentially a string of voltage comparators or differential amplifiers, each having one of its two inputs (+) connected to sequential taps on a scaling voltage-divider network **(Fig 1).** The other inputs (−) connect in parallel to the chip's analog-signal-input terminal.

The bias from the resistor network is proportioned to give each of these comparators a succeedingly higher "turn-on" threshold value than that of the preceding stage. With zero input, all of the comparators are in a cut-off state, and no driver output is available. But as the input voltage rises, it sequentially exceeds the threshold values of each of the individual stages, and the comparators switch, one by one, until the input reaches or exceeds its maximum level. The comparators in turn activate drivers that turn LED or VF elements on in the same sequence.

As the input voltage drops, the process reverses, and the lighted elements turn off one by one. The divider-string resistances can be proportioned to produce a linear output function or a logarithmic or other nonlinear relationship.

Temperature a key parameter

The values of the diffused resistors in the comparator scaling networks of the driver ICs are highly temperature sensitive: Over the devices' operating-temperature range, they can vary by as much as 30%. However, because all the resistances vary proportionally and have identical temperature coefficients, the resistor ratios' close tolerances provide a reference with better accuracy and tracking capability over temperature than a 1% external discrete network.

The reference voltage applied to a driver IC's comparator network proves important because it determines the height of the voltage-threshold levels at which the comparators change state—and thus the chip's input response. A driver IC can thus accommodate a broad range of input signals by means of a simple setting of the reference voltage to the input's full-scale value. The device's supply voltage establishes the maximum allowable input, while the input's minimum value depends on the minimum threshold values at which the comparators can change state.

Features vary

While all of the analog-to-discrete-level driver chips incorporate comparators, their other features differ. One obvious difference lies in the number of dots and bars you can drive with a chip, which varies from five to 16 **(table).**

To form larger arrays, you can stack two or more driver chips in sequence, and circuitry in some of the chips simplifies this procedure.

BAR/DOT DISPLAY DRIVERS

MANUFACTURER	PART NO	DISPLAY ELEMENTS NO	DISPLAY ELEMENTS TYPE LED	DISPLAY ELEMENTS TYPE VF	METER APPLICATION	SCALE	NOMINAL SUPPLY VOLTAGE (V)	FULL-SCALE INPUT-SIGNAL RANGE (V)	NO OF PINS	PRICE ($) (100 QTY)
EXAR	XR-2276	12		BAR	VU LEVEL	−20 TO +8 dB	12 TO 18	4.5 TO 5.5	16	2.00
HITACHI	HA12010	12		BAR	LINEAR (VU)[2]	−20 TO +8 dB	12 TO 24	3.00	16	1.77
	HA12019	12		BAR	VU LEVEL	−20 TO +8 dB	12 TO 24	3.77	16	1.77
NATIONAL SEMICONDUCTOR	LM3914	10	BAR	BAR	LINEAR	10 STEP	3 TO 18	1.2 TO 12	18	2.65
	LM3915		OR	OR	LOG	3 dB/STEP	3 TO 18	1.2 TO 12	18	2.65
	LM3916		DOT	DOT	VU LEVEL	−20 TO +3 dB	3 TO 18	1.2 TO 12	18	2.65
SANYO	LB1405	5	BAR		VU LEVEL	−15 TO +2 dB	4.4 TO 12	2.8	16	0.82
	LB1415	5	BAR		VU LEVEL	−10 TO +6 dB	4.4 TO 12	2.8	16	0.82
	LB1409	9	BAR		LOG (−18/+3)[2]	3 dB/STEP	5.5 TO 16	2.8	16	1.02
	LB1416	5	BAR		VU LEVEL	−10 TO +6 dB	5.5 TO 16	2.8	14	0.88
	LB1426	5	BAR		VU LEVEL	−10 TO +6 dB	5.5 TO 16	2.8	14	0.88
	LB1470	16		DOT	SPOT TUNING	LINEAR	9 TO 14	1.2 TO 8	22	1.83
	LB1473	16	DOT		SPOT TUNING	LINEAR	9 TO 14	1.2 TO 8	22	1.85
SHARP	IR-2406	12	BAR		LINEAR	12 STEP	8 TO 16	5.5 TO 6	22	2.00
	IR-2431	12	BAR		LOG	−44 TO 0 dB	8 TO 16	5.5 TO 6	22	2.00
	IR-2432	12	BAR		VU LEVEL	−20 TO +6 dB	8 TO 16	0.6 TO 1.6	22	2.00
	IR-2433	12	BAR		LINEAR	12 STEP	8 TO 16	5.5 TO 6	22	2.00
SIEMENS	UAA 170	16	DOT		LINEAR	16 STEP	10 TO 18	1.4 TO 4	16	2.49
	UAA 170L	16	DOT		SPOT TUNING	LOG SCALE	10 TO 18	1.4 TO 4	16	2.49
	UAA 180	12	BAR		LINEAR	12 STEP	10 TO 18	1.4 TO 4	16	2.49
TELEFUNKEN	U237B[3]	5	BAR		LINEAR	5 STEP	12 TO 18	1.0	8	2.50
	U247B	5	BAR		LINEAR	5 STEP	12 TO 18	0.9	8	2.50
	U257B	5	BAR		VU LEVEL	−15 TO +6 dB	12 TO 18	2.0	8	2.50
	U267B	5	BAR		VU LEVEL	−20 TO +3 dB	12 TO 18	1.4	8	2.50
TEXAS INSTRUMENTS	TL487	5	BAR		LOG	3 dB/STEP	10 TO 18	1.0	8	0.65
	TL489	5	BAR		LINEAR	5 STEP	10 TO 18	0.5 TO 2	8	0.65
	TL480	10	BAR		LOG	2 dB/STEP	10 TO 18	1.0	14	1.24
	TL481	10		BAR	LOG	2 dB/STEP	10 TO 18	1.0	14	1.51
	TL490	10	BAR		LINEAR	10 STEP	10 TO 18	1.6	16	1.08
	TL491	10		BAR	LINEAR	10 STEP	10 TO 18	2.0	16	1.22

NOTES
1. RANGE OVER WHICH INPUT SIGNAL CAN BE EXTERNALLY ADJUSTED.
2. FOR LINEAR LOGARITHMIC INCREMENTS IN VU-METER DISPLAY. STANDARD VU LEVELS ARE BASED ON AUDITORY RESPONSE AND HAVE NONLINEAR LOG INCREMENTS.
3. U237B/247B OR U257B/267B ARE PAIRED FOR 10-LED METER APPLICATIONS.

Additionally, some chips incorporate on-board voltage references to energize the scaling resistance-divider string, while others are driven from external sources. Some provide controlled constant-current sources to limit LED current, while others require external resistors for this purpose. And there are additional differences as well.

Linear, log, or VU readouts

One valuable feature that National Semiconductor has designed into its LM3914/15/16 10-element-driver series is the ability to use the devices in both traveling-dot and multiple-dot-bar modes (**Fig 1**). For the traveling-dot configuration, you leave a mode-select pin (9) open; for the bar mode, you tie this pin to the positive-supply-voltage pin (3).

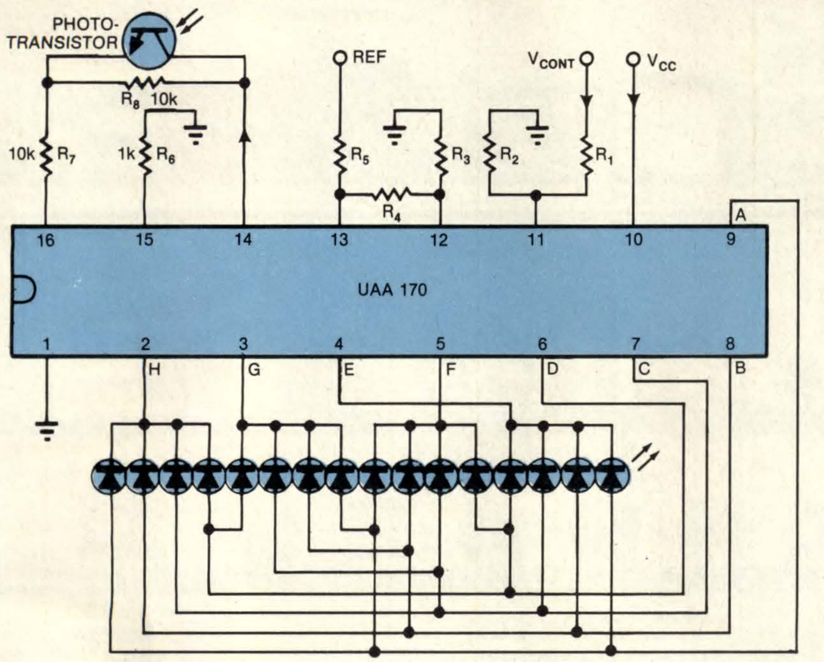


Fig 2—Adding a phototransistor *to the LED current-control network provides control of LED-output intensity in this Siemens UAA 170 16-element dot driver. As the ambient light level increases, the LEDs become brighter.*

The relative intensities of spectral components *in a 31.5-Hz to 16-kHz audio-frequency band correspond to the heights of the red-LED bar-graph columns in this spectrum analyzer from Audio Developments International. Each column consists of two 10-element Litronix RGB-1000 stackable modules.*

The comparator voltage-divider networks in the National chips are proportioned to provide linear, log or VU-scale readouts. Specifically, the LM3914 is a 10-step linear driver, the 3915 has a 30-dB logarithmic-scale range of 10 3-dB steps and the 3916 provides a 10-bar LED or VF version of the familiar −20 to +3 VU (dB) volume-level meter.

These three 18-pin, $2.65 (100) ICs furnish millivolt accuracy at each of the comparator trip points and can operate from a 3 to 20V supply, with a typical standby current (all LEDs OFF) of 1.6 mA. A low (3V) operating voltage provides maximum chip efficiency when driving LEDs in battery-operated equipment—all other competitive drivers (except for some Sanyo chips) require a minimum of 8 to 12V.

Another desirable feature of the National ICs (eliminating the cost of current-limiting resistors for the LEDs) is an on-board constant-current source that controls the output of the open-collector transistors driving the LEDs. You program this source by connecting a resistor between pin 7 and ground.

Approximately 10 times the pin 7 resistor current flows through the LEDs; by varying the resistance with a second signal (such as from a phototransistor), you can modulate LED brightness with a time-varying function (or with another variable) to provide novel types of displays.

You can utilize the National chips with high-impedance inputs because their input buffer amplifiers have a guaranteed 50-nA max input current. For applications involving driving VF displays, the driver-

Continued on pg 51

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Model	Freq. range (MHz)	Min. isol.-dB (Mid-band	Max. insert. loss-dB (Mid-band)	See notes below	Price (Qty.)
2-WAY 0°					
PSC-2-1	0.1-400	20	0.75		**$9.95** (6-49)
PSC-2-1W	1-650	20	0.9		**$14.95** (6-49)
PSC-2-2	0.002-60	20	0.6		**$19.95** (6-49)
PSC-2-1-75	0.25-300	20	0.75	1	**$11.95** (6-49)
PSC-2375	55-85	25	0.5	1	**$19.95** (6-24)
PSC-2-4	10-1000	20	1.2		**$19.95** (6-49)
MSC-2-1	0.1-450	20	0.75		**$16.95** (5-24)
MSC-2-1W	2-650	25	0.8		**$17.95** (5-24)
ZSC-2-1	0.1-400	20	0.75	3	**$27.95** (4-24)
ZSC-2-1-75	0.25-300	20	0.75	1,3	**$29.95** (4-24)
ZSC-2-1W	1-650	20	0.8	3	**$32.95** (4-24)
ZSC-2-2	0.002-60	20	0.6	3	**$37.95** (4-24)
ZSC-2375	55-85	25	0.5	3	**$37.95** (4-24)
ZMSC-2-1	0.1-400	20	0.75	4	**$37.95** (4-24)
ZMSC-2-1W	1-650	20	0.8	4	**$42.95** (4-24)
ZMSC-2-2	0.002-60	20	0.6	4	**$47.95** (4-24)
ZFSC-2-1	5-500	20	0.6	5	**$31.95** (4-24)
ZFSC-2-1W	1-750	20	0.8	5	**$35.95** (4-24)
ZFSC-2-2	10-1000	20	1.0	5	**$39.95** (4-24)
ZFSC-2-4	0.2-1000	20	1.0	5	**$44.95** (4-24)
ZFSC-2-5	10-1500	20	1.0	5	**$49.95** (4-24)
ZFSC-2-6	0.002-60	20	0.6	5	**$36.95** (4-24)
ZFSC-2-6-75	0.004-60	20	0.8	5	**$38.95** (4-24)
ZAPD-1	500-1000	19	0.6	6	**$39.95** (1-9)
ZAPD-2	1000-2000	19	0.6	6	**$39.95** (1-9)
ZAPD-4	2000-4000	19	0.8	6	**$39.95** (1-9)
2-WAY 90°					
PSCQ-2-13	12-14	25	0.7†	2	**$12.95** (5-49)
PSCQ-2-14	12-16	25	0.6†	2	**$16.95** (5-49)
PSCQ-2-40	23-40	18	0.7†	2	**$16.95** (5-49)
PSCQ-2-50	25-50	20	0.7†	2	**$19.95** (5-49)
PSCQ-2-90	55-90	20	0.7†	2	**$19.95** (5-49)
PSCQ-2-180	120-180	15	0.7†	2	**$19.95** (5-49)
ZSCQ-2-50	25-50	20	0.7†	2,3	**$39.95** (4-24)
ZSCQ-2-90	55-90	20	0.7†	2,3	**$39.95** (4-24)
ZSCQ-2-180	120-180	15	0.7†	2,3	**$39.95** (4-24)
ZMSCQ-2-50	25-50	20	0.7†	2,4	**$49.95** (4-24)
ZMSCQ-2-90	55-90	20	0.7†	2,4	**$49.95** (4-24)
ZMSCQ-2-180	120-180	15	0.7†	2,4	**$49.95** (4-24)
2-WAY 180°					
PSCJ-2-1	1-200	25	0.8		**$19.95** (5-49)
PSCJ-2-2	0.01-20	25	0.5		**$29.95** (5-49)
ZSCJ-2-1	1-200	25	0.8	3	**$37.95** (4-24)
ZSCJ-2-2	0.01-20	25	0.5	3	**$47.95** (4-24)
ZMSCJ-2-1	1-200	25	0.8	4	**$47.95** (4-24)
ZMSCJ-2-2	0.01-20	25	0.5	4	**$57.95** (4-24)
ZFSCJ-2-1	1-500	25	1.5	5	**$49.95** (4-24)
ZFSCJ-2-3	5-300	25	1.5	5	**$39.95** (4-24)

Model	Freq. range (MHz)	Min. isol.-dB (Mid-band	Max. insert. loss-dB (Mid-band)	See notes below	Price (Qty.)
3-WAY 0°					
PSC-3-1	1-200	25	0.7		**$19.95** (5-49)
PSC-3-1W	5-500	15	1.4		**$29.95** (5-49)
PSC-3-1-75	1-200	25	0.7	1	**$20.95** (5-49)
PSC-3-2	0.01-30	25	0.45		**$29.95** (5-49)
PSC-3-13	1-200	35	0.6		**$24.95** (5-49)
ZSC-3-1	1-200	25	0.7	3	**$37.95** (4-24)
ZSC-3-1-75	1-200	25	0.7	1,3	**$38.95** (4-24)
ZSC-3-2	0.01-30	25	0.45	3	**$47.95** (4-24)
ZSC-3-2-75	0.02-20	25	0.6	1,3	**$48.95** (4-24)
ZMSC-3-1	1-200	25	0.7	4	**$47.95** (4-24)
ZMSC-3-2	0.01-30	25	0.45	4	**$57.95** (4-24)
ZFSC-3-1	1-500	20	0.9	5	**$39.95** (4-24)
ZFSC-3-1W	2-750	20	1.0	5	**$41.95** (4-24)
ZFSC-3-13	1-200	35	0.6	5	**$39.95** (4-24)
4-WAY 0°					
PSC-4-1	0.1-200	20	0.75		**$28.95** (6-49)
PSC-4-1-75	1-200	20	0.9	1	**$24.95** (6-49)
PSC-4-3	0.25-250	20	0.75		**$23.95** (6-49)
PSC-4A-4	10-1000	15	1.1		**$49.95** (6-49)
PSC-4-6	0.01-40	25	0.5		**$29.95** (6-49)
ZSC-4-1	0.1-200	20	0.75	3	**$46.95** (4-24)
ZSC-4-1-75	1-200	20	0.8	1,3	**$46.95** (4-24)
ZSC-4-2	0.002-20	25	0.5	3	**$69.95** (4-24)
ZSC-4-3	0.25-250	20	0.75	3	**$43.95** (4-24)
ZMSC-4-1	0.1-200	20	0.75	4	**$56.95** (4-24)
ZMSC-4-2	0.002-20	25	0.5	4	**$79.95** (4-24)
ZMSC-4-3	0.25-250	20	0.75	4	**$53.95** (4-24)
ZFSC-4-1	1-1000	18	1.5	8	**$89.95** (1-4)
ZFSC-4-1W	10-500	20	1.5	8	**$74.95** (1-4)
ZFSC-4375	50-90	30	1.2	1,8	**$89.95** (1-4)
6-WAY 0°					
PSC-6-1	1-175	18	1.0		**$68.95** (1-5)
ZFSC-6-1	1-175	20	1.2	9	**$89.95** (1-4)
8-WAY 0°					
PSC-8-1	0.5-175	20	1.1		**$68.95** (1-5)
PSC-8-1-75	0.5-175	20	0.8	1	**$69.95** (1-5)
PSC-8A-4	5-500	18	1.8		**$89,95** (1-5)
PSC-8-6	0.01-10	23	1.1		**$79.95** (1-5)
ZFSC-8-1	0.5-175	20	1.1	10	**$89.95** (1-4)
ZFSC-8-1-75	0.5-175	20	1.0	1,10	**$90.95** (1-4)
ZFSC-8375	50-90	25	1.3	1,10	**$119.95** (1-4)
ZFSC-8-4	0.5-700	20	1.5	10	**$129.95** (1-4)
ZFSC-8-6	0.01-10	23	1.1	10	**$109.95** (1-4)
16-WAY 0°					
ZFSC-16-1	0.5-125	18	1.6	11	**$174.95** (1-4)
24-WAY 0°					
ZFSC-24-1	0.2-100	20	2.0	12	**$264.95** (1-4)

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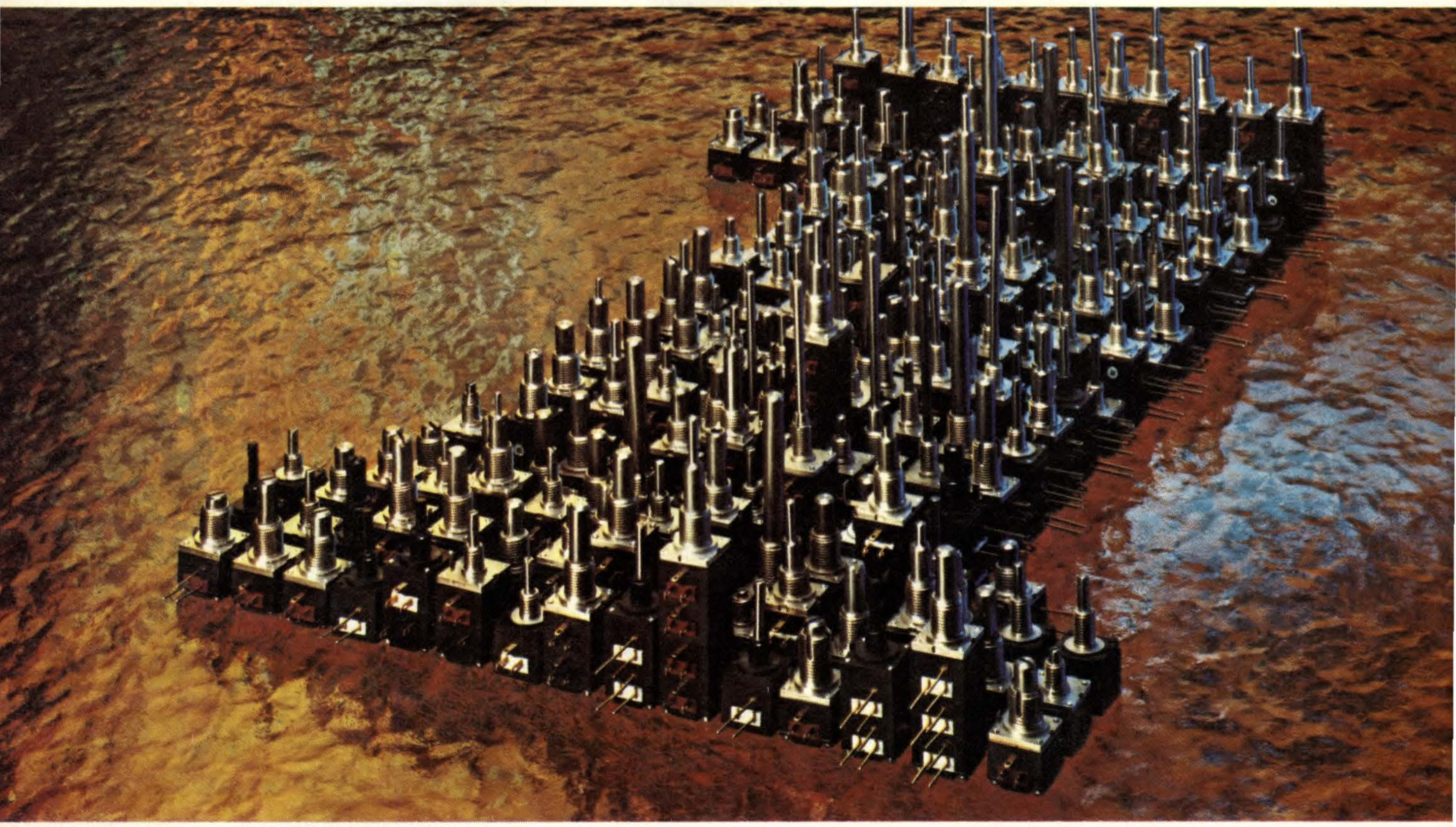
	250 ohms to 10 megs		Modified Log CW (A) or CCW (B)			
Cermet	100 ohms to 5 megs	±10%	Linear (U)	2.0 Watts at 70°C	1.0 Watt at 70°C	2.0 Watts at 70°C
Conductive Plastic	100 ohms to 1 meg	±10% or ±20%	Linear (U)	0.5 Watt at 70°C	0.25 Watt at 70°C	0.5 Watt at 70°C
	500 ohms to 1 meg		Modified Log CW (A) or CCW (B)			



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Technology News

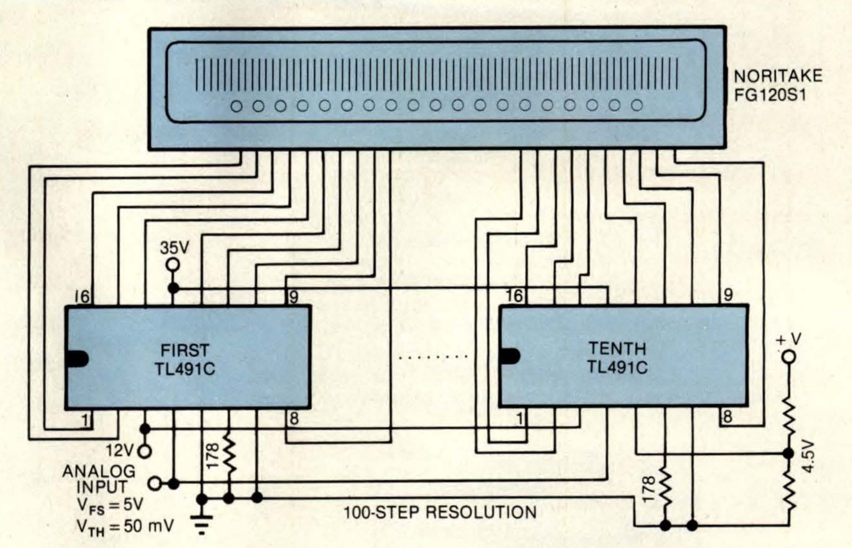

Fig 3—100-step resolution *of an analog input quantity results when you drive a Noritake 100-bar vacuum-fluorescent display with cascaded Texas Instruments 10-step analog detector/drivers. For a 5V full-scale input, each lighted bar represents a 50-mV increment.*

output transistors' collectors can withstand up to 25V.

The 3914/15/16 chips incorporate an adjustable voltage reference, which supplies the potential across the comparator voltage divider and accommodates full-scale inputs of 1.2 to 12V. These inputs are essentially independent of the actual supply voltage. The firm's *Linear Databook* (pg 9-108) describes several types of applications using both single- and multiple-chip drivers for LED displays.

Dedicated drivers

While the National chips can perform in either traveling-dot or bar-graph modes, other manufacturers have developed dedicated chips for each of these formats. For example, Siemens' UAA 170, designed for use in an electronic tuning dial in varactor-tuned radios and TVs, switches a traveling light spot across an array of 16 LEDs. You can switch all 16 LEDs with a control input that ranges from 1.4 to 4V, depending on the reference (scale) voltage across the voltage-divider resistor string.

But whereas the National devices require 10 pins to drive 10 LEDs, the Siemens parts need only eight to drive 16—a reduction achieved by passing the outputs of the UAA 170's 16 comparators through a logic matrix controlling eight 50-mA drivers.

Constant-current control of LED drive current (and consequently LED brightness) results from adjusting the current applied to pin 16 by varying the resistance between pins 16 and 14 (a 5V regulated source). By making a phototransistor a part of the control resistance, you can automatically vary the LED intensity over a range of ambient lighting conditions **(Fig 2)**. (You can also employ this technique with other drivers that control LED current similarly.)

In another control function possible with the Siemens chip, you can make a lighted dot either appear to glide smoothly along a scale or advance in abrupt jumps by varying the scale reference voltage (1.4 to 6V) between pins 12 and 13. And if you want a 30-LED scale, you can cascade two of the devices. Furthermore, if your application is a VU-meter display, you can drive 16 LEDs in a semilog scale by employing the UAA 170L.

Providing a linear-bar-type presentation, Siemens' UAA 180 drives

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12 LEDs, with each diode's current adjustable to 10 mA max. As with the UAA 170, you can vary LED transition smoothness by adjusting the reference voltage. And to obtain an extended scale, you can cascade as many as seven of these devices.

Floating-point tuners

Sixteen-element dot drivers for LED and VF displays are available from Sanyo Semiconductor and find use as floating-spot tuning indicators in radio and TV receivers. Both of these devices come in 22-pin plastic ICs—the LED (LB1473) and VF (LB470) drivers consist of identical circuitry.

These parts have no on-chip regulated voltage sources for their scaling-resistor networks; a nominal

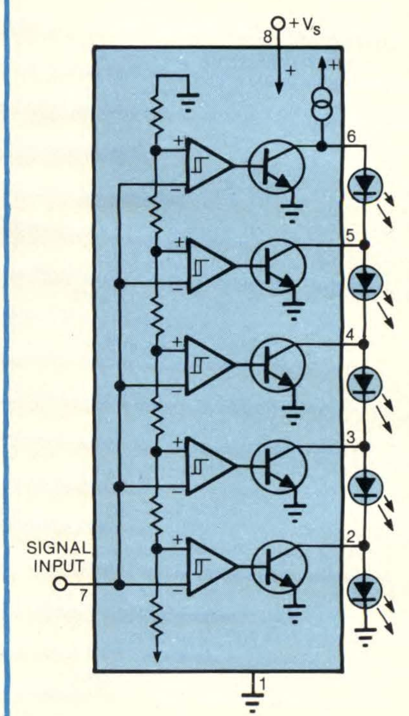

Fig 4—Low power dissipation *highlights the 8-pin Telefunken LED drivers. It's achieved by passing current through them in series rather than by driving them individually. In the comparators' OFF state, the LED drive current is shunted to ground through turned-on transistors. When the comparators turn on in response to an input signal, the transistors are cut off, and the drive current shunts through the LEDs.*

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8V dc supplies it externally. With this type of display, one of the dots is always ON so long as the radio or TV is in operation. Dot-sweep voltage must thus be 1.2V min; it rises in increments of 0.4V to 8V.

The Sanyo LED-driver chip's maximum supply voltage is 22V. The VF chip, designed to drive a 12V-type VF bar display, has a 16V maximum. Recommended supply voltages for both devices range from 9 to 14V. Additionally, maximum output current for the LED driver equals 18 mA, while that for the VF device is 0.4 mA.

Bar types more popular

Despite the many uses for such dot-display drivers, LED bar types remain more popular. They find use in applications where the illuminated elements mount alongside or stack on top of one another.

For example, Sharp offers the IR-2431/32/33 Series 22-pin devices: log-, VU- and linear-scale drivers for its integral 12-element multicolored horizontal-bar LEDs (GL-112 Series), described in the **box,** "Mating displays with drivers."

The 2431/32/33 drivers require external control of their on-board constant-current supply to limit the LEDs to 14 mA max drive current each. You must also supply the maximum and minimum reference voltages for the high and low ends of the scaling-resistor network. Typical supply voltages for these devices range from 8 to 16V; you can easily cascade them by means of a few external resistors.

A line of six bar-graph drivers from Texas Instruments includes devices for driving five or 10 display elements. Each IC contains a voltage-comparator string, a buffer-amp input, a reference-voltage regulator, a scaling-resistor network and output-driver transistors; all parts work from a 10 to 18V supply over 0 to 70°C. (This temperature span is typical of most bar/dot-display ICs.)

The 5-output drivers have eight pins and are configured as linear (TL489) or logarithmic (TL487) devices with open-collector output transistors that sink 40 mA and withstand 18V in the OFF state. They drive LEDs or small incandescent bulbs (as well as TTL, CMOS or other high-level logic).

Typical input for the linear driver is 0 to 1000 mV; the comparator

Mating displays with drivers

If you're incorporating a dot or bar-graph display in your design, note that you can achieve novel visual effects by using individual LEDs configured in nonconventional linear arrays. On the other hand, the easiest approach to display configuration employs packaged arrays. Principal sources of these LED dot and bar-graph elements include Litronix, General Instrument, Hewlett-Packard and Sharp.

Litronix supplies 4- to 10-element red and green dot arrays as well as 10-element bar arrays (BG-1000 Series), the latter packaged in 1-in.-long 20-pin DIPs that you can stack end to end. The bars are on 0.1-in. centers and come in red (RBG-1000), high-efficiency red (OBG-1000), yellow (YBG-1000) and green (GBG-1000). For a 20-mA forward current, these arrays exhibit typical forward voltages of 1.2 (red), 2.2 (high-efficiency red), 2.4 (yellow) and 2.4V (green). Prices are $2.30 (100) for the RBG-1000 and $3.15 (100) for the other three units.

General Instrument manufactures a similar end-stackable 10-element bar display, the high-efficiency-red MV57164. Green and yellow versions of the $3.75 (100) device will be available in production quantities later this year.

Hewlett-Packard offers red, yellow and green rectangular light-bar modules that you can stack side by side or end to end. This HMP-2300/2400/2500 Series comes in two sizes of in-line packages with pins on standard 0.1-in. centers. One package has a 4-diode bar with a 0.75×0.15-in. luminous area; the other incorporates two diodes that illuminate a 0.35×0.15-in. surface.

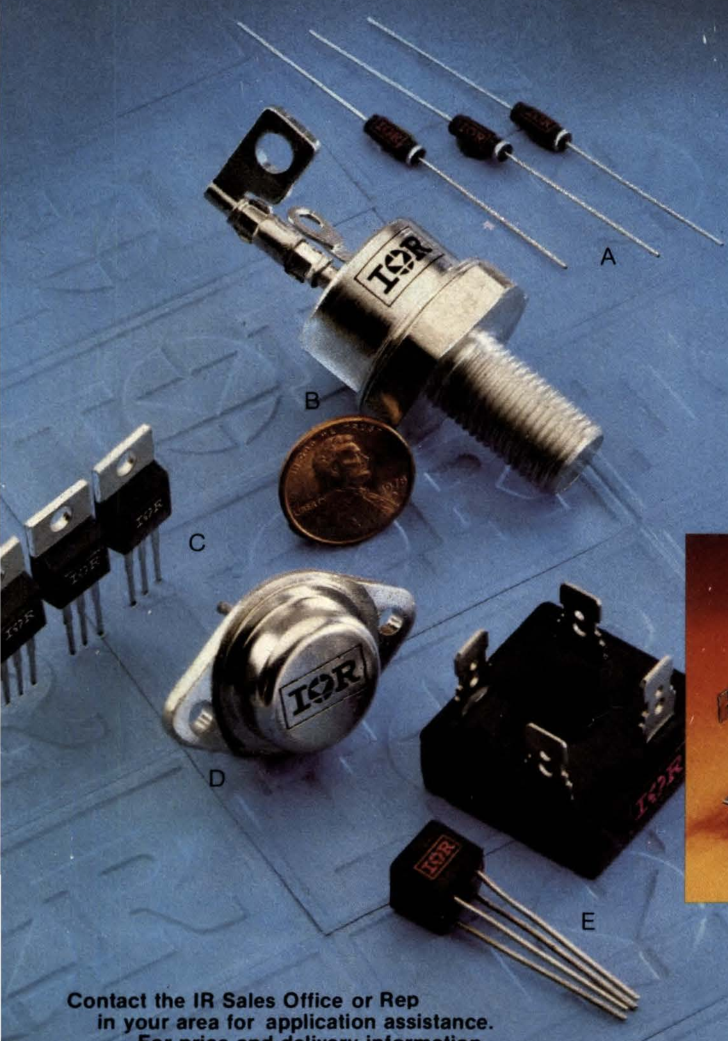
Sharp's line of 12-element red, yellow or green LED assemblies has the bars aligned horizontally rather than vertically. These red (GL-112R), green (GL-112G), yellow-green (GL-112N) and yellow (GL-112H) units can be driven by Sharp's IR-2400 Series 12-element drivers, described in the text. You can also specify these 12-element bars in combinations like these: nine yellow-green and three red elements (FL-112S); eight yellow-green and four red (GL-112M); four yellow-green, four yellow and four red (GL-112T).

These 12-bar assemblies come in two lengths: one about 2.28 in. and the other about 2.75 in. In-line pins for the devices are on 0.1-in. centers, and each diode has individual connections. Similar 5- (GL-105) and 6-element (GL-106) packages in red, yellow-green and yellow are also available.

Vacuum-fluorescent displays come from three sources: Futaba, NEC America and Noritake (Ise Electronics). Standard products range from audio VU bar-graph meters to 100-element bar graphs. The usual display color is green, although others are available on special order.

LCDs and gas-discharge displays can also be driven by the ICs described in the text. However, the process involves more components and greater circuit complexity, which in general tend to offset the cost advantages and simplicity of the dedicated driver chips.

6 NEW AND BETTER WAYS TO BETTER EQUIPMENT DESIGN!



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D. New IR6543-5-7 "SUPERSPEC" TO-3 Power Transistors feature improved turn-off switching times and saturation voltage ratings over JEDEC 2N6543-5-7 devices to optimize switching power supply performance. For example, rise time is 0.6 μs vs. 0.7 to 1.0 μs for JEDEC types, and fall time is only 0.2 μs vs. the JEDEC 0.4 μs. Saturation voltage is 0.75V vs. 1.0V to 1.5V for JEDECS. Other SUPERSPEC types with superior switching times include the IR6582 and IR6583, improved versions of the 2N6582-2N6583. **Circle No. 53**

E. Molded Diode Bridges rated from 1 to 100 Amps include 1 to 3 Amp bridges in three case styles for PC board mounting, U.L. recognized, isolated base "JB" units rated from 10 to 25 Amps with surge ratings up to 300 Amps, and "HB" models for applications in the 80 and 100 Amp range. Send for detailed Selection Guide and Cross Reference to other industry types.

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F. Standard Rectifier Assemblies available off-the-shelf include single and three phase types rated from 15 to 1500 Amps, 400 thru 1200 volts. 85 models. Cost-effective candidates for "make or buy" decisions. Send for Data Sheet PD-7.003 for complete information.

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stages switch every 200 mV. Input for the logarithmic device spans 0 to 1058 mV, with switching for every 3-dB voltage increase. Built-in 10-mV switching hysteresis in these 5-step devices prevents oscillation when sensing slow transitions.

For driving 10-bar displays, TI offers linear 16-pin and logarithmic 14-pin devices. The essential difference between two of the linear drivers (TL490, TL491) lies in their driver-transistor outputs: The 490 incorporates open-collector drivers that sink 40 mA and withstand 32V when OFF, while the 491 has open-emitter drivers that sink 25 mA and hold off 25V. Additionally, the 490 can drive LEDs (or lamps), while the 491 suits VF bar displays.

A separate pin aids in cascading these devices to form longer displays **(Fig 3)**. Input impedance is only 10 kΩ for both units, and threshold intervals adjust from 50 to 200 mV via a resistor going from pin 6 to ground. Nominal full-scale inputs equal 500 and 2000 mV, respectively.

Two logarithmic 10-step detector/drivers from TI (TL480, TL481) provide an input impedance of 100 kΩ. But these 14-pin devices omit the simplified cascade-connection features of their linear counterparts. The TL480 contains 40-mA, 32V LED drivers, while the TL481 incorporates 25-mA, 35V VF drivers. The first comparator stage of both devices switches at a typical input of 203 mV, with subsequent outputs switching at 2-dB increments up to 1614 mV—when all 10 display elements are lighted.

Series LED drive cuts dissipation

Telefunken's contribution to bar-scale driver design is a series of 8-pin DIPs that drive five LEDs with either linear or log-scale outputs. The circuitry in these ICs is basic: An external regulated voltage feeds the scaling-resistor network for the 5-comparator string, and the lower end of the string is grounded.

But the chips provide an

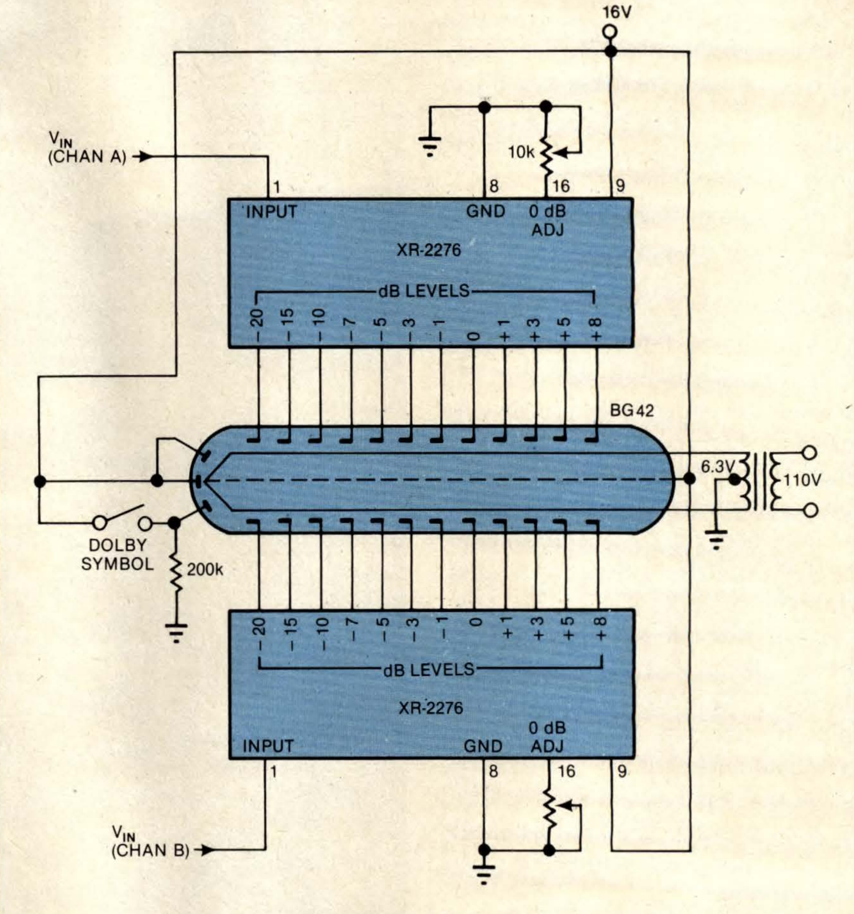

Fig 5—Twin-channel audio-level indication *results from using two Exar 2276 12-element VF bar-graph drivers. The output of each 2276 illuminates half of a dual 12-bar display (Futaba BG42 or NEC 2B1745). The 12 elements span a range of −8 to +20 dB; the 10-kΩ pots adjust the 0-dB reference levels for both channels.*

interesting power-saving capability. An internal constant-current supply is adjusted for 20 mA of LED current. The LEDs connect in series, and their junctions connect to the IC's driver terminals **(Fig 4).** When all comparators are OFF (or down), the LED current diverts to ground through bypass transistors connected to the comparator outputs. As the comparators turn on (or up), the transistors turn off one by one, allowing current to then flow through the LEDs to ground.

As a result, the chip's dissipation is minimized because the drive current remains at only 20 mA with all LEDs ON. Contrast this arrangement with a parallel-drive one like National's, where the current through each LED adds to the total. In this case, the current would be 100 mA—an excessive amount for the small Telefunken IC.

With the Telefunken chips, supply voltage is the sum of the voltage drops across the LEDs and the constant-current supply. Assuming that red LEDs have a maximum forward voltage of about 2V at 20 mA, the drop across the five devices is 10V, plus another 2V for the current source—12V total. For all-green or all-yellow LEDs, forward voltage equals about 3.2V, implying a total of 18V for the supply.

The Telefunken ICs are designed to be paired for cascading. For example, the U237B and U247B each provide a 5-step linear output, but the thresholds of the U237B's comparator string lie between those of the U247B.

Specifically, fairly sharp thresholds exist for the U237B at 0.2, 0.4, Introducing the HS5200 Series ADC's:

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0.6, 0.8 and 1V, while those for the U247B are at 0.1, 0.3, 0.5, 0.7 and 0.9V. To obtain a 10-step LED drive, you apply the same input voltage to both ICs; the LEDs driven by each chip then light up alternately. For more gradual transitions, you can use the firm's U244B/U254B as a 10-step pair.

Telefunken's U257B and U267B are similarly paired, but in this case the steps are logarithmic, ranging in a 10-step connection from −20 dB for a 0.1V input to +6 dB for a 2V input to the U257B.

VF units in consumer applications

The use of VF displays in automotive and consumer products is growing fast. One VF driver for such applications, employed with a Futaba display in a Hitachi tape deck, is the 16-pin Hitachi HA12019. It was developed to produce a 12-point VU bar-graph display that logarithmically corresponds to the input dc voltage. In it, an on-chip constant-current generator supplies the scaling-resistor network from the input supply voltage.

For a nominal 12V input supply, a 5-mA max output current is available for the VF-tube anodes; the IC operates from a 10 to 24V supply. The 12 driven VF bars display an input-voltage span of −20 to +8 dB. A similar 16-pin chip with a linear-step output to a VF bar display (HA12010) is also available.

With another offering, Exar has developed a 12-bar dB-level display detector/driver specifically for interfacing with VF displays. This 16-pin XR-2276 contains an input buffer, a bias network and 12 comparators. The bias network consists of a voltage reference and a string of scaling resistors, weighted to provided logarithmic-step outputs between −8 and +20 dB with reference to a 0-dB level setting. A pin provides 0-dB adjustment. Allowable input signals range from 4.5 to 5.5V. A dual-channel VF display using two XR-2276s appears in **Fig 5**. **EDN**

For more information...

For more information on the products described in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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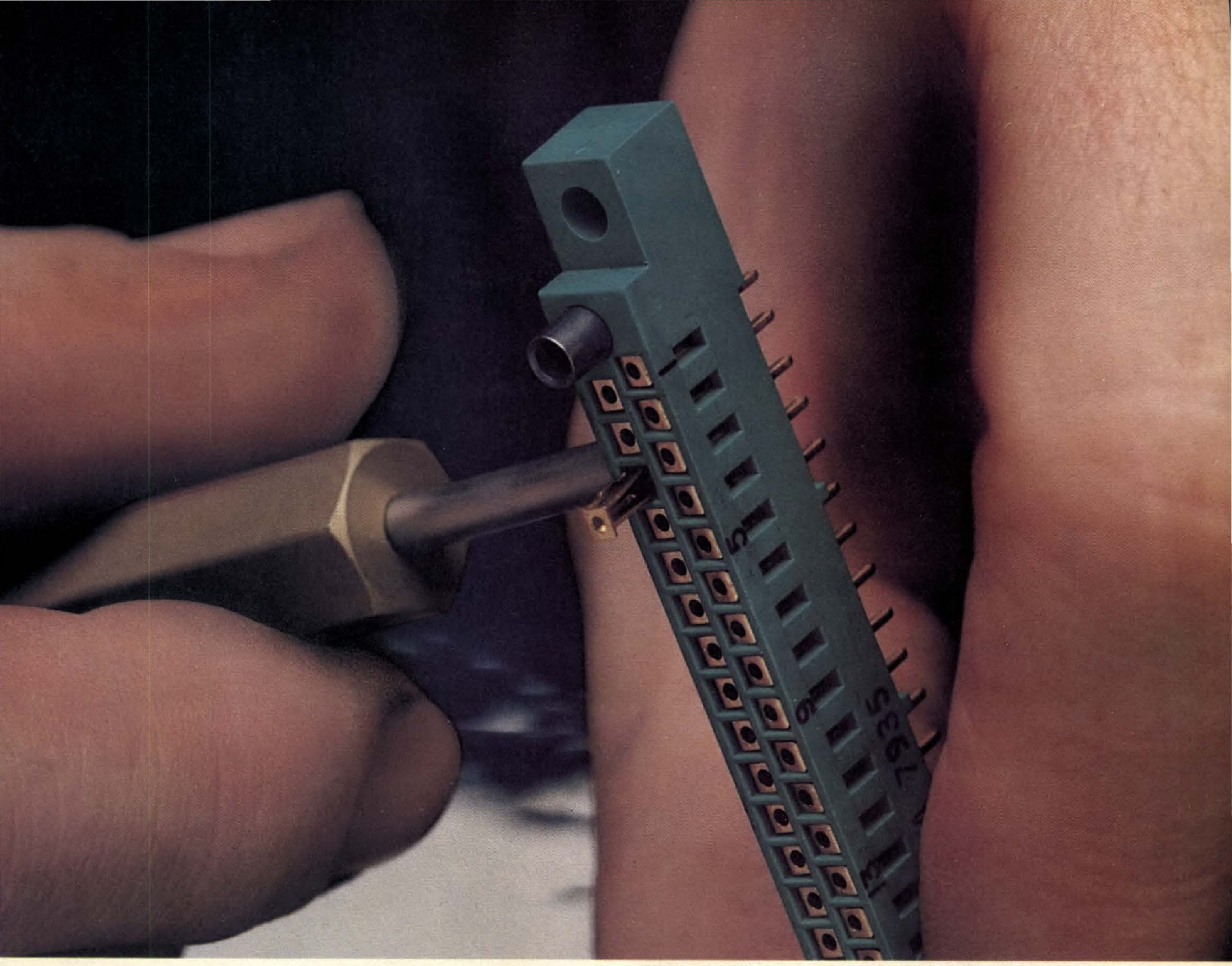
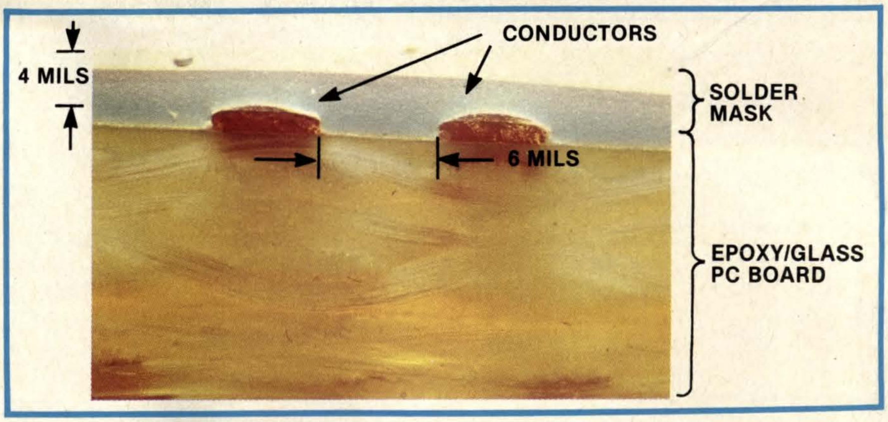


Readers confirm dense-pc-board failures, report additional leakage, shorts problems

Dale Zeskind, Contributing Editor

Reports of the discovery of an intrinsic failure mechanism in high-density pc boards (EDN, September 5, 1979, pg 59) have generated reader responses not only confirming the existence of the mechanism but detailing additional failure phenomena as well. The responses point up some of the difficulties involved in applying designs with conductor spacings in the 10-mil range to conventional epoxy/glass boards.



If improperly applied, *dry-film solder masks leave voids between closely spaced conductors on the surface of a pc board. These voids can trap moisture and impurities, thereby creating leakage paths. This cross-sectional view illustrates the proper application of such a mask; the 4-mil-thick mask (blue-tinted layer) completely fills the 6-mil-wide space between conductors on the surface of an epoxy/glass board. Note also the glass-fiber weaving inside the board (Photo courtesy Dynachem Corp)*

Insulation loss a danger

Researchers J N Lahti and D J Lando and their colleagues at Bell Labs, Whippany, NJ, had reported a catastrophic loss in insulation resistance between the conductors on the high-density boards under high-humidity (greater than 80%) conditions. The loss results from the electrochemical growth of a conductive copper compound along the boards' internal glass filaments.

In the case of at least one domestic equipment manufacturer, several instances of pc-board fires have been tentatively linked to this phenomenon.

Lahti and Lando have since been contacted by 20 to 30 domestic and foreign manufacturers who have experienced this and other difficulties with their high-density pc-board designs. Until now, many of these companies—among them some of the largest computer and instrument manufacturers—have been reluctant to openly discuss their difficulties, mistakenly assuming that their problems are unique to their manufacturing processes.

In addition to insulation-resistance failure, designers of dense pc boards commonly report the erratic appearance and disappearance of leakage paths between closely spaced conductors.

The experiences of Tom Valone, research engineer at the Scott Aviation Div of ATO Inc, Lancaster, NY, are typical. He reports observing several kilohms of leakage between 10-mil-spaced conductors. By baking his boards, he manages to completely eliminate the problem, only to see it slowly reappear over several hours. Other designers report a seasonal variation of this phenomenon—they encounter many leakage problems during the warm, humid summer months and few during winter.

Designer disbelief

But despite the appearance of such reports, it's often difficult to convince design engineers of the possibility of pc-board or material-induced circuit failures, says John Bauer of Sperry Univac, Roseville, MN. These designers sometimes incorrectly assume that a pc board is a tried-and-true component with little likelihood of failure.

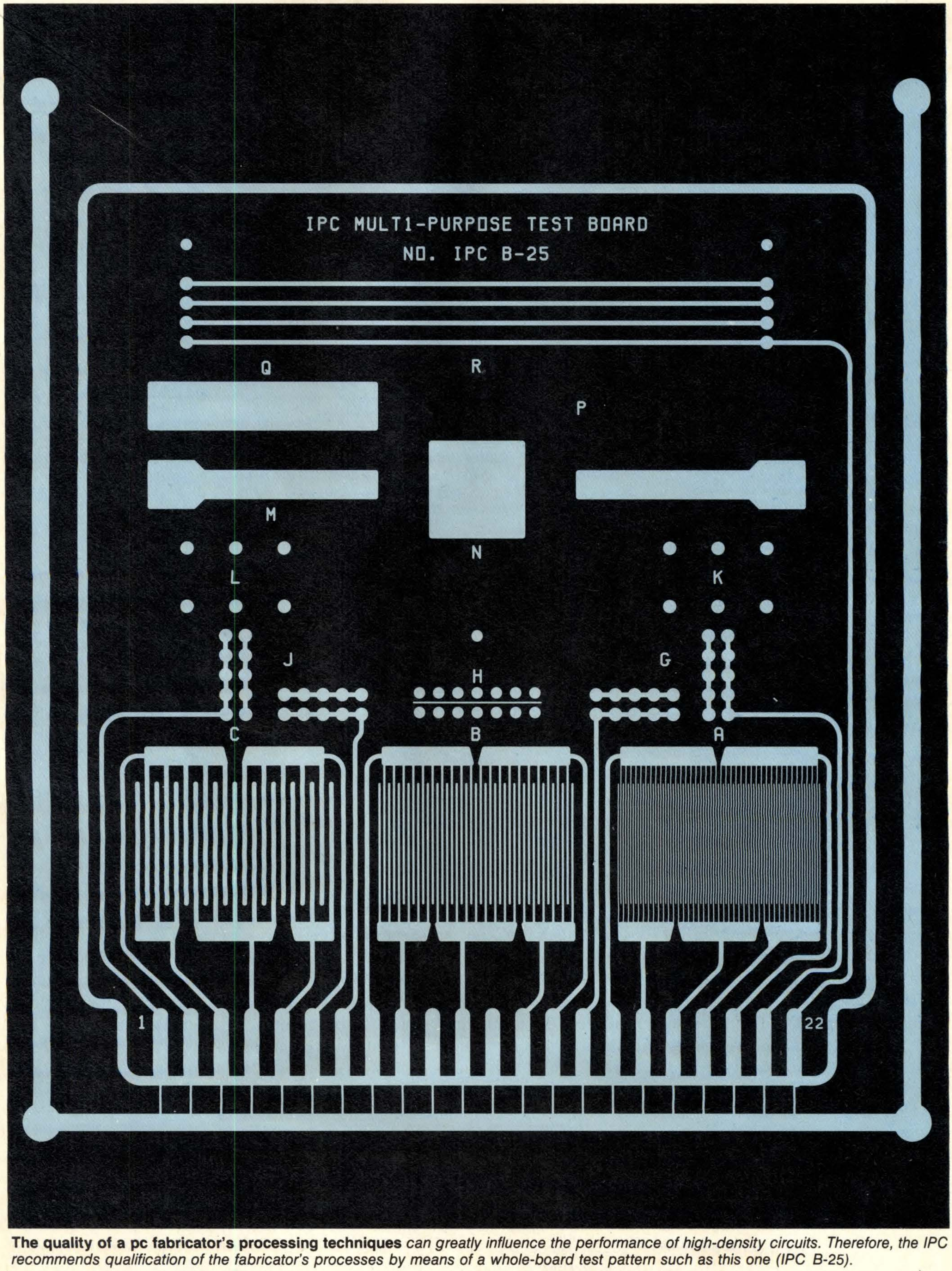
Of course, many leakage problems merely result from dirty boards: Surface residues absorb moisture and create conductive paths, whose effects closely spaced conductors exacerbate.

But several industry experts point out that merely cleaning boards after mounting and soldering components on them often doesn't suffice to alleviate the problem. Residues from the etching and plating process, if not properly removed by the pc fabricator, can become permanently affixed to the pc-board surface.

Faulty drilling causes problems

Another problem that can plague high-density designs results from improper drilling procedures. Robert Williams of General Electric's Laminated and Insulating Materials Div, Coshocton, OH, explains that localized heat generated by improper drilling rates can actually force separation of the glass/epoxy interface. Impurities and sometimes even metal can wick into these separations during etching and plating processes, causing leakage paths and, in some cases, dead shorts.

Other industry sources explain that excessive thermal shock can, in general, weaken a board's ability to inhibit moisture and impurity penetration. (GE has recently announced an improved Engineered



The quality of a pc fabricator's processing techniques *can greatly influence the performance of high-density circuits. Therefore, the IPC recommends qualification of the fabricator's processes by means of a whole-board test pattern such as this one (IPC B-25).*

FR-4 material, which it believes exhibits greater resistance to these types of problems.)

Use solder masks wisely

Solder masks often give rise to another problem in high-density designs.

Most pc fabricators employ one of two basic solder-mask concepts. In the first, a wet paint-like material, applied to the boards through a silkscreen, is cured either thermally or through exposure to UV light. Walt Custer of Thiokol's Dynachem Div, Santa Ana, CA, points out that you can specify several different grades of these so-called wet solder-mask materials. He recommends that if dealing with leakage-sensitive circuitry, you choose one of the higher grades.

The second solder-mask concept employs a dry photosensitive film consisting of a layer of polyethylene, a layer of photopolymer and a layer of Mylar. A special machine applies this film by first removing the polyethylene layer, then laminating the remaining two layers onto the pc surface under heat and pressure. The board is then photographically exposed through a photographic mask, and the Mylar is removed. The developed photopolymer acts as the solder mask.

PC fabricators often employ this dry-film approach in dense designs, where registration accuracy and dimensional stability prove critical. But the comments of C B Wilson of Texas Instruments, Lubbock, TX, typify those of many pc designers who warn against the potential pitfalls of the dry-film approach: If not properly applied, the film might not conform to the grooves between closely spaced conductors. The resulting cavities can trap impurities and moisture, resulting in serious leakage problems.

Communication needed

If you are experiencing these types of problems in your high-density designs, what can you do? Most industry sources agree that it

News

pays to develop a close working relationship with your pc fabricator, making sure you understand each other's needs and the nature of the foregoing problems.

It also pays to periodically inspect pc fabricators' facilities and processes and to make sure they agree with you regarding the importance of proper drilling rates and cleaning procedures. Several observers suggest that you pay particular attention to the fabricators' temperature-control and cleaning procedures—before, during and after infrared reflow plating.

Additionally, you should establish comprehensive incoming inspection of fabricated pc boards. Measure electrical parameters such as leakage under a variety of environmental conditions; Texas Instruments, for example, routinely tests many of its boards for 2 wks at 45°C and 95% relative humidity.

Standard test pattern

Noel Poduje, manager of product development for ADE Corp, Watertown, MA, additionally suggests that you incorporate into each of your sensitive pc designs a small standard pattern for testing leakage. Such a pattern should contain closely spaced conductors as well as plated-through holes.

Several such patterns already exist in various MIL and NEMA standards and in standards of the IPC (Institute for Interconnecting and Packaging Electronic Circuits, 3451 Church St, Evanston, IL 60203). However, only some of them are geared directly to high-density applications.

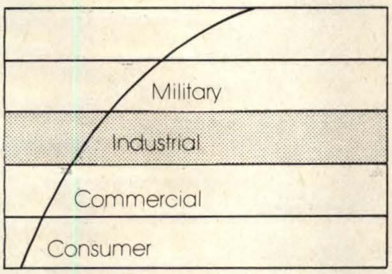
Finally, if you need more assistance, Dieter Bergman, technical director of the IPC, points out that there *are* solutions to most of the pc problems designers encounter. To this end, the IPC (considered by many to be the best source for up-to-date pc design information) offers a 3-day workshop geared directly to the needs of design engineers. **EDN**

ENOUGH IS

IT'S TIME SOMEONE ESTABLISHED 'INDUSTRIAL GRADE' COMPUTER SPECS

It's Time Someone Established 'Industrial Grade' Computer Specs. Computers started in clean rooms and then moved into offices. Soon people tried to put them out in the plants where they couldn't stand up to the heat, humidity and other hostile environmental factors.

But, just because a computer is smart enough to run a machine doesn't make it an 'industrial grade' computer. Too much computer hardware that is billed as 'industrial' breaks down in the real world of the plant.



Industrial specifications for military computers are too stringent and too costly to be practical for industrial applications.

Temperature. We believe that the minumum acceptable 'industrial grade' temperature specification should be 60°C. Factories are not comfortable like offices. The temperature inside sealed enclosures is usually 15°C higher than the ambient plant temperature. XYCOM's '180+' line carries a 65°C specification.

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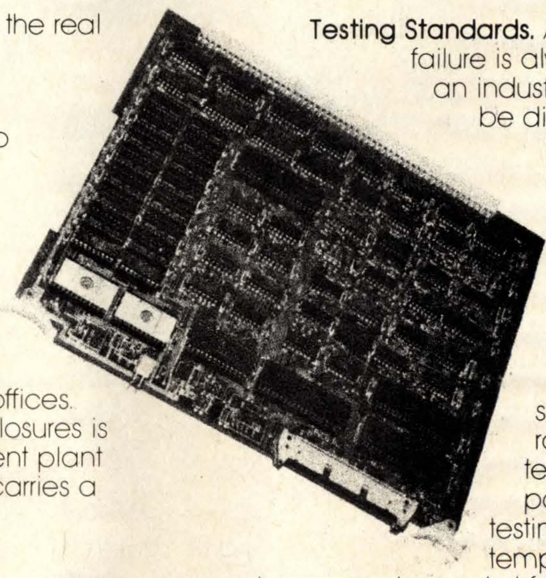


Testing Standards. A computer failure is always bad, but in an industrial *situation* it can be disastrous. Testing Standards for 'industrial grade' should be higher than for 'commercial grade'. All components and assemblies should be tested at all stages of production. They need to be subjected to the full range of dynamic testing which includes power cycling and stress testing under extreme temperatures under microcomputer control for up to 72 hours. This is in addition to our stress vibration cycle. All XYCOM products are tested to our 'industrial grade' standards.

Warranty. For industrial purposes a warranty needs to cover the period soon after installation when most failures will occur. We believe that a year warranty offers the most desirable cost to reliability ratio for both manufacturer and user. It is our philosophy that, although the extent of our testing is extensive, the resulting savings due to greatly reduced warranty claims keeps XYCOM products competitive and your plant operating.

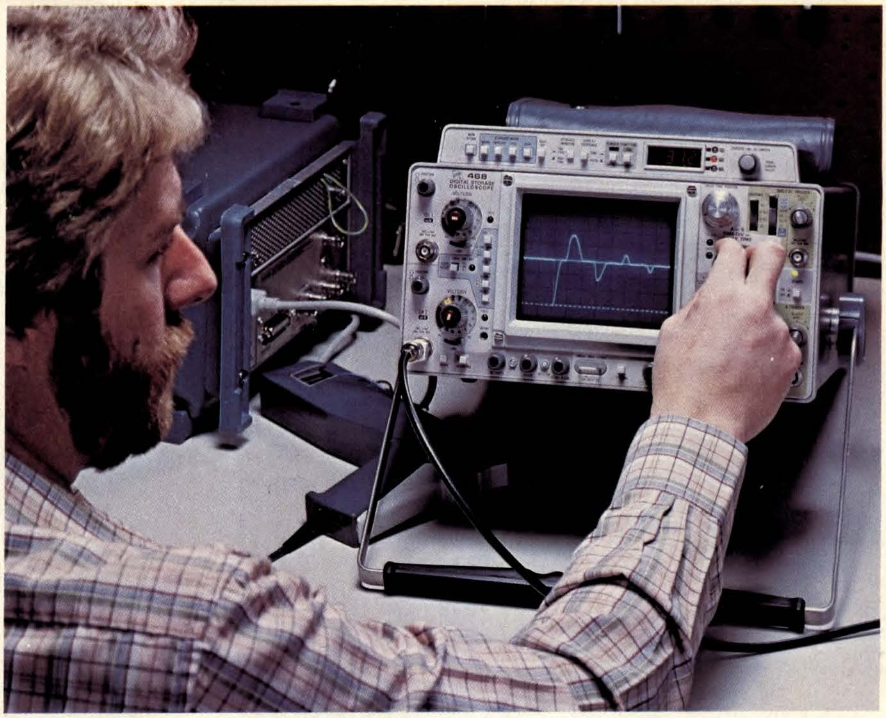
Laboratory-oscilloscope choices grow as makers expand cost, performance options

Andy Santoni, Western Editor

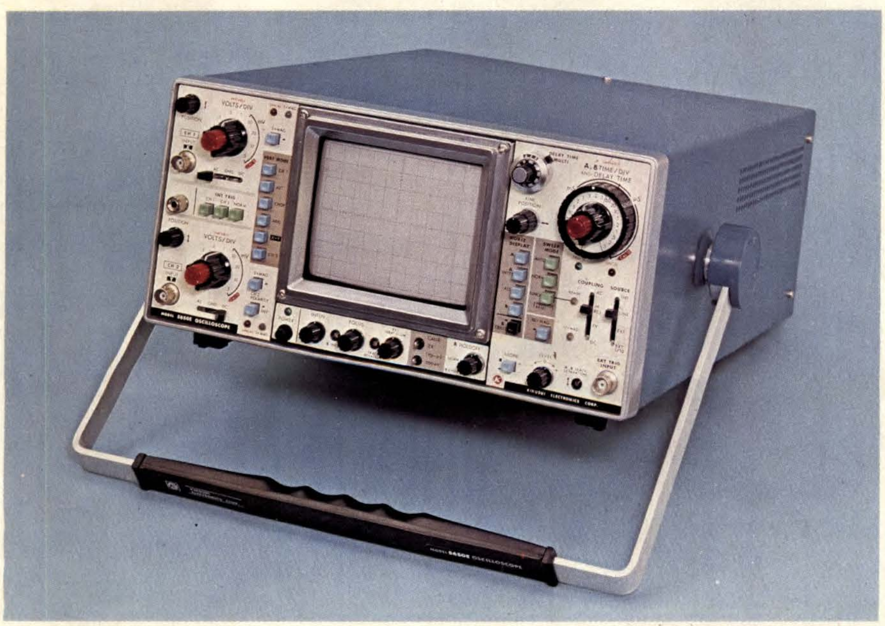
Since EDN's recent Special Report on laboratory oscilloscopes (January 20, pg 98), your choices have broadened at both ends of the lab-scope price/performance spectrum: Scope makers have introduced high-performance units that help you make measurements more easily than ever, plus low-cost units with features never before available in the low-end price range.

Here are the latest introductions:

- Model 5650 from Kikusui International Corp—a dual-trace, 50-MHz unit with alternate timebase, plug-in construction and a price $150 less than its competition's.
- Model SC60 from Sencore Inc—a $1595 60-MHz, dual-trace unit that marks the firm's first venture outside the TV/service field and into the engineering lab
- Model 468 from Tektronix Inc—identical to the firm's industry-standard Model 465 but with an added feature: digital storage with a useful bandwidth to 10 MHz
- Model 7854 from Tektronix—a 400-MHz plug-in scope that combines analog performance with µP-based waveform processing in a $10,500 package.



Add 10-MHz digital storage *to the industry-standard 465B and you have the Tektronix 468.*



Alternate timebase *lets you view as many as four waveforms simultaneously on Kikusui's Model 5650.*

488-bus compatibility

The Tektronix 7854 offers the features you'd expect in a high-performance lab scope: dc to 400-MHz bandwidth at 10 mV/div, calibrated sweep rates to 500 psec and a choice of more than 30 7000 Series plug-ins. Additionally, it provides digital storage of repetitive waveforms up to 400 MHz, signal averaging to reduce noise, storage of single-shot events with a sweep rate as fast as 50 µsec/div and (with an optional 7B87 plug-in) pretrigger display from 0 to 100%. Digital storage also gives you vertical and horizontal resolution of up to 0.01 div on stored data, with a choice of 128, 256, 512 or 1024 horizontal points per waveform.

The scope is preprogrammed so that you can make the most common

Technology News

measurements (rise time, fall time and pulse width), along with complex waveform comparisons, by pushing a button on a calculator-like keyboard. This keyboard also allows you to create your own measurement programs, monitor signals without being present or automate a series of measurements.

Keystroke instructions for the CRT text can go to the 7854 via an IEEE-488 interface, which can also handle waveform data or measurement results. Tied to Tektronix's Model 4052 graphic desktop computer, the scope becomes a WP 1310 signal-processing system, priced at $26,350.

465B goes digital

Digital storage costing less than the 7854's is a feature of Tektronix's $4600 Model 468. This scope has all the capabilities of Model 465B in its

A $1595 price tag *and 60-MHz bandwidth combine in Sencore's Model SC60.*

Digital storage, *programmability and an IEEE-488 interface combine with 400-MHz analog performance in Tektronix's 7854.*

nonstorage mode and works just like a nonstorage scope even in its digital-storage mode. (Pushing a button selects the appropriate mode.)

With digital storage, no interactions take place between storage-level and intensity controls. The combination of a 25M-sample/sec, 8-bit digitizer and a display-interpolation technique that requires only 2.5 samples/cycle to display sinusoidal signals accurately provides a useful bandwidth of 10 MHz.

An Envelope mode uses dual sampling rates and records maximum and minimum values of a waveform envelope into memory over a selectable number of sweeps—two to 256 or continuous. It can capture narrow pulses on long sweeps and proves useful for glitch catching, waveform-excursion viewing and aliasing detection.

Optional signal averaging and cursors for time and voltage differences simplify operation. An IEEE-488 interface is also optional.

Competition heats up

Although scopes like Model 465B have given Tektronix the lead in the lab-quality portable-scope arena, new competition is appearing. For example, Kikusui's Model 5650 is comparable in basic specs to Tektronix's Model 455 but provides more features. And its price is $1895—$150 less than that of a 455.

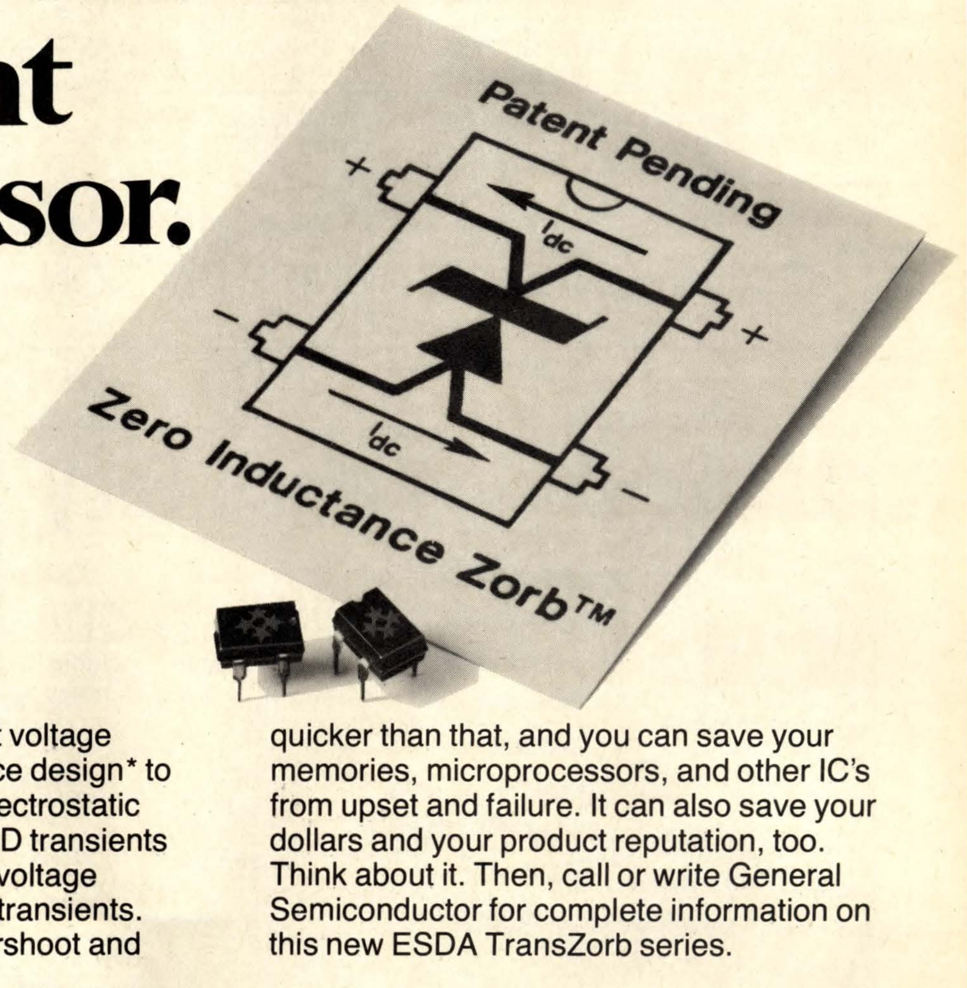
Like the 455, the 5650 has 50-MHz bandwidth at 5-mV/div minimum deflection factor. However, the 455 provides faster sweep speeds: 5 nsec/div min at ×10 magnification, compared with 10 nsec/div in the 5650.

But the 5650 features alternate timebase—a capability that can make troubleshooting easier. With it, you can compare four traces simultaneously—the two input channels and expanded segments of each.

It's easy to troubleshoot the 5650, too, if that task should ever prove necessary. Modular construction

For exceptional ESD circuit protection.

Meet the New Zero Inductance transient suppressor.



This all new TransZorb® transient voltage suppressor uses a zero inductance design* to protect integrated circuits from Electrostatic Discharge (ESD). It will clamp ESD transients and stop the inductive overshoot voltage caused by nanosecond rise-time transients. Zero inductance means zero overshoot and lower clamping.

ESD is characterized by rise-times of 2 Kilovolts per nanosecond and peak current of 40 Amps at 20,000 Volts. The new Zorb™ is quicker than that, and you can save your memories, microprocessors, and other IC's from upset and failure. It can also save your dollars and your product reputation, too. Think about it. Then, call or write General Semiconductor for complete information on this new ESDA TransZorb series.

*Patent Pending

TransZorb® is a registered trademark of General Semiconductor Industries, Inc.

Zorb ™ is a registered trademark of General Semiconductor Industries, Inc.

For more information, Circle No 69

GENERAL SEMICONDUCTOR INDUSTRIES, INC.

2001 West Tenth Place • P.O. Box 3078 • Tempe, Arizona 85281 • 602-968-3101 • TWX 910-950-1942

News

For more information...

For more *information* on the latest in laboratory oscilloscopes, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Kikusui International Corp
17121 S Central Ave
Carson, CA 90746
(213) 638-6107
Circle No 447

Sencore Inc
3200 Sencore Dr
Sioux Falls, SD 57107
(605) 339-0100
Circle No 448

Tektronix Inc
Box 1700
Beaverton, OR 97075
(503) 644-0161
Circle No 449

and plug-in boards cut disassembly time to 5 min.

Cutting costs

The lowest priced of the four new scopes, Sencore's Model SC60 Widebander provides a 60-MHz bandwidth (−3 dB) and is usable to 100 MHz, where its response is down 12 dB. Input sensitivity equals 5 mV/div, and maximum measurable input voltage with a ×10 probe is 1600V p-p. Inputs are protected to 2 kV.

The unit provides TV sync separators and TV preset positions, and signals only 0.5 div high can trigger it. It also incorporates a beam finder so you can be sure a signal's there and properly connected, even though the scope's controls might be improperly set. **EDN**

10 to 30 MHz oscilloscopes with more performance and reliability than you ever thought possible.

The surprising leader.

It's easy to see why LEADER oscilloscopes are now specified more than ever. More performance and quality for less cost... with immediate deliveries from over 100 stocking distributors. They also come with the best two-year warranty in the industry... backed by efficient factory service depots on the East and West Coasts.

A full-range of reliable, medium bandwidth oscilloscopes.

LEADER's oscilloscope line includes 11 models, single and dual trace versions, for bench or field use. All models offer comprehensive triggering controls, TTL compatible Z-axis modulation, front panel trace alignment control and convenient, color-keyed front panel layout. Probes are furnished with every oscilloscope and options include probe pouches, carrying cases, front panel covers and rack mounting adapters.

30 MHz delayed sweep – $1,530.

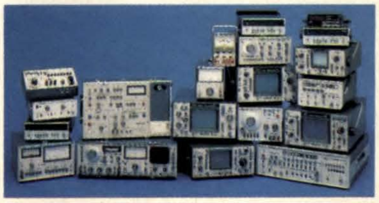
LBO-515B is a compact, precision oscilloscope at a moderate price. Using a PDA 4-inch CRT with parallax-free internal graticule, it features 5 mV sensitivity and delayed sweep for viewing and measuring complex waveforms. Also has 120 ns signal delay, trigger hold-off and x-y operation at full sensitivity.

30 MHz with signal delay – $1,100.

LBO-520 combines a 11.7 ns rise time with 5 mV sensitivity and 120 ns signal delay lines. Has single shot triggering, X10 sweep magnifier and bright, sharp PDA CRT. Triggers to 50 MHz.

20 MHz dual and single trace – $835., $610.

LBO-508A and LBO-507A give you versatility at low cost. Rise time is 17.5 ns with 1 MΩ (35 pFd) input impedance. Automatic or external triggering, X5 sweep magnifier, 10 mV/cm sensitivity and add/subtract modes.



Oscilloscopes, frequency counters, function generators, video and audio instruments... a LEADER instrument for almost every need.

10 MHz with 1 mV sensitivity – $645.

LBO-514 has both vertical and horizontal X5 magnifiers. Sensitivity is from 1 mV/cm to 10 V/cm. Sweep speeds from 0.2 s/cm to 0.1 μs/cm. Auto or normal triggering. Z-axis modulation. (Single trace version, LBO-513, $495.)

For product literature, Circle no 23
For product demonstration, Circle no 24

20 MHz battery/ac portable – $950.

LBO-308S provides lab performance and high reliability in field service applications. Sensitivity is 2 mV with a complete set of triggering controls and 18 sweep ranges to 0.1 μs/div. with X5 magnifier. Compact, lightweight with 3-inch rectangular, internal graticule CRT. (Optional 2 hour internal battery pack is recharged during ac operation, $75.00.)

Two-year warranty. Evaluation units.

A history of high reliability permits LEADER to provide a generous 2-year warranty... backed by factory service depots on the East and West Coasts. A free, trial use of LEADER instruments is available to all qualified companies.

Call toll-free (800) 645-5104 to request:

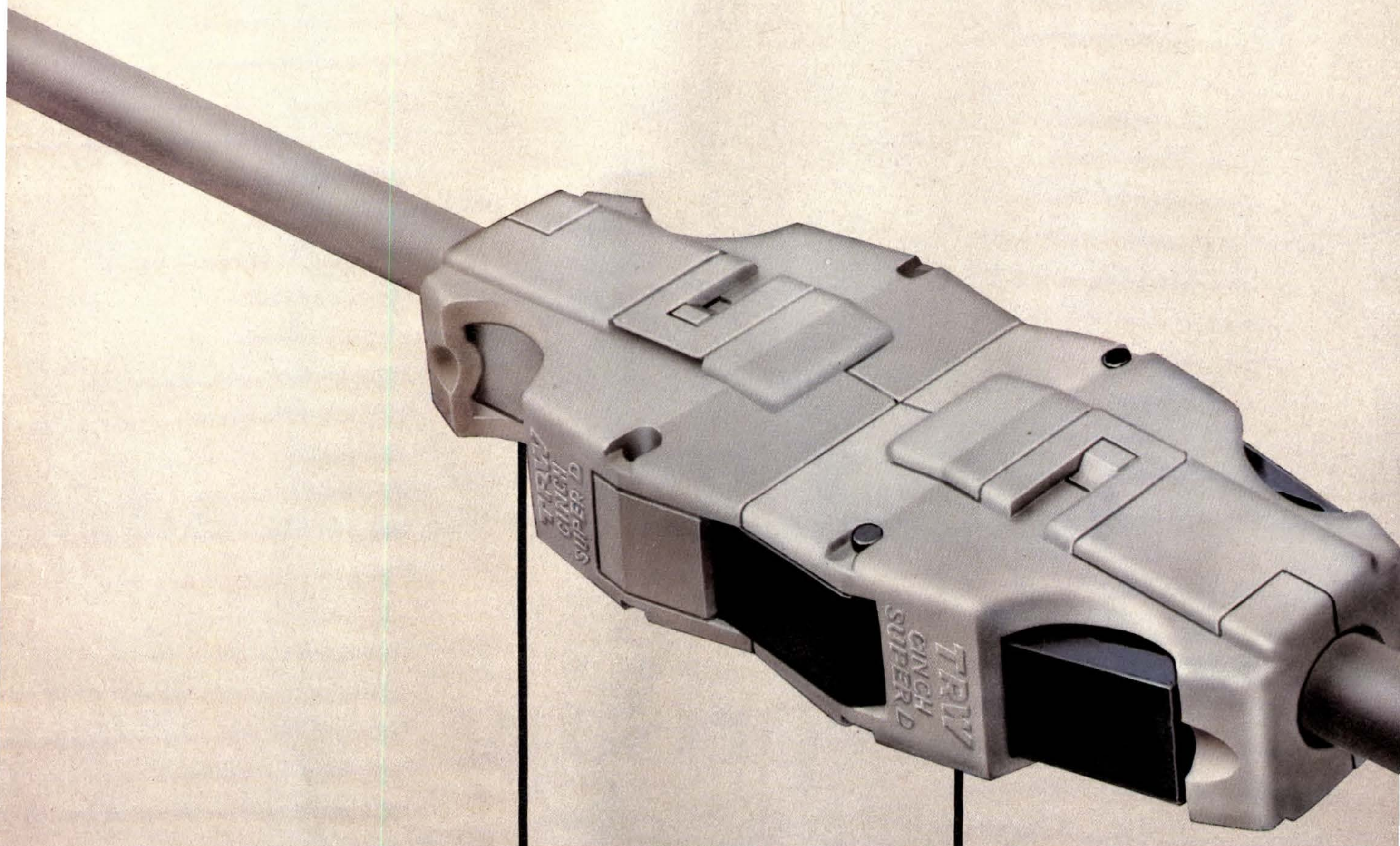
- an evaluation unit
- our 40-page catalog
- the name of your nearest "Select" distributor
- additional information

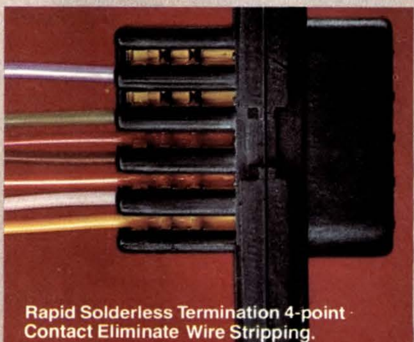
When Quality Counts

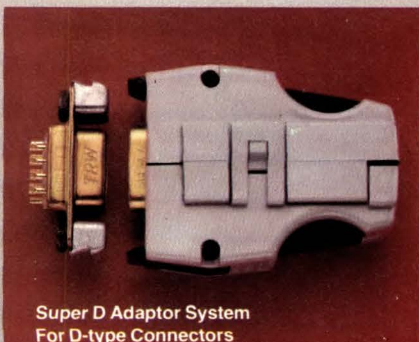
LEADER Instruments Corporation

380 Oser Avenue
Hauppauge, N.Y. 11787 (516) 231-6900
Regional Offices:
Chicago, Los Angeles, Dallas.

Super D*




Rapid Solderless Termination 4-point Contact Eliminate Wire Stripping.


Super D Adaptor System For D-type Connectors


Choose From Four Standard Super D Connector Sizes... 9 (on left), 15, 25, and 37 (right) contacts.

*Trademark TRW Inc.

U.S. Patent Nos.
3,902,154 4,035,049 4,090,770
other Patents Pending

A unique all plastic snap-locking connector system that costs less and does more than standard D-Subs.

Here's Why Super D* is "The D With The Difference".

Different? You bet! TRW Cinch's all new Super D connector system has the exclusive design features and cost-saving benefits that move it to the top of any D-Sub line!

Let's begin with cost savings. Most D-subs require soldering or crimping. Not Super D connectors. Our new pre-loaded pin/socket contacts provide solderless insulation displacement 4-point termination.

This unique contact also gives you twice as many contact points at mating end as other D-sub designs. All without wire prepping or stripping. Result? Immediate assembly time reduction and a positive cost savings with increased reliability!

But that's not all! Besides fast, solderless termination, Super D connectors also have snap-on plastic hoods that feature an exclusive Latch-N-Lock design for positive, audible locking with no additional tools, parts or labor. Just push to connect, squeeze and pull to disconnect. It's that easy!

To convert standard TRW Cinch D-subs to the Super D system, ask us about our special adaptor system for D-type connectors.

Looking for style and design? Look no further! Super D's cost-effective all-plastic assembly is both smooth and functional to complement the styling of your computer, peripheral, data communication, instrumentation or video equipment.

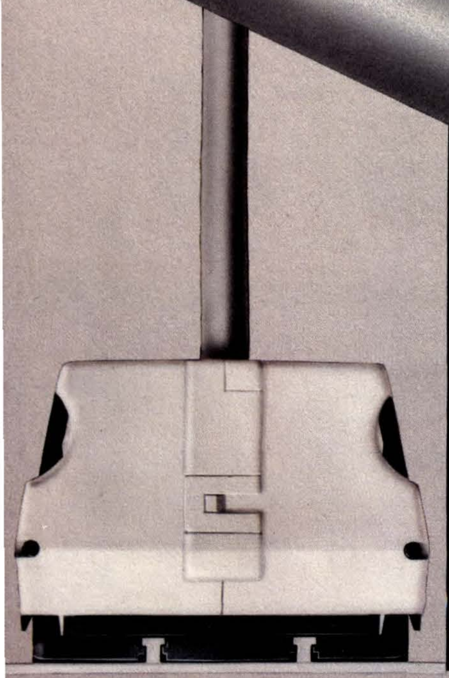
This plastic design effectively insures against shock hazards.

Super D connectors employ *selective* gold plating only where it is needed. We've eliminated expensive gold from non-functioning surfaces. So you get performance without added cost.

The Super D connector is available in four sizes (9, 15, 25, and 37 contacts) for cable-to-cable and cable-to-panel modes. Each will intermate with existing D-type connectors. And, you'll be glad to know that the Super D system is designed to meet EIA Standard RS449 plus IS04902 and 4903 for your DTE and DCE equipment.

To further speed your termination time, TRW Cinch has designed three terminating tools specifically for the Super D connector system. Use Auto-Clinch D* for high volume; Certi-Clinch D* for moderate production and field installation; and Uni-Clinch D for field repair.

So take a long, hard look at the D-subs you're using now. Then, take a look at Super D connectors. There *is* a big difference! To get the Super D difference, write or call your TRW Electronic Component Sales Office ... listed in EEM, or TRW Cinch Connectors, A Division of TRW Inc., 1501 Morse Avenue, Elk Grove Village, IL 60007. 312/981-6000



TRW *CINCH CONNECTORS*

For more information, Circle No 74

"Our hole-to-hole registration is critical. Photocircuits boards help set the standard."

Dick Johnson, Production Manager, Teltone.

"Teltone is riding the crest of growth and change in the telecommunications industry.

"Our central office, PBX, key telephone and service analysis equipment is important but not unique to our customers. So we've got to be extremely competitive.

"Today we're building a new plant to be even more competitive. Which is where automatic insertion and Photocircuits come in.

"About three years ago we decided that our board quality had to be better. Especially as we moved toward incorporating automatic insertion.

"We looked over the field and decided to give Photocircuits a try.

"We'd been having a fair amount of trouble with PTH boards in automatic insertion because hole-to-hole registration is critical.

"Then we began running Photocircuits boards. Their boards performed greater than Teltone expectations and Photocircuits helped establish our standard.

"And Photocircuits has helped us in other ways. Board warpage is an industry problem that has a lot to do with laminates. When some of their boards would not insert into our equipment housings, Photocircuits assisted us in investigating the problem.

They offered design ideas on board layout to minimize the problem. And as the biggest independent board maker, they're in an excellent position to consult and negotiate with manufacturers.

Teltone is located across the country from Photocircuits (Kirkland, Washington), and we're getting response as if they were local.

"What I notice is the constant flow of questions about drawings. They are tougher on artwork than we are. Nothing is left to chance.

"But most important, they know that the board is a major unit of our products. A key to our being cost effective. And their attitude is much like our own.

"They know they'll succeed with their customers if they keep leading in quality, service and competitive prices."

If you want to succeed like Teltone, perhaps you need a supplier like Photocircuits. To find out, just contact your Photocircuits representative. Or call or write Photocircuits, PCK Sales, 31 Sea Cliff Avenue, Glen Cove, New York 11542. (516) 448-1301. A Division of Kollmorgen Corporation.

Photocircuits

Printed circuitry for mass-produced electronics.

See us at Electro '80 Booth No. 3101-3103

For more information, Circle No 75


Why do people buy Digital's high-performanc
micros more than anyone else's?
Maybe it's because there's
more to buy.

Digital Equipment Corporation has sold more 16-bit microcomputers than any other company in the business.

Over 100,000 of them.

And the reason is simple. We give you more to work with. More hardware, more software, and more true systems capability.

So you can develop your products faster, and offer your customers the right balance of cost and performance every time.

What's more, Digital's micros are software-compatible. Not just with each other, but with our entire PDP-11 minicomputer family as well.

So you'll never run out of ways to expand your business.

Just look at what we offer:

Digital's microcomputer family.

You can choose from eight different configurations of our LSI-11/2 and -11/23 micros, in both boards and boxes. With high-performance features like general-purpose registers. Double-precision floating point processor. Up to 256Kb memory addressing. And the full instruction set of the PDP-11 family.

You also get the best form factor in the industry, because our micro boards measure just 5.2" x 8.9".

More options on the industry-standard bus.

Once you have the micro you want, your possibilities are wide open.

You can choose from dozens of micro products: 9 different memory boards, 11 I/O modules, 9 communications options, even kits for designing your own custom interfacing.

There are also 8 different peripherals, including the TU 58 micro tape cartridge subsystem.

And the whole family runs on Digital's industry-standard LSI-11 Bus, the most widely copied bus structure in micros.

The only high-performance hardware with software to match.

Digital's micro software is literally years ahead of the competition.

There's RSX-11M, the multitasking real-time operating system that sets performance standards for superminis. RSX-11S, a streamlined run-time version of -11M. And RT-11 for smaller single-task applications.

You also get development tools like an optimized FORTRAN IV-PLUS compiler and BASIC-PLUS-2. Even a ROM-mable FORTRAN for RT-11.

And Digital's development systems let you break your complex applications into manageable pieces, so several programmers can work on the same application at once.

That can save you plenty of development time.

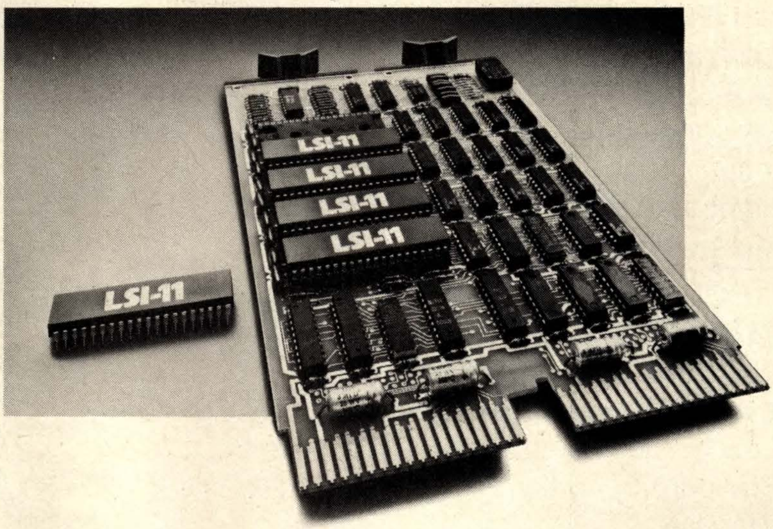
The total approach to micros.

Behind all Digital's micro products is a support commitment that's unmatched in the industry.

We have 13,000 support people worldwide. Technical consultation and training. And a wide range of support agreements – from do-it-yourself service using our special kits, to full support including coverage for your customers.

It's the total approach to micros, only from Digital.

For more information, contact **Digital Equipment Corporation,** MR2-2/M70, One Iron Way, Marlboro, MA 01752. Or call toll-free 800-225-9220. (In MA, HI, AK, and Canada, call 617-481-7400, ext. 5144.) Or contact your local Hamilton/Avnet distributor. In Europe: 12 av. des Morgines, 1213 Petit-Lancy/Geneva. In Canada: Digital Equipment of Canada, Ltd.



It took the minicomputer company to make micros this easy.

digital

For more information, Circle No 76

Leadtime Index

ACTIVE COMPONENTS

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
DISCRETE SEMICONDUCTORS			
Diode, switching	9	11	=
Diode, zener	7	10	=
Rectifier, low-power	8	11	=
Rectifier, power	8	11	=
Thyristor, low-power	7	10	=
Thyristor, power	5	11	=
Transistor, bipolar power	8	12	=
Transistor, bipolar signal	8	15	=
FET, power	15	20	=
FET, signal	14	22	=
Transistor, RF power	6	10	=
DISPLAYS			
Fluorescent	4	12	=
Gas-discharge	8	16	=
Incandescent	10	12	=
LED	5	12	=
Liquid crystal	7	16	=
Plasma panel	8	19	=
ELECTRON TUBES			
CRT, black and white TV	2	14	=
CRT, color TV	5	15	↓
CRT, industrial	5	18	=
Industrial power	10	18	↓
Light and image sensing	4	7	=
Microwave power	14	18	=
INTEGRATED CIRCUITS, DIGITAL			
CMOS	16	20	=
Diode transistor logic (DTL)	9	16	=
Emitter-coupled logic (ECL)	13	28	=
Low power Schottky TTL	25	35	=
Standard Schottky TTL	20	30	up
Standard TTL	24	33	=
INTEGRATED CIRCUITS, LINEAR			
Communications circuit	12	18	=
Data converter	8	12	=
Interface circuit	8	14	=
Operational amplifier	11	16	=
Voltage regulator	9	15	=

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
MEMORY CIRCUITS			
EPROM	10	14	=
PROM, bipolar	20	40	=
RAM, bipolar	7	16	=
RAM, CMOS	5	12	=
RAM, 4k MOS dynamic	8	11	=
RAM, 16k MOS dynamic	30	40	=
RAM, 1k MOS static	6	13	=
RAM, 4k MOS static	8	10	=
ROM, masked MOS	17	22	=
MICROCOMPUTER/MEMORY SYSTEMS			
Core memory board	8	13	=
IC memory board	2	6	=
Interface board	9	15	=
Microcomputer board	8	12	=
MICROPROCESSOR IC'S			
CPU, bipolar bit slice	7	18	=
CPU, 4-bit MOS	9	18	=
CPU, 8-bit MOS	10	20	up
CPU, 16-bit MOS	8	14	up
Peripheral chip	9	17	=
OPTOELECTRONIC DEVICES			
Coupler and isolator	10	17	up
Discrete light-emitting diode	5	9	=
PACKAGED FUNCTIONS			
Amplifier, instrumentation	8	12	=
Amplifier, operational	7	11	=
Amplifier, sample/hold	4	10	=
Converter, analog/digital	5	9	=
Converter, digital/analog	5	10	=
PANEL METERS			
Analog	12	28	↓
Digital	12	20	↓
POWER SUPPLIES			
Custom	17	25	=
Enclosed modular	12	16	up
Open-frame module	13	18	=
Printed circuit	14	16	=

Leadtimes are based on recent figures supplied to *Electronic Business* magazine by a composite group of major manufacturers and OEMs. They represent the typical times necessary to allocate manufacturing capacity to build and ship a medium-sized order for a moderately popular item. Trends represent changes expected for next month.

Dow Corning® 631 silicone epoxy molding compound. Because you can't make tomorrow's electronic components with yesterday's technology.

A little over a year ago, Dow Corning quietly changed the state-of-the-art of the electronics industry.

We changed it with a product so unique, so totally outstanding, that it overshadowed all existing technology. The product was Dow Corning 631 silicone/epoxy molding compound. And it marked the dawn of a new generation of product performance.

We looked at the advantages of silicone. We looked at the advantages of epoxy. And brought them together to make the world's first successful silicone/epoxy molding compound.

Dow Corning 631 gives semiconductor device manufacturers the compatibility, moisture resistance, and ease of molding of silicone, coupled with the strength, strong lead seal, and salt-spray resistance of epoxy. What it means to semiconductor devices is unmatched reliability and exceptional performance.

In almost any electronic product. Computers. Telecommunications equipment. Auto electronic devices. Almost anything.

For the past year, almost every major semiconductor manufacturer in the country has been testing Dow Corning 631. And the initial reports indicate that 631 is everything we designed it to be: strong, compatible, reliable.

Experience the dawn of the new generation of product performance for yourself. For more information about what Dow Corning 631 silicone/epoxy molding compound can do for your products, write Dow Corning Corporation, Department D-8578, Midland, Michigan 48640.

DOW CORNING

DOW CORNING

For more information, Circle No. 77


Gates
Energy Products
RECHARGEABLE
2 VOLT

Editor's Choice: New Products

6809-μP evaluation kit serves designers, technicians

Filling the need for evaluation and training material to assist both design engineers and technicians, the MEK6809D4 evaluation unit is part of its manufacturer's MOKEP (Motorola Kit Expansion Product) Series and is the firm's most powerful low-cost evaluation unit. It's the natural expansion of the company's familiar MEK6800D2 but offers considerably more power and features than that unit.

Among these features is a 300/1200-baud cassette interface that permits punch, load and verification of data with or without an offset. The unit's hardware / software operation allows a user to stop on an address; trace software either one instruction or one line at a time; modify, fill or search memory; enter ASCII characters; and set breakpoints.

Expansions possible

Included on the board are 512 bytes of system RAM (expandable to 1k), 1k of user RAM and either 2k or 4k of ROM. You also get provisions for an additional 4k of user RAM and six user-ROM sockets that configure for 1k, 2k, 4k or 8k single- or triple-supply ROMs and E-PROMs. Furthermore, the board provides a fully buffered 70-pin edge connector that fits into the MEK68MB5 mother-board module for use in expanded systems.

The basic D4 module requires +5V at 2A, +12V at 25 mA and −12V at 23 mA. Its system clock comes from a 3.579-MHz crystal oscillator; provision for an external clock is also present. An optional RS-232-compatible serial port includes buffered handshake signals, and the board's baud-rate generator provides values ranging from 110 to 9600.

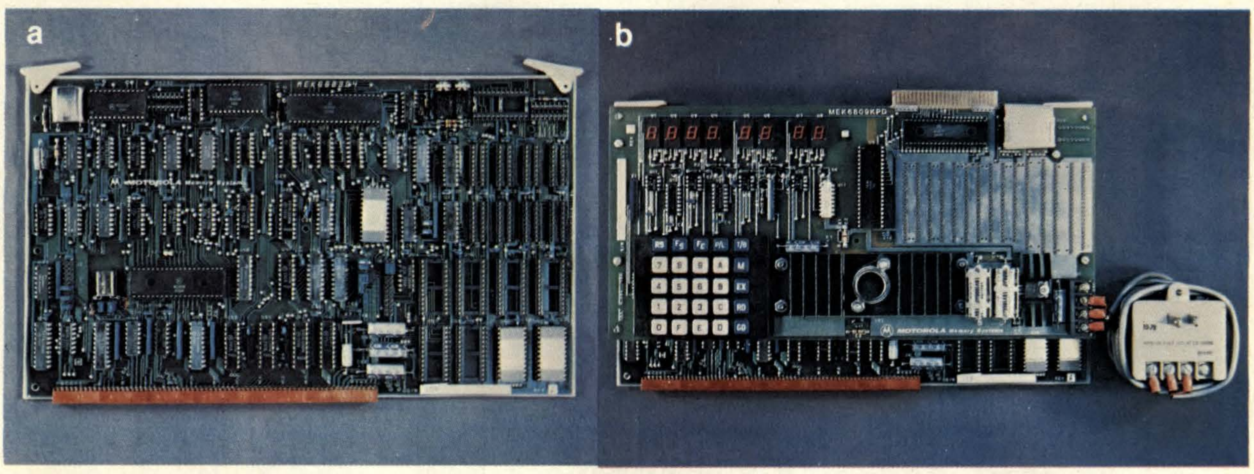
2-board system

In contrast to the manufacturer's previous evaluation line, the D4 Series can either stand alone and function with a terminal via its optional serial port and 4k-ROM operating system, or be used in conjunction with the MEK68KPD. This latter module includes a 25-key keypad, eight 7-segment LED displays, an on-board 5V power supply and an uncommitted MC6821 peripheral interface adapter.

The 68KPD also includes a wire-wrapping area; the company feels that when using the kit in this configuration, designers and technicians will want the flexibility of later employing the D4 board in actual system designs. Partitioning the system in this manner also reduces the D4's cost.

The MEK6809D4's 1-board design implies expansion through use of the company's other offerings in the MEK Series, including mother boards and EPROM-programmer modules. The basic D4 unit costs $445, with RS-232 interface $25 additional. The MEK68KPD costs $250.

Motorola Inc, 3501 Ed Bluestein Blvd, Austin, TX 78721. Phone (512) 928-6000.
Circle No 454

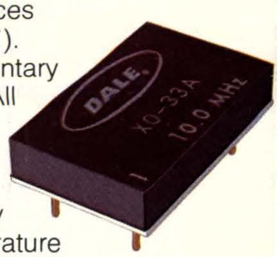


A low-cost means *of providing μP-technology updates, Motorola's MEK6809D4 evaluation module* ***(a)*** *can function in a stand-alone mode or in concert with the MEK68KPD display/keyboard/wire-wrapping board* ***(b).***

An edge for versatility

Dale .156″ Edgeboard Connectors give you extra freedom in matching body materials, mounting variations, contact plating and termination styles. Choose from double or single readouts, .140″ or .200″ row spacing, 6 to 25 contact positions. Instant interchangeability with major connector manufacturers.
Phone 605-665-9301 or Circle 35

When timing is important



Dale Clock Oscillators are ready from stock in a choice of prices and profiles (as low as .200″). Functions include complementary output and enable/disable. All have 14-pin DIP configuration and TTL compatibility. Standard frequencies from 250 KHz to 25 MHz. Stability from .005% to 2.5%. Temperature compensated styles also available.
Phone 602-967-7875 or Circle 36

The many faces of Dale.

Get to know them better.

DALE®

DALE ELECTRONICS, INC., Box 609, Columbus, Nebraska 68601 *A subsidiary of The Lionel Corporation*
IN CANADA: Dale Electronics, Ltd. • IN EUROPE: Dale Electronics GmbH, 8031 Puchheim, West Germany

Editor's Choice: New Products

Programmable function generator features high intelligence

By incorporating both an autoprogrammer and nine storage registers in Model 5900, this instrument's designers have equipped it with capabilities not previously offered in a GPIB generator.

The autoprogrammer permits the generator to learn an entire procedure, which it can repeat at any specified rate. A 200-step capacity eliminates the need for a controller in low-level systems; it also dramatically reduces demands on CPU time in larger systems.

Combined with the instrument's arithmetic, autoincrement and autodecrement functions, the autoprogrammer provides precise, linear sweeps over a 10,000:1 range, log sweeps over the instrument's entire range and nested loops that can intermix log and linear sweeps. It also can operate on frequency, period, pulse width, duty cycle, amplitude (peak or rms), dc offset and burst-cycle count.

The nine storage registers allow you to keep on hand that many combinations of generator parameters for rapid retrieval — a timesaver in applications where many parameters must be changed for each test or where operating simplicity is required for production testing.

Five waveform types

Covering 100 μHz to 5 MHz, Model 5900 puts out sine, square, triangle, pulse and sawtooth waveforms. Modes include continuous, gated, triggered, digital lin/log sweep and triggered burst.

Put this function generator to work *and you'll drastically reduce the manual labor required for repetitive measurements. Model 5900 provides high intelligence and extreme versatility in the expression of nonsymmetrical waveforms.*

The instrument's 30V p-p output has 10-mV resolution, followed by a 20-, 40-, 60-dB attenuator. Other features include fixed and/or variable dc offset up to ±15V, 1 to 99% duty cycle, waveform inversion and zero/peak start levels for gated and triggered modes.

Nonsymmetrical versatility

The instrument's intelligence provides extreme flexibility in expressing nonsymmetrical waveforms, permitting you to achieve any combination of frequency or period, positive duration, negative duration and duty cycle. You can enter amplitude as either a peak or an rms value, although peak amplitude is normally held constant and the rms value calculated and displayed based on the selected waveform. $3000. Delivery, 90 days ARO.

Krohn-Hite Corp, Avon Industrial Park, Avon, MA 02322. Phone (617) 580-1660.

Circle No 455

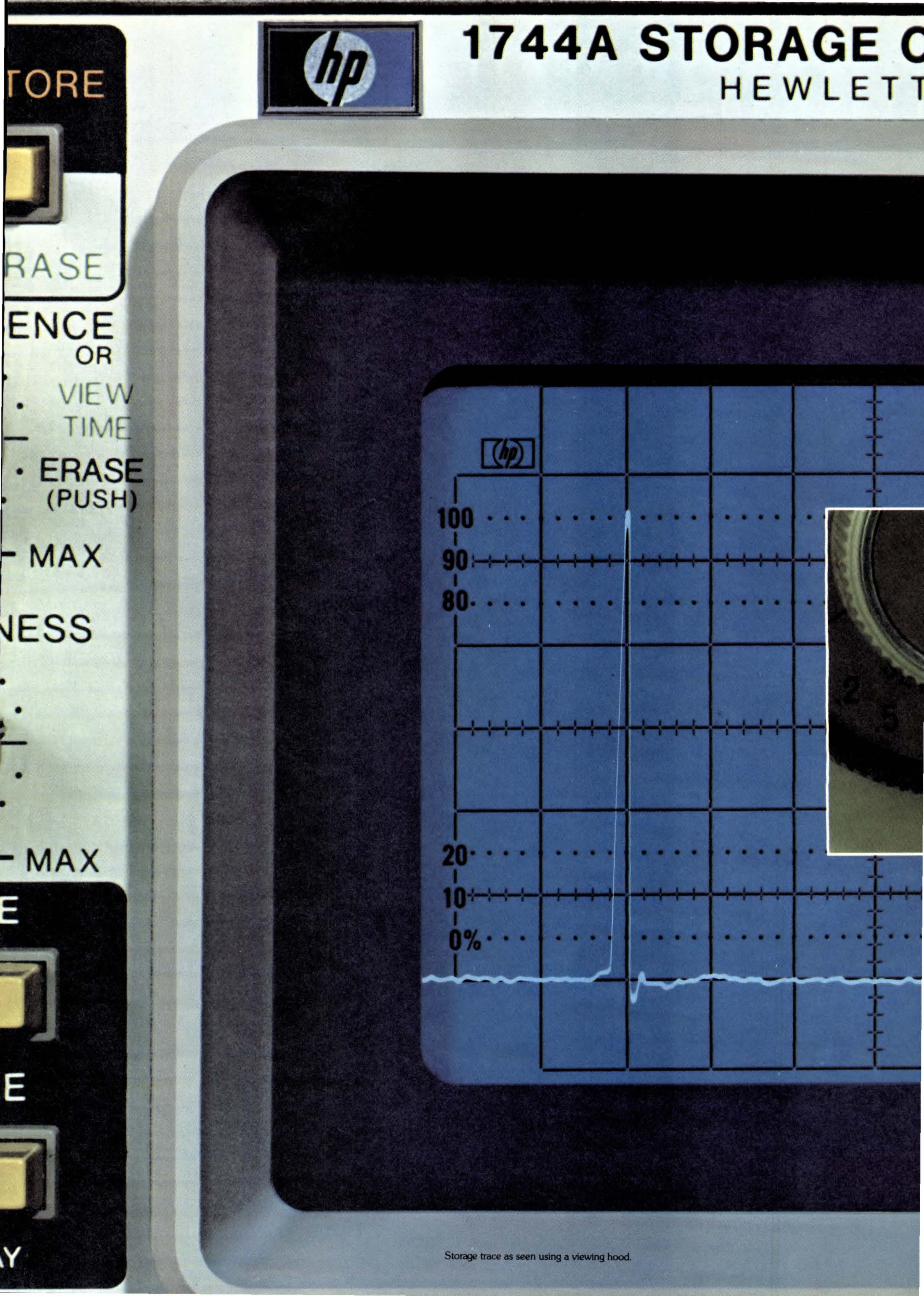
NEXT TIME

In EDN's May 5 issue, look for a preview of key sessions and product exhibits at NCC '80. This year's National Computer Conference promises to be bigger and better than ever, and EDN will be there. Also look for feature articles on

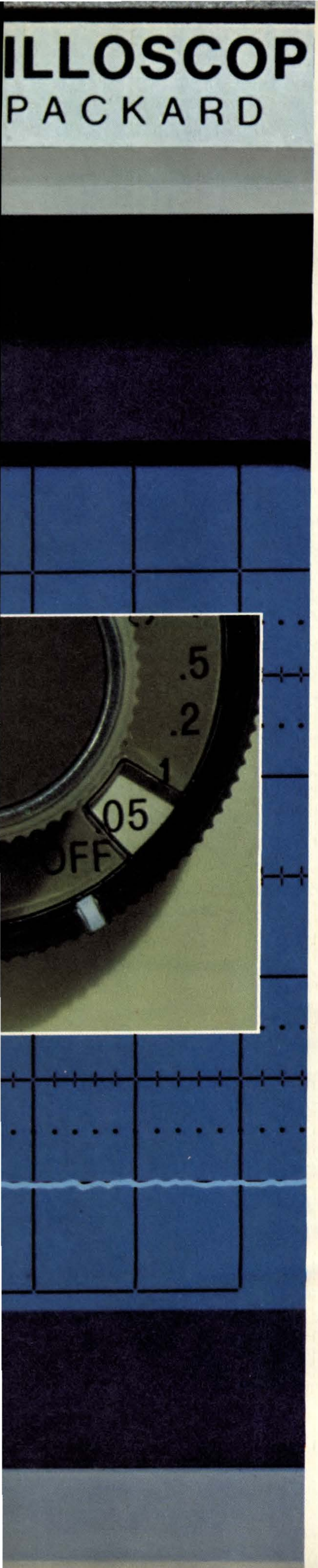
- The latest serial printers, complete with a handy clip-out chart
- The next step in EDN's hands-on μC Design Series exploration of analog μPs

You can't afford to miss this issue!

EDN: Everything Designers Need



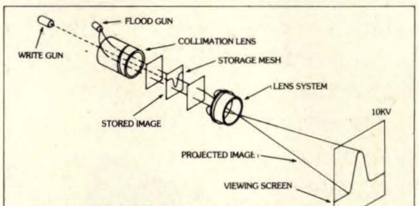
Storage trace as seen using a viewing hood.



For a 100 MHz storage scope that can capture its bandwidth and display glitches this sharply...

HP's new 1744A is the Answer.

The key to this storage scope's superior performance is HP's advanced CRT design. It's called Expansion Storage. And this faster-writing technique lets you capture single-shot and low-rep-rate events over a larger display area with greater clarity.



EXPANSION STORAGE CRT

Take a good, hard look. Any input signal within bandwidth specification will be displayed cleanly by the 1744A, even at the maximum writing speed of 1800 cm/μsec when using a viewing hood. That provides the sharpness you need for detailed evaluation of hard-to-catch waveforms. Our Auto Erase/ provides hands-off operation while Auto Store prepares the scope to snare the troublemaker the instant it occurs. Both are powerful tools for capturing the spurious spikes that disrupt your logic circuitry.

Catch that glitch. Expansion Storage technology combines a small storage mesh (about the size of a postage stamp) and an expansion lens system. This exclusive arrangement permits a writing speed of 1800 cm/μs and a fine spot size, which lets the 1744A write faster and further than any other 100 MHz storage scope. That gives you full-scan glitch capture capability over a broad range of sweep speeds and repetition rates.

A new view. Three channels are better than two. And with the 1744A you have pushbutton selection of a third-channel trigger view. Now you can view timing relationships between the trigger signal and the two vertical channels simultaneously.

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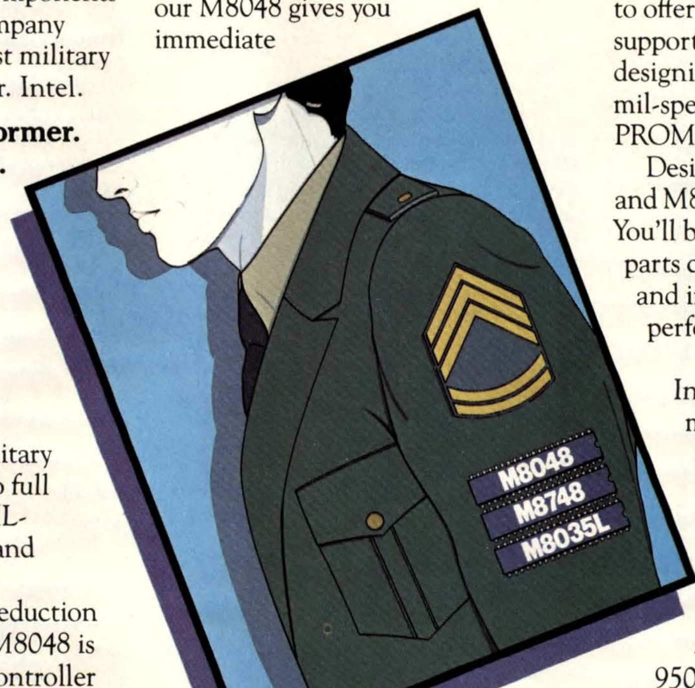

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Editor's Choice: New Products

Self-calibrating RF power meter easily measures insertion loss/gain

Microprocessor control, stored-program memory and additional nonvolatile memory give the Model 4200 RF power meter capabilities not previously available in such instruments. Basically a 200-kHz to 18-GHz autoranging unit, it accepts either its manufacturer's diode sensors (41-4 or 41-5 Series) or a modified General Microwave thermal sensor. The meter's display reads directly in mW, μW, nW, dBm or dBr (relative to an arbitrary reference) and provides a 3½-digit readout of power values as well as 4-digit dB readings, each with 0.01-dB resolution.

Offering advanced capabilities, *Model 4200 RF microwattmeter easily handles insertion-loss and reflection-coefficient tasks.*

Auto offset and calibration

To correct displayed readings, an automatic panel-operated zero-correction facility stores all zero offsets as a function of range. Additionally, an on-board 1-mW, 50-MHz reference requires only the touch of a panel button to calibrate the power sensor and instrument.

Other convenience features include high- and low-limit operation and a dc-recorder output. Options offer added capabilities, such as IEEE-488-bus compatibility (Option -01) and rechargeable-battery operation (Option -02).

As aids to serviceability, the instrument offers easy access to all pc boards, plug-in interconnecting cables and full active-device socketing. It also includes provisions for using signature analysis as a trouble-shooting technique.

One does the work of two

Conventional setups for measuring insertion loss (or gain) call for two separate power meters, but one Model 4200 equipped with the second-channel Option -03 handles the job alone. For this purpose, you connect one power sensor to a directional coupler's output test port, set test frequency and level and then read (using Channel 3) the difference in decibels between test-port power and incident power.

Next, replace the power sensor with the device to be measured and connect the sensor to its output. Take another Channel 3 reading; the decibel difference between readings is the device's gain or loss.

Measuring reflection coefficients involves little more difficulty than checking insertion loss and is readily performed by an Option -03-equipped unit. This option also furnishes 2-channel and differential power-measurement capabilities—allowing simultaneous use of two power sensors.

The unit's display can present values from Channel 1, Channel 2 or their difference, expressed in decibels. You can use two 50Ω sensors, one 50Ω and one 75Ω sensor or a diode and a thermal sensor.

Square-law response

The diode sensors available from the 4200's manufacturer inherently provide true square-law operation at low levels, and the instrument responds to the true average power of cw, AM, FM and pulsed signals. Above this square-law-response region, diode response gradually tends toward the peak signal value, but even here, the power meter is calibrated to display the true average power of cw or FM signals.

High-power AM or pulsed waveforms require attenuators to buffer the power detector or a directional coupler to implement power sampling.

The basic instrument costs $1800; $265 to $515 each for sensors; $375 for Option -01; $495 for Option -02; $400 for Option -03.

Boonton Electronics Corp, Rte 287 at Smith Rd, Parsippany, NJ 07054. Phone (201) 887-5110. **Circle No 456**

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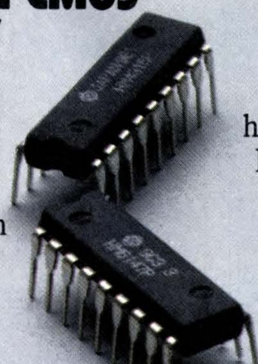

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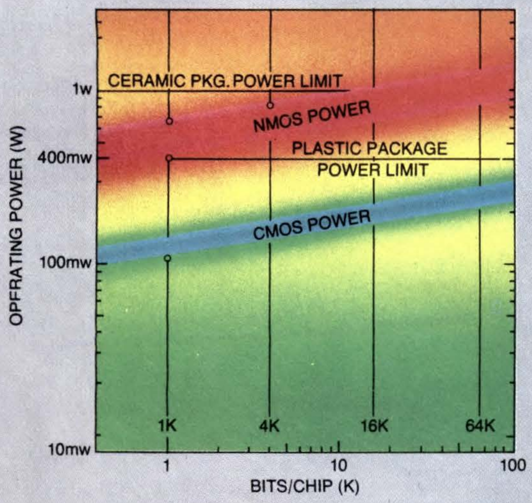

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6148	1K x 4	55/70	150mw	Samples
6116	2K x 8	120/150/200	200mw	Samples
4334	1K x 4	300/450	20mw	Now
4315	4K x 1	350/450	20mw	Now

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A little hardware single-steps Z80

Jim Grady
Hewlett-Packard Co, Waltham, MA

You can implement single-step capability for a Z80 μC system with the small amount of hardware shown in **Fig 1** and some support software added to the system's monitor. The hardware generates an interrupt during a program's instruction fetch; the interrupt-service routine stores the processor status, displays it and returns to the system monitor. A single-step command causes the processor to jump to a subroutine that sets the processor to Interrupt Mode 1, restores processor status, enables interrupts, initializes the single-step hardware and returns the processor to the user program, where the cycle repeats.

The single-step hardware consists of a 74LS95 parallel-in/parallel-out 4-bit shift register and a 74LS02 quad 2-input NOR gate. This circuit is initialized at the end of the single-step subroutine shown in **Fig 2.** An OUT instruction loads a ONE into the shift register's least significant bit (Q_A) and a ZERO into the remaining bits. Each falling edge of the Z80's $\overline{M}_1$ signal shifts the ONE to the right. When Q_C is a ONE, the CPU is fetching the opcode for the program's next instruction; its output is inverted to generate an active-LOW interrupt-request signal. Z80 instructions having 2-byte opcodes require an additional delay because their fetch cycles encompass two $\overline{M}_1$ pulses. Q_C and Q_D are thus gated together to generate an interrupt when either is a ONE; the interrupt request remains ON until the Int line is tested at the end of the instruction.

If an instruction utilizes only a 1-byte opcode, the prolonged interrupt request doesn't disturb operation because the first instruction of the interrupt-service routine **(Fig 3)** disables interrupts. The interrupt request is cleared when shifted out of the shift register, so disable interrupts during the first

Continued on pg 101

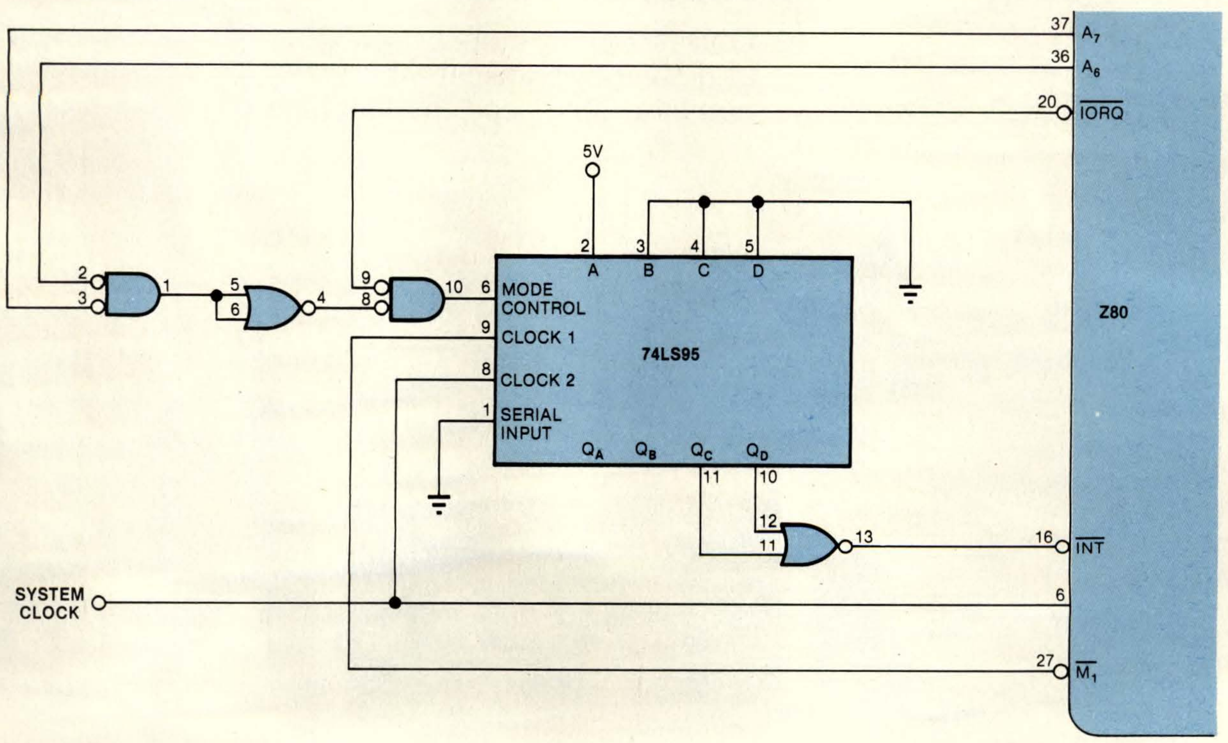

Fig 1—Using only Interrupt Mode 1 *simplifies the hardware needed to generate an interrupt during an instruction fetch.*

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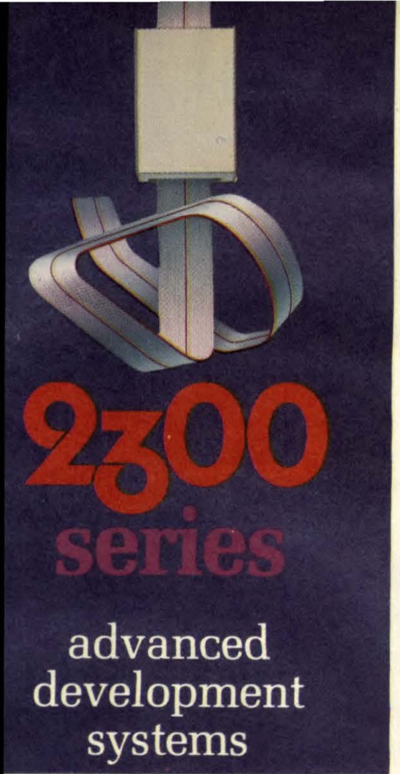

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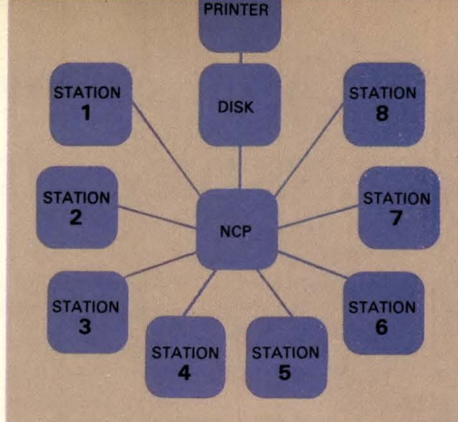

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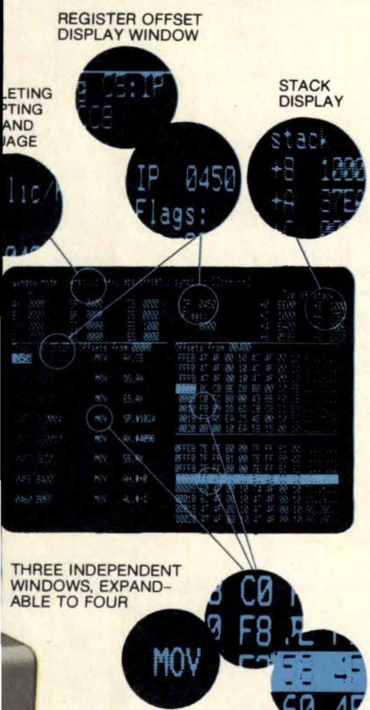

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four instructions after power-on to clear any ONEs that might remain in the shift register.

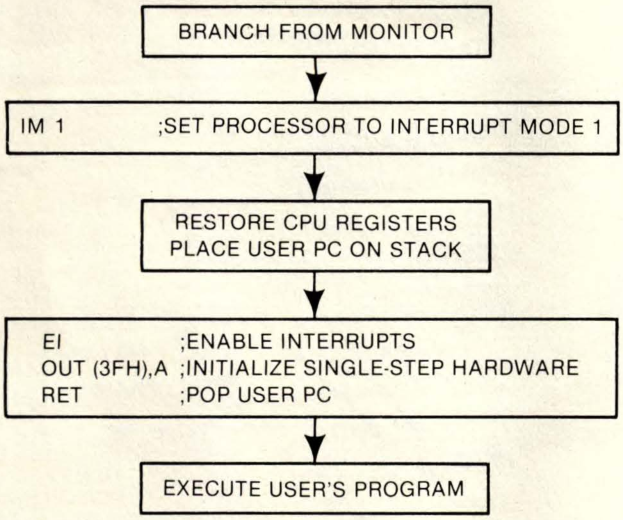


Fig 2—A single-step subroutine *sets the processor to Interrupt mode, enables interrupts, initializes the associated hardware and returns the processor to the user program.*

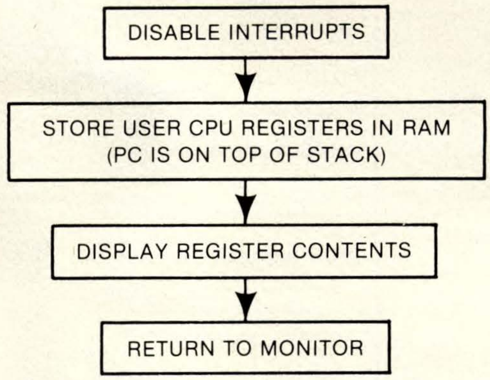


Fig 3—An interrupt-service routine *stores the processor's status, displays it and returns to the system monitor.*

As a result of the desire to provide single-step capability with minimum board space, the hardware required for this approach was minimized by using only the Z80's Interrupt Mode 1 and a simple I/O address-decoding scheme. If you aren't especially concerned about minimizing hardware, you can employ the more flexible Interrupt Mode 2 and add hardware to provide the CPU with the interrupt-service routine's address. **EDN**

EDN Software Note #48

Economical FIFO stack needs two RAM bytes

Zvi Herman
Elbit Computers Ltd, Haifa, Israel

The input and output routines shown in **Fig 1** implement a FIFO stack that requires only 43 bytes of ROM and two bytes of RAM, in addition to the user-programmable stack. With them, a Z80 with a 2-MHz clock achieves a 43-μsec input to the FIFO and a 41.5-μsec output time.

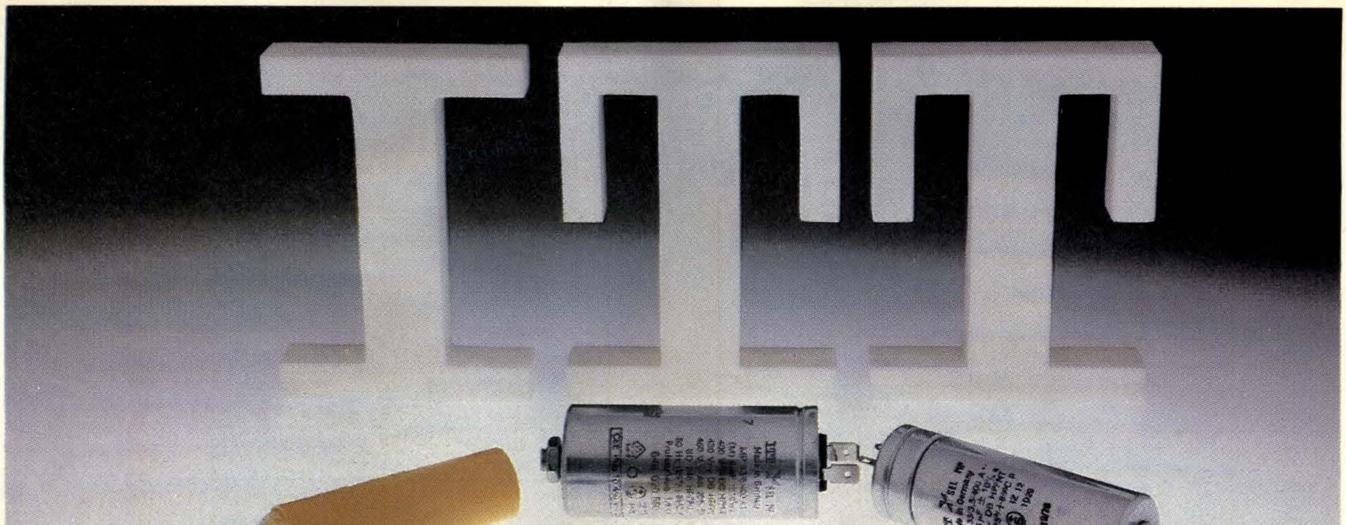
The stack design employs two pointers in RAM—FIN and FOUT. The former points to the next available stack location, while the latter points to the location of the next data byte to be read.

Assign the stack space at the beginning of a 256-byte memory block. The routines then treat the stack as a cyclic memory space—you can visualize it as a drum. In line with that analogy **(Fig 2):**

- Initialize FIN and FOUT with the same value, pointing anywhere inside the stack; the pointer is denoted relative to the beginning of the stack. Equality of FIN and FOUT thus implies that the buffer is empty.
- The first character that arrives goes to the location pointed to by FIN, and FIN is incremented. When another byte arrives, the operation repeats.
- To output from the buffer, the output routine reads the byte in the location pointed to by FOUT, then increments FOUT so it points to the next byte to be read.
- If FIN is incremented more rapidly than FOUT (which means that writing into the FIFO occurs at a higher rate than reading out of it), the buffer becomes full when FOUT leads FIN (around the "drum") by only one location.

The routines use only the pointers' six least significant bits; ignoring the seventh and eighth bits makes them cyclic.

When reading from the FIFO, the output routine


ITT

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```
; INPUT  TO FIFO
; ==============
;
;
;INPUT:NONE
;OUTPUTS: HL- INPUT ADDRESS
;CALLS: NONE
;DESTROYS:A,HL,F
;
;
FIFOIN:
        LD      HL,(FIN)        ;H=(FOUT),L=(FIN)
        LD      A,L
        INC     A               INCREMENT (FIN)
        AND     3FH             ;RESET BITS 6,7 TO MAKE
                                ;IT CYCLIC
        CP      H               ;COMPARE WITH (FOUT)
        JP      Z,ERROR         ;FIFO IS FULL-JUMP TO
                                ;ERROR ROUTINE
        LD      (FIN),A         ;STORE NEW FIN
        LD      HL,FIFO         ;GET START OF FIFO -
        ADD     L               ;ADD POINTER
        LD      L,A             ;HL=POINTER TO RAM
        RET


; OUTPUT FROM FIFO
; ================
;
;
;INPUTS:NONE
;OUTPUTS:HL-OUTPUT ADDRESS
;CALLS:NONE
;DESTROYS: A,HL,F
;
;
FIFOUT:
        LD      HL,(FIN)        ;H=(FOUT),L=(FIN)
        LD      A,H
        CP      L               ;COMPARE (FOUT)
                                ;WITH (FIN)
        JR      Z,FIFOUT-$      ;EMPTY,LOOP
        INC     A               ;INCREMENT FOUT
        AND     3FH             ;RESET BITS 6,7
        LD      (FOUT),A        ;STORE NEW (FOUT)
        LD      HL,FIFO         ;GET START OF FIFO
        ADD     L
        LD      L,A
        RET
```

Fig 1—Using only two bytes of RAM, *plus the RAM already assigned to the stack, these routines implement storage that acts like a cyclic memory space.*

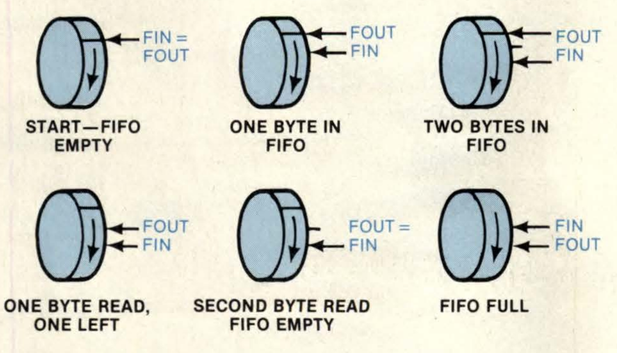

Fig 2—Two pointers *indicate the next available memory location (FIN) and the last-used location (FOUT).*

checks whether FIN equals FOUT. If so, the FIFO is empty; otherwise, FOUT is advanced and the pointer to the RAM constructed. When writing to the FIFO, the input routine checks whether FIN+1 equals FOUT. If so, the FIFO is full; otherwise, FIN is used to construct the RAM pointer. **EDN**

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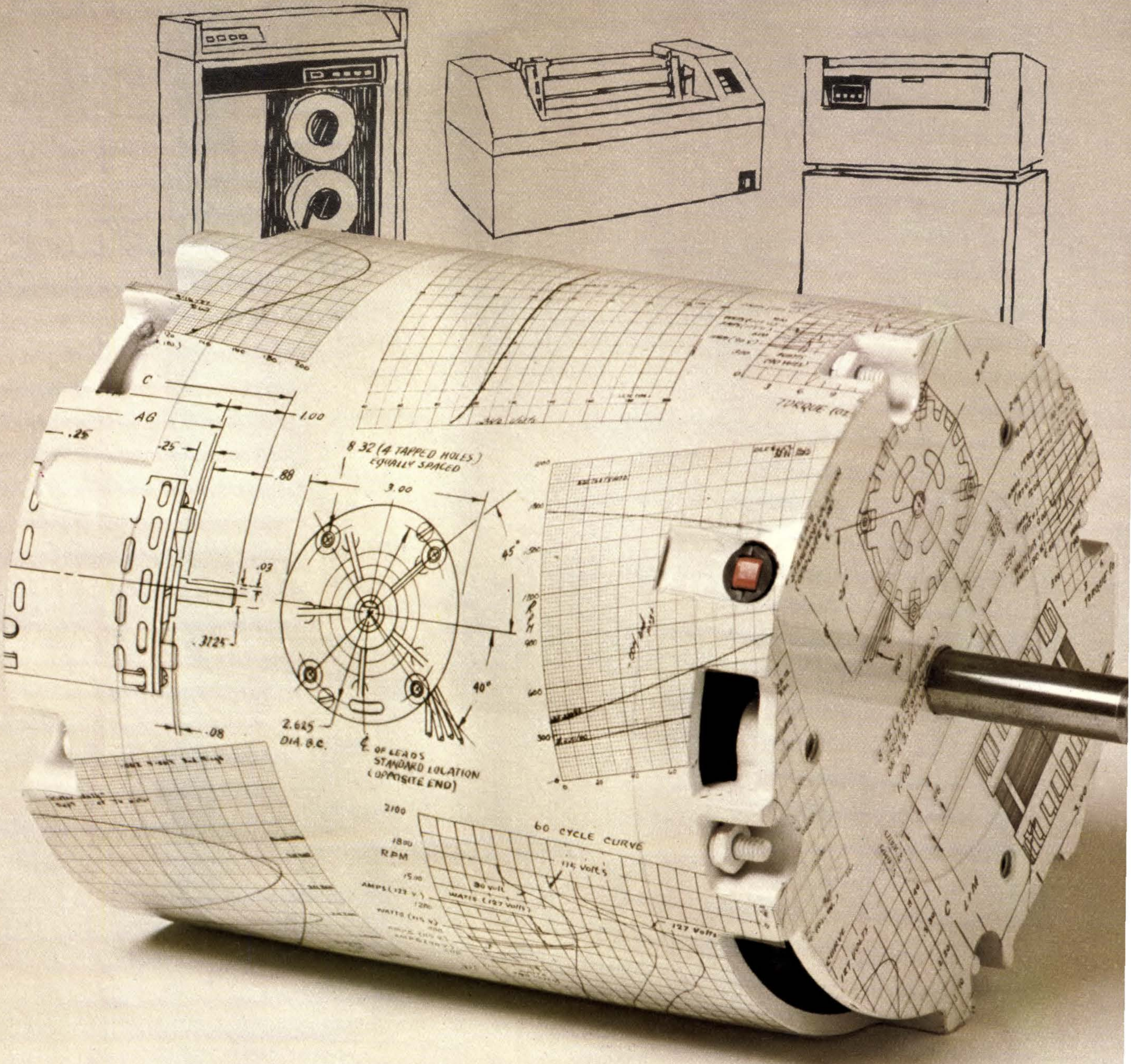

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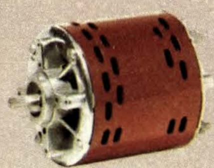
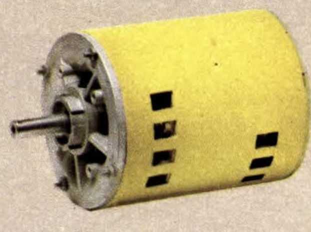


33 Frame Induction Motor



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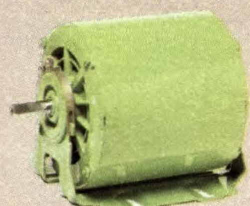

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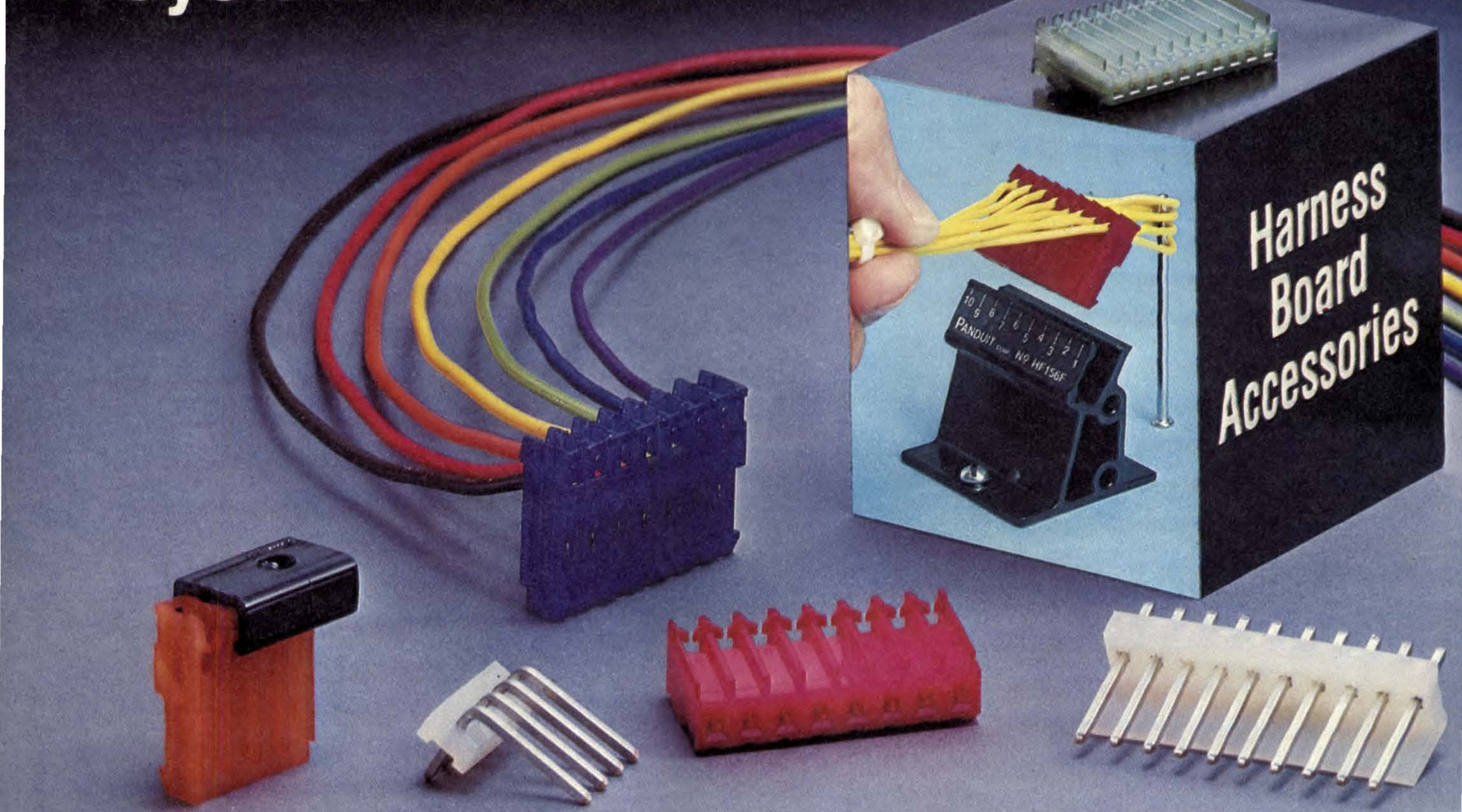

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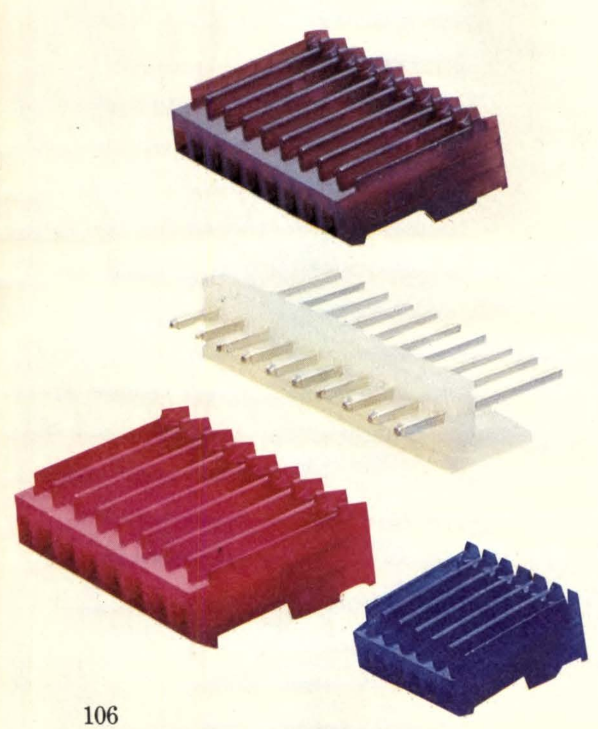

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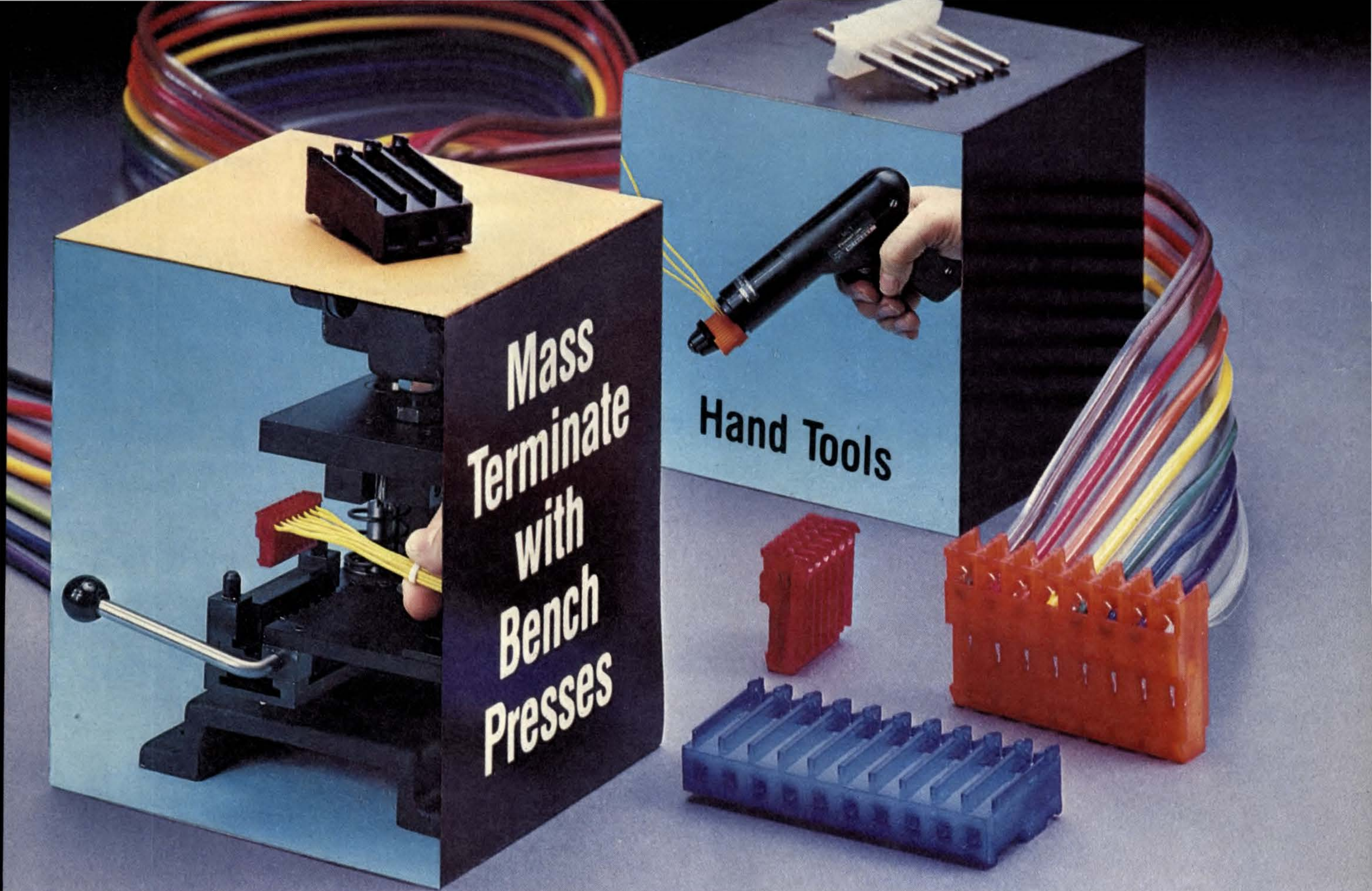

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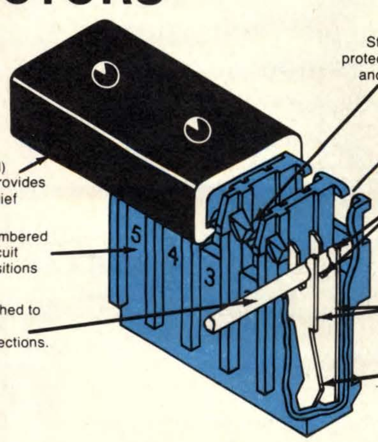

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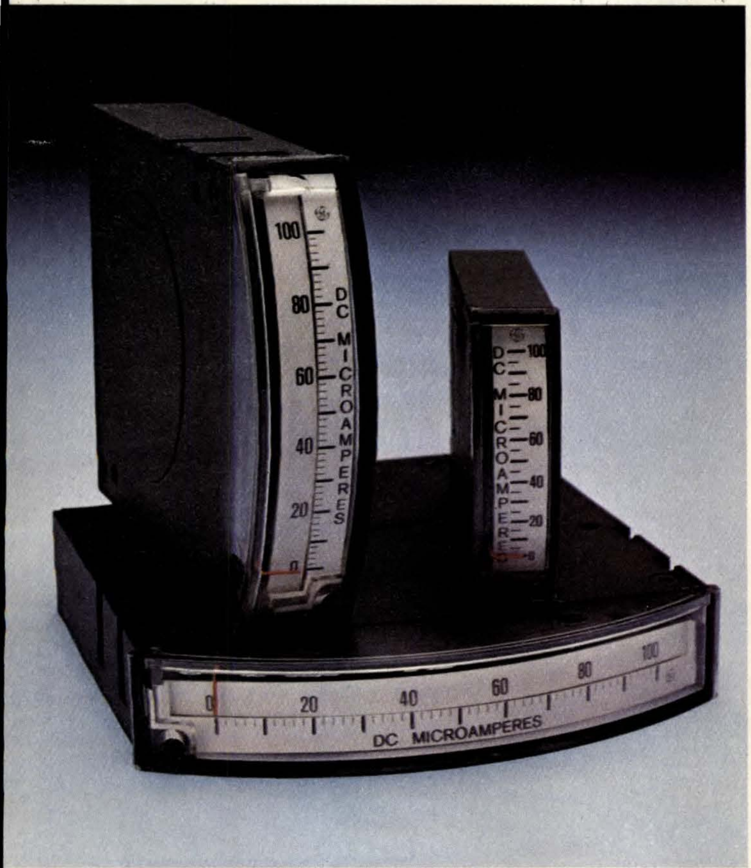

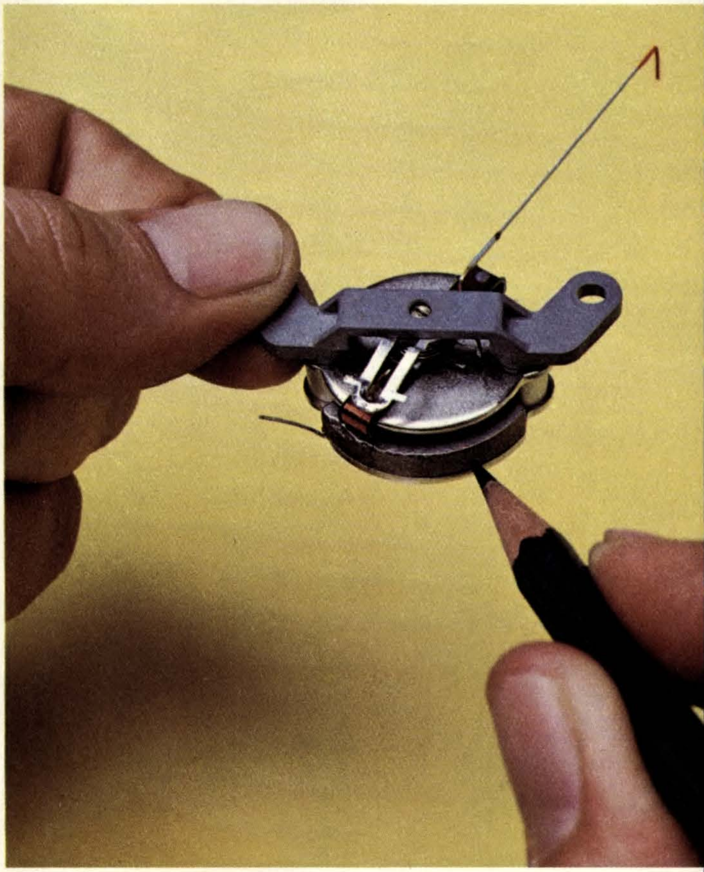

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A Question of Law

Edited by Jesse Victor

When a noncompetition agreement limits an ex-employee's business activities

Professor H Newcomb Morse
Pepperdine University, Malibu, CA

Can a company's noncompetition agreement prevent a former employee from working in the same field for a different firm?

In the early 1970s, Electronic Data Systems Corporation (EDS) brought suit in US District Court for the Northern District of Texas. The suit sought to compel a former employee, Federick A Kinder Jr, to comply with an agreement not to engage in competition with EDS after termination of his employment with the company. Kinder counterclaimed for a bonus of $2500, which he asserted was never paid him, and for additional wages he maintained he was entitled to.

At the trial of the suit, the evidence disclosed that since 1962, EDS had performed data-processing services consisting primarily of formulating computer programming systems and using these systems to solve the problems of its clients. A successful data-processing firm maintaining offices in 22 cities and servicing clients throughout the US, the company attributed its success, at least in part, to the formulation and development of computer programs that it considered superior to those of its competitors. Specifically, EDS claimed that its programs were more efficient, resulting in faster and lower cost services to its clients.

EDS safeguards programming methods

To perpetuate its success, EDS had made substantial efforts to prevent information concerning its programming methods from becoming known and used by its competitors. For example, it retained ownership of the processing systems rather than selling them to its customers, maintaining the documentation of the systems in confidence and contractually binding the customers for a minimum of 5 yrs from disclosing information about the systems. It also added to employment agreements covenants that prevented employees from engaging in competition with it. Specifically, the pertinent covenants stated that for 3 yrs after termination of employment with EDS, former employees would not engage in the following conduct:

"(i) Recruit, hire, assist others in recruiting or hiring, discuss employment with or refer to others concerning employment, any person who is, or within the then preceding 12 months was, an employee of EDS or any subsidiary or affiliated company, or of any present, prospective or former customer of EDS or any subsidiary or affiliated company, (ii) compete with EDS or any subsidiary or affiliated company within 200 mi of any city in the United States in which EDS or any subsidiary or affiliated company does business, or (iii) use in competition with EDS or any subsidiary or affiliated company or customer prospective customer or former customer, any of the methods, information or systems developed by EDS or any subsidiary or affiliated company or its customers, prospective customers, or former customers within 200 mi of any city where such customer, prospective customer or former customer does business."

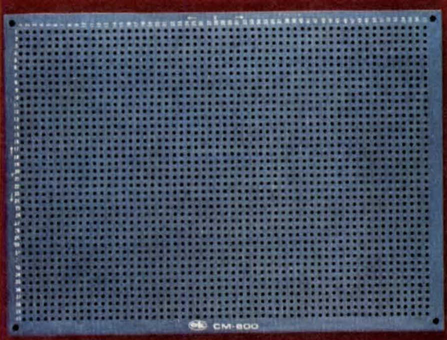
Kinder signs noncompetition agreement

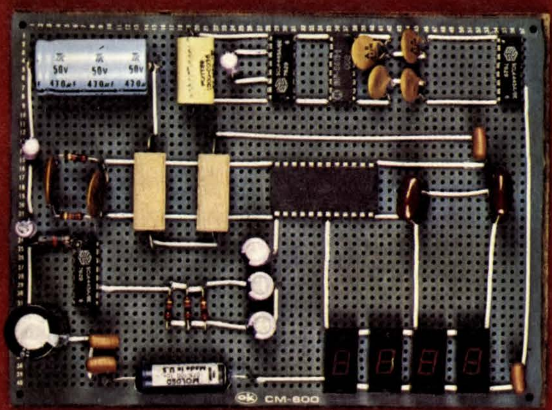
After receiving about 4 yrs of training and experience in data processing while he served in the US Marines, Kinder went to work for EDS and signed an employment agreement containing the foregoing covenants. While he was employed at EDS, he became familiar with the processing of health-care claims and was instrumental in the development of a new system for processing such claims. This system, EDS contended, greatly facilitated the processing of these claims and additionally constituted a confidential competitive advantage that the firm maintained over its business rivals.

After leaving EDS, Kinder went to work for Systems Research Inc (SRI). In the course of his employment with SRI, he became involved in business operations involving health-care claims. Stationed in Kansas City, MO, he acted as an intermediary between the Kansas City Blue Shield, a customer of SRI, and the SRI data-processing offices in Dallas, TX.

Kinder's work consisted of solving the daily problems encountered in processing health-care claims and in making recommendations for solving processing problems to the Dallas office. Additionally, he participated in discussions with prospective customers, explaining the virtues of SRI's data-

CM-600 Circuit Mount





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processing services in an attempt to attract business.

It was this involvement in SRI's health-care-processing business, EDS contended, that constituted competition with EDS in violation of the covenants not to compete. Kinder should thus be enjoined by the Court from so acting, EDS maintained.

EDS' contention was partially upheld in 1973 by the US District Court, which issued an injunction, but only to the extent of enjoining Kinder from soliciting the employees of EDS to work for SRI. While it denied Kinder's request for the claimed additional wages, the Court concluded that he was entitled to the $2500 bonus.

EDS appealed the decision to the Court of Appeals for the Fifth Circuit. In 1974, that body affirmed the decree of the District Court, stating: "We believe that the limited injunctive relief granted by the District Court is fully adequate for the protection of plaintiff's [EDS'] business. There is no evidence that Kinder ever disclosed to anyone, or used in competition against his former employer, any confidential information obtained in the course of his employment with EDS. Indeed, SRI does not use EDS' highly prized, confidential system for processing its health-care claims, but uses instead a system called the 'Model System' for processing these claims that is formulated and made available by the government to any person or firm engaged in this type of data processing. As EDS attributes so much of its business success to the confidential nature of its superior processing systems, its business is adequately protected, because none of this information has ever been disclosed by Kinder. Expanding the injunctive relief now is unnecessary for protection of plaintiff's business.

"Even though the restrictive covenants proscribed mere competition apart from the disclosure or use of any confidential information obtained as a result of Kinder's employment, the injunctive relief granted is adequate. The meaning of the term 'competition' in the context of these restrictive covenants must be determined in light of the fundamental policy underlying the imposition of such restrictions. While Kinder was involved generally in the processing of health-care claims and had some dealings with prospective customers, this conduct alone is not a threat to plaintiff's confidential system for processing health claims. Kinder's employment with SRI consisted simply of his acting in a general capacity as a data processor. To restrict him from such employment is not only unnecessary for the protection of the business of EDS, but also is an unwarranted limitation on Kinder's freedom to work as a data processor." **EDN**

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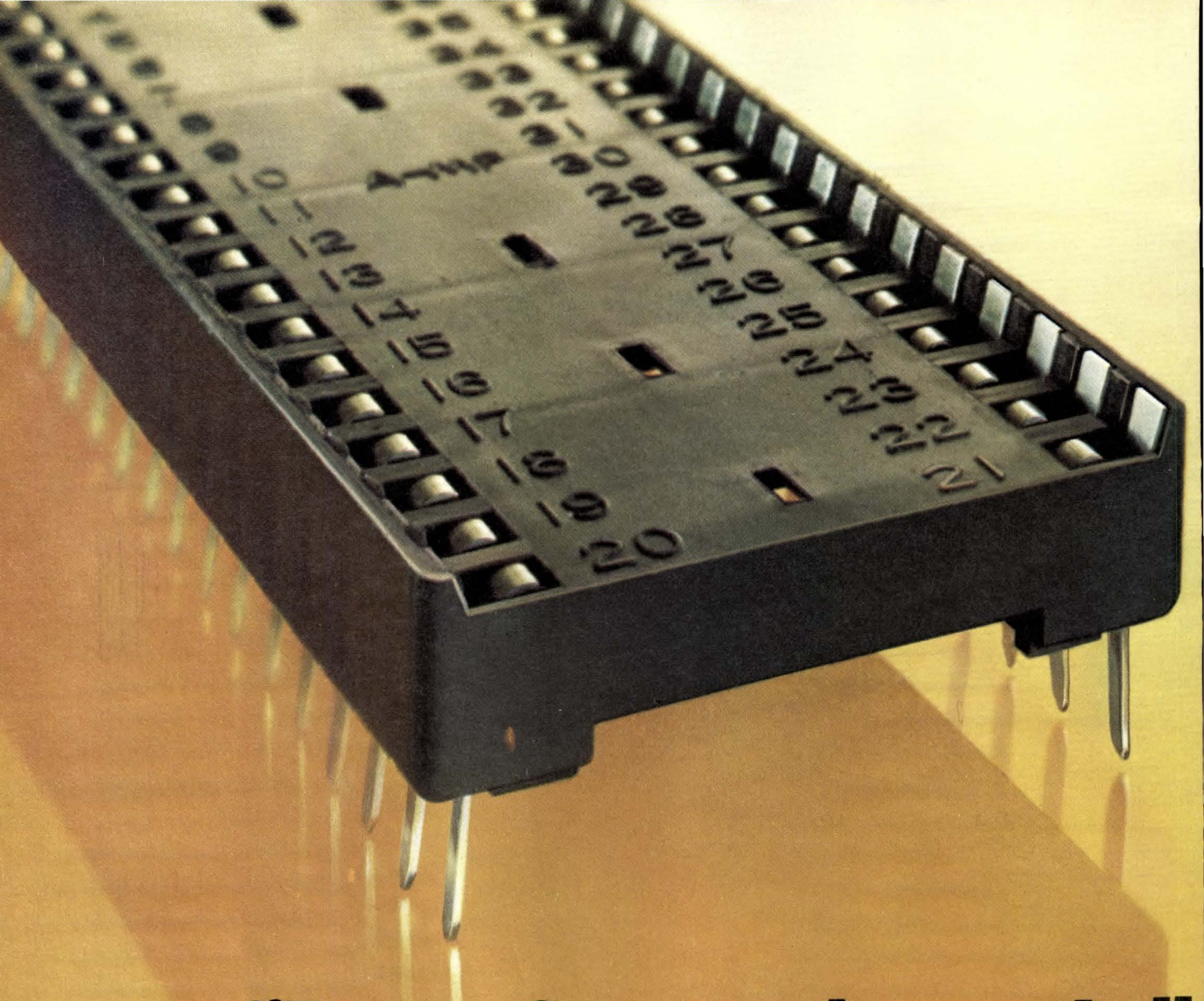

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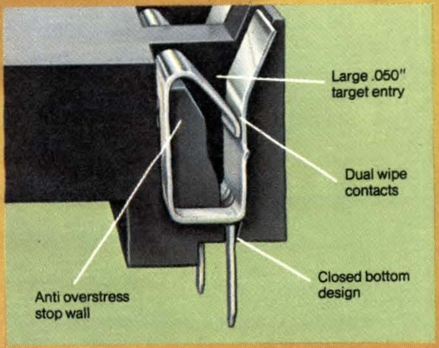

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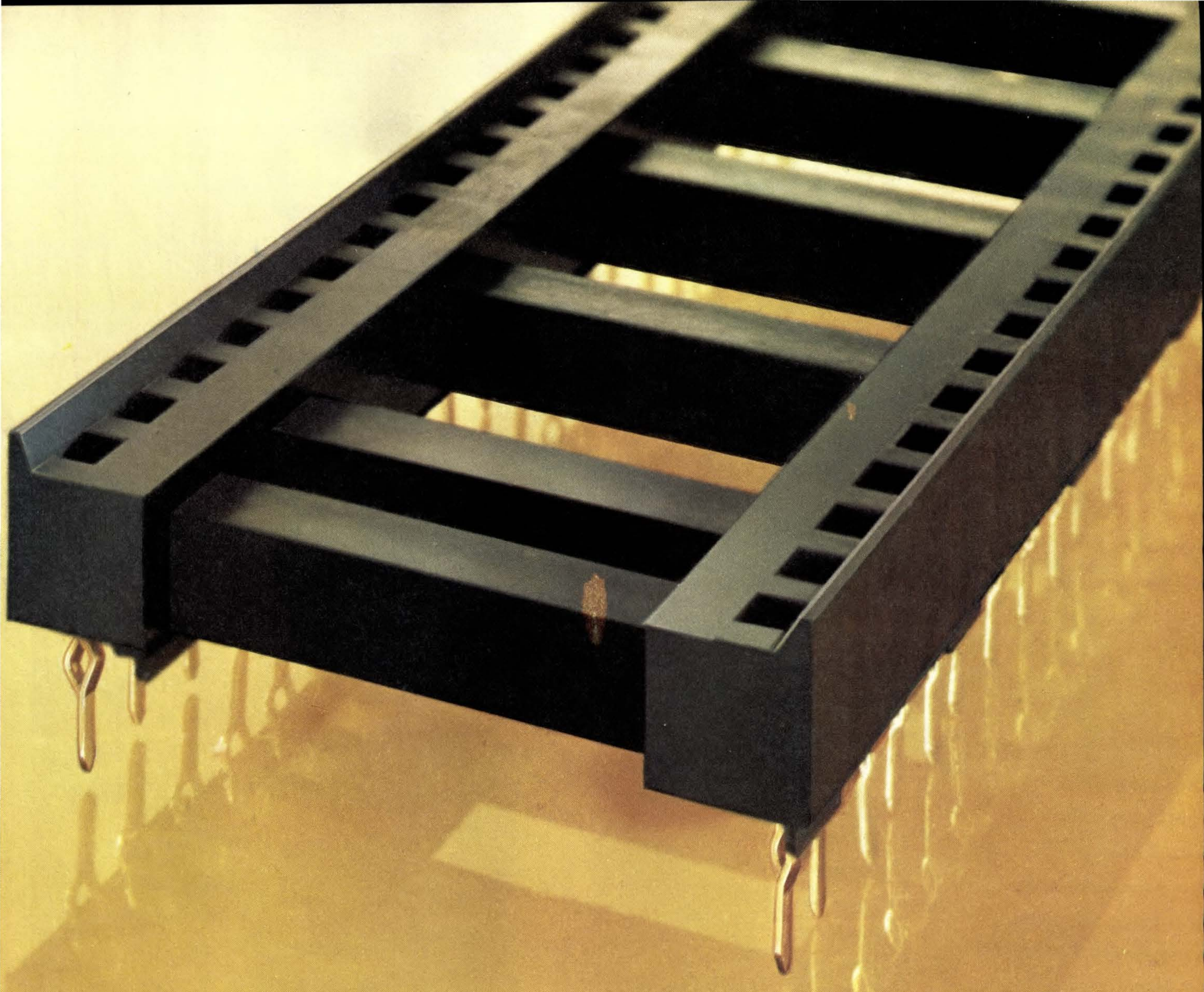

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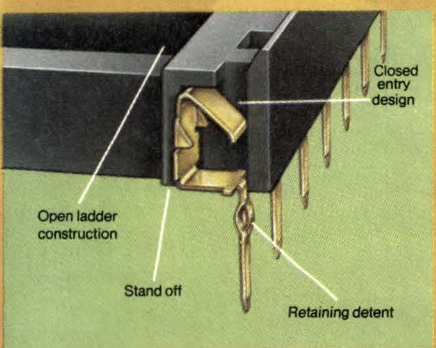

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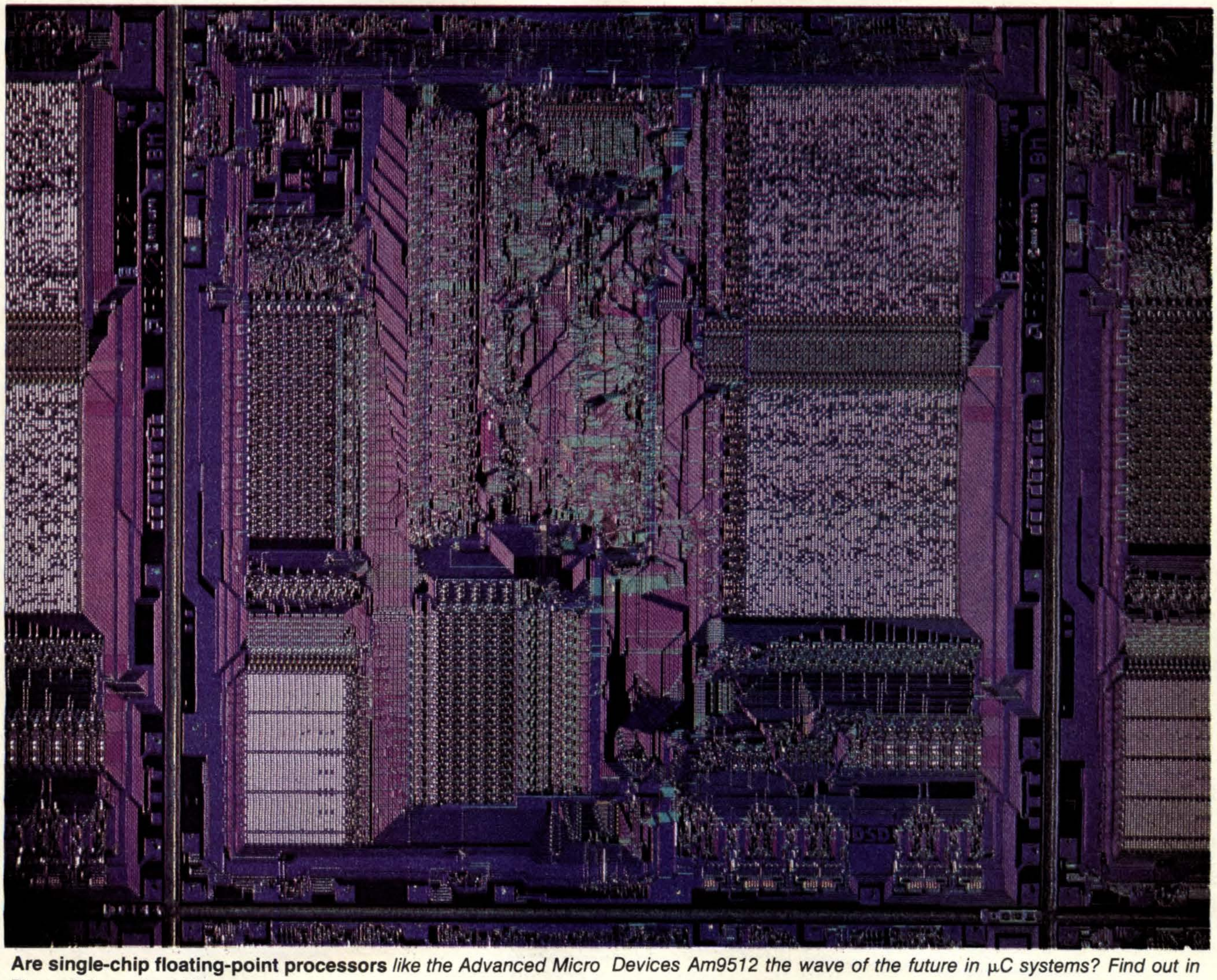
Electro/80

As Boston braces for the first Electro bash of the '80s, the focus is on gate arrays, μCs and their LSI peripherals, and μP-based instrumentation.



Are single-chip floating-point processors *like the Advanced Micro Devices Am9512 the wave of the future in μC systems? Find out in Electro/80* **session 14.**

John Tsantes, Eastern Editor

With the theme "Electronics Leads The Way," the first Electro of the '80s will offer attendees the chance to examine emerging technology in all areas of electronics. Electro/80's more than 120 technical and professional presentations, however, will place particular emphasis on microcomputers, μP-related LSI devices and instrumentation.

Highlights among these presentations include:

- A look at the latest developments in gate arrays, stressing those devices' advantages over such alternative approaches as bipolar bit slices and custom LSI parts
- An examination of the growing trend toward single-chip floating-point processors
- An overview of the current status of μP-memory technology, with special emphasis on nonvolatile devices
- A report on μP-based instrumentation

Leading the way toward tomorrow's electronics

Schedule details for Electro/80

Electro/80 will take place in Boston on May 13 to 15. All technical sessions will be held in the Sheraton Boston Hotel, between 9 AM and 5 PM; exhibits in the nearby Hynes Auditorium will run from 9 AM to 6 PM on May 13 and 14 and 9 AM to 5 PM on May 15.

In the interests of greater flexibility, Electro/80 will present three blocks of professional sessions each day—a departure from the traditional 2-per-day blocks. Show officials feel that the new format will allow registrants to attend a greater variety of discussions and avoid potential conflicts.

Daniel Carroll, president of Gould Inc, will deliver the Electro keynote address at a noon gathering on Monday, May 12, in the Sheraton Boston Hotel. He is expected to discuss opportunities in the electronics industry, with reference to Gould's activities.

For additional information, contact the Electro office at 999 N Sepulveda Blvd, Suite 410, El Segundo, CA 90945; phone (213) 772-2965. Electro's Boston office is at 1387 Washington St, West Newton, MA 02165; phone (617) 527-6944.

ELECTRO/80 — PROFESSIONAL PROGRAM SCHEDULE

	GRAND BALLROOM	CONSTITUTION BALLROOM	REPUBLIC BALLROOM	INDEPENDENCE BALLROOM
TUES MAY 13 9:00 TO 11:00 AM	1 PERSONAL COMPUTERS IN OEM, SCIENTIFIC AND INDUSTRIAL	2 INTEGRATED SOLID-STATE MICROWAVE-AMPLIFIER DESIGN	3 IEEE-488: USER FUNDAMENTALS	4 STATE-OF-THE-ART DATA-ACQUISITION SYSTEMS
TUES MAY 13 12:00 TO 2:00 PM		5 RECENT DEVELOPMENTS IN COMMUNICATIONS RECEIVERS	6 IEEE-488 CASE HISTORIES: PROGRESS AND PROBLEMS	7 NEW ADVANCES IN FLOPPY-DISC TECHNOLOGY
TUES MAY 13 3:00 TO 5:00 PM		8 CURRENT DEVELOPMENTS AND APPLICATIONS IN THE RF POWER-DEVICE FIELD	9 THE FUTURE OF INTELLIGENT MEASUREMENT INSTRUMENTS AND SYSTEMS	10 THE INFLUX OF SOLID-STATE MEMORY INTO BULK-STORAGE APPLICATIONS
WED MAY 14 9:00 TO 11:00 AM	11 MEMORIES FOR MICROPROCESSORS	12 APPLYING THE NEW GENERATION OF ANALOG COMPUTATIONAL ICs	13 STARTING AND OPERATING A SMALL HIGH-TECHNOLOGY BUSINESS	14 HARDWARE ALTERNATIVES FOR FLOATING-POINT PROCESSING
WED MAY 14 12:00 TO 2:00 PM	15 A TURNING POINT IN ENGINEERING EDUCATION (PANEL DISCUSSION)	16 THE FRONTIERS OF HIGH-TEMPERATURE ELECTRONICS	17 TECHNIQUES FOR BRIDGING THE GAP BETWEEN LINEAR APPLICATIONS AND THE MICROCOMPUTER	18 FLOATING-POINT STANDARDS FOR MICROS AND MINIS
WED MAY 14 3:00 TO 5:00 PM	19 ADVANCED ARCHITECTURES: HARDWARE AND SOFTWARE CONSIDERATIONS FOR THE NEW 16-BIT MICROPROCESSORS	20 A/D- AND D/A-CONVERTER TECHNOLOGY	21 NEW IDEAS FOR ENGINEERING MANAGERS	22 HIGH-PERFORMANCE DIGITAL GATE ARRAYS — STRUCTURE, DESIGN METHODOLOGY AND APPLICATIONS
THURS MAY 15 9:00 TO 11:00 AM	23 EVOLUTION OR REVOLUTION TO NEXT-GENERATION DEVELOPMENT SYSTEMS?	24 FIBER-OPTIC COMMUNICATIONS SYSTEMS: CURRENT STATUS	25 NEW BIPOLAR CIRCUITS ENHANCE HIGH-PERFORMANCE MICROPROGRAMMED BIT-SLICE MACHINE DESIGN	26 ARRAY-PROCESSOR ARCHITECTURE
THURS MAY 15 12:00 TO 2:00 PM	27 BUT HOW DOES *YOUR* MICROPROCESSOR DEVELOPMENT SYSTEM DEVELOP *MY* SYSTEM	28 FIBER-OPTIC DATA-BUS STATUS AND APPLICATIONS	29 TOTAL SOLUTION ON A SINGLE CHIP	30 INTERDEVICE COMMUNICATIONS AND BUS ARCHITECTURE
THURS MAY 15 3:00 TO 5:00 PM	31 MICROCOMPUTER LANGUAGES FOR THE '80s	32 STATIC PROTECTION OF HIGH-CIRCUIT-DENSITY COMPONENTS AND ASSEMBLIES	33 SINGLE-CHIP MICROCOMPUTERS AS SYSTEM COMPONENTS	34 DIGITAL IN THE TELEPHONE-SUBSCRIBER-LOOP PLANT

- An analysis of the state of the art in single-chip μCs.

Gate arrays mature

With both manufacturers and users paying greater attention to high-performance gate arrays (EDN, April 5, pg 88), **session 22** ("High-Performance Digital Gate Arrays—Structure, Design Methodology and Applications") should prove particularly enlightening. Gate arrays are now mature LSI circuit-design elements that offer architectural flexibility, fast manufacturing turnaround and high probability of first-pass design success.

Session 22 will focus on the structure, characteristics and applications of several digital high-performance gate-array units. Chaired by Stephen Lau, marketing manager for custom LSI at Signetics Corp, Sunnyvale, CA, this session will include papers on gate-array power/speed tradeoffs, a fast-turnaround system for a 400-gate array and the use of high-performance, low-power Schottky arrays.

One of the session's papers, "F300 Advanced Gate Array Offering Power/Delay Tradeoffs," will tout the advantages of using these devices rather than custom LSI in highly complex low-volume applications. According to author Tom Goodman, manager of bipolar-LSI-logic marketing at Fairchild Semiconductor, Mt View, CA, today's very fast computing systems call for the shortest possible logic-state delays and consequently the fastest possible switching circuits. But increasing density and reducing gate delays in conventional LSI components might not by themselves prove adequate to meet these needs; Goodman feels that reducing the number of interconnects in a computing system via gate arrays will also play a part **(Fig 1)**. Fairchild's F300, for example, offers the equivalent complexity of approximately 2000 gates with delays as short as 400 psec.

But why employ gate arrays rather than bipolar bit slices or dedicated custom-LSI designs? Bit slices satisfy the LSI requirements of some applications and might offer significant cost advantages compared with custom designs or LSI arrays, but they frequently don't suit the architectural partitioning requirements of very fast systems, says Goodman. In many applications, using standard bit slices might actually produce slower computing systems than using SSI and MSI devices.

Dedicated custom-LSI designs, on the other hand, are tailored to specific system requirements and provide the ultimate in speed and power efficiency. However, the time and money required for their development (as high as $150,000 for each circuit) can be prohibitive, especially when a system requires many types of LSI in small quantities.

The gate-array approach effectively deals with these difficulties **(Fig 2)**. And while gate arrays might not be as efficient as custom parts in terms of chip size and power, they can prove more economical, considered in terms of overall IC cost over system life **(Figs 3 and 4)**.

According to Goodman, future gate arrays will develop in two directions: Some will emphasize speed at the expense of greater complexity, while others will emphasize complexity over speed, in each instance exhibiting subsequent advances in the weaker area. But Fairchild's F300, he says, will address both high-

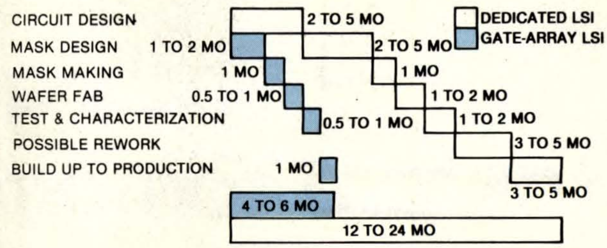


Fig 2—Gate arrays *provide significant development-time advantages compared with conventional LSI. (Source: Fairchild Semiconductor Div)*

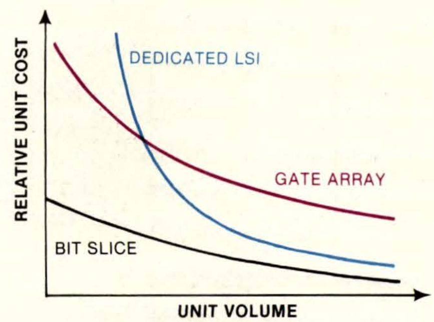


Fig 3—The relative unit cost *of logic-design alternatives shows gate arrays with an advantage over dedicated LSI at lower volumes. (Source: Fairchild Semiconductor Div)*

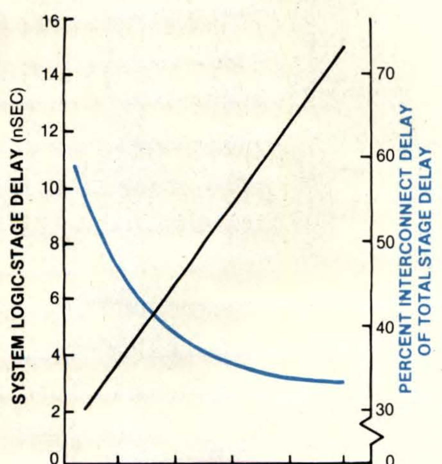


Fig 1—Shorter gate delays *imply a need for fewer computer-system interconnects in order to achieve optimum performance. As Electro/80* **session 22** *will show, gate arrays provide one way of achieving this goal. (Source: Fairchild Semiconductor Div)*

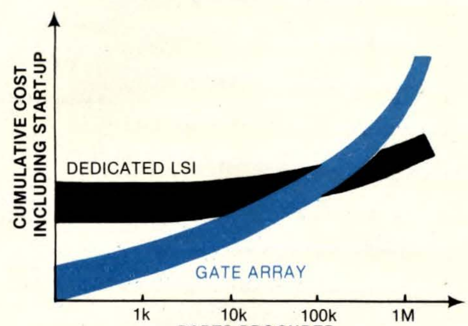
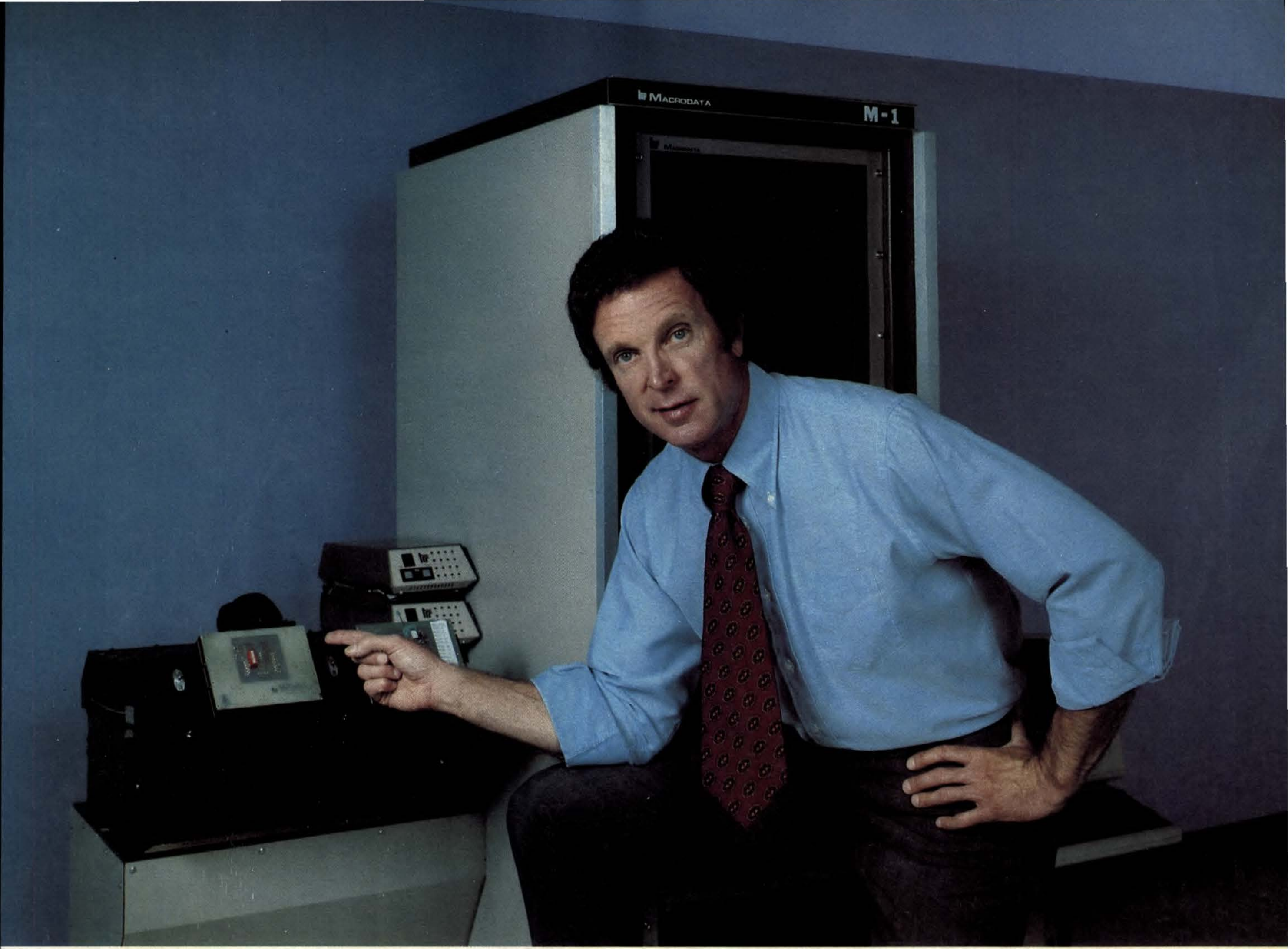


Fig 4—The cost of LSI procurement *(including start-up) is lower for gate arrays than for dedicated LSI at lower volumes. (Source: Fairchild Semiconductor Div)*



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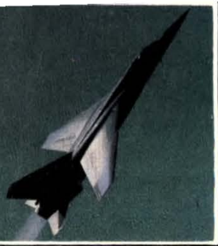

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High-level gate arrays improve design efficiency

Another **session 22** paper will be "Using the MECL 10K Macrocell Array as a Basic Building Block for Standard Product Development." According to author Randy King, systems engineer at Motorola's IC Div, Mesa, AZ, the firm's Macrocell Array (**Fig 5**) is an extension of the gate-array concept. However, rather than gates, each of its cells contains several unconnected transistors and resistors. Computer-stored specifications can create interconnection patterns for these components, transforming the cells into SSI/MSI logic functions termed macros. These macros take the form of standard logic elements such as dual D-type flip flops, dual full adders, quad latches and other predefined functions. Currently, the Macrocell Array library consists of 85 different logic functions.

King claims that using Macrocell Arrays as basic circuit building blocks is extremely easy and efficient because designers, when producing LSI configurations, need only be concerned with selecting the appropriate macros from the library, placing them in particular cell locations and creating the necessary cell-interconnection pattern. The computer generates the proper interconnection pattern within each cell.

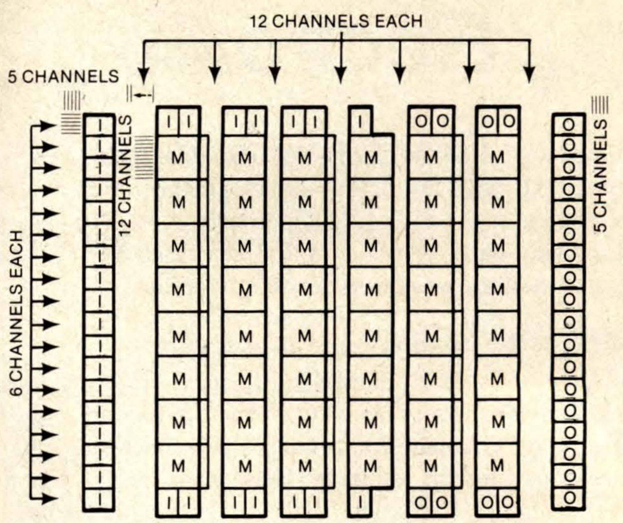

Fig 5—A series of fixed arrays *of unconnected transistors and resistors, Motorola's Macrocell Array consists of 48 major cells (M), 32 interface cells (I) and 26 output cells (O). Electro/80* **session 22** *will cover this alternative to custom-logic configurations.*

Compared with the conventional approach to custom-LSI circuits, the Macrocell Array offers a tremendous reduction in delivery time, says King. With a stockpile of fully diffused wafers, turnaround time can

A look at how to deal with job stress

Paper 2 of Electro **session 21** will deal with a timely topic: "Managing Personnel Under Stress." Author John Moody of Management Consultants, Hollis, NH, will present his ideas as part of **session 21**'s theme, "New Ideas for Engineering Managers."

Moody will define stress and discuss its effects on managers in terms of current theories. He'll also discuss the various stages that an individual goes through in coping with a crisis; understanding these stages provides managers with information on their progress (and that of their subordinates) in dealing with problems.

Moody points out that approximately one-third of people's working lives are involved with job-related activities. And investigators are realizing that on-the-job and off-the-job stresses are extensively intertwined. While managers have little or no control over the problems they and their co-workers bring to the job, they can exert some control by learning to reduce anxiety in themselves and others. The result, says Moody, will be reflected in improved performance both at and away from work.

Moody will discuss some current stress-reducing techniques that seem effective both on and off the job:

- Anticipate stressful events and attempt to schedule them if they are unavoidable or avoid them if possible.
- Monitor the amount of stress you are under by periodic self-evaluation, using devices such as the Social Readjustment Rating Scale (to be discussed during the session).
- Undergo routine physical examinations to detect responses to stress, particularly the silent killers such as hypertension.
- Initiate stress-reducing activities (whether they be job oriented or not) in a positive direction rather than toward a specific goal. Goals tend to be distant and perhaps unrealistic and should at best be considered milestones.
- Be realistic—know what you can and can't do; what you will and won't do; what people will let you do and what they won't let you do.
- Self actualize; attempt to see yourself as others see you.
- Realize that life crises can leave physical and mental scars; learn to live with them rather than relive them.
- Be patient. The memory for pain is short.

be 12 wks. He also claims that the Macrocell Array will pave the way for future developments in high-speed digital arrays, including Macrocell units with several thousand gate equivalents and increased performance, plus smaller low-power-Schottky versions.

Year of the floating-point processor

For many years, hardware floating-point processors have been an expensive option available only on high-performance computers. The presentations in **session 14** will indicate that such units are now becoming available outside their traditional realm.

Organized by Shlomo Waser, product planning manager at Monolithic Memories Inc, Sunnyvale, CA, the session will focus on semiconductor firms' development of single-chip floating-point processors. It will examine the major hardware alternatives for implementing floating-point processing—ranging from a single-chip approach to a fully parallel method requiring several hundred ICs—plus tradeoffs such as performance vs chip count and precision vs complexity.

According to session-paper coauthors Stephen Cheng and Krishna Rallapalli of Advanced Micro Devices Inc, Sunnyvale, CA, most 8-bit μPs perform poorly in computation-intensive applications. Why? Because the μPs' limited internal-data-path width makes for a slow computation-execution speed. And if the numbers in the computation are represented in floating-point notation, execution speed is slower still.

A typical 32-bit floating-point-arithmetic operation requires approximately 2 to 5 nsec. But AMD's Am9512 floating-point processor, to be described by Cheng and Rallapalli, provides an order-of-magnitude performance improvement in floating-point computations. And by improving the throughput of 8-bit systems, such a 1-chip floating-point processor can often eliminate the need for costly upward redesigns to 16-bit systems.

The Am9512 **(Fig 6)** is fabricated with n-channel silicon-gate MOS technology and comes in an industry-standard 24-pin DIP. It provides single-precision (32-bit) and double-precision (64-bit) add, subtract, multiply and divide operations and interfaces with most of the popular 8-bit processors.

The bottom-line message of **session 14?** Devices like the Am9512 offer many significant advantages over software-based approaches to floating-point computations (see the article on pg 179 of this issue for a discussion of one such approach). For instance, single-chip floating-point processors can provide an approximately tenfold speed improvement over an 8080A software counterpart. And, because most of the devices contain the entire floating-point computation algorithm in microcode, external memory usage declines by as much as 2k bytes. By eliminating software, the floating-point chips save money. And they save hardware as well: A direct hardware floating-point implementation requires more than 10 times the board real estate of single-chip devices. Another advantage: lower power consumption.

Memories stress nonvolatility

In the area of microcomputer memory devices, Electro/80 will continue the coverage initiated at February's ISSCC. **Session 11** ("Memories for Microprocessors"), chaired by Michael Bolan, senior applica-

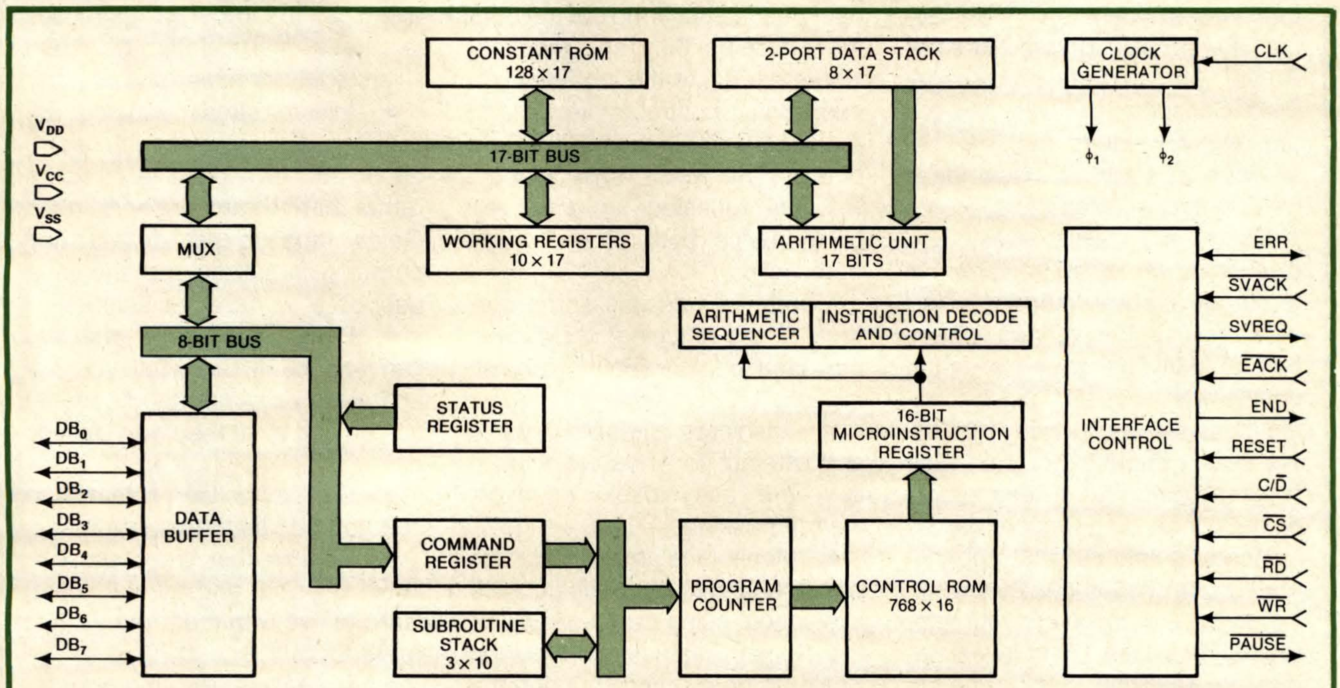

Fig 6—A single-chip floating-point processor, *Advanced Micro Devices' Am9512 can produce a tenfold speed improvement compared with its 8080A-μP software counterpart. Electro/80* ***session 14*** *will examine current developments in such devices.*

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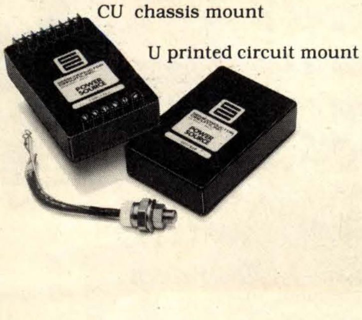

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tions engineer at Mostek Corp, Carrollton, TX, will focus on such memory issues as software, packaging, performance and nonvolatility.

One of the more vital of these issues is that of nonvolatility, which will form the subject of the paper "System Effective 5-Volt-Only Nonvolatile Static RAM." In it, coauthors Bud Koch and Wallace Tchon of Xicor, Sunnyvale, CA, will discuss the company's X2201.

Director of planning Tchon points out that traditionally, ROMs and EPROMs have provided nonvolatile storage. But ROMs must be factory mask programmed, and EPROMs require unsocketing, expensive quartz lids and high voltages for reprogramming. Tchon believes a better solution to microprocessor-system memory requirements is an electrically erasable device in which a user can change data without removing the device from the circuit.

The Xicor X2201 (**Fig 7**) eliminates the need for high voltages, quartz lids and unsocketing. The only power supply this 1k×1 device requires is 5V; all control signals are simple TTL levels. The part contains two independent bit-for-bit overlaid memories: one a standard static RAM, the other a nonvolatile EEPROM. While General Instrument has previously produced a similar device, it employs MNOS technology to achieve nonvolatility; the Xicor part utilizes a conventional n-channel silicon-gate process.

The heart of the X2201 is a floating-gate nonvolatile element, which according to Tchon is programmed and erased by enhanced tunnel current flow between multiple levels of polysilicon. Charging the floating gate with electrons turns on the element's transistor and accomplishes programming; removing the electrons turns the transistor off and erases the element. In operation, the system reads and writes all data into the device's standard static RAM; data then goes into the EEPROM by copying the entire RAM array in parallel in response to a TTL-level Store signal. Readout from the nonvolatile memory occurs by first transferring the data into the RAM by means of a TTL-level Array Recall signal; once the data is in RAM, it can be read or modified in the standard manner. Note that a copy of the original EEPROM data remains unaltered in the nonvolatile memory.

One aspect of a device like the X2201 is that it's an extremely versatile and simple-to-use nonvolatile memory component. And such nonvolatile RAMs can replace existing products because they are both static

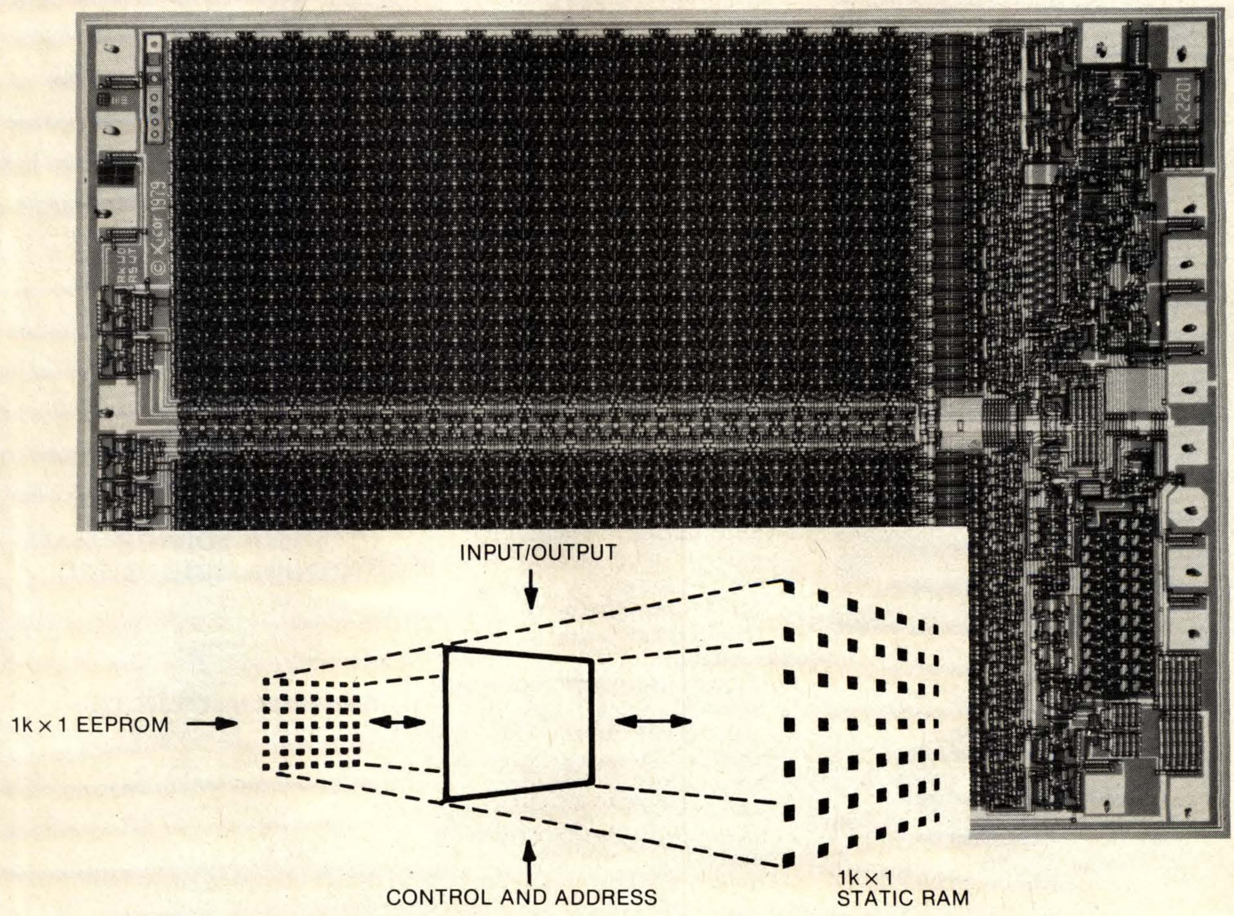

Fig 7—Requiring only one 5V supply, *Xicor's X2201 nonvolatile RAM combines two independent bit-for-bit overlaid memories and employs n-channel floating-silicon-gate technology. Learn more about it at Electro/80* **session 11.**


GOULD

RAMs and EEPROMs. Performance is up to snuff as well: The X2201 has an access time of less than 250 nsec.

The future of μP-based instruments

If you're concerned with "The Future of Intelligent Measurement Instruments and Systems," you'll find Electro's **session 9** of particular interest. This session will explore how designers are taking advantage of the μP in instrumentation systems by means of three approaches: systems based on the IEEE-488 interface bus, μP-based systems employing A/D modules that communicate with the system CPU over a microprocessor bus, and systems exemplifying a fully integrated approach.

The session will start with remarks by chairman Dr Henriecus Koeman, engineering manager at John Fluke Mfg Co, Everett, WA. Initially, he says, the μP replaced complex LSI circuits; now, with the advent of sophisticated software for use in microprocessor circuits, considerable arithmetic capability and programmability result from the intelligence of a μP-controlled instrument.

What limits exist on this added power? They center on factors relating to ease of control and programmability. For example, Koeman says that the design or definition of a display and function keys can be complicated: The objective is to make totally obvious the operation of an intelligent instrument from its front panel, but a front panel with a large number of pushbuttons or an alphanumeric keyboard can have a negative impact on an instrument's "friendliness."

Other highlights of **session 9** include a paper by Tom Rousseau, project engineering manager at Tektronix Inc, Beaverton, OR, that will highlight the integration of an oscilloscope-type measurement function with digital-signal-processing capability. And Martin Larson, engineering section manager at Fluke, will discuss the integration of signal-processing power and measurement functions in digital voltmeters.

The session will also address the difficulty of cost-effectively solving some measurement problems with a single intelligent test instrument. This difficulty arises, for example, when you must measure several signals simultaneously and wish to adapt the system to your needs. Here, a μP-based system and analog signal-conditioning boards appear to be the best approach. Jawed Wahid of Data Translation Inc, Natick, MA, will examine the capabilities, advantages and flexibility of this kind of solution.

In the related **session 3**, "IEEE-488: User Fundamentals," Dave Ricci, interface engineer with Hewlett-Packard Co, Palo Alto, CA, will explore the use of this interface bus. **Session 9** chairman Koeman points out that both sessions cover related topics; attend both if you want a complete picture of future instrumentation.

The single-chip solution

Session 29 should prove useful in providing an overview on another key electronics area. Entitled "Total Solution on a Single Chip" and chaired by K S Padda, systems engineer with Texas Instruments Inc, Houston, it will focus on single-chip microcomputers.

Only recently, single-chip CPUs were considered a triumph in the electronics industry, yet they were rapidly followed by single-chip μCs. Consequently, 1-chip devices can now implement a large number of controller applications—a possibility that has changed traditional design economies. Now, the cost of peripheral interface circuitry exceeds that of the controller. **Session 29** will examine the trend toward also placing interfacing circuits on-chip, thus resulting in a true single-chip total solution. **EDN**

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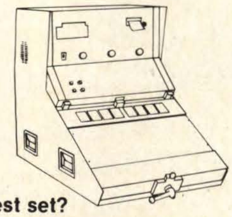

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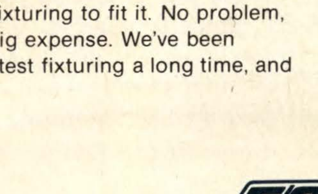

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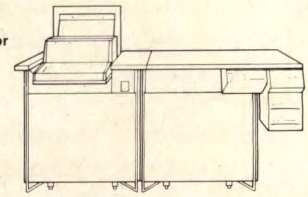

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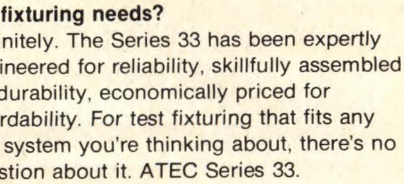

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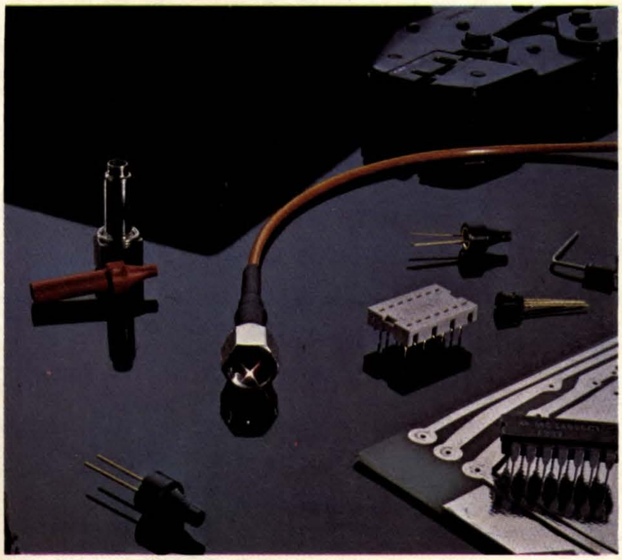
Electro/80 Products

Fiber-optics kit speeds data at 20M baud



Many currently available fiber-optics kits and data-link modules might get your systems up and running in short order, but without your learning anything in the process. This kit, however (the result of a collaboration between AMP and Motorola), brings theory and practice together.

The package includes the optical emitters, detectors and connectors, drilled pc boards, ancillary semiconductors and other parts required to build a pair of transceiver modules. A 1m-long preterminated fiber is provided, in addition to the connectors, tools and materials required for terminating other fibers. A complete set of device data sheets and Motorola's Application Note AN-794 documents the project.

The note includes the transceiver schematic, parts list and full-size, reproducible pc-board artwork. Transmitter/receiver performance and testing are completely characterized with waveform photographs and dc measurements.

The data link's only interface requirements are TTL-compatible rise times and levels. Any data-encoding scheme, combination of ONEs and ZEROs and idle-channel condition can be employed, and either simplex or half- or full-duplex operation is possible, provided the data rate doesn't exceed 20M baud. A module can operate over a 100m range (depending on fiber type) and be configured as an optical repeater by looping back the receiver data output to the transmitter data input. $495. Delivery, 8 wks ARO.

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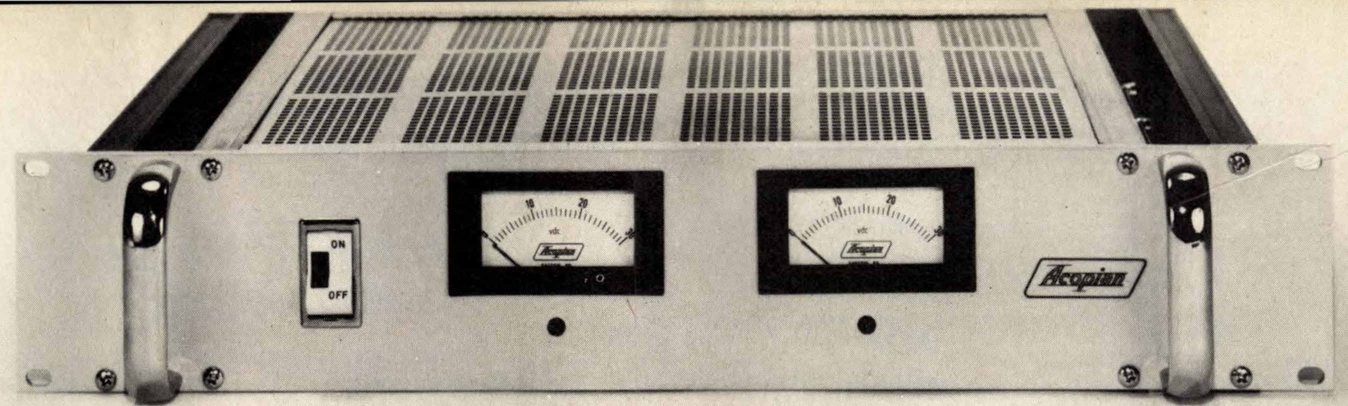

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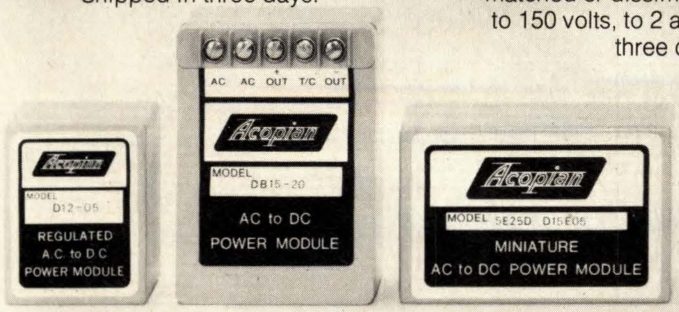

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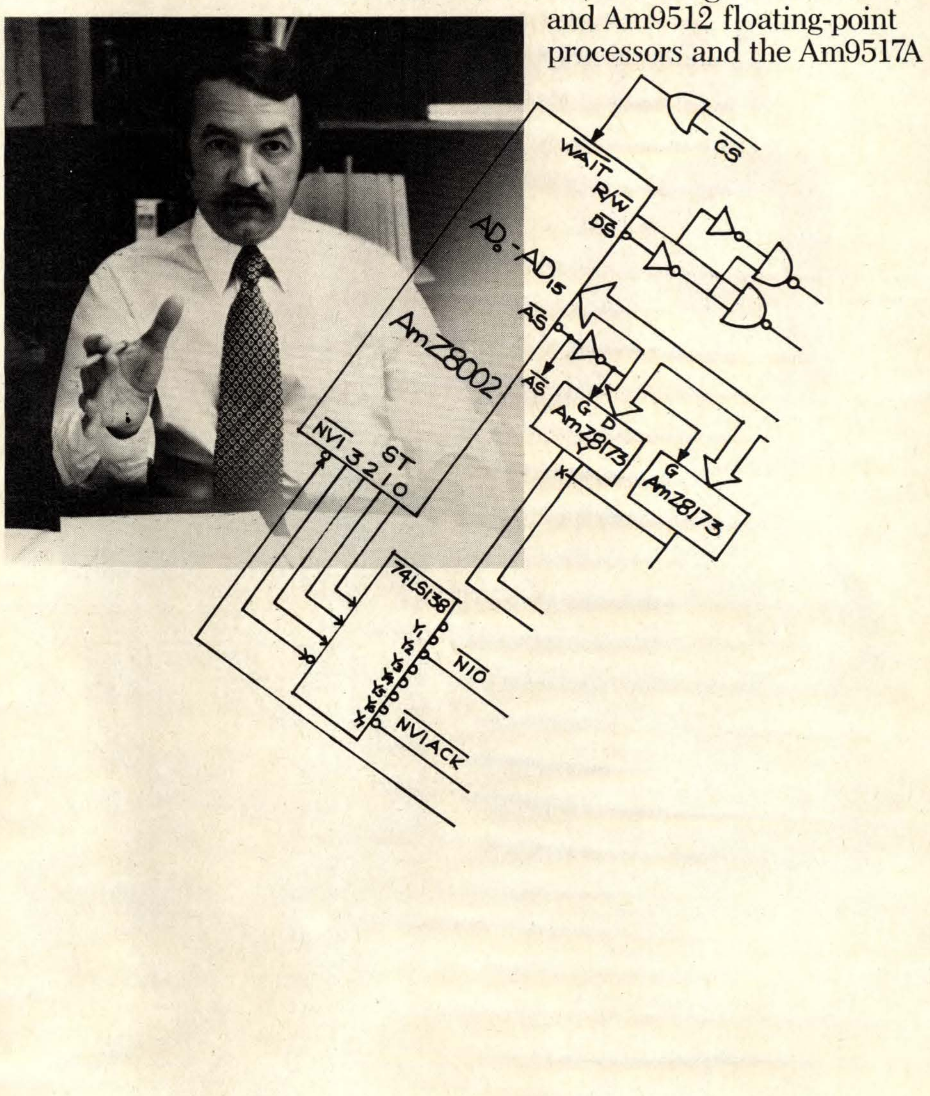

Sven Simonsen, Vice President and Technical Director, Advanced Micro Devices

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Requiring a single AA battery, Model 1001 draws just 800 μA—permitting up to 500 hrs operation with an MN1500 alkaline cell—and sports resolution of 1°C and accuracy of 0.3%±1 digit. An LCD automatically indicates battery end of life. $189, including an X10 probe and zinc-carbon battery.

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Storing 64k bits in a 0.78×1.77×2.36-in. package (equivalent to the storage capacity of 65 ft of paper tape), the FBM31CA can replace paper tape, punch cards or magnetic tape in many portable-memory applications. Utilizing serial-loop data organization and a 100-kHz drive frequency, the cassette features a transfer rate of 100k bps and 740-msec max access.

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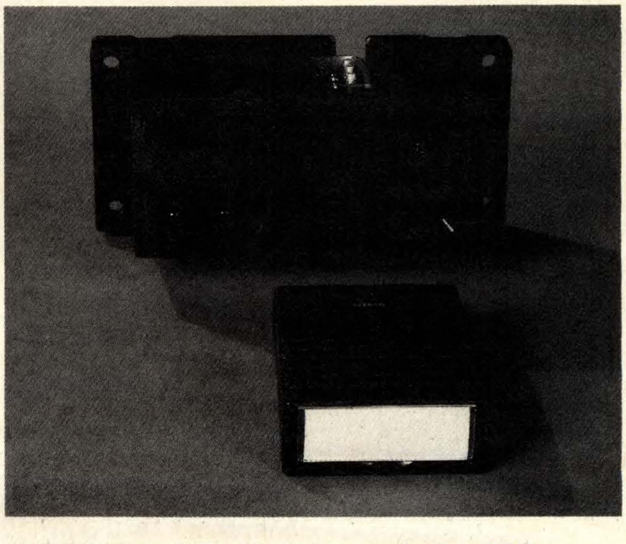
All of the cassette's TTL-compatible interface logic, timing circuits and power-supply regulators mount on the FBC308C1A control card. Data is normally 8-bit parallel processed, but a DMA mode is also possible. Measuring 9×6.3 in., the control card requires +5V (1.5A max), +12V (0.25A max) and −12V (0.1A max).

FBM31CA, $117.50; FBMU001, $212.50; FBC308C1A, $331.25. Delivery, 8 wks ARO.



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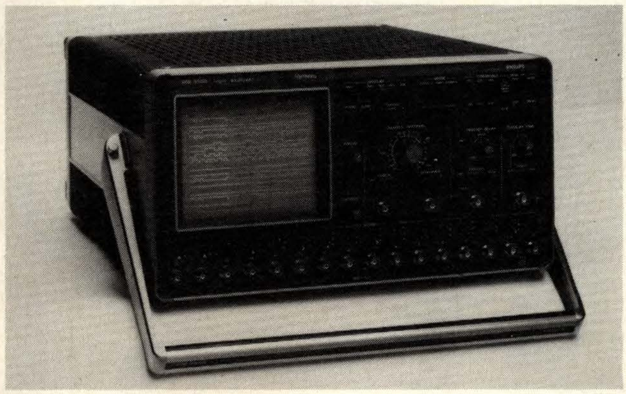
Logic analyzer catches 3-nsec glitches



Logic analyzers don't analyze: Only you can do that, and then only if your test equipment is versatile and fast enough to capture the data stream accurately—as Model PM3500 is. Clocked at 100 MHz, the unit can capture 3-nsec, 400-mV hardware-generated glitches.

Memory capacity equals 16 bits wide×505 words deep, and you can display this entire data block. Alternatively, you can expand the display to show 50- or 20-bit segments for a closer look at the timing.

The instrument can display the state of stored data in binary, octal or hexadecimal notation; you can locate (via cursor) and show any 16-bit-wide 16-word segment of the memory.

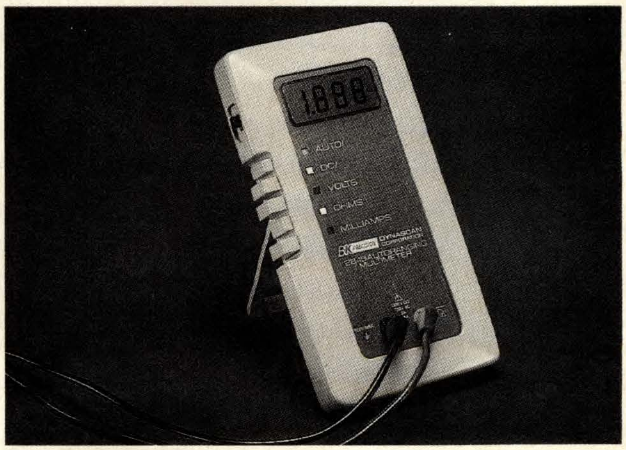
Internal triggering occurs upon recognition of a 16-bit word denoted by means of front-panel switches (an X "don't care" state is also permitted). Threshold sensitivity for channels 0 to 7 and 8 to 15 can be independently set to TTL, ECL or a variable level; 100-MHz recording requires 500 mV p-p.

Measuring 7.9 in. high, 15.2 in. wide and 18.5 in. deep, the PM3500 weighs 30 lbs and costs $8995, including its standard probe set.

Philips Test & Measuring Instruments Inc, 85 McKee Dr, Mahwah, NJ 07430. Phone (201) 529-3800. Booth Nos 1010-14, 1109-13.

Circle No 428

Versatile DMM employs μC control



With a single-chip, 3½-digit ADC handling measurement and display-driver operations and a 4-bit μC performing decision-making and housekeeping chores, there isn't much left for you to do when using Model 2845 except select the desired function and measure. You can measure ac or dc voltage and current, resistance and continuity; the continuity buzzer (when enabled) sounds for a measured resistance value of less than 180Ω.

Offering features not usually found in its price/performance/size range, the digital unit furnishes an Autoranging mode, which operates for any parameter measurement unless range locked by the user. This capability reduces measurement time because the instrument doesn't have to determine the optimum range setting step by step.

Voltage measurement (ac and dc) spans 1 to 1000V FS with a minus sign displayed when appropriate. Input impedance equals 10 MΩ, and the input is protected by a fuse/diode network. DC accuracy equals ±0.1%±1 LSD for all ranges; ac accuracy is determined by both range and frequency, with the 50- to 500-Hz, 1 to 100V value being ±0.5%±3 LSD. AC/DC current ranges cover 1 to 1000 mA and have similar accuracy limits and tolerances.

Measuring less than 7×4×1.5 in. and weighing 1 lb, the 2845 has an operating range that spans 0 to 55°C and 0 to 80% relative humidity.

With test leads and spare fuses, Model 2845 costs $170. Delivery, 6 to 8 wks ARO.

B&K-Precision, 6460 W Cortland St, Chicago, IL 60635. Phone (312) 889-9087. Booth Nos 1207, 09.

Circle No 425

WHEN YOU'RE HERMETICALLY SEALED, YOU CAN COUNT ON LONG LIFE.

LIKE OUR MINIATURE METAL-CASE RELAYS. MILITARY QUALITY AT PLASTIC PRICES.

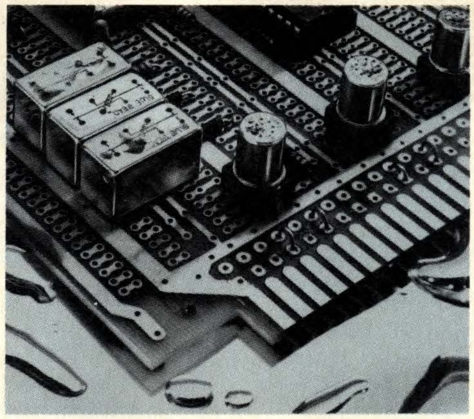
PLASTIC? OR HERMETIC METAL CASE. WHICH RELAY IS THE REAL SURVIVOR?

Sure, some plastic relay manufacturers claim their non-hermetic sealed products will survive flow-solder and solvent baths. We say *maybe*. And even if they do, will they really survive in the field?

For our hermetically-sealed all-metal relays, there's *no question* about long life. Our MM-5 microminiature (TO-5 type relays) are going strong after 10 million operations. Our Flagship® family of half-size crystal cans, 50 million or more. That's why we call them the "Survivors" – they keep performing in applications where plastic won't last.

MILITARY QUALITY AT PLASTIC RELAY PRICES.

Like our military relays, both Flagship and MM-5 relays are made to last – not just strong, but truly leak-free as only hermetic devices can be. They reliably withstand punishing atmospheres, demanding electrical performance requirements, and as much as 30g shocks and vibration of 10g's to 500 Hz. You can operate them over a −55 to +85°C temperature range without derating or heat sinking. Even immerse them again and again in strong industrial solvents and flow-solder baths. With leak rates of less than 10^{-6}cc/s, they can take it. Millions of cycles later, there's still no corrosion, no perceptible wear, no contact degradation. And, unlike solid state devices, no risk of false operation.



Electrical Characteristics/Selector Chart
Write on company letterhead for evaluation sample.

	Nominal Voltage Vdc	Pick-up Voltage (Max.)			Coil Resistance (Ohms) ± 10%		
		FS2	FS3	FS5	FS2	FS3	FS5
Flagship	6	4.4	4.4	4.4	55	130	25
DPDT	12	8.7	8.7	8.5	220	520	100
Contact Ratings:	24	17.5	17.5	17.0	870	2070	400
up to 5 Amps	36	26.0	26.0	26.0	1960	4550	900
	48	35.0	35.0	34.0	3480	8300	1600
MM-5	5.0		3.6			50	
DPDT	6.0		4.2			100	
Contact Ratings:	12.0		8.4			390	
10 mA to 1 Amps	18.0		13.0			880	
	26.5		17.0			1560	

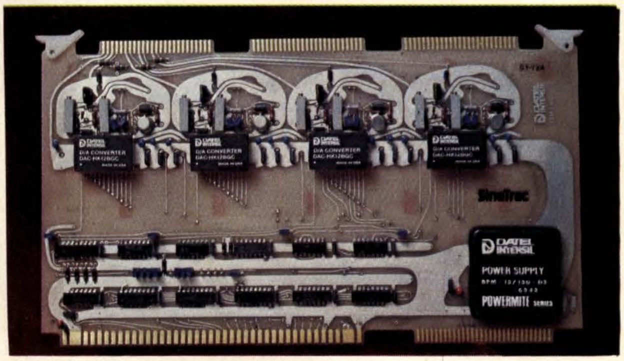
(Other tolerances and specifications upon request.)

PRODUCTION SAVINGS, RIGHT DOWN THE LINE.

Use Flagship and MM-5 relays with automated component insertion equipment to keep high volume assembly costs down. Save on PC-board space, too, with TTL-compatible MM-5 relays that fit on ½″ centers, and Flagship relays that are just ⅓ the size of competitively-priced "equivalent" plastics. Write or call for latest catalog and pricing and/or request sample on letterhead. Relay Division, Hi-G Incorporated, 580 Spring St., Windsor Locks, CT 06096; (203) 623-2481.

For more information, Circle No 104

4-channel DAC settles to 12 bits in 4 μsec



The ST-724 analog-output board provides four D/A channels with 12-bit resolution and an accuracy to within 0.05% FSR. Hardware, software and pin compatible with SBC-80 and Multibus-based μCs, it's a direct replacement for the SBC-724. Supplied with a systems manual and paper-tape-based diagnostics, the unit is controlled by Intel's RMX-80 software—facilitating installation and calibration.

A wide range of user-selectable parameters adds to the unit's versatility, and a variety of input formats (0 to 5 and 0 to 10V) and output ranges (±5 and ±10V dc), including a 4- to 20-mA current output, is available. Current outputs require a user-provided external excitation source of 18 to 30V dc.

The digital inputs from the host-computer bus are converted by four 12-bit hybrid DACs, each having an input storage register. D/A linearity lies within ±½ LSB, and differential nonlinearity equals ±½ LSB max. Zero TC (unipolar ranges) is less than ±5 ppm/°C (FSR), and bipolar offset TC is within ±10 ppm/°C of FSR. DAC settling time to ½ LSB specs at 4 μsec max, and slew rate is 20V/μsec; FSR gain TC is less than ±20 ppm/°C.

Board size stands at 12 in. wide, 6.75 in. deep and 0.5 in. thick—permitting adjacent-board slot installations. $595. Delivery, 8 wks ARO.

Datel-Intersil Inc, 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-9341. Booth Nos 1723, 25, 27. **Circle No 429**

Phase-locked loop stabilizes RF sweeper

Spanning a 10½-octave range, Model XR-1500 RF sweep generator covers 1 to 1500 MHz without band breaks. An exception to the old rule of thumb that wide-band sweepers can't also exhibit high narrow-band stability, it employs phase-lock techniques to achieve its performance: With a sweep width of 2 MHz or less, residual FM equals 1 kHz p-p and drift is 50 kHz, permitting accurate alignment of narrow filters and networks.

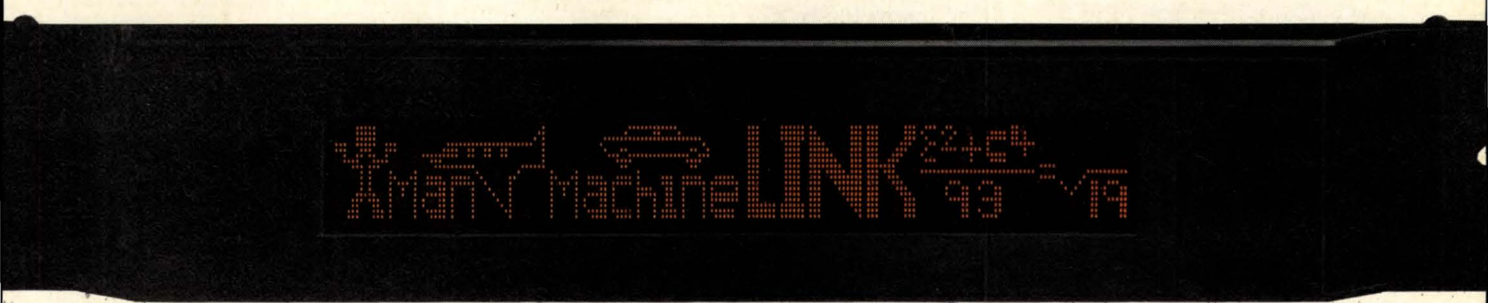
The XR-1500 incorporates a digitally generated marker system that alleviates the usual problems associated with harmonic (birdy) markers: nonconstant amplitude over the complete sweep range and interbeating between different market oscillators. Marker amplitude, width and tilt are individually controllable.

Leveled to within ±0.25 dB of the desired value, RF output is controlled by two step attenuators (10 and 1 dB/step) in conjunction with a high-resolution vernier. An LED display shows center frequency; active functions are identified by color bars and enunciators. You can switch select sweep width over 0.2 to 1500 MHz; continuous fine adjustment is provided by a vernier. Sweep rate is controllable from 0.01 to 100 Hz, and you can also synchronize it to the line or vary it manually.

Measuring 4 in. high, 12 in. wide and 15 in. deep, the XR-1500 weighs 18.5 lbs and requires only 50W from a 120/240V, 50- or 60-Hz source. Priced at $2850, it comes with the marker package, a 1-kHz modulator and RF/video-blanking capability. Delivery, 12 wks ARO.

Texscan Corp, 2446 N Shadeland Ave, Indianapolis, IN 46219. Phone (317) 357-8781. Booth No 1825. **Circle No 431**

On a single new Burroughs SELF-SCAN® panel you can vividly display
graphics
foreign languages
large and small characters
upper and lower case letters
single or multiple lines
blinking lines and characters
or anything else you want.



That's versatility.

The SELF-SCAN "One-for-All" gas plasma display offers maximum display capability on a *single* panel. This includes alphanumerics, symbols, charts, etc., for word processing, typesetting systems, signature verification, plotting trends, and many other applications.

With 17 horizontal rows and 192 vertical columns of addressable dots (3294 programmable dots in all), you can display single or multiple character lines on 5x5, 5x7, 6x12, 7x12, 8x12, etc. dot matrices (max. 17 vertical dots).

You've never seen a display this bright, crisp, or easy to read. It's rugged and reliable. Get all this, including drive electronics, for only $262 per display in lots of 100. And, you get 90-day delivery.

Nothing . . . but nothing beats this Burroughs SELF-SCAN panel display. We'll prove it! Write **Burroughs OEM Marketing Corporation**, Burroughs Place, Detroit, MI 48232, (313) 972-8031. In Europe, High Street, Rickmansworth Hertfordshire, England. Telephone 09237-70545.

For general information, Circle no 33
For detailed specifications, Circle no 34

Burroughs

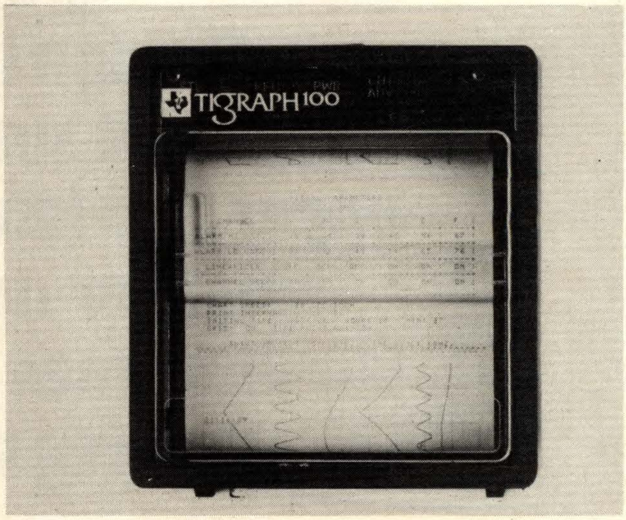
Electro/80 Products

Recorder achieves 100-dots/in. resolution

By employing a 1-piece solid-state thermal printhead, the Tigraph 100 graphic display achieves 100-dot/in. resolution across its full 4.2-in. recording width. Case size (5.75 in. wide×6.25 in. high) permits side-by-side mounting of three units in a 19-in. rack panel—providing up to 18 data-recording channels in a height of only 7 in.

The recorder's only moving parts are contained in its chart drive, powered by a print-rate-synchronized stepping motor. And because the unit prints all pertinent data, including timing marks and grids, you needn't use preprinted sprocketed chart paper. A print rate of 5 lps max combines with 282 chart speeds (0.3 in./hr to 3 in./min) to provide 164 days of recording on a single chart 94 ft long.

Sporting a 10-MΩ impedance, the recorder provides a standard input range that spans 0.5 to 2V (1 mV to 100V optional). Full-scale specs include resolution of 0.25% and accuracy of ±0.5%. Zero-offset adjustment can occur over ±100% of input span, and zero drift equals 0.6 μV/°C max. Common-mode rejection stands at 120 dB at 60 Hz to 100V dc or ac pk.



Operating from 117/230V, 50 or 60 Hz, the unit typically requires 65W. $1995 for the basic 6-channel model. Delivery, 6 wks ARO.

Texas Instruments Inc, Box 1443, M/S 663, Houston, TX 77001. Phone (713) 490-2888. Booth Nos 596, 97. **Circle No 430**

Couplers ease IEEE-488 interfacing

Interfacing instruments to the industry-standard IEEE-488 bus is now easier and less expensive: A Series 2488A coupler allows you to buy and use an instrument without a built-in interface and later add the bus capability when you need it.

The unit interfaces several standard TTL-compatible instruments to the IEEE-488 bus by translating their bit-parallel or serial codes, signals or data into the bus' byte-serial format. In operation, the coupler provides all the necessary functions to interconnect an instrument with a bus controller and/or other instruments and functions as a listener, talker or both.

Passive cabling interconnects your instruments to the coupler. You can connect several couplers in parallel on the bus; the system controller outputs command their respective instruments and accept their data. All bus cabling is terminated by the standard IEEE-488 connector.

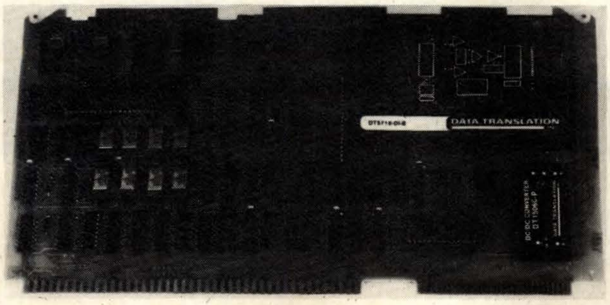
By properly cabling two instruments to the coupler, you can employ it as a talker/listener to control one and take data from the other. In any mode of operation, the coupler is a transparent device, acting as though it resides in the instrument being addressed.

The standard 2488A's μP follows programs contained in a PROM programmed for the manufacturer's and other firms' general-purpose instruments. $995; interconnect-cable set, $165.

Ballantine Laboratories Inc, Box 97, Boonton, NJ 07005. Phone (201) 335-0900. Booth No 1509. **Circle No 432**

Electro/80 Products

ANALOG DAS



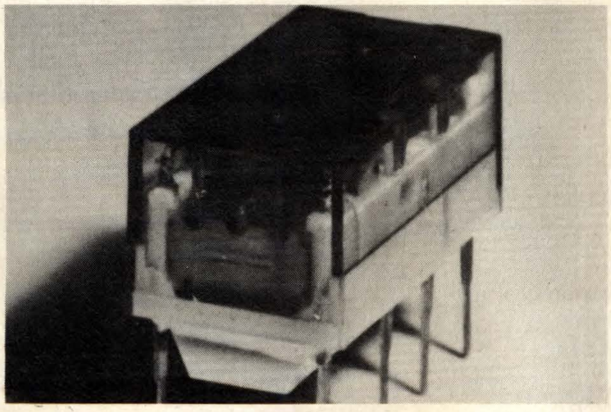
Although it's called an intelligent analog peripheral, Model DT3752 is really a µC-based, stand-alone, single-board analog data-acquisition system. The standard version provides 16 single-ended or eight differential-input multiplexed analog channels, a 12-bit ADC, 35-kHz throughput rate, 16k bytes of dual-port RAM, on-card DMA and serial as well as parallel I/O.

Sporting a 100-MΩ, 100-pF ON input impedance (100 MΩ, 10-pF OFF), the unit provides 0 to 5V, ±5V, 0 to 10V and ±10V jumper-selectable input ranges. Programmable-gain-amplifier gains of 1, 2, 4 and 8 further extend the input-range options, with gain and offset errors adjustable to zero. ADC linearity equals ±½ LSB, and overall analog accuracy stays within ±0.03% FSR. Common-mode voltage specs at ±10V max, and CMRR at 60 Hz is 76 dB min.

Provided with user's manual, software diagnostic tape and either differential or single-ended inputs, the DT3752 costs $1895.

Data Translation, 4 Strathmore Rd, Natick, MA 01760. Phone (617) 655-5300. Booth Nos 602, 04. **Circle No 400**

PC-BOARD RELAYS

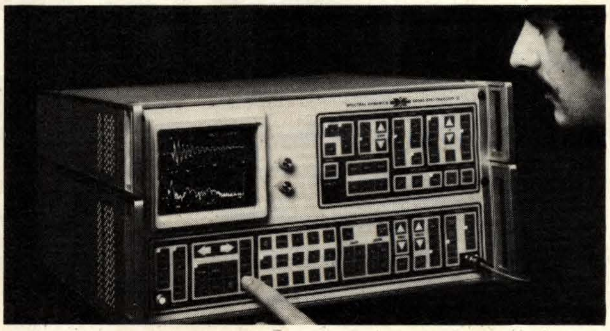


Sealed against wave soldering and cleaning-solvent damage, RD Series DIP-sized relays offer a wide selection of coil-voltage and contact configurations. Insulation resistance specs at 100-MΩ min, and dielectric strength between contact and coil or opposite-polarity contacts equals 1 kV ac.

Available coil voltages are 3, 5, 6, 12 and 24V dc; requiring 0.5W typ, the relays operate in 6 msec max and release in less than 4 msec. Contact settling time specs at 5 msec max, and electrical life expectancy is more than 500,000 cycles at rated load. Contact arrangements include spdt (3A max), dpdt (2 and 3A), spdt/dpdt (2A) and a 2A-rated, 2-coil 4pdt unit. $6.20 for a dpdt, 3A (Model RD2V-33) unit.

IDEC Systems & Controls Corp, 3050 Tasman Dr, Santa Clara, CA 95050. Phone (408) 988-7500. Booth Nos 2020, 23. **Circle No 401**

SIGNAL ANALYZER



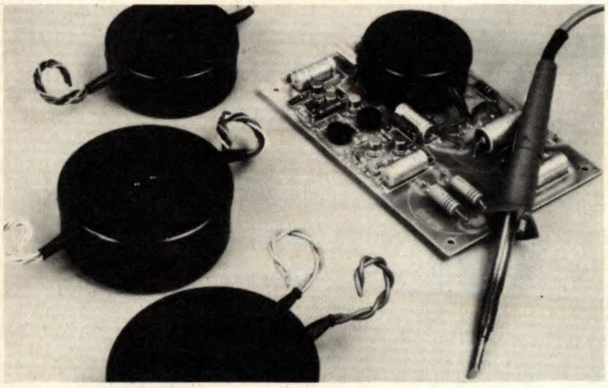
Featuring a full 70-dB dynamic range and touch-control front-panel operation, Model SD345 FFT signal analyzer provides 400-line spectral analysis to 100 kHz. Options include IEEE-488/RS-232 I/O interfaces, ⅓- and full-octave acoustic data analysis and digital spectrum expansion to 100×.

With an input impedance of 100 kΩ, vertical sensitivity spans 10 mV to 20V in 11 steps. The unit's frequency capability ranges from 1 Hz FS to 100 kHz FS in 16 steps.

Operating over a 5 to 45°C range, the unit requires 350W at 115/220V ac. $12,500. Delivery, 45 to 60 days ARO.

Spectral Dynamics, Box 671, San Diego, CA 92112. Phone (714) 268-7100. Booth 603. **Circle No 402**

POWER TRANSFORMERS



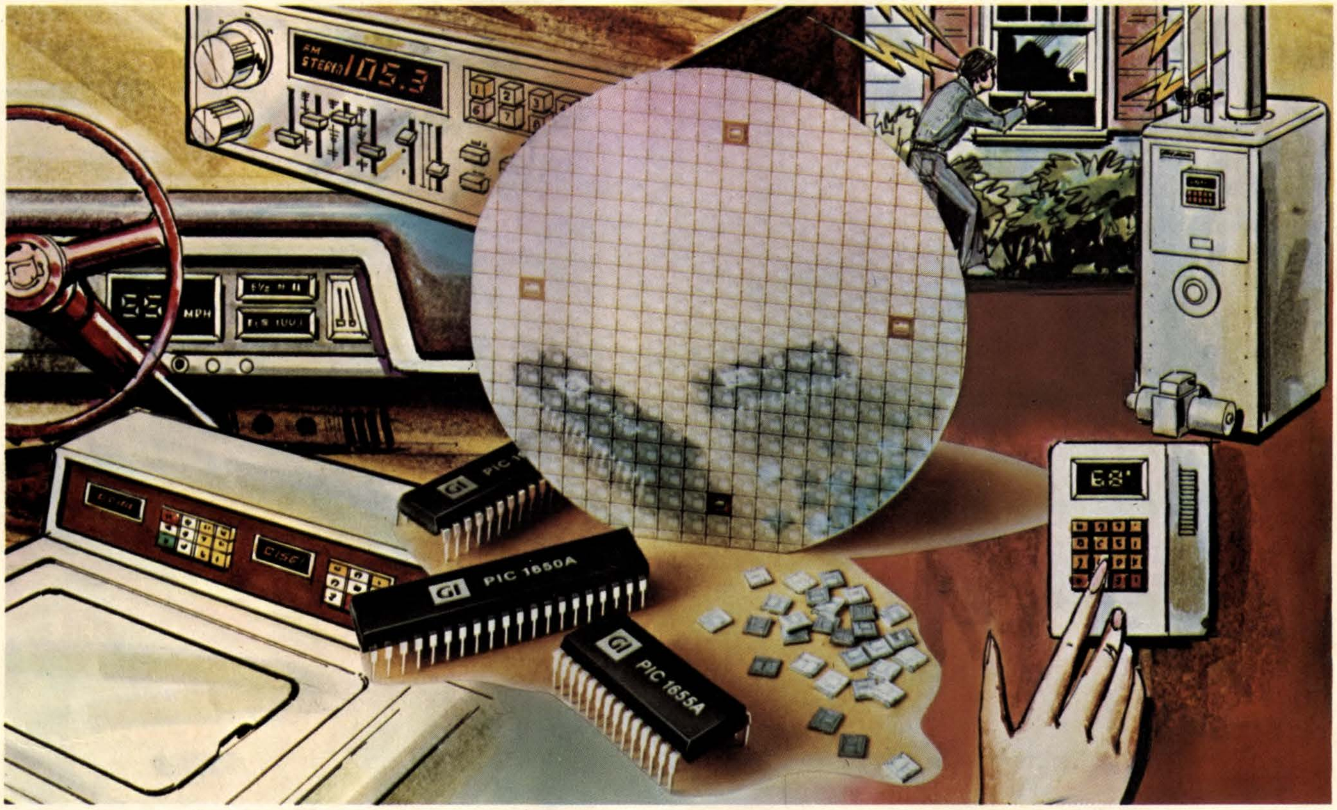
Employing toroidal cores, devices in this family of 50/60-Hz power transformers manufactured by Avel-Lindberg Ltd are about 50% smaller and lighter than equivalently rated units. Because there's no air gap, reluctance losses are low—important in "instant-on" applications—and electrically induced hum or noise is eight times lower than that exhibited by stacked, laminated transformers.

Derived from 50 basic types, units in the 40/30 Series come in a wide range of primary and secondary voltage and current combinations. Encapsulated in resin-filled thermoplastic cases, they're offered in flexible-lead and pc-board styles; mounting occurs through 8-32 threaded bushings molded into the case.

All units have dual isolated primary windings, permitting parallel connection for 115V operation or a series hook-up for 230V applications. Additionally, the transformers have dual secondary windings, permitting series, parallel or completely separated outputs. Nominal load ratings extend from 15 through 130 VA, with dual secondaries of 6V (1.25A per winding min) to 40V at 1.62A per winding. 15 VA, $21.96; 130 VA, $35.34.

Connecticut Research Associates Inc, Box 37, Danbury, CT 06810. Phone (203) 744-3020. Booth 2460. **Circle No 403**

4,000,000 PICs Prove Our Point.



The point is, more designers are choosing General Instrument PIC microcomputers than ever before. And they're using them in an ever-widening range of applications; including consumer appliances, energy management systems, electronic games, security systems, keyboards, display drives, TV/radio tuning systems, and automotive dashboard instrumentation, to name but a few.

That's why General Instrument delivered more than four-million 8-bit microcomputers in 1979; more than *twice* as many as our leading competitor.

Big numbers, certainly, but more than that, our record is a direct reflection of the success and designer acceptance of General Instrument's business philosophy: Deliver high quality products at competitive prices, backed by comprehensive customer service and support. For example, PIC can revolutionize the performance and energy efficiency of universal motors. As a closed loop controller, PIC provides soft starting and current limiting, improves efficiency under variable loads, protects against motor-jam, prevents overheating plus controls speed. What about cost? Remember the facts: General Instrument's PIC microcomputers are already proven cost effective in high volume applications.

To support our many users, we offer a complete set of hardware and software aids, including the PICAL two-pass assembler program and PICES In-Circuit Emulation System. These help customers in their design, development, and evaluation of a particular application. In short, we deliver more microcomputers, because our microcomputers deliver more to our customers. And that's the *real* bottom line.

For more information on the PIC Series, write to: Microelectronics Division, General Instrument Corporation, 600 West John Street, Hicksville, New York 11802, Attention: Literature Department, or call 516-733-3107.

We help you compete.

GENERAL INSTRUMENT

How Nicolet fits into this box than

Fitting more oscilloscope into a cubic foot took one big first step —the use of modern digital methods. Plus a lot of little steps such as recognizing what's *"oscilloscope,"* what's not, and keeping the *"not"* outside where it belongs. Here are some of the great things the digital method has made possible.

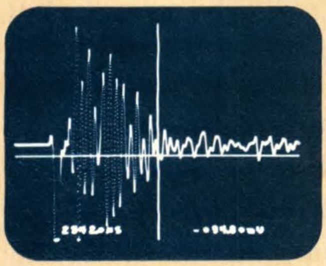
Resolution and Accuracy

Scientists and engineers (thousands of them)

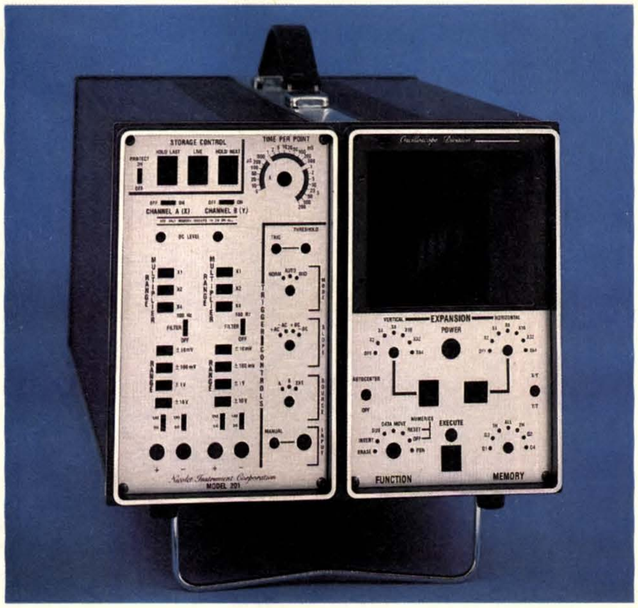
are delighted with the Explorers' 4000-line resolution, and accuracy literally an order of magnitude better than that of analog scopes and other digital scopes.

Super Storage

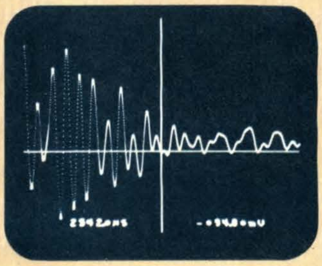
Users appreciate the Explorer's waveform

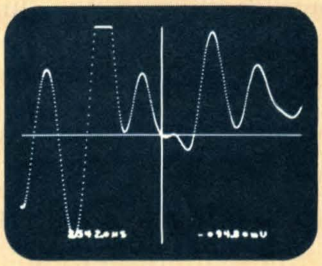


storage. At equivalent writing rates of up to 50 cm/μsec an Explorer can clearly remember, every time, without fade or bloom, literally hundreds of times as much about signals as the finest analog



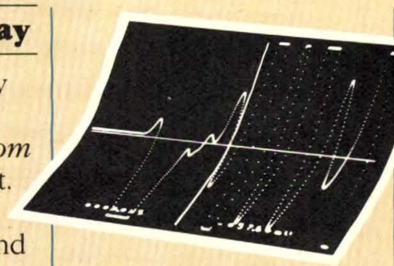
storage scopes. Best of all, Explorers store waveforms with no hassle.



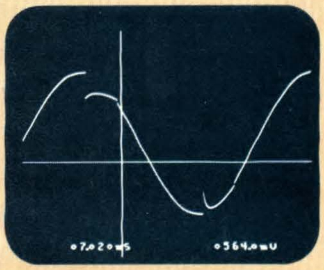


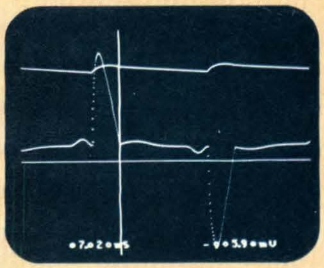
64X Zoom Display

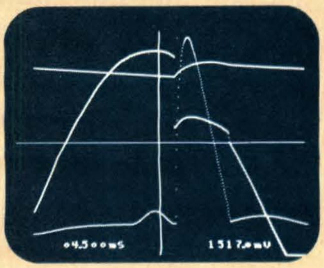
Explorer users enjoy the convenient display that allows them to *zoom in* on details of interest. They also can superimpose "old" signals and



live, "fresh" signals for extremely sensitive observation of differences or changes. They can







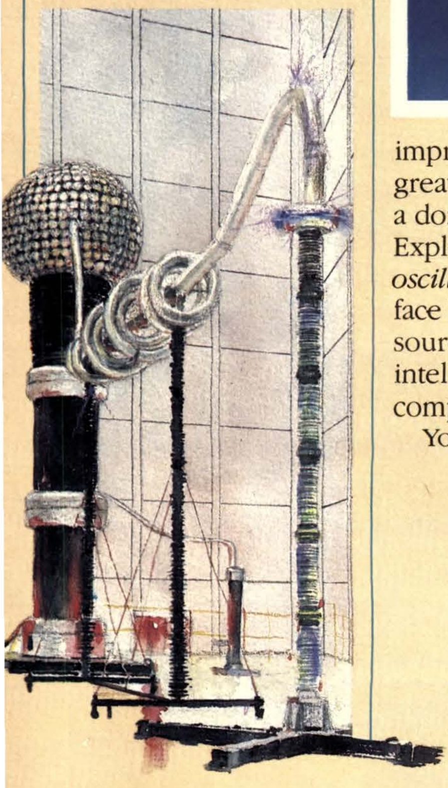
superimpose two (or four) old waveforms, or two live waveforms. And zoom in on details with up to 64X digital display scale magnification.

more oscilloscope anyone else.

They're Pure Oscilloscopes

The digital method results in other welcome improvements. Sweep speeds that range down to days in length to allow you to precisely measure very slow phenomena. Pre-trigger sweep start

allows you to see what precedes an event as well as what follows. XY operation provides even greater precision



than servo-driven XY recorders, but at speeds a million times greater. Speeds as high as most analog XY oscilloscopes.

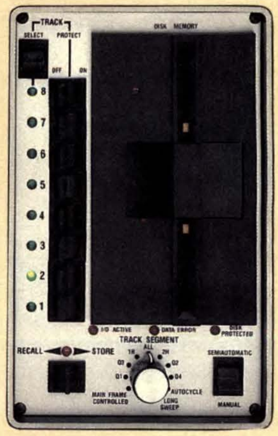
All of these are oscilloscope function improvements. The

improvements include greater ease of use, for a dozen reasons. The Explorers are *"pure oscilloscope."* They interface between the signal source and the most intelligent and powerful computer in the world.

You.

Disk Memory Option

The optional, built-in disk memory can remember signals for years, storing as much data per disk as you could capture on thousands of photos. Disks are inexpensive and reusable, don't need developing, and store data at the touch of a button.



Matching Your Needs

You can choose the Explorer model that fits your measurement needs from a family of instruments, plug-ins and IEEE-488 or RS-232 options.

For More Details

To get complete information quickly, to discuss your application or to arrange a demonstration, call (608) 271-3333.

NICOLET INSTRUMENT CORPORATION
OSCILLOSCOPE DIVISION
5225 Verona Road
Madison, WI 53711
Telephone: (608) 271-3333
TWX: 910-286-2737
Sales and Service Offices Worldwide

ELECTRO SHOW BOOTHS 117 & 119

For more information, Circle No 106

Electro/80 Products

SIGNAL GENERATOR

Spanning 300 kHz to 650 MHz, the Model 460 synthesized signal generator combines a −140-dBc/Hz noise-floor figure with stability and accuracy specs of $\pm1\times10^{-8}$/24 hrs.

Output frequency (displayed on a 9-digit LED readout) is spin-wheel tuned in steps of 1, 10, 100 and 1000 kHz/step with 100 steps/turn. A vernier control provides continuous fine adjustment over a 1-kHz range with 1-Hz resolution.

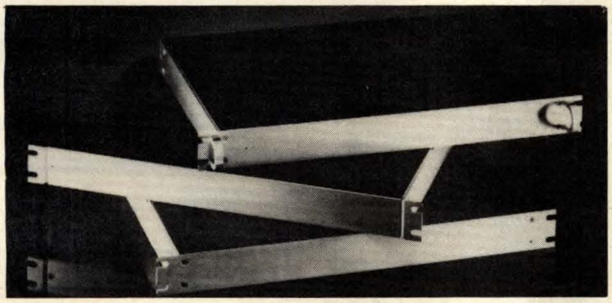
Internal AM frequencies are 400 and 1000 Hz; an external 3-dB bandwidth capability extends from dc to 100 kHz. External dc-coupled FM rates extend to 150 kHz with maximum peak deviations of at least 300 kHz below a 100-kHz rate. A maximum 300° pk phase deviation is possible for PM rates to 50 kHz.

Options include a built-in frequency doubler and a GPIB interface. $13,850. Delivery, 6 wks ARO.

Alltech Div Cutler-Hammer, 2070 Fifth Ave, Ronkonkoma, NY 11779. Phone (516) 588-3600. Booth Nos 216-219.

Circle No 404

INSTRUMENT CASES



Offered with blue, black or brown vinyl-clad aluminum top and bottom covers, FC Series instrument cases are suitable for mounting small components and large pc boards in standard 19-in. racks. All versions have 1¾-in. front-panel heights and are available with 10- or 12-in. inside depths.

Several selective-ventilation patterns for the top and bottom covers are standard; customer-specified configurations are optional. A 5⁄16-in. tubular threaded front-to-back brace and heavy, serrated, front-panel finger pulls are also available. $37 (50).

Buckeye Stamping Co, 555 Marion Rd, Columbus, OH 43207. Phone (614) 445-8433. Booth Nos 1422, 24.

Circle No 405

PROM-PROGRAMMER MODULE

The UniPak module augments the capabilities of its manufacturer's System 19 PROM and logic-device programmer. You set up the module by simply entering the appropriate 4-digit code for a particular PROM via the System 19's hexadecimal keyboard; the unit's software assembles the programming algorithm and

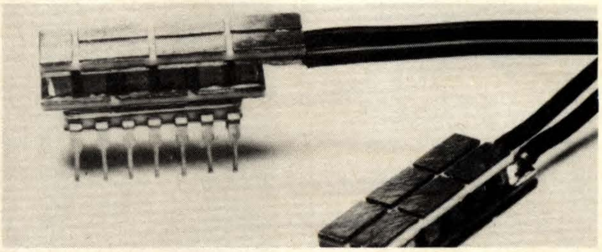
selects the correct 16- through 28-pin PROM socket.

The algorithm permits programming of more than 200 MOS and bipolar PROMs with typical time savings claimed of one-third to one-half compared with standard programming methods. (For example, a 64k EPROM can be programmed in less than half the time required for a 16k device using standard methods, according to the manufacturer.) $1800. Delivery, 6 wks ARO.

Data I/O Corp, Box 308, Issaquah, WA 98027. Phone (206) 455-3990. Booth Nos 1730, 32.

Circle No 407

THERMOELECTRIC COOLER



Sandwiched between a DIP and its heat sink, this small thermoelectric module can pump as much as 3.5W of heat out of the DIP.

Measuring 0.3×1.025×0.21 in. overall (active area covers 0.9×0.3 in.), the unit has a maximum heat-pumping capacity of 3.3W. Operating at a nominal 0.7V dc, it requires as much as 9A, depending on the differential DIP-to-ambient temperature. The module can heat or cool within a maximum temperature differential of ±60°C so long as the maximum operating-temperature limit of 125°C isn't exceeded. Model 801-1029-01-00-00, $4.90 (OEM quantities).

Cambridge Thermionic Corp, 445 Concord Ave, Cambridge, MA 02238. Phone (617) 491-5400. Booth No 2028.

Circle No 408

STEPPER TRANSLATOR

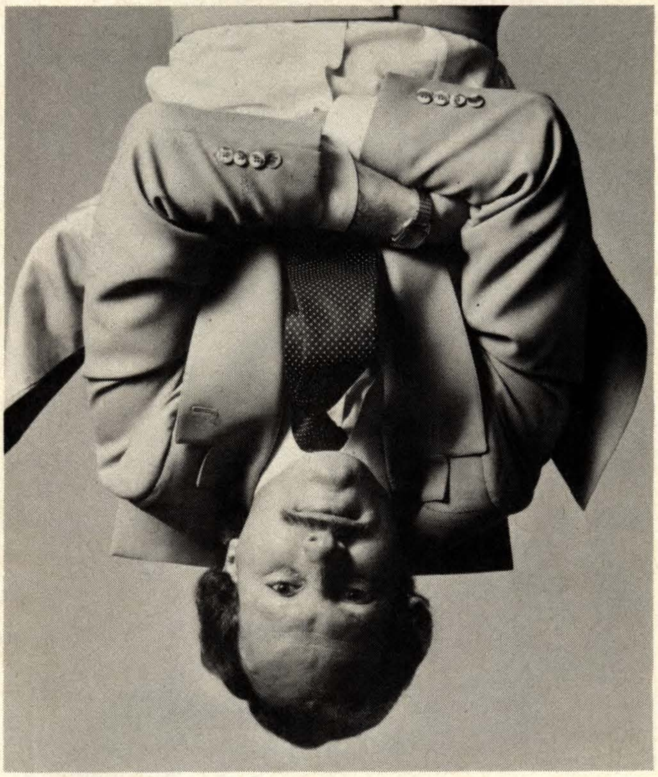
Providing both RS-232 and TTL input/output compatibility, the TM600 translator can provide up to 0.8 hp to Slo-Syn-type stepper motors. In addition to μP controllability, this modular open-frame unit has an on-board oscillator, permitting manual (off-line) operation at up to 20k half-steps/sec (0.9° increments).

In the full-step mode, the driver's base speed ranges from 0 to 1k steps/sec; the high-speed range offers 400 to 20k steps/sec.

Designed to control M092 to M172 frame-size motors, the unit requires 120/240V at 50/60 Hz and 12A max. Maximum overall dimensions are 15¾×13⅛×10¼ in., and weight equals 54 lbs typ. Provided with temperature and supply-voltage monitors,

"We stock 150 different analog I/O boards and guarantee delivery in five days. We're turning this business upside down."

Fred Molinari, President



By our competitors' standards, we run a pretty unorthodox operation.

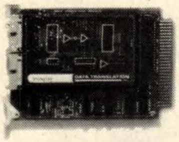
We stock all the analog I/O our customers need, and we deliver it quickly.

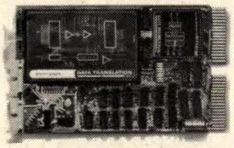
Some of our boards are unique. Many are technically better than their "equivalents" and less expensive to boot.

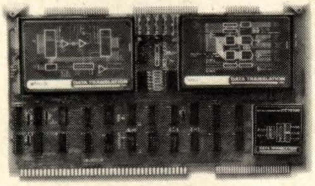
In fact, we offer the widest selection of high accuracy, high resolution DAS boards in the business.

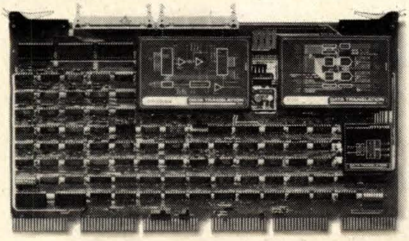
We stock more Multibus™ compatible DAS than Intel or National. Even some advanced models with on-board intelligence. More LSI-11 and PDP-11 DAS than DEC. And our prices are lower.

We can deliver dual height boards for LSI-11 and quad-size boards with features no one else has. Like DMA, 125KHz throughput to memory, isolated low level, 64 channel analog input capability and DEC compatibility.









What's more, we have an extensive software library to tie it all together. A new catalog to make ordering easier. And free diagnostics and user manuals.

The performance of our PDP-11 Unibus™ analog boards is also unequalled, thanks to isolated low-level, DMA I/O, 64 channel analog input capability, DEC compatibility, and 8 channel analog outputs.

Whether your application is laboratory or industrial, we offer you the means to upgrade your system quickly.

Unlike our "competitors," we'll never leave you hanging.

Data Translation, 4 Strathmore Road, Natick, Massachusetts 01760, (617) 655-5300, Telex: 948474. In Europe: Data Translation Ltd., Reading, Berkshire/England. Phone (0734) 669-335; Telex: 847482.

We stock the industry's widest selection of microcomputer analog I/O systems for DEC LSI-11 and PDP-11, Intel Multibus, Mostek/Prolog STD Bus, Zilog, and Computer Automation.

DATA TRANSLATION

SALES OFFICES AZ602-994-5400, CA 415-965-9180, 213-681-5631; CO 303-371-2422; FL 305-791-9292, 813-725-2201, GA 404-455-7222; IL 312-960-4054; IN 317-788-4296; MA 617-655-5300; MD 301-636-1151; MI 313-227-7067; MN 612-441-6190; NC 919-723-8102; NJ 609-428-6060; NM 505-292-1212, 505-523-0601; NY 516-488-2100; OH 513-253-6175; OK 405-528-6071, OR 503-297-2581; PA 412-327-8979; TX 713-988-9421, 512-451-5174, 214-661-0300, 713-780-2511, 512-828-2251; UT 801-466-6522; WA 206-455-5846; CANADA 416-625-1907.

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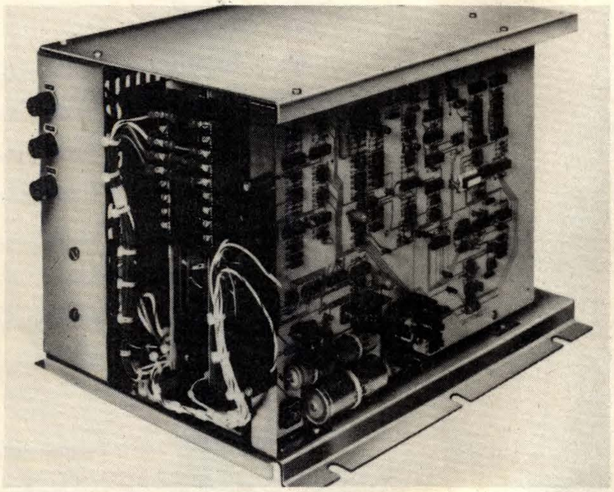
For more information, Circle No 107

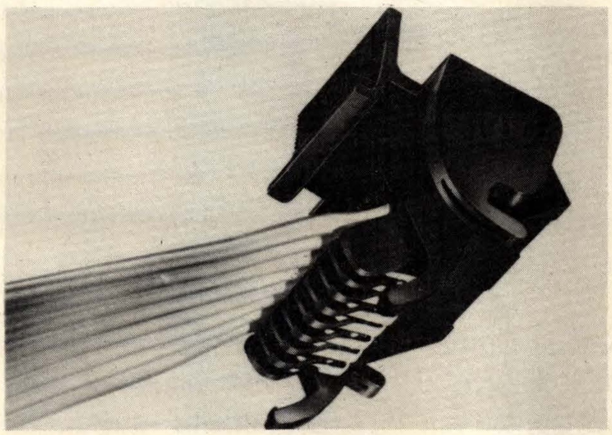
Electro/80 Products



the TM600 operates over 0 to 55°C and costs $1250.

Superior Electric Co, Bristol, CT 06010. Phone (203) 582-9561. Booth Nos 2310, 2409-10. **Circle No 406**

ZIF CONNECTORS



Employing an insulation-displacement contact scheme, Midas Series zero-insertion-force connectors provide a disconnectable interface with pc-board interior surfaces—without the need for an on-board mating unit. Their 4-slot design provides eight separate contact points with each lead, eliminating the need for wire stripping and soldering.

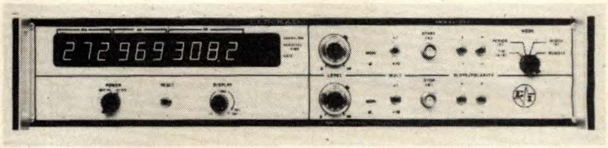
Available with eight through 24 positions, the 100-mil-centered connectors accommodate 24- and 26-AWG leads, permitting currents up to 4.5A.

Because these connectors require so little pc-board real estate, they should find use in such high-density applications as home computers and alarm systems. Approximately $0.035 per position.

T&B/Ansley Corp, 817 Morse Ave, Schaumberg, IL 60193. Phone (312) 893-8013. Booth Nos 1234-36, 1333-35.
Circle No 409

INTERVAL COUNTER

A combination of dual start/stop clock oscillators and a low-speed-logic vernier-interpolation technique allows Model 797 time-interval counter to achieve 100-psec resolution. Trigger level, polarity and slope are all independently adjustable for



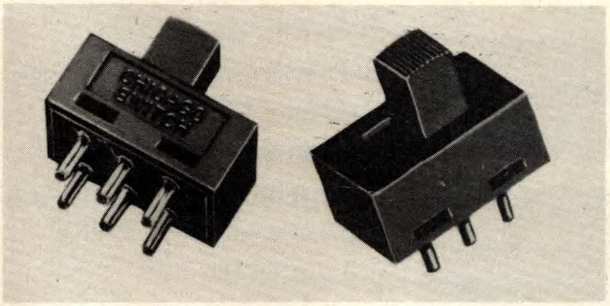
both the Start (A) and Stop (B) inputs, permitting three operational modes:

- Tim—Measures the interval between two events; these can be selected separate trigger levels or (for rise- and fall-time measurements) the 10%/90% levels of a single pulse
- Per—Measures the period (duration) of one input cycle on A input
- Width—Measures the width of one input pulse on A.

An optional GPIB interface provides control of mode, slope, polarity and trigger-level functions and outputs the 10-digit interval data. Other options include a temperature-controlled crystal oscillator, 10-turn potentiometers for start/stop trigger level and a 19-in. rack-mounting kit. $5000. Delivery, 16 wks ARO.

E-H International Inc, 7303 Edgewater Dr, Oakland, CA 94621. Phone (415) 638-5656. Booth Nos 1407-09.
Circle No 410

SLIDE SWITCHES



Featuring 2-piece bodies, Series 124 slide switches can be wave soldered without contaminating their contacts. Only the lower base inserts into the pc board and is wave soldered and cleaned; the units' top half is then hand-snapped on.

The switches' hard-gold-and-nickel-over-brass contacts—rated for 500 mA at 125V ac—have initial resistance of 0.02Ω and mechanical life expectancy of 50,000 operations. Insulation resistance equals 100 GΩ, with an interterminal breakdown rating of 1 kV/60 Hz.

Standard configurations include spst, spdt, dpst, dpdt and Form Z. With an overall body size of $0.5 \times 0.3 \times 0.24$ in., the units operate over −40 to +100°C. SPST, $0.28 (10k).

Chicago Switch Inc, 1714 N Damen Ave, Chicago, IL 60647. Phone (312) 489-5500. Booth No 2322. **Circle No 411**

IC TESTER

Utilizing a control-console/device-module architecture, the LSI-1 integrated-circuit tester can perform full-function parametric evaluation of μPs, RAMs, ROMs and peripheral chips.

The NMOS-μP-governed control console outputs up to two supply voltages, handles system housekeeping tasks, downloads device-module test programs and evaluates test results. Clock independent, the console can interface to an automatic IC handler and an RS-232-compatible data-logging port.

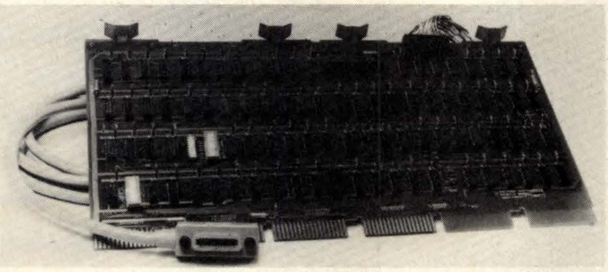
Because each device module contains its own clock, it can perform device tests up to 50 MHz without burdening the

For more information, Circle No 108

control console. A key feature of the test system is its no-reference-part approach: Device modules contain ROM-stored stimulation and results patterns, eliminating the need for known-good devices. $8495 for basic unit; individual device modules from $1500.

***System Sales Inc, 3330 W Dundee Rd, Northbrook, IL 60062. Phone (312) 564-9280. Booth No 1505.* Circle No 412**

GPIB INTERFACE BOARD



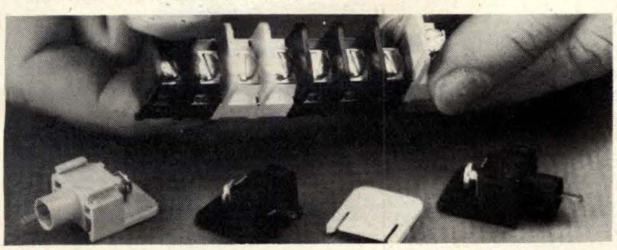
Plugging into any hex-wide SPC slot, the GPIB11-2 interface provides hardware for decoding GPIB talker, listener and controller functions and can be used in single- or multicontroller systems.

A switch-selectable option provides transfer rates of up to 500k bytes/sec (3-state operation) or 250k bytes/sec (open collector). The high-speed operation is provided by circuitry that automatically holds the Unibus for 16-byte bursts before releasing it to higher priority tasks.

Support software includes drivers, utilities and an interactive control program. The driver program, including the interrupt-service routines, can be assembled as a FORTRAN-, macro- or BASIC-callable subroutine package for stand-alone use or as a handler under RT-11 or RSX-11 operating systems. $1995, including 4m cable and software.

***National Instruments, 8900 Shoal Creek Blvd, Austin, TX 78758. Phone (512) 454-3526. Booth No 1503.* Circle No 413**

TERMINAL BLOCKS



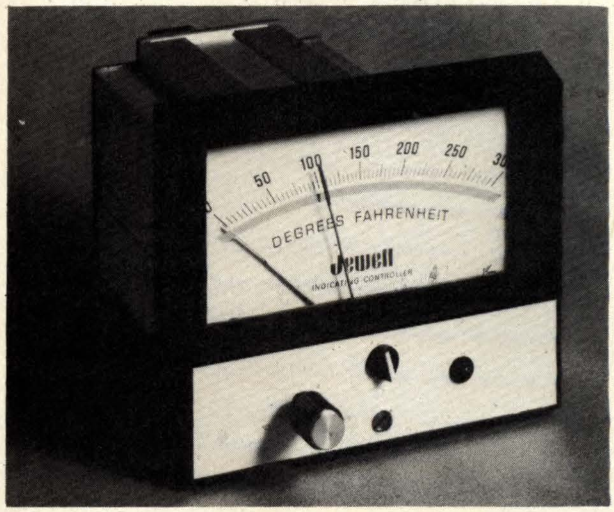
Regular barrier terminal blocks are generally molded in long, single-color lengths—requiring users to stock a range of sizes and figure out a color-coding scheme. Not so with JB6 and JB7 Series units.

Both versions of the click-together blocks are available in blue, red, green, black and natural, and both carry a 20A rating; the 3/8-in. version is spec'd at 300V and the 7/16-in. type at 600V. Terminal styles include pc pin, solder turret, quick connect (insulated and uninsulated feedthrough) and surface mount.

Molded of UL 94V-0-rated nylon, the blocks have a 105°C max operating temperature. $9.40 (100) for a typical unit.

***RDI/Reed Devices Inc, 525 Randy Rd, Carol Stream, IL 60187. Phone (312) 682-4100. Booth No 3119.* Circle No 414**

SETPOINT CONTROLLERS



Featuring a wide selection of ac, dc and temperature ranges, 368 through 370 Series indicating setpoint controllers can provide either on/off or time-proportioning control. Housed in a standard 1/4 DIN housing, they provide a 4-in. mirror-backed scale and offer a choice of vertical or horizontal mounting.

Fifteen standard dc current ranges span 0 to 5 μA (5-kΩ input resistance) through 0 to 50A. The dc-voltage-measuring models span 0 to 5 mV (680Ω) through 0 to 300V (3 MΩ); the two ac units cover 0 to 5A (0.02Ω) and 0 to 150V at 1 kΩ/V.

The single—and optional double—setpoints control a 5A dpdt relay and are settable over the full-scale range. With a 1-sec-max meter-response time, the units require 5W typ from a 105/130V or 210/260V ac source.

Model 368 (dc ranges), $148; Model 369 (ac ranges), $165; Model 370 (temperature ranges), $176.

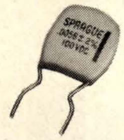
***Jewell Electrical Instruments Inc, Grenier Field, Manchester, NH 03108. Phone (603) 669-6400. Booth No 2249.* Circle No 415**

CLOCK GENERATOR

Containing four synchronized 50-MHz channels, the PI-100A clock generator is a plug-in instrument that interfaces with Tektronix TM-500 Series power modules. Its 2V min outputs can drive TTL and ECL devices over unterminated 50Ω lines.

Master clock A generates clock periods varying from 20 nsec to 2 msec; it can be synchronously gated (producing pulse bursts) or single-pulse-to-pulse triggered at rates to 50 MHz. Channels B, C and D can each be delayed from 10 nsec to 1 msec with respect to A and furnish normal or inverted outputs. All

TYPE 287P STYRACON® CAPACITORS



LOW COST, TIGHT CAPACITANCE TOLERANCE

- Polystyrene film dielectric . . . rugged epoxy coating.
- Capacitance tolerances . . . ±1%, ±2%, ±3%.
- Extended foil construction avoids reliability and inductance problems of laid-in-lead imports.
- Short lead times . . . unlike uncertain deliveries of imported film capacitors.
- Standard capacitance values from 100 pF to .1 μF. Voltage ratings of 50 and 100 WVDC.

Write for Engineering Bulletin 2052.3 to
Technical Literature Service, Sprague Electric Co.,
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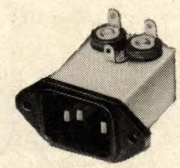
SERIES JX5400 FILTERS

. . . U.L. Recognized



SUPPRESS POWER LINE EMI

- Reduce noise emanating from or interfering with equipment.
- Furnished in 4 different circuit configurations suppressing both common mode (line-to-ground) and differential mode (line-to-line) interference.
- Ideal for filtering external transients in 150 KHz—30 MHz range in equipment containing low-level logic circuitry.

Write for Engineering Bulletin 8212 to
Technical Literature Service, Sprague Electric Co.,
491 Marshall St., North Adams, Mass. 01247.

4SF-7152R1

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

SPRAGUE
THE MARK OF RELIABILITY
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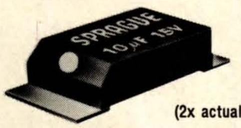
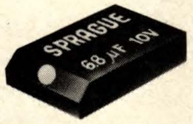
For more information, Circle No 110

TYPE 193D DOMINO® CAPACITORS





(2x actual size)

HIGH μF, LOW PROFILE

- Solid-tantalum capacitors with two standard terminal configurations . . . leadless with flush solderable pads, or extended-tabs.
- Fully-molded construction eliminates possibility of mechanical damage during handling and mounting.
- Excellent stability . . . undesirable parametric changes and catastrophic failures due to mechanical degradation are minimized.
- Capacitance values from .082 to 100 μF, voltage ratings from 3 to 35 WVDC.
- For —55° C to +85° C operation . . . to +125° C with voltage derating.

Write for Engineering Bulletin 3532A to
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491 Marshall St., North Adams, Mass. 01247.

4SE-8141R1

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

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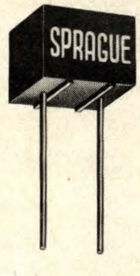
For more information, Circle No 111

TYPE 834P METFILM® 'S' CAPACITORS



THE 'ZERO TC' CAPACITOR

- Metallized polysulfone-film section in rectangular molded plastic case offers superior electrical characteristics, small size, rugged construction.
- Capacitance change is typically ±0.25% over broad temperature range of —40°C to +125°C.
- Low dissipation factor (high Q), low dielectric absorption.
- Capacitance tolerances as close as ±1%.

Write for Engineering Bulletin 2610 to
Technical Literature Service, Sprague Electric Co.,
491 Marshall St., North Adams, Mass. 01247.

4SD-8123R1

Dearborn electronics division
SPRAGUE ELECTRIC COMPANY

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Heinemann has it. NOW

A resettable pushbutton circuit protector– small size, small price.

We call it the **Re-Cirk-It**® protector. You'll call it the perfect replacement for those old-fashioned cylindrical fuses and fuseholders.

The **Re-Cirk-It** protector looks like a conventional ⅝" fuseholder. In fact, it installs in the same panel space. But that's where the resemblance ends. Your customer will never have to worry about blown fuses with the **Re-Cirk-It** protector. Or nuisance tripping caused by normal starting surges. A white band signals when it's tripped, with reset as easy as pushing a button. No bothersome fuses to replace. No unnecessary and expensive service calls.

Of course, the **Re-Cirk-It** protector is UL-recognized and CSA-approved. Current ratings from 0.25 through 15A at up to 250Vac and 32Vdc are available at your Heinemann distributor's.

Don't re-fuse. **Re-Cirk-It!** Request Bulletin KD-4001 or call our toll-free number: **1-800-257-9590.**

The only independent manufacturer of fully-magnetic circuit breakers.

We serve you better.

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For more information, Circle No 259

A low cost storage scope with autotrigger...another better product from Kikusui.

We call it the 5516ST. Rugged and portable, this dual-trace 10MHz scope will do everything that Tek's T912A will do...and a lot more. It offers a combination of features that are unequalled by any other instrument in its price range. Features such as an *enhance* capability that lets you vary the writing speed from 20 to 40 usecs/cm; a *hold* button that freezes the waveform on the CRT for up to one hour; and a patented *autoerase* that lets you set any predetermined hold time from one to thirty seconds. After the preset time the waveform is automatically erased and the sweep circuit is reset. The 5516ST also has an ADD mode, an X-Y mode and four trigger modes.

But there's a lot more to this KIK-scope than performance and specifications. For one thing, your KIK-scope is completely modular. All components are on plug-in boards. In the event of trouble, just send us the faulty board and we'll send you a replacement by return mail. This swap-out program assures fast maintenance turnaround and minimum down-time. Then there's our 2-year warranty (CRT 1-year). That's twice as long as the warranty from most manufacturers and a reflection of the confidence we have in the quality components and workmanship that go into all KIK-scopes.

And, just to give you a little added assurance, your KIK-scope comes with a 30-day "satisfaction-or-your-money-back" insurance policy. We wouldn't make an offer like this if we weren't sure we had a better scope.

In addition to the Model 5516ST, there are nine other KIK-scopes in the line from 10MHz to 50MHz. They're described in our new catalogs along with our lab power supplies and other instruments.

Kikusui International Corporation
17121 South Central Ave., Suite #2M
Carson, California 90746
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INTERNATIONAL CORP.
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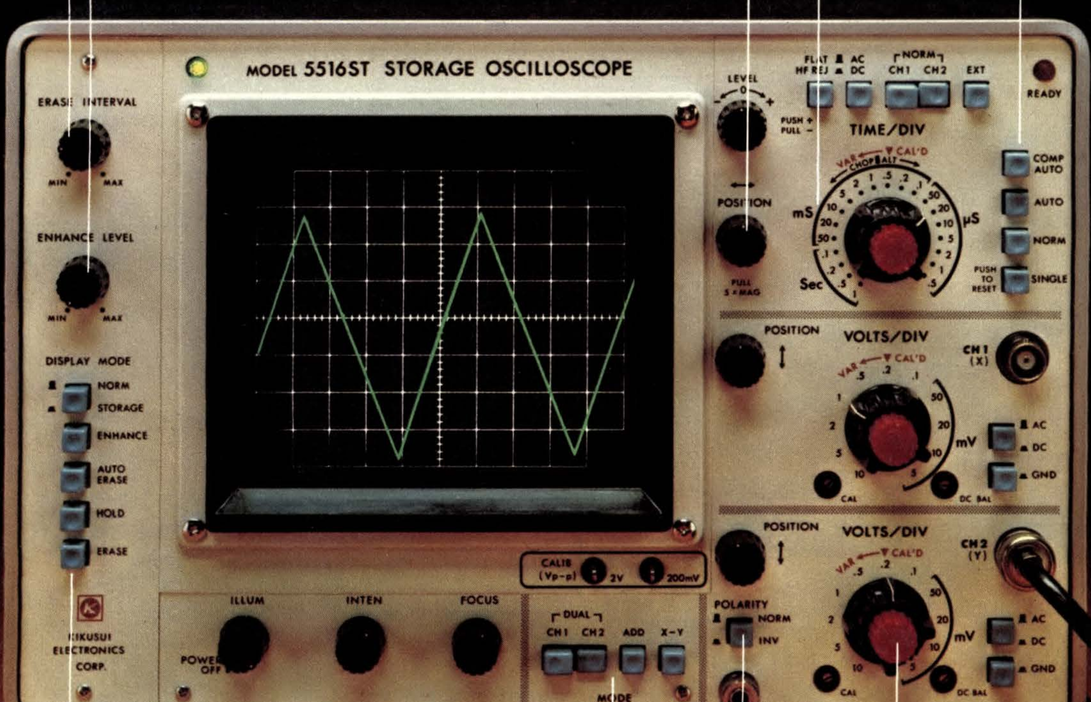
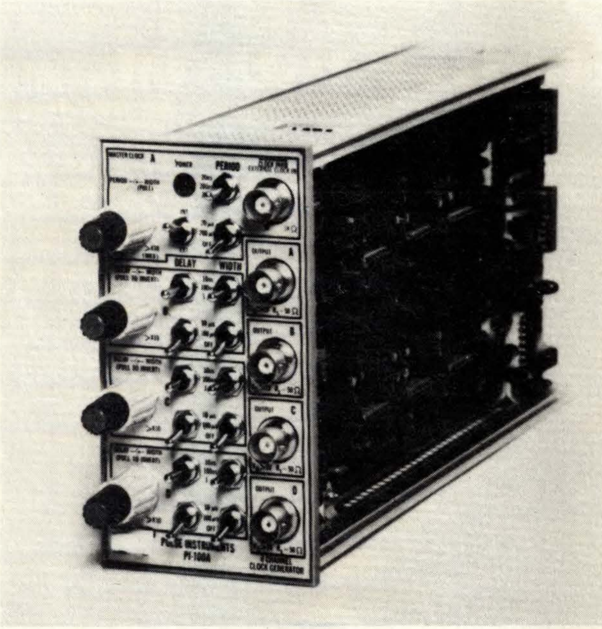


See us at Electro Booth 412.

Electro/80 Products



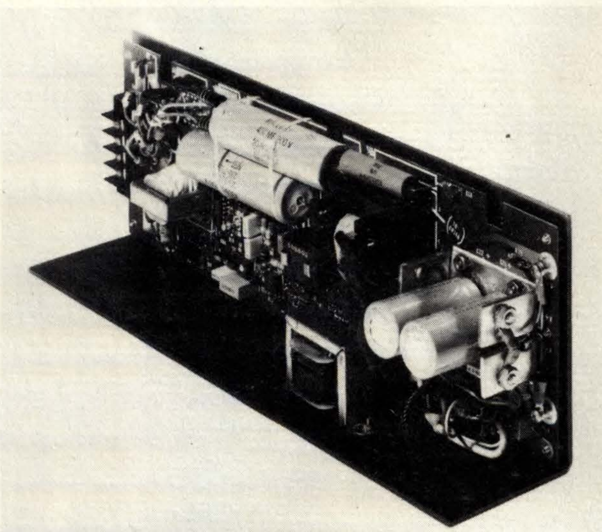
channels provide pulse widths variable from 10 nsec to 1 msec.

Driving a terminated 50Ω line, the 2V-min output pulses exhibit rise and fall times of less than 7 nsec. $790.

Pulse Instruments Co, 1536 W 25th St, San Pedro, CA 90732. Phone (213) 541-3204. Booth Nos 1505, 07.

Circle No 417

OPEN-FRAME SWITCHERS



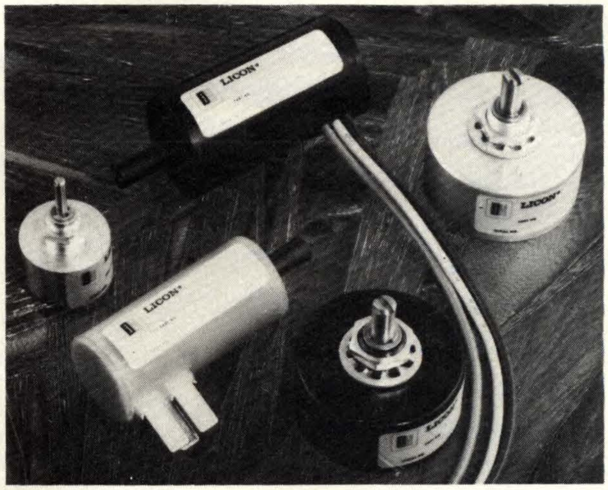
Designated the 250 T&Q Series, these open-frame multioutput switching power supplies achieve up to 80% efficiency at a rated 250W output. Available in four models, they provide various output combinations of 5, 12 and 15V dc at up to 25A.

The two triple-output units provide 5, 12 and 12V dc outputs at 25, 4 and 4A and 5, 15 and 15V at 25, 4 and 4A. Quad-output units deliver 5, 5, 12 and 12V at 25, 1, 4 and 4A and 5, 5, 15 and 15V at 25, 1, 4 and 4A.

Triple-output units (250T), $310; quad-output versions (250Q), $335.

Standard Power Inc, 1400 S Village Way, Santa Ana, CA 92705. Phone (714) 558-8512. Booth No 2437. **Circle No 418**

POSITION SENSORS



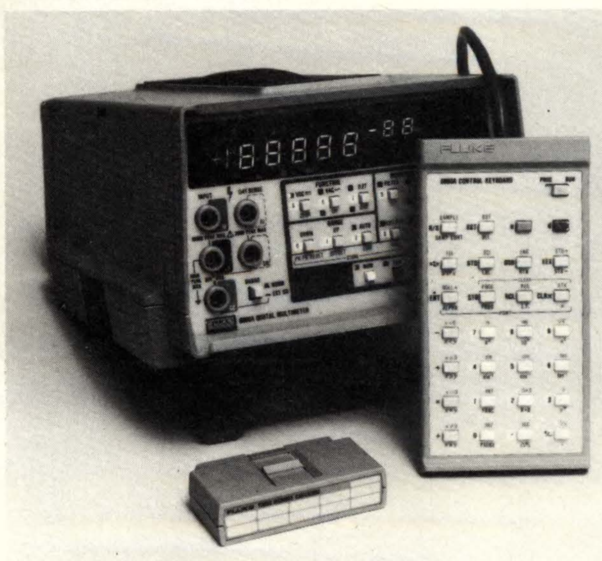
Available in linear and rotary versions, Series 33 position sensors employ two ferrite tubes wound as inductors and connected in series. Attached to each unit's input shaft, a permanent magnet linearly varies the core's differential inductance in direct relation to shaft position. When excited with an ac signal, the sensors output an ac voltage linear and proportional to position.

Driven with a 3 to 7V, 50- to 250-kHz sine or square wave, the linear sensor produces an output that varies over an approximately 6:1 range for a ½-in. shaft travel; a 2.5:1 output variation is generated by the rotary unit for a 50° shaft rotation.

Operating over −40 to +150°C, both sensor types have 25°C linearity of ±2%. $15 to $20 (1k), depending on type and specs.

Licon, 6615 W Irving Park Rd, Chicago, IL 60634. Phone (312) 282-4040. Booth Nos 2021-23. **Circle No 416**

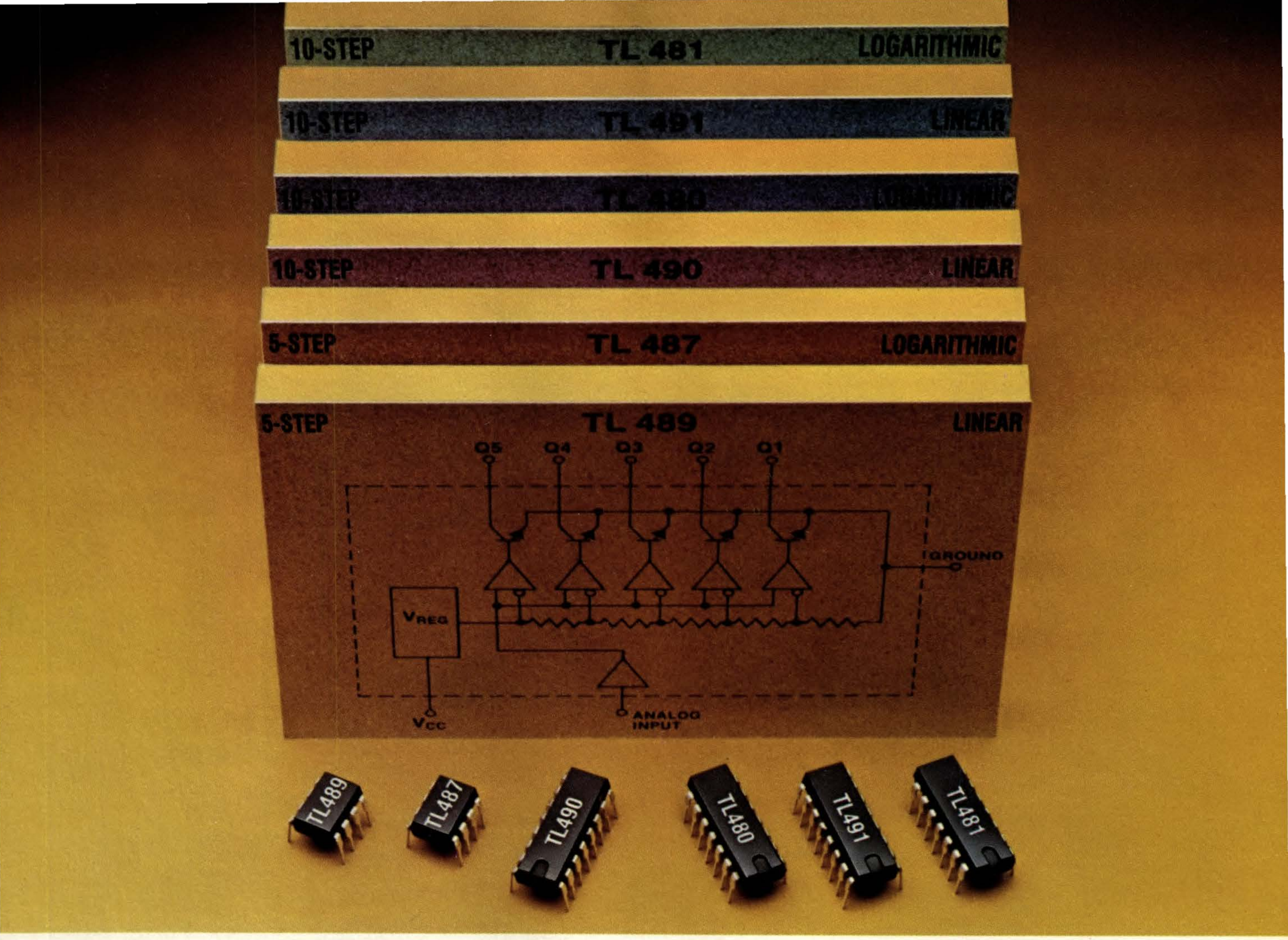
INTELLIGENT DMM



The 5½-digit Model 8860A features two μPs, which control its front-panel-selectable functions and permit operation with two mutually exclusive options—IEEE-488 interface and calculator control.

As a stand-alone DMM, the mainframe measures dc volts (to

Continued on pg 156



Versatile analog level detectors. From Texas Instruments.

Our line of monolithic analog level detectors is designed to meet all your cost/performance goals.

Each is unique. Because it combines a large number of components on a single chip — and sells for a fraction of the individual component cost.

Design flexibility

Now designers have more flexibility for a wider variety of applications.

Applications such as warning signal indicators, analog-to-digital converters, feedback regulators, industrial controls, audio level indicators — even light intensity and frequency detection.

Two degrees of resolution

TI analog level detectors are available as five and ten step detectors in both linear and logarithmic scale formats. For applications requiring greater resolution than 10 levels, the 10-step linear detectors can be cascaded to detect up to 80 levels.

Device	Input	Steps	Display Type	Price* 100 Pcs.
TL489	Linear	5	LED	$0.65
TL487	Logarithmic	5	LED	0.65
TL490	Linear	10	LED	1.08
TL480	Logarithmic	10	LED	1.20
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How STC speeds production testing by a factor of five to one . . .

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Critical to the success of this technology are complex, high-speed, analog read/write and servo boards. In fact, STC's read/write board contains more than 350 separate active and passive components.

When conventional methods were used, it took approximately 15 minutes to test each board. As this testing time became more and more unacceptable, the decision was made by STC to switch to automatic testing.

Paul Zieschang, Manager of Hardware Development, recommended that the company assemble its own system using 12 HP-IB compatible insruments, an HP 9835A Desktop Computer as system controller and a 9885 Disc. Zieschang reports that the 9835A was chosen because its large CRT display made it easy for an operator to interface with the system, and because of its programming ease. What's more, STC incorporated diagnostics into the system which help STC technicians better understand the testing procedure. This software even helps technicians locate — via a flashing cursor and a graphic display of the board's topology — the position of any component on the board. Finally, the 9835A also delivers a print-out of the component's value and STC part number.

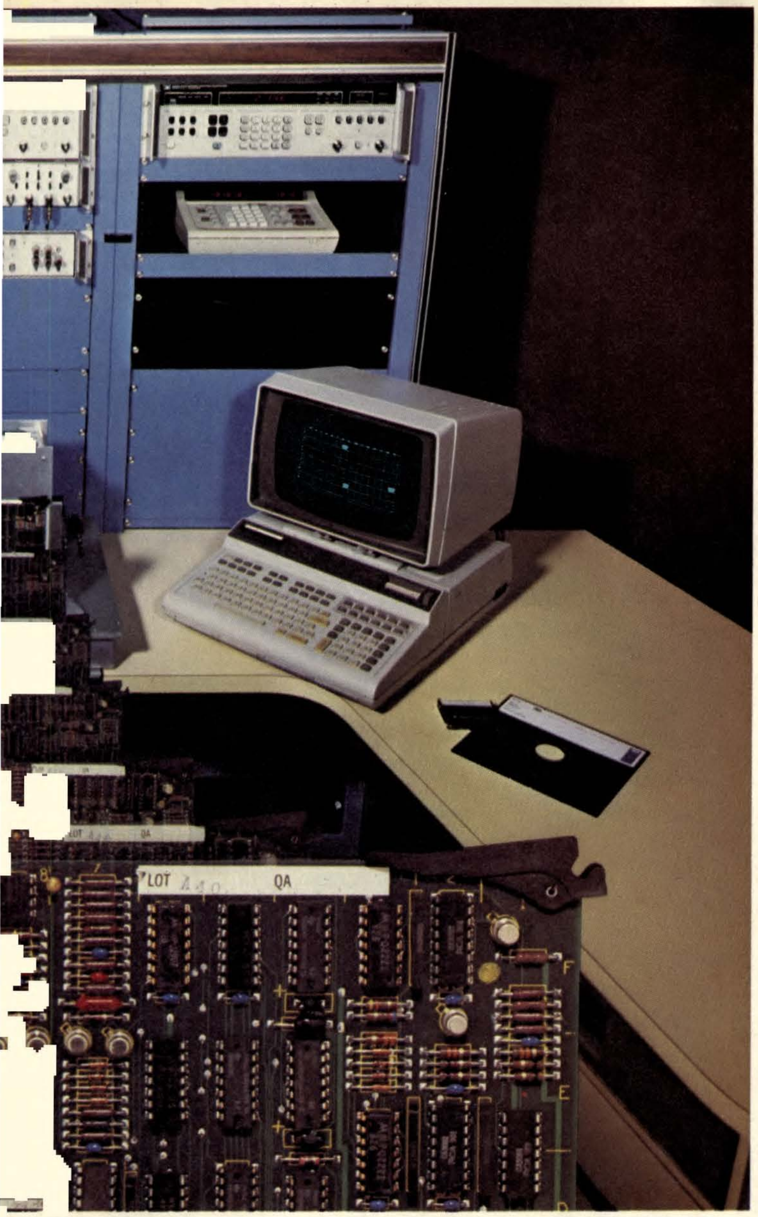
Documentation simplifies system configuration.

According to Zieschang, some of the many application notes supplied by Hewlett-Packard were helpful both in deciding the first configuration and speeding assembly of STC's first HP-IB system.

Flexibility that reduces the chance for obsolescence and speeds assembly.

Twelve HP-IB compatible instruments were chosen for this system, according to Zieschang, because HP's bus architecture and programming ease permit the flexiblity necessary to make changes within the system as STC's requirements change and, thus substantially reduce the possibility of system obsolescence.

HP instruments also provide STC with speed of assembly. The company assembled and programmed its first automatic



using HP-IB "designed for systems" instruments and computers.

test system faster than other comparable ways of solving its system test needs. Zieschang believes they will be able to assemble and program future systems even faster.

The bottom line.

Just as important, Zieschang says the STC HP-IB compatible system will reduce testing time from 15 minutes per board to approximately three minutes. A factor of five to one. The system is also expected to reduce the time required to debug faulty boards from 45 to 20 minutes. In short, STC's HP-IB system will help the company turn out more boards per day.

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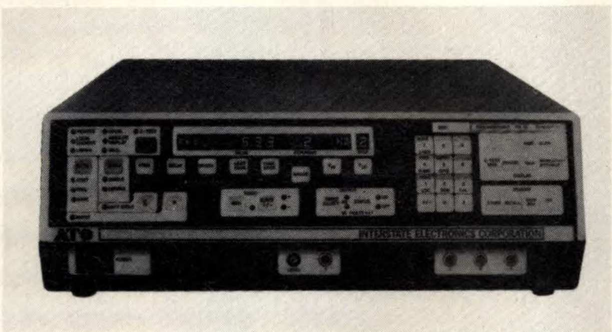
PULSE GENERATOR



Exhibiting maximum rise and fall times of 7 nsec for a 20V output pulse, Model 2021 pulse generator is ideal for ATE applications. Its self-contained GPIB interface, in conjunction with a built-in memory, controls all pertinent test parameters. PRF, delay, width, rise and fall times, amplitude, mode and offset can all be specified, stored and recalled for up to 10 separate tests. Even with the power off, a rechargeable battery keeps the memory alive for about 4 wks.

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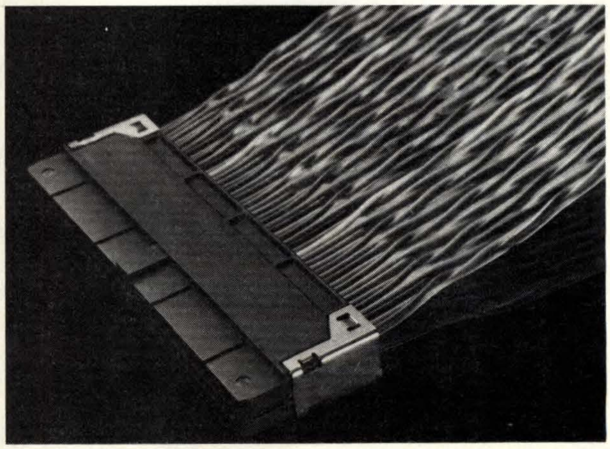
A companion pc-board mounting header completes the



system. Featuring full 4-sided shrouding and a high-strength housing, this Type SGH unit comes with vertical or right-angle pinouts and an integral grounding option.

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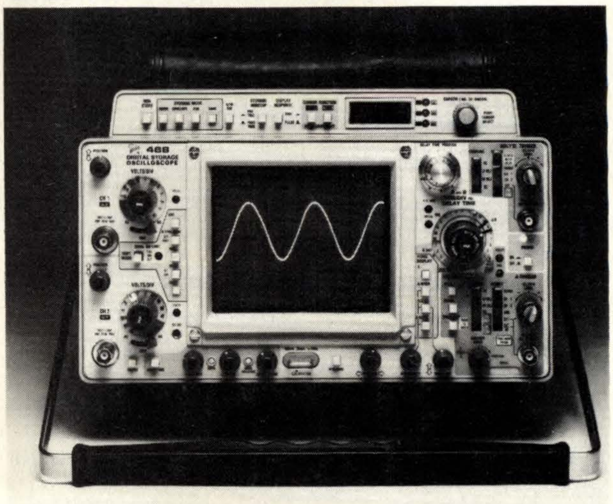

By combining a display-interpolation technique with a 25M-sample/sec, 8-bit digitizer, Model 468 achieves a 10-MHz useful storage bandwidth. Utilizing the interpolation concept, the unit requires 2.5 samples per cycle to achieve this capability.

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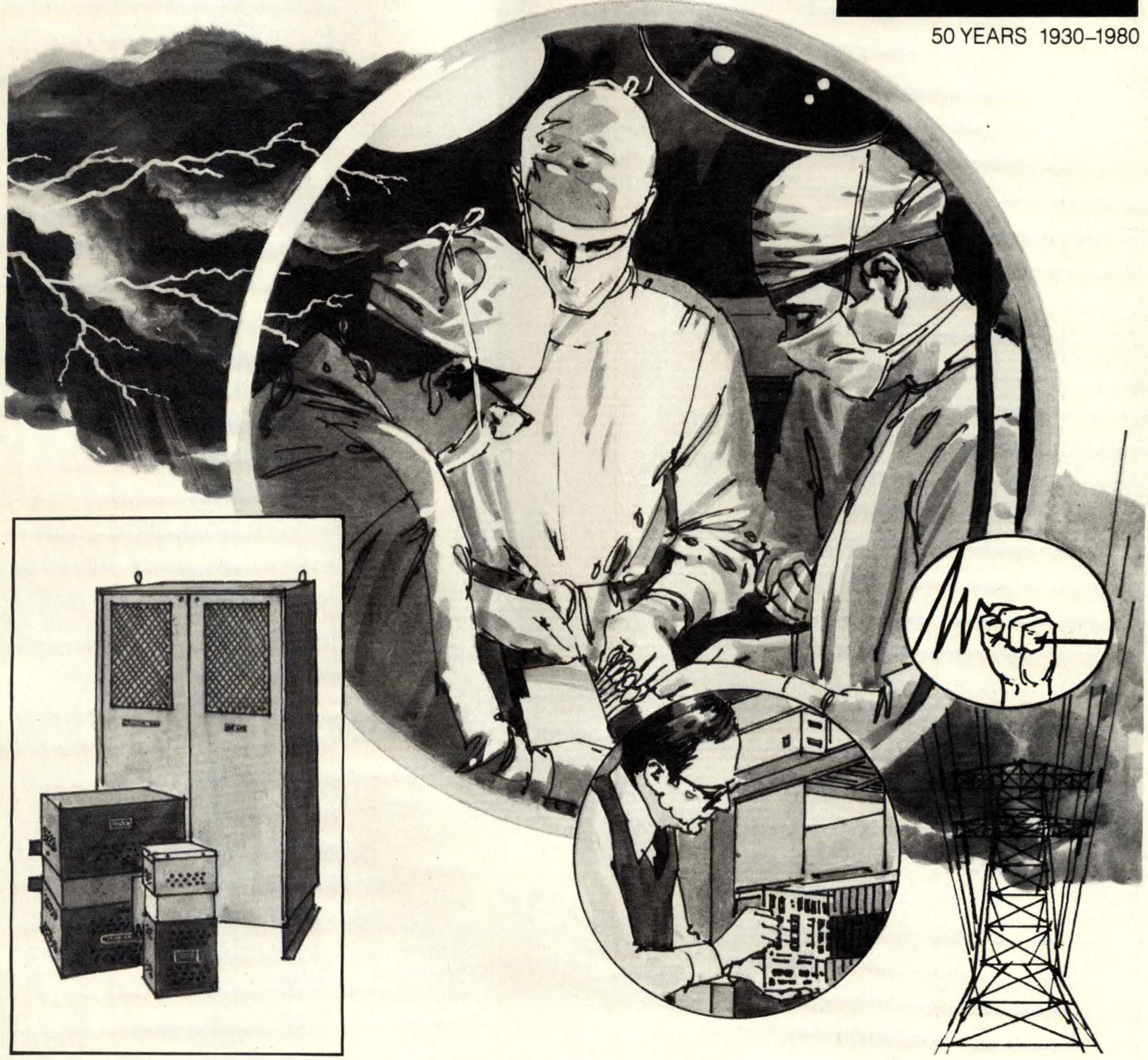

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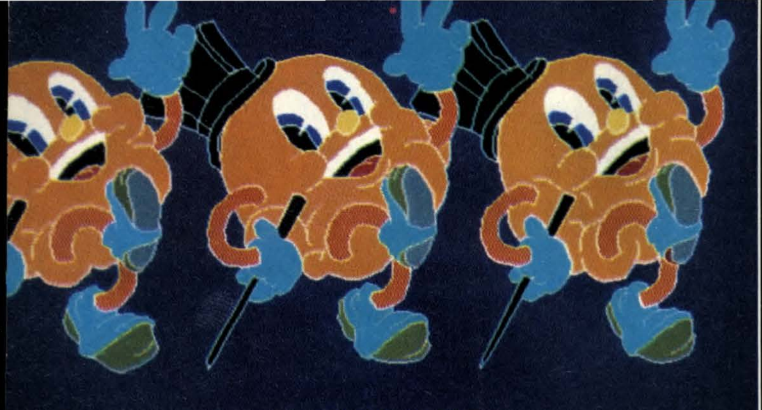

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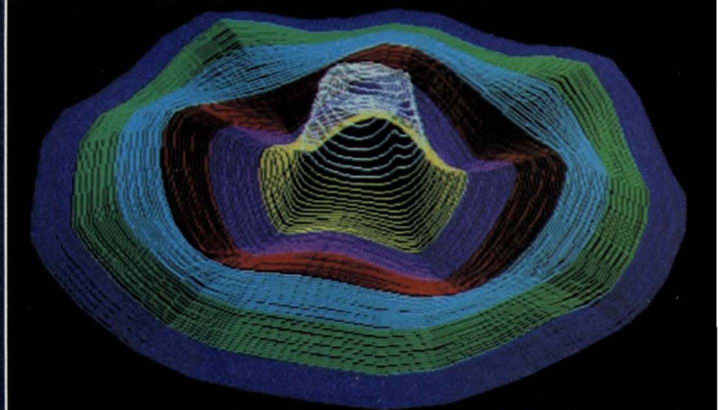

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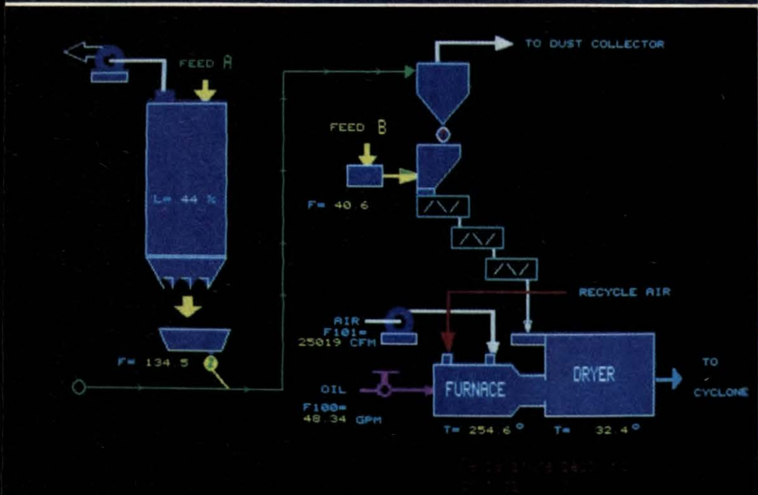

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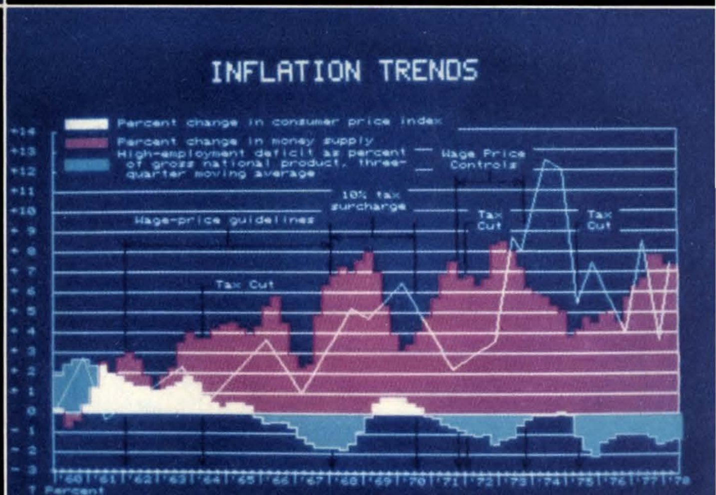

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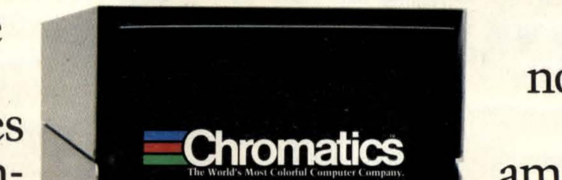

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Universal active filters make designing a snap

UAFs offer designers uninitiated in network theory the ability to construct complex filter configurations. An example illustrates the process.

John Tsantes, Eastern Editor

Hybrid universal active filters have simplified the job of active-filter design: By employing relatively straightforward techniques, you can construct relatively complex filters—even if your filter-design know-how is comparatively limited. And the promise of monolithic versions of these devices (EDN, March 20, pg 49) offers the possibility of even greater design flexibility in the future.

The design procedure summarized here illustrates the ease with which you can obtain even complex filter responses with today's devices. This example employs General Instrument's ACF7092C, but because all UAFs are essentially the same, the technique applies to all of them.

A review of basic theory

First, a quick overview of basic active-filter network theory.

A second-order function, termed the biquadratic, is the basic building block employed in the synthesis of a large class of active filters:

$$H(s) = \frac{K(s+z_1)(s+z_2)}{(s+p_1)(s+p_2)}. \quad (1)$$

For complex poles and zeros,

$$\begin{aligned} z_1 &= \mathrm{Re}(z_1) + j\mathrm{Im}(z_1),\ p_1 = \mathrm{Re}(p_1) + j\mathrm{Im}(p_1) \\ z_2 &= \mathrm{Re}(z_1) - j\mathrm{Im}(z_1),\ p_2 = \mathrm{Re}(p_1) - j\mathrm{Im}(p_1). \end{aligned} \quad (2)$$

Because a pair of poles can be represented in terms of the pole frequency (ω_p) and the pole Q (Q_p) and a pair of zeros can be treated similarly, you can rewrite the biquadratic formula as:

$$H(s) = \frac{Ks^2\left(\frac{\omega_z}{Q_z}\right)s + \omega_z^2}{s^2 + \left(\frac{\omega_p}{Q_p}\right)s + \omega_p^2}. \quad (3)$$

The equation then appears in the basic form employed by all filter manufacturers for outlining design steps in their UAF data sheets.

A filter's dc gain is

$$20 \log_{10} \left|K\left(\frac{\omega_z^2}{\omega_p^2}\right)\right|,$$

and its infinite-frequency gain is given by

$$20 \log_{10} |K|.$$

The pole Q, which determines the filter's sharpness at ω_p (the point of maximum response) is

$$Q_p = \frac{\omega_p}{(BW)_p}$$

where BW is the filter's bandwidth. Similarly, the zero Q is

$$Q_z = \frac{\omega_z}{(BW)_z}$$

and measures the sharpness of the filter's minimum response.

Low-pass filters pass frequencies ranging from dc to the cutoff frequency ω_p; a high-pass filter passes frequencies from this cutoff frequency to ∞. Similarly, a bandpass filter passes signals that lie between two frequencies (ω_1 and ω_2), and a band-reject (notch) filter rejects frequencies in a stopband bounded by ω_3 and ω_4.

For these four cases, **Eq 3** becomes:

Low pass (LP):

$$H(s) = \frac{\omega_p^2}{s^2 + \left(\frac{\omega_p}{Q_p}\right)s + \omega_p^2}$$

High pass (HP):

$$H(s) = \frac{s^2}{s^2 + \left(\frac{\omega_p}{Q_p}\right)s + \omega_p^2}$$

Bandpass (BP):

$$H(s) = \frac{\left(\frac{\omega_p}{Q_p}\right)s}{s^2 + \left(\frac{\omega_p}{Q_p}\right)s + \omega_p^2}$$

Band reject (BR):

$$H(s) = \frac{s^2 + \omega_z^2}{s^2 + \left(\frac{\omega_p}{Q_p}\right)s + \omega_p^2}.$$

With these basic equations, you can obtain any desired filter response.

UAFs offer the promise of virtual cookbook design

The poles of the biquadratic function are the values of s that make the denominator zero. Similarly, the zeros are the s values that make the numerator zero. Using these definitions and **Eq 2,** you can solve for s, ω_p and Q:

$$s = a \pm jB \quad (a, B = \text{constants})$$

$$\omega_p = \sqrt{a^2 + B^2}$$

$$Q = \frac{\omega_p}{2a}.$$

Thus, by picking the values of a and B, you can locate the poles to provide the desired response. Equations exist to tell you where to put the poles of a transfer function in order to achieve a certain response shape; the well-known Butterworth, Chebyshev, Bessel and Cauer (elliptical) approximations can also serve. Many references also supply look-up tables that list the various parameters and constants for a desired response. Here's a brief review of the four basic responses:

- A Butterworth response, also termed maximally flat, yields a filter with its flatest amplitude response in the passband. Here, the cutoff frequency's attenuation rate is n×6 dB/octave, where n is the filter's number of poles, or order.
- A Chebyshev response yields a filter with its maximum attenuation rate beyond the cutoff frequency but adds ripple to the passband. This equiripple property means that the filter's error oscillates between maxima and minima of equal amplitude in the passband. Chebyshev approximation tables are usually categorized in terms of maximum ripple, measured in decibels.
- The Bessel response offers excellent phase-shift linearity. Its amplitude cutoff is not as sharp as that of the Butterworth or Chebyshev response, but it does offer a linear phase response. Bessel filters pass rectangular signals with a minimum amount of distortion and with a delay time linearly proportional to the phase-shift characteristic. In other words, the time delay through the filter is almost constant with respect to frequency and equal to the slope of the filter phase characteristic.
- The Cauer response yields a filter with equiripple in the passband and stopband and has a steeper transition than the Butterworth or Chebyshev responses. This elliptic approximation is one of the most commonly used functions in the design of active filters, because with it, a filter of a lower order can achieve results similar to those of the Chebyshev and Butterworth responses. Because a lower order filter requires fewer components, this approximation produces the least expensive filter realizations.

A UAF design example

For simplicity, the following design example refers to the cutoff frequency as ω_n. Most manufacturers employ either this symbology or ω_o in their literature.

For the ACF7092C (**Fig 1**), the equations describing the three available outputs are:

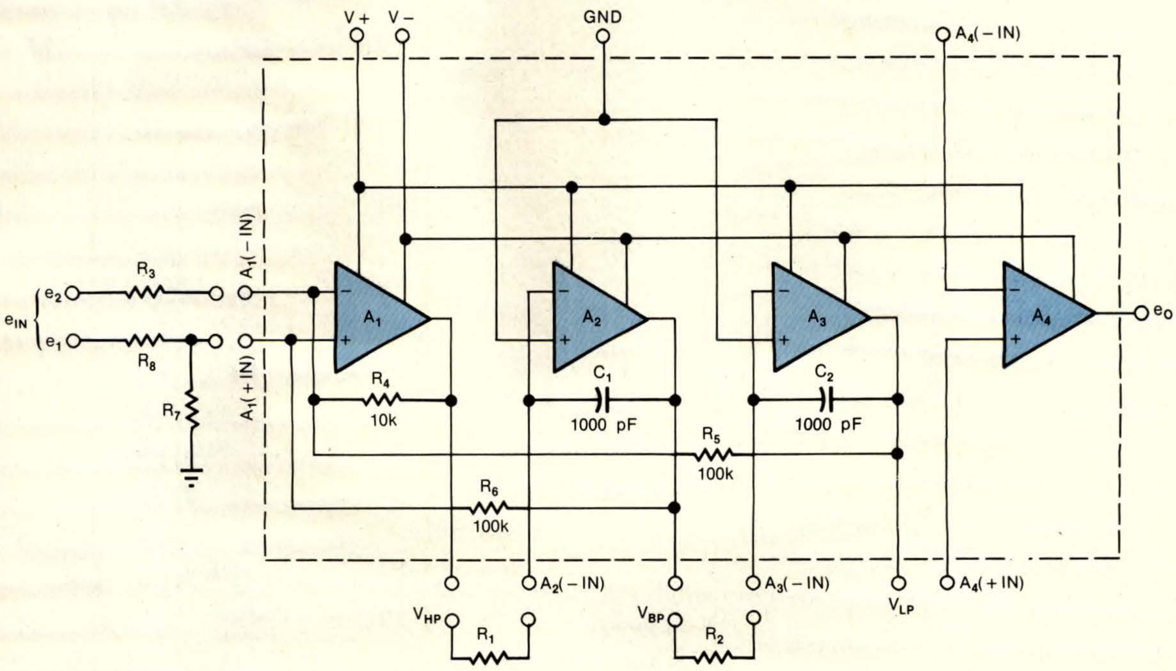

Fig 1—The universal active filter *used in this article's design example, General Instrument's ACF7092C is similar to most other UAFs.*

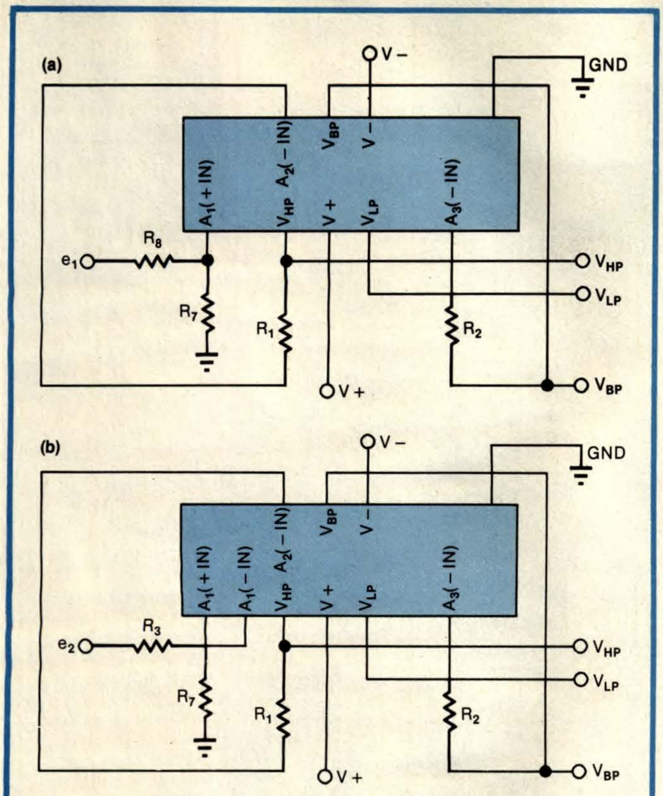

Fig 2—A hybrid UAF *like the ACF7092C can realize both noninverting* ***(a)*** *and inverting* ***(b)*** *configurations.*

$$G_{(LP)} = \frac{G_{LP}\ \omega_n^2}{s^2 + \left(\frac{\omega_n}{Q}\right)s + \omega_n^2}$$

$$G_{(BP)} = \frac{G_{BP}\left(\frac{\omega_n}{Q}\right)s}{s^2 + \left(\frac{\omega_n}{Q}\right)s + \omega_n^2}$$

$$G_{(HP)} = \frac{G_{HP}\ s^2}{s^2 + \left(\frac{\omega_n}{Q}\right)s + \omega_n^2}.$$

To obtain band-reject characteristics, you can sum the low-pass and high-pass outputs to form a pair of jω-axis zeros:

$$G_{(BR)} = \frac{A(s^2 + \omega_n^2)}{s^2 + \left(\frac{\omega_n}{Q}\right)s + \omega_n^2}.$$

In these equations, $f_n = \omega_n/2\pi$ is the natural or corner frequency for low- or high-pass outputs and the center frequency for a bandpass output. Additionally,

s=transform variable
G_{HP}=gain at infinite frequency (high pass)
G_{BP}=gain at center frequency (bandpass)
G_{LP}=gain at zero frequency (low pass)
$A = G_{LP} = G_{HP}$
Q=center frequency/bandwidth (bandpass)
Q=gain at natural frequency/gain at infinite frequency (high pass)
Q=gain at natural frequency/gain at dc (low pass).

TABLE 1 — CALCULATION OF GAIN

	NONINVERTING FIG 2a	INVERTING FIG 2b
G_{HP}	$a_1(1+a_3+a_4)$	$-a_4$
G_{BP}	$-\frac{a_1}{a_2}$	$\frac{a_4}{a_2(1+a_4+a_3)}$
G_{LP}	$\frac{a_1(1+a_3+a_4)}{a_3}$	$-\frac{a_4}{a_3}$

TABLE 2 — CALCULATION OF R_3 OR R_8

CONFIGURATION	NONINVERTING FIG 2a	INVERTING FIG 2b
LOW PASS	$R_8 = \frac{316k}{Q_{DESIGN}}$	$R_3 = 100k$
BANDPASS	$R_8 = \frac{Q_{DESIRED}}{Q_{DESIGN}}(100k)$	$R_3 = Q_{DESIGN}(31.6k)$
HIGH PASS	$R_8 = \frac{31.6k}{Q_{DESIGN}}$	$R_3 = 10k$

TABLE 3 — CALCULATION OF R_7

CONFIGURATION	NONINVERTING FIG 2a	INVERTING FIG 2b
LOW PASS	$R_7 = \frac{100k}{3.16(Q_{DESIGN})-1}$	$R_7 = \frac{100k}{3.8(Q_{DESIGN})-1}$
BANDPASS	$R_7 = \frac{100k}{3.48(Q_{DESIGN})-2}$	$R_7 = \frac{100k}{3.48(Q_{DESIGN})}$
HIGH PASS	$R_7 = \frac{100k}{0.32(Q_{DESIGN})-1}$	$R_7 = \frac{100k}{6.64(Q_{DESIGN})-1}$

The design equations for these transfer functions are:

$$\omega_n = \sqrt{a_3\omega_1\omega_2}$$

$$\text{where } \omega_1 = \frac{1}{R_1C_1},\ \omega_2 = \frac{1}{R_2C_2}$$

$$Q = \left[\frac{1}{a_2(1 + a_4 + a_3)}\right]\sqrt{a_3\left(\frac{\omega_2}{\omega_1}\right)}$$

$$\text{where } a_1 = \frac{1}{1 + \frac{R_8}{R_6} + \frac{R_8}{R_7}}$$

$$a_2 = \frac{1}{1 + \frac{R_6}{R_7} + \frac{R_6}{R_8}}$$

$$a_3 = \frac{R_4}{R_5}$$

$$a_4 = \frac{R_4}{R_3}.$$

Resistors R_1 and R_2 determine the natural frequency; resistors R_3, R_7 and R_8 determine gain and Q. You must apply these five resistors externally to the UAF; R_4, R_5 and R_6 are internal and fixed.

Gain, depending on the type of filter selected and whether it is inverted or noninverted **(Fig 2)**, appears in **Table 1**. Use **Table 2** for the calculation of R_8 or R_3 and **Table 3** to calculate R_7.

A 4-step process defines an active filter

A 4-step procedure

The following 4-step tuning procedure permits selection of all external resistors. It's based on first selecting an output function and configuration; if you desire gain values other than those given in **Table 1,** you can use the uncommitted operational amplifier:

- **Step 1:** Select f_n and determine the design Q. Because the maximum f_nQ product is specified on the UAF data sheet, you should calculate this product to ensure that the design will operate within the filter's limits. (In the case of the ACF7092C, $f_nQ=10{,}000$.) The selected Q can now serve in all subsequent calculations. (Keep in mind that at this point, you can use look-up tables which specify normalized frequency f_n and desired Q for an nth-order filter to obtain a Butterworth, Chebyshev or Bessel response.)
- **Step 2:** Calculate R_3 or R_8 as a function of design Q, using the equations listed in **Table 2.**
- **Step 3:** Calculate R_1 and R_2 as a function of f_n. For the basic unity-gain configuration,
  $$R_1=R_2=(5.04\times10^7)f_n.$$
- **Step 4:** Calculate R_7 as a function of design Q, using the equations listed in **Table 3.**

These four steps are all that's required. If the mathematics seems a bit cumbersome, remember that any programmable calculator can make light work of the job. In fact, many manufacturers provide programs right in their data sheets for transfer-function calculations as well as programs for specific responses and low-pass-to-bandpass transformations.

Cascade for higher orders

These design steps yield a second-order response; you can cascade several universal active filters to yield higher order functions. Many manufacturers' data sheets tell you how to design higher order filters using the basic UAF; they provide suggestions on how to design or locate the various sections to optimize performance and eliminate inter-section distortions. The data sheets provided by Burr-Brown and National prove particularly helpful in this regard and offer a great deal of design and application information as well as tuning tips. Additionally, all UAF suppliers provide application notes to aid in circuit design.

While universal active filters are extremely versatile and save design time, some responses might be difficult to realize with them. In such cases, a custom design might prove more useful and less expensive in the long run; contact manufacturers to discuss the tradeoffs involved. **EDN**

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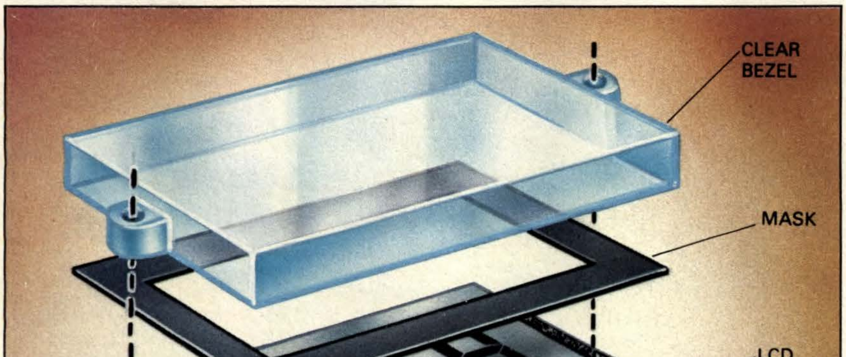

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Offsetting, linearization methods improve transducer performance

Simple offset and linearization circuits adjust and compensate for transducer operation under varied conditions—and handle low-level signals with care.

Dan Sheingold, Analog Devices Inc

Properly applied, offsetting and linearization can boost a transducer system's noise immunity, improve measurement accuracy, extend operating-temperature ranges and reduce device sensitivity to error contributions from other components. And while the many sensor types available (EDN, March 20, pg 122) present a variety of interfacing challenges, design considerations such as those discussed in this article help meet these challenges in a straightforward manner.

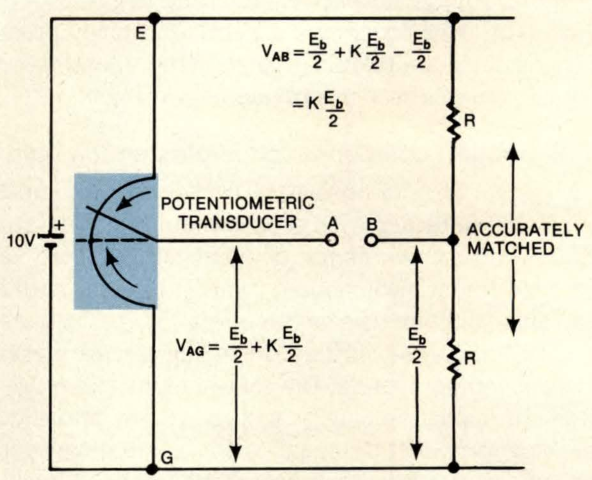
Offsetting—what and when?

Offsetting embraces the use of analog techniques to shift a signal level by a predictable amount. Typical applications include

- Measurement of small changes about a large initial value
- Incremental measurements employing a device that operates over an absolute scale (gauge vs absolute pressure, degrees Celsius vs degrees Kelvin)
- Reduction of common-mode levels
- Restoration or introduction of a beneficial offset (converting a 0 to 10V range to a 4- to 20-mA range for transmitting analog signals, for example).

An accurately developed constant (offset) isn't necessary in all applications, however. For example, an isolation amplifier allows you to measure small differential signals riding on large common-mode voltages and ignore the common-mode voltage in the process. And if the useful portion of a transducer's output is an ac signal, capacitive or transformer coupling eliminates the dc level.

For applications that do require offsetting, though, **Fig 1** illustrates one method utilizing a bridge configuration—a useful technique with transducers such as thermistors, resistance temperature detectors (RTDs) and strain gauges, which don't inherently involve bridge circuits. The transducer in **Fig 1** acts as a linear voltage divider, and the variable of interest is the fractional deviation from half scale, $KE_b/2$. If E_b equals 10V, a deviation (K) of 0.1% results in a 5-mV change. An accurate digital voltmeter at AG, between the potentiometer wiper and E_b's low end, would read 5.005V, so you could read the 0.005V positive deviation by ignoring the initial digit. Unfortunately, the circuit's output is highly sensitive to error—a 0.02% error in either the power-supply voltage or the meter reading results in a 20% error in the measured value of $KE_b/2$.



FOR K = 0.001:

E_b (V)	V_{AG} (V)	V_{AB} (V)
10.000	5.005	0.00500
10.002	5.006	0.00500

Fig 1—An offsetting bridge *provides reduced sensitivity to variations in power-supply voltage. Note that even a 20% change in the fractional part of V_{AG} essentially produces no change in V_{AB}.*

However, by forming a bridge (employing an accurately matched resistance pair) to produce an offsetting voltage V_{BG} and placing the meter to read the circuit's difference value V_{AB}=0.005V, you cancel the effects of small changes in power-supply voltage, because both voltages experience the same amount of change. In addition, use of a low full-scale voltage range

Bridge circuits reduce transducer sensitivity to error sources

(0.1999V on a 3½-digit meter, for example) and/or preamplification of the difference voltage further improve meter accuracy.

You can also employ another less critical form of offsetting to reduce measurements from absolute to gauge or from degrees Kelvin to degrees Celsius, or to translate the outputs of high-level transducers that produce ranges inherently offset from zero. Two simple ways to accomplish these adjustments involve input summation in operational or instrumentation amps and use of an instrumentation amplifier's reference input.

Fig 2a illustrates how you can use resistance to scale the 1-μA/°K output of an AD590 temperature transducer to 1 mV/°K and insert a fixed 273.2-mV offset to provide a voltage output representing degrees Celsius. Similarly, **Fig 2b** shows a semiconductor pressure transducer's 2.5 to 12.5V output (representing a 0 to 100-psi range) offset to provide 0V for 0 psi.

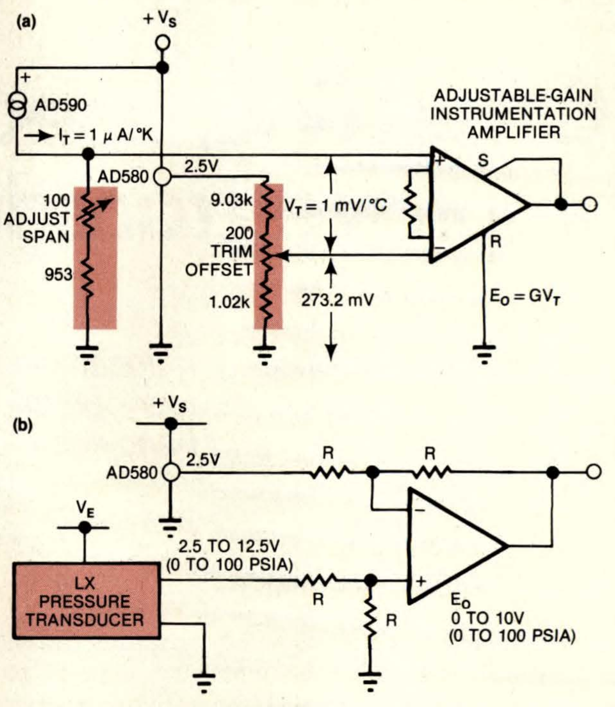
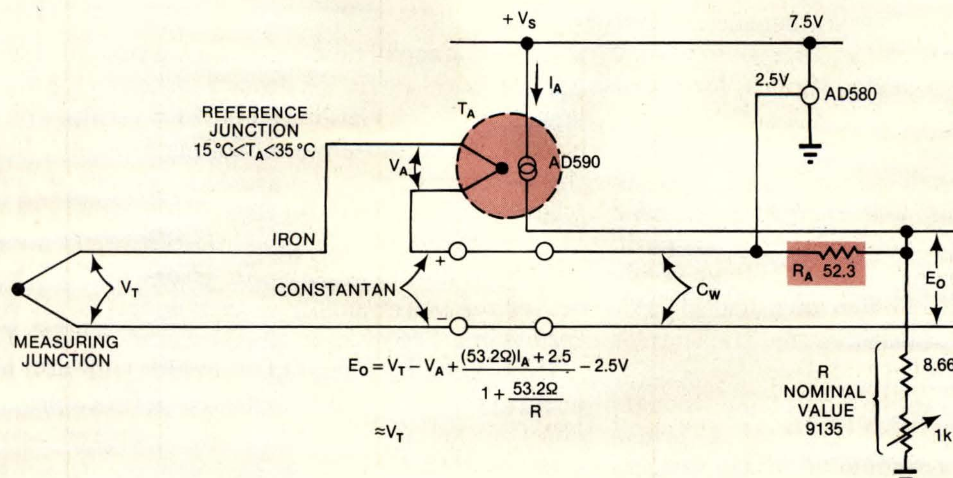


Fig 2—Range offsetting *is a simple but effective method for converting measurements from degrees Kelvin to degrees Celsius* **(a)** *or translating the output of high-level transducers whose ranges are offset from zero* **(b).**

Cold-junction compensation avoids an ice bath

A special form of offsetting, cold-junction compensation (CJC) finds use with thermocouples in applications where you expect large ambient-temperature variations and find it inconvenient to provide an ice bath for a reference junction (the vast majority of applications fall into this category). The offsetting circuit measures ambient temperature at the cold-junction reference and adds an opposite-polarity voltage to the transducer's output approximately equal to the value developed by the cold junction. The net circuit output equals the measuring junction's inherent Seebeck voltage.

The circuit shown in **Fig 3** provides CJC for a Type J thermocouple (iron-constantan). (When utilizing such an approach, place the reference junction in intimate thermal contact with the temperature transducer.) The circuit's 2.5V reference and AD590 temperature sensor add a constant term plus a term proportional to temperature; when adjusted to read the correct output voltage at a nominal reference temperature (say 25°C), the circuit offers accuracy to within about 0.5°C over an ambient range of 15 to 35°C. Principal error contributions in **Fig 3**'s circuit arise from the temperature coefficients of the voltage reference and resistors. (Note that while the figure shows a Type J device, the circuit accommodates other thermocouple types if you substitute different values for R_A as shown in **Fig 3**'s table.)



TRANSDUCER TYPE	R_A NOMINAL VALUE (Ω)
J	52.3
K	41.2
E	61.4
T	40.2
S, R	5.76

Fig 3—Cold-junction compensation *provides a thermocouple reference in applications where using an ice bath for the reference junction is inconvenient. Through changes in the value of R_A, the circuit accommodates a variety of thermocouple types.*

Offsetting improves system performance

Many process-control applications transmit transducer information in current form with a full-scale span of 16 mA and an offset of 4 mA. Current transmission provides a degree of noise immunity because the received information remains unaffected by voltage drops in the power line, stray thermocouple effects, contact voltage or resistance and induced-voltage noise. At the same time, the offset provides a distinction between a ZERO (represented by 4 mA) and no information arising from an open circuit (zero current flow).

Current transmission also offers another benefit: In some applications, you can use the 4-mA current not needed for information transfer to remotely furnish power. The system then transmits power in one direction and information in the other. You thus need no local transducer power source and require only two wires for transmission.

Finally, current transmission allows you to connect several loads at various locations in series. You could, for example, use a transducer output to drive both a chart recorder and a meter and provide a controller input. Process-control current-transmission networks **(Fig 4)** can implement current-based systems by employing modular voltage-to-loop-current converters either sharing or isolated from system common.

The devices shown in **Fig 4** provide low-cost guaranteed performance, but you can find many published circuits that allow you to implement successful voltage-to-current converters using op-amp circuitry. Just be sure, though, to consider the accuracy, grounding, input-voltage-range, output-current and compliance-voltage, power-supply, reference and dc-stability requirements.

Classify devices according to nonlinearity

The second transducer design factor considered in this article—linearization—concerns a device's inherent performance characteristics. A linear system or element is one for which cause and effect are proportional; if there are several inputs, the system's output is proportional to their weighted sum.

Nonlinearity specs designate how much a device deviates from perfect proportionality. For some devices (such as log-antilog amplifiers), nonlinearity is a desired characteristic. For others (such as thermocouples and off-null bridges), it represents a performance limit predictable from the nature of the device's characteristics. Many devices' nonlinearity, however, differs from device to device, allowing characterization only as a worst-case specification. The linearization schemes discussed here consider only the second class (undesired but predictable) of nonlinearities.

Digital or analog—which way to go?

If you wish to digitize data for processing at the earliest practical point in a circuit, you'll probably find it expedient to perform any necessary linearization in the digital domain. The principal digital techniques involve ROMs and computational algorithms.

ROM provides the fastest access and proves useful in the face of limits on processing capability and time and when nonlinearity is fixed and well defined. You can hardwire the ROM to an A/D converter's output and gate this memory with the ADC's end-of-conversion flag to assure a linearized signal for further processing. Each converter output level corresponds to an address in ROM; the word stored at each address can be either the correctly linearized value of the measured variable or an additive correction term.

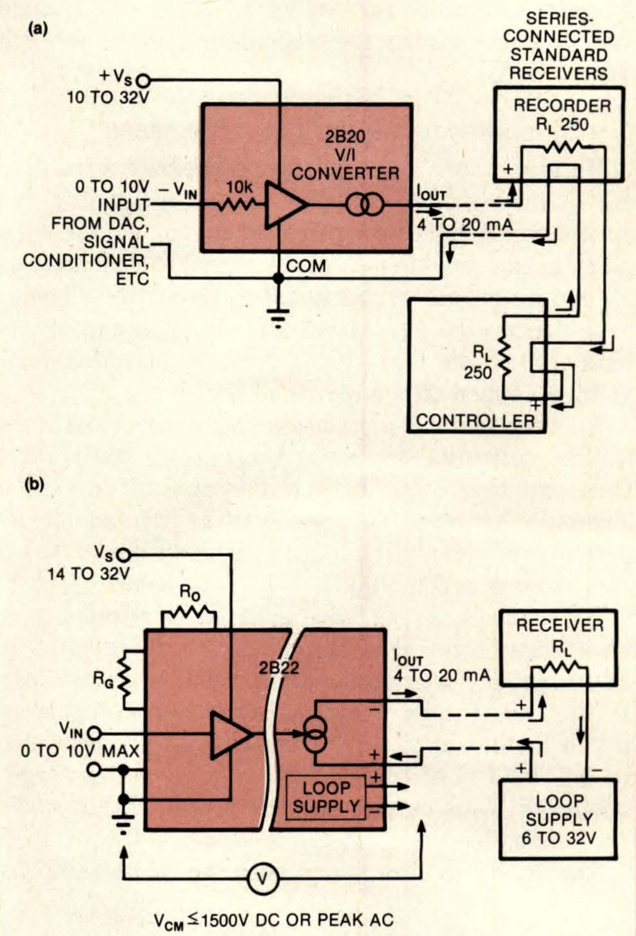


Fig 4—Improved noise immunity *is a primary advantage afforded by transmitting information as a current. While shared-common* **(a)** *and isolated* **(b)** *loops employ packaged V/I converters, with some design effort op-amp circuitry can furnish identical results.*

If rapid mathematical capability is available, you can employ another scheme in systems that look at their nonlinear input sources infrequently and afford only limited memory capacity: Derive a mathematical function that approximates the inverse of the nonlinear relationship—or the difference between the ideal and actual signals—and store it in program memory. Then, whenever the system requires the nonlinear source's signal, the processor computes a correct value based on the signal's mathematical relationship to the measured input variable.

Current transmission improves transducer-system noise immunity

For many applications, however, it's best to linearize transducer output at some point in the analog process. This approach obviously makes sense in systems that employ no digital processing, but it's also reasonable for applications incorporating only limited digital-processing capability and/or memory and where you can implement analog processing simply and economically. Two general avenues are available to effect analog linearization—modify the transducer itself or adjust its output signal.

Circuit modifications work in some cases

Many methods are available to linearize a transducer's output signal by utilizing corrective circuitry. If an application involves a bridge arrangement, for example, you can provide a feedback signal to balance it and obtain an output proportional to the active element's resistance change. Alternatively, you can drive a bridge's active leg with a current derived from the voltage applied to the reference leg.

Another example of transducer circuitry modification utilizes networks employing thermistors and resistors that provide a linear output over limited ranges. Transducer manufacturers utilize this technique to provide devices with linearities to within 0.2°C over ranges such as 0 to 100°C.

By connecting resistance in series or parallel with a thermistor, you can linearize circuit output (in a rudimentary way) over limited temperature ranges. While the simple circuit shown in **Fig 5** furnishes a much lower sensitivity than that of the thermistor itself—1%/°C of the applied voltage over a range of about 50°C—its output is linear to well within ±5% of the range.

The approach here starts with the relationship

$$\frac{V_{OUT}}{R_S} = \frac{V_S - V_{OUT}}{A(R_{25})}; \qquad (1)$$

then,

$$\frac{V_{OUT}}{V_S} = \frac{1}{A\frac{R_{25}}{R_S} + 1} \qquad (2)$$

where

V_{OUT}=the resistive divider's output voltage into a high-impedance load

V_S=the constant input voltage

A=the ratio of thermistor resistance at any temperature (R_T) to its resistance at 25°C (R_{25})

R_{25}=the thermistor's specified resistance at 25°C when operated at a power low enough to avoid significant dissipation

R_S=the value of series compensating resistance.

With the reasonable assumption that over a limited temperature range (T denoted in degrees Kelvin):

$$A \approx \alpha e^{\beta/T} \qquad (3)$$

where α and β are unknown arbitrary constants, you can pick values of A from **Fig 5**'s curve at two temperatures (0 and 50°C, for example) and calculate α and β to be 1.44×10^{-6} and 4016°K, respectively.

Substituting values from **Eq 3** into **Eq 2** and differentiating with respect to temperature (utilizing various values of R_{25}/R_S in the 0 to 25°C range) shows that the derivative exhibits little change (implying linearity) at a R_{25}/R_S ratio of 0.61. One of the curves plotted in **Fig 5b** is based on this value, calculated for a 0 to 25°C range, while the other is based on $R_{25}=1.67R_S$ over a 0 to 70°C range. The respective nominal values of R_S for these ratios and with V_S=5V and R_{25}=10 kΩ are 16.4 and 6 kΩ; useful ranges would span −10 to +30°C and −5 to +70°C, with temperature sensitivities of 55 and 45 mV/°C.

As a final example of linearizing a transducer by modifying its circuitry, the circuits shown in **Fig 6**

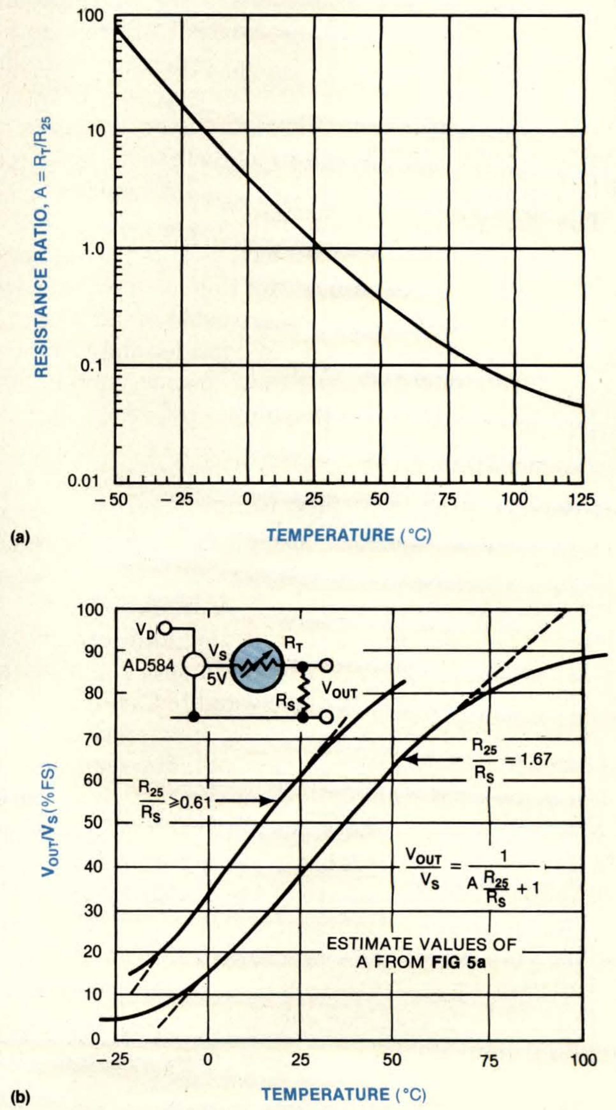
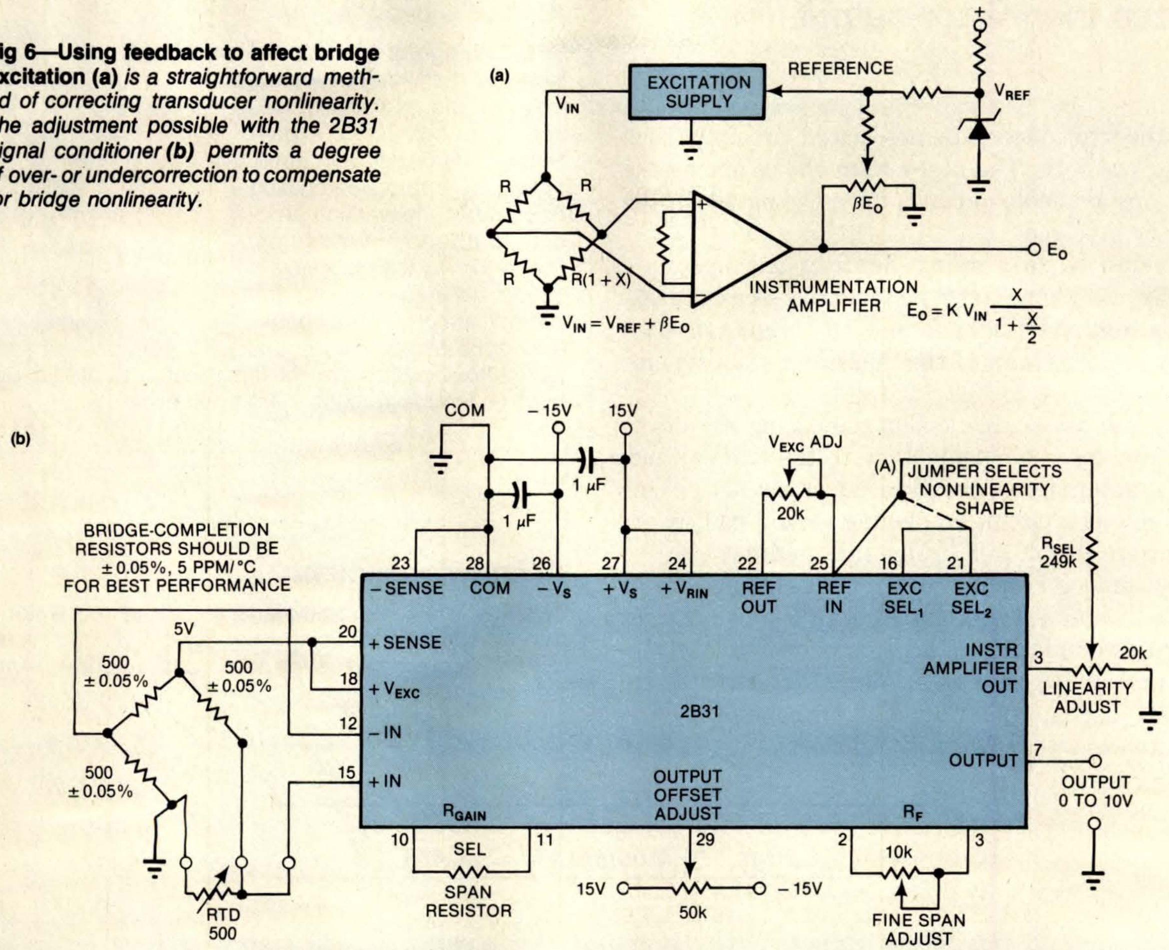


Fig 5—Although quite sensitive to temperature, *thermistors are also highly nonlinear. Connecting resistors in series or parallel with a thermistor crudely linearizes device output* ***(a)*** *over a limited temperature range* ***(b).***

Fig 6—Using feedback to affect bridge excitation (a) *is a straightforward method of correcting transducer nonlinearity. The adjustment possible with the 2B31 signal conditioner* **(b)** *permits a degree of over- or undercorrection to compensate for bridge nonlinearity.*



utilize the output of a bridge preamplifier to modulate a bridge's excitation. An external adjustment circuit applied to the 2B31 bridge/signal conditioner provides a degree of over- or undercorrection to partially compensate for the nonlinearity of the device (such as an RTD) as well as the bridge.

In **Fig 6a**'s simplified circuit, amplifier output E_O depends on the fractional resistance deviation x and excitation voltage V_{IN} according to the expression

$$E_O = KV_{IN}f(x). \qquad (4)$$

Feeding back a small fraction (β) of the bridge's output makes V_{IN} a function of E_O:

$$V_{IN} = V_{REF} + \beta E_O\,; \qquad (5)$$

substituting **Eq 5** into **Eq 4** results in

$$E_O = \frac{KV_{REF}f(x)}{1 - K\beta f(x)}. \qquad (6)$$

If the bridge response is of the form f(x)=x/(1+x/2),

$$E_O = \frac{KV_{REF}x}{(1 + x/2)\left(1 - \frac{K\beta x}{1 + x/2}\right)}$$

$$= \frac{KV_{REF}x}{1 + x(\frac{1}{2} - K\beta)}. \qquad (7)$$

To cancel any nonlinearity, the denominator must equal 1, so

$$K\beta = \tfrac{1}{2}. \qquad (8)$$

The network shown in **Fig 6b** applies this result to a bridge circuit in which a 2B31 signal conditioner provides excitation and amplification for an RTD (although the circuit also handles most other bridge-based sensors). Nonlinearity slope (concave upward or downward) determines the sense of the required feedback. Resistor R_{SEL} sets the magnitude of the linearity correction, and the linearity-adjust pot provides a fine trim.

If you're using an RTD, you can efficiently make the linearity adjustment without actually changing temperature by simulating the RTD with a precision decade resistance. You can adjust offset at the low end of the resistance range, fine span at about one-third of the range and linearity at a resistance corresponding to full-scale temperature. You'll probably have to perform one or two adjustment iterations, because linearity and scale-factor errors will interact.

Linearize the output signal instead

Where necessary, you can apply analog processing to a transducer's output signal to compensate for nonlinearity in the transducer, the associated circuitry (such as a bridge) or both. The best circuit choice among the many options available depends upon the nature of the nonlinearity involved.

One option is to employ devices that provide inherently complementary nonlinearity—circuits exhibiting a logarithmic response to compensate for exponential functions of the measured quantity, for example.

You can also use simple analog computing circuits to provide functions complementary to the known functional characteristic of the transducer circuitry. One such example is a circuit employing analog multipliers to compensate for off-null bridge nonlinearity.

Finally, analog circuitry can implement analytic or piecewise-linear approximations to compensate for nonlinearities exhibiting an arbitrary form (in thermocouples and RTDs, for example). Circuits utilizing general-purpose multiplier/dividers or op amps used as ideal diodes can also perform satisfactorily. **EDN**

Author's biography

Dan Sheingold, manager of technical marketing at Analog Devices Inc, Norwood, MA, has more than 20 yrs experience in the design and application of analog computing equipment, conversion products and function modules. Since joining the company in 1969, he has written and edited numerous handbooks and applications guides and edited *Analog Dialogue,* the firm's technical journal. Dan's hobbies include running, hiking and flying.

Acknowledgement

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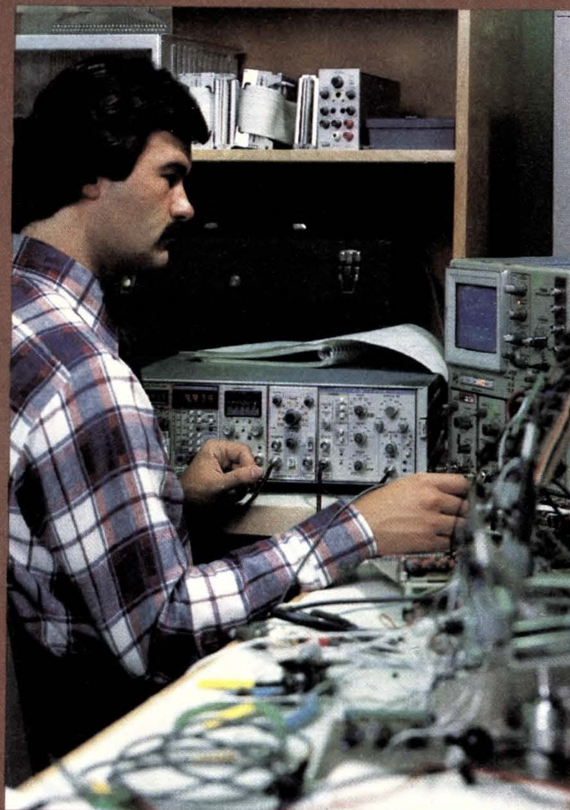

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Increase Z8000 power with floating-point routines

A unified set of floating-point subroutines in 32-bit binary format provides the Z8000 with fast arithmetic operations having up to 7-digit precision.

Robert Grappel, Consultant,
and **Jack Hemenway,** Consulting Editor

As powerful as today's 16-bit μPs are in the sense of providing a full complement of arithmetic operations on 16- and 32-bit operands, they still lack one important feature: floating-point arithmetic. This capability proves essential, though, when working both with extremely large or small values and with fractions. Minicomputers and mainframes provide floating-point instructions as part of their hardware, but currently available 16-bit μPs must employ software to perform these functions. This article presents such software for the Z8000.

Four components form a floating-point value

While an integer consists only of a sign and a value, a floating-point number must also include information about the position of its decimal point. This decimal-point information, termed an exponent, is itself an integer; the floating-point number's value part is termed its mantissa and is also an integer. Hence, you can treat a floating-point number as an integer pair, comprising two values and two signs.

A few examples from base-10 arithmetic help clarify these ideas. The number 100 could be expressed in floating-point notation as 1.E+2. The number sign is plus (implied), the mantissa value is 1, the exponent sign is plus and the exponent value is 2. Similarly, −0.12345 might also be expressed as −12345.E−5. Here, the number sign is minus, the mantissa value is 12345, the exponent sign is minus and the exponent value is 5.

You can express any number in this manner. And because the 16-bit μPs can manipulate signs and integer values, they can manipulate such floating-point numbers by properly operating on those numbers' four components.

Floating point calls for tradeoffs

This particular floating-point representation is only one of many, each with its advantages and drawbacks. The mathematical capabilities of the particular computer employed affect the design of a floating-point format for that computer; the demands of the computations envisioned also affect format choice. The task calls for four basic decisions.

- First comes the choice of the representation's size. The 16-bit μPs manipulate 16-bit words and can also handle 32-bit double words, so it proves convenient to use one of these word lengths for a floating-point representation. But single 16-bit words don't provide enough space for all four floating-point components; the smallest workable representation is thus 32 bits—the one used here. The drawback of such a 32-bit representation is that it limits mathematical accuracy; large computers employ 64-bit and larger representations to gain that advantage.
- Second comes the choice of the exponent format. Because the 16-bit μPs readily manipulate byte values, an 8-bit representation appears optimal; allowing for a sign bit, this format permits exponents ranging from −127 to +127. However, because it's convenient to employ the first bit of a floating-point value for representing the mantissa sign (permitting easy checking of that sign with Test instructions), the representation described here employs the remaining

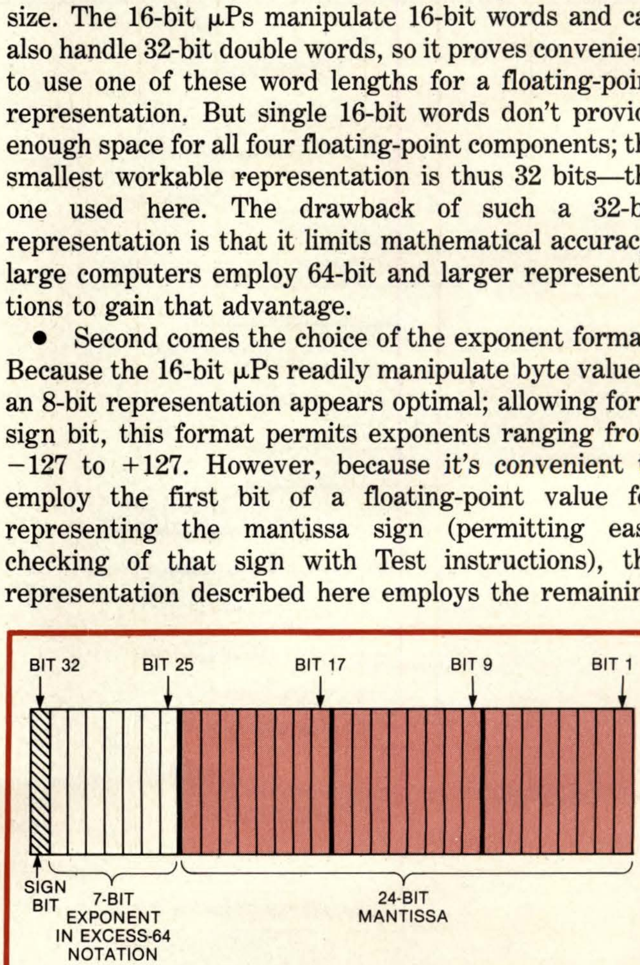


Fig 1—The 32-bit binary representation *of a floating-point value consists of a sign bit, an exponent and a binary-format mantissa.*

16-bit μPs require software for floating-point operations

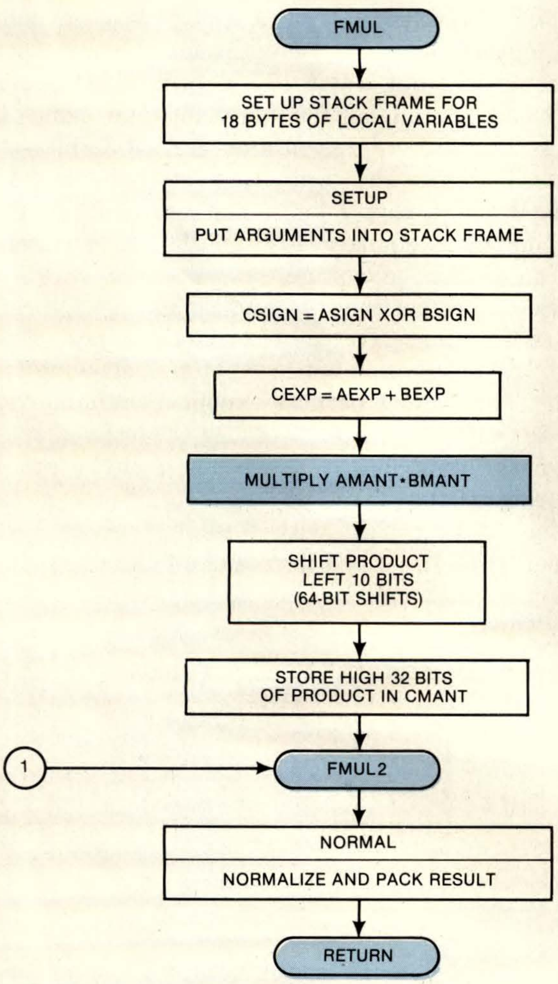
seven bits of the first byte as the exponent. This approach still allows an exponent range of ±63—adequate for most problems not involving extremely large or small numbers.

Note, however, that the 16-bit μPs don't readily manipulate 7-bit signed values—a shortcoming dealt with by the use of excess-64 notation. In essence, this technique adds the actual value of an exponent (−64 to +63) to 64; the sum then represents the exponent—and it's a positive 7-bit value for all exponents, efficiently operated on by a 16-bit μP as an unsigned byte.

- The third decision required in constructing a floating-point representation centers on representing the mantissa's sign. As noted, this is the representation's high-order bit; to maintain consistency with the μP instructions, plus denotes a ZERO and minus a ONE.
- Fourth, the mantissa of the floating-point number occupies the remaining 24 bits; representing it calls for several additional choices. Specifically, the mantissa could be a binary value, or it could be encoded in BCD format; the latter stores six decimal digits in 24 bits, while the former handles nearly seven digits in the 24-bit space. Performing BCD arithmetic is somewhat clumsy with 16-bit μPs, while binary arithmetic is their forté. But the BCD format makes conversion routines to and from ASCII simpler, while the binary format makes the conversions required for floating-point I/O more complex. However, because I/O speed is usually restricted by the I/O device and not the μP, the extra processing required for binary conversions is not a major drawback to the binary representation. Hence, the floating-point implementation employed here utilizes the binary format **(Fig 1)**.

Hold that precision

Conserving the hard-won bits of precision provided by a floating-point representation involves always normalizing the mantissa, i e, shifting it so that its high-order ONE aligns with the representation's 24th bit. Bit 24 is always a ONE in a normalized format, and some floating-point implementations gain an extra bit of precision by simply assuming that fact and shifting in one more bit to realize an effective 25th bit. However, this representation avoids such an approach in the




```
*
* FLOATING-POINT MULTIPLICATION SUBROUTINE
*
* CALL WITH ARGA @R10, ARGB @R11, RR0= ARGA*ARGB
*
FMUL    PUSH @R15,R14           SAVE FRAME POINTER
        LD R14,R15              NEW FRAME
        SUB R15,#18             18 BYTES OF STORAGE
        CALR SETUP              SET-UP ARGS.
        LDB RH0,ASIGN(R15)
        XORB RH0,BSIGN(R15)     CSIGN=ASIGN XOR BSIGN
        LDB CSIGN(R15),RH0
        LDB RH0,AEXP(R15)
        SUBB RH0,#64            ADJUST AEXP TO BINARY
        LDB RL0,BEXP(R15)
        SUBB RL0,#64            ADJUST BEXP TO BINARY
        ADDB RH0,RL0            CEXP=AEXP + BEXP
        JR OV,OVFIX             FIXUP OVER/UNDERFLOWS
*
        ADDB RH0,#63            ADD IN CEXP BIAS
        LDB CEXP(R15),RH0
        LD R2,AMANT(R15)        SET UP FOR MULTIPLY
        LD R3,AMANT+2(R15)
        MULTL BMANT
         FDB %58F0
         FDB BMANT
        SLLL RR2                SHIFT LEFT 64-BIT VALUE
        RLC R1
        RLC R0
        SLLL RR2                SHIFT AGAIN
        RLC R1
        RLC R0
        LDB CMANT(R15),RL0      STORE (W/8-BIT SHIFT)
        LDB CMANT+1(R15),RH1
        LDB CMANT+2(R15),RL1
        LDB CMANT+3(R15),RH2
FMUL2   JR NORMAL               NORMALIZE AND PACK
*
```

Fig 2—The FMUL subroutine *performs floating-point multiplication of two 32-bit arguments.*

```
*
* STORAGE FOR TWO ARGUMENTS AND RESULT
*
ASIGN   EQU 0          FIRST ARGUMENT
AEXP    EQU 1
AMANT   EQU 2
*
BSIGN   EQU 6          SECOND ARGUMENT
BEXP    EQU 7
BMANT   EQU 8
*
CSIGN   EQU 12         RESULT  C=A (OP) B
CEXP    EQU 13
CMANT   EQU 14
*
*
* SET UP FOR BINARY FUNCTIONS
* R10 POINTS TO FIRST ARG., R11 POINTS TO SECOND
*
SETUP   LDB RH0,@R10
        ANDB RH0,#%80          GET SIGN ("ARGA"")
        LDB ASIGN+2(R15),RH0
        LD R0,@R10
        ANDB RH0,#%7F          GET EXPONENT
        LDB AEXP+2(R15),RH0
        CLRB RH0
        LD AMANT+2(R15),R0     GET MANTISSA
        LD R0,2(R10)           GET MANTISSA (WORD 2)
        LD AMANT+4(R15),R0
*
SETUP2  LDB RH0,@R11
        ANDB RH0,#%80          GET SIGN ("ARGB")
        LDB BSIGN+2(R15),RH0
        LD R0,@R11
        ANDB RH0,#%7F          GET EXPONENT
        LDB BEXP+2(R15),RH0
        CLRB RH0
        LD BMANT+2(R15),R0     GET MANTISSA
        LD R0,2(R11)           GET MANTISSA (WORD 2)
        LD BMANT+4(R15),R0
        RET
*
```

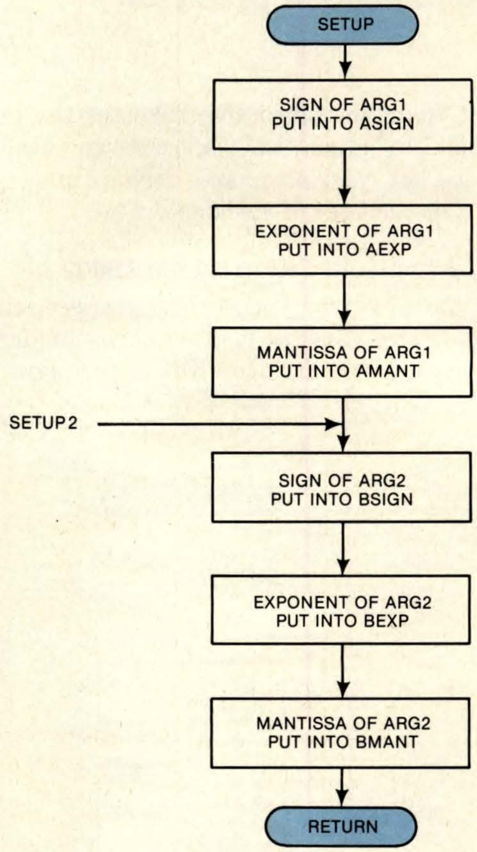


Fig 3—SETUP breaks apart the floating-point arguments *and stores them on the stack frame.*

interests of simplicity and speed; here, the assumed decimal point lies to the right of the number's high-order bit.

One last choice is required in a floating-point representation—the exponent base. Most floating-point representations employ base 2 or base 16; the choice affects the size of the exponents you can represent. In base 2, the 7-bit excess-64 exponent format only allows numbers up to 2^{63} (approximately 1.E+20), while base 16 permits numbers up to 16^{63} (about 1.E+75).

On the debit side, normalization of a base-16 representation shifts the mantissa four bits at a time because four bits represent one base-16 digit. The mantissa representation of a base-16 number can thus contain as many as three leading zeros—lost bits of precision that don't occur in a base-2 representation. Furthermore, base-2 normalization is simpler to implement on a 16-bit μP, and it executes more quickly. The bottom line? The implementation shown here employs base 2.

Illustrating the foregoing considerations with some examples helps clarify them. In this article's floating-point representation, 1.0 becomes 40800000_H or 01000000100000000000000000000000. (The sign bit is zero; the excess-64 exponent is 64—representing 2 raised to the zeroth power; the mantissa is just the high-order 1.) Similarly, $C0800000_H$ is −1, $41C00000_H$ is 3.0 and $BD800000_H$ equals −0.125. The maximum value possible in this format is $7FFFFFFF_H$; zero is 40000000_H.

Implementing re-entrant floating-point subroutines

With a floating-point representation chosen, the task of actually writing the arithmetic subroutines for it can begin. Ideally, these subroutines should be interruptible and re-entrant so that many programs can use them simultaneously. Modern 16-bit μPs provide sufficient power to make writing re-entrant code relatively painless; the main idea centers on storing all necessary local variables on the stack so that each program using the subroutines can have its own copy. This approach also makes the subroutines ROMable—another desirable feature.

Handling variable storage on the stack calls for two pointers. One, obviously, is the stack pointer itself, which provides the offsets by which the subroutine variables get accessed. The second pointer aids in removal of the local variables from the stack when the subroutine returns; this frame pointer holds the stack-pointer value required to return from the subroutine.

Calling a re-entrant subroutine involves first pushing the value of the frame pointer onto the stack, then placing the current stack-pointer value in the frame pointer. Next, you adjust the stack pointer to allow storage for the local variables used in the subroutine.

Base-2 representations provide increased precision

Returning from the subroutine reverses the process. This mechanism automatically allocates and deallocates stack space for variables, and each subroutine call allocates a distinct set of variables.

A practical implementation on the Z8002 μP

To put the foregoing theory into practice, consider the task of multiplying two floating-point numbers. The product's sign is the exclusive OR of the signs of the multiplier and the multiplicand, and its exponent is the sum of the exponents of those quantities. Furthermore, the product's mantissa is the normalized product of the multiplier and multiplicand. You can see that the algorithm is simple to describe, and the power of the Z8002 instruction set makes it simple to program.

The subroutine FMUL **(Fig 2)** starts by setting up the stack and frame pointers. (R_{15} is the stack pointer on the Z8002, and R_{14} is the register chosen here as the frame pointer.) Eighteen bytes are allocated for local variables.

The subroutine SETUP **(Fig 3)** transfers the multiplier and multiplicand to the local variables. It takes the first argument (multiplicand), pointed to by

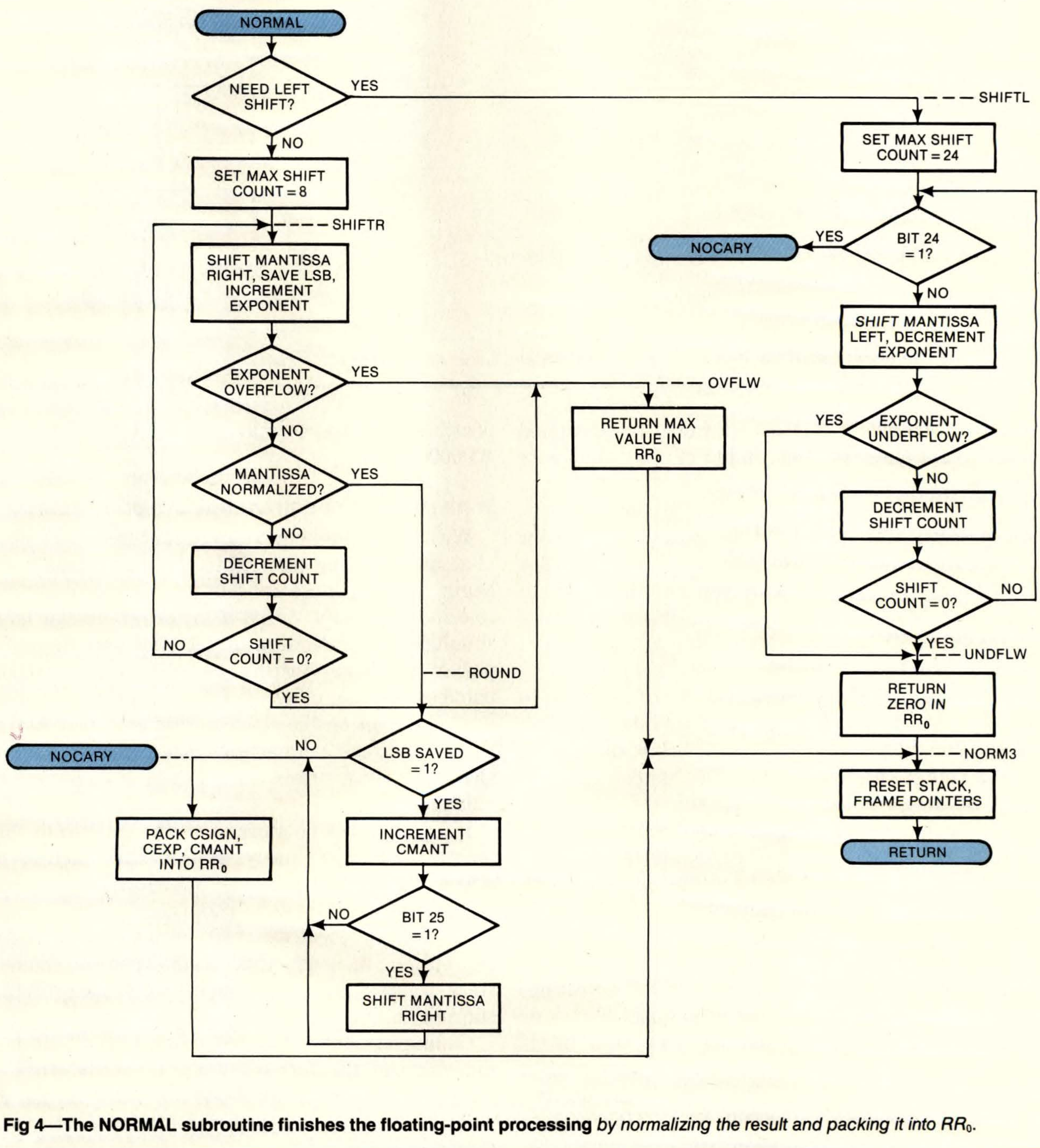


Fig 4—The NORMAL subroutine finishes the floating-point processing *by normalizing the result and packing it into RR_0.*

the register R_{10}, and moves that argument's sign to ASIGN, its exponent to AEXP and its mantissa to AMANT. The second argument (multiplier), pointed to by R_{11}, is moved to BSIGN, BEXP and BMANT. CSIGN, CEXP and CMANT provide space for the product that FMUL generates. Note that ASIGN, AEXP and the rest are merely offsets from the stack pointer, not memory addresses.

SETUP expands a floating-point value to six bytes: one for the sign, one for the exponent and four for the mantissa. Note that this routine employs an additional 2-byte offset to allow for the subroutine return on the stack formed when SETUP is called.

As FMUL executes, CSIGN is set to the exclusive OR of ASIGN and BSIGN; CEXP, to the sum of AEXP and BEXP. The excess-64 notation requires some juggling to avoid byte overflow in the addition; if such an overflow occurs (i e, the product is too big to represent), FMUL returns the largest possible value. (The routine handles underflow by returning the smallest possible value.)

The Z8002 can multiply two 32-bit values to form a 64-bit product. Here, register quad RQ_0 (composed of R_0, R_1, R_2 and R_3) contains the product of AMANT and BMANT. Because the mantissas are each actually only 24 bits long, the product contains only 48 bits, of which FMUL requires the high-order 24. A 9-bit left shift of RQ_0 moves these bits into the proper position—the low-order 24 bits of register pair RR_0. Performing 10 shifts gains an extra bit of precision, used in the normalization process.

```
*
* NORMALIZE AND PACK RESULT INTO RRO
*
NORMAL  LD RO,CMANT(R15)      MANTISSA INTO RRO
        LD R1,CMANT+2(R15)
NORM2   LDB RL6,CEXP(R15)     EXPONENT INTO RL6
        TESTB RHO             CHECK SHIFT DIRECTION
        JR Z,SHIFTL           SHIFT LEFT?
*
* SHIFT RIGHT NORMALIZE--SAVE CARRY FOR ROUNDING
*
        LDB RH6,#8            AT MOST 8 SHIFTS
*
SHFTR   SRLL RRO              SHIFT MANTISSA
        RRCB RH7              SAVE CARRY BIT
        INCB RL6              BUMP EXPONENT
        JR MI,OVFLW           CHECK FOR OVERFLOW
*
        TESTB RHO             DONE YET?
        JR Z,ROUND            YES, ROUND IT
*
        DBJNZ RH6,SHFTR       NO, LOOP UNTIL DONE
*
* EXPONENT OVERFLOW--RETURN MAX. VALUE
*
OVFLW   LD RO,#%7FFF
        LD R1,#%FFFF
        ORB RHO,CSIGN(R15)    MERGE IN SIGN
        JR NORM3              FINISH UP
*
* ROUND OFF VALUE USING CARRY STATE
*
ROUND   TESTB RH7             CARRY SET IN SHIFT?
        JR PL,NOCARY          NO
*
        CLR R2
        ADD R1,#1             YES, ROUND UP
        ADC RO,R2
        TESTB RHO             CARRY OUT?
        JR Z,NOCARY           NO
*
        SRLL RRO              YES, SHIFT AGAIN
*
NOCARY  ORB RHO,RL6           MERGE IN EXPONENT
        ORB RHO,CSIGN(R15)    MERGE IN SIGN
NORM3   LD R15,R14            RECOVER STORAGE FRAME
        POP R14,@R15          RESTORE FRAME POINTER
        RET
*
*
* LEFT SHIFT NORMALIZATION HERE
*
SHIFTL  LDB RH6,#24           AT MOST 24 SHIFTS
*
SHFTL1  TESTB RLO             CHECK FOR DONE
        JR MI,NOCARY          YES, FINISH UP
*
        SLLL RRO              SHIFT MANTISSA
        DECB RL6              DECREMENT EXPONENT
        JR MI,UNDFLW          CHECK FOR UNDERFLOW
*
        DBJNZ RH6,SHFTL1      LOOP UNTIL DONE
*
* UNDERFLOW CONDITION--RETURN ZERO
*
UNDFLW  LD RO,#%4000
        CLR R1
        JR NORM3              FINISH UP
```

Normalization completes the task

The NORMAL subroutine **(Fig 4)** finishes processing the floating-point subroutines. It combines the sign in CSIGN, the exponent in CEXP and the mantissa in CMANT into a floating-point number in RR_0. CMANT must be normalized so that its highest order ONE is in bit position 24—a process that also changes the exponent value.

NORMAL therefore checks the high-order byte of CMANT for any ONEs. If any are there, CMANT must be shifted right; if all eight high-order bits are ZEROs, left shifting is required.

Right-shift normalization might require as many as eight shifts. Because a right shift is equivalent to a division by two, the routine increments the exponent for each shift in order to compensate. It performs right shifts until bit 24 becomes a ONE or eight shifts have occurred—the latter limitation necessary because the mantissa could be a ZERO. (A zero mantissa can be shifted forever without making bit 24 a ONE.) A check for exponent overflow also occurs each time the exponent is incremented.

Right shifts result in a loss of mantissa bits from the right end of the register pair—an inevitable occurrence because the format allocates only 24 bits for the mantissa. However, the last bit shifted out can be saved and employed to round off the 24-bit mantissa—a technique that saves one more hard-won bit of precision.

If the last bit shifted out in a right shift is a ZERO, it's ignored; if a ONE, the 24-bit mantissa is incremented. (Effectively, this procedure constitutes a round-up operation.) This increment might cause a propagation of a ONE into bit 25, in which case one further right shift is required to normalize the mantissa.

Left-shift normalization occurs at SHIFTL; this process might call for as many as 24 shifts. But these shifts cause no loss of significant bits, so no rounding is required, in contrast to right shifts. Left shifts are multiplications by two, so the exponent is decremented for each shift in order to compensate. The routine,

Floating-point add proves more difficult than multiplication

however, must check for underflow of the exponent. After normalization, processing goes to NOCARY.

At label NOCARY, the subroutine merges the sign, exponent and normalized mantissa into a single 32-bit value in RR_0. It then restores the stack and frame pointers and returns.

Floating-point addition on the Z8002

Floating-point addition proves more complex to implement than multiplication. FADD (**Fig 5**) starts like FMUL, with setup of the two arguments and the frame and stack pointers. Then, if the first argument is negative, its mantissa AMANT is negated (two's complement). Similarly, if the second argument is negative, BMANT is negated. It might seem that the two mantissas could then merely be added, but recall that they are both normalized. The sum of 1.E+2 and 2.E+1 can't be directly formed; the numbers must have the same exponent before you can add their mantissas.

Note, though, that forming the sum of 10.E+1 and 2.E+1 is easy—it's 12.E+1. To this end, FADD must determine which argument to scale; it chooses the smaller one to preserve as much precision as possible. But also note that if one argument is much bigger than the other in magnitude, scaling the smaller argument in this manner might not serve any purpose. Specifically, if the exponent of the larger argument is more than 24 greater than that of the smaller one, scaling the smaller argument proves unnecessary—the routine need merely return the larger argument. (Shifting the smaller argument more than 24 bits leaves it all ZEROs.)

Thus, adding two floating-point numbers calls for considering four cases: The first argument could be much bigger than the second; the converse could be true; the first argument should be scaled; the second

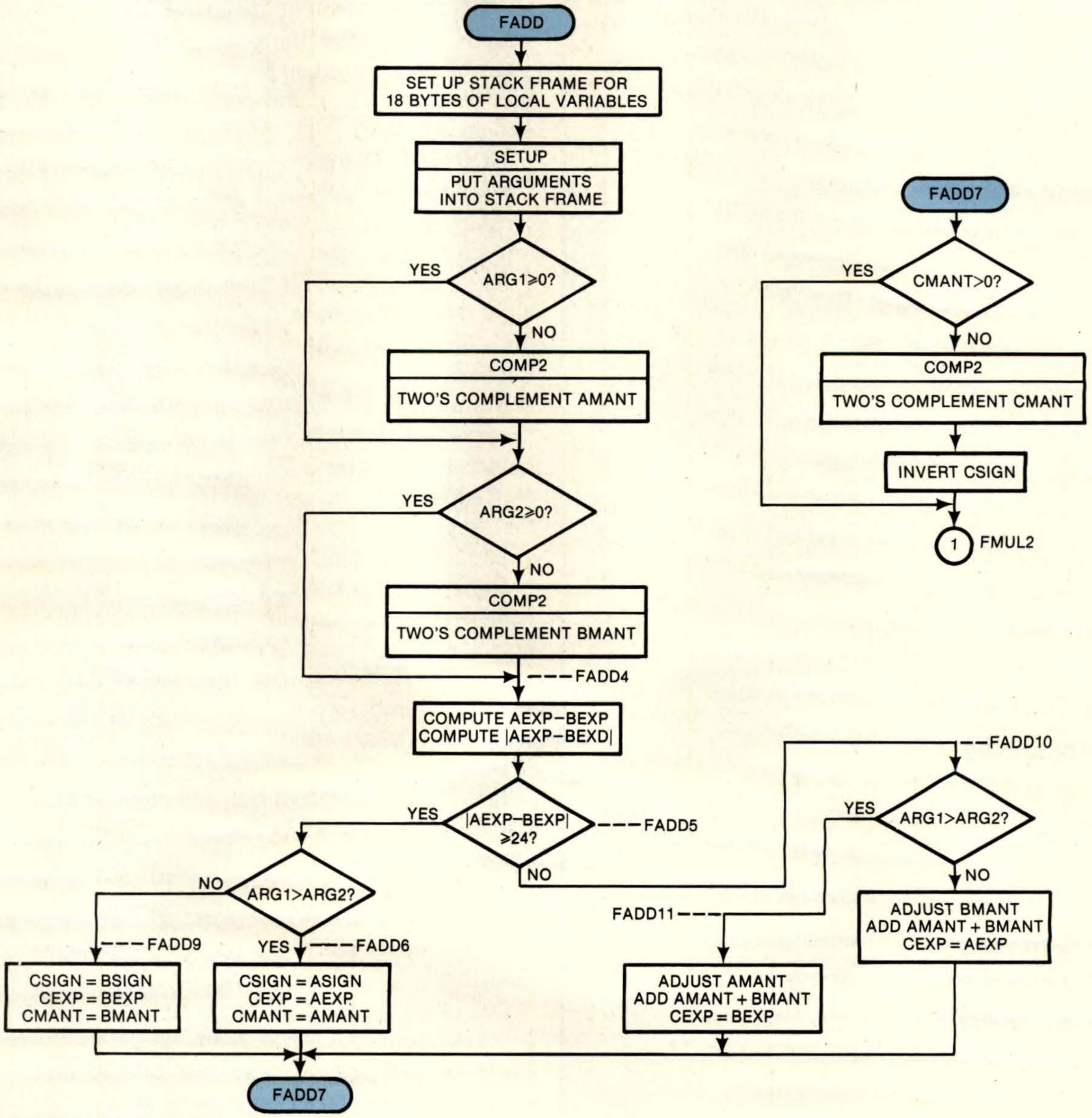


Fig 5—FADD performs floating-point addition *of two 32-bit arguments.*

should be scaled.

At FADD4, the routine computes the required scaling; FADD5 checks to see that scaling is necessary. At FADD6, the first argument is returned unchanged; at FADD9, the second is returned unchanged. The subroutine scales BMANT at FADD10 and AMANT at FADD11. The exponent of the result is then the exponent of the unscaled argument. FADD7 adjusts the result's sign if the sum of the mantissas is negative, and NORMAL, when called, finishes up the addition.

Other subroutines follow the pattern

Floating-point subtraction is easy to implement with the foregoing routine—change the subtrahend's sign and call FADD. And floating-point division is similar to multiplication: The result's sign is the exclusive OR of the argument signs, its exponent is the difference of the argument exponents and its mantissa is the quotient of the argument mantissas.

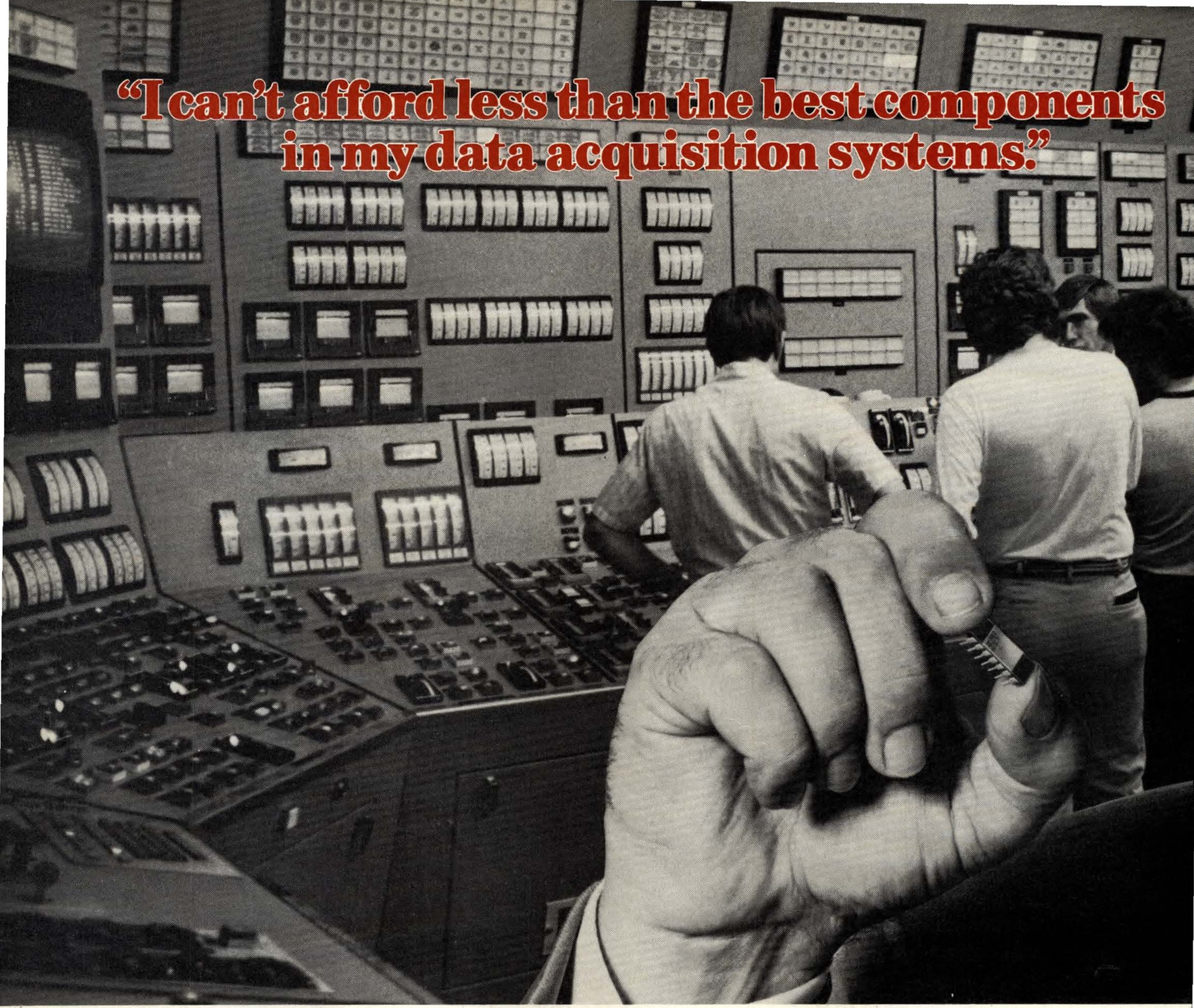
Converting a 32-bit integer to floating-point format is also easy—set the sign (CSIGN) to the sign of the integer while forcing the integer positive, set the exponent (CEXP) to 23 (in excess-64 format) and store the integer in CMANT. NORMAL then finishes the processing, returning the floating-point representation in RR_0. Floating-point absolute value and many other functions are also relatively easy to implement. **EDN**

Author's biography

Robert Grappel is vice president of Hemenway Associates Inc, Boston, MA.

Article Interest Quotient (Circle One)
***High* 479 *Medium* 480 *Low* 481**

```
*
*
* FLOATING-POINT ADDITION SUBROUTINE
*
* CALL WITH ARGA @R10, ARGB @R11, RR0=ARGA+ARGB
*
FADD   PUSH @R15,R14          SAVE FRAME POINTER
       LD R14,R15             NEW FRAME
       SUB R15,#18            18 BYTES OF STORAGE
       CALR SETUP             SET-UP ARGS.
*
FADD2  CLRB CSIGN(R15)
       TESTB ASIGN(R15)       CHECK ARGA SIGN
       JR PL,FADD3            IF PLUS, O.K.
*
       LD R0,AMANT(R15)       IF MINUS, - AMANT
       LD R1,AMANT+2(R15)
       CALR COMP2             TWOS-COMPLEMENT
       LD AMANT(R15),R0
       LD AMANT+2(R15),R1
*
FADD3  TESTB BSIGN(R15)       CHECK ARGB SIGN
       JR PL,FADD4            IF PLUS, O.K.
*
       LD R0,BMANT(R15)       IF MINUS, - BMANT
       LD R1,BMANT+2(R15)
       CALR COMP2             TWOS-COMPLEMENT
       LD BMANT(R15),R0
       LD BMANT+2(R15),R1
*
FADD4  LDB RH6,AEXP(R15)
       SUBB RH6,BEXP(R15)     GET DIFFERENCE OF EXPS.
       LDB RL7,RH6            COPY DIFFERENCE
       EXTSB RH7              MAKE WORD
       TESTB RH6
       JR PL,FADD5            IF PLUS, O.K.
*
       NEGB RH6               IF MINUS, NEGATE IT
*
FADD5  CPB RH6,#24            WITHIN RANGE (0-23)?
       JR ULT,FADD10          YES
*
* OUT OF RANGE, RETURN LARGER OF "A" OR "B"
*
       TEST R7                WHICH WAS BIGGER?
       JR MI,FADD9            IF <0, B>A
*
* A >> B, RETURN C=A
*
       LD R0,AMANT(R15)
       LD R1,AMANT+2(R15)
       LDB RH2,AEXP(R15)
       LDB RL2,ASIGN(R15)
FADD6  LD CMANT(R15),R0       STORE VALUE INTO "C"
       LD CMANT+2(R15),R1
       LDB CEXP(R15),RH2
       LDB CSIGN(R15),RL2
FADD7  TEST CMANT(R15)        FIXUP RESULT SIGN
       JR PL,FADD8            IF PLUS, O.K.
*
       LD R0,CMANT(R15)       IF MINUS, NEGATE CMANT
       LD R1,CMANT+2(R15)
       CALR COMP2             TWOS-COMPLEMENT
       LD CMANT(R15),R0
       LD CMANT+2(R15),R1
       LDB RH2,CSIGN(R15)     INVERT SIGN
       XORB RH2,#%80
       LDB CSIGN(R15),RH2
*
FADD8  JR FMUL2               NORMALIZE AND PACK
*
* B >> A, RETURN C=B
*
FADD9  LD R0,BMANT(R15)
       LD R1,BMANT+2(R15)
       LDB RH2,BEXP(R15)
       LDB RL2,BSIGN(R15)
       JR FADD6               FINISH UP
*
* WITHIN RANGE, SHIFT SMALLER NUMBER AND ADD
*
FADD10 TEST R7                A>B?
       JR MI,FADD11           NO
*
       LD R0,BMANT(R15)
       LD R1,BMANT+2(R15)
       NEG R7
       SDAL RR0,R7            ADJUST BMANT
       LD R2,AMANT(R15)
       ADD R1,AMANT+2(R15)
       ADC R0,R2
       LD CMANT(R15),R0       CMANT=AMANT + BMANT
       LD CMANT+2(R15),R1
       LDB RH0,AEXP(R15)      CEXP=AEXP
       LDB CEXP(R15),RH0
       JR FADD7               FINISH UP
*
FADD11 LD R0,AMANT(R15)
       LD R1,AMANT+2(R15)
       SDAL RR0,R7            ADJUST AMANT
       LD R2,BMANT(R15)
       ADD R1,BMANT+2(R15)
       ADC R0,R2
       LD CMANT(R15),R0       CMANT=AMANT + BMANT
       LD CMANT+2(R15),R1
       LDB RH0,BEXP(R15)      CEXP=BEXP
       LDB CEXP(R15),RH0
       JR FADD7               FINISH UP
```



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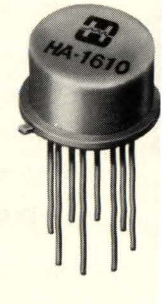

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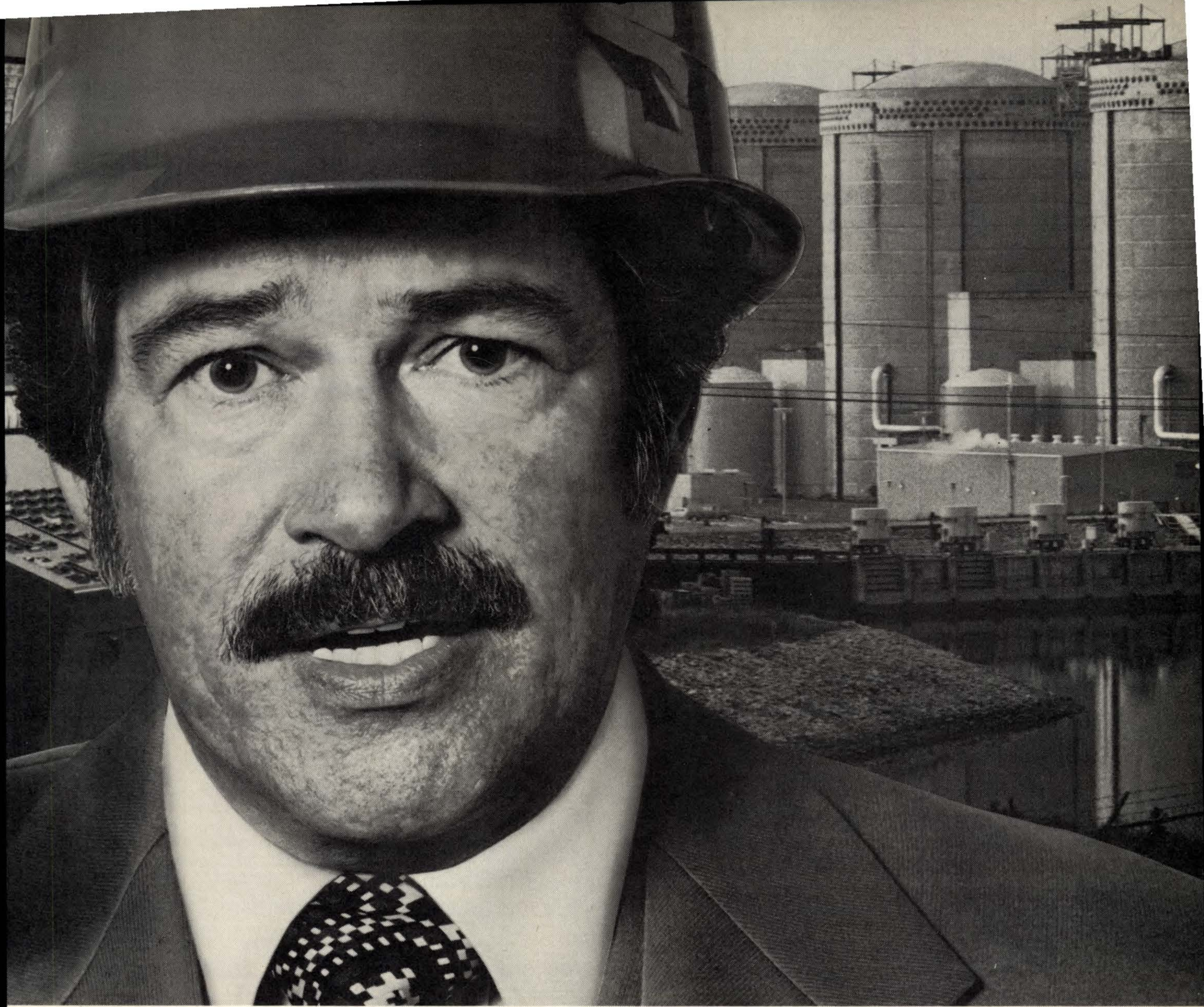

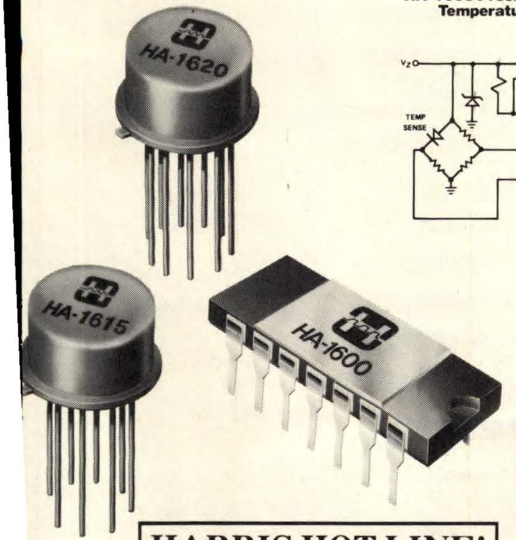

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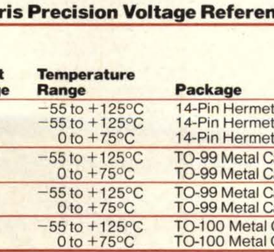

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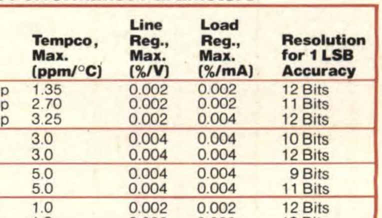

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Harris Part No.	Output Voltage	Temperature Range	Package	Tempco, Max. (ppm/°C)	Line Reg., Max. (%/V)	Load Reg., Max. (%/mA)	Resolution for 1 LSB Accuracy
HA1-1600-2	+10	−55 to +125°C	14-Pin Hermetic Dip	1.35	0.002	0.002	12 Bits
HA1-1602-2	+10	−55 to +125°C	14-Pin Hermetic Dip	2.70	0.002	0.002	11 Bits
HA1-1605-5	+10	0 to +75°C	14-Pin Hermetic Dip	3.25	0.002	0.004	12 Bits
HA2-1610-2	+10	−55 to +125°C	TO-99 Metal Can	3.0	0.004	0.004	10 Bits
HA2-1610-5	+10	0 to +75°C	TO-99 Metal Can	3.0	0.004	0.004	12 Bits
HA2-1615-2	+10	−55 to +125°C	TO-99 Metal Can	5.0	0.004	0.004	9 Bits
HA2-1615-5	+10	0 to +75°C	TO-99 Metal Can	5.0	0.004	0.004	11 Bits
HA2-1620-2	+5	−55 to +125°C	TO-100 Metal Can	1.0	0.002	0.002	12 Bits
HA2-1620-5	+5	0 to +75°C	TO-100 Metal Can	1.0	0.002	0.002	13 Bits

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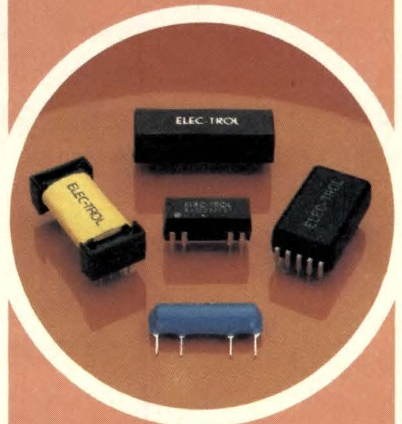

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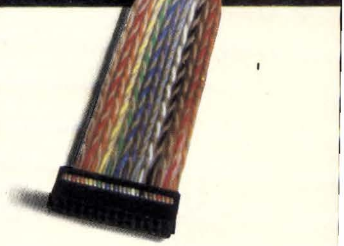

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Lick power-supply heat problems with good thermal management

Based on the premise that it's better to prevent problems than be forced to solve them, this simplified method quantifies the heat rise of a power supply to help forestall thermal woes.

Paul J LaBrie and **William D Miller,**
Semiconductor Circuits Inc

A few simple calculations can tell you whether a system and its power supply will thrive or perish when both share the same enclosure. Based on fundamental physical laws, the method lets you approximate the average case-temperature rise of your power supply as a function of the unit's power output, efficiency and package characteristics. By factoring in the supply's temperature rise with that measured for the system, you can determine whether the result exceeds specified temperature limits.

Note, however, that although this approach warns you of early catastrophic failures caused by excessive internal heating, it tells nothing about the extent to which elevated-temperature operation reduces a supply's mean time between failures (MTBF). Here, what you *can't* compute can hurt you (see **box,** "High temperatures reduce MTBF").

Consider some power-source basics

The appropriate power source for a given application must satisfy several general requirements:

- Deliver specified dc power, yet produce minimal rise in case temperature
- Perform to rated specifications within the actual system environment
- Maintain an acceptable life expectancy under actual operating conditions
- Fit the mechanical requirements imposed by the system
- Meet the price/performance criteria set forth for its function.

To quantify power-supply performance, recall that a source's output power is the product of its dc output voltage and current:

$$P_{OUT} = V_{OUT} \times I_{OUT}. \quad (1)$$

Additionally, input power is the product of instantaneous voltage and current averaged over a full power-input cycle:

$$P_{IN} = P_{AVG} = \frac{1}{T}\int_0^T V(t)I(t)dt. \quad (2)$$

(Usually, an electrodynamic wattmeter provides sufficient accuracy to measure P_{IN} for either line-operated power supplies or dc/dc converters. See EDN, October 5, 1979, pg 129 for more details.)

Defining efficiency as the ratio of output to input power expressed as a percentage results in

$$\eta = \frac{P_{OUT}}{P_{IN}} \times 100\%. \quad (3)$$

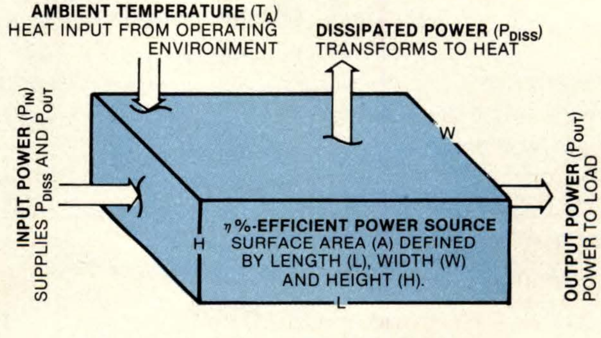
All practical power sources exhibit internal power losses that transform into heat, generating the all-too-familiar case-temperature rise. Power transformers, rectifiers, regulators and electronic switches make major contributions to these internal dissipative power losses, producing a total loss expressed as

$$P_{DISS} = P_{IN} - P_{OUT}. \quad (4a)$$

Thus, the difference between a supply's input and output power determines its internal power dissipation, which in turn produces a temperature rise.

The power-dissipation relationship expressed by **Eq 4a** becomes more useful when expressed in terms of

THE INS AND OUTS OF THERMAL MANAGEMENT



A QUICK THERMAL-MANAGEMENT REVIEW

EFFICIENCY $(\eta) = P_{OUT}/P_{IN} \times 100\%$

$P_{DISS} = P_{IN} - P_{OUT} = \frac{P_{OUT}}{\eta} - P_{OUT} = P_{OUT}\left(\frac{1-\eta}{\eta}\right)$ — P_{DISS} PRODUCES SELF HEATING ARISING FROM INTERNAL LOSSES.

$\phi_{DISS} = \frac{\text{DISSIPATED POWER}}{\text{CASE SURFACE AREA}} = \frac{P_{DISS}}{A}$ — DEFINED AS UNIT POWER DISSIPATION IN WATTS PER SQUARE INCH.

$\phi_{ENCL} = \frac{\text{RADIATED ENERGY LOSS}}{\text{CASE SURFACE AREA}}$ — A FUNCTION OF SURFACE AREA AND ITS HEAT-EMITTING CAPABILITIES (SEE TEXT).

Hot-running supplies lead to dissipation problems and low MTBF

efficiency (η) and output power:

$$P_{DISS} = P_{OUT} \frac{(1-\eta)}{\eta}. \quad \textbf{(4b)}$$

With P_{DISS} now a function of known or easily measured quantities, you can define ϕ_{DISS} as the unit power dissipation in watts per square inch:

$$\phi_{DISS} = \frac{P_{DISS}}{A} \quad \textbf{(4c)}$$

where A represents the power source's surface area (usually that of the case), which radiates its internally generated heat to the surrounding environment.

In **Fig 1,** curve A indicates the surface-temperature rise of an enclosure as a function of ϕ_{DISS} for a nominal enclosure-surface emissivity of 0.9. Curve A closely conforms to Stefan's Law, which describes the rate of radiant-energy emission from a body's surface:

$$R = \epsilon_T \sigma (T_2^4 - T_1^4) \quad \textbf{(5a)}$$

where ϵ_T is emissivity (a dimensionless ratio), T_2 and T_1 are the absolute temperatures of the power source and ambient, respectively, and σ is a constant. In a 23°C (300°K) ambient, a dimensionally modified form of **Eq 5a** results in

$$R \approx (7.34 \times 10^{-11}) \epsilon_T (T_2^4 - T_1^4) \quad \textbf{(5b)}$$

with the temperature difference $(T_2 - T_1)$ expressed in degrees Celsius.

Adjust the theory for practical uses

Again referring to **Fig 1,** note that curve B, a straight line with a slope of 125°C/W/in.², closely approximates curve A. Given a power source's output power, efficiency and geometry and assuming a surface emissivity of 0.9, it becomes a simple exercise to calculate the source's average case-temperature rise.

Example 1: Compute the average case-temperature rise of an encapsulated modular power source that operates at 75% efficiency when delivering 24W of output power. The package measures 5.5 in. long, 3.5 in. wide and 1.25 in. high; emissivity specs at 0.9, and all six surface areas radiate heat.

Solution: Knowing that P_{DISS}, the internal power dissipated by the source, generates the case-temperature rise of interest:

1. Calculate P_{DISS} as expressed in **Eq 4b:**

$$P_{DISS} = P_{OUT}\left(\frac{1-\eta}{\eta}\right)$$

$$= 24\text{W}\left(\frac{1-0.75}{0.75}\right) = 8\text{W}$$

2. Calculate the radiating surface area:

$$A = 2[(LW) + (LH) + (WH)]$$
$$= 2[(5.5 \times 3.5) + (5.5 \times 1.25) + (3.5 \times 1.25)]$$
$$= 61 \text{ in.}^2$$

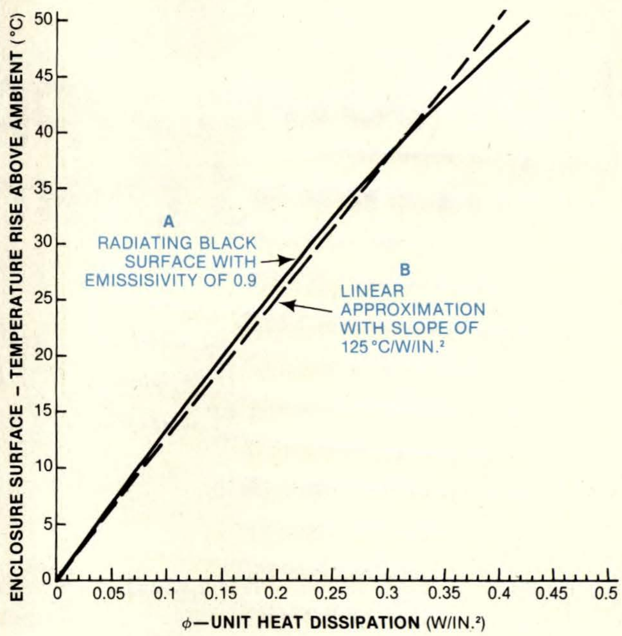


Fig 1—An enclosure's surface-temperature rise *as a function of its unit power dissipation ϕ_{DISS} (assuming 0.9 surface emissivity) becomes easy to compute when using curve B—a linear approximation of the actual thermodynamic curve A.*

3. Calculate the average case-temperature rise ($\Delta\overline{T}_C$) using the straight-line equation of **Fig 1:**

$$\Delta\overline{T}_C = \frac{125°\text{C}}{\text{W/in.}^2} \times (P_{DISS}/A) = \frac{125}{8/\text{in.}^2} \times \frac{8}{61} = 16.4°\text{C}.$$

The value of $\Delta\overline{T}_C$ in this example applies to a specific encapsulated modular power supply manufactured by Semiconductor Circuits Inc; thermocouple measurements averaged over the case surface area yield a measured $\Delta\overline{T}_C$ in close agreement with the value

High temperatures reduce MTBF

Because power-supply manufacturers possess the schematic and parts list for each of their product designs, only they can calculate each product's reliability in terms of MTBF *and the reduction in* MTBF with increasing temperature. For example, the MTBF of one commercially available power-supply family decreases by about 2500 hrs/°C between 25 and 55°C and by about 3000 hrs/°C between 55 and 71°C. These figures are unique to the product in question, though, so don't consider them generally applicable.

Operating in a 25°C ambient, these power sources are rated at 100,000 hrs MTBF. Now suppose one of the units must operate in a system enclosure that maintains an equilibrium temperature of 55°C. Operation at this elevated temperature decreases the supply's MTBF to approximately 25,000 hrs—a whopping 75% loss of reliability for a 30°C temperature rise.

computed in **Example 1.** However, the method described works equally well for other package configurations, provided you evaluate the geometry and thermal characteristics of each design.

Allowing for these characteristics yields a general method for estimating the average case-temperature rise of a power source with known efficiency (η), radiating-surface area (A) and output power (P_{OUT}). First, use **Eq 4b** to calculate the unit dissipated power in watts. Then calculate the radiating-surface area of the package in square inches. Next, using **Eq 4c,** calculate unit power dissipation in watts per square inch. Finally, calculate the average case-temperature rise in degrees Celsius:

$$\Delta\overline{T}_C = \frac{125°C}{W/\ in.^2} \times \phi_{DISS} = \frac{125°C}{W/\ in.^2} \times \frac{P_{OUT}\left(\frac{1-\eta}{\eta}\right)}{A} \quad (6)$$

where 125°C/W/in.^{2} is the linear approximation of the slope of curve A in **Fig 1.**

Note that you can easily determine any of the four key parameters involved in these thermal-management calculations in terms of the remaining three. Specifically, it's easy to transpose **Eq 6** to solve for one of the other three parameters of interest:

Radiating-surface area—

$$A = \frac{125°C}{W/\ in.^2} \times \frac{P_{OUT}}{\Delta\overline{T}_C}\left(\frac{1-\eta}{\eta}\right) \quad (7a)$$

Output power—

$$P_{OUT} = \left(\frac{\eta}{1-\eta}\right)\left(\frac{A\Delta\overline{T}_C}{125}\right) \quad (7b)$$

Efficiency—

$$\eta = \frac{1}{1 + \frac{A\Delta\overline{T}_C}{(125)P_{OUT}}}. \quad (7c)$$

These equations serve as useful cross-checks to confirm that you're managing heat as well as you think you are.

Example 2: Suppose you're considering a 20W power supply which claims 80% efficiency and exhibits an average case-temperature rise of 10°C. What must the surface area be?

Solution: To meet these requirements, **Eq 7a** demands a radiating-surface area of

$$A \geq \frac{125°C}{W/in.^2}\left(\frac{20W}{10°C}\right)\left(\frac{1-0.8}{0.8}\right)$$

$$\geq \frac{250}{4} \geq 62.5\ in.^2$$

Now compare this figure to the surface area of the power source you're evaluating.

If you're evaluating an encapsulated modular power supply or dc/dc converter, it's usually safe to assume that all surfaces radiate. Additionally, the solution to **Example 2** assumes that the stated efficiency value is valid for all conditions of interest. In practice, though, remember that efficiency generally varies with input and load conditions; the solution varies accordingly.

If A for the evaluated supply is significantly less than 62.5 in.^{2}, that supply might be touted as providing "more watts per cubic inch" while operating with an excessive case-temperature rise. Such performance increases the likelihood of premature failure of both the supply and any system that shares an enclosure with it. To avoid this situation, demand a lower temperature rise per watt of output power—an approach that calls for appropriate values of radiating-surface area and efficiency.

Graphical solutions are all in the family

As an alternative to computing all the heat-management variables required for an application, **Fig 2** displays a family of solutions to **Eq 6;** these curves relate average case-temperature rise to efficiency, with unit output power a parameter. A hand-held calculator also provides quick and easy solutions to **Eq 6,** making it equally simple to generate additional curves or solve for a single set of conditions.

The range of operating conditions spanned by **Fig 2**'s curves covers many applications, and graphical addition allows you to derive values of $\Delta\overline{T}_C$ that correspond to equivalent curves for which ϕ_{OUT} can range between 0.1 and 2.2W/in.^{2}. **Fig 2** shows an example in which the constant-efficiency line for η=50% intersects the 0.1 and 0.2W/in.^{2} curves at $\Delta\overline{T}_C$=12.5°C and 25°C, respectively. The result is the sum of the two average temperature rises:

$$\Delta\overline{T}_{C1} + \Delta\overline{T}_{C2} = 12.5°C + 25°C = 37.5°C.$$

Although this value happens to coincide with the 0.3W/in.^{2} curve, you can compute between-curve values just as simply.

The curve family solves problems

In addition to providing specific **Eq 6** values for a given set of parameters, the curves of **Fig 2** display trends and can point out limits beyond which thermal management becomes a dubious proposition. The following example illustrates how useful **Fig 2**'s curves are.

Example 3: You wish to predict the average case-temperature rise of an 80%-efficient switching power supply. It delivers 5V dc at 12A and occupies a package having 60 in.^{2} of radiating surface area and an emissivity of 0.9.

Solution: To utilize **Fig 2,** first calculate ϕ_{OUT}:

$$\phi_{OUT} = \frac{E_{OUT} \times I_{OUT}}{A} = \frac{P_{OUT}}{A} = \frac{5 \times 12}{60} = 1W/in.^2$$

Now refer to the 1W/in.^{2} curve and follow it to the 80%-efficiency intersection. The average case-temperature rise corresponding to 80% efficiency and ϕ_{OUT}=1W/in.^{2} is 30°C.

Suppose you consider this example's temperature

Good thermal management avoids nonuniform surface temperatures

rise excessive and want to halve it. **Fig 2** shows that if you halve the output power while efficiency remains at 80%, you also halve the temperature rise; the curve labelled ϕ_{OUT}=0.5W/in.^{2} now describes the supply's thermal behavior. Other alternatives include increasing efficiency and/or radiating-surface area.

If **Fig 2** contains neither a curve nor a graphically additive value equal to your computed ϕ_{OUT}, merely plot the computed value on the appropriate vertical constant-efficiency line and note its distance from the curves that bound it. For example, a computed ϕ_{OUT} of 0.15W/in.^{2} lies midway between the curves labeled 0.1 and 0.2W/in.^{2}. For a 50%-efficient supply, a $\Delta\overline{T}_C$ of 18°C is a reasonable approximation, inasmuch as the value computed by **Eq 6** equals 18.75°C. In practice, regard the temperature increases obtained by the algebraic or graphical methods presented here as boundaries that mustn't be crossed and that should, in fact, be given the widest possible margin.

Utilize these methods carefully

When you apply the methods described in this article, realize that many factors affect the accuracy of the solutions obtained. To get valid plotted results, for example, the specified efficiency must be accurate, free space must be available for radiation and all radiating surfaces must be equally efficient as dissipators.

Remember when specifying efficiency that it can vary with changes in either input or load conditions; use the actual efficiency value achieved by a supply under the operating conditions in question when solving **Eq 6** in its algebraic or graphical form. You might have to measure input and output power to determine efficiency if the manufacturer doesn't provide sufficient information.

Without forced-air cooling, a supply's efficiency and radiating-surface area determine the average case-temperature rise for any permissible power output. Thus, the laws of thermodynamics and electronics establish a power source's package size. As a rule of thumb, assume that power sources requiring no derating over the standard operating-temperature range (typically 25 to 71°C) *usually* incorporate effective thermal management.

A standard range can vary

Bear in mind when applying this rule, however, that the definition of operating-temperature range can differ among power-source manufacturers. One manufacturer, for example, might specify temperature range relative to ambient conditions, while another specs behavior relative to the case temperature. A vaguely defined temperature reference creates problems by implying greater thermal ruggedness than really exists, leading to supply misapplication and early failures induced by excessive thermal stressing.

Fig 3 illustrates three types of thermal behavior.

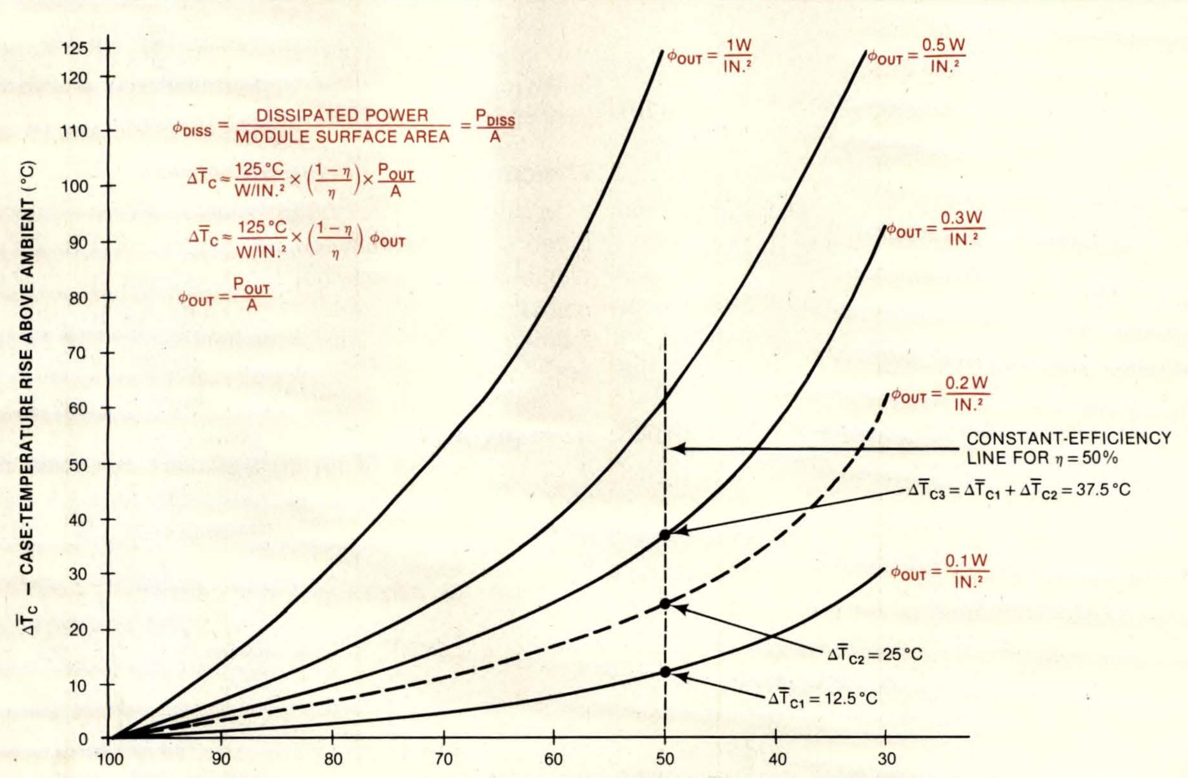


Fig 2—These curves solve for case temperature, *using known parameters of η, A and P_{OUT}.*

Curve A displays the thermal capability of a power source that delivers full rated output over the −40 to +70°C ambient operating-temperature range. Because this unit requires no derating within its specified operating environment, it serves as a predictable and easy-to-use system component.

Curve B applies to a power source that requires derating but is still specified relative to ambient conditions. For it, output derating must begin at 40°C and requires a 1%/°C derating factor. Provided derating conditions are clearly specified, this source also warrants consideration as a viable system component. The need for derating, though, indicates a higher internal temperature rise and probably somewhat reduced reliability.

For curve C, the power source carries a specification based on permissible case-temperature rise rather than ambient temperature. This specifying method's validity relies upon a clear declaration of its use and a clear definition of its limits. For example, a power source described by curve C could be specified over an operating-temperature range of −40 to +100°C. This apparently broad range becomes less impressive when you note that the source requires output derating above 0°C ambient and that you must derate power output to zero at the 100°C ambient-temperature extreme.

The moral is clear. If you're informed that a specification refers to case temperature and a graphical or verbal statement clearly defines the derating curve, you're dealing with a properly specified power source having predictable thermal requirements.

But keep your guard up against implied performance characteristics. For example, **Fig 3** clearly shows that the power sources described by curves A and B require significantly less derating than the source described by curve C. However, the curves say nothing about the advisability of prolonged operation at or near the high-temperature limit. Because MTBF decreases with temperature extremes, you'll get the best reliability from a source by operating it in a moderate thermal environment, avoiding both high- and low-temperature extremes. (Extremely low temperatures can cause component failure arising from mechanical contraction, as well as condensation and reduced performance because of degraded transistor gain.)

Note that many respected manufacturers of 100W-and-above power sources specify their products relative to permissible case-temperature rise. No problem ensues, because they explicitly state the temperature reference and fully define any need for derating, cooling or heat sinking.

Cool can be hot

Another thermal-management consideration relevant to power sources arises when a packaged source is enclosed with other system components. A source operating in the still air of a system enclosure can be approaching its melting point while the outer surface of the enclosure barely seems warm to the touch. As is true with a power source alone, an enclosure's internal temperature rise and the area and emissivity of its outer surface rank among the main factors that determine its surface-temperature rise.

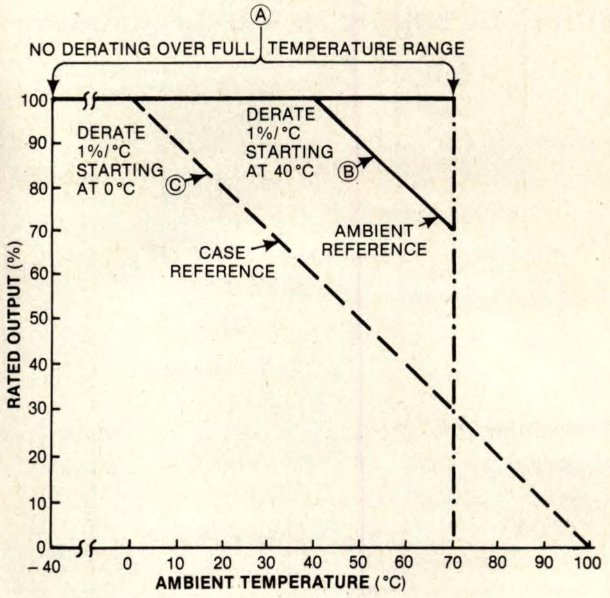


Fig 3—Power-supply temperature specs *can be stated relative to ambient or case temperatures. If you assume the wrong reference, though, the supply will probably go up in smoke. A, B and C refer to supplies exhibiting three different temperature characteristics (see text).*

Example 4: Place both a 40%-efficient, 8W power supply with 40 in.^{2} of surface area and the circuitry it serves in an enclosure having 200 in.^{2} of surface area; all surface areas exhibit an emissivity of 0.9. Find the average surface-temperature rise of both the enclosure and the supply.

Solution: With regard to the enclosure, its surface-temperature rise results from heat generated by both the power supply's internal dissipation and the load dissipation (assuming no other heat-contributing elements). Under these assumptions, the enclosure-temperature rise becomes proportional to the sum of P_{DISS} and P_{OUT}:

$$P_{IN} = \frac{P_{OUT}}{\eta} = P_{DISS} + P_{OUT} = \frac{8W}{0.4} = 20W$$

Because the supply operates within the enclosure, outputting its heat to the enclosure walls, the supply becomes the source of unit output power:

$$\phi_{OUT} = \frac{P_{IN}}{A_{ENCL}} = \frac{P_{OUT}/\eta}{A_{ENCL}} = \frac{20W}{200\ in.^2} = 0.1W/in.^2$$

Either **Eq 6** or the ϕ_{OUT}=0.1W/in.^{2} curve in **Fig 2** yields an average *enclosure*-temperature rise ($\Delta\overline{T}_{C_{ENCL}}$) of 18.75°C.

Either **Eq 6** or **Fig 2**'s graphical approach gives the average power-supply *case*-temperature rise ($\Delta\overline{T}_{C_{SUPPLY}}$) as 37.5°C.

To compare the average temperature rise of the supply with that of the surrounding enclosure, note the

Cool can be hot—if you bury a compact supply in a big enclosure

following relationships:

$$\frac{\Delta\overline{T}_{C_{SUPPLY}}}{\Delta\overline{T}_{C_{ENCL}}} = \frac{\phi_{OUT_{SUPPLY}}}{\phi_{OUT_{ENCL}}} \quad (8)$$

$$= \frac{P_{OUT}/A_{SUPPLY}}{P_{OUT}/\eta A_{ENCL}}$$

$$= \frac{\eta A_{ENCL}}{A_{SUPPLY}}.$$

Comparing the previous solutions for average case-temperature rise with the equivalent equation just derived produces

$$\frac{\Delta\overline{T}_{C_{SUPPLY}}}{\Delta\overline{T}_{C_{ENCL}}} = \frac{\eta A_{ENCL}}{A_{SUPPLY}} = \frac{(0.4)(200\ in.^2)}{40\ in.^2} = 2.$$

Note that increasing values of A_{ENCL} increase the proportion by which the power supply's average case-temperature rise exceeds that of the enclosure.

Utilizing an enclosure with a surface area much greater than the supply's, however, can mask a severe problem. If, for example, ϕ_{ENCL} is 1/10 of ϕ_{SUPPLY}, the supply's temperature can rise to catastrophic levels, even though the enclosure's surface-temperature rise might be barely discernible. For this condition, **Eq 8** calls for a 10:1 ratio between $\Delta\overline{T}_{C_{SUPPLY}}$ and $\Delta\overline{T}_{C_{ENCL}}$, making $\Delta\overline{T}_C = 10\Delta\overline{T}_{C_{ENCL}}$.

Allocate enclosure space carefully

Power sources installed within enclosures also prompt several other considerations. To begin with, the internal layout of an enclosure that doesn't employ forced-air cooling must encourage the free flow of convective currents, particularly around the power source. Moreover, both energy conversion and the load's dissipated power generate heat, which the enclosure must shed efficiently to minimize its internal temperature rise. To avoid enclosure hot spots, therefore, never cram system components that dissipate significant amounts of power into corners or allow adjacent components to block airflow. Wherever possible, isolate heat-generating system components from one another; try to locate them so that a nearly uniform average temperature rise exists over the enclosure's outer surface.

Additionally, when mounting heat-generating components inside a system enclosure, orient each component to maximize heat transfer from it to the system environment. If, for example, a function module's heat-generating components reside near its top surface, that surface should face the top of the enclosure. Also, ensure that the radiated heat doesn't flow into an adjacent system component or into the power source itself.

Expect absolutely no absolutes

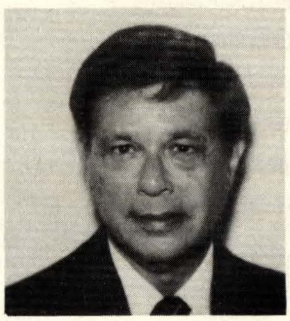
When you apply the methods presented in this article, be aware that despite the fancy curves and rigorous-appearing equations, the methods do contain approximations. Specifically, the analysis linearizes Stefan's Law and then assumes that all radiating surface areas exhibit emissivities of 0.9. In addition, the examples involve only encapsulated modular power sources because of their clearcut geometry.

The linearization and the resulting **Eq 6** provide results accurate to within ±5% of the exact values over the range of 0 to 0.4W/in.²—sufficiently close for most applications. Of course, not all materials have an emissivity of 0.9, but most of those used for electronic-system enclosures come remarkably close. If in doubt about an enclosure material you're considering, by all means investigate. And for power sources not packaged in encapsulated modules, determine the thermal characteristics from the specifications and/or by contacting the manufacturer.

Finally, the temperature-averaging technique used here involves a further approximation—temperature gradients do exist in power sources. But proper design should minimize them sufficiently to validate computed averages. To dispel uncertainties, you can always perform simultaneous multipoint surface-temperature measurements of a source (or of an enclosure's internal temperature profile), using suitable resistance-temperature devices. **EDN**

Authors' biographies

Paul J LaBrie, president of Semiconductor Circuits Inc (SCI), Haverhill, MA, holds a BSEE from Merrimack College and has been granted four patents; he is an IEEE member. Active hobbies such as jogging, skiing, sailing and scuba diving occupy some of his spare time.



William D Miller, who heads Wm D Miller & Associates, Bedford, MA, served for 4½ yrs as technical communications consultant to SCI. Bill holds an Associate degree from Northeastern University. Alpine skiing and photography are his hobbies, but the avocation of microcomputer technology sometimes crowds them a bit.

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Asynchronous-sampling method simplifies dual-port memories

By increasing memory access speed, an innovative multiport-memory design overcomes the complex arbitration and synchronization constraints usually imposed on processors or peripherals.

Robert W Schmidt, Texas Instruments Inc

If your system processing application calls for two or more devices to share a multiport memory, don't feel that you're confined to conventional techniques and their inherent shortcomings (see **box,** "Traditional memory-sharing techniques"). The asynchronous-sampling shared-memory method described in this article operates independently of attached devices, grants virtually instant memory access and obeys simple timing rules.

The technique easily handles such varied memory-interface applications as processor-to-processor connections and links between processors and CRT displays, disc controllers or ADCs. Although this article focuses on dual-port memories, you can readily expand the method to accommodate additional ports.

Asynchronous sampling quickens memory speed

Basically, an asynchronous-sampling dual-port memory system consists of a shared-RAM array, input multiplexers, input sampling latches and output latches **(Fig 1).** The output latches are clocked at the end of every other memory cycle, while the input latches are clocked at the beginning of every memory cycle. The input multiplexers alternately connect the data, address and control lines from ports A and B to the shared RAM.

To determine the minimum clock rate that permits nearly ideal multiport operation, make the following assumptions: Attached devices A and B operate asynchronously, and device A—the faster of the two—has a memory-access-time requirement of t_{AC} **(Fig 2a).** Note, too, that device Read and Write cycles designate simple Start/End sequences. At the beginning of either a Read or Write cycle, the data, address and control buses contain valid information. At the end of a Read cycle, stable Read data becomes available. Similarly, at the end of a Write cycle, the data-bus contents have been fully stored at the addressed locations. Finally, assume that in a manner mutually asynchronous to devices A and B, the

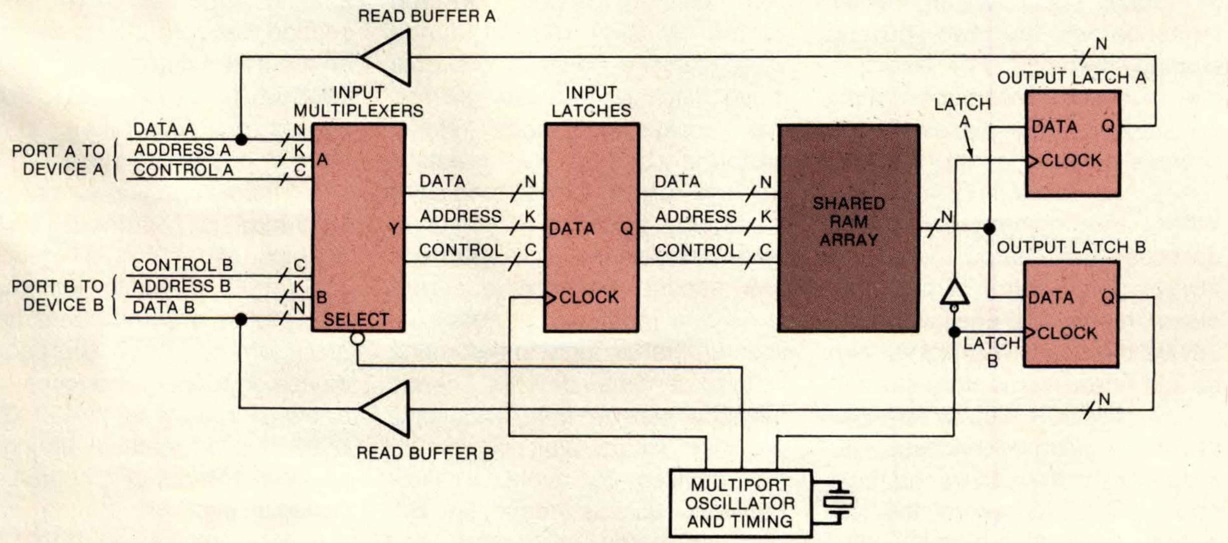

Fig 1—In an asynchronous-sampling dual-port memory system, *devices A and B do not compete for access to the shared RAM array. Instead, under precise clock timing, input multiplexers and input and output latches alternately allocate memory access to ports A and B for data, address and control transactions.*

Current techniques inflict rigid access rules on shared memory

multiport sampling oscillator functions at a 50% duty cycle.

For a memory Read cycle in which the clock's sampling edge **(Fig 2b)** just misses the start of device A's access cycle (Δt exceeds 0), the next port-A cycle must complete before t_{AC}'s trailing edge occurs. Consequently, as Δt approaches 0, $3t_{SAMPLE}$ approaches t_{AC}. You thus need at least two complete port-A cycles for the shortest possible device-A access cycle. (These conditions closely resemble those of the sampling theorem, which states that the sampling frequency must be at least twice the signal frequency.) Because a port-B cycle occurs between the two port-A cycles, however, t_{SAMPLE} actually becomes less than $\frac{1}{3}t_{AC}$. (You can conveniently extend this analysis to n ports, where t_{SAMPLE} becomes less than $[1/(n+1)]t_{AC}$.)

Recall that all inputs are latched at the beginning of a memory cycle; therefore, a memory Write cycle can complete after device A's access cycle has ended **(Fig 2c)**. In this case, at least one clock sampling edge must occur asynchronously during the access cycle—a requirement guaranteed by forcing two or more sampling edges during any t_{AC} (Write) period. Although many CPUs provide short Write Enable signals, a 2:1 sampling rate achieves a much shorter t_{AC}.

Dual-port design supports timing concepts

Turning from the theoretical to the real world, note that the system components that permit a single RAM array to function as a multiport memory also add propagation delays to all signal paths. Thus, you must subtract these delays from t_{SAMPLE} to obtain the practical timing value for a memory chip's access cycle. Likewise, bus and decoder delays effectively reduce a device's access time (t_{AC}).

Although the dual-port prototype described in this article utilizes a Texas Instruments TM 990 format card, the design works with virtually any CPU system whose access-time requirements exceed 330 nsec. The TM 990 8k-byte card contains 70-nsec 4k-bit static RAM chips. Allowing for worst-case input-latch propagation delays and output-latch setup times, a memory cycle executes in less than 95 nsec—and at room temperature, as fast as 83 nsec. Because three memory cycles are needed for one Read cycle, a 250-nsec CPU access time results. To assure safe operation over a wide temperature range with worst-case devices, however, and to accommodate commonly available oscillator crystals, this design employs 110-nsec memory cycles to obtain a t_{AC} of 330 nsec—fast enough to handle most μPs.

Because the multiport oscillator frequency depends on t_{AC}, the sampling rate becomes 1 cycle per 110 nsec or 9 MHz. You can implement a 50% - duty - cycle system clock by dividing the output of an 18 - MHz oscillator by 2. To settle the input - latch data far in advance of clocking, the circuit's input multiplexers select each port 90° out of phase from the input sampling clock. This key timing innovation realizes a simple, CPU-independent dual-port memory design.

Memory card handles diverse applications

In a straightforward processor-to-memory dual-port application, you connect the 8k-byte memory card's

Traditional memory-sharing techniques

Commonly employed dual-port techniques severely limit the performance of the two devices sharing memory. For example, one dual-port technique (prioritized access) multiplexes the two devices' address, control and data buses by assigning priorities. When the high-priority device accesses the shared memory, it always gets control of the multiplexer. Meanwhile, the low-priority device idles until the high-priority device releases memory control.

Low-cost CRT display terminals employ prioritized-access arrangements that allow the high-priority CPU to control the low-priority video-refresh logic. Unfortunately, though, when a CPU request overrides the video logic during character readings, random glitches appear on the screen. A CPU request during video blanking, however, prevents these glitches. Because glitches and access limitations restrict performance, high-cost graphics displays rely on a dedicated CPU or employ a local CPU for synchronous dual-port operation.

A second common dual-port technique (arbitrated access) utilizes arbitration logic to determine which of two devices needs memory service first. This logic provides Ready/Wait signals to the devices to avoid conflicts between access requests. But because some processors and peripherals can't enter a Wait state, the arbitrated-access method doesn't suit many memory-sharing applications. (In an exception, though, clever design of an arbitrated dual port on the Intel iSBC 86/12 permits two CPUs to access one memory with a maximum of one Wait state.)

A third traditional dual-port technique (synchronous access) enables two CPUs to generate concurrent requests for shared memory in a complicated timing arrangement. This approach is device dependent, however—only a few μPs, such as the 6800 and 6502, exhibit suitable timing parameters. These μPs furnish fixed periodic intervals during which memory access cannot take place—thus permitting interleaved memory sharing.

port A (P_1 connector) to a TM 990 CPU bus **(Fig 3a).** The uncommitted port B interfaces through the 40-pin P_4 connector.

You can configure ports A and B for 8- or 16-bit operation as either byte- or word-organized memory. Address decoders for both ports allow memory mapping at any 8k-byte boundary in the 64k address space, and because the decoders perform independently, the same information block can appear at different locations.

Three 990 CPU output signals direct each port's operation: $\overline{\text{Memory Enable}}$ indicates that a valid memory address is currently available, $\overline{\text{Write Enable}}$ strobes data into shared memory and Data Bus In specifies the direction in which data can flow through the dual-port data-bus buffers. Assure CPU independence by disconnecting all processor-dependent timing signals, such as Memory Ready and Wait State Indicator.

To reduce transmission-line effects, terminate all port-B lines. Use a ground-shield cable to connect port B to device B if the cable distance exceeds 12 in. And if you must connect port B to another system's bus, insert bus buffers to isolate the extension cable from device B's system bus.

Adapt to processor-to-processor applications

Another dual-port-memory configuration implements a high-speed communications link between two processors. For this link, you add a TMS 9900 peripheral processor to the 8k-byte dual-port memory card **(Fig 3b)**; connector P_3 joins this processor to memory port B (P_4). Support parts for this application include a 9904 clock driver, a 9902 asynchronous communications controller and a pair of 2516 2k×8 EPROMs.

In this configuration, the peripheral processor uses the dual-port memory for both workspace area and communications to an off-board backplane CPU via full interrupt handshaking. The backplane CPU sets interrupt requests to the peripheral processor by writing to one of the last 16 words in dual-port memory. Likewise, this CPU acknowledges interrupts from the peripheral processor by writing to one of the eight next-to-last words in dual-port memory. The backplane CPU's $\overline{\text{IORESET}}$ signal holds the peripheral processor in the Reset mode; writing to one of the last 16 words in shared memory releases the processor. This interrupt handshaking technique eliminates the requirement for a separate I/O interface to the backplane CPU.

Yet another asynchronous-sampling memory application connects an off-board CRT graphics-display system to the 8k-byte dual-port card. An off-board TM 990/100M CPU creates and processes images in screen memory via port A without causing display glitches. Independently of CPU operation, the graphics system constantly reads 256×256-pixel displays out of port B, into a 74LS166 output shift register and then to the CRT screen. A 9927 video timing controller scans port B and provides TV synchronizing and blanking signals.

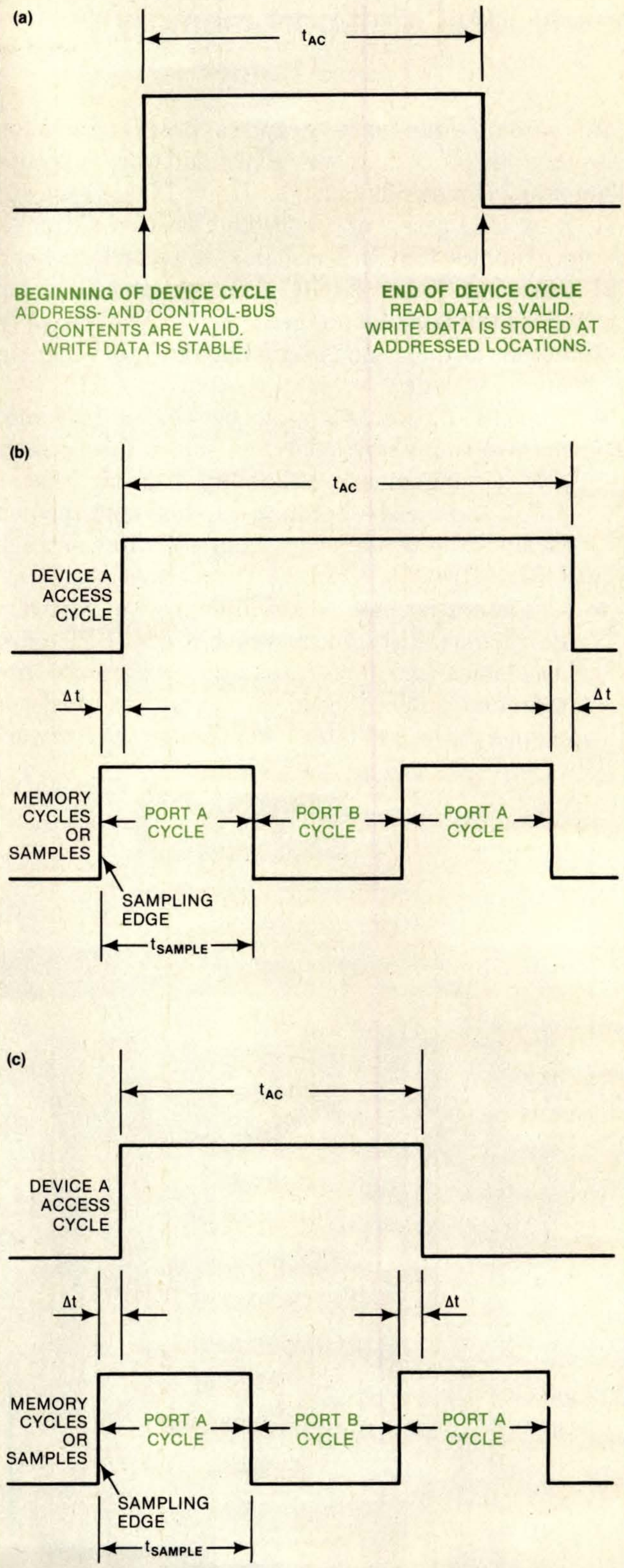

Fig 2—Clock timing for an asynchronous-sampling dual-port memory *involves three steps: establishing memory access as a simple Start/End sequence, t_{AC}* ***(a),*** *squeezing two port-A cycles into device A's Read cycle to guarantee a complete asynchronous memory cycle* ***(b)*** *and requiring only one sampling-clock leading edge for device A's Write cycle, because the input latches allow memory Write cycles to complete independently of the attached device* ***(c).***

Asynchronous sampling achieves a nearly ideal multiport memory

An assembly-language graphics program manipulates the display memory. This software executes elementary commands (such as Draw Line, Draw Box and Draw Character) at a specified location. Attached to the graphics CPU's serial link, a second off-board CPU executing Power BASIC allows graphics development in a high-level language.

Still other asynchronous-sampling dual-port-memory applications include:

- Implementation as a buffer between a CPU and a mass-storage controller for, say, a disc system; this arrangement's reliability exceeds that of DMA approaches because the dual-port memory isolates the system bus from the disc-controller CPU.
- Configuration as a key part of a software-development system in which a host CPU edits, assembles and links prototype programs; after the final object code is stored in dual-port memory, the emulator CPU debugs the software. In this manner, a catastrophic program bug cannot crash the host CPU.
- Use as a data-rate buffer between a high-speed ADC and a CPU; unlike traditional DMA buffering schemes, the ADC and CPU subsystems need not compete for memory access. **EDN**

Author's biography

Robert W Schmidt, a microprocessor systems designer at Texas Instruments, Houston, when this article was written, now works as a design engineer at the Public Broadcasting Service, Washington, DC. He holds a patent on a 16-bit memory system and counts home computing among his hobbies. (Bob rented his computer and graphics system to a TV station for election-returns reporting in 1976.)

Article Interest Quotient (Circle One)
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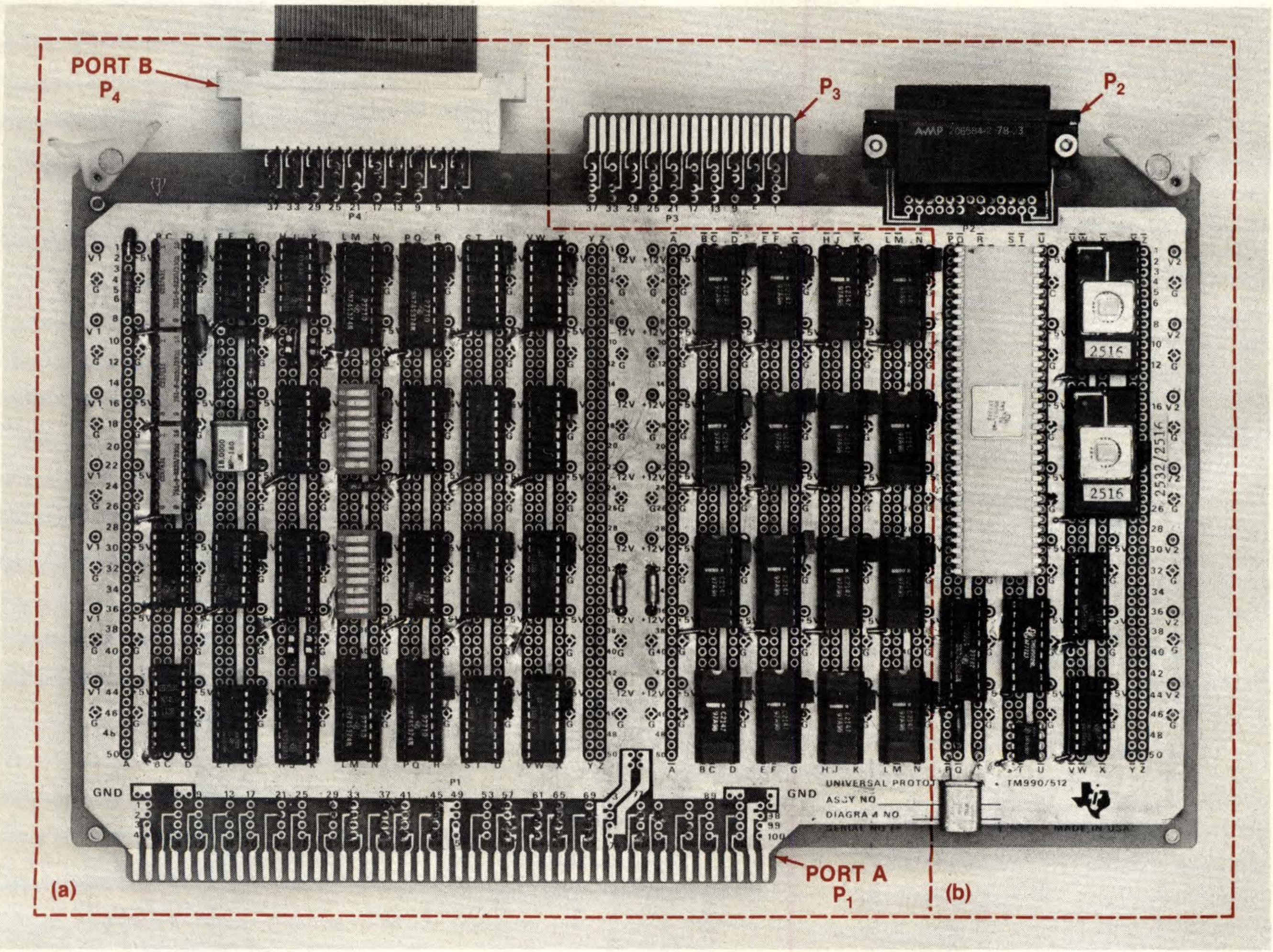

Fig 3—An asynchronous-sampling 8k-byte dual-port memory card *(designed in this case for a Texas Instruments TM 990 computer system) serves varied applications: as a stand-alone asynchronous-sampling memory with ports at P_1 and P_4* **(a)** *and as a multiprocessor system with an on-board peripheral processor interacting with an off-board backplane CPU* **(b).**


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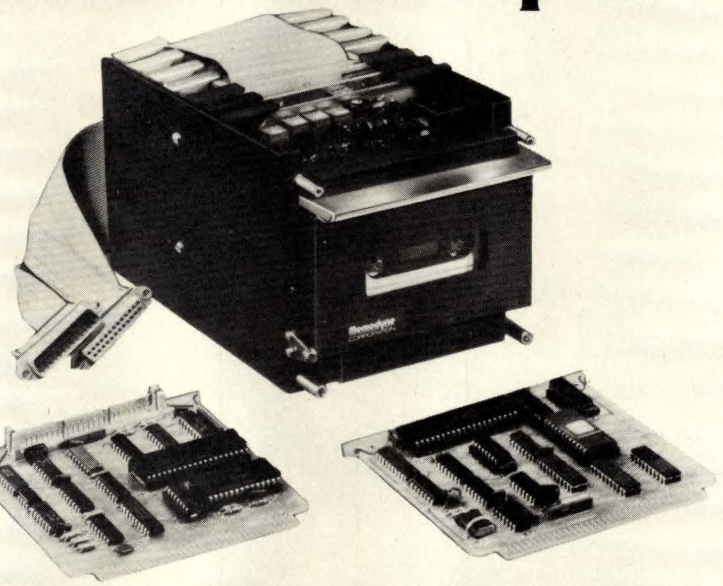

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Circuit-design approach improves transistor reliability

Designs based on the Ebers-Moll amplifier model yield reduced power dissipation and lower circuit voltage—with little or no output-power reduction—through proper use of device transconductance and voltage gain.

Keats A Pullen Jr, US Army

Transistor reliability continually presents problems that designers typically blame on inadequate or underspecified devices but that a change in circuit-design methodology can solve. Although improved device fabrication and circuit integration have de-emphasized discrete-circuit design considerations, these factors are still important. Re-examining circuit fundamentals helps you avoid some pitfalls of traditional design methods, such as the attempt to use the maximum voltages consistent with device specs.

Present bipolar-transistor circuit-design procedures, based on the matched-impedance method, generally focus on transistor current gain (β), ignoring stage voltage gain for the most part **(Ref 1).** Disadvantages of this approach include possible selection of a high supply voltage, leading to excessive power dissipation and an incipient runaway condition; voltage gains in excess of 10 to 20 per stage, leading to phase instability; excess phase shift and oscillation; and dependence (through β) on a derivative with respect to a small difference between two large numbers: the collector and emitter current values.

New method reduces β effects

You can eliminate these disadvantages through an approach to circuit optimization that greatly reduces the importance of β. This method, based on transconductance, permits lower circuit voltages with at most a slight reduction in power output, improves circuit stability and increases reliability. The resulting reduction in power dissipation in turn reduces the required amount of cooling, facilitates the sealing of circuitry from dirt and moisture and extends battery life in portable designs.

Understanding this method begins with a consideration of amplifier representation by means of the Ebers-Moll equations **(Ref 2),** which lead to a derivation for amplifier voltage gain **(Ref 3).** You can calculate this gain for the simplest resulting circuit from the equation

$$K_v = -\kappa \Lambda I_C Z_L \qquad \textbf{(1)}$$

where κ is transconductance-per-unit-current efficiency, Λ is q/kT, I_C denotes collector current and Z_L represents load impedance. With bipolar transistors, the value of κ approaches 1, and the value of Λ equals 39 siemens/A. Neither of these parameters is a function of β, and neither depends sensitively on small differences between large numbers or on minority-carrier lifetime. The only restriction on β is that it be greater than a specified minimum value (such as 10).

Based on κ, the approximate value of collector supply voltage required to achieve proper amplifier operation in the common-emitter mode is given by this equation **(Ref 1):**

$$V_{CC} \approx 1V/\kappa, \qquad \textbf{(2)}$$

while a common-base-configured amplifier requires a voltage of

$$V_{CC} \approx 7.5V/\kappa. \qquad \textbf{(3)}$$

These equations also apply to FETs and electron tubes.

Now recall that a high κ value severely limits the power-handling ability of a bipolar transistor when employed as an RF amplifier, even in the common-base configuration. This limitation's effect frequently appears in practical circuits, but its cause is not always recognized.

To illustrate the point, consider a common-base RF amplifier. Here, an emitter-to-collector voltage gain of 75 to 100 yields a stable overall gain of 10 for properly configured circuits. For a peak collector current of 20A, the forward (intrinsic) admittance reaches 750S, calling for a maximum tuned impedance (loaded) of 0.1Ω.

Transconductance-based designs improve on traditional methods

Consequently, an output circuit must transform load impedances between 0.1 and 50Ω. A peak power input of 200W with a collector supply of 10V calls for a tuned loaded impedance of 0.4Ω, if you can tolerate a voltage gain of 300. The resulting input power of 100W makes 50 to 60W available (unless you achieve internal stabilization through emitter resistance), as observed in practice.

Accordingly, the circuit should be designed (via the transconductance method) in a manner potentially least destructive to the device rather than to achieve the maximum input power theoretically possible (through the matched-impedance method), because the stable output power available differs only slightly in either case.

Check supply-voltage requirements

Now consider some related design factors. First, examine whether the transconductance method's reduced collector voltage allows sufficient signal drive for the next stage. From **Eq 2,** a κ of approximately 1 (as for a bipolar transistor) requires a supply voltage only 1V greater than the device saturation voltage. With bipolar transistors, as with simple diodes, a 200-mV change applied across the input junction causes a more than 2000-fold change in device current. So long as the voltage from collector to emitter exceeds the saturation voltage by even a few hundred millivolts, the transistor amplifies as well in most applications as it would with 5 or 10V applied.

Second, note that the traditional method's use of higher voltages requires a high value of Z_L for impedance matching. In either approach, limitation of stage voltage gain (typical military and commercial RF and IF linear amplifiers usually include one stage per decade of voltage gain) to assure stability requires limiting the effective value of Z_L—sometimes intentionally but often accidentally—either at the design stage or in the final circuit. While the transconductance approach inherently provides a reduced Z_L, matched-impedance designs depend on input loading from a following stage to reduce the voltage gain from as much as 1000 to a safe value of 10 to 20.

Also consider the effect of β on circuit performance. Inserting a super-β transistor into a traditional circuit can cause circuit oscillations incorrectly blamed on the transistor. Transconductance-based designs incorporate a lower impedance output circuit having the proper Q value, allowing operation with any transistor having a β greater than 5 or 10 and sufficient alpha cutoff frequency. In addition, such circuits have the intended amount of gain, because each stage is designed to use a stabilized level of output current and the appropriate level of impedance, with gain unaffected even by a nuclear event so long as the postevent β exceeds a

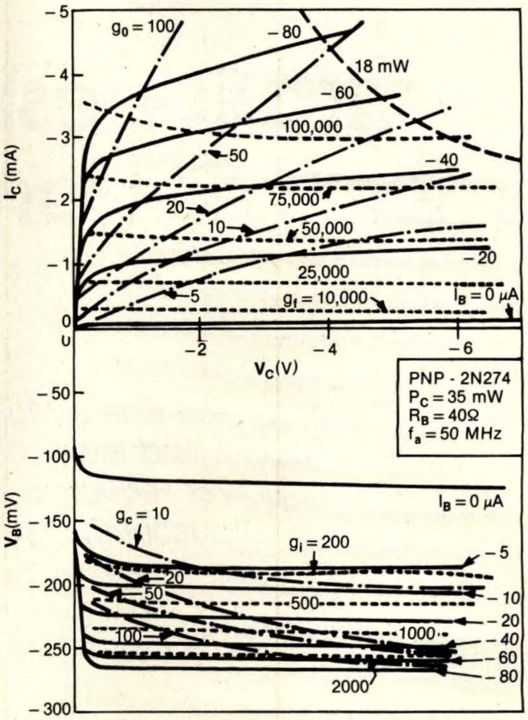


Fig 1—Typical transistor augmented curves *illustrate data used in the design examples outlined in this article.*

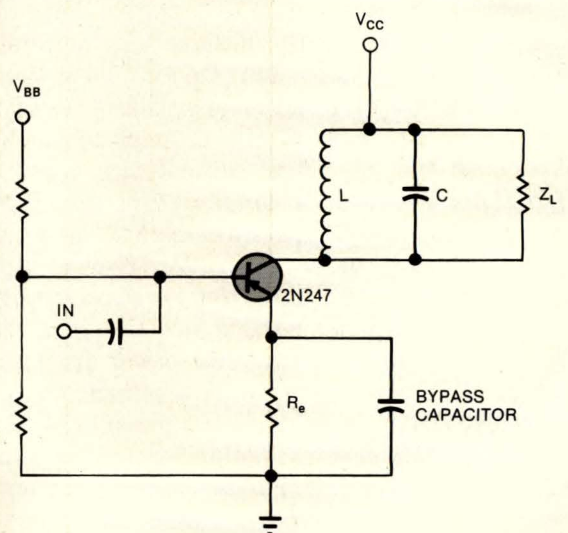


Fig 2—Design of an IF/RF amplifier circuit *illustrates the benefits of the transconductance design technique.*

TABLE 1 — DESIGN-DATA COMPARISON

PARAMETER	CASE 1	CASE 2
V_{CC}	1V	10V
Z_L	25Ω	1000Ω
I_b	<500 μA	<500 μA
R_e	5Ω (BYPASSED)	5Ω (BYPASSED)
X_L	0.25Ω	10Ω
X_C	0.25Ω	10Ω
L	0.004 μH	0.16 μH
C	64,000 pF	1600 pF
UNLOADED K_v	10	400
LOADED BANDWIDTH	1 × DESIGN BANDWIDTH	40 × DESIGN BANDWIDTH
POWER INPUT	10 mW	100 mW
TEMPERATURE RISE	4.7°C	47°C

selected design minimum. (Wire-wound decoupling resistors help protect active devices, which can look like short circuits during nuclear events.)

Base your design on the proper procedure

The transconductance design procedure for discrete-transistor amplifier circuits should follow these steps:

- Selection of the desired output load impedance
- Selection of the desired output current
- Design of the bias circuit to provide the output current
- Selection of the appropriate base supply voltage
- Selection of the appropriate collector supply voltage
- Design of the linear networks for use with the device.

After completion of the first three steps, select the supply voltages, keeping in mind that the base supply, with 10V typically available, must provide less than a tenth as much current as the collector supply, which in turn must supply only a tenth to a fifth as much voltage as the base supply. This consideration results in a 50 to 75% reduction in the total net power required with normal design procedures. The supplies require good filtering but need little if any special regulation. Thus, the two supplies called for in the transconductance method need not cost more than a traditional circuit's single supply, and the benefits resulting from better circuit operation, less required cooling and improved reliability are free.

Actual values for input-signal voltage and output-circuit supply voltage depend on the transconductance efficiency, which you should select based on application considerations. Where maximum separation of signal from noise is required, use devices with the maximum possible κ, because this approach provides the maximum transconductance and gain for any current level. (Noise level is highly current dependent. Note, however, that space-charge effects help minimize noise with both electron tubes and FETs.)

On the other hand, maximum power-output requirements dictate the use of devices with reduced κ values. In fact, you will find that with most high-power 2-port electron tubes, the recommended control-supply-voltage value falls within a factor of two of that defined by **Eq 2.**

Examples contrast design methods

The design benefits of the transconductance technique stand out with respect to the traditional matched-impedance method, as an example illustrates. Consider the design of a 10.7-MHz IF amplifier with an overall stage gain of 10 by use of the transconductance technique (Case 1) and the matched-impedance method (Case 2). Assume collector current of 10 mA, base voltage of 10V, β greater than 20, a desired K_v of 10 and loaded Q of 100. The typical device curves appear in **Fig 1,** the circuit configuration in **Fig 2** and the design results in **Table 1.** Note the collector supply voltage of 1V for Case 1 and 10V for Case 2 and the corresponding input power requirements. Had a 40-mA collector current been selected, the power input for the two cases would have been 42 and 402 mW, respectively, leading to a significant overload in Case 2.

Although the design values for L and C for Case 1 appear difficult to obtain, the tuned circuit can employ a tapped coil, with the inductance to the tap as the rated value. Then you can increase the overall inductance by four or more times and correspondingly reduce the capacitance.

Clearcut advantages result from the use of the transconductance method in this example and in general:

- Loading from the following amplifier has a negligible effect on the stage gain and bandwidth so long as the minimum β is high enough (20 is usually sufficient) to make the input impedance of the following stage large compared with 25Ω. This impedance would probably not be near 1000Ω, as is required by Case 2.
- Power input to the collector circuit is reduced to one-tenth that required for Case 2, making possible substantial increases in MTBF **(Ref 4).**
- Little danger of either oscillation or phase instability occurs, given good layout practice.
- The characteristics of the transistor in the following amplifier have little effect on the stage designed.
- The circuit's reduced overall impedance level, even with use of the tapped-coil arrangement, makes the impedance transformation required with common-base configurations substantially easier to obtain.
- The technique alleviates circuit problems arising from a little-known relation between tuned-circuit Q and step-down ratio in systems employing a tapped-capacitor-tuned transformer.

TABLE 2 — 2-STAGE AMPLIFIER DESIGN DATA

PARAMETER	STAGE 1	STAGE 2
Z_L	25Ω	2.5Ω
I_b	<100 μA	<1000 μA
R_e	25Ω (BYPASSED)	2.5Ω (BYPASSED)
X_L	1Ω	0.1Ω
X_C	1Ω	0.1Ω
EFFECTIVE L	16 nH	1.6 nH
EFFECTIVE C	1280 pF	12,800 pF
MINIMUM STAGE β	25	25
POWER INPUT	4 mW	40 mW

Another example illustrates the use of the transconductance technique to build up the power level of an RF source. Assume a 2-stage design of a 25-MHz amplifier; let the voltage gain for each stage be 2, with the input signal starting at 10 mV. Use first- and second-stage collector currents of 2 and 20 mA. Choose a Q value of 25 for the loaded tuned circuits and a V_{CC} of 2V. **Table 2** summarizes the results, which show a requirement for tapped coils or transmission lines and demonstrate the difficulty of designing adequate parallel-tuned circuits for very high-frequency transistor amplifiers. Where

Lowered power-supply voltages still permit adequate gain

possible, then, use series-tuned circuits.

This amplifier yields a 40-mV output, and the variation in voltage gain of an amplifier following the second stage would be about 4:1. (The third stage would approach Class C operation—see **box,** "Notes on Class C amplifier design.") The signal-frequency current available from the collector of the second stage in this semipower-amplifier arrangement can reach 7 mA rms or more. So long as the minimum required β is available, stable operation in the designed mode is achievable.

Technique simplifies analysis

The transconductance technique also serves other applications. Because transconductance as a function of device current is readily available (from **Eq 1**) in terms of I_C, calculation of the properties of nonlinear circuits, including frequency multipliers, mixers and switching circuits, proves relatively straightforward **(Ref 5).**

Important consequences of the transconductance design approach include academically simple analysis of solid-state-device characteristics and ease of circuit optimization, as well as improved performance and reliability. You need only watch a circuit fail from excessive dissipation to appreciate the benefits. **EDN**

Article Interest Quotient (Circle One)
High* 488 *Medium* 489 *Low 490

Notes on Class C amplifier design

Traditional design of transistorized RF power amplifiers involves the use of a collector supply voltage as high as device second breakdown and fundamental breakdown will permit. The following analysis evaluates the validity of this practice.

Any amplifier is to some extent a feedback amplifier, and its operating equation therefore assumes the simplified form:

$$K = K_v/(1 - K_f K_v)$$

where K is the overall voltage amplification, K_v denotes the forward voltage amplification and K_f represents the amplification (much less than unity) for the amplifier feedback path. So long as the overall value of K as a function of frequency does not include a zero value for the denominator, the circuit should prove stable, but minimum-phase characteristics require that the $K_f K_v$ magnitude be as small as possible.

Because of the assortment of stray inductances and capacitances in RF amplifier circuits, assume that if the magnitude of $K_f K_v$ approaches unity, unstable conditions can occur and that the amplifier's phase transfer function will thus vary erratically with frequency. The existence of such excess phase shift is probably the most sensitive indicator of a potentially unstable amplifier—one that might self-destruct.

Efficiency considerations require that amplifier power stages operate in the common-base configuration, which yields ratios of peak available energy taken from the tuned circuit to loss in the active device greater than 10:1. Alternative configurations, however, exhibit ratios as small as 2:1. The changeover point from the use of the common-emitter configuration to the common-base configuration is thus a critical point in power-amplifier circuit design—achieving adequate drive for the first common-base amplifier and assuring phase stability simultaneously can prove difficult.

With proper design and layout, it's possible to obtain stable operation in the common-emitter mode with input-to-output voltage gains of up to 10, and in the common-base mode with gains of approximately 100 (emitter to collector). Thus, the maximum feedback gain in the two cases typically cannot exceed either 0.01 or 0.001.

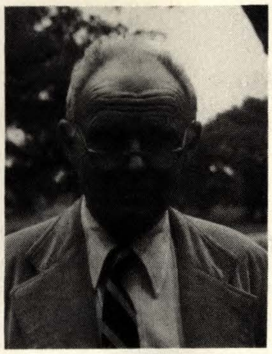
The feedback paths for transistors at high frequencies are complex, including intrinsic capacitances and various parasitic elements. This combination makes neutralization difficult, particularly in the common-emitter mode. And this difficulty in turn makes the forward - voltage - gain limitation even more important; achieving such limitation is possible only by limiting the circuit impedance levels, particularly Z_L.

Theory shows that to obtain maximum effective bandwidth for a chain of amplifiers using discrete circuit elements in the presence of Miller-effect capacitance, stage voltage gains between 2 and 3 are optimum. In practice, though, other considerations might apply, with the result that voltage gains typically should not exceed 10 to 20 overall (input to input).

For efficient operation of a transistor in a Class C amplifier, collector-to-emitter voltage must be as small as possible during the current pulse that charges the circuit's frequency-determining components. The supply voltage then must be sufficient to produce this voltage at peak current with the allowed value of loaded tuned impedance.

When the operating load line for these conditions is established for a Class C amplifier, it appears somewhat like curve D in the **figure (Ref 5).** The dotted section develops from energy exchange in the frequency-stabilizing circuit. The actual load contour starts

Author's biography



Keats A Pullen Jr is an electronic research engineer in the Tactical Operations Analysis Office of the US Army Material Systems Activity, Aberdeen Proving Ground, MD. Holder of a BS in physics from Cal Tech and a Doctor of Engineering from Johns Hopkins University, he is a Life Fellow of the IEEE. Keats' hobbies include photography, computer science and ham radio. He says this article "represents the culmination of many years of effort to reduce temperature rise and increase MTBF of electronic hardware."

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3. Pullen, K A, *Design of Transistor Circuits with Experiments,* Howard W Sams & Co Inc, Indianapolis, IN, 1979.
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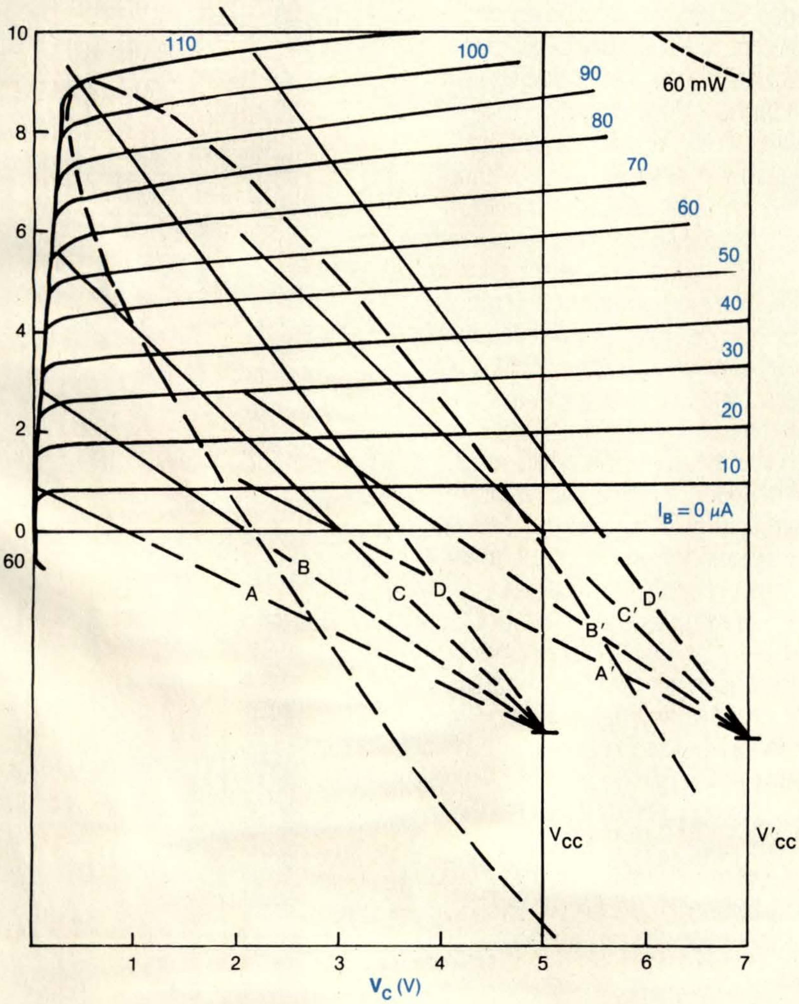
initially through the V_{CC} point and within a number of cycles equal to Q essentially moves to the indicated location. (Strictly, an elliptic load contour is generated, resulting in energy storage that proves vital in circuit operation.)



Operation-contour plot *shows the load line for a Class C amplifier.*

The direction of traversal of the elliptic load contour is indicated by the arrowheads on the graph. And as the coupling to the load tightens, the resistive axis of the load line shifts from A′ to D′ for an excess-voltage situation.

When the transistor amplifier operates near its maximum frequency (f_{max}), it might prove necessary to increase the selected value of V_{CC} sufficiently to assure that the load contour is properly located with respect to existing f_{max} contours. This condition might indicate that the device chosen doesn't suit the intended application. Thus, where possible, avoid such a voltage boost.

The important point to note from the **figure** is that with matched impedances, the voltage gain in the power amplifier (as shown by C′) quickly develops a maximum value so great that stability is no longer assured. As the impedance is reduced through loading to assure stability, the transistor power input increases, and the power output at the chosen output frequency might decrease simultaneously. The only way you can avoid this situation is by selecting a reduced value of collector supply voltage.

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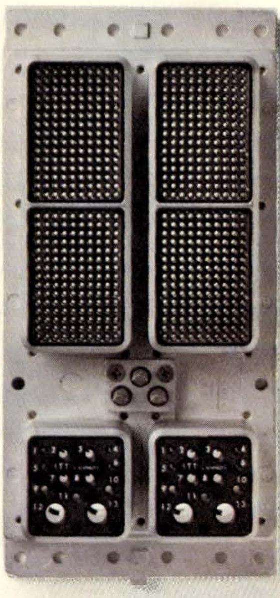

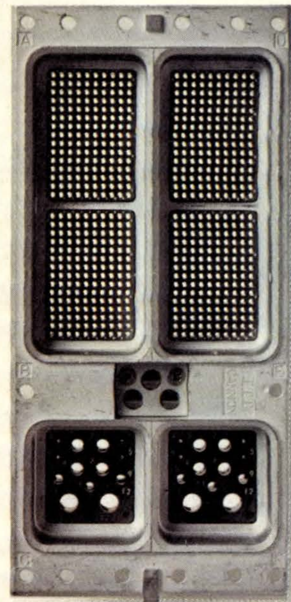

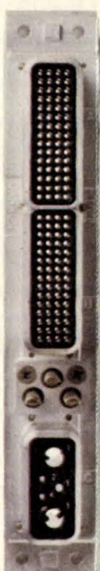

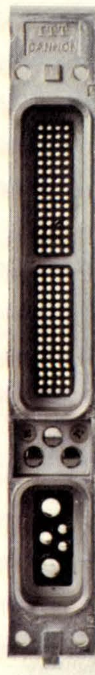

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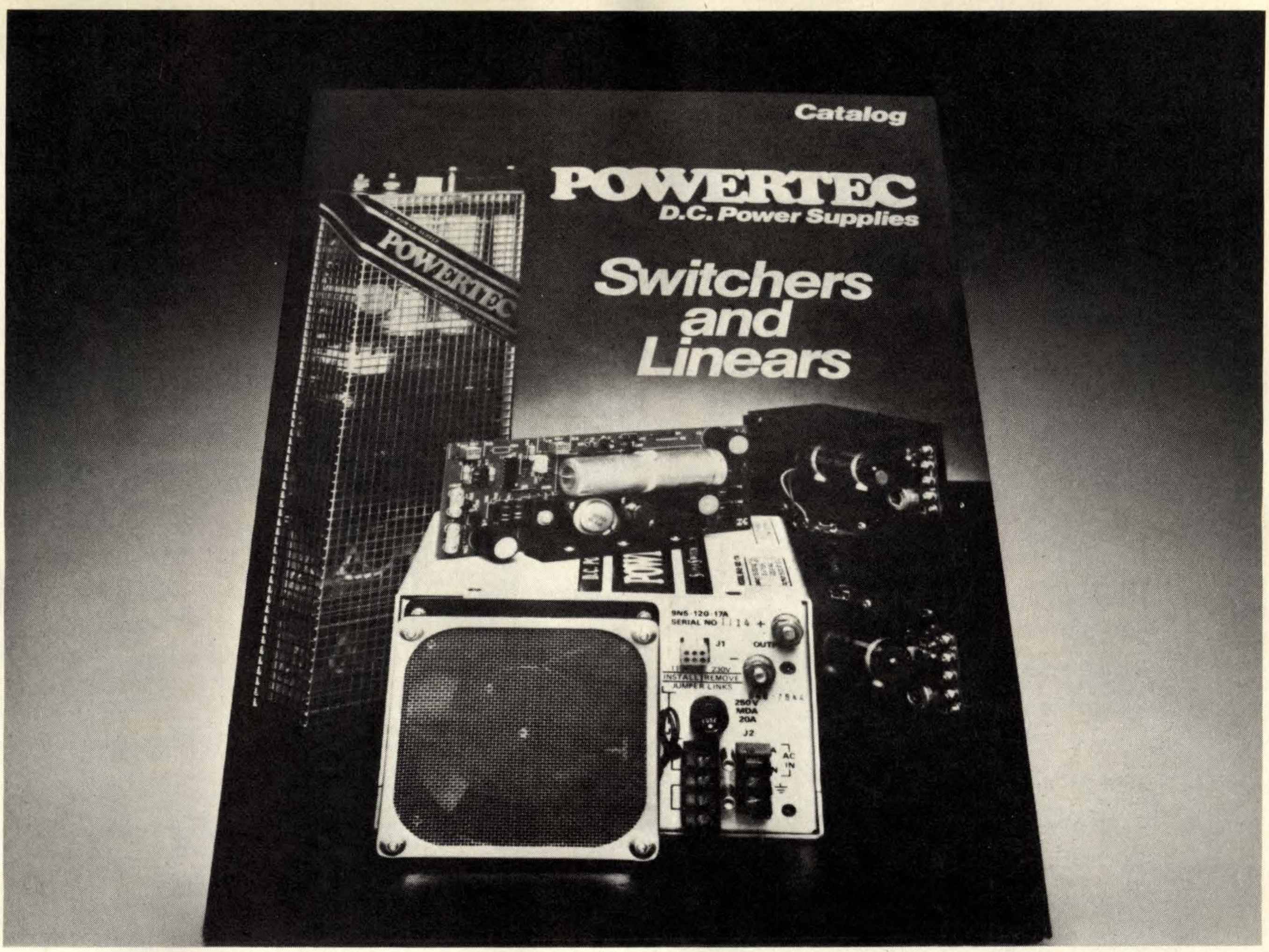

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Notes: D (Design Ideas); F (Design Features); M (μComputerist Corner); N (News); P (Feature Products, Editor's Choice)

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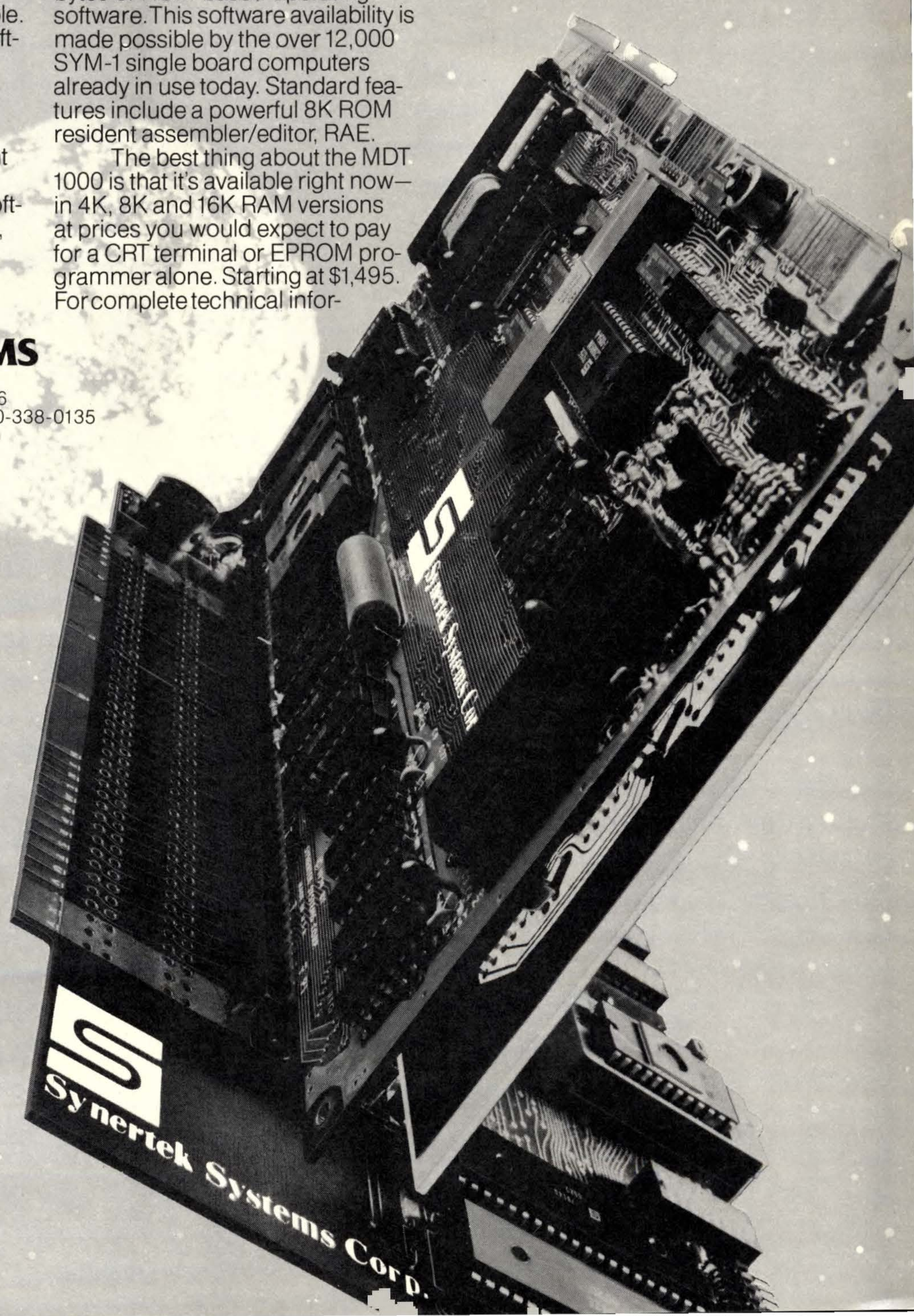

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Article Interest Quotient (Circle One)
***High* 491 *Medium* 492 *Low* 493**

NEXT TIME

In EDN's May 5 issue, look for a preview of key sessions and product exhibits at NCC '80. This year's National Computer Conference promises to be bigger and better than ever, and EDN will be there. Also look for feature articles on

- The latest serial printers, complete with a handy clip-out chart
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. . . and much more. Look, too, for news roundups on developments in PROM programmers and color CRTs, plus a report on the latest action in 8-in.-hard-disc standards, plus our regular μComputerist Corner and Design Ideas departments. You can't afford to miss this issue!

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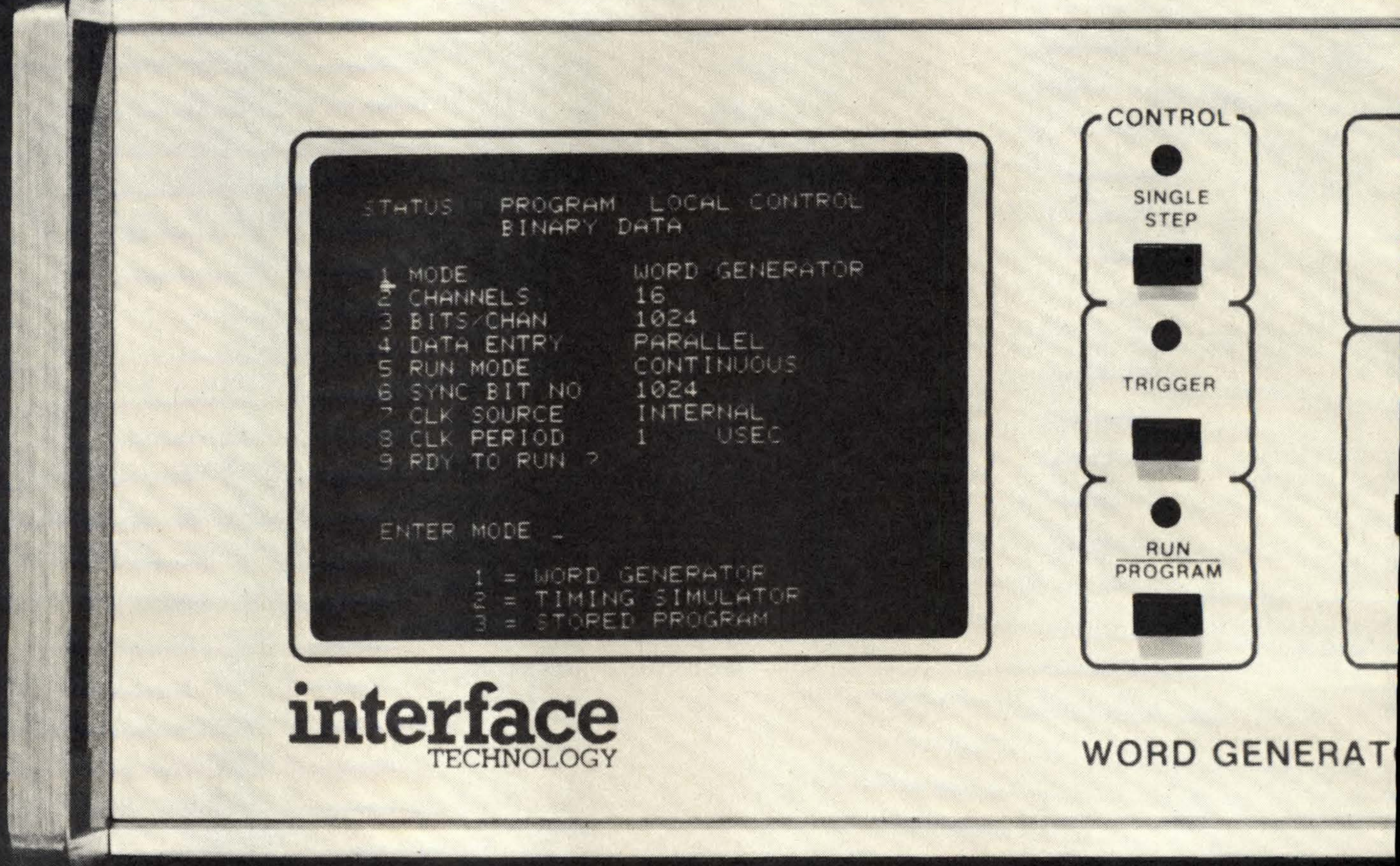

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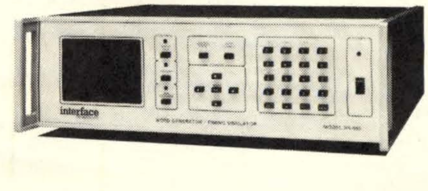

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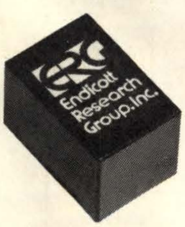

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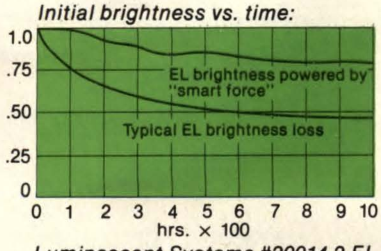

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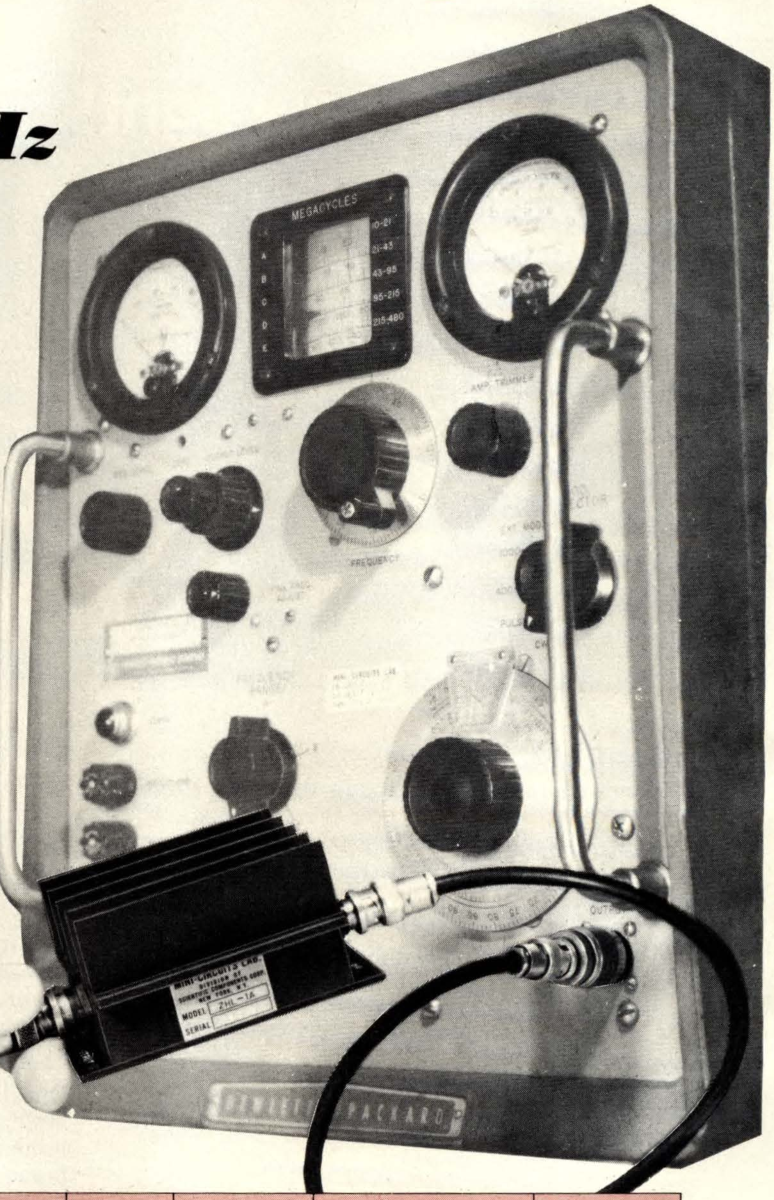

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ZHL-2	10-1000	16 Min.	±1.0 Max.	+29 Min.	18 Typ.	+38 Typ.	+24V	0.6A	349.00	(1·9)
ZHL-3A	0.4-150	24 Min.	±1.0 Max.	+29.5 Min.	11 Typ.	+38 Typ.	+24V	0.6A	199.00	(1·9)
ZHL-2-8	10-1000	27 Min.	±1.0 Max.	+29 Min.	10 Typ.	+38 Typ.	+24V	0.65A	449.00	(1-9)
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Design Ideas

Edited by George Huffman

Speedy 12-bit DAS combines hard/software

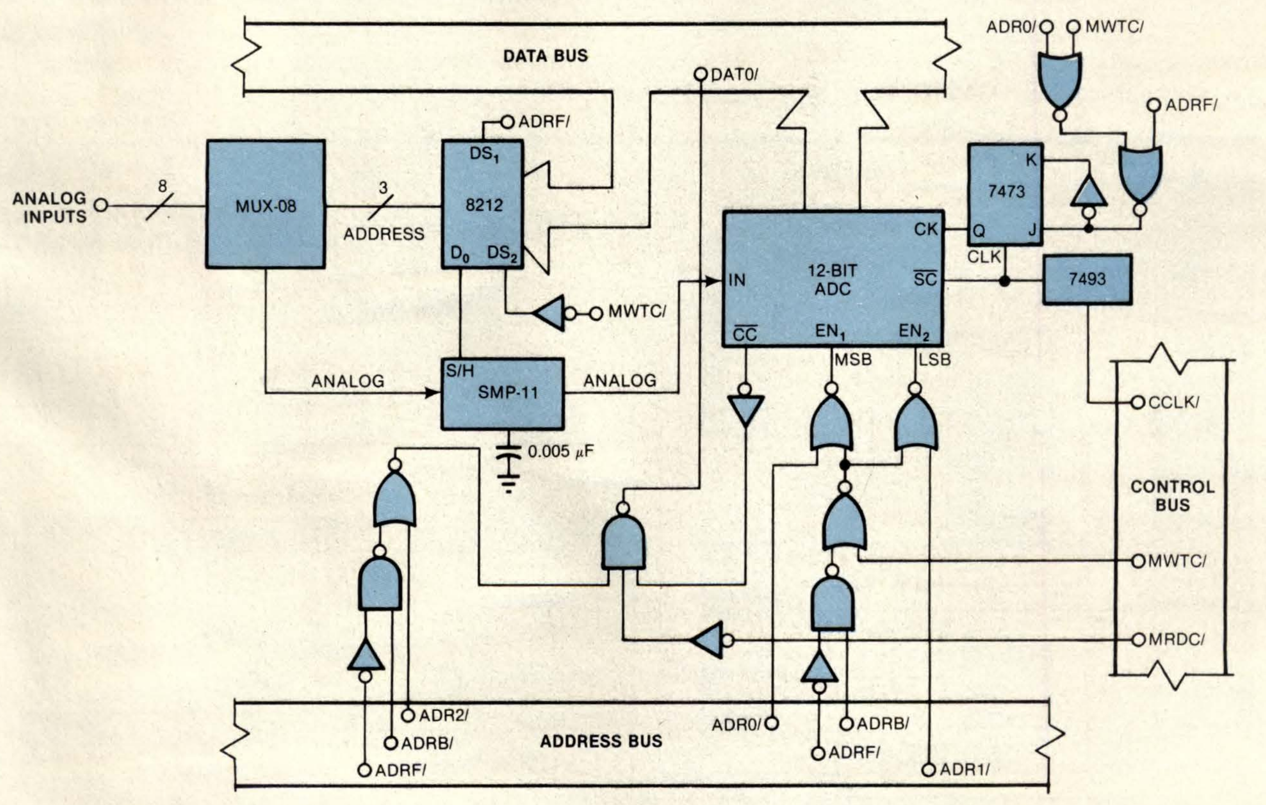
Mike Parsin
Precision Monolithics Inc, Santa Clara, CA

With the increasing availability of high-accuracy (0.1%) analog transducers, data-acquisition-system designers more than ever face conflicting requirements. On the one hand, they should employ 12-bit ADCs so as not to mask transducer accuracy with system errors (ADCs are generally spec'd at ±½ LSB, which equates to ±0.012% for a 12-bit device—just adequate for the job). But on the other, they usually must try to read several channels at a high throughput rate.

There are three basic ways of resolving this conflict. The first employs an all-hardware system using multiple flash converters—a very fast and expensive approach. The second involves an all-software configuration using successive-

```
        ORG   1000H     ;
BEGIN:  LXI   D, 1808H  ; LOAD MUX COUNTERS
        LXI   SP,200FH  ; SET STACK POINTER
START:  LXI   H, 8000H  ; SET MEMORY MUX ENABLE
        MOV   A, D      ; READY MUX
        MOV   M, A      ; ADDRESS MUX AND SAMPLE
        NOP             ; WAIT FOR MUX TO SETTLE
        MOV   A, E      ; ADDRESS MUX AND HOLD
        MOV   M, A      ; HOLD ANALOG INPUT
STCON:  LXI   H, 8005H  ; ADDRESS START CONVERT
        MOV   M, A      ; START CONVERSION
DELAY:  LXI   H, 8004H  ; WAIT FOR CONV COMPLETE
        MOV   A, M      ; CHECK CC
        ANA   A         ; SET PARITY
        JPO   DELAY     ; CC?
        LHLD  8001H     ; TRANSFER 2 BYTE DATA
        PUSH  H         ; STORE DATA IN STACK
        DCR   D         ; COUNT DOWN SAMPLE COUNTER
        DCR   E         ; COUNT DOWN HOLD COUNTER
        MOV   A, E      ; TEST 8 CHANNELS
        JNZ   START     ; START NEXT CHANNEL
        HLT
```

Occupying just 37 memory bytes, *this 8080 software routine is faster than the hardware it drives. Initialization, single-channel conversion and data storage require only 83 μsec; MUX settling time accounts for the NOP.*



Speedy data acquisition *results with this 8-channel, 12-bit system. Interfacing to an 8080 Microbus, it expands to 64 channels with the help of four MUX-16s.*

approximation conversion (SAC) techniques—a method low in hardware costs and throughput rate but high in processor overhead. The third method, described here, centers on a fast 8080-based software driver coupled to a low-cost hardware design.

The circuit depicted in the **figure** interfaces with the 8080 Microbus and the SBC 80/10 bus. You can expand the 8-channel version shown to 40 inputs by using five MUX-08s or to 64 inputs by employing four MUX-16s.

The software routine is only 21 instructions long and occupies 37 bytes of memory. Memory mapping speeds it up: Initialization, single-channel conversion and data storage combined take only 83 μsec (in fact, the design calls for a NOP to slow the software down so that the MUX can settle).

When addressed, the MUX selects and inputs an analog channel to the S/H; from there, the signal goes to the 12-bit ADC for conversion. BEGIN starts loop initialization, setting registers D and E and the stack pointer (SP); then, START addresses the MUX and S/H. Conversion commences (STCON) with a LOW at SC, then loops in DELAY while waiting for completion.

Instruction LHLD 8001 loads the μP's H and L registers with the 2-byte ADC word, which PUSH H then pushes onto the stack. Counters D and E are decremented, and (if they are not zero) the program loops back to START, ready to input the next analog signal. After conversion of all eight channels, data is stored in memory locations 2000 through 200F. **EDN**

To Vote For This Design, Circle No 457

Output Enable resolves bus contention

Michael Bolan and **Sandy Scherpenberg**
Mostek Corp, Carrollton, TX

A microprocessor system can be plagued by performance problems unless you give proper attention to timing parameters. One often overlooked timing-related problem, memory-bus contention, can produce symptoms ranging from catastrophic system damage to soft errors that don't yield to straightforward troubleshooting techniques.

Continued on pg 234

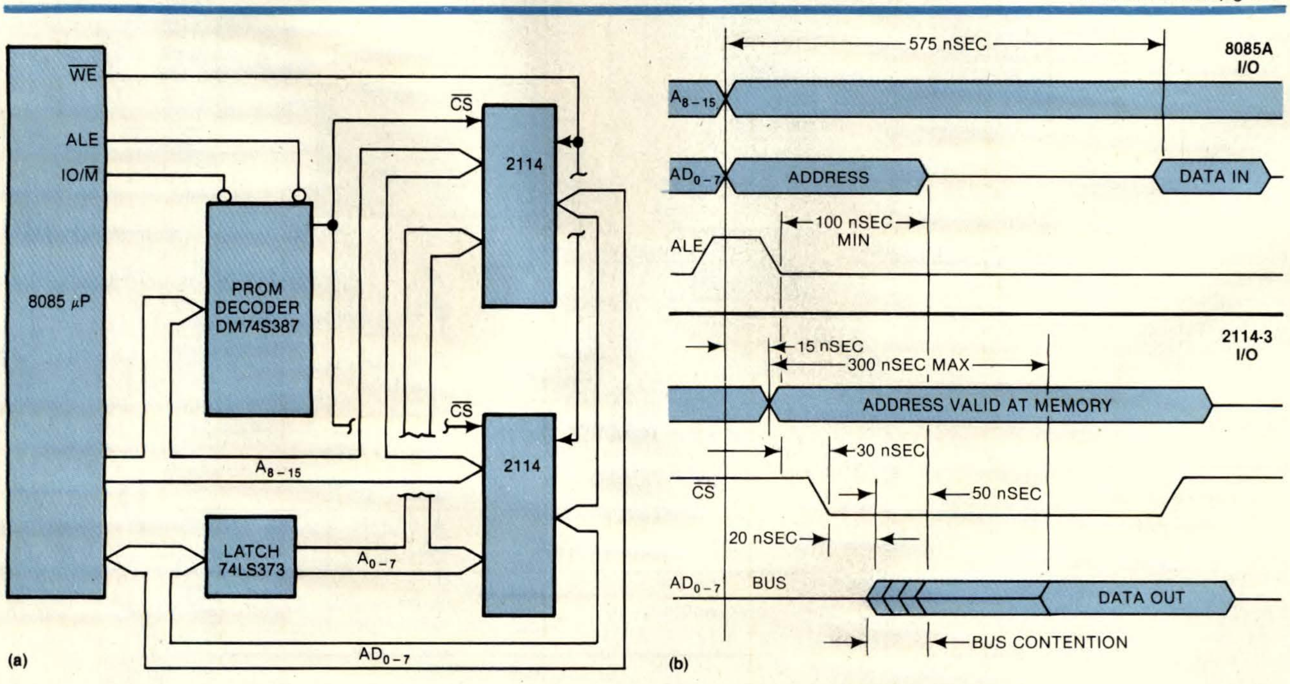


Fig 1—Bus contention *results when two or more buffers on the address/data bus* **(a)** *are simultaneously enabled. Timing overlaps arising from device delays* **(b)** *can cause hardware/software failures.*

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  The SE Amber relay's 4-gap balanced armature delivers a highly efficient polarized magnetic circuit–sensitive enough to be driven directly by an IC, in a space 28L x 12W x 10H mm.

Sensitivity

Pick-up power	100 mW
Nominal operating power	200 mW

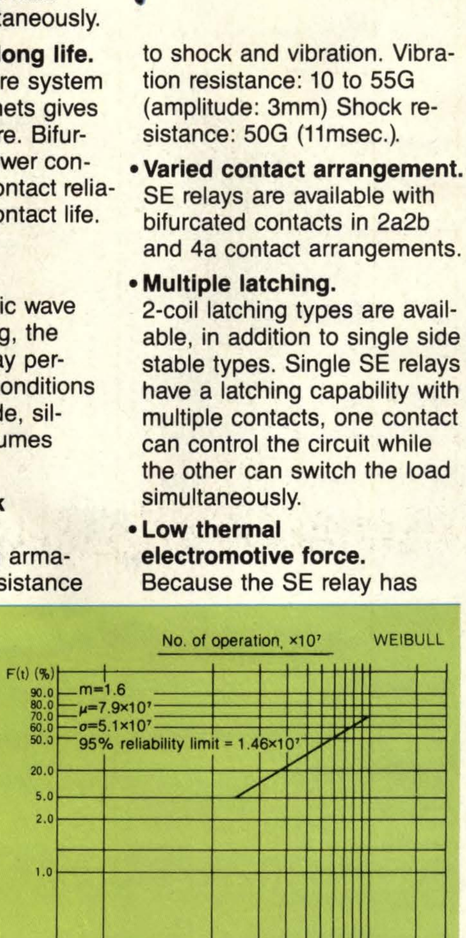
Dimensions

Volume	28L x 12W x 10H mm	1.102 x .472 x .394 inch
Header area	336mm²	.521 inch²
Height	10mm	.394 inch

Wide switching range.
$\left[\begin{array}{c}\text{The sum of all contacts'} \\ \text{switching capacity (VA)}\end{array}\right]$
Switching is possible from 100μA 100mV DC to 4A 250V AC, thanks to the 4-gap balanced armature system and special multi-layer clad contacts. A single SE relay can handle maximum and minimum switching simultaneously.

- **High reliability and long life.** The balanced armature system with permanent magnets gives larger contact pressure. Bifurcated contacts and lower contact bounce add to contact reliability and expected contact life.
- **Amber design and construction.** Designed for automatic wave soldering and cleaning, the sealed SE Amber relay performs reliably under conditions where hydrogen sulfide, silicone and ammonia fumes prevail.
- **High vibration/shock resistance.** The balanced rotating armature provides great resistance to shock and vibration. Vibration resistance: 10 to 55G (amplitude: 3mm) Shock resistance: 50G (11msec.).
- **Varied contact arrangement.** SE relays are available with bifurcated contacts in 2a2b and 4a contact arrangements.
- **Multiple latching.** 2-coil latching types are available, in addition to single side stable types. Single SE relays have a latching capability with multiple contacts, one contact can control the circuit while the other can switch the load simultaneously.
- **Low thermal electromotive force.** Because the SE relay has completely separate coil and contact chamber areas, extremely low thermal electromotive forces are possible.
- **Dual in-line package arrangement.** This 2-track terminal arrangement allows easier component insertion, easier layout and identification of terminal locations, and simpler in-line checking.

Contact reliability
Test condition:
DC1V/1mA,
4 contacts in series
Detection level 10Ω
Sample: S4E-24V
Q'ty = 10



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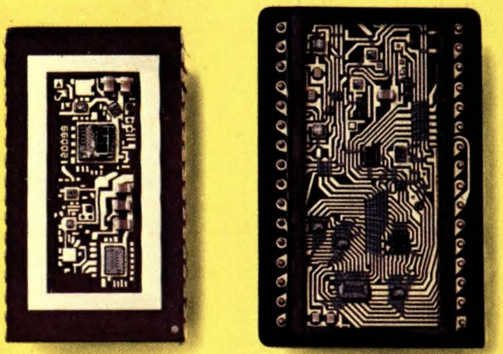
Our ADC80 is a complete 12 bit successive approximation analog-to-digital converter that includes an internal clock, reference and comparator. It needs no external components to perform a 12 bit accurate A/D conversion in only 25 μs. To make it the best ADC80 you can get, we added lots of improvements. First, we only used half as many chips, so it's much more reliable. Then, we used a monolithic D/A chip so we can guarantee no missed codes over a wider temperature range. Ours also consumes less power, and the reference output can supply up to 1.5 mA of current to external circuitry. We even have a 40ns status delay that guarantees valid data at the end of a conversion. After we made a better ADC80, we made darn sure we put plenty into stock. So you can get as many as you need. Now.

DESIGNED AND BUILT TO LAST FAR LONGER.

Our ADC80 is not only better, it's more reliable. Not only does it have half as many chips (17 versus 34), but we've reduced the number of bond wires by 63% from 177 to 73. We've even improved the packaging with a "SLAM" ceramic dual-in-line package that eliminates the substrate. The result in terms of calculated MTBF is that ours will far outlast theirs.

CAN GET, YOU CAN GET.

AD vs. BB



ACTUAL SIZE

	AD	BB
Number of Chips	17	34
MTBF (failures/million hrs.)*	15.1	24.8
Temperature Range for No Missing Codes	-25°C to +85°C	0° to +70°C
Power Dissipation	800mW	950mW
Max. Reference Output Current	1.5mA	0.2mA

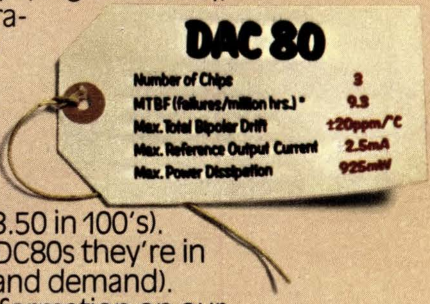
Chip count determined from actual devices. *MTBF's calculated per MIL-HNBK-217C. Other BB data taken from published data sheet.

PERFORMANCE SPECS THAT ARE SPECTACULAR.

Our ADC80 clearly beats the competition (see chart) in terms of chip count, calculated MTBF, temperature performance, power consumption and reference output current. And our 40ns status delay allows you to latch output data directly into a data register without losing the 12th bit. This is a real cost saver, because it means you don't have to add external status delay circuitry.

IF YOU LIKE OUR ADC80s, YOU'LL LOVE OUR DAC80s.

If you're looking for a pin-for-pin replacement for the industry standard DAC80 12 bit D/A converter, look no further. Our DAC80 features an internal output amplifier that settles to ±0.01% in 3 μs (voltage models), guaranteed monotonicity over the 0 to +70°C temperature range, and a low profile ceramic dual in-line package. The same innovative design techniques used in our ADC80s are also incorporated in our DAC80s. So we also have the best DAC80, with fewer chips, high reliability, better temperature drift, and lower power consumption. You'll even love the price of our DAC80 (starting at $18.50 in 100's). And like our ADC80s they're in great supply (and demand).



For more information on our ADC80s and DAC80s, get in touch with Doug Grant or Don Travers at (617) 935-5565, or write Analog Devices, Inc., P.O. Box 280, Norwood, MA 02062.

ANALOG DEVICES

WAY OUT IN FRONT.

Analog Devices, Inc., Box 280, Norwood, MA 02062; East Coast: (617) 329-4700; Midwest: (312) 894-3300; West Coast: (714) 842-1717; Texas: (214) 231-5094; Belgium: 031/37 48 03; Denmark: (02) 84 58 00; England: 01/94 10 46 6; France: 687-3411; Germany: 089/53 03 19; Japan: 03/26 36 82 6; Netherlands: 076/879 251; Switzerland: 022/315760; and representatives around the world.

For more information, Circle No 153

Bus contention occurs when two or more output buffers on the same line are simultaneously enabled and can prove particularly troublesome when the data bus is bidirectional and address multiplexed. The resulting large current transients can disturb adjacent circuits or cause power-supply fluctuations sufficient to destroy memory-data integrity.

Fig 1a shows an 8085 microprocessor system, with time-multiplexed address/data functions, that employs a PROM for memory selection and a latch for separating the lower eight addresses from the data bus. The system's memory consists of a matrix of 2114-3 1k×4 static RAMs, which access in 300 nsec. The PROM is inhibited by the IO/$\overline{M}$ and ALE signals until address decoding is established. It then generates a clean chip-select signal ($\overline{CS}$) for the selected memory device within 30 nsec of the ALE's trailing edge. The address arrives at the appropriate 2114 delayed 15 nsec because of the latch's propagation delay, shown in **Fig 1b.**

Once $\overline{CS}$ arrives at the memory device, $\overline{CS}$-to-data-active time begins, and the output can become active in as little as 20 nsec. As a result, 50 nsec (30+20) after the trailing edge of ALE, the output buffers become active (low impedance) onto the address/data bus. However, because the 8085's address-hold time is 100 nsec min from ALE, the bus is in contention for 50 nsec.

You can resolve this contention problem by adding some logic to delay the $\overline{CS}$ signal. However, for some applications this approach could degrade access—requiring the use of a higher performance memory device. The circuit board would also suffer the loss of potentially valuable real estate to the extra logic devices.

A better solution involves using a memory device with an output-enable function ($\overline{OE}$): **Fig 2a** shows the 8085 memory interface with an MK4118 substituted for the 2114s. $\overline{CS}$ and address signals are handled exactly as before; however, the read ($\overline{RD}$) signal now connects directly to the memory to provide control of the output buffers. The timing diagram **(Fig 2b)** illustrates how the $\overline{OE}$ control function holds the memory output inactive for 130 nsec min until the output is activated by the microprocessor. Because the $\overline{OE}$ access time is faster than the $\overline{CE}$ access time, no performance loss results. **EDN**

To Vote For This Design, Circle No 458

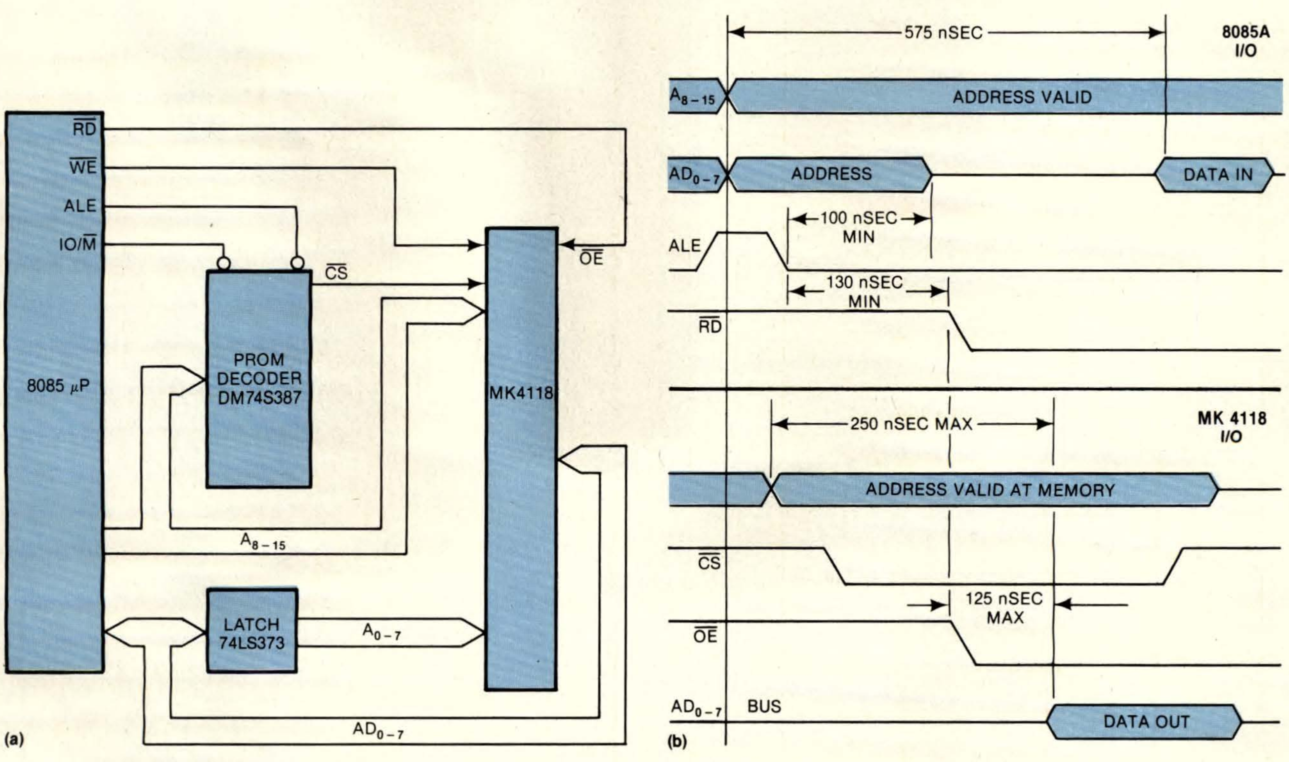
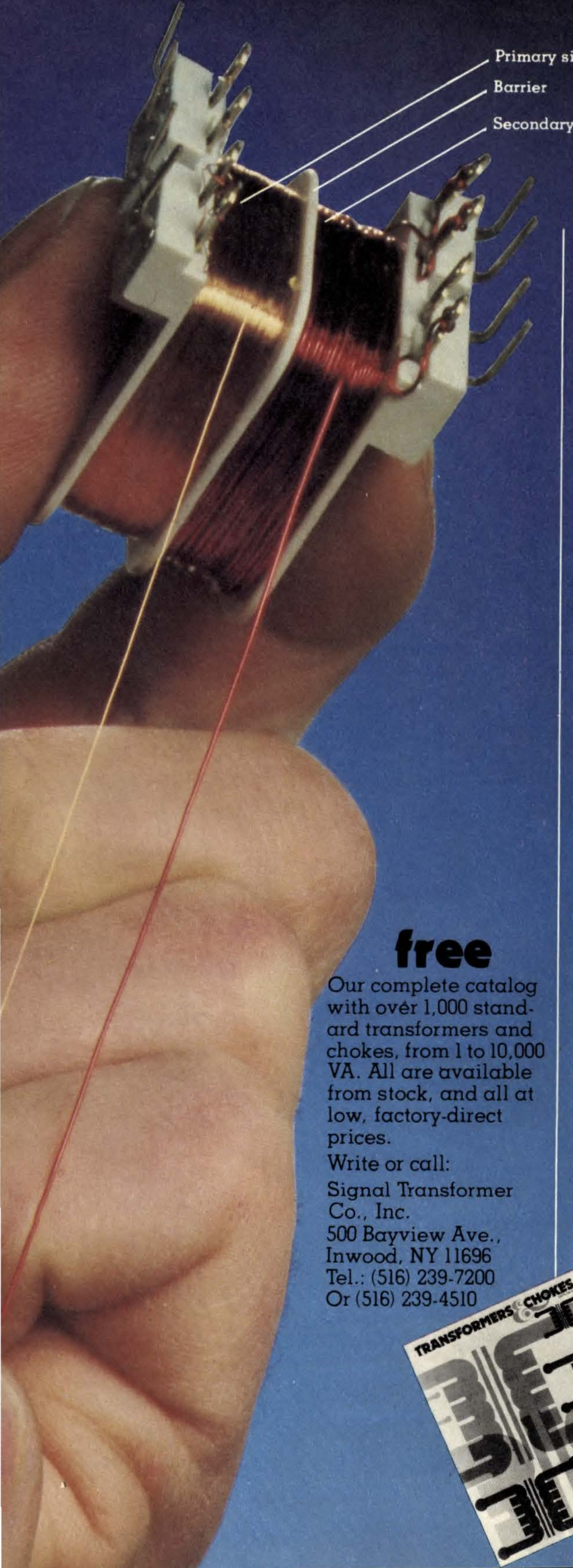


Fig 2—By substituting *an MK4118 for the 2114 memory chips* ***(a)*** *and employing the μP's $\overline{RD}$ function as an output enable ($\overline{OE}$), you hold the memory's output inactive* ***(b);*** *bus contention thus can't occur.*

Split Personality.



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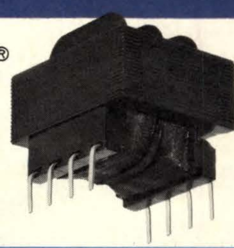

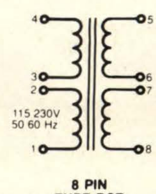

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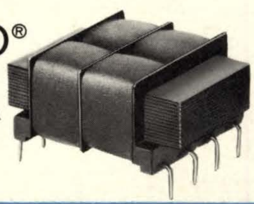

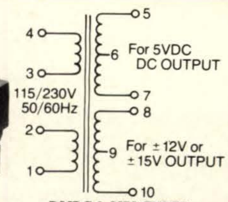

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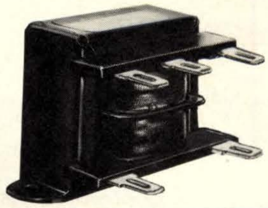

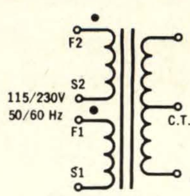

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For more information, Circle No 154

Envelope generator has isolated timings

Bonaventura A Paturzo
Xerox Corp, El Segundo, CA

This envelope-generator design (unlike most equivalent circuits published) provides truly independent attack, sustain and decay adjustment—without affecting output amplitude. Gated by IC_1 and IC_2, the CMOS switches (IC_3) isolate the attack and decay adjustments, and the R_2/IC_{3A} combination permits post-decay-effect adjustment by controlling circuit recovery time. The clocked JK flip flop (IC_6) allows one and only one output for each positive-going input transition.

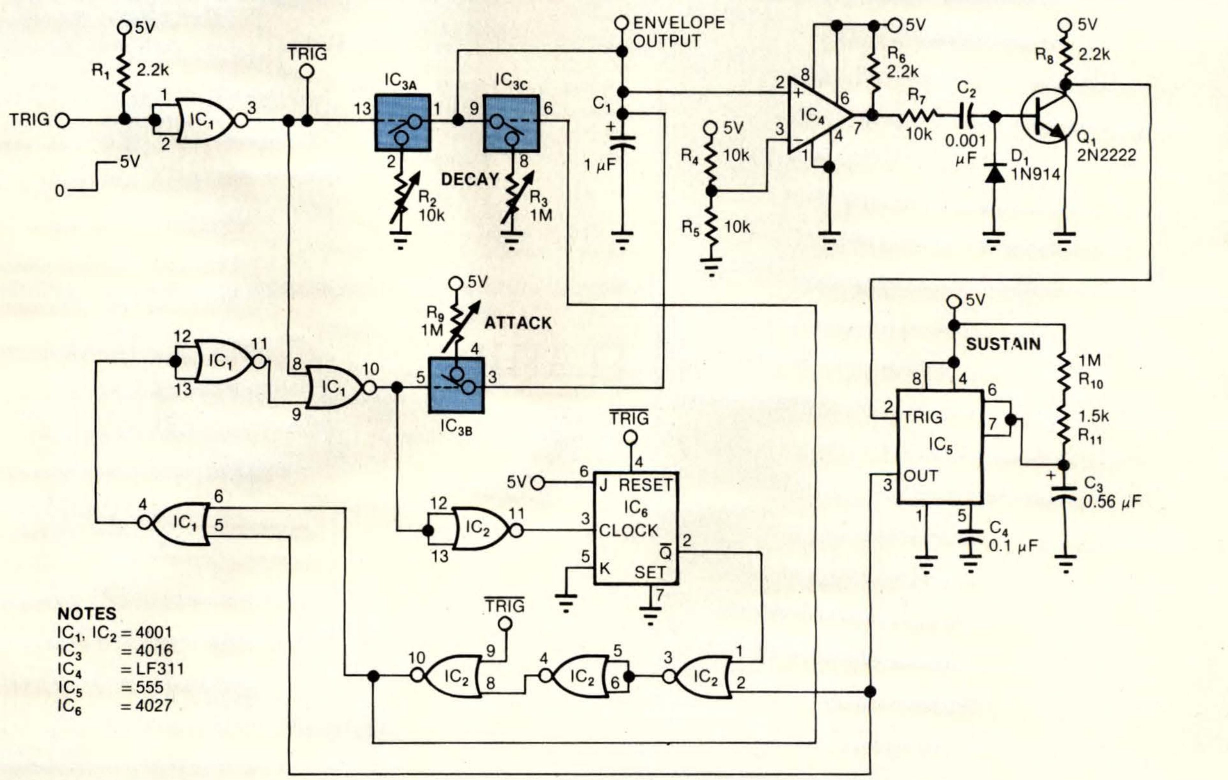
At rest, IC_{3A} is enabled, shunting to ground (through R_2) any charge on C_1. Triggering disables IC_{3A} and enables IC_{3B}, initiating the attack function—the charging of C_1 through R_9. When the voltage on C_1 reaches 2.5V (set by the R_4/R_5 ratio) the comparator (IC_4) switches HIGH. The $R_7C_2Q_1$ stage then generates a negative-going pulse, triggering IC_5 (a 555 configured as a monostable whose ON (sustain) time is set by R_{10}). While IC_5 is HIGH, all of the CMOS switches (IC_3) are disabled, holding (sustaining) C_1 at the 2.5V level. When IC_5 times out, IC_{3C} is enabled, starting the R_3C_1 decay time cycle. When the trigger returns to ZERO, IC_{3A} is re-enabled, bleeding-off C_1's remaining charge through R_2.

Attack and decay times are simple functions of their respective RC time constants. Sustain time, however, is defined by

$$T_S = 1.1(R_{10} + R_{11})C_3.$$

The circuit requires no precision components, although low-leakage, temperature-stable capacitors (for C_1 and C_3) are recommended for achieving repeatable operation. Additionally, use a high-impedance, dc-coupled buffer to couple the output to an external circuit—unless, of course, that circuit introduces negligible loading of C_1. **EDN**

To Vote For This Design, Circle No 459



CMOS switches *isolate the independently adjustable attack, sustain and decay times of this envelope generator. Determined by the 5V supply and the R_4/R_5 ratio, the output swings between 0 and 2.5V—even for zero sustain times.*

Your choice!

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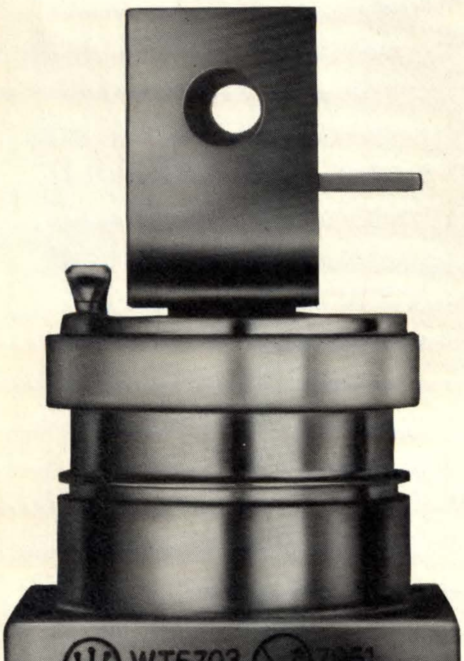

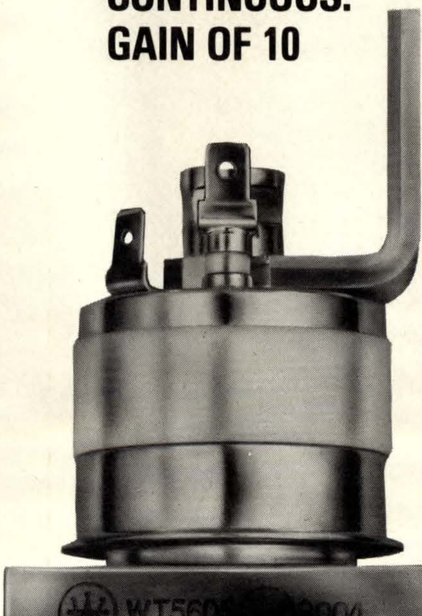

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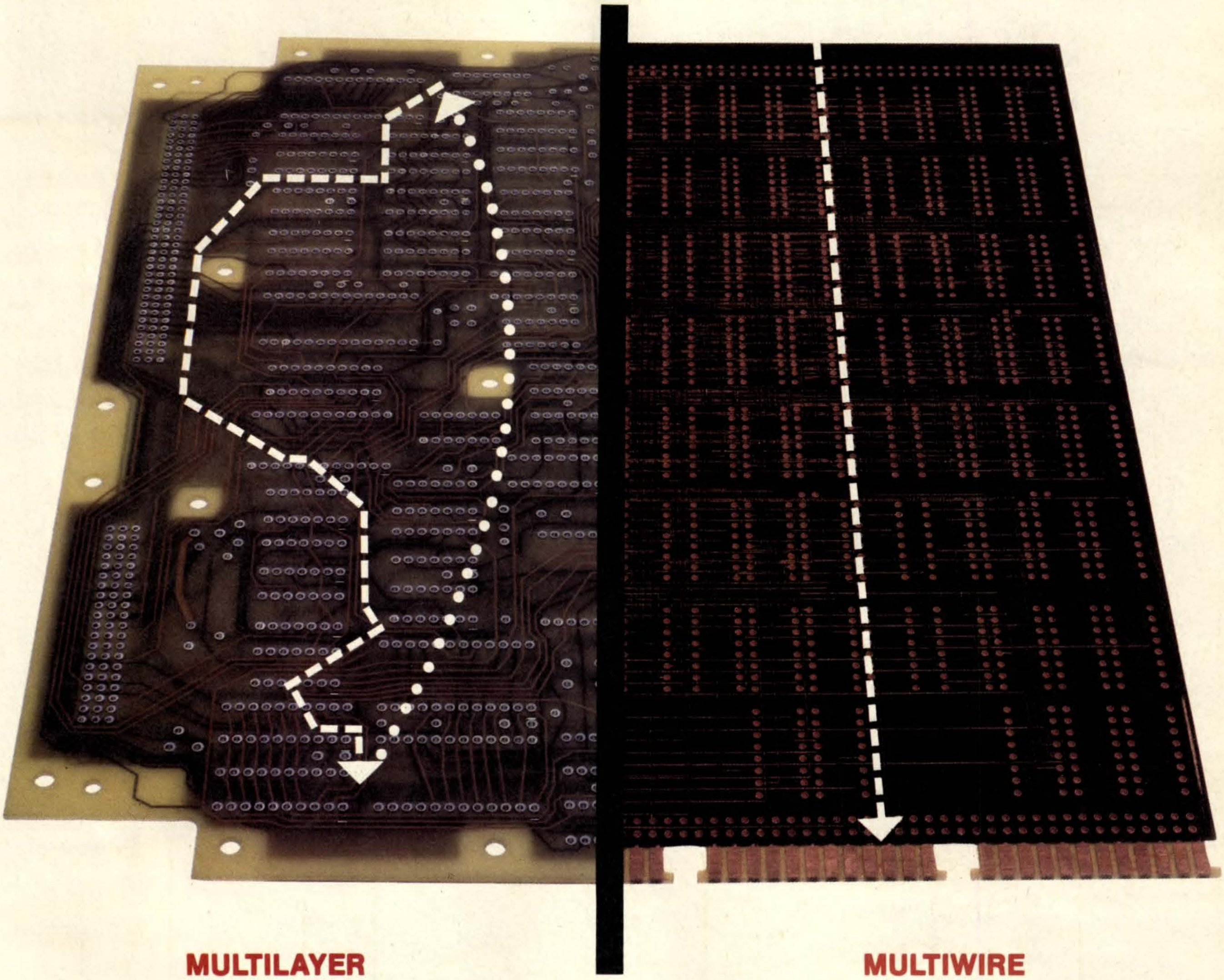

MULTILAYER

Regardless of what design technique you use — even with a computer aided system — designing multilayer PC boards can be a guessing game. Many times, in the last 5% of the routing, you find yourself up a "blind alley" and you have to go back to "start".

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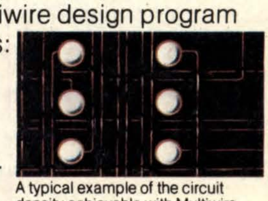
With Multiwire, you can easily avoid such blind alleys . . . for design-time savings in your circuit boards. Routing is under complete computer control. All you have to do is prepare artwork for the power and ground planes, the net or "from-to" list, and a fabrication print showing component location and board configuration. The Multiwire design program takes over from there. Results: your design time is cut. And, when design changes are needed, Multiwire lets you make them . . . quickly, easily. Electrical characteristics are consistent and controllable, inspection costs are cut and production yields go up.



A typical example of the circuit density achievable with Multiwire circuit boards.

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*Multiwire is a U.S. registered trademark for the Kollmorgen Corporation discrete wired circuit boards.

For more information, Circle No 156

Small economy size.

Generally, when the size goes down, the cost goes up. Not at C. Itoh. You can get the precision Model 210 (roll feed) or 210S (sprocket feed) dot matrix impact printer for a lot less than you're paying for comparable printers. But just because the price is low doesn't mean the quality is. Both are 2.4 LPS two-color printers capable of printing 5 x 7, 7 x 7 and 9 x 7 matrixes from a highly reliable seven-wire head. Requiring only 24 VDC power, these compact printers are the perfect OEM unit for POS cash registers, home computers, data loggers, electronic calculators and general peripherals ... anyplace where small size and low price make a difference. Measuring only 3.1" H x 4.8" W x 5.8" D, the Model 210 prints 26-35 columns in 2.6" of printable area; the 210S prints 22-30 columns in 2.2" of printable area. Economy size. Economy price. Of course. It's from C. Itoh.

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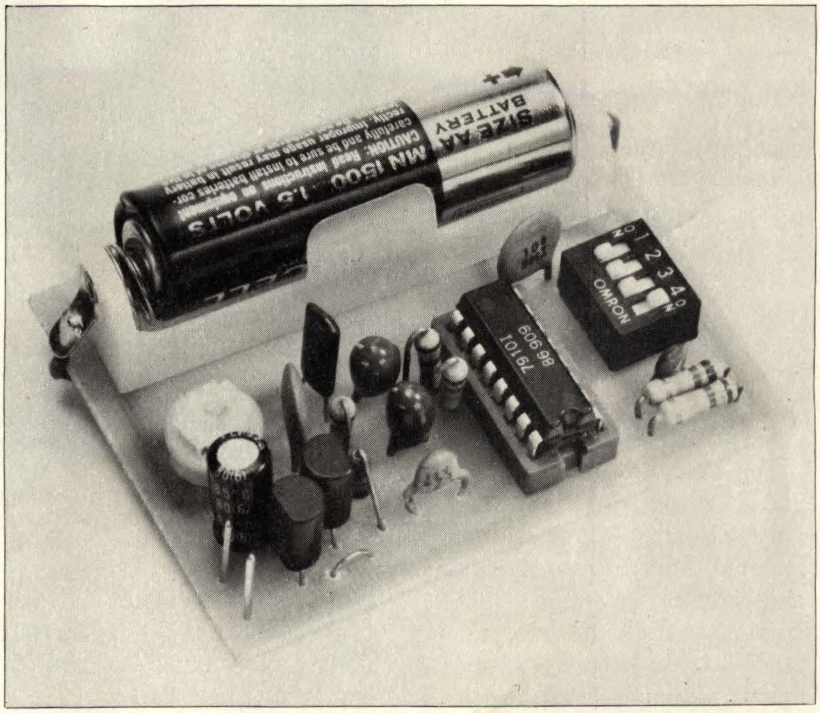
Feature Products

Monolithic music makers croon lullabyes, sound alarms

If you hear music and there's no one there, you could be listening to a 7910 Series IC. Six of the eight standard preprogrammed chips in this series offer renditions of "Greensleeves," "Home on the Range," "Mary Had a Little Lamb" and several other tunes. Additionally, four of those parts can imitate a door chime and emit a beeping alarm.

The family's remaining two devices emulate Westminster chimes. Designed for use in toys, music boxes and clocks, the chips are also available custom programmed with your own musical selection.



Two melodies, a door chime and a beeping alarm *emerge from a 16-pin 7910 Series IC, shown here mounted in its evaluation board. The chip contains separate main-tune and accompanyment generators and several ROMs that allow it to play tunes of up to 128 notes over a wide range of tempos.*

Virtuoso performance

The manufacturer has packed considerable potential virtuosity into these monolithic CMOS music makers. In addition to music/alarm-select logic, a master oscillator and an output preamp, you get two envelope generators (main melody and accompanyment) and several ROMs:

- The melody ROM is the heart of the devices. Twelve bits wide and 128 words long, it can store one or two tunes with a total length of 128 notes and rests. The note durations range from one-sixteenth through whole, and frequency range spans 2½ octaves in pure or even temperament.
- The tempo ROM can supply 16 different cadences, ranging from prestissimo (as fast as possible) to largo (slow and solemn), with any two cadences appearing in the same tune.
- The control ROM (in concert with a 6-bit address counter) not only keeps track of the tunes' starting addresses, but also provides for up to eight repeats within a piece.

Operate on 1.5V

Housed in 16-pin DIPs, the 7910 devices operate over −10 to +55°C and require a single 1.5V battery. The chips' standby (oscillator off) current is only 2 μA typ; with the oscillator on, they need just 70 μA typ plus whatever current the outboard audio-driver devices require. Each chip sports a 2-terminal true push/pull output capable of sourcing and sinking at least 150 μA of base current for the drivers.

You can evaluate the 7910 Series' performance with a board available from the manufacturer. Pick a chip, add a battery and speaker and listen—the board contains the other necessary components.

The board (without chip, battery or speaker) costs $14. Standard preprogrammed chips cost $3.50 (10).

Epson America Inc, 23844 Hawthorne Blvd, Torrance, CA 90505. Phone (213) 378-2220.

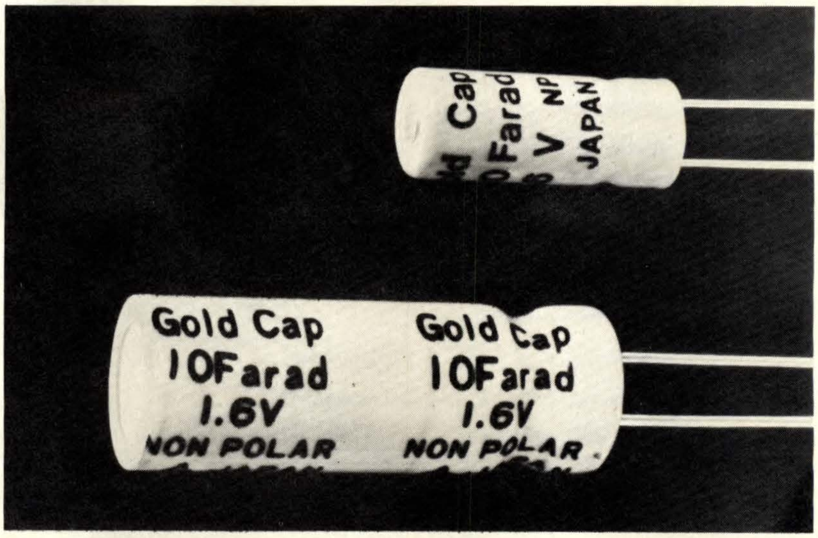
Circle No 451

Ultraminiature liquid electrolytics sport high electrostatic capacitance

Would you believe a capacitor that packs 10F in 0.3 in.^{3}? That's exactly what Gold Series devices provide. Despite their high capacitance, though, these devices are compatible with pc-board mounting requirements—a 10F unit measures 1.46 in. long and only 0.51 in. in diameter.

The units capitalize on a proprietary construction technique, based on the use of a liquid electrolyte and double-layer foil, to achieve the high values, ranging from 1 to 100F.

Specifications for a 10F unit include rated working voltage of 1.6V dc, ±20% tolerance, 1Ω internal impedance (at 1 kHz and 20°C), minimum leakage current of 1 mA (after 10 min at 20°C and rated voltage), operating range of −20 to +70°C and high reliability—less than 3% failure rate after 50,000 hrs (at rated voltage and 40°C).



High capacitance in a small package *highlights the Gold Series of electrolytic capacitors. A 10F device, for example, measures 1.46 in. long×0.51 in. in diameter—dimensions that qualify the units for pc-board mounting.*

Backup capability

While Gold Series units offer improved performance in many typical capacitive applications (long-time-constant circuits, for example), they also perform as backup sources for RAMs in case of power failure.

To serve such applications, you can connect four 10F units in series to obtain a 2.5F capacitor with a voltage rating of 6.4V dc. Under a 1-mA load, this combination requires more than 1 hr to discharge to 2V.

$1 (10,000) for 10F unit. Delivery, stock to 12 wks ARO.

Panasonic Co, Electronic Components Div, 1 Panasonic Way, Secaucus, NJ 07094. Phone (201) 348-7173.

Circle No 452

NEXT TIME

In EDN's May 5 issue, look for a preview of key sessions and product exhibits at NCC '80. This year's National Computer Conference promises to be bigger and better than ever, and EDN will be there. Also look for feature articles on

- The latest serial printers, complete with a handy clip-out chart
- The next step in EDN's hands-on μC Design Series exploration of analog μPs
- A handy programmable-calculator program for calculating the noise bandwidth of filters
- Spec'ing CRTs for use in video terminals
- The creation and use of microcode for minicomputers

. . . and much more. Look, too, for news roundups on developments in PROM programmers and color CRTs, plus a report on the latest action in 8-in.-hard-disc standards, plus our regular μComputerist Corner and Design Ideas departments. You can't afford to miss this issue!

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Feature Products

Low-cost dot-matrix printer delivers high-quality output

High-quality printing *and text-processing features make Centronics' Model 737 a versatile dot-matrix impact printer.*

You don't usually associate correspondence-quality printing with dot-matrix impact printers, but Model 737 challenges that viewpoint. Its high-density dot-matrix printhead, printing characters in an n×9 array, not only handles the pesky true-descender problem with style, but also furnishes true underlining capability and prints superscripts and subscripts as well.

Of course, this unit's magic isn't all in its printhead; bidirectional paper control makes precise dot placement a breeze.

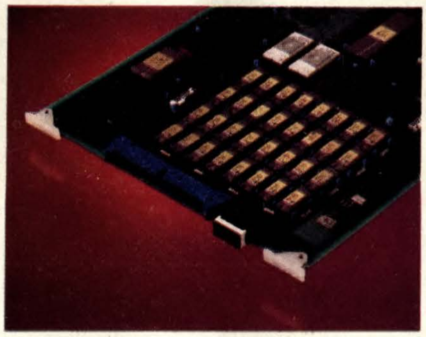
Obviously intended for the text - processing marketplace, the 737 outputs 80 cps while furnishing proportional spacing and right-margin justification. Users can also select character density: The unit provides both 10 and 16.7 cpi. A full 96-character ASCII set ensures the printer's ability to express whatever needs expressing.

Because not everyone's text-processing requirements are the same, the 737 handles three paper types with equal ease—letterhead, fanfold and roll. For users with a lot to say, one command lets the printer output 132 columns in the same space normally required for the 80-column format. $995 (OEM). Delivery, 60 days ARO.

Centronics Data Computer Corp, Hudson, NH 03051. Phone (603) 883-0111.

Circle No 453

Match with MSC custom memories



...and microcomputers too. Standard off-the-shelf systems may not match up to your special needs. MSC can design and produce a memory system using the best technology, parts, and form factors available to meet your specific operating requirements. Our custom engineering capabilities also extend to microcomputers designed to an industry standard bus.

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Monolithic Systems corp.

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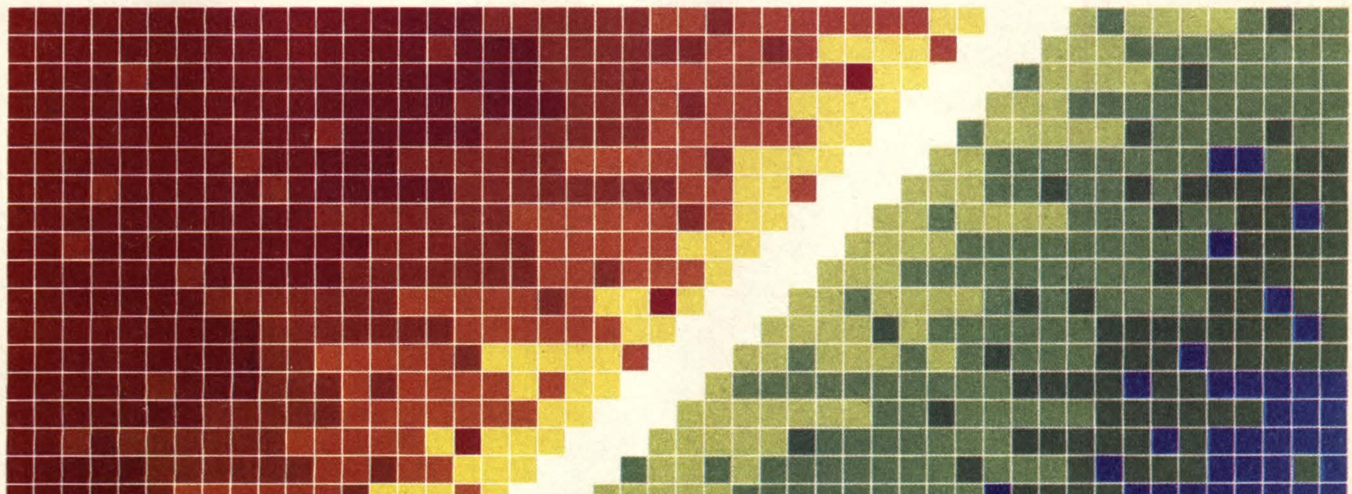

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WHEN μS COUNT, YOU CAN COUNT ON FTS.

We've pushed the state of the art in cesium beam technology a long way. High-performance FTS units are on airborne, shipboard, and mobile platforms and in the laboratory, with frequency accuracy of $\pm 7 \times 10^{-12}$ and frequency stability of 1×10^{-13}. And FTS is unique, offering a 5-year cesium tube warranty.

Our no-charge instrument loan program (if warranty repairs require more than 30 days) will cut down time and costs at your end.

Now, FTS offers three configurations:

FTS 4050 — Rack-mountable instrument designed for laboratory and field use, with outputs of 1, 5, and 10 MHz and 1 pps. Complete operating controls and monitors. $22,000.

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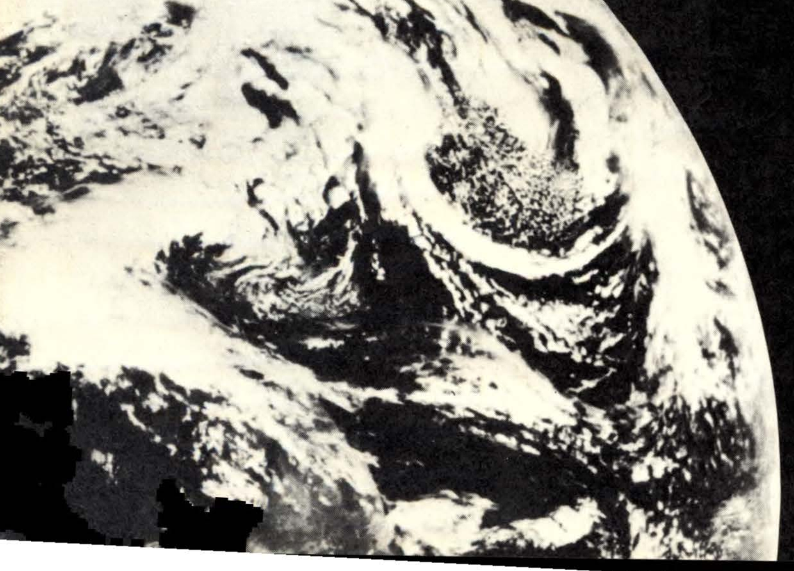

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Life expectancy of General Electric long-life hermetically sealed relays:

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Yes! Please send me one FREE General Electric long-life hermetically sealed relay to test for myself:

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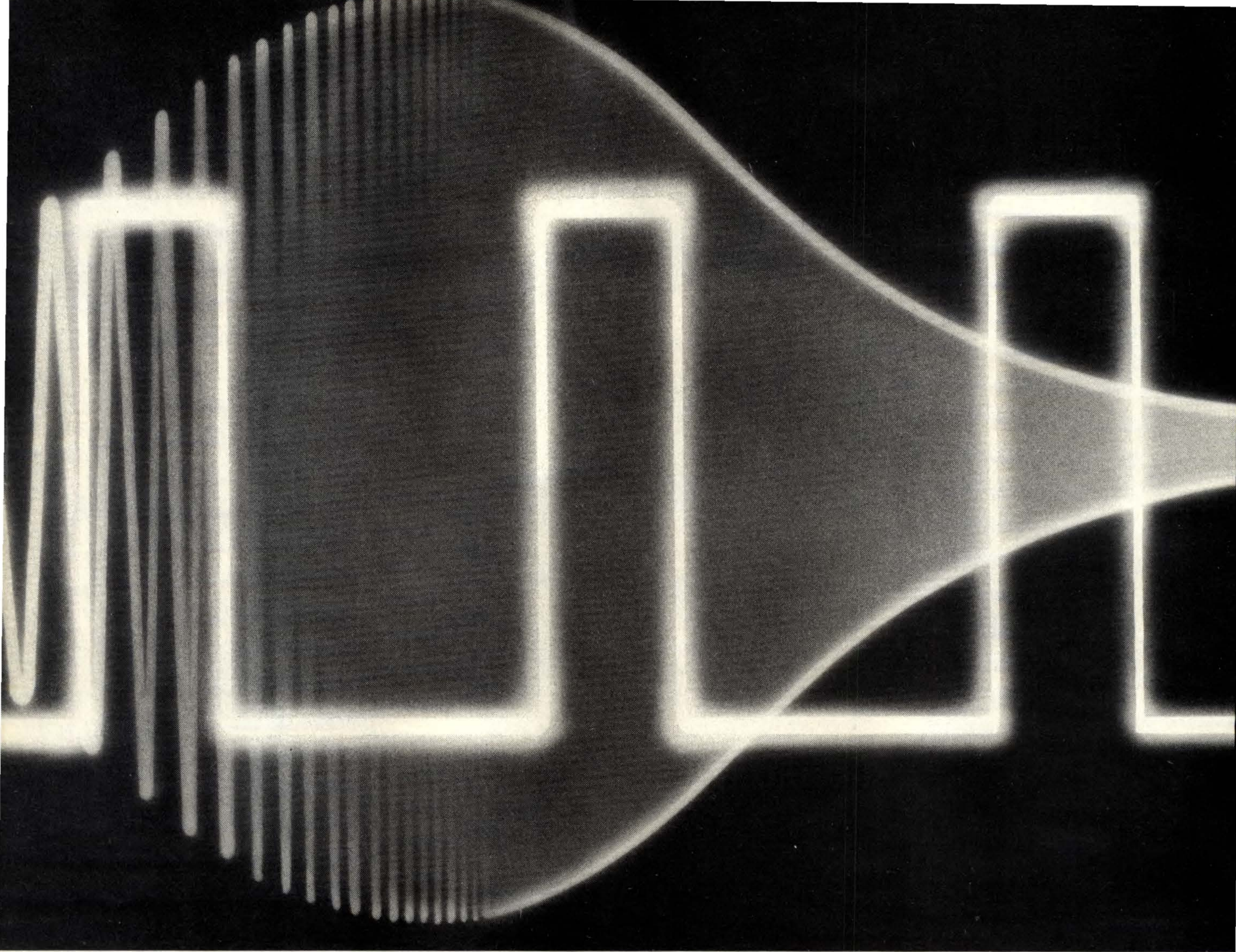

We've had longer to perfect the Function/Pulse Generator. After all, we offered it first.

In 1975 we combined a true pulse generator capability and a function generator. In Interstate's Series 70.

Today, many of our competitors are showing us the sincerest form of flattery.

But don't settle for an imitation when you can have the original for about the same price.

Our Series 70 Function/Pulse Generators are true pulsers. The F-77, for example, produces a precise, stable 15 nanosecond rise time pulse with constant width adjustable down to 30 nanoseconds, unipolar or with full offset and amplitude flexibility, and triggered or gated.

And Series 70 offers something very few of our competitors have caught up with: a choice of constant width or constant duty cycle pulses.

And all Series 70 models produce sine, square, triangle and dc-level waveforms with 5 to 95% waveform variable symmetry control, and calibrated coarse/fine frequency tuning.

Sweep start and stop limits are easily set with direct reading sweep dial.

Frequency ranges are the most usable—from 0.00002 Hz to 20 MHz—from infrasonics through video and beyond.

Series 70 also gives you FM Capability—externally applied voltages provide frequency control over each 1000:1 frequency range for sweeping frequency-sensitive devices, test programming, and other voltage-to-frequency and frequency modulation applications.

Before you buy any Function/Pulse Generator, take a long hard look at the original Series 70 from Interstate Electronics.

We've had longer than anyone to perfect our electronics and prove our reliability.

For our catalog including the Series 70, and our other bench and programmable test equipment write: Bob Sorenson, 1001 East Ball Road, Anaheim, CA 92803. Or Call: (714) 635-7210.

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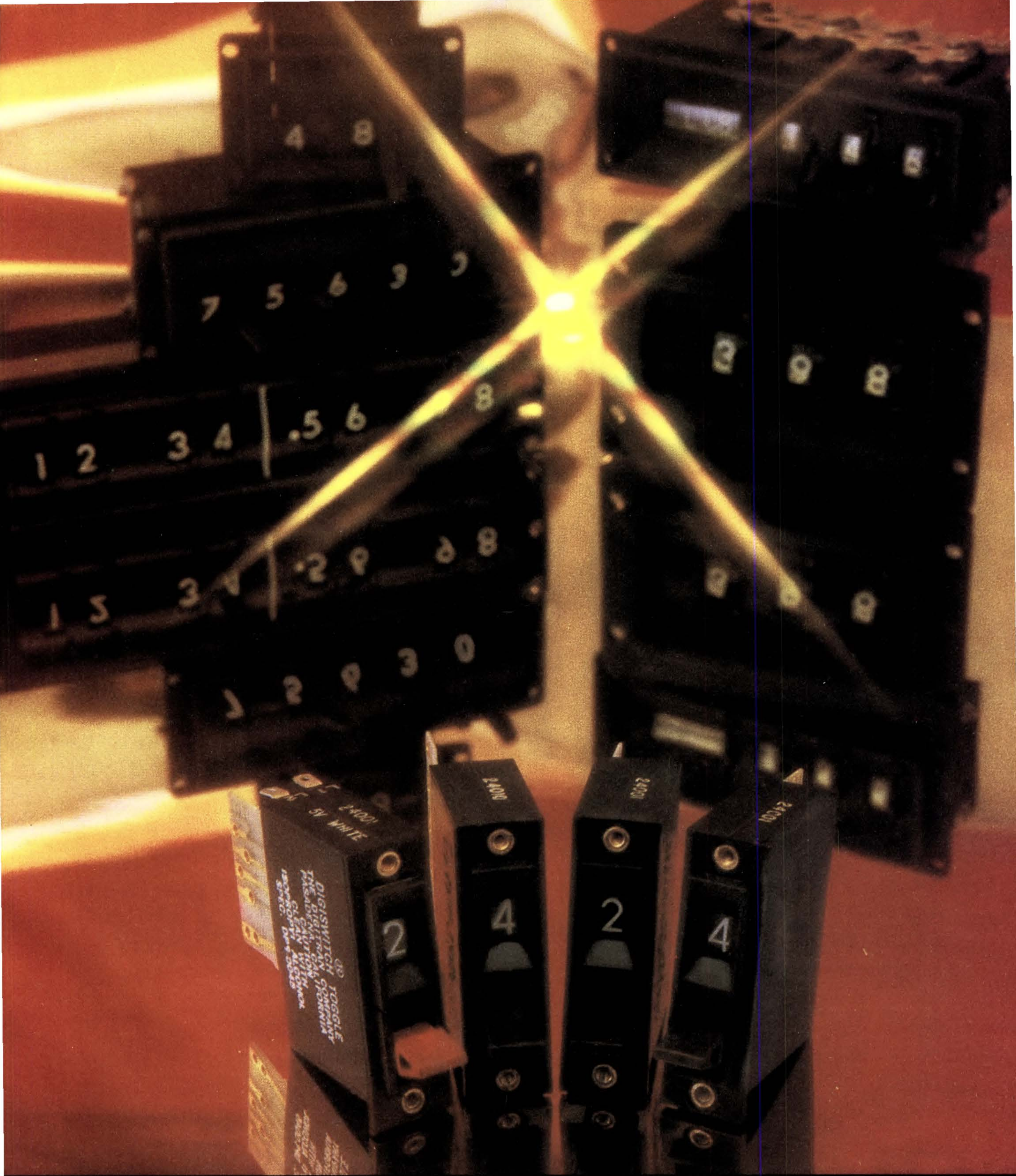

The New Generation of Custom Monolithic Hybrid Converters from DDC.

By using customized monolithic chips, DDC has taken a giant step forward in converter technology. The new product—Monobrid—is much smaller, less complex, more reliable and requires less power than conventional hybrids.

The first of DDC's new Monobrid series is a *single* 36-pin DDIP module containing a complete 14-bit S/D or R/D converter. At half the size of conventional hybrids the new DDC-8915 Series Monobrid packs the same kind of high performance. Accurate to ±2.6 minutes, the new S/D Monobrid offers tri-state latched outputs in two bytes and continuous tracking, even during data transfer. It accepts broadband inputs of 360 to 1000 Hz, or 47 to 1000 Hz; and is made to order for applications where small size, high MTBF and low power are critical.

For more information about DDC's new 8915 Series Monobrid converter, call or write Department B-8, today.

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Note: Monobrid™ is a trademark of ILC Data Device Corporation

See us at Electro '80, Booths #2342 and #3220

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LAST NOVEMBER, DATA GENERAL AND DEC ANNOUNCED NEW COMPUTERS. THE SIMILARITY ENDS THERE.

COMPARE:	SPEED Thousands Whetstone instructions/second Single Precision	 Double Precision	PRICE
DEC PDP 11/44 System	314*	231*	$41,900* Includes PDP 11/44 with 256 ERCC memory, 20.8 MB dual RL02 disc subsystem, floating point processor and LA120 console printer
Data General ECLIPSE S/140 System	450	380	$37,450 System including S/140 with 256KB ERCC MOS memory, Model 6100 25MB non-removable moving head disc with integral 1.26 MB diskette floating point hardware and Dasher TP2 180 CPS console printer
ECLIPSE S/140 is:	43% faster	65% faster	10% lower price

*As reported in COMPUTER SYSTEMS NEWS, Dec. 3, 1979; MINI-MICRO SYSTEMS, Jan. 1980.

What more can we say? Our new ECLIPSE® S/140 is not only a great deal faster than the 11/44, it's also a great deal, period. Read the chart. Then you'll understand why our ECLIPSE S/140 is your only choice. Break the speed limit without paying the price. Send in the coupon.

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Hughes Semiconductor Products
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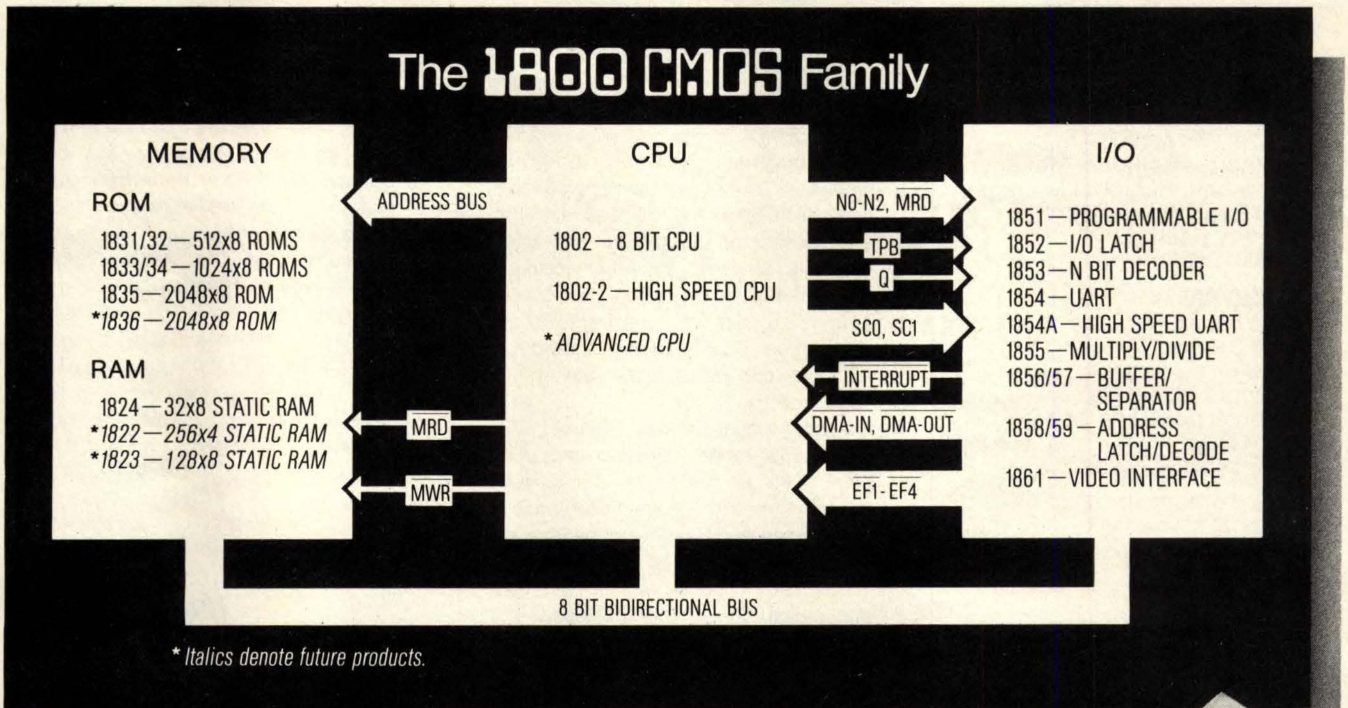

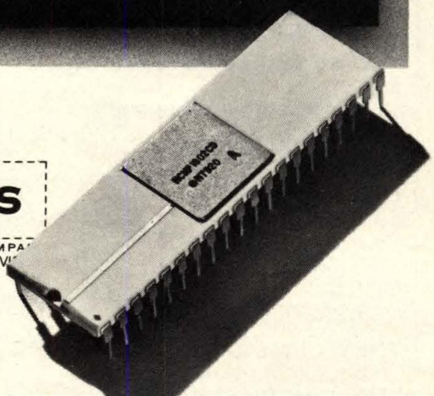

Hughes delivers a complete 1800 CMOS Microprocessor Family in both commercial and military versions.

The commercial grade devices provide low power, wide operating temperature range and the expected high noise immunity of CMOS to such diverse applications as data processors, portable instrumentation, process controllers, and complex electronic games.

The military grade version, screened to standard military reliability requirements, offers the same CMOS advantages and the exacting performance demanded by such programs as space telecommunications, aircraft navigation controls, and geophysical data logging. These units, as well as the commercial units, are available in either a 4 to 6.5 volt or 4 to 12 volt operating range.

The 1800 CMOS Microprocessor Family offers an extensive complement of memory and I/O devices, including such new parts as the 1851 Software Programmable Input/Output Port and the 1855 Eight-Bit Expandable Multiply/Divide units. In addition, several new support devices are being designed for introduction in 1980.

The support doesn't end at the device level; Hughes offers an inexpensive, easy-to-use Hughes Microprocessor Development System which includes a real time hardware emulator. High level software language is also available. In addition to the 1802 CMOS Microprocessor, the Hughes Development System supports other industry-standard microprocessors.

Write for our new 24-page, 1800 CMOS Product Guide; for further information, call (800) 854-3515 or (714) 759-2907.
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EDN 4/80

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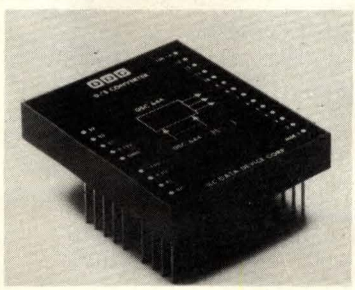
New Products

COMPUTER-SYSTEM SUBASSEMBLIES

SAMPLE/HOLD. For use with ultrafast A/D converters with up to 10-bit resolution, SHM-UH3 features 30-nsec acquisition time and 30-psec aperture uncertainty time. It samples a 20-MHz, 10V p-p sinusoid to 8-bit accuracy (½-LSB uncertainty); it can also sample at up to 10 MHz while making full-scale acquisitions. Sample-mode bandwidth is 45 MHz, and output slew rate equals 500V/μsec.

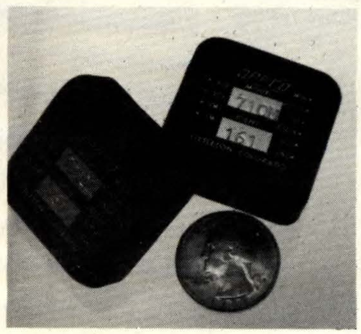
Analog characteristics include ±5V input-signal range, constant near-unity gain (0.95 to 0.98) and 0.05% max linearity error. Hold-mode droop specs at 50 μV/μsec, and Hold-mode feedthrough equals −66 dB from dc to 10 MHz.

The unit provides a 100-kΩ input impedance, 50-μV/°C output offset drift and ±30-mA output current and comes in a 2×2×0.375-in. case. Power-supply requirement is ±15V dc at 50 mA and 5V dc at 100 mA; operating-temperature range is 0 to 70°C. $230. **Datel-Intersil,** 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-9341. **Circle No 311**



D/S CONVERTER. A 14-bit 400-Hz unit, DSC-644 is a pin-for-pin replacement for the industry-standard 400-Hz EDSC-H and -L. The 3.125×2.625×0.52-in., 5.5-oz module meets or exceeds MIL-STD-202E and features a typical output-scale-factor variation of 0.05% and a current-limiting output stage that is short-circuit proof. Accurate to ±4″, the unit accepts a digital input angle (TTL and CMOS compatible) and a reference excitation for conversion to a synchro or resolver output. Two standard operating-temperature ranges are available: 0 to 70°C and −55 to +85°C. From $440. **ILC Data Device Corp,** 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. **Circle No 312**

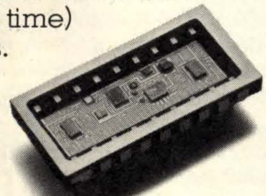
BUBBLE-MEMORY SYSTEM. The TM990/211 module uses the TIB1000 1-million-bit bubble-memory device and has an on-board controller (TIB0903), which provides complete interface to the TM990 bus and transfers data via the CRU mode. The unit can perform single- or multipage transfers at a maximum data-transfer rate of 85k bps and can be purchased with 1M-, 2M-, 4M- or 6M-bit devices to provide 128k, 256k, 512k or 768k bytes of nonvolatile storage, respectively. Average access time equals 11.2 msec. $3200 (128k bytes) to $15,200 (768k bytes). Delivery, 8 to 10 wks ARO. **Texas Instruments Inc,** MS 308, Dallas, TX 75265. Phone (214) 238-2011. **Circle No 313**



MODEM ELIMINATORS. 700 Series full-duplex TTL- and DTL-compatible devices allow user communications without modifications to existing data formats, protocols, speeds or software. They operate from one 5V dc power supply and require <2.25 in.^{2} of pc-board space; because they are TTL compatible, any data that can be converted into a serial bit stream can be transmitted. The low-speed version handles data at 1M baud at 1000 ft with <±5% distortion and at 20k baud at 11,000 ft. The medium-speed version operates at 5M baud at 1000 ft and 250k baud at 11,000 ft with ±5% distortion. $24 for low-speed version; $35 for medium-speed unit (100). **Oppco,** 7200 E Dry Creek Rd, Suite F 201, Englewood, CO 80112. Phone (303) 771-7580. **Circle No 314**

FAST LATCHED MIL D/A's

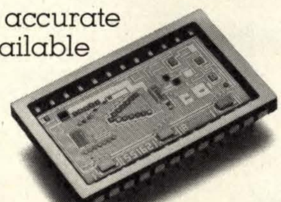
Each of these fast settling Micro Networks' converters contains a TTL input latch, for easy interfacing and rapid throughput in high speed data distribution systems. There's no bottleneck. They set up in 40 nSec and have no data overlap (hold time) requirements.



MN3020H/B

Latched 8 Bit D/A
Monotonic −55 to +125°C
Settling Time 3 μSec max
MIL-STD-883 Processing

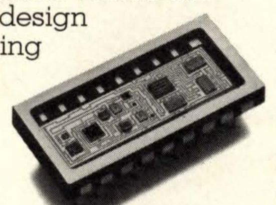
All are excellent performers. We guarantee absolute accuracies and ±½ LSB linearity and monotonicity over the full military temperature range (−55 to +125°C). As a matter of fact, the MN3860H/B (±0.3% absolute accuracy guaranteed over temperature) is still the most accurate 12 Bit D/A available in a DIP.



MN3860H/B

Latched 12 Bit D/A
Monotonic −55 to +125°C
Settling Time 7 μSec max
MIL-STD-883 Processing

They are multi-range converters, complete with internal reference and output amplifier. This means greater versatility and significant, built-in economies. You'll save board space, design time, purchasing time and money.



MN3040H/B

Latched 10 Bit D/A
Monotonic −55 to +125°C
Settling Time 5 μSec max
MIL-STD-883 Processing

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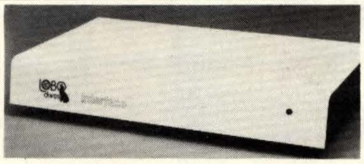

DISC INTERFACE. For TRS-80 computers, Model LX80 expands memory storage capacity up to 40M bytes, provides facilities for up to 32k of RAM and offers a second serial port. A switch permits overriding the keyboard ROM for booting-in diagnostics and customized operating systems. Connectors for 5.25- and 8-in. floppy-disc drives and other peripheral devices are provided on the side and rear panels. Other features include parallel Centronics printer port, screen printer port, two μP-controlled bidirectional serial ports and a crystal-controlled real-time clock. $525. Delivery, 45 days ARO. **Lobo Drives International,** 935 *Camino Del Sur,* Goleta, CA 93017. Phone (714) 641-1436. **Circle No 315**

PRINTER INTERFACE. Interfacing with NEC, Diablo and Qume letter-quality printers as well as high-speed Centronics/Dataproducts printers for draft and non-letter-quality applications, I/OMaster S-100 interface board features two serial and two parallel ports plus an 8-level interrupt control and dual interval-timer circuitry. The two 8251-based serial ports have built-in 32-character FIFO buffers. $400. **MicroPro International Corp,** 1299 Fourth St, San Rafael, CA 94901. Phone (415) 457-8990.
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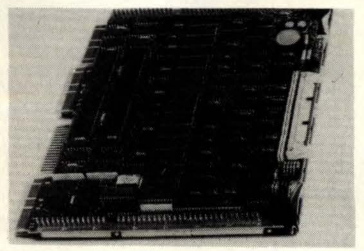

STORAGE-MODULE-DRIVE controller Model S03/B is a μP-based device for DEC LSI-11 μCs. It emulates DEC's RK611 controller, which interfaces to the RK07 storage-module drive and operates under RT-11 and RSX-11M. The unit also operates with Control Data Corp's 80MB 9762 and 300MB 9766 storage-module drives or equivalent drives from Ampex, Ball and Century Data Systems; up to four 80M-byte drives can be daisy-chained. The controller installs in any two standard quad slots in the host LSI-11. Power requirements are 5V dc at 9A and −15V dc at 0.7A. $5400. **Dataram Corp,** Princeton-Hightstown Rd, Cranbury, NJ 08512. Phone (609) 799-0071.
Circle No 317

EPROM PROGRAMMER. Multibus compatible, Model ZX-908 uses a 5V power supply. It is available in versions to program Intel 2716, 2732 and 2732A EPROMs and can program 16k bytes in one operation. Eight zero-insertion-force sockets are provided for PROM insertion and withdrawal. $450. **Zendex Corp,** 6398 Dougherty Rd, Dublin, CA 94566. Phone (415) 829-1284. **Circle No 318**

SIEMENS

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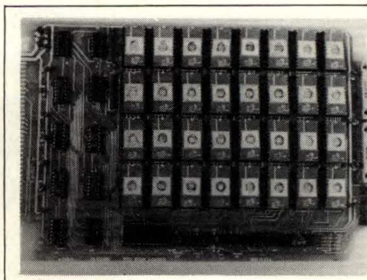
New Products

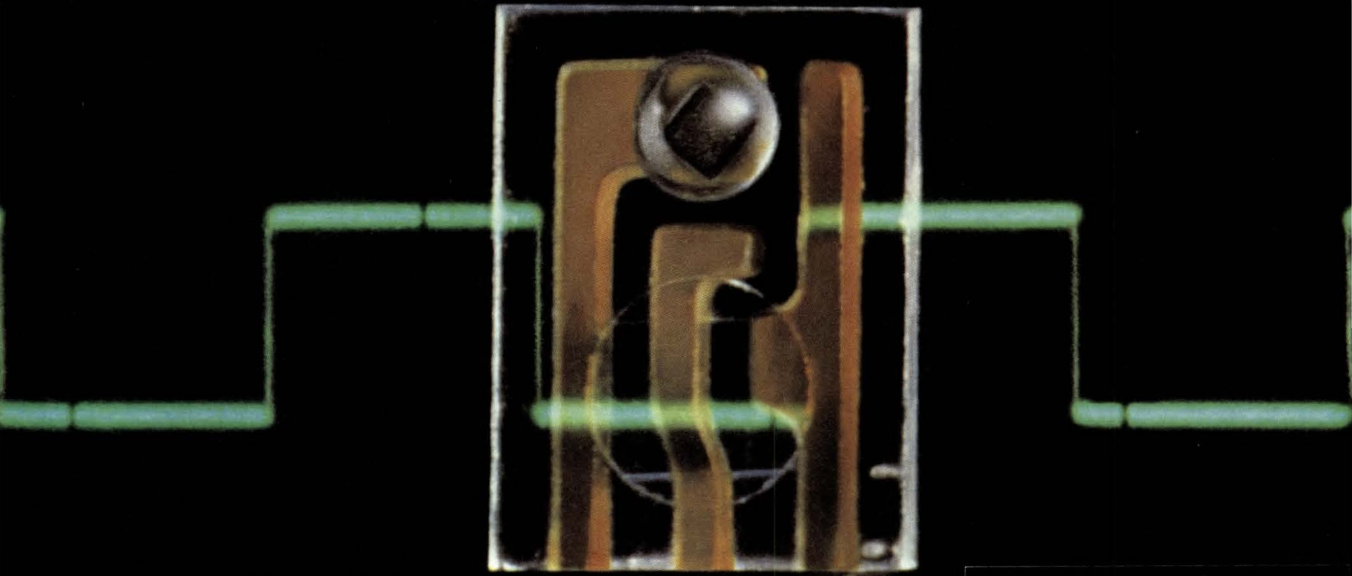


ROM LOADER. Permitting rapid reloading of remote Texas Instruments 990 processors, RL 990-1, by activating Load on the front panel, transfers a program from the EPROM into RAM. Features include 64k bytes of program storage using the TMS 2516 (128k bytes using TMS 2532), approximately 400k-bytes/sec data-transfer rate, four independent user-programmable indicators and software-readable hexadecimal switch. The unit uses loader PROMs and requires 5V at 400 mA (max) plus 100 mA (max) for each TMS 2516 and 160 mA (max) for each TMS 2532. $350. **National Data Corp,** One National Data Plaza, Corporate Square, Atlanta, GA 30329. Phone (404) 329-8513.
Circle No 319

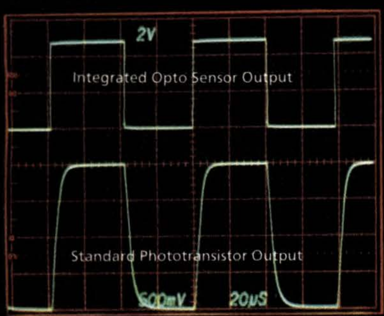
PRIORITY-INTERRUPT controller SB8301 adds vectored-interrupt capabilities to STD Bus systems. The unit relieves the CPU from having to poll all devices to determine where the appropriate service routine is located, accepts 16 discrete interrupt inputs, resolves priority and generates Call instructions during the interrupt-acknowledge sequence. You can use an expansion connector to implement 64 prioritized interrupts by cascading cards. $285. **Micro/Sys Inc,** 1353 Foothill Blvd, La Canada, CA 91011. Phone (213) 790-7957. **Circle No 320**

64k MEMORY BOARD. The Model 460 dynamic RAM is organized into four blocks, each of which is individually deselectable under program control for memory mapping. The unit supports 8080 or Z80 CPUs, serves S-100-bus applications and operates at 4 MHz with no wait states. A parity feature provides increased data security: In the event of an error, a parity bit is set that lights an LED on the board and can be used to set a vectored interrupt or halt the CPU. <$1000. **Industrial Micro Systems Inc,** 628 Eckhoff St, Orange, CA 92668. Phone (714) 978-6966. **Circle No 321**

ANNOUNCING THE FIRST OPTO SENSOR WITH BRAIN WAVES.

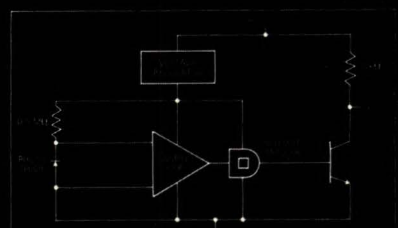


It's a logical breakthrough from Spectronics. We've designed the first opto detector IC offering compatability with TTL, CMOS and other standard logic families.



The SDP 8600 integrates a Schmitt trigger, voltage regulator, differential amplifier and photodiode onto the same substrate—replacing a complete PC board. This neat integration hasn't cost any performance. It has a propagation delay time of only 5 μs and a 50 ns rise and fall time.

Designed for use with an infrared LED, it's ideal for sensing applications such as computer peripherals, toys and automatic cruise control systems. With significant benefits like improved



noise immunity, higher reliability and better performance.

The 8600 is just one example of a long line of optoelectronic firsts from Spectronics.

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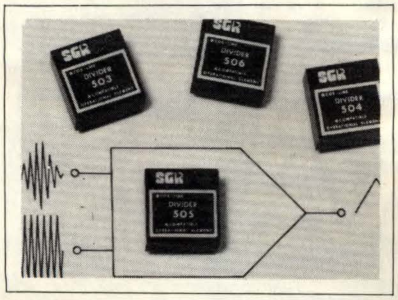
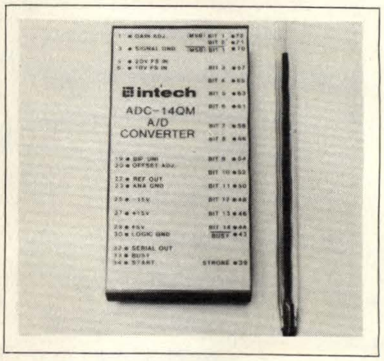
New Products



2-QUADRANT DIVIDERS. For interfacing with μP-based systems, Models 503 through 506 0.5-in.^{3} microhybrid modules include a transconductance dividing element, a stable reference and an output amplifier with specified accuracy, internally trimmed for feedthrough, output zero and gain. Transfer function is 10X/Y, and dividing accuracy (at 25°C) ranges from 1.0 to 0.1%, including the effects of offset voltage, feedthrough, scale factors and nonlinearity. Features include 0 to 70°C operation, ±10V/5-mA output, 1-MHz small-signal bandwidth, 750-kHz full-power bandwidth and slew rate of 45V/μsec. $65 to $160. **SGR Corp,** Box 391, Canton, MA 02021. Phone (617) 828-7773. **Circle No 322**



14-BIT ADC. Providing four selectable input ranges of ±10, ±5, 0 to +5 and 0 to +10V, ADC-14-QM offers conversion time of 50 μsec and differential linearity of ±½ LSB max over the temperature range of 0 to 70°C. The stable unit furnishes differential nonlinearity and offset TCs of <±5 ppm/°C and measures 2×4×0.4 in. Power dissipation specs at 2.5W. $186 (25). **Intech,** 282 Brokaw Rd, Santa Clara, CA 95050. Phone (408) 244-0500. **Circle No 323**

SERIAL INTERFACES. These self-contained 2½- and 4½-port software-programmable units provide two or four independent, full-duplex serial-communication controllers, respectively. The GPIB to the host computer can be adapted to most μCs with plug-in modules and adapter cables. The units operate with 8080, Z80, 6800 and 6502 μPs in memory-mapped or I/O-mapped environments; using 8251A serial controllers, they support synchronous communication to 64k baud and asynchronous communication to 19.2k baud. The 2½-port unit furnishes two RS-232C and one isolated current-loop interface; the 4½-port device, four RS-232C and two current-loop interfaces. 2½ port, $395; 4½ port, $695. **AES Computers,** 118 S Loara, Anaheim, CA 92802. Phone (714) 635-5981. **Circle No 324**

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If you think you're stuck with tantalum capacitors because you need their high-performance, low-leakage characteristics, but are getting upset because of their soaring prices and increasing scarcity — do this:

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The kit has 60 units, four each of the most popular values. It covers the range of 0.1 through 100 mfd with working voltages from 6.3wv through 50wv. Leakage current 0.006cv or 0.5μA, whichever is greater (after 1 minute charge at DC rated voltage) and 20% or better tolerance.

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New Products

COMPUTERS & PERIPHERALS

GRAPHICS SYSTEM. The PGM computer weighs about 85 lbs (complete with 300k bytes of RAM and a 29M-byte disc), resides in a 19×18×25-in. cabinet and functions either as a stand-alone graphics-oriented computer or as an intelligent distributed processor. As a graphics station, it produces output on several devices simultaneously and uses an inexpensive console terminal to avoid interfering with the graphics function.

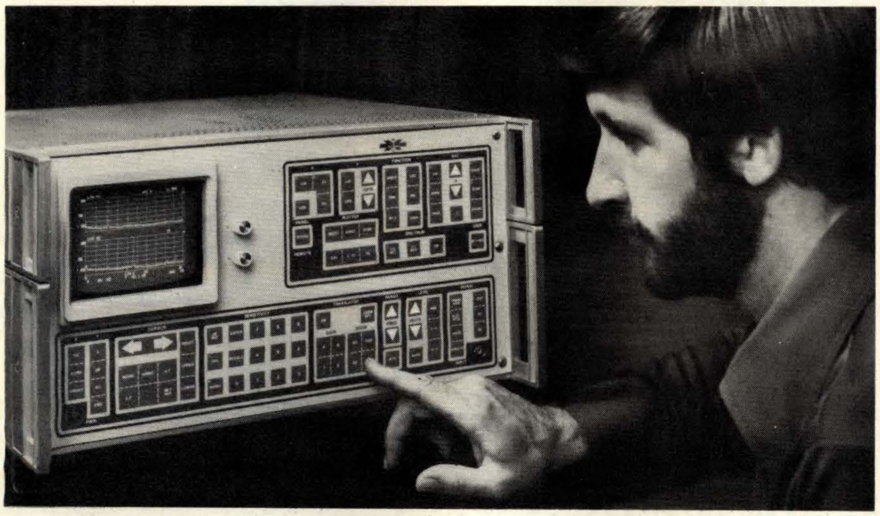
The system uses no programmer-addressable registers, no assembly language, no I/O instructions to operate channels or any other *machine* features unnecessary to a high-level language. Every instruction carries out extensive checking for invalid data or addressing conditions; all I/O is handled by a front-end Intel 8080 µP via asynchronous RS-232 protocol with external peripherals.

Software includes extended DISSPLA with publication-quality graphics capability including more than 60 type fonts, projection in 3D with hidden-line removal, curve fitting with various interpolations, a text editor and an interactive graphics system for creating graphics on-line.

The system includes five RS-232 ports, a front-end processor and a 48-bit processor. $49,000. **Superset Inc,** 11675 Sorrento Valley Rd, Suite L, San Diego, CA 92121. Phone (714) 452-8665. **Circle No 265**

8080 SIMULATORS. The Apple-II simulator package is an 8080 simulator/debugger program that runs directly on any 16k or larger Apple II computer. The KIM 1 version offers the same package; it runs on any KIM 1 computer and requires 1k bytes of RAM or ROM. Both packages allow the study of 8080 architecture on the same hardware used for 6502 studies and permit Apple II or KIM 1 users to use 8080 software. The Apple II version includes a BASIC program serving as an explanation manual and the machine-language program; the KIM 1 version is a KIM-format cassette tape containing the object code of the program. $19.95. **Sybex,** 2344 Sixth St, Berkeley, CA 94710. Phone (415) 848-8233. **Circle No 266**

µC OPERATING SYSTEM. An updated version of the REX-80 real-time executive enhanced to support either 8080/8085 or Z80 µCs, REX-80 V03 is fully event driven, allowing asynchronous operation of up to 255 independent tasks, each with 16 local-event flags. Because of its orthogonal data structure and virtual-processor approach, the system provides improved responsiveness compared with its predecessor. The enhanced Z80 version takes advantage of the Z80 instruction set and its Mode-2 interrupt structure. $1500 in linkable object code on development-system-compatible media. **Systems & Software Inc,** Suite 101, 2801 Finley Rd, Downers Grove, IL 60515. Phone (312) 932-9320. **Circle No 267**



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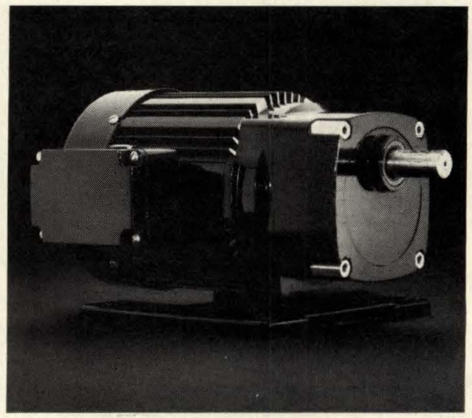

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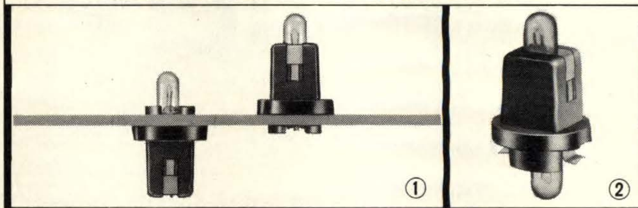

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HEMENWAY ASSOCIATES INC.
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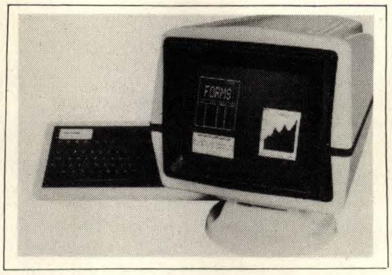
Boston, MA 02108
617-426-1931

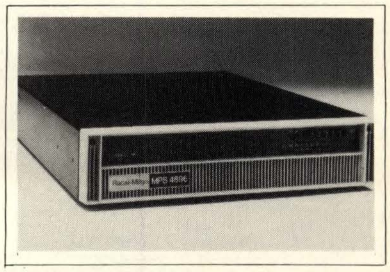
For more information, Circle No 46

New Products

COMPUTING SYSTEM. A small computer available in 12 versions, Model 5120 offers two choices of printers and an optional diskette storage unit that retains up to 2.4 million characters of additional information. It features a 9-in.-diagonal viewing screen, two built-in diskette files (up to 2.4-million-character capacity), a typewriter-like keyboard and main-storage options ranging from 16,384 to 65,536 characters of information. Six business application packages are available. $13,500 for a representative configuration using BASIC, a 13,768-character main-storage capacity and 120-cps printer. **IBM General Systems Div,** Box C-1645, Atlanta, GA 30301. Phone (404) 238-3643. **Circle No 268**

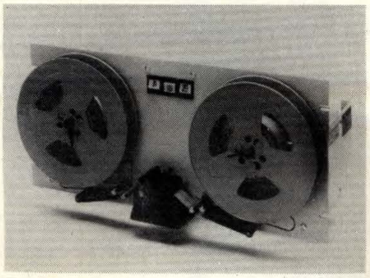


DISPLAY TERMINALS. Concept 520 Series units emulate DEC's VT-52 alphanumeric CRTs, providing standard features such as cursor control, home cursor, direct cursor addressing, reverse line feed, clear functions and alternate keypad mode. Other standard features furnished include windowing, programmable function keys, functional support for word processing and data-entry/retrieval applications, business graphics, multiple character sets and multiple I/O ports (including a printer port). $1330 (75) for standard ASCII version with one full page of display memory. **Human Designed Systems Inc,** 3700 Market St, Philadelphia, PA 19104. Phone (215) 382-5000.
Circle No 269

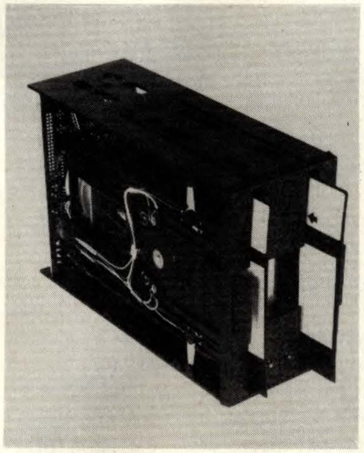


DUAL-SPEED MODEM. Installed at remote sites, MPS 4896 Fastran transmits data at 4800 bps and receives data at 9600 bps, operating on less expensive unconditioned multidrop lines. Using a μP digital equalizer, it provides 30-msec RTS/CTS response time and half-duplex operation over 4-wire dedicated unconditioned channels; it can also accommodate dial backup. Built-in diagnostic functions automatically switch the modem receiver to the operating speed of the transmitter for self test and analog and digital loopback to enable fault-isolation testing. $7200, or $165 per month on a 36-month lease. **Racal-Milgo Inc,** 8600 NW 41st St, Miami, FL 33166. Phone (305) 592-8600.
Circle No 270

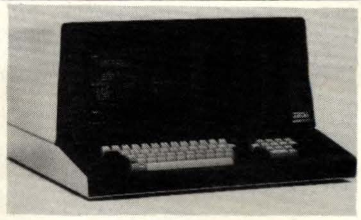
New Products



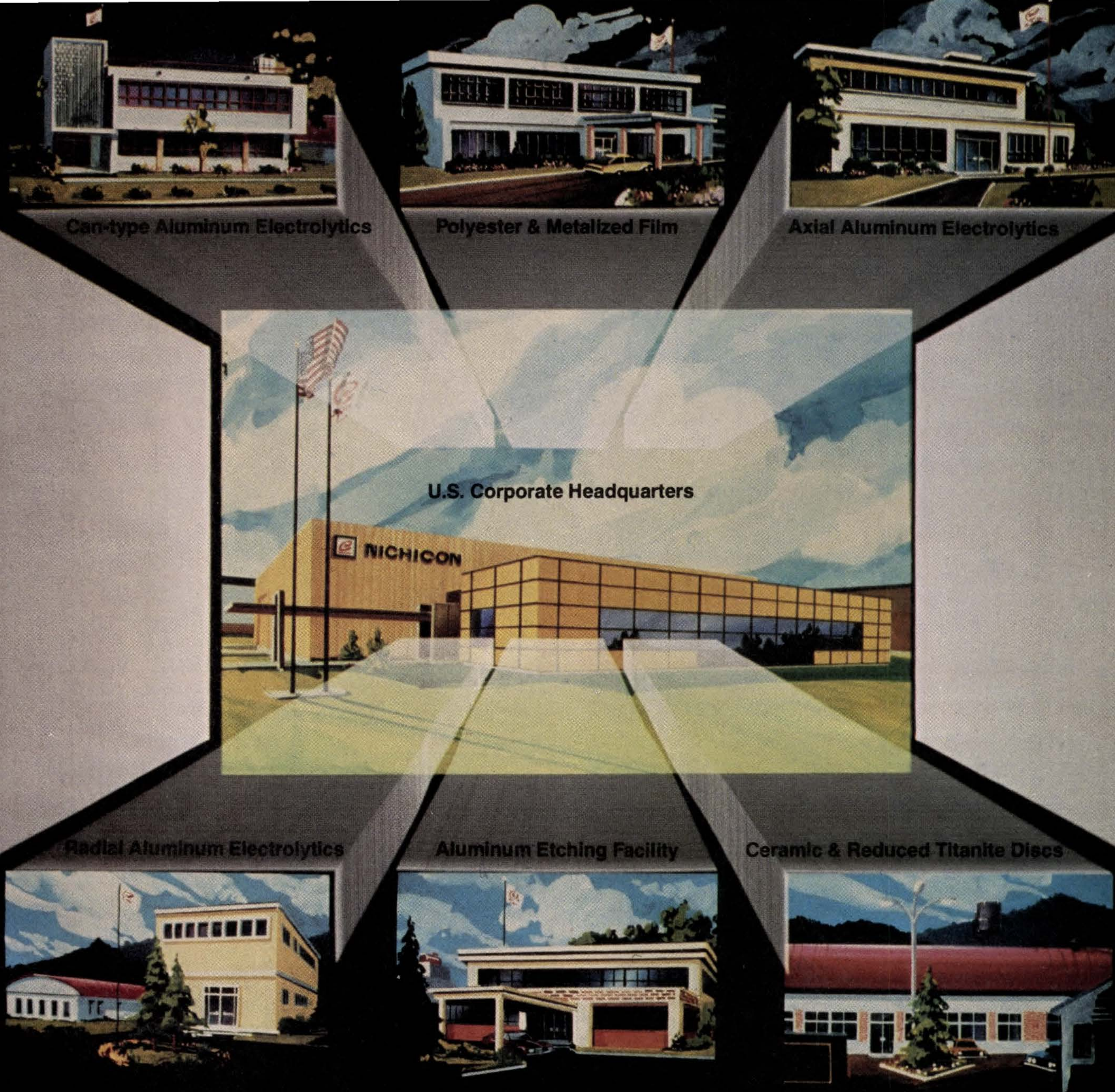
PAPER-TAPE READER. Model RR7155 has 200-cps asynchronous or synchronous read speed and 400-cps tape-positioning mode for rewinding on program cueing. Stepper-motor controlled, the 5.5-in.-high unit uses only one moving part, offers stop-on-character capability at all speeds and mounts on a 19-in. rack. An optional add-on fanfold tank assembly is available; MTBF specs at 16,000 to 20,000 hrs. $657 (OEM qty). **Remex,** Box C-19533, Irvine, CA 92713. Phone (714) 557-6860. **Circle No 271**



FLOPPY-DISC DRIVE. A double-disc drive that handles two independent 5.25-in. diskettes while maintaining size and interface compatibility with other single 5.25-in. disc drives, Model A-40 Dam provides single-side dual-density recording on 40 tracks of each diskette. Track-to-track access time of 12 msec produces a random average seek time of 170 msec. Unformatted storage capacity is 256k bytes per diskette or 512k bytes per drive. $450. **T and E Engineering,** 1015 W 190th St, Gardena, CA 90248. Phone (213) 327-7657. **Circle No 272**



μC SYSTEM. A completely self-contained μC with CPU, CRT display and dual mini-floppy disc drives housed in a desktop-sized metal cabinet, Model 580 provides 64k of dynamic RAM and a 4-MHz Z80A μP. The system supports two RS-232 serial ports, two parallel ports plus a parallel printer port, one hard-disc port and one connector capable of supporting two external floppy-disc drives. All interfaces are fully programmable and expandable. A CP/M compatible ZEDOS disc operating system is included; BASIC, COBOL and FORTRAN also operate on the unit. $6837, including operating system and a choice of one software package. **Zeda Computers International,** 1662 West 820 North, Provo, UT 84601. Phone (801) 377-9948. **Circle No 273**



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New Products

BAND-SPLITTING MODEM. Employing multiplexing techniques, μP-controlled Model DL 9600 permits several terminals and/or modems at one location to share one line and allows the combination of up to four medium-speed channels over a single high-speed line; each channel can operate independently. Operating point-to-point in full-duplex mode on a 4-wire 3002 private line at 4800 or 9600 bps (switch selectable), the modem features extensive self-testing capabilities including digital and analog loopback of remote unattended units. $5500; $1000 for bandsplitting option. Delivery, 30 to 60 days ARO. **Infotron Systems Corp,** Cherry Hill Industrial Center, Cherry Hill, NJ 08003. Phone (609) 424-9400. **Circle No 274**

SERIAL PRINTER. For no-frills applications where reliability is important, Model 877 receive-only bidirectional 9×7 dot-matrix unit uses 8½-in.-wide paper, features a heavy-gauge, hardened metal chassis and stainless-steel drive screw and utilizes a cartridge ribbon to

eliminate ribbon-reversing mechanisms. It prints at 120 cps, 80 characters/line, 10 cpi, using the 95-character ASCII set and operates at asynchronous baud rates of 300 to 9600. $830 (100). **Printer Terminal Communications Corp,** 124 Tenth St, Ramona, CA 92065. Phone (714) 789-5200. **Circle No 275**

FREQ - RESPONSE SIMULATION. LINAC is a FORTRAN program for simulation and analysis of the frequency response of active or passive circuits containing only linear elements, using an efficient nodal analysis method. For minicomputers such as the DEC LSI-11 or PDP-11/05 or large mainframe units, the current version (2.1) runs on PDP-11s under RT-11 and requires 20k words of memory. The program prints and plots the frequency response at user-requested nodes in the circuit. $1250 for binary, user's manual, operator's manual and license. **Gary Gaugler,** Consultant, 5706 Seascape Ct, Citrus Heights, CA 95610. Phone (916) 966-8076. **Circle No 276**

HARD-DISC SYSTEM. A 26M-byte (formatted) system for S-100 μCs, Discus M26 features the Shugart 4008 14-in. Winchester hard-disc drive, includes a metal cabinet, power supply and cables and can be used either as a table-top model or rack mounted. The unit comes with an intelligent single-board controller to supervise all data transfers and a 512-byte sector buffer; the controller can generate interrupts at the completion of each command to increase system throughput. Communication with the CPU occurs via four I/O ports. $4995. **Thinker Toys,** 5221 Central Ave, Richmond, CA 94804. Phone (415) 524-2101. **Circle No 277**

TANTALUM TECHNOLOGY: CAN IT GIVE US MORE CAPACITORS PER POUND?

Dr. John Piper
Manager of Research and Development
Electronics Division
Union Carbide Corporation

The recent escalations in the cost of tantalum materials concern everyone who must pay more for tantalum capacitors. The situation is very similar to the oil crunch and automobiles.

In both cases, the true supply situation is distorted by spot shortages and speculation. Potential substitutes for cars or tantalum capacitors are often discussed but, in reality, are quite unattractive. The intelligent way out is through more exploration, expanded production and greater conservation.

Conservation—more capacitors per pound of tantalum—is where KEMET® Capacitor's R&D will make its biggest impact. We have, in fact, surprised ourselves by making in the lab solid tantalum capacitors with conventional KEMET Capacitor quality, but using only a fraction of the tantalum. The tantalum savings are so great, they largely offset the cost increases of materials during the last two years.

Now, the job is to get this innovation out of the pilot plants, into production, and on to you. We are in an excellent position to do the job, because we have both KEMET Capacitor's own extensive research, development and engineering staffs, plus the vast technical resources of Union Carbide Corporation backing us up.

KEMET technology is proud to play a major role in easing the tantalum crunch. Our work, together with expanded production and new mineral exploration, will assure you of a continuous supply of quality KEMET solid tantalum capacitors to meet your highest performance requirements at a reasonable cost.

That's our commitment to you.

John Piper

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Designed for Remote Logging – The 3.5 Mbyte capacity of our 300D is available without interruption, using a serpentine recording technique to avoid rewind. A non-volatile memory stores conditions in the event of power outage...so it can automatically initialize itself for unattended restart. The 300D is remotely pollable, for direct data access at any time.

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For more information, Circle No 177

MR. CLEAN II

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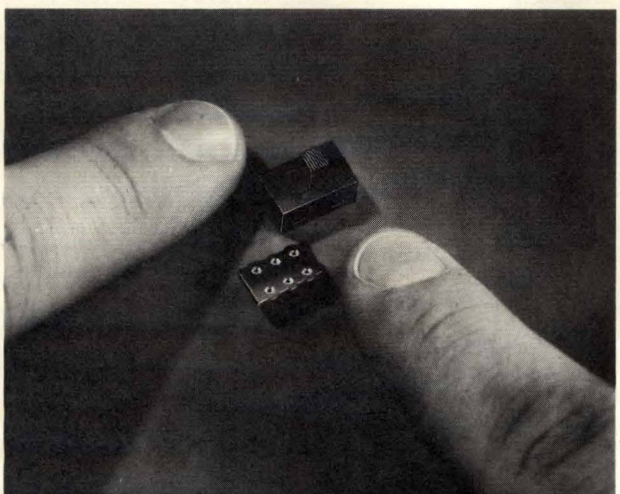

Mr. Clean II is our latest addition in our line of miniature, high quality, wave-solderable slide switches. This low cost switch is designed to work on our unique (Patented and Patents Pending) 2-piece principle. This revolutionary design allows for soldering and cleaning of only the simple exposed base half of the switch. The switching mechanism in the upper half is never exposed to any possible contamination.

These switches are designed for high reliability at a low cost. Mr. Clean II features insert molded pin terminals in a high-heat temperature resistant base. Contacts are of hard gold over nickel barrier and recommended for low energy applications. Available circuit configurations include SPST, SPDT, DPST, DPDT, and Form "Z".

Mr. Clean II is ideal for use in precision instruments and equipment, or wherever contamination during wave-soldering is found to be a problem.

Sample switches will be provided on requests stating application and annual requirements.

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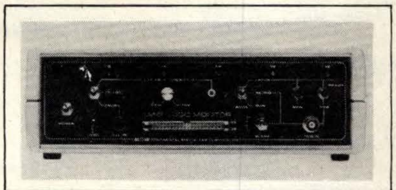
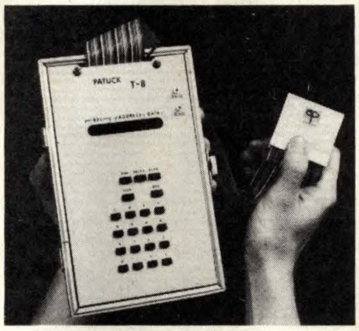
New Products

INSTRUMENTATION & POWER SOURCES



LOGIC MONITOR. With adjustable threshold levels and 0.5-MΩ, 6-pF input, Model LM-3 provides 40-channel logic-state indications of any solid-state logic family. Threshold selections include: a fixed 2.2V for TTL devices, a front-panel-controlled −5 to +10V level and a value equal to 70% of the sampled supply voltage. The 40-LED display follows input data during Run-mode operation. A Retrig mode permits an external trigger signal or manual pushbutton to freeze the display; a Latch mode disables external or manual triggering until after operation of an Arm pushbutton.

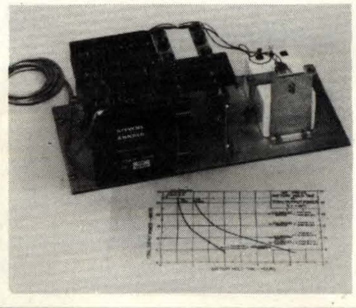
Forty clips (preassembled on a ribbon cable that plugs into the unit's keyed, locking front-panel receptacle) provide connection to the circuit under test. A front-panel switch allows rising- or falling-edge triggering. $585. **Continental Specialties Corp,** 70 Fulton Terrace, New Haven, CT 06509. Phone (203) 624-3103. **Circle No 331**



μC ANALYZER. You can troubleshoot 6800-μP-based systems by single stepping through development or diagnostic programs with the hand-held, μP-based Model T-8. The unit stores information from 63 machine cycles occurring before a user-selected break-point, provides test data on an 8½-digit display and connects to the μC under test via a 40-pin chip clip. *Field-interchangeable interfaces allow testing* of 2650, Z80, 8080, 6502, 6505, 8060 and 8085 μCs. $745; each interface, $50. **Patuck Inc,** 5073 Russell Ave, Pennsauken, NJ 08109. Phone (609) 662-0677. **Circle No 332**

CRT POWER SUPPLY. A 28V source powers the dedicated dc/dc Model RMC18PX900. The unit provides 18 kV (±5%) at 200 μA, a focus voltage of 800V at 200 μA, a 300 to 600V grid-#2 voltage at 200 μA, and −45V at 40 μA for grid #1. Line regulation for a ±5% change is 0.02% for all outputs. Anode-load regulation equals 0.05% (static) and 0.3% (dynamic) for a 0 to 200-μA load change; full-load ripple equals 0.1% p-p. The auxiliary outputs regulate to 0.5% for a 10% load change and limit ripple to 0.1% p-p. From $175 (OEM qty). Delivery, stock to 12 wks ARO. **Spellman High Voltage Electronics Corp,** 7 Fairchild Ave, Plainview, NY 11803. Phone (516) 349-8686. **Circle No 333**

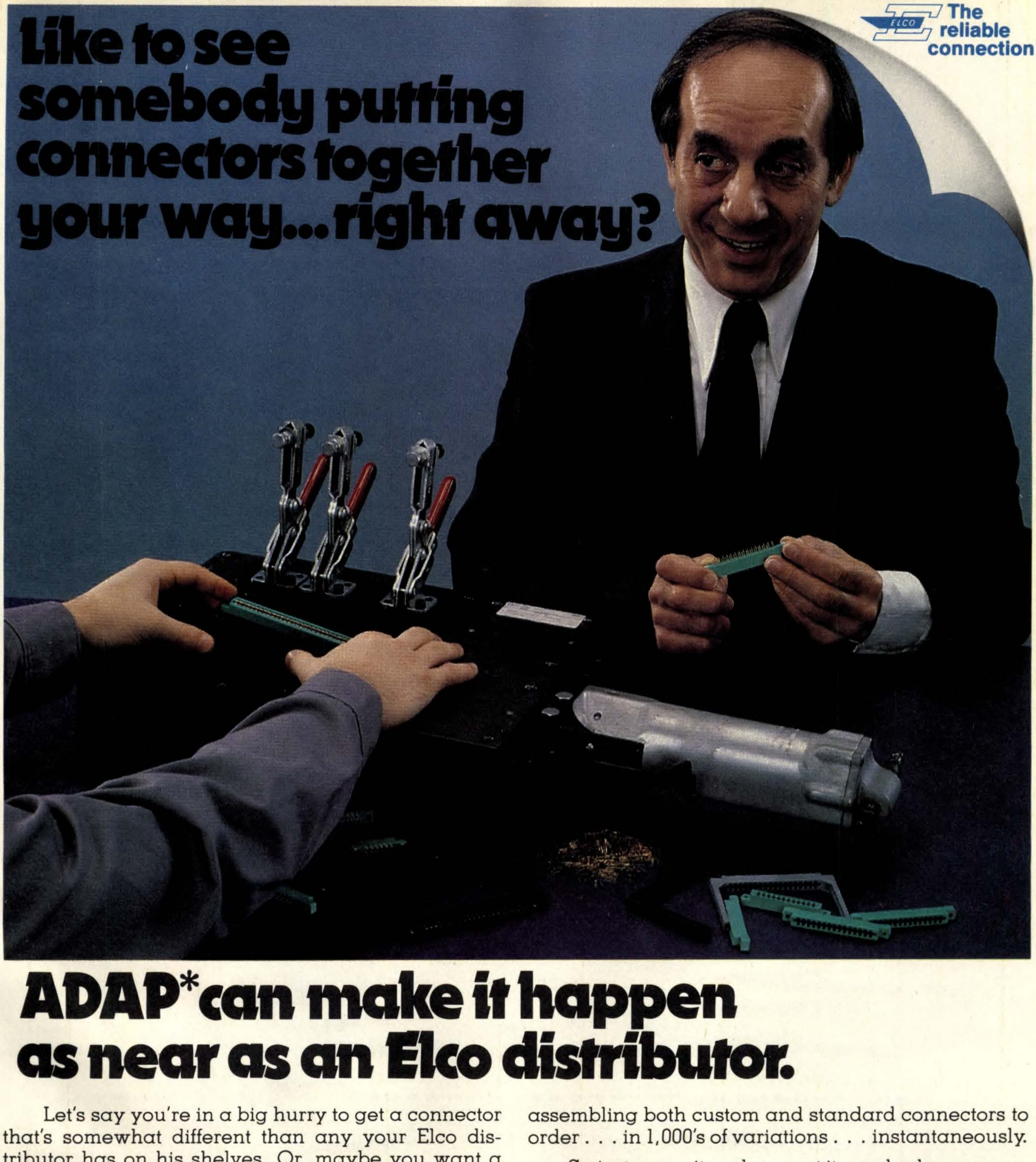
New Products



UPS. For systems with an essential-circuitry power bus isolated from the main dc bus, the UPS-2708B maintains memory and refresh logic power during outages or system shutdown. With twice the capacity of its -2708A predecessor, the unit delivers 3A at 5V (±0.5%) and 1A at 12V (±0.5%), derived from its 12V 5-Ahr sealed lead-acid battery. It operates on 100 to 127V, 50- or 60-Hz input, and features protection against overvoltage and short-circuits. $365 (100). Delivery, stock to 12 wks ARO. **Stevens-Arnold Inc,** 7 Elkins St, South Boston, MA 02127. Phone (617) 268-1170. **Circle No 334**

X-Y-Y RECORDER. The 2-pen DIN A3 Model 6432 recorder features electrostatic paper holddown with two pinpoint light marks on the chart table for easy setup of the paper, full-scale zero adjustment, rack-mount capability and remote and local penlift. It has 15 switch-selectable continuously variable ranges from 0.2 mV/cm to 10V/cm. The built-in time base sweeps the X-axis with six calibrated ranges of 0.2 sec/cm to 10 sec/cm. The writing speed of 600 mm/sec for three axes allows accurate recordings of fast-changing input signals. $3495. Delivery, 60 days ARO. **Soltec Corp,** 11684 Pendleton St, Sun Valley, CA 91352. Phone (213) 767-0044. **Circle No 335**

POWER ANALYZER. Microprocessor control eases power measurement with Model 4612, which features operator-controlled averaging of amperes, volts and watts; it simultaneously displays the true-rms value of each parameter with floating-point notation. Typical accuracy specs at better than ½% on all 25 pushbutton-selected ranges (to 50A and 600V) with no need for burden compensation or other correction. Options include analog and digital outputs. $2385. Delivery, 6 to 8 wks ARO. **Magtrol Inc,** 70 Gardenville Parkway West, Buffalo, NY 14224. Phone (716) 668-5555. **Circle No 336**



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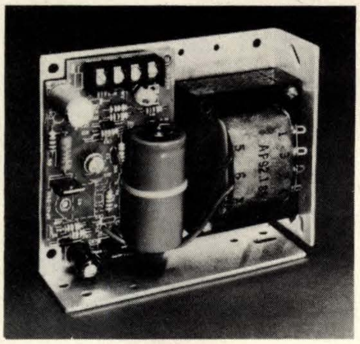

LINEAR SUPPLIES. EAPS U Series devices operate from a 103 to 130V or 206 to 260V (47 to 63 Hz) input and deliver 5V at 3A, 12V at 1.6A, 15V at 1.5A or 24V at 1A. Regulation is ±0.05% (line) and ±0.1% (load), with ripple limited to 5 mV p-p max. The 4×4.87×2.07-in. units feature rated power to 50°C, electrostatically shielded transformers, reverse-polarity protection, hermetically sealed IC regulator, UL-recognized glass/epoxy circuit boards and a 5-yr warranty. $23.25; optional overvoltage protection, $1.50. **Adtech Power Inc,** 1621 S Sinclair St, Anaheim, CA 92806. Phone (714) 634-9211.

Circle No 337

EPROM PROGRAMMER. Designed to program the 2732A, Model PM9074 generic personality module will also accommodate other, yet-to-be-developed HMOS EPROMs and higher density PROMs (including 64k devices). Plugging the unit into a Series 90 PROM programmer master control unit permits listing, programming, duplication and verification. Features include cold sockets that allow installation and removal of PROMs without applying V_{CC} to the sockets and high/low voltage verification to permit reading of PROMs with V_{CC} adjusted to its high and low limits. $550. Delivery, 6 to 8 wks ARO. **Pro-Log,** 2411 Garden Rd, Monterey, CA 93940. Phone (408) 372-4593.

Circle No 338

WAVEFORM DIGITIZER. The programmable Model 7612D captures, digitizes and stores signals for subsequent computer processing. The 2-channel GPIB-compatible instrument features 200-MHz max sampling frequency, 8-bit resolution, two time bases and 2048 8-bit words of memory per channel, with selectable record length. It allows pre/post-triggering, up to 13 sample-rate changes per record and multiple waveform capture. µP control monitors incoming data and avoids incompatible settings. $24,000. **Tektronix Inc,** Box 1700, Beaverton, OR 97077. Phone (503) 644-0161. **Circle No 339**

HIGH-VOLTAGE PROBE. Combining Model HV40B with any of a wide range of instruments permits measurement to 40,000V dc or peak ac. The unit has a 1000:1 voltage-division ratio (VDR) when terminated by 1 or 10 MΩ and a 2000:1 VDR when terminated by 20 MΩ. Features include retractable safety-sleeved 4-mm banana plugs, a probe body with rectangular safety shields to prevent rolling, a 2m cable with attached alligator clip and a cable for chassis ground. $75. Delivery, 6 to 8 wks ARO. **Test Probes Inc,** Box 2113, La Jolla, CA 92038. Phone (714) 459-4197.

Circle No 340

For more information, Circle No 187

New Products

LCD DMM. 0.1% dc-measurement accuracy and a 0.5-in.-high 3½-digit display highlight Model LC5000. A 9V alkaline battery provides more than 6 months of operation on five true-rms ac and five dc voltage ranges from 200 mV to 1000V, five dc current ranges from 200 μA to 2A and six resistance ranges from 200Ω to 20 MΩ. The 3×8×9-in. unit features banana-plug receptacles, fused input and a 1-yr limited warranty. $169.95. **DSI Instruments Inc,** 9550 Chesapeake Dr, San Diego, CA 92123. Phone (714) 565-8402. **Circle No 341**

DIGITAL THERMOMETER. The hand-held Model 42822 provides μC-controlled accuracy of ±0.1° from 0 to 110°C. The unit features an LED display that indicates °C or °F, a NiCd battery that provides up to 4 hrs operation per charge and an ac adapter. $169.95; air probe, $24.95; surface probe, $19.95. **Edmund Scientific Co,** 7082 Edscorp Building, Barrington, NJ 08007. Phone (609) 547-3488. **Circle No 342**

PROM PROGRAMMER. A 4-ft flat ribbon cable connects the Model PP-2532 to any read-only PROM socket via a 24-pin plug, forming a table-top programmer for the TMS 2532 EPROM. Each unit comes with an internal dc/dc switching regulator and zero-insertion-force socket. $295. **Oliver Advanced Engineering Inc,** 676 W Wilson Ave, Glendale, CA 91203. Phone (213) 240-0080. **Circle No 343**

PORTABLE μP LAB. The Portable Training Lab (Course 525A) consists of 20 self-training modules (4 vols, 1650 pgs) and a complete 8080A-based hardware system. The texts cover programming fundamentals, real-time-interrupt handling, control of programmable interfacing devices and closed-loop control-system implementation. Each module provides hands-on experiments that involve program coding and execution. $1595. **Integrated Computer Systems Inc,** Box 5339, Santa Monica, CA 90405. Phone (213) 450-2060. **Circle No 344**

Put on the versatile coating that lets your product give an all-star performance:

Elastoplastic silicone resin.

Now on the Qualified Product List for Mil spec I-46058: Insulating compound-electrical for coating printed circuit board assembly.

Flexibility, toughness, versatility—you'll discover that Dow Corning elastoplastic silicone resin has it all—everything it takes to protect product dependability. Check these advantages, with your product in mind:

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Apply coating easily, as thick or thin as you need it. Its noncorrosive cure can match your process, at room temperature or under heat acceleration. The coating's repairable, so components are easy to fix or replace, and recoat.

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New Products

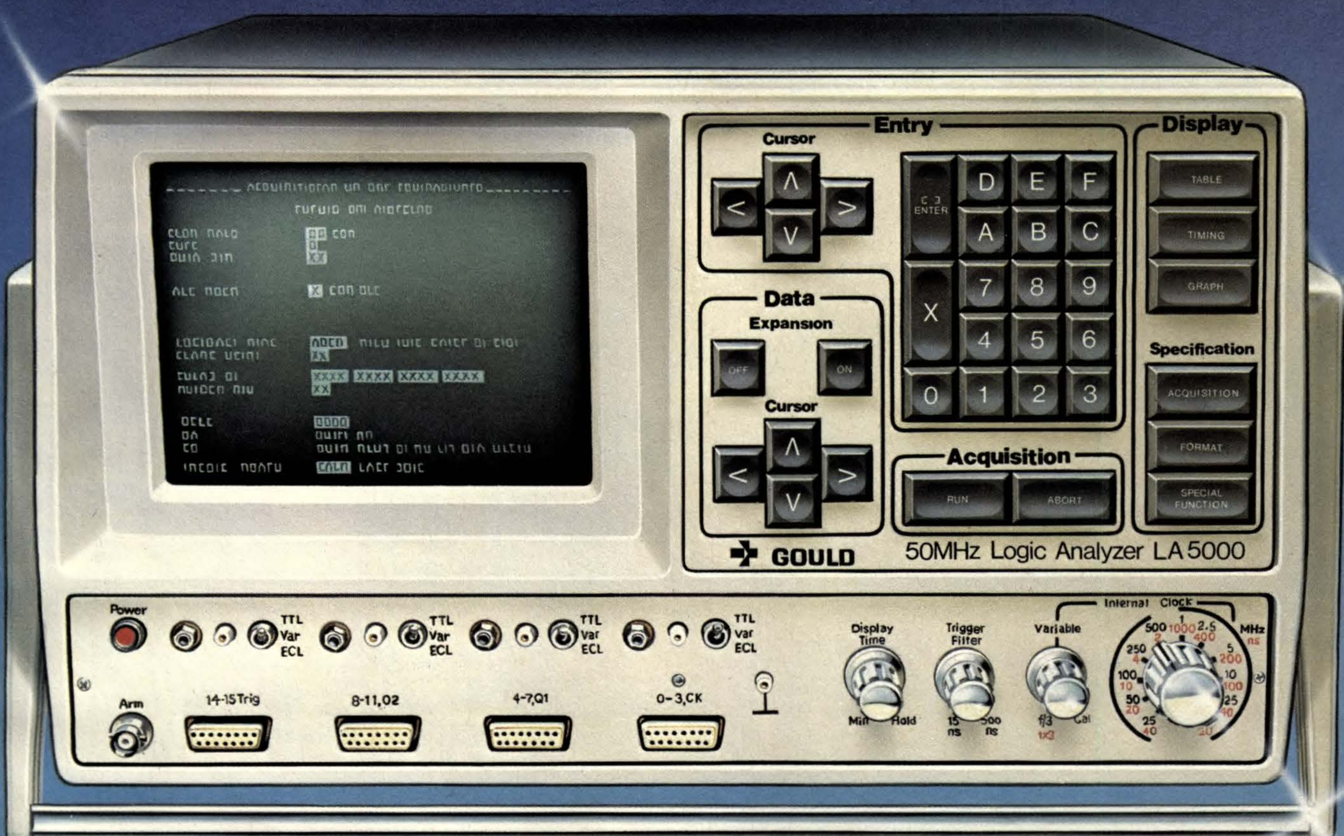
VIDEO GENERATOR. Designed for CCTV and monitor applications as well as VTR and TV adjustment and repair, Model 240 features both video and adjustable RF output, a 10-step gray-scale staircase, 3- and 10-bar gated rainbows, a trigger output and built-in battery check. Controlled by a thumb-operated integrated slide switch, the unit generates 11 video or RF patterns and operates from an ac adapter (included with unit) or two 9V batteries. $159. **Hickok Electrical Instrument Co,** 10514 Dupont Ave, Cleveland, OH 44108. *Phone (216)* 541-8060.

Circle No 345

THERMOMETER. Applications requiring 0.01°C resolution and high stability benefit from Series 4000 units. Instrument accuracy (for 90-day recalibration interval) specs at ±0.08°C or ±0.1°F, and custom calibration provides total system accuracy (instrument and sensor) of ±0.05°C over a limited range. Available models provide either °C or °F readouts and feature multiple inputs, analog and BCD outputs and digital alarms. Delivery, stock to 10 wks ARO. From $595. **Instrulab Inc,** Box 426, N D Station, Dayton, OH 45404. Phone (513) 223-2241. **Circle No 346**

TIMER/COUNTERS. Using an 8-bit μP, Series 9000A units permit handshake interface commands in 8 μsec—at least 10 times faster than their Series 9000 predecessors. Access to pulse-parameter and arithmetic capabilities through the GPIB interface permits improved operator control. Four models with frequency ranges to 512 MHz are available. Functions provided include period, period average, time interval, time-interval average, totalize and ratio. $2995 to $4295. **Racal-Dana Instruments Inc,** 18912 Von Karman Ave, Irvine, CA 92715. Phone (714) 833-1234. **Circle No 347**

MICROPROCESSOR GLITCHES: MEET YOUR FIXER.



Biomation's new LA-5000 50MHz logic analyzer brings the convenience of our K100-D to microprocessor designers.

Following our K100-D, which sets the industry standards for digital system debugging, Biomation brings you a new glitch fixer, the LA-5000. A logic analyzer matched in cost and capability to the needs of microprocessor system designers.

The LA-5000 is ideal for data domain and timing analysis with clock rates from 12.5 MHz with 16 recording channels, to 50 MHz with 4 channels. Three display modes give you: data domain information in binary, octal or hexadecimal; timing diagrams; even a graphic plot of successive word values.

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Convenience features? The LA-5000 features two memories with an auto-stop function to simplify fault-finding. Reverse video highlighting calls attention to memory differences. The reference memory is easily accessible via the keyboard. And, a memory search feature matches like sequences in both working and reference memories.

Introduce the glitches plaguing your system to their fixer. You'll enjoy efficient system debugging at a price well below what you'd expect to pay. For more information on the LA-5000, or any of Gould's full line of logic analyzers, write:
Gould Instrument Division,
Santa Clara Operations,
4600 Old Ironsides Drive,
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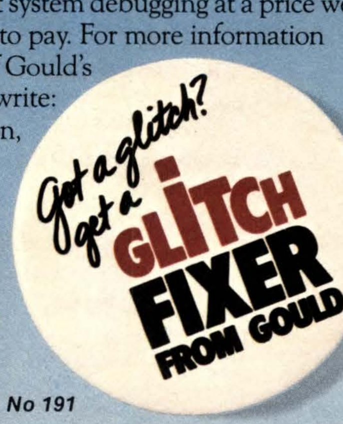
Or call (408) 988-6800.



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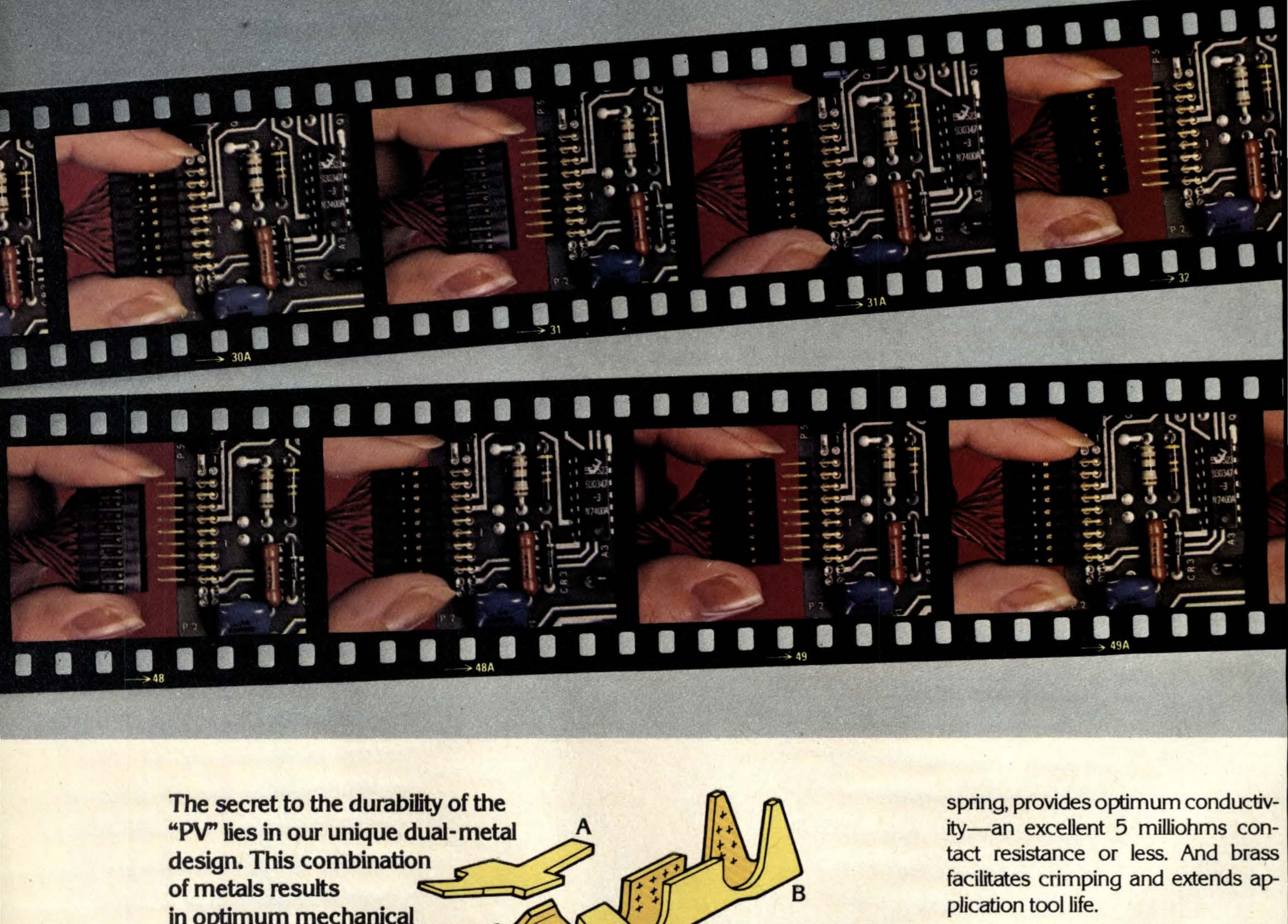
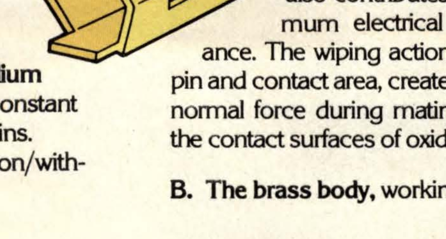
Berg's 0.025" PV™ receptacle
And do it time...after tim



The secret to the durability of the "PV" lies in our unique dual-metal design. This combination of metals results in optimum mechanical and electrical performance.



A. The heat-treated beryllium copper spring maintains constant mechanical pressure on pins. Even after repeated insertion/withdrawal cycling.

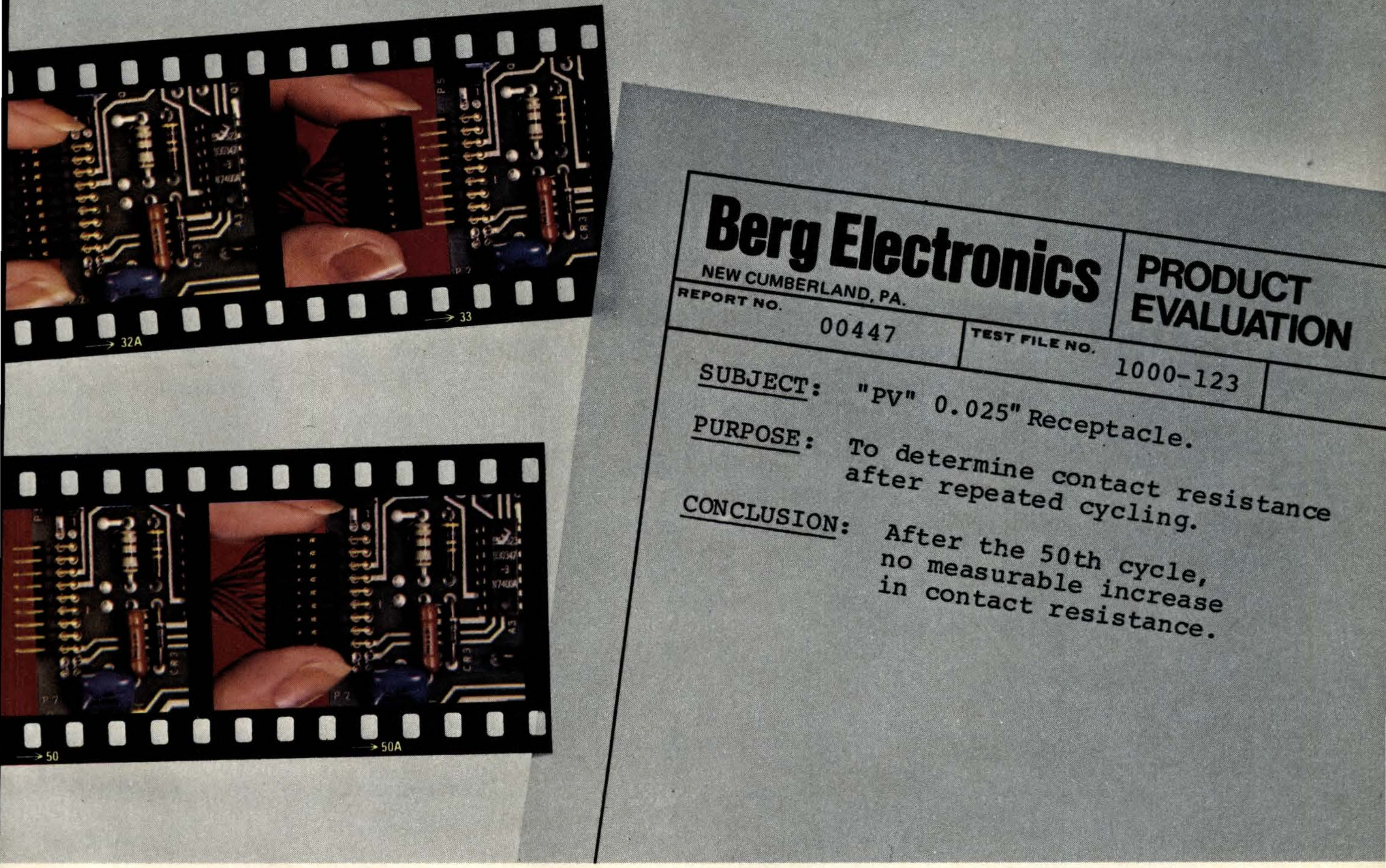
This constant force also contributes to maximum electrical performance. The wiping action between pin and contact area, created by high normal force during mating, cleans the contact surfaces of oxides.

B. The brass body, working with the spring, provides optimum conductivity—an excellent 5 milliohms contact resistance or less. And brass facilitates crimping and extends application tool life.

The "PV" line allows wide design flexibility.

A choice of three spring thicknesses are available to help meet specific insertion/withdrawal force requirements. There are four terminal variations in crimp-to-wire sizes from AWG 18-36. The wide variety of

...deliver low contact resistance.
..after time...after time...



types and sizes, and the option of several gold or tin-lead platings, offer maximum design flexibility.

The Berg "PV" is the heart of the most complete 0.025" interconnection system available today. The BergCon™ system.

The "BergCon" system consists of a variety of mateable terminations for board-to-board, cable-to-board, or cable-to-cable packaging:

- BergStik™ pins, conveniently molded in plastic, can be manually inserted into P.C. boards for on-line production without a machine.
- Standard housings allow simultaneous connection of as many as 72 "PV" terminated connectors.
- Low cost, easy to load hand tools available through distributors make the "BergCon" system practical for even the lowest-volume user. Or a low cost air-operated applicator is available from Berg.
- And the entire "BergCon" system is Underwriters recognized.

For detailed information on the complete "BergCon" system, write or call: The Du Pont Company, Berg Electronics Division, New Cumberland, Pennsylvania, 17070, Telephone: (717) 938-6711. Or contact your nearest Berg Electronics connector distributor.
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Our new, dual-channel Model 619 electrometer/multimeter offers you electrometer sensitivity, multimeter ease, systems capabilities and will not interfere with system level decisions. Unless you want it to.

The 619 is loaded with real-world features which make it as flexible as your imagination. It will correct for internal voltage offsets, store up to 50 readings for examination later at the convenience of the system, define a baseline allowing you to read either absolute values or deviations from the baseline—all automatically.

Optional dual-channel capability gives you two instruments for the price of one. Ratio. Difference. Capability for charge or logarithmic current measurement. Speeds up to 18ms/conversion. 4½ or 5½ digit resolution. On the bench or on the IEEE-488 bus.

As an electrometer. As a systems multimeter. As a picoammeter. As a current source.

It lets you decide what it should or shouldn't do.

From its status-at-a-glance annunciators to its programmable trigger modes, every detail of the 619 was painstakingly thought through to give you, the user, full command of the instrument and your application.

Sensitivity. Adaptability. Ease of use. Value. If ever there was an example of Keithley's user-oriented, price/performance design philosophy, it's the 619. It's as much or as little as you need, whenever and however you need it.

Contact your Keithley representative. He'll be happy to show you how the 619 does exactly what you expect a sophisticated measurement instrument to do—and not do.

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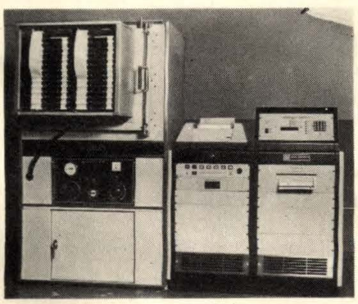
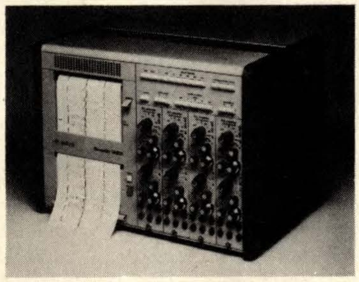
For more information, Circle No 193

PROM EMULATOR. The ROSI ROM-simulation personality module allows program evaluation before ROM programming when used with the IM1010 PROM-programming system. The module features a 4k×8-bit RAM, which permits emulation of one to four PROMs and allows correspondence between PROM and RAM addresses. The module features standard RAM access time of 300 nsec; faster times are also available. $595. **International Microsystems Inc,** 11554 C Ave, Auburn, CA 95603. Phone (916) 885-7262. **Circle No 348**



RAM EVALUATOR. System Super 20 (SS20) provides all power and stimulus requirements for evaluating 4k- to 64k-bit RAMs at burn-in temperatures. A self-checking μP-based monitoring system continually supervises the data inputs and outputs of each device under test and distinguishes hard failures and soft errors. All faults are identified by board, device and temperature and selectively displayed and printed out in real time at 300 baud. Four electrical sections permit simultaneous testing of four different RAM types. $95,000. Delivery, 120 days ARO. **Marin Controls Co,** 517 K Marine View Ave, Belmont, CA 94002. Phone (415) 591-8924. **Circle No 349**

HIGH-VOLTAGE PULSER. Model P-10 applies 6-kV square pulses to 50Ω resistive or coaxial-cable loads. Suited for driving Pockel cells used in mode-locked laser systems, the unit features a throughput delay of 10 nsec (with a 5-nsec pulse width), input trigger response of 400 psec and an input-to-output jitter of ±250 psec. $3450. Options include pulse widths of 7 to 25 nsec ($100), 5- to 60-nsec front-panel-adjustable throughput delay ($375), 7-kV output ($200) and HN output connector ($100). Delivery, 90 days ARO. **Energy Research,** Box 3623, Simi Valley, CA 93063. Phone (805) 526-1143. **Circle No 350**



THERMAL-ARRAY RECORDER. No pens, ink or pen-motor linkages are used in Model TA600. It monitors 32 overlapping analog channels on a 6-in. chart, while the basic mainframe has space for four dual-signal conditioners. The unit features capability for full annotation of data-acquisition conditions and μP entry of user text messages; an optional μP allows remote-control operation. A thermal array composed of 512 thermal styli spaced 100 to the inch contributes to system accuracy of ±0.2% FS. $4650. **Gould Inc,** 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315. **Circle No 351**

LASER RADIATION ALARM. Claimed to provide an audible indication of the presence of pulsed laser radiation above the level of eye safety, the 7.6×5.1×2.5-cm I-LID (instantaneous laser incidents detector) monitors pulsed energy from 1064-nm-wavelength lasers. The unit's normal threshold is set at 20 nJ/cm²; a press-to-operate switch provides recalibration to the claimed eye-damage threshold of 1 μJ/cm². A built-in test laser permits device self-test. The 98g unit operates on a rechargeable battery and built-in solar-cell charger. $375. **International Laser Systems Inc,** 3404 N Orange Blossom Trail, Orlando, FL 32804. Phone (305) 295-4010. **Circle No 352**

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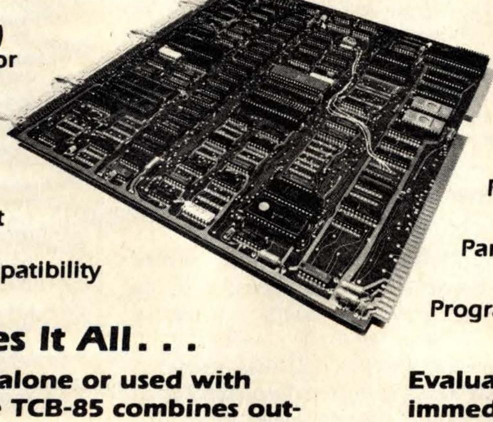

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The TCB-85 uses the Intel 8085A CPU and can optionally be ordered with the Intel 8085A-2/10 MHz CPU.

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Our 1657 Digibridge gives you everything you need for basic RLC testing at a modest $1500. It's accurate to 0.2%, and lets you test at 1 kHz as well as 120 or 100 Hz. The 1657 gives you continuous measurements at 3 per second and the choice of series or parallel measurement modes.

1658 RLC Digibridge

For more critical measurements, our 1658 gives you the measurement accuracy of 0.1% at 1 kHz and 120 or 100 Hz. Its features include automatic limit comparison capability and selectable test speeds for fast error free measurements. Range selection is automatic and the 1658 has external DC bias capability, too. All for just $3,200. As an option an IEEE bus/handler package for data communication and high speed automated testing is available.

1687 1 MHz LC Digibridge

In a 1 MHz tester our 1687 gives you 0.1% accuracy on C measurements, 0.2% accuracy on L measurements. You get most of the features of our 1658: automatic range selection, selectable measurement speeds, automatic limit comparison capability, external DC bias capability, and more. Like self-check diagnostics. At a cost of just $4000. Optionally, you can also get an IEEE bus/handler interface, external fixturing and a 1.0V rms test voltage.

1688 Precision LC Digibridge

Our top of the line 1688 provides basic accuracy of 0.02%, a choice of 254 frequencies from 240 Hz to 20 kHz, and a 1 PPM D measurement resolution. Test speeds can be set at .5, 1.5, 3.0 or 7.0 measurements per second and test voltages at .25V or 1.0V. Of course range selection, limit comparison capability and self-check diagnostics are also included. And that's the most performance you can buy for $4900.

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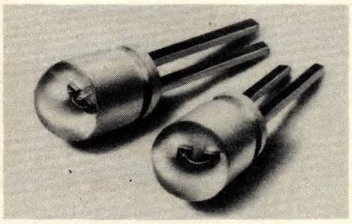
New Products

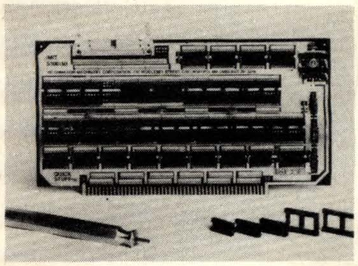
COMPONENTS & PACKAGING



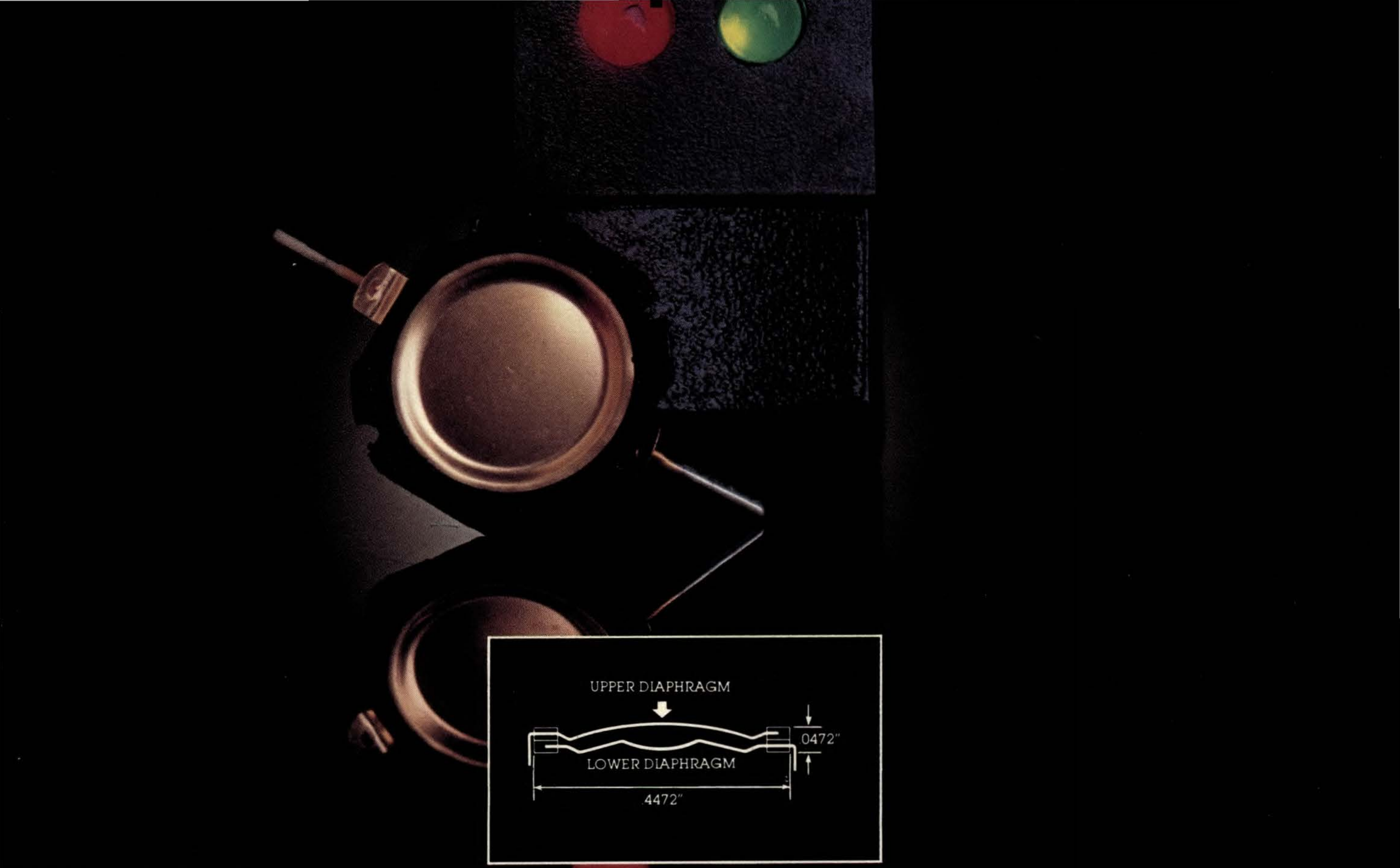
LED LAMPS. Units in the subminiature Illuminator Series (MK9150/MK9350) employ *high-efficiency* gallium-phosphide semiconductor technology to produce a luminous output of 45 to 80 mcd. The *monochromatic* devices, capable of up to 0.5W operation, are available initially in orange and yellow with green to follow; the orange lamp can be filtered to produce high-efficiency red.

Resistant to shock and vibration, each lamp comprises two LED chips wired internally in series and mounted in a 1-piece injection-molded T-1¾ package with built-in lens and molded light reflector.

When operated under normal conditions, the units have a useful life of 100,000 to 1 million hrs. Approximately $1.20 (small qty). **General Instrument Optoelectronics,** 3400 Hillview Ave, Palo Alto, CA 94304. Phone (415) 493-0400. **Circle No 280**



PROTOTYPING BOARD. For S-100-bus systems, the reusable S100/50 comes with a wiring tool and consists of a pc board with a 64-pin I/O area, gold edge connector, an assortment of DIP sockets, 5V regulator, heat sink and capacitors. Insulation-displacement connectors are used to ease circuit changes: 30-gauge Kynar insulated wire is pushed into the contacts, piercing the insulation and forming a gas-tight connection. The unit accommodates all widely used 2- to 64-pin DIPs and discretes. From $127. **Information Machinery Corp,** 110 Middlesex St, Chelmsford, MA 01863. Phone (617) 251-3270. **Circle No 281**



The assignment: offer a reliable switch element capable of evolving into a variety of specialized key- and rocker switch designs.

The result: ITT Schadow's Disc Switch.

At ITT Schadow, we specialize in taking basic switch designs and changing them to fit your specific applications. We've built a reputation on our awareness that the first two syllables of "customer" are "custom."

Customized adaptations work best when they're based on products with a proven record of reliability. Our popular Disc Switch is a case in point. When depressed, its upper dome-shaped diaphragm flattens to make positive contact with a lower diaphragm over a broad circular contact area. This simple, sturdy design has a rated service life of up to 10,000,000 cycles. Schadow's Disc Switch is available as a basic switch element, in a variety of standard packages as shown, and in custom packages. You can choose from a selection of colors and graphics.

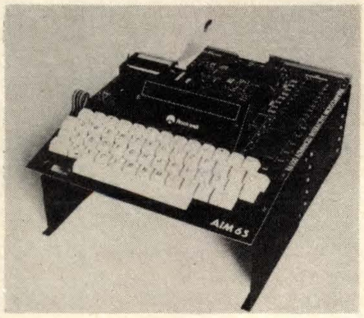
Over the past two decades, we've made millions of pushbutton, key-, rocker, and rotary switches for some of America's largest consumer and industrial OEM's. We are your "creative switchmaker" with the ability to design, adapt, and manufacture switches for nearly every requirement.

Your ITT Schadow manufacturer's representative or distributor can tell you more. Or contact ITT Schadow Inc., a subsidiary of International Telephone and Telegraph, 8081 Wallace Road, Eden Prairie, MN 55344. Phone 612/934-4400, TWX 910-576-2469, Telex 29-0556.

ITT Schadow

For more information, Circle No 199

New Products



CARD FILE. The K-1005-A integrates the Aim-65 computer, a keyboard and a series of expansion boards into one compact, portable unit complete with mother board. Drawing no power, the unbuffered mother board utilizes the Aim bus structure to carry expansion-connector signals to up to four additional boards; a fifth undedicated position is provided for a board not on the bus. To reduce noise, the mother board is a double-sided pc board with ground plane. An applications mother board (*K-1005-3-AP*) is optional. $95; K-1005-3-AP, $29. **Micro Technology Unlimited,** Box 4596, Manchester, NH 03108. Phone (603) 627-1464. **Circle No 282**

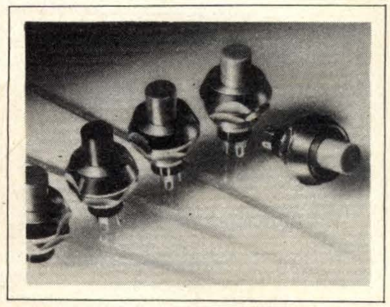
OSCILLATOR. Model P-453 L-C voltage-controlled unit is available at any frequency in the 100- to 400-MHz range. Frequency deviation ranges to ±10% with a ±5V dc control voltage; the control voltage can be modulated at a rate up to 1% of the output frequency. Output power equals +10 dBm into 50Ω. Single-sideband phase noise in a 1-Hz bandwidth equals −60 dB at 300 Hz, −81 dB at 1 kHz, −108 dB at 10 kHz and −142 dB at 500 kHz. $420 (10). **Greenray Industries Inc,** 840 W Church Rd, Mechanicsburg, PA 17055. Phone (717) 766-0223. **Circle No 283**

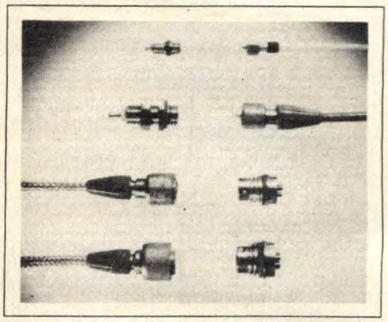
OSCILLATOR. Featuring current requirements as low as 50 μA and suitable for battery-powered products requiring a 10- to 250-kHz time base, Model LQXO-4 is a self-contained hermetically sealed, hybrid quartz crystal oscillator consisting of a Statek tuning-fork crystal, CMOS amplifier and capacitors and resistors mounted on a thin-film substrate. The unit is available in eight stock frequencies, has an operating-temperature range of −55 to +125°C, withstands shock to 1000g and provides accuracy to ±0.01% (±0.02% typ). $12.50 (1k). **Statek Corp,** 512 N Main, Orange, CA 92668. Phone (714) 639-7810. **Circle No 284**

New Products

CRYSTAL CLOCK oscillators in the BW9101 Series utilize hybrid-circuit packaging techniques and cover the frequency range of 250 kHz to 50 MHz. Having a height of 0.2 in. and occupying 0.815×0.515 in. on a circuit board, the hermetically sealed units operate from a 5V supply, are TTL compatible and provide frequency stability of ±0.01% over the specified operating range. They are also claimed solvent resistant and leak tested to MIL-STD-883A. $6 (10k). **Bulova Watch Co Inc,** 61-20 Woodside Ave, Woodside, NY 11377. Phone (212) 335-6000. **Circle No 285**

MOMENTARY PUSHBUTTONS. MSPF Series units sport an exceptionally large button and a full-threaded, 15/32-in. body that suits front- or rear-panel mounting. The devices feature a contact self-leveling capability to furnish minimum contact resistance and come with a choice of standard red, white, blue, black or custom-colored buttons. Available as normally open, normally closed or normally open/normally closed devices, all units have epoxy seals to reduce contamination during soldering. $0.99 (250) for normally open unit. **Alco Electronic Products Inc,** 1551 Osgood St, North Andover, MA 01845. Phone (617) 685-4371. **Circle No 286**





ULTRAMIN CONNECTORS. Featuring simplified assembly, these coaxial connectors come in ultraminiature and miniature sizes with outer diameters of 1/8 and 1/4 in., respectively. Overall plug length is <0.25 in. Bodies and pins are gold-plated brass; the sockets, gold-plated beryllium-copper; the insulators, TFE Teflon. From $0.95 (1k). **Microtech Inc,** 1420 Conchester Hwy, Boothwyn, PA 19061. Phone (215) 459-3566. **Circle No 287**

STRIPLINE HYBRIDS. Constituting a line of 90° quadrature hybrids covering 200 to 18,000 MHz, H Series units are specified in the standard full-octave bands. Typical specs for Model 7012 include frequency range of 7 to 12 GHz, isolation of 20 dB min, insertion loss of 0.5 dB max, maximum VSWR of 1.35, phase balance of ±3° and amplitude balance of ±0.3 dB. All units come with sealed SMA steel connectors and captivated center conductors. $95; except Model H1218 (12 to 18 GHz), $125. **Engelmann Microwave Co,** Skyline Dr, Montville, NJ 07045. Phone (201) 334-5700. **Circle No 288**

LU SERIES SPECIFICATIONS

DC Output
Voltage range shown in tables opposite page.

Regulated Voltage
regulation, line 0.4%
regulation, load 0.85%
ripple and noise ....120mV p-p for 5V models, 150mV p-p for 12V and 15V models, 200mV p-p for 24V models
temperature coefficient ..0.02%/°C

AC Input
line ....105 to 132 VAC, 47-440 Hz
efficiency minimum .....62% for LUS-8 models, 66% for LUS-9 models, 72% for LUS-10 models

DC Input .... 130-160 VDC.

Overshoot
No overshoot at turn-on, turn-off or power failure

Ambient Operating Temperature
Continuous duty 0° to 50°C with suitable derating shown in table on opposite page.

Storage Temperature
−30°C to +85°C

Overload Protection
External overload protection, automatic factory preset electronic current limiting circuit limits the output current thereby providing protection for the load as well as the power supply. Internal failure protection provided by fuse.

Overvoltage Protection
Overvoltage protection is standard on LUS-9 and LUS-10 models. For other models see accessory pages in catalog.

Cooling
Convection cooled, no fans or blowers needed.

DC Output Controls
Simple screwdriver voltage adjustment over the entire voltage range.

Mounting
One mounting surface, one mounting position.

Input and Output Connections
Heavy duty terminal block on front of chassis.

Physical Data

Package Model	Weight (lbs.) Net	Ship	Size Inches
LUS-8	0.62	0.75	3.82 x 1.38 x 3.54
LUS-9	0.78	1.00	3.82 x 1.38 x 4.53
LUS-10	1.04	1.25	3.82 x 1.46 x 6.02

Finish
Gray, Fed. Std. 595, No. 26081.

Accessories
Overvoltage protectors available see catalog. (Built-in LUS-9, LUS-10 models.)

Guarantee
90 days guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 90 days.

UL

Designed for listing in Underwriter's Laboratories recognized component index.

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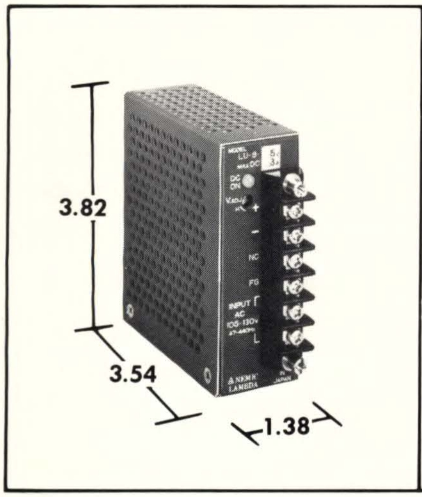

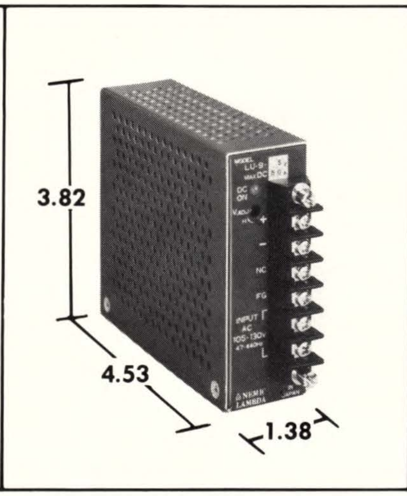

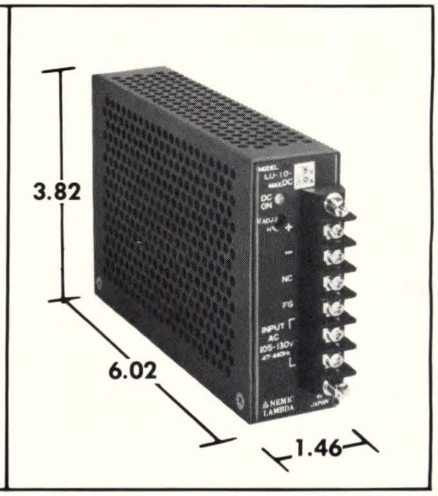

LU-8 PACKAGE
UP TO 24V
UP TO 3A

LU-9 PACKAGE
UP TO 24V
UP TO 5A

LU-10 PACKAGE
UP TO 24V
UP TO 10A

VOLTAGE AND CURRENT RATINGS

MODEL	REGULATION (LINE, LOAD)	RIPPLE (mV p-p)	MAX CURRENT (AMPS AT) 40°C	50°C	PKG SIZE	DIMENSIONS (INCHES)	PRICE
5V ±5% ADJ.							
LUS-8-5	0.4%, 0.85%	120	3.0	2.1	8	3.82 x 1.38 x 3.54	**$46**
LUS-9-5	0.4%, 0.85%	120	5.0	3.5	9	3.82 x 1.38 x 4.53	**70**
LUS-10-5	0.4%, 0.85%	120	10.0	7.0	10	3.82 x 1.46 x 6.02	**95**
12V ±5% ADJ.							
LUS-8-12	0.4%, 0.85%	150	1.3	0.9	8	3.82 x 1.38 x 3.54	**$46**
LUS-9-12	0.4%, 0.85%	150	2.1	1.5	9	3.82 x 1.38 x 4.53	**70**
LUS-10-12	0.4%, 0.85%	150	4.2	2.9	10	3.82 x 1.46 x 6.02	**95**
15V ±5% ADJ.							
LUS-8-15	0.4%, 0.85%	150	1.0	0.7	8	3.82 x 1.38 x 3.54	**$46**
LUS-9-15	0.4%, 0.85%	150	1.7	1.2	9	3.82 x 1.38 x 4.53	**70**
LUS-10-15	0.4%, 0.85%	150	3.4	2.4	10	3.82 x 1.46 x 6.02	**95**
24V ±5% ADJ.							
LUS-8-24	0.4%, 0.85%	200	0.6	0.4	8	3.82 x 1.38 x 3.54	**$46**
LUS-9-24	0.4%, 0.85%	200	1.0	0.7	9	3.82 x 1.38 x 4.53	**70**
LUS-10-24	0.4%, 0.85%	200	2.1	1.5	10	3.82 x 1.46 x 6.02	**95**

L120

WHAT THIS COUNTRY NEEDS IS A GOOD $46. SWITCHING POWER SUPPLY.*

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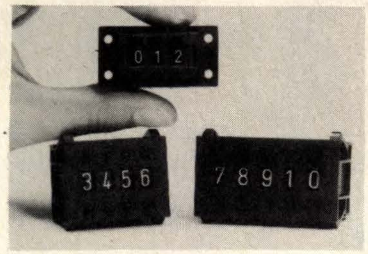
THE NEW LU SERIES, UP TO 24V, UP TO 10 AMPS

***LUS-8-5, 5V, 3A—$46.**

LAMBDA ELECTRONICS

New Products



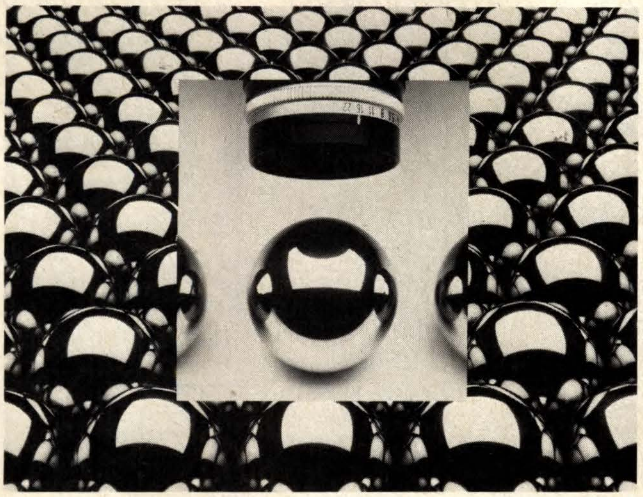
CODE SWITCHES. Capable of retrofitting many popular thumbwheel switches, DPS 8, -9 and -10 Series bidirectional units come with decimal, BCD and BCD-complement codes, have readout characters up to 60% larger than similar thumbwheel types and are designed for mounting from front of the panel. The 0.315-(-8 and -9 models) and 0.394-in.-wide (-10) devices snap together to form groups of any size. Heavy gold-clad contacts improve reliability. Model DPS 9-131-AK (BCD code), $2.96 (100). **Alco Electronic Products Inc,** 1551 Osgood St, North Andover, MA 01845. Phone (617) 685-4371. **Circle No 289**

CONDUCTIVE-INK CONNECTOR. A compact, low-profile UL 94V-0 rated termination for conductive-ink circuitry, Flexlok CIC 1-piece unit uses a contact shape designed to minimize abrasion of the ink during extraction and insertion. It provides gas-tight high-pressure interconnections, claimed as reliable as gold-plated systems but at a lower cost. The connector is supplied with contacts assembled and comes in two versions: with 90° approach angle (side entry) or with perpendicular attitude (top entry). Six to 21 traces on 0.1-in. centers and conductive - ink - circuitry thickness of 0.006 to 0.02 in. can be accommodated. **Burndy Corp,** Norwalk, CT 06852. Phone (203) 838-4444. **Circle No 290**

RESISTOR NETWORKS. Type T912 precision networks are constructed with Tetrinox resistance films that provide ratio tolerances from ±0.1 to ±0.01%, ratio TCs of either 10, 5 or 2 ppm/°C and ratio stability of resistance at full load (2000 hrs) within ±0.01%. Available in 12 standard models with two equal-resistance values from 5000Ω to 1 MΩ, the thin-profile units have standard lead spacings of 0.1 in. $1.35 (1k) for standard, 10,000Ω, 0.1%-tolerance and 10-ppm/°C TC tracking unit. Delivery, stock to 6 wks. **Caddock Electronics Inc,** 3127 Chicago Ave, Riverside, CA 92507. Phone (714) 683-5361. **Circle No 291**

FAIRCHILD

A Schlumberger Company



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XVIII INTERNATIONAL IMAGE, SOUND AND ELECTRONICS SHOW

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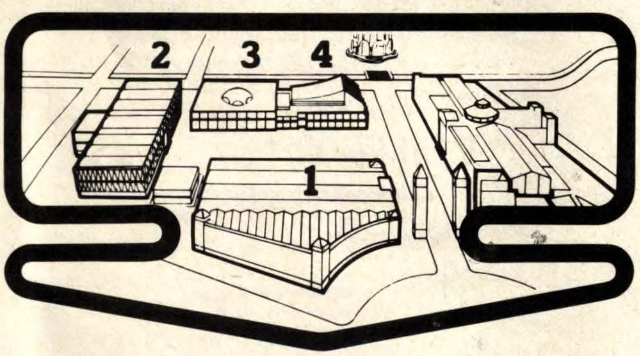

4 LARGE EXHIBITION PALACES DEALING WITH

1 Manufacturers of T.V., Radio, Hi-Fi Recording and play back equipment.

2 Components, Production Systems, Materials, Control Instruments, Security Systems, Communications (Professional, Radio hams).

3 Hi-fi, Sound and Vision, Recording, Musical Instruments and Spectacular lighting systems.

4 Symposiums, Conventions, Meetings. Hi-Fi and Video demonstrations.

FAIR GROUNDS: BARCELONA (SPAIN) 29th september, 5th october, 1980
Trade visitors: 29th, 30th september and 1st october - General Public: 2nd, 3rd, 4th and 5th october

INFORMATION: Avda. M.ª Cristina, s/n. - BARCELONA-4 (Spain) Tel. 223 31 01
Telex 50458 FOIMB-E

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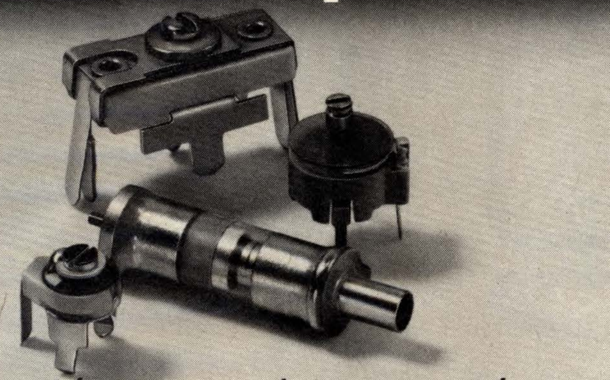
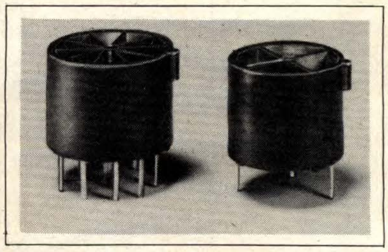
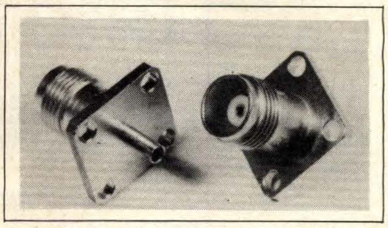


New Products



BURN-IN SOCKETS. Available with three through 12 gold-plated contacts, TS-5173 TO-pattern devices come in both standard (150°C with BeCu contacts) and high-temperature versions (200°C with BeNi contacts). The units provide very low insertion force for fast loading/unloading and have a center locating stud for added mounting rigidity. $0.63 (1k). **Robinson-Nugent Inc,** 800 E Eighth St, New Albany, IN 47150. Phone (812) 945-0211. **Circle No 292**



FLANGE-MOUNT CONNECTORS. For 0.085- and 0.141-in. semirigid cable that operates at up to 18 GHz, 4500 Series units meet or exceed MIL-C-39012. Model 4055-0002 and -0003 devices come with gold-plated brass bodies, Teflon insulators and beryllium-copper contacts; Model 4055-6002, -6003 units have gold-plated stainless-steel bodies, Teflon insulators and beryllium-copper contacts. Typical specs include VSWR of 1.10 and insertion loss of 0.05 dB from dc to 15 GHz, 0.1 dB from 15.1 to 18 GHz. Models 4055-0002 and -0003, $7.60; Models 4055-6002 and -6003, $10.95 (100). Delivery, 14 to 18 wks ARO. **Solitron/Microwave,** Cove Rd, Port Salerno, FL 33492. Phone (305) 287-5000. **Circle No 293**

CW LASER. An addition to the company's line of low-divergence lensed cw units, Model LCW-30 combines a multimode cw laser with an NSG Selfoc lens, all in an LDL-9F package. The device provides <7-mrad divergence at 5-mW output. Typical specs include a threshold of 100 mA and operating current of 135 mA at a peak wavelength of 820 nm. $500. Delivery, 4 to 6 wks ARO. **Laser Diode Laboratories Inc,** 1130 Somerset St, New Brunswick, NJ 08901. Phone (201) 249-7000. **Circle No 294**

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Our 1108 Series Dip IC Handler is the tester's choice for several great reasons.

One is speed. In ambient or hot configurations, the 1108 is the fastest commercially available handler you can buy: 10,000 per-hour maximum, with 250 ms of test time, and 8 output sorts.

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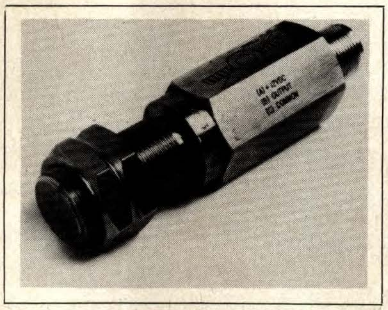
Contact us now for applications assistance, and for the equipment that's the tester's choice on both ends of the interface cable. Just write or call Mr. Cliff Small, Siemens Corporation, Measurement Systems Division, 2 Pin Oak Lane, Cherry Hill, NJ 08034. (609) 424-9210.

The Siemens 1108 DIP IC Handler Series

For more information, Circle No 212

New Products



DIGITAL PICKUP. Model 4-0063 Zero-Velocity unit uses solid-state circuitry combined with Hall-effect principles to provide constant-amplitude logic pulses from dc to 10,000 Hz. Providing high noise immunity (to 800V transients; UHF radiation of 4W at 462 MHz and a distance of 2 ft; and noise pulses of ±100 to 800V pk), the unit operates over −25 to +80°C. The stainless-steel-housed pickup's output signals can feed a square-wave fanout of up to 10 TTL inputs at 50% (±10%) duty cycle. $190. **Airpax,** 6801 W Sunrise Blvd, Ft Lauderdale, FL 33313. Phone (305) 587-1100. **Circle No 295**

SENSING RELAY. Series RSR provides single-level control in liquid-level applications requiring nonmechanical detecting and switching. A probe is used to sense the level of water or other slightly conductive liquids. Continuity is sensed between the probe and the liquid, causing the output relay contacts to transfer. Housed in a plug-in package and operating from a 115V ac power supply, the unit has isolated, 5A spdt relay output that energizes when the resistance across the sensing input falls below the preset value. Sensitivity can be supplied fixed or adjustable. $40. **Control Engineering Inc,** 1686 Riverdale St, West Springfield, MA 01089. Phone (413) 781-1330. **Circle No 296**

HALL-EFFECT SENSORS. Housed in thermoplastic threaded bushings, solid-state 200SR Series units are sensitive to magnetic fields and operate at speeds from 0 to 100,000 operations per second. They feature a single digital current-sinking output and come in either 4.5 to 5.5V dc or 6 to 16V dc versions. The logic-level output eliminates the need for amplifiers in most applications. Absolute maximum supply voltage ranges from −1.2 to +20V dc, with output current to 40 mA max; operating-temperature range equals −40 to +105°C. $8.25 for a typical unit. **Micro Switch,** 11 W Spring St, Freeport, IL 61032. Phone (815) 235-6600. **Circle No 297**

TI Distributors

ALABAMA: Huntsville, Hall-Mark (205) 837-8700.

ARIZONA: Phoenix, Kierulff Electronics (602) 243-4101; R.V. Weatherford (602) 272-7144; **Tempe,** Marshall Industries (602) 968-6181.

CALIFORNIA: Anaheim, R.V. Weatherford (714) 634-9600; **Canoga Park,** Marshall Industries (213) 999-5001; **Chatsworth,** JACO (213) 998-2200; **Costa Mesa,** TI Supply *(714) 979-5391*; **El Monte,** Marshall Industries (213) 686-0141; **El Segundo,** TI Supply (213) 973-2571; **Glendale,** R.V. Weatherford (213) 849-3451; **Goleta,** RPS (805) 964-6823; **Irvine,** Marshall *Industries (714)* 556-6400; **Los Angeles,** Kierulff Electronics (213) 725-0325; RPS (213) 748-1271; **Mountain View,** Time Electronics *(415) 965-8000*; **Palo Alto,** Kierulff Electronics (415) 968-6292; **Pomona,** R.V. Weatherford (714) 623-1261; **San Diego,** Arrow Electronics (714) 565-4800; Kierulff Electronics (714) 278-2112; *Marshall Industries* (714) 278-6350; R.V. Weatherford (714) 278-7400; **Santa Barbara,** R.V. Weatherford (805) 465-8551; **Sunnyvale,** Arrow Electronics (408) 739-3011; Marshall Industries (408) *732-1100; TI Supply* (408) 732-5555; United Components (408) 737-7474; **Torrance,** Time Electronics (213) 320-0880; **Tustin,** Kierulff Electronics (714) 731-5711.

COLORADO: Denver, Arrow Electronics (303) 758-2100, Diplomat/Denver, (303) 427-5544; Kierulff Electronics (303) 371-6500; **Englewood,** R.V. Weatherford (303) 770-9762.

CONNECTICUT: Hamden, Arrow Electronics (203) 248-3801; TI Supply (203) 281-4669; **Orange,** Milgray/Connecticut (203) 795-0714; **Wallingford,** Wilshire Electronics (203) 265-3822.

FLORIDA: Clearwater, Diplomat/Southland (813) 443-4514; **Ft. Lauderdale,** Arrow Electronics (305) 776-7790; Diplomat/Ft. Lauderdale (305) 971-7160; Hall-Mark/Miami (305) 971-9280; **Orlando,** Hall-Mark/Orlando (305) 855-4020; **Palm Bay,** Arrow Electronics (305) 725-1480; Diplomat/Florida (305) 725-4520; **St. Petersburg,** Kierulff Electronics (813) 576-1966; **Winter Park,** Milgray Electronics (305) 647-5747.

GEORGIA: Doraville, Arrow Electronics (404) 455-4054; **Norcross,** Wilshire Electronics (404) 923-5750.

ILLINOIS: Arlington Heights, TI Supply (312) 640-2964; **Bensonville,** Hall-Mark/Chicago (312) *860-3800*; **Elk Grove Village,** Kierulff Electronics (312) 640-0200; **Chicago,** Newark Electronics (312) 638-4411; **Schaumburg,** Arrow Electronics (312) 893-9420.

INDIANA: Ft. Wayne, Ft. Wayne Electronics (219) 423-3422; **Indianapolis,** Graham Electronics (317) 634-8202.

IOWA: Cedar Rapids, Deeco (319) 365-7551.

KANSAS: Lenexa, Component Specialties (913) 492-3555; **Shawnee Mission,** Hall-Mark/Kansas City (913) 888-4747.

MARYLAND: Baltimore, Arrow Electronics (202) 737-1700, (301) 247-5200; Hall-Mark/Baltimore (301) 796-9300; **Columbia,** Diplomat/Maryland (301) 995-1226; **Gaithersburg,** Cramer/Washington (301) 948-0110; **Rockville,** Milgray/Washington (301) 468-6400.

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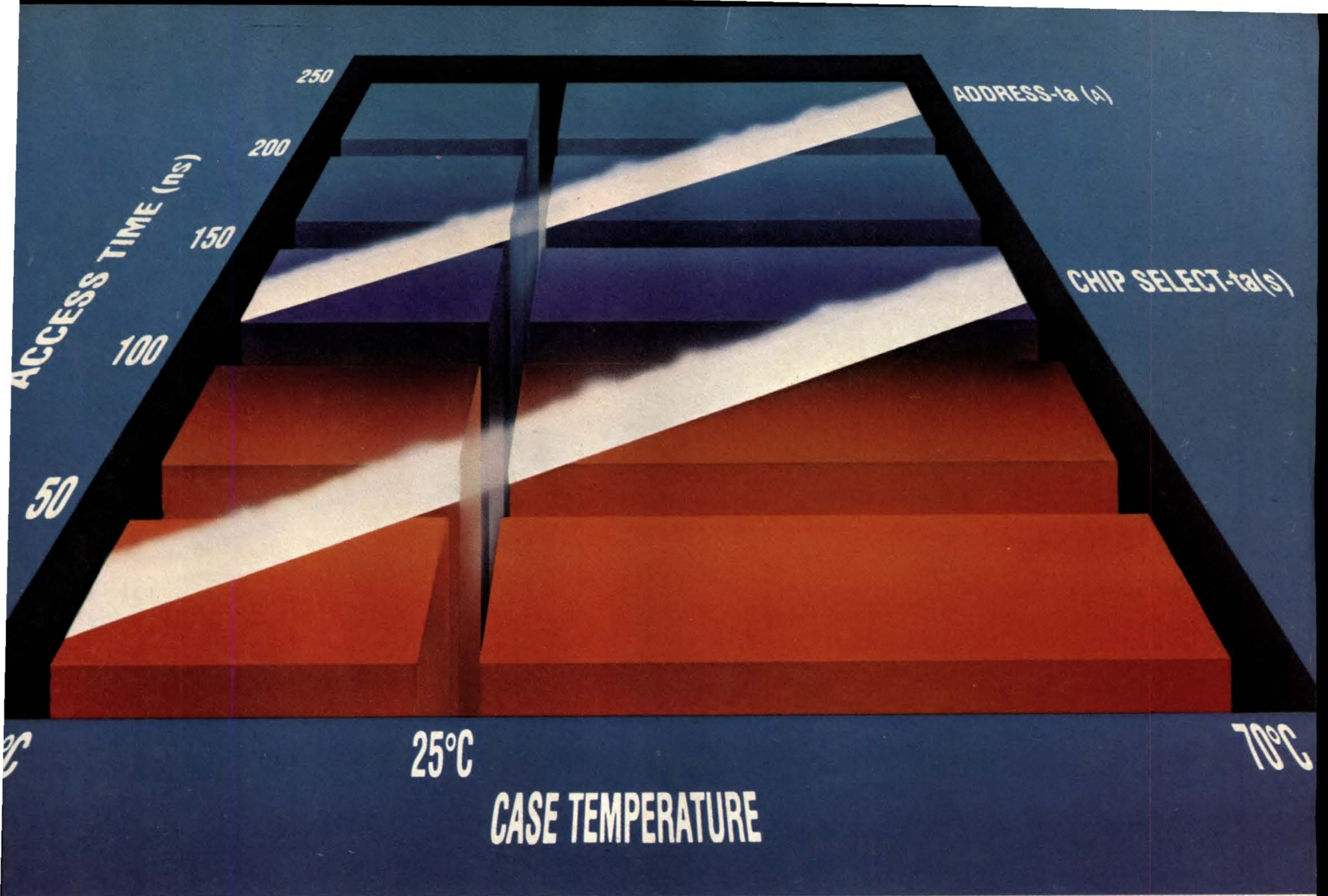

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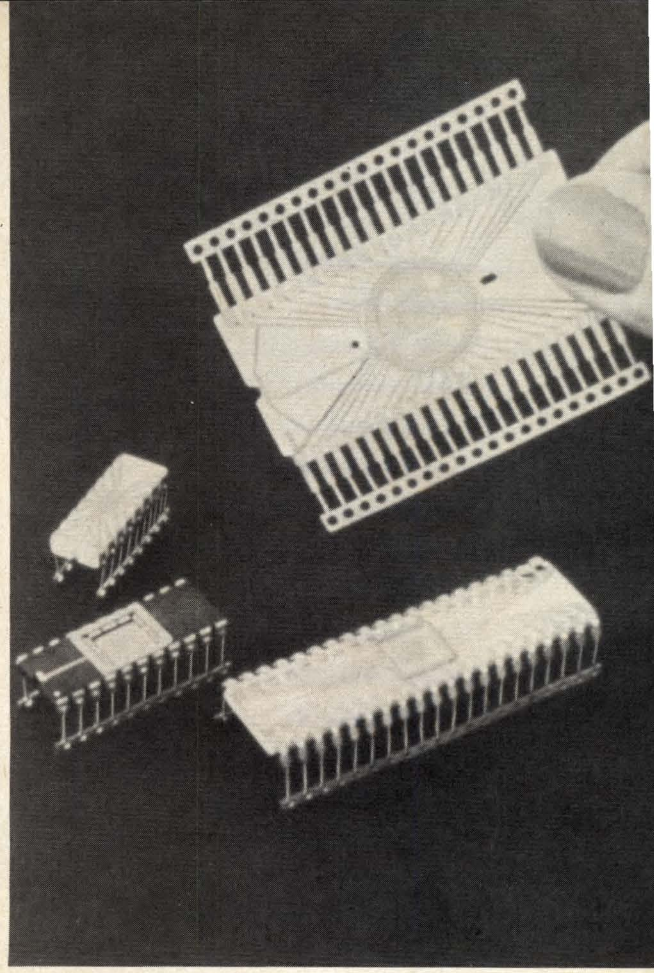

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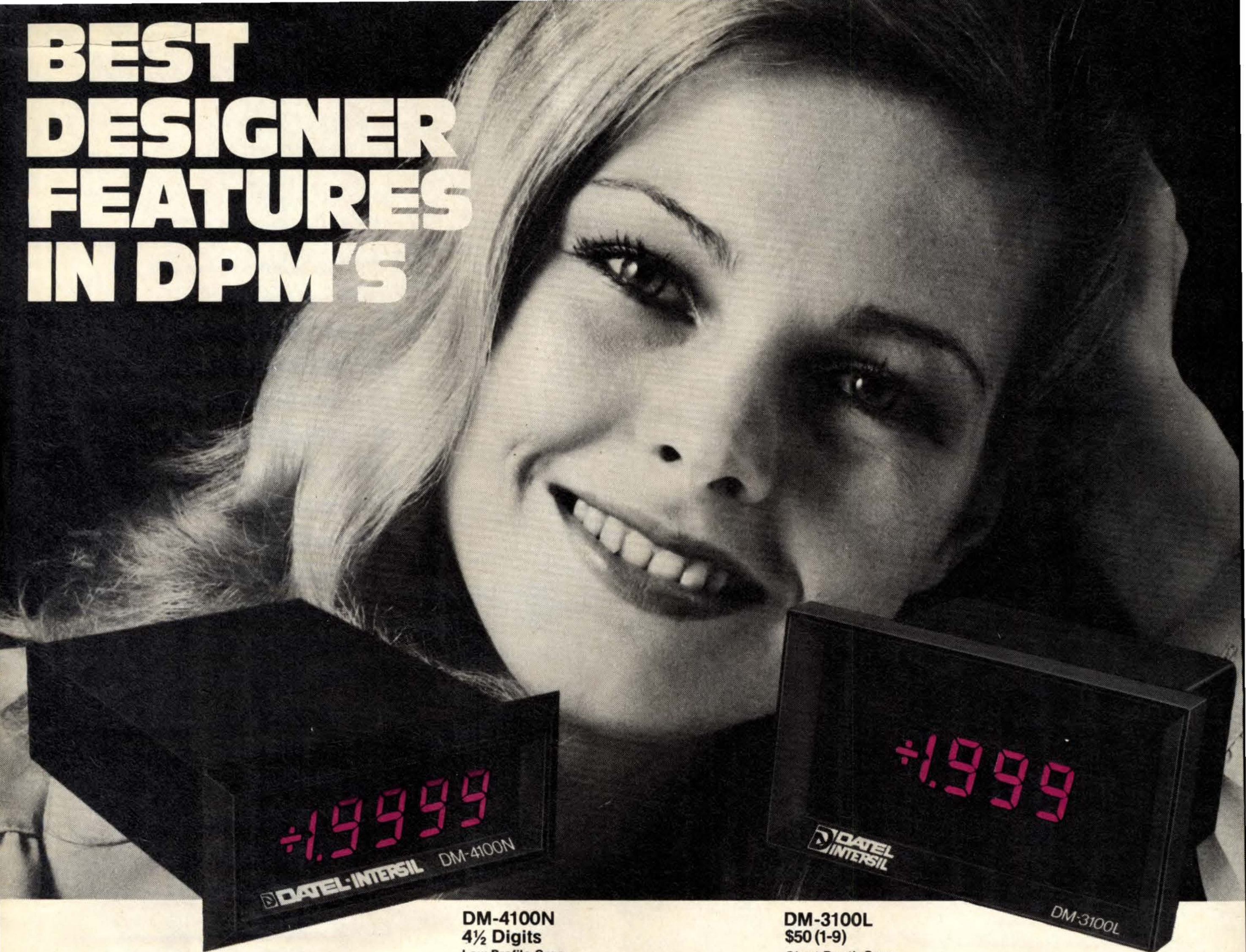

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	DM-3100U1	±2V, balanced differential	Low Profile	.5" High Liquid	+5V, 6mA or 9-15V	Programmable Descriptors	$60	(1-9)
	DM-3100U2 DM-3100U3	±2V, balanced differential	Low Profile	.5" High Liquid Crystal	115AC(U2) 230AC(U3)	Programmable Descriptors	$69	(1-9)
4½ DIGIT DPM'S								
LED DISPLAY	DM-4100L	±2V, single-ended	Short Depth	.56" High LED's	±5Vdc @ .4A	Low cost 4½ digit	$88	(1-9)
	DM-4100N	±2V, single-ended	Low Profile	.3" High LED's	+5Vdc @ .4A	Low cost, 4½ digit	$93	(1-9)

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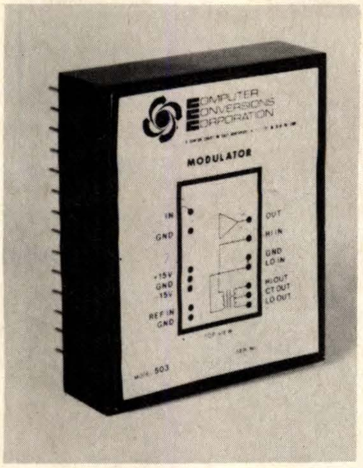

MODULATOR. Model MOD503 furnishes up to ±0.1% full-scale linearity, accepts ±10 or ±100V dc inputs (100 kΩ min) and provides an ac output of 0 to 7V rms. Output impedance equals 1Ω max; outputs are short-circuit protected, and the unit is insensitive to ±10% reference line changes. Other features include reference input of 26V, 400 Hz (±5%) (60-Hz units also available) and ±15V at 50 mA (max) power requirement. Gain- and zero-adjustment capability comes standard. <$100 (OEM qty). **Computer Conversions Corp,** 6 Dunton Ct, East Northport, NY 11731. Phone (516) 261-3300. **Circle No 298**

DC MOTOR. Requiring no external electronics, this 12V dc unit suits cassette recorders, data recorders and any other devices requiring a constant-speed motor. Model SE34-T1M1 holds its rated speed of 2400 rpm to within ±36 rpm by means of a built-in electronic control. Rated load is 9 g-cm; rated current, 90 mA; starting torque equals 80 g-cm at 10V. The 39-mm-diameter, 34.2-mm-long device weighs 120g. <$3 (OEM qty). **Canon USA Inc,** 10 Nevada Dr, Lake Success, NY 11042. Phone (516) 488-6700. **Circle No 299**

RECTIFIER BRIDGES. Units in the 1/1.5DB Series of DIP devices come in current ratings of 1 and 1.5A avg, with peak-inverse-voltage ratings of 50 to 1000V. The metal-oxide-passivated silicon-rectifier junctions employed in the transfer-molded epoxy units provide high-temperature performance and reliability said to equal that of hermetically sealed glass devices. The bridges withstand a 25A current surge for up to 10 msec, and two of the units fit end-to-end in a standard 14-pin DIP socket. $0.45 for a typical 1A, 400V unit; $0.50 (1k) for 1.5A version. Delivery, 4 to 6 wks ARO. **Codi Semiconductor Inc,** Pollitt Dr, Fair Lawn, NJ 07410. Phone (201) 797-3900. **Circle No 300**

AMP/BIAS OSCILLATOR. Model 34 audio amplifier and 100-kHz magnetic-tape bias oscillator/buffer is a dual-purpose module suited for general-purpose signal processing. Features include short-circuit-proof output, up to 1-μF output capacitive loading capability and 20V rms output into a 1-kΩ load when functioning as a 100-kHz oscillator. Other specs include 8 to 30V (24V nominal) power requirement, 34-dB (×50) gain and 20-Hz to 20-kHz (±2 dB) frequency response (0.25% THD, +18 dBm). $25. **Opamp Labs Inc,** 1033 N Sycamore Ave, Los Angeles, CA 90038. Phone (213) 934-3566. **Circle No 301**

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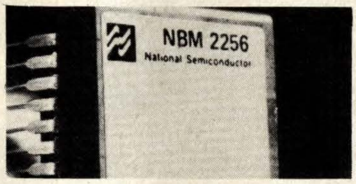
New Products

ICs & SEMI-CONDUCTORS



BUBBLE MEMORY. The 256k-bit NBM2256 chip is organized into even and odd loops of 1024 bits each, which are loaded through swap gates and read via replicate gates at opposite ends of 10 storage loops. The architecture, designed to store data in 256 loops and an error-correcting code in six loops, provides usable data storage of 262,144 bits or 32k bytes. A redundancy map is also furnished on chip in a dedicated map loop.

At an operating frequency of 100 kHz, the unit has a data rate of 100k bps and 7-msec average access time to the first bit of a random data block. Typical power dissipation equals about 750 mW, and the 16-pin-DIP device uses 5 and 12V power supplies.

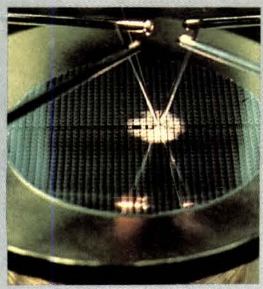
Until the support circuits become available this summer, you can get the NBS100 evaluation board containing the 256k-bit bubble memory, all drive and support circuitry and μP-based controller. The NBS101 expansion board offers 1024k bits of memory storage and utilizes the controller from the NBS100. NBM2256, $500; NBS100, $1300; NBS101, $2500. **National Semiconductor,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 737-5000.

Circle No 325

COUNTER/DRIVERS. Providing 4½-digit capability and direct interface to nonmultiplexed vacuum-fluorescent displays, the ICM7236 decade counter furnishes a maximum count of 19,999; intended for timing, the -A Model provides a maximum count of 15,959. Both CMOS devices include on-chip decoders, output latches, count inhibit, reset and leading-zero blanking circuitry, in addition to 29 high-voltage open-drain p-channel transistor outputs. High-frequency counting rates are guaranteed to 15 MHz with typical rates of 25 MHz at 5V. $4.25 (100) in 40-pin plastic package. **Intersil Inc,** 10710 N Tantau Ave, Cupertino, CA 95014. Phone (408) 996-5100.

Circle No 326

No compromise solutions.



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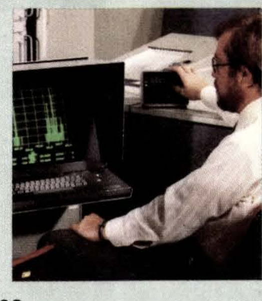

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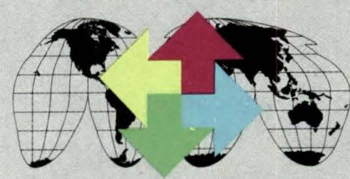

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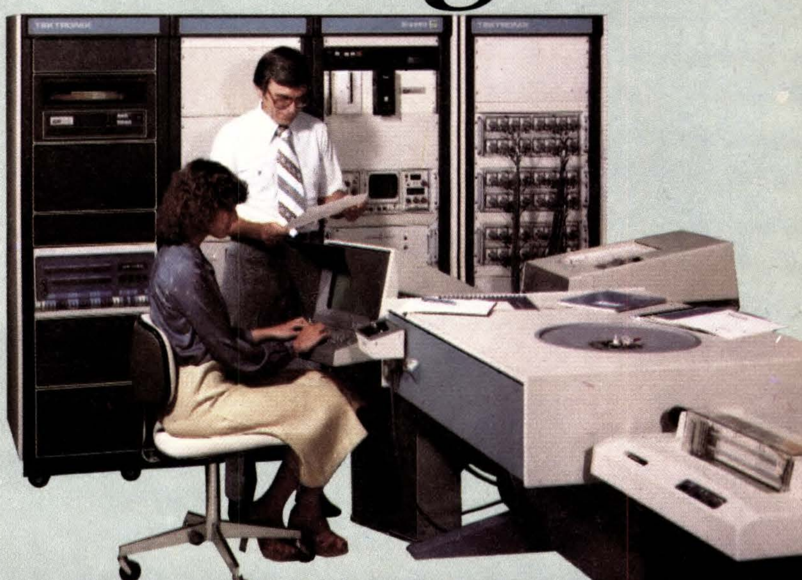

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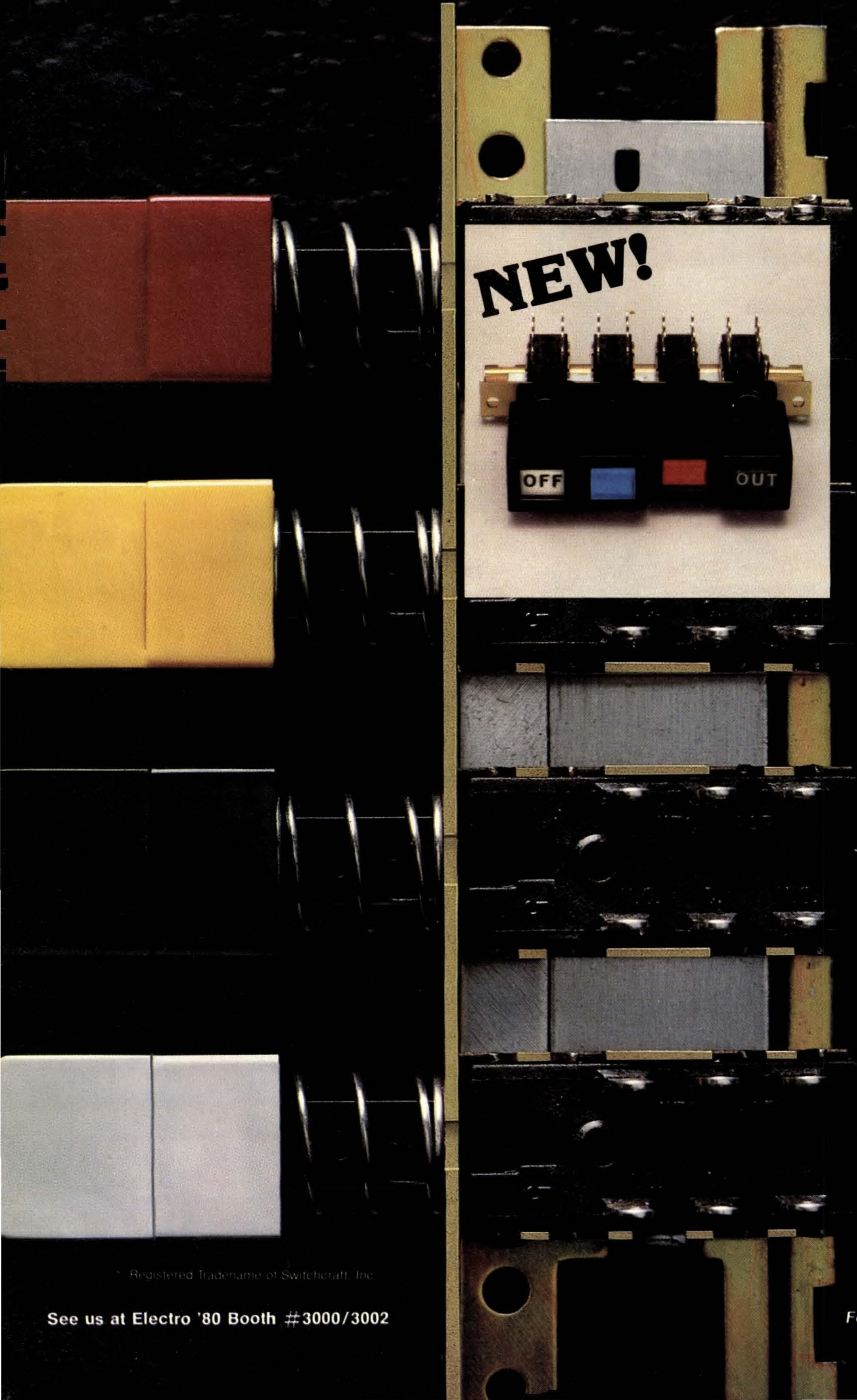
COMMUNICATIONS IC. The F6856 communications-protocol controller provides both bit- and byte-oriented protocol capability, including complete on-chip Bisync protocol processing. It handles most popular line protocols, including SDLC, HDLC, ADCCP and DDCMP. You can program the four 16-bit addressable on-board registers to specify the desired protocol. Functions provided by the TTL-compatible, 1M-bps device include conversion of bit-serial data to either an 8- or 16-bit parallel data stream and conversion of transmission codes to computer codes (normally NRZI to NRZ). $24.50 in 40-pin plastic package; $29.90 (100) in ceramic side-brazed package. **Fairchild MOS Products Group,** 101 Bernal Rd, San Jose, CA 95119. Phone (415) 962-3816. **Circle No 327**

TINI-DW

a good reason to switch



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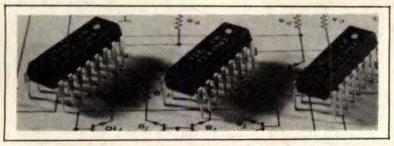
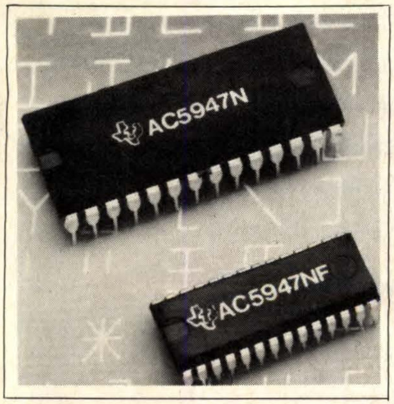


VHF IC. Model TDA1062, claimed the only available monolithic integrated VHF front end capable of operating in a 30- to 250-MHz frequency range, contains on one chip an integrated RF amplifier, oscillator, double-balanced mixer, AGC preamplifier and voltage-regulating circuitry. Applications for the 16-pin-DIP unit include use in medium- and high-quality communications tuners, FM front ends and high-frequency mixers. Specs include typical supply voltage of 10V at 30 mA, RF power gain of 30 dB, 5.5-dB noise figure and −40 to +85°C operating-temperature range. $0.75 (OEM qty). **AEG-Telefunken Corp,** Rte 22-Orr Dr, Somerville, NJ 08876. Phone (201) 722-9800. **Circle No 328**

45-NSEC MULTIPLIER. The MPY-8HUJ unsigned-magnitude TTL multiplier has on-chip input and output registers that speed up operation, reduce system overhead and simplify interfacing to 8-bit μP systems. Suited to digital video-signal processing and digital filtering, the 40-pin ceramic DIP is a parallel-array unit that accepts 8-bit inputs and provides a 16-bit double-precision product. The unit achieves a speed-power performance index of <0.8 pJ per equivalent gate and requires one 5V power supply. $48 (100). **TRW/LSI Products,** 2525 E El Segundo Blvd, El Segundo, CA 90245. Phone (213) 535-1831. **Circle No 329**



DISPLAY DRIVER. For 18-segment alphanumeric displays, Model AC5947 features on-chip latches for the ASCII input data and output enable for display blanking and duty-cycle dimming. TTL compatible, the unit uses a 5V supply and produces the ASCII set of letters, numbers and characters while using only ⅕ the number of digit lines required by a 5×7 dot-matrix system. Maximum output current is 64 mA per segment, allowing one device with the addition of external multiplexing circuitry to drive up to 16-digit displays without external segment buffers. AC5947N, in a 0.6-in.-wide package with 0.1-in. pin spacing, $3.76; AC5974NF, in a 0.4-in.-wide package with 0.07-in. pin spacing, $2.93 (100). **Texas Instruments Inc,** M/S 308, Dallas, TX 75265. Phone (214) 238-2011. **Circle No 330**

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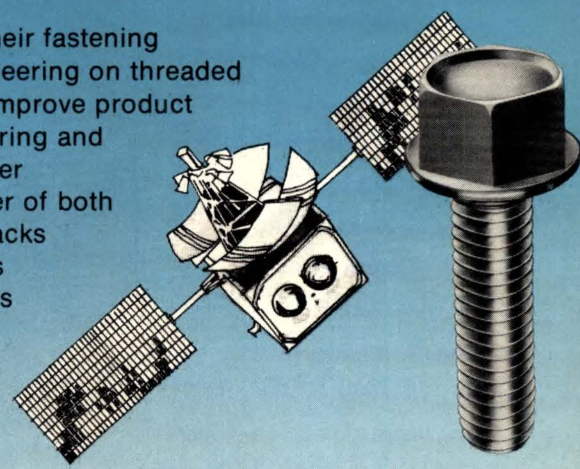
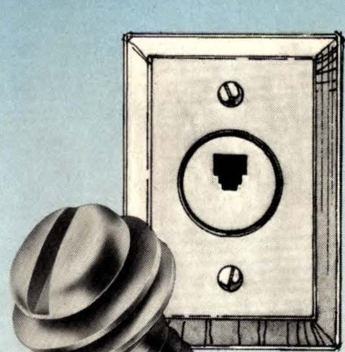


This Taptite® high performance thread forming fastener is so reliable it is in service in satellites that support America's Satellite Communications System.

CAMCAR TEXTRON

Camcar Division of Textron Inc.

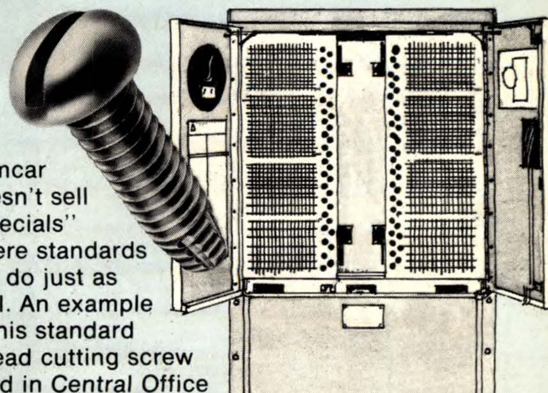
600 Eighteenth Avenue
Rockford, Illinois 61101



Two beveled captive washers on a slotted steel screw form this Camcar Spade-Sert® for easy quick connections in walljack assemblies.

SHAPES that fasten and save®

A special double-ended machine screw stud serves as an essential and durable working part in push button multi-line telephones.

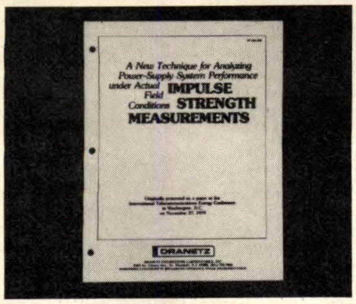


Camcar doesn't sell "specials" where standards will do just as well. An example is this standard thread cutting screw used in Central Office switching equipment.

Taptite® is a registered trademark of Research Engineering and Manufacturing.
Spade-Sert® and Shapes that fasten and save® are registered trademarks of Camcar Division of Textron Inc.

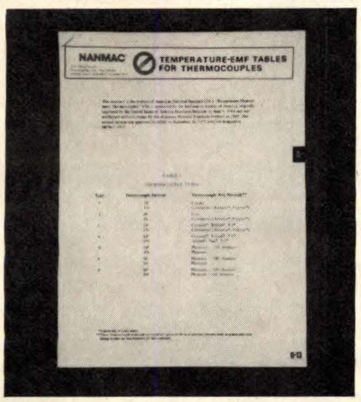
For more information, Circle No 228

Literature



Measurement technique analyzes power supplies

A comprehensive applications bulletin examines a new technique for analyzing power-supply system performance under field conditions, using impulse-strength measurements. The 8 pages are fully illustrated with block diagrams, graphs and instrument printouts and focus on methods of line-disturbance monitoring—the ability to measure, record and analyze an impulse in terms of its volt-second strength, its polarity and its direction. Two applications—computing a pulse's destructive power and computing impulse propagation through a filter—are described in the appendix. **Dranetz Engineering Laboratories Inc,** 2385 S Clinton Ave, South Plainfield, NJ 07080. **Circle No 303**



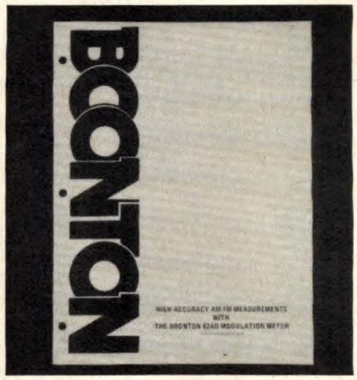
Temperature-EMF tables for thermocouples

An 18-pg booklet includes the full ANSI revised standard tables for all standard thermocouple element/wire combinations. It presents all temperature-EMF tables in both °F and °C; current temperature-EMF tables for three widely used W/Re thermocouples complete the brochure. **Nanmac Corp,** 9-11 Mayhew St, Framingham Center, MA 01701. **Circle No 304**

Extensive information on digital panel instruments

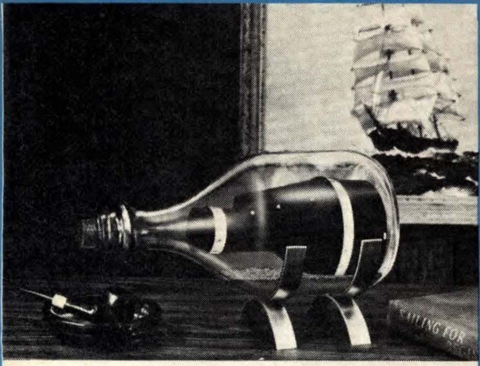
The extensive designer's-guide tutorial section of this catalog contains tips on how to select digital panel instruments and provides successful application information. Along with definitions, the 100 pgs include full data sheets describing 20 digital panel meters from a 3-digit "displayless DPM" and a true-rms/dB meter to 4¾-digit instruments and 6-channel, automatic-scanning temperature meters. The catalog also details temperature probes, low-level signal conditioners and power supplies—and includes a selection checklist. **Analog Devices,** Rte 1 Industrial Park, Norwood, MA 02062. **Circle No 305**

Literature



How to interpret displayed AM/FM modulation data

App Note No 19 covers high-accuracy AM/FM measurements using this company's Model 82AD modulation meter. Topics in the 27-pg brochure include the effects of noise and spurious responses, AM detector linearity and envelope distortion and FM detector linearity and carrier shift on overall measurement accuracy. **Boonton Electronics Corp,** Rte 287 at Smith Rd, Parsippany, NJ 07054. **Circle No 306**



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For more information, Circle No 237

COMPUTER AIDED CIRCUIT ANALYSIS

A computer program is now available which performs nonlinear transient circuit analysis and simulation using DEC PDP-11 computers. **MINICAP** is a FORTRAN program which was developed especially for minicomputer use. **MINICAP** allows simulation and analysis of integrated and discrete circuits containing resistors, capacitors, inductors, voltage sources, current sources, diodes, transistors, and operational amplifiers. Computer-aided circuit simulation allows the designer greater flexibility in evaluating circuit operation and performance when varying topology, component values, or temperature.

MINICAP contains complete built-in models for diodes, transistors and operational amplifiers. The user need only specify parameters which are necessary to customize the device model to match a specific real device. **MINICAP** also allows modeling of batteries and zener diodes.

The program uses efficient sparse matrix techniques and an automatic time-step integration algorithm suited to small computers.

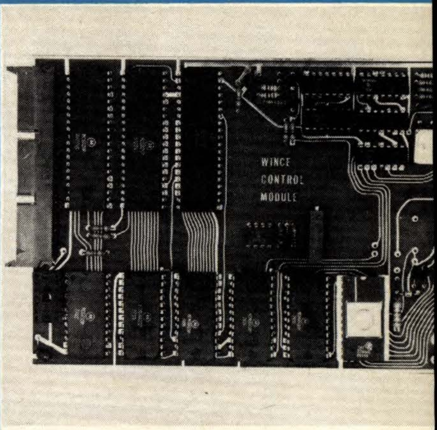
Circuit data is input in a concise, easy to learn free format. Provision is made for specifying simulation at many different temperatures and for specifying different types of output. **MINICAP** produces printed tabular outputs as well as line printer plots. A complete "snapshot" of the circuit operating conditions can also be obtained at specific timepoints.

MINICAP runs overlaid in 25k words of memory on any DEC PDP-11 (including LSI-11) under RT-11 or equivalent.

A linear AC analysis and simulation program is also available.

Gary Gaugler, Electronics Consultant
5706 Seascape Court, Citrus Heights, CA 95610
(916) 966-8076 or 966-7776

For more information, Circle No 238



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For more information, Circle No 239

Literature

Voice-readout systems have no moving parts

Design and operational specs for an entire line of telecommunications and voice-readout systems are included in this 12-pg catalog. It contains a descriptive and technical section explaining the capabilities of and applications for the seven products; functional and timing diagrams accompany each product photo. **Master Specialties Co,** 1640 Monrovia, Costa Mesa, CA 92627.

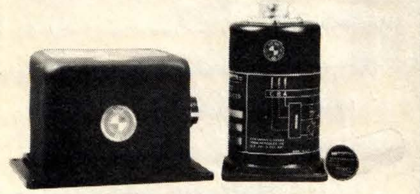
Circle No 307

394-pg catalog describes power semis

The "1980 Data Book" contains specs for more than 1200 power switching transistors, rectifiers, zener diodes and varactors. The handbook comprises eight parts: introductory material; quick reference sections on transistors, rectifiers, zeners, Varicap varactors, high-reliability products and special products; and 20 application notes. The latter section covers 113 pages and is illustrated with photos, drawings, diagrams and graphs. **TRW Power Semiconductors,** 14520 Aviation Blvd, Lawndale, CA 90260. **INQUIRE DIRECT**

Results of CP/M-based software survey

A survey directory claims that CP/M-software-based micros may be the best supported computers in the world. It contains a general section on topics such as classification, description, price and number of software packages sold as



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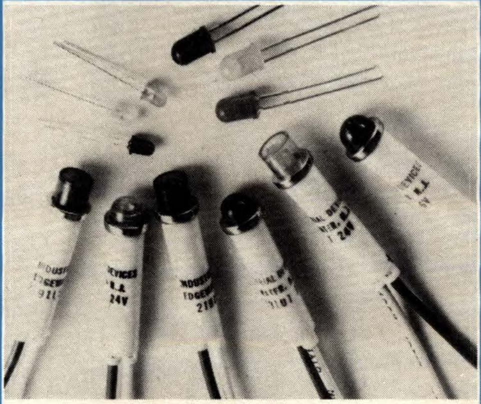
Tel. (714) 565-6631.

For more information, Circle No 240



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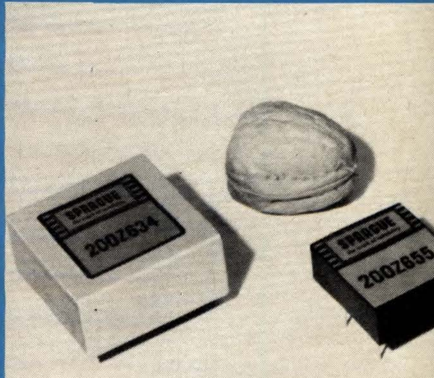

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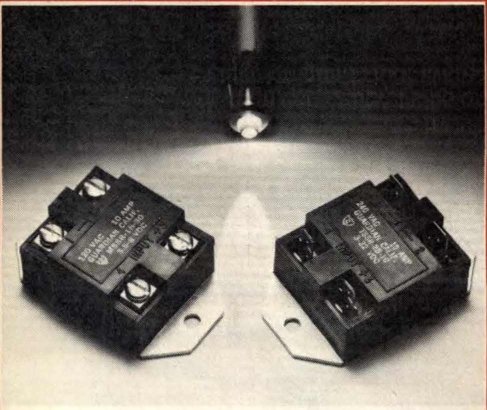
shall St., North Adams, Mass. 01247. (413) 664-44**

For more information, Circle No 242



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Literature

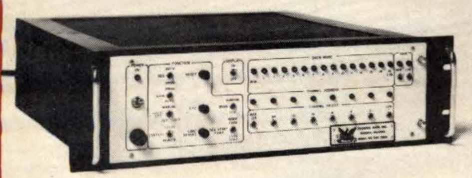
well as a configuration section that covers memory, disc, terminal and printer requirements. $2 (or $1 with a self-addressed stamped envelope). **The Small Systems Group,** Box 5429, Santa Monica, CA 90405. **INQUIRE DIRECT**

The pros and cons of thick-film trimming

The "Primer on Thick-Film Trimming Principles" covers the basic objectives in resistor trimming and the factors that affect trim stability. The 16-pg brochure gives guidelines for increasing yields and discusses the major principles of laser trimming such as controlling the laser beams and determining Q rate and bite size. In addition, the catalog describes the various types of cuts: straight cuts, L cuts, L cuts with vernier cut, double cuts, double-reverse cuts, serpentine cuts and scan cuts. Diagrams and recommendations for usage accompany the description of each type of cut. **Teradyne Inc,** 183 Essex St, Boston, MA 02111.
Circle No 308

Courses on linear ICs, μPs, μC modules

Publication No 83018 describes the company's facilities and courses offered from now to June. The 16-pg bulletin discusses the capabilities and purpose of the center where the courses are held; it also provides a detailed list of the available courses, including length and cost. **Texas Instruments Inc,** Technology Center, 515 W Algonquin Rd, Arlington Heights, IL 60005.
Circle No 309



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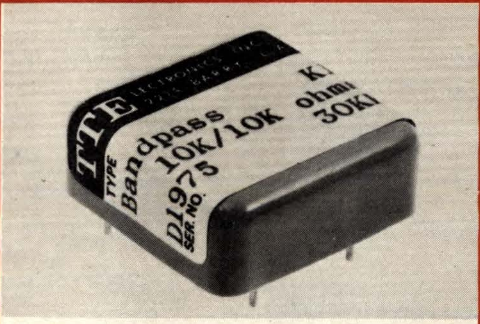

MINIATURE FILTERS for Highpass, Lowpass, Bandpass and Band Reject signal conditioning applications are described in the New Catalog. Flat passbands and sharp cut-offs are featured. Any frequency from 3Hertz to 300 Megahertz may be specified. These Filters are used in biomedical, radar, analysis, modem, antialiasing, telemetry, sonar, seismic, control and many otner electronic systems to eliminate noise and harmonics without signal distortion. Many types are available from stock. **T T Electronics, Inc., 2212 Barry Ave., Los Angeles, CA 90064, (213) 478-8224.**

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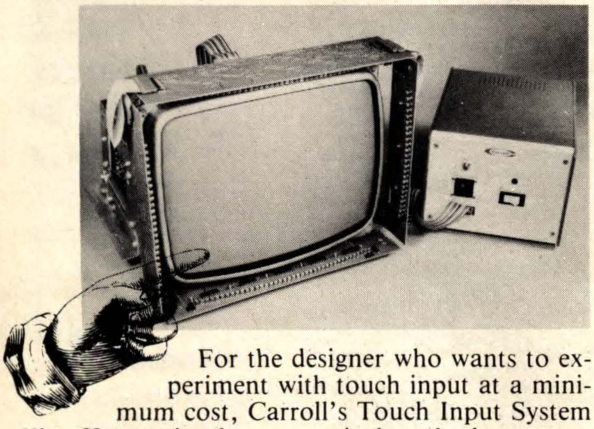

For the designer who wants to experiment with touch input at a minimum cost, Carroll's Touch Input System Kit offers a simple, economical method.

The Touch Input System Kit is produced for standard CRT monitor sizes. Easily installed, the system provides a man/machine interaction that is natural, friendly, fast and accurate.

Carroll's Touch Input System utilizes the scanning infrared beam technology which is implemented by surrounding the display area with LED emitters and phototransistor detectors in such a way as to produce a grid of infrared light beams. Whenever both an X and Y beam have been detected as broken, the coordinate information is transmitted to the host computer.

Carroll, the leader in touch technology, has been designing and manufacturing touch systems since 1974. This experience is the basis for a handbook, **Touch Technology,** available on request. It explains in detail the theory of operation, design and programming considerations, and much more about Carroll's systems.

Clip and return the coupon below to find out how you can add the benefits of touch technology to your system.

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- ☐ Please call me to discuss placing an order.

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COMPANY ADDRESS ______________________

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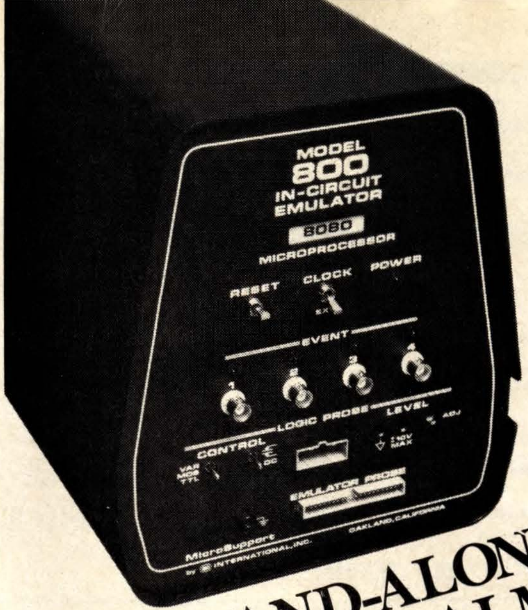
For more information, Circle No 208



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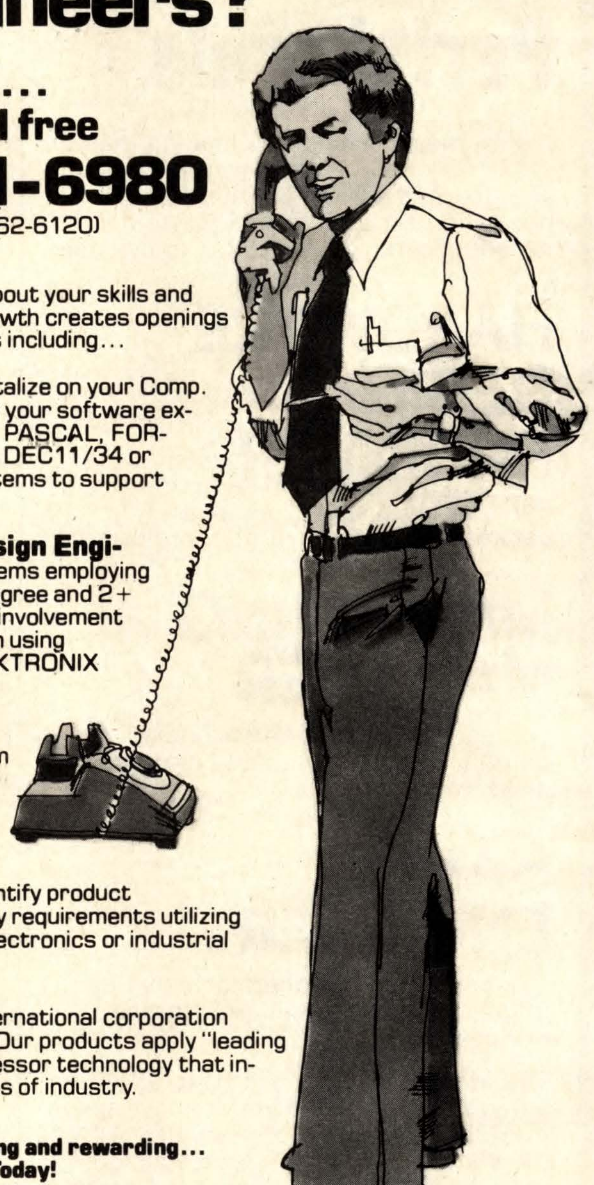

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Looking Ahead: Trends and Forecasts

Semi production equipment: up 17.1%/yr

US semiconductor production and test-equipment markets will exhibit 17.1% annual growth to reach $2.3 billion in 1989, up from $465 million last year, according to Frost & Sullivan, New York City.

Contributing to this healthy growth rate will be increasing IC density, requiring more stringent production and testing methods (VLSI devices will account for 56% of all IC production by 1989). Another key contributor: explosive demand for photovoltaic cells by the latter part of the decade.

MARKET FOR SEMICONDUCTOR PRODUCTION & TEST EQUIPMENT

ANNUAL GROWTH RATE (%) 1979 TO 1989	
WAFER PREPARATION	16.4
PATTERN & MASK GENERATION	15.4
WAFER MASKING	17.0
WAFER PROCESSING	16.3
ASSEMBLY EQUIPMENT	23.9
TOTAL	17.1

SOURCE: FROST & SULLIVAN INC

The test-equipment market alone will grow 17.5% annually, spurred on by shock, vibration, temperature and other environmental testing needs. Electronic-function tests, accounting for the market's largest equipment segment, will be increasingly conducted on wafers, as well as on end products.

Additionally, denser geometries and finer line widths will propel fast-climbing markets for projection printers, E-beam systems and X-ray printers, which will come into their own during the latter half of the 1980s.

F&S foresees cold fabrication processes increasingly preferred to hot ones that cause "runout" and wafer warping, as increasing wafer size necessitates very tight control over dimensional variations. And ion implantation should displace diffusion techniques, while sputtering will increasingly substitute for thermal-evaporation processes.

In other developments, a growing market will arise for floating-zone equipment; furthermore, new types of equipment for making ribbon-type silicon materials will become available by the mid-1980s.

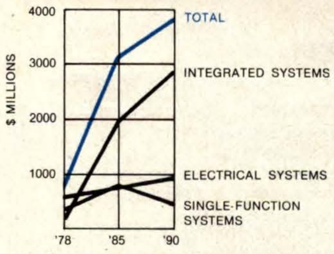
Other trends include the increasing use of in-line systems for wafer masking (replacing manual handling) and a healthy market (growing fourfold over the next 5 yrs) for digitizers to encode circuit diagrams.

Electronics on the rise in automotive systems

Automobile manufacturers will increasingly turn to high-technology electronic products in their attempt to meet more stringent federal fuel-economy and emissions standards, analysts predict.

Annual production of electronic engine systems, growing at a 22.3% rate between 1978 and 1985, will reach $3.4 billion by 1985 and top $3.9 billion by 1990, forecasts Gnostic Concepts Inc, Menlo Park, CA. Electronic-convenience-system production, rising at an average annual rate of 11.1% through 1985, will spurt to $919 million by that date and exceed $2.4 billion by 1990—up from $440 million in 1978. Automotive electronic components' value, almost $60 million in 1978, will top $460 million by 1990.

ELECTRONIC-ENGINE-SYSTEMS PRODUCTION



SOURCE: GNOSTIC CONCEPTS INC

Tight supply seen for polycrystalline silicon

Reports of an industry-wide shortage of polycrystalline silicon, the base material of integrated circuits, have been greatly exaggerated, say experts. Thus, while suppliers are placing shipments of the material on an allocation basis and leadtimes on new orders have typically been running 4 to 5 months, what emerges is not a shortage but rather a tight supply of ICs.

The reasons? Heavy demand for ICs, overcapacity problems and anticipation of explosive demand for silicon photovoltaic cells by the middle of the decade.

But the potential for a future silicon shortage does exist, based on current capacity and future demand, contends Dan Rose, president of Rose Associates, Los Altos, CA. In 1978, usage of silicon in solar cells amounted to only about 8 million in.^{2}, Rose notes, but he predicts solar-cell production will utilize a phenomenal 6.3 billion in.^{2} by 1986—roughly 10 times that expected to be required for IC-device production at that time.

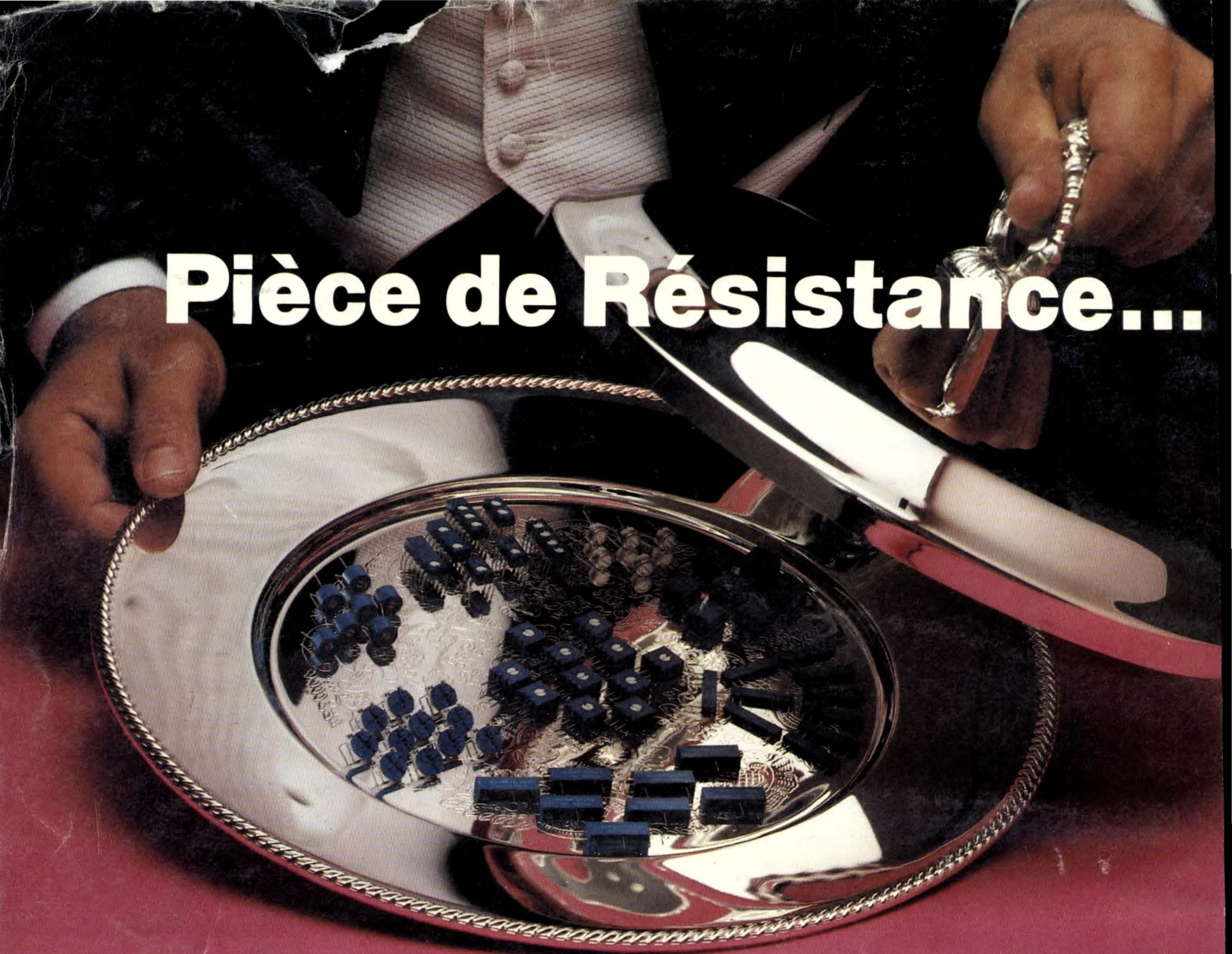
SILICON-WAFER USAGE BY US IC FIRMS

	1978	1979	1983
VALUE OF SHIPMENTS ($ MILLIONS)	360	468	731
WAFERS UTILIZED (MILLION IN.^{2})	513	666.9	895

SOURCE: ROSE ASSOCIATES

Material for this page developed from *Electronic Business* magazine and other sources by Jesse Victor, Assistant/New Products Editor, and Joan Morrow, Production Editor.

Pièce de Résistance...



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