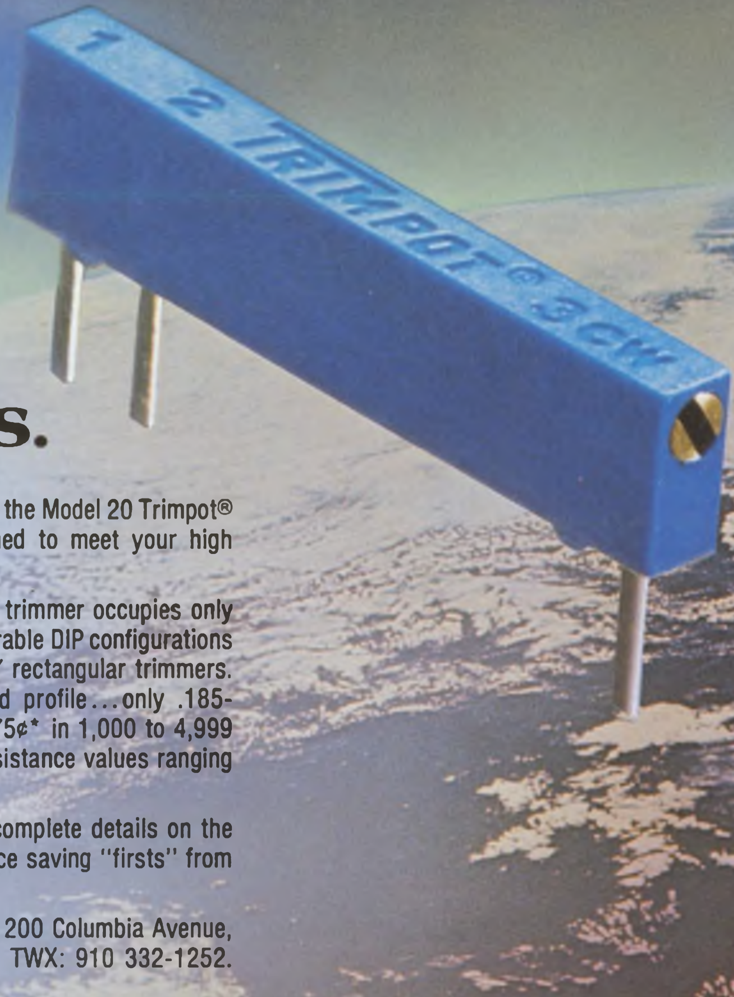
Electronic Design

VOL. 26 NO. 6
FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE
MARCH 15, 1978

Minicomputer architecture — it's changing, but slowly. The latest diagnostic routines help increase mini reliability, while LSI chips and μPs improve performance by easing the CPU's burden. Further progress in architecture hinges on availability and cost of standardized components. To see what's building, go to p. 26.

The World's First SIP Trimmer...



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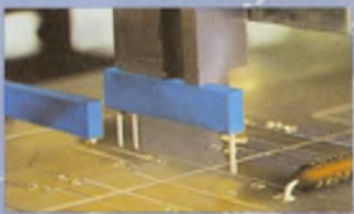
TRIMPOT PRODUCTS DIVISION, BOURNS, INC., 1200 Columbia Avenue, Riverside, CA 92507. Phone: 714 781-5050 — TWX: 910 332-1252.



The Model 20 SIP trimmer . . . machine insertable and compatible with automatic test equipment for significant cost savings.

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For Immediate Application — Circle 130
For Future Application — Circle 230

Our Model 3001 starts at $2,980. For that you get a signal generator that's already frequency programmable with 0.001% accuracy over the 1 to 520 MHz frequency range. If you also want to program your output power, we have a programmable attenuator option available for $500.

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SPECIFICATIONS

Frequency Range: 1-520 MHz
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CIRCLE NUMBER 2

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Total Range		6.5	8.5
Isolation, dB		**Typ.**	**Min**
Lower Band Edge to One Decade Higher	LO-RF	50	35
	LO-IF	45	30
Mid Range	LO-RF	45	30
	LO-IF	40	25
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21/REV/E

CIRCLE NUMBER 3

VOL. 26 NO.

Electronic Design® 6

FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE

MARCH 15, 1978

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by George Young, courtesy of Hewlett-Packard.

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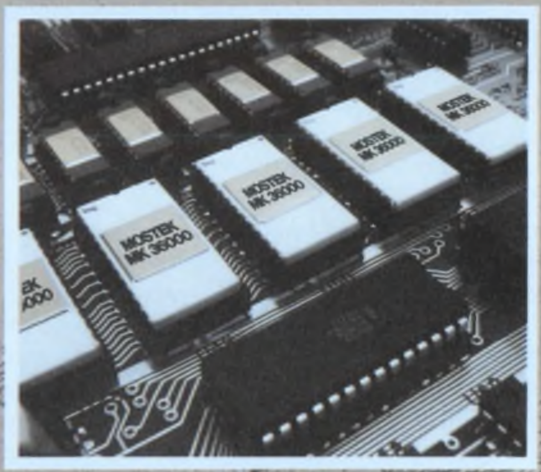
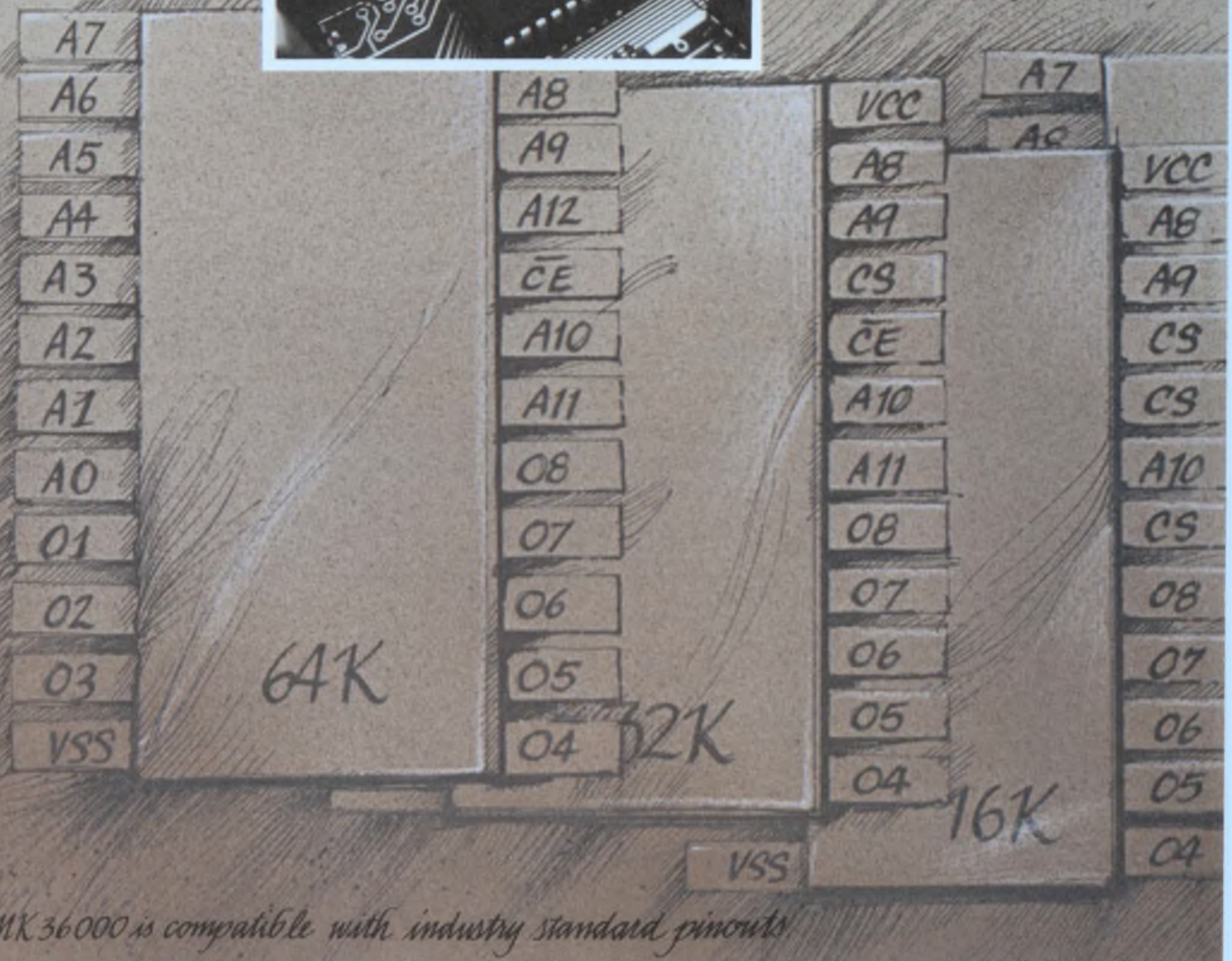
Mostek's 64K ROM sets new standards for speed and power.

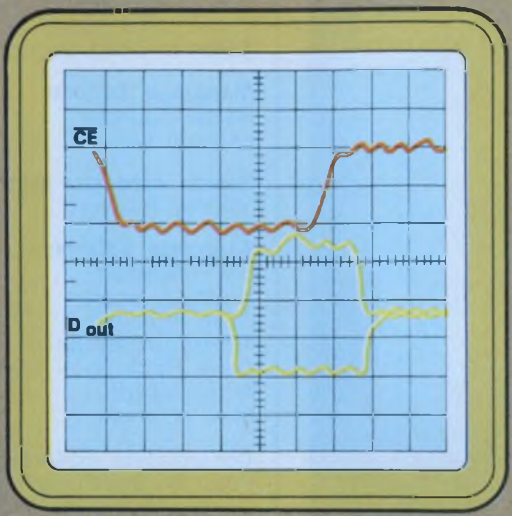
Pin compatibility, from 8K to 64K, means easy system upgrade in density and performance.





Mostek's newest ROM was developed by a design and process team with years of experience in dynamic RAMs. Their goal was to produce the industry's highest density ROM with all the features you expect in Mostek RAMs.

They met that goal with the MK36000 65,536-bit Read-Only Memory. It sets new standards with the industry's highest density, fastest access, and lowest power.



Speed and power. Mostek's MK 36000-4 offers 250 ns access time max! It's ideal for fast microprocessor applications like Mostek's 4MHz Z80, as well as storage for higher level languages. With speeds like this you might expect a sacrifice in power. Not from Mostek. The MK 36000-4 requires only 200 mW active power max. Automatic standby power is just 25 mW typical.

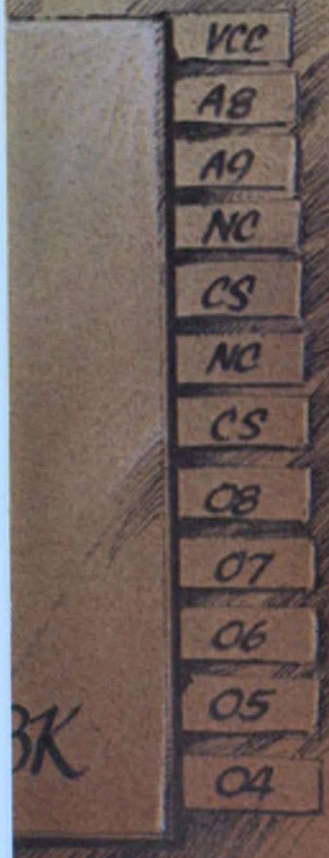
Greater system performance and efficiency. Mostek's ROM family now includes 8K, 16K, and 64K organizations. All are pin-for-pin compatible so you can easily upgrade your existing designs in both density and performance. (With each increase in bit density a chip select input is replaced by the necessary address pin.) The 36000 is pin-compatible with existing EPROMs also allowing upgrades to higher density at much lower costs.

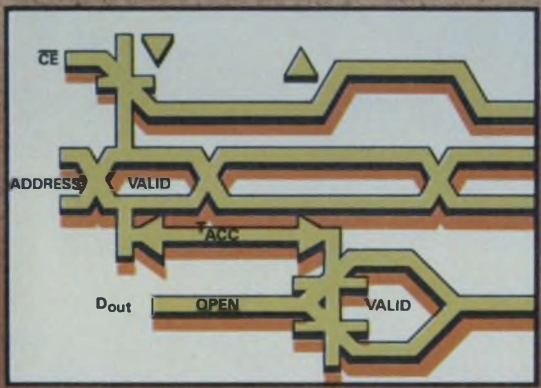
Mostek's Edge-Activated™ design concept provides many other features including +5V only power with ±10% tolerance, on-chip address latches, totally static operation and direct TTL compatibility with common I/O.

In applications with Mostek's Z80 microcomputer and Mostek 4K static RAMs you can activate the entire system with one common timing signal achieving a 75% reduction in device operating power for an automatic standby power mode.

Proven technology for lower cost, greater reliability. The proven technology for high performance and volume production is N-Channel, Silicon Gate MOS. Mostek's years of experience with Poly I™ process allow confident planning of next-generation products like the 36000. Now, Mostek process engineers can quickly move these designs from R&D to full production with proven reliability in millions of circuits.

There's more information on Mostek ROMs. Contact your nearest field sales representative or Mostek Corporation, 1215 W. Crosby Road; Carrollton, Texas 75006, (214) 242-0444. In Europe contact Mostek GmbH.West Germany; Telephone, (0711) 701096





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CIRCLE NUMBER 4

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Across the desk

Engineering decisions from nonengineers

Basically, I agree with Mr. Morroni's comments (see "Sons of Laetrile," ED No. 23, Nov. 8, 1977, p. 14). But I do believe that several aspects of the problem should be restated. For example, what can the individual do when companies refuse to let engineering decisions be made on a sound engineering basis? Too often nonengineering managers box us in by making these decisions, and too often price is *not* a controlling factor.

I will note just a few examples:

1. The use of "n" to designate the following kinds of devices:
   - npn silicon transistors
   - npn germanium transistor
   - Enhancement FETs, p type
   - MOSFETs, both types
   - Depletion FETs, p type
   - pnp silicon transistors
   - pnp germanium transistor SCRs
   - Enhancement FETs, n type
   - Dual diodes
   - Darlington pairs, all types
   - Unijunctions
   - Depletion FETs, n type

The "n" could easily be replaced by a two or three-letter code that would identify *all* of these by type.

2. The use of beta as a prime characterizing parameter for bipolar transistor devices, it being a *small difference* of large numbers.

3. Failure to recognize the importance of transconductance-per-unit-current efficiency as it relates to small-signal and power-circuit design.

4. Inept characterization of all solid-state devices I know of. This has been true since electron tubes first came on the market. Tube transconductance as a function of plate current is an important parameter with these devices (and the corresponding relation for both bipolar and field-effect transistors), whereas transconductance as a function of control-grid bias is indefensible. Yet *no* tube manufacturer credits this parameter with its true importance, and one of the major manufacturers still presents such data as he gives as a function of grid bias, a singularly unreliable relation.

5. Integrated-circuit manufacturers' turning out special-code ICs by the millions, using "MOSFET" technology. These get out onto the market by the millions, too, and you can't even find out the pinout or supply-voltage requirements. Manufacturing says, "Get the dope from our customer," but doesn't even take the trouble to tell you who the customer is. The result? You don't even dare try to test the stuff, it is so delicate and sensitive!

All we need to do is to get some checks and balances that will assure that the views of a spectrum of engineer and technician users are fairly considered in the decision-making process, instead of having governance controlled completely by the manufacturers themselves. Otherwise, we will continue to require that Naderites, Common Causers and others of their ilk scream for more government regulations. And since we apparently *won't* police our own operations adequately, we really can't argue much about their views, even though they really aren't sound.

Keats A. Pullen, Jr. E.D.
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Jerusalem Rd.
Kingsville, MD 21087

Rise time probed

The assumed input-circuit topology of "Let Your Scope Measure Its Own Rise time—Almost," by Raymond Pizzi (ED No. 24, Nov. 22, 1977, p. 130) is not valid for most oscilloscopes. But the mathematical derivations are interesting.

At the risk of divulging a scope-

(continued on page 10)

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

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At $3 in OEM quantities, our new 8021 is quite simply the world's lowest priced 8-bit microcomputer. It's a cost reduced version of our 8048, the microcomputer which won industry acceptance for the single-chip system concept. Then there's our new top-of-the-line 8049, the microcomputer that sets a new standard for single-chip system performance.

The entire line of MCS®-48 microcomputers is priced right and designed to lower your total system cost. For example, they all operate from a single 5V power source, and the 8021 has the broadest operating range in the industry (4.5V to 6.5V).

The 8021 also has an internal clock generator that lets you control system timing with a single 2¢ resistor. Built-in zero cross detection enables the 8021 to accurately control system

chip microcomputers without compromise.

timing operations and perform time-of-day accumulation.

For sheer performance, there's not a single-chip microcomputer anywhere that can catch our new 8049. With twice the on-chip memory of the 8048, the 8049 enables you to economically perform complex functions that previously required more costly multi-chip systems. And it's a drop-in replacement for the 8048, so you can upgrade 8048-based products with no redesign.

We've made MCS-48 microcomputers the easiest to use, too. Our 8748, for example, provides on-chip erasable and reprogrammable EPROM. That enables you to beat the ROM turnaround cycle during design and field testing. And its 100-piece prices start at just $39, making the 8748 economical for low to medium volume production. To ensure maximum flexibility, all members of the MCS-48 family are software compatible.

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MCS-48 Microcomputers

Model	Program Memory	Data Memory	I/O Lines	Instructions	Package Size
8021	1K Bytes ROM	64 Bytes	21	65	28 Pin
8048*	1K Bytes ROM	64 Bytes	27	96	40 Pin
8748*	1K Bytes EPROM	64 Bytes	27	96	40 Pin
8035*	(External)	64 Bytes	27	96	40 Pin
8049*	2K Bytes ROM	128 Bytes	27	96	40 Pin
8039*	(External)	128 Bytes	27	96	40 Pin

*Designed for easy expansion of program/data memory and I/O.

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FOR MORE INFORMATION CIRCLE NUMBER 7

Across the desk

(continued from page 7)
industry "secret" about times 10 probes, let it be known that a typical probe is constructed by shunting the 9-MΩ resistor with a capacitor. This configuration, when joined to a 1-MΩ, 10-pF oscilloscope input, forms a compensated voltage divider, and is not the primary determinant of oscilloscope rise time. Once a compensated probe is employed, the bandwidth and rise time depend upon other things, including the amplifiers that drive the CRT. It is not difficult to cite examples of oscilloscopes with virtually identical input characteristics but widely different bandwidths: the TEK 453 and 475A at 60 MHz and 250 MHz, respectively.

Calvin Diller
Dennis Feucht
Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97077

Misplaced Caption Dept.

If tests on a pilot production item show that our new design just isn't making it, our engineers accept the setback philosophically and adjust the design parameters appropriately.

Sorry. That's Pablo Picasso's "Guernica," which hangs in the museum of Modern Art in New York City.

New Books

Modern Digital Communications—E.J. Foss, Tab Books, Blue Ridge Summit, PA 17214, 308 p. $7.95 paperback, $10.95 hardbound.

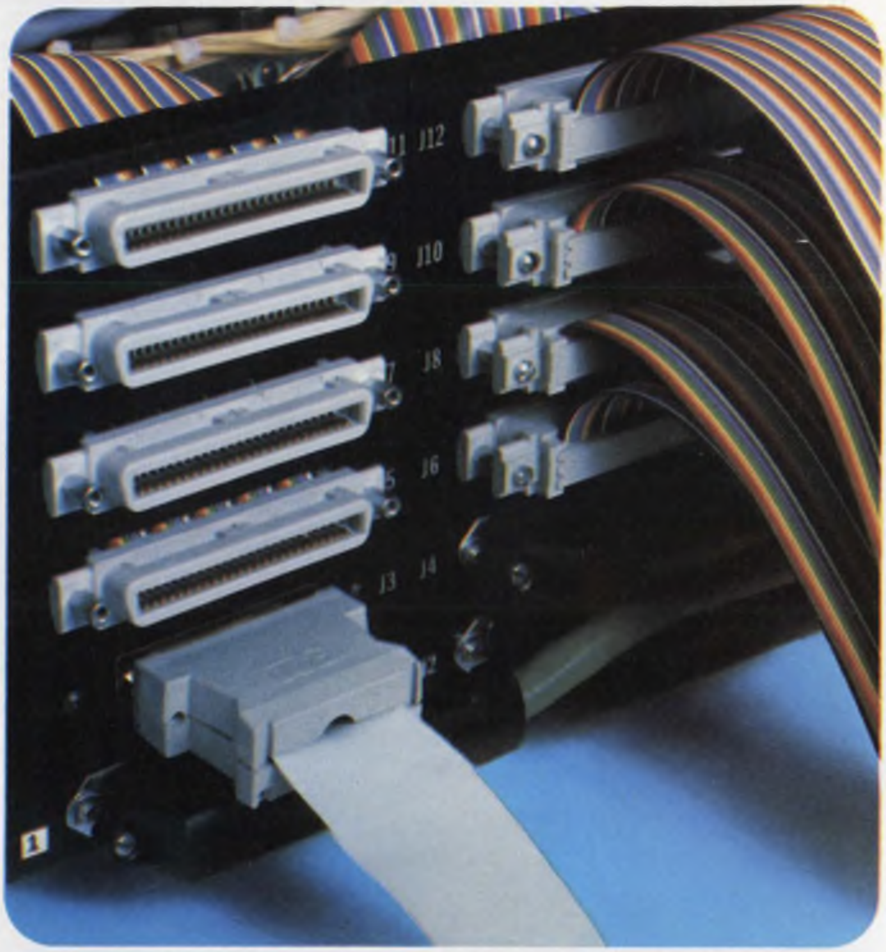
CIRCLE NO. 501

Surface Wave Filters—Design, Construction and Use—H. Matthews, John Wiley & Sons, One Wiley Drive, Somerset, NJ 08873, 521 p. $29.95.

CIRCLE NO. 502

Now you can mass terminate with ribbon connectors...

Here's another industry first from 3M that's good news for you: the Scotchflex brand Delta Ribbon Connector System for intra-system or I/O interconnections. In computer applications, in telecommunications, in any place or any way you want to use flat cable and ribbon connectors, this versatile system can do the job at sharply reduced assembly time and labor costs.

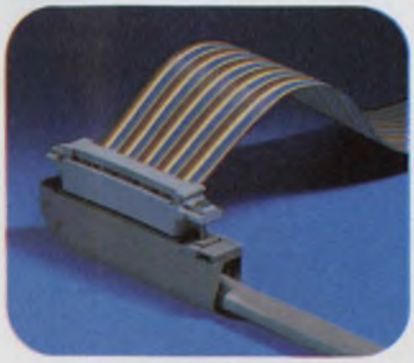


With Scotchflex Delta Ribbon Connectors, no stripping, soldering or other wire preparation is necessary. You can mass terminate a parallel-lay 50-conductor (25-pair) .0425″ center-spaced flat cable in less than 30 seconds with one step. That's about ten times faster than other available methods. And thanks to 3M's field-proven, gold-plated berylium copper U-contacts, all connections are reliably corrosion-resistant and gas-tight.

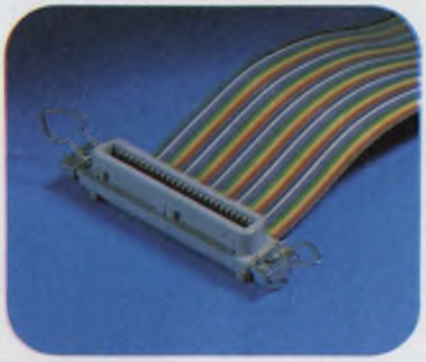
After termination, there are more savings. You can buss from point to point without disassembling or breaking existing cables. And there's no need to redesign or rework first generation components. This Scotchflex system mates perfectly with all standard miniature ribbon connectors.

...in 30 seconds or less!

There's no costly investment to make in equipment or training. All you need are two locator plates and the Scotchflex manual or pneumatic assembly press. You can start mass terminating assemblies quickly and economically. No special operator skills are required. Rejects and reworking are greatly minimized.



The Scotchflex Delta Ribbon system includes 50-position male and female connectors, plus appropriate bail mount, screw mount and jack screw kits, strain relief clips and dust covers. Color-coded flat cable is available in parallel-lay conductors #28 AWG stranded or #26 AWG solid.



Only 3M offers you so broad a range of flat cable and system components. A nationwide network of stocking distributors. Best off-the-shelf availability. Proven performance. And the unmatched experience of the people who pioneered mass terminations.

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3M COMPANY

See our catalog in EEM, page 2256

CIRCLE NUMBER 10

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CIRCLE NUMBER 11


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You'll have a whole team of experts on your side whenever you specify Dormeyer SOLENOIDS, TRANSFORMERS OR CONVERTER/CHARGERS.
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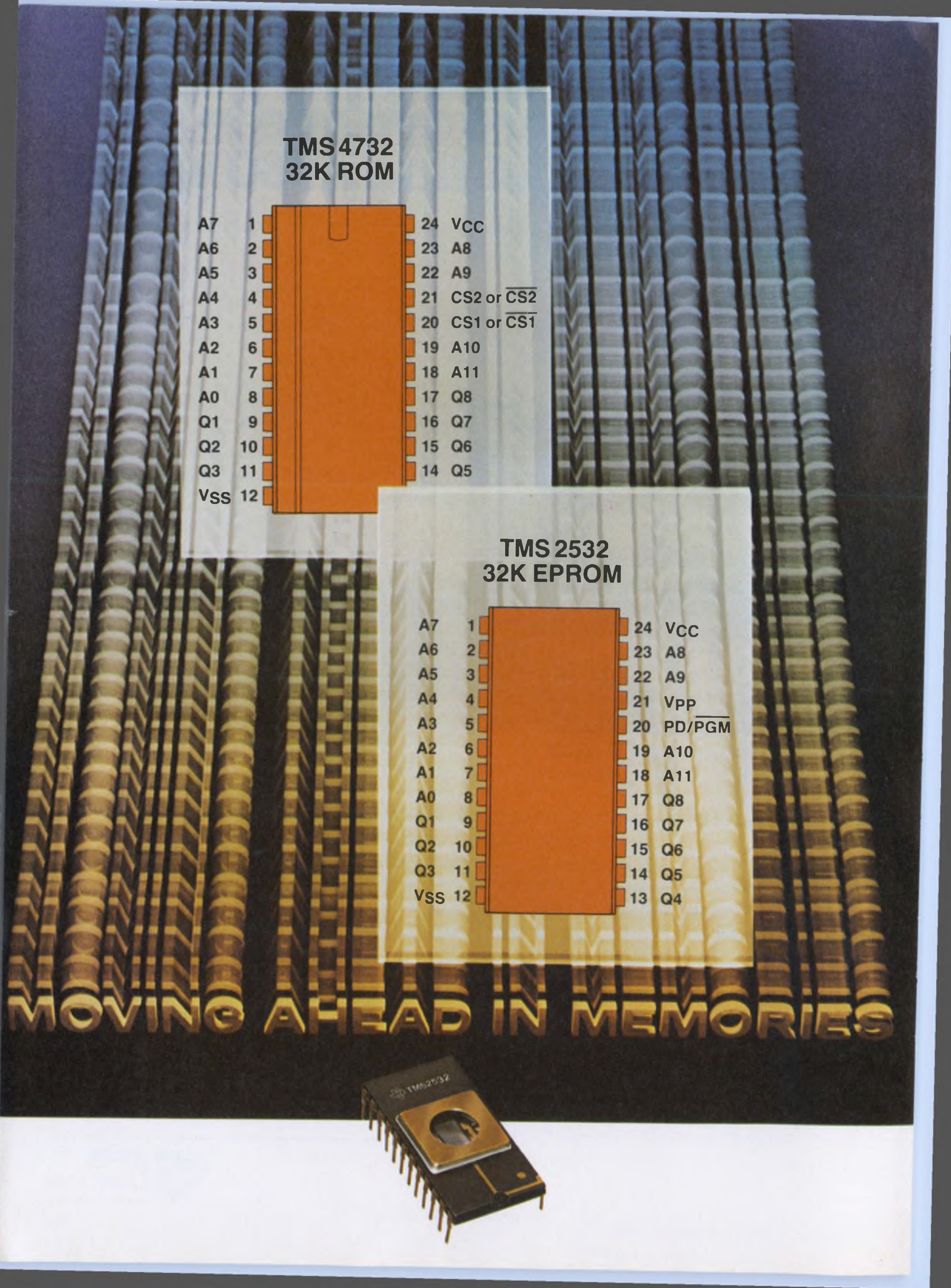

TMS 4732
32K ROM
A7 1
A6 2
A5 3
A4 4
A3 5
A2 6
A1 7
A0 8
Q1 9
Q2 10
Q3 11
V_{SS} 12
24 V_{CC}
23 A8
22 A9
21 CS2 or $\overline{CS2}$
20 CS1 or $\overline{CS1}$
19 A10
18 A11
17 Q8
16 Q7
15 Q6
14 Q5
TMS 2532
32K EPROM
A7 1
A6 2
A5 3
A4 4
A3 5
A2 6
A1 7
A0 8
Q1 9
Q2 10
Q3 11
V_{SS} 12
24 V_{CC}
23 A8
22 A9
21 V_{PP}
20 PD/$\overline{PGM}$
19 A10
18 A11
17 Q8
16 Q7
15 Q6
14 Q5
13 Q4
MOVING AHEAD IN MEMORIES
TMS2532

Introducing the first 32K EPROM.

Single 5-volt supply. Fully static. Biggest ever. From Texas Instruments.

Four 8Ks in a single 24-pin package. Or two 16Ks. TI's new TMS 2532 – a 32K 5-volt EPROM (erasable programmable read-only memory). The first and the biggest of its kind.

With applications now demanding more and more memory in the same size space, the new TMS 2532 is both practical and economical. Because TI offers a plug-in 32K ROM for volume production. Because system upgrading is a snap – the TMS 2532 is pin-compatible with 8K and 16K 5-volt models.

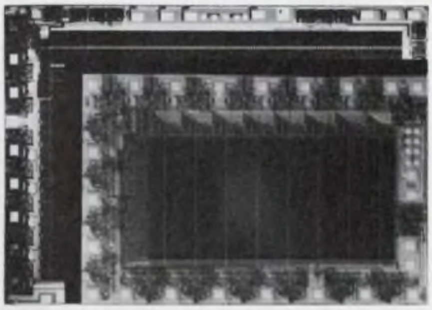
In addition, there is less assembly cost. Greater board density. Improved reliability. And, the TMS 2532 is a dollar saver compared to 8Ks and 16Ks.

Easy programming

Designed for facilitating rapid program changes in high-density, fixed-memory applications, the new TMS 2532 features speedy programming. A single TTL level pulse is all that's needed for simple in-system programming.

Any location can be programmed in any order. Either individually, in blocks, or at random. Which cuts programming time to a minimum. Existing EPROM programmers can do the job.

Erasing is simple, too. All you do is just expose the chip to high intensity ultra-violet light through the quartz window exactly as you would with any other EPROM.



***MORE MEMORY CAPACITY** results from state-of-the-art design techniques that keep the TMS 2532 EPROM chip only slightly larger than an 8K chip (foreground).*

Fully static operation

Like all EPROMs from TI, the new TMS 2532 continues the fully static tradition that makes designing much easier. There are no clocks. No timing signals. No hassles. Cycle time equals access time.

Low-power operation

The TMS 2532 also sets new standards in energy saving. At 840 mW maximum power (worst case – $T_A = 0°C$), it uses less power than a 2708. Yet has four times the memory capacity. And when the TMS 2532 is deselected, it automatically assumes a low power mode – 50 mW typical.

Matching 32K ROM

When programming is finalized and you're set for volume production, you can readily switch over to TI's TMS 4732, a 32K mask-programmable, production-proven read-only memory.

It's a direct plug-in for the TMS 2532. Note on the illustration that they utilize practically identical pin configurations. In fact, when you order the TMS 4732, merely specify that Pin 20 be active low ($\overline{CS1}$) and Pin 21 be active high (CS2) to achieve plug-in compatibility.

Wide-choice EPROM family

With the addition of the TMS 2532, TI now offers you a broad selection of compatible EPROMs. All available in 24-pin packages. All having speeds of 450 ns. All sharing the same production-proven N-channel process. All having the same basic pin configuration. Which paves the way for increasing memory capacity in the future should your needs so dictate.

This wide-choice EPROM family includes the 8K TMS 2708, the low-power 8K TMS 27L08, and the cost-effective 16K TMS 2716 (see table below). And more members are on the way.

For additional information on the first 32K EPROM, as well as on other family members, write Texas Instruments Incorporated, P. O. Box 1443, M/S 669, Houston, Texas 77001.

TI's Growing EPROM Family

Device	Complexity	Organization	Operating Supplies	No. of Pins
TMS 2708	8K	1K x 8	+12 V, ±5 V	24
TMS 27L08	8K	1K x 8	+12 V, ±5 V	24
TMS 2716	16K	2K x 8	+12 V, ±5 V	24
TMS 2532	32K	4K x 8	+5 V	24

TEXAS INSTRUMENTS

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CIRCLE NUMBER 15

85104

MARCH 15, 1978

Electron beams take aim at Gbyte memory systems

Electron-beam-addressable memories will offer capacities of thousands of megabytes at two to five millicents per bit, thanks to a technique that deflects the beam twice, then passes the beam through an array of lenses. Memory systems storing 256 Mbytes will be available within two years, and gigabyte memories will follow, says Don Smith, who heads the technical side of Micro-Bit Corp., a Lexington, MA, firm that has been studying electron-beam addressable memories for nearly a decade.

An 8-Mbyte system, already developed by Micro-Bit (recently acquired by Control Data Corp. in Minneapolis), incorporates 22 single-deflection tubes—16 for data and six for parallel Hamming-code error correction and detection. But this system is slower than and as expensive as MOS random-access memory and will not become commercially available, explains Smith, who has prepared a paper on electron-beam addressable memories for the IEEE Computer Society International Conference (Compcon '78) in San Francisco.

The next generation of electron-beam addressable memories will use a coarse deflector and a lens/fine deflector array to increase density and drop costs below those of MOS memories, says Smith, adding: "The constraining limitations on single-channel electron optics imposed by deflection can be pushed outward by several orders of magnitude by employing two-stage deflection and an array of lenses known as the 'fly's eye' configuration."

The coarse deflector aims the beam at one of the lenslets in the array, and the fine deflector addresses the memory target area under each lenslet. "By subdividing the deflection into two stages, we can access a much larger target area and the limitations on capacity set by deflection aberrations and deflection voltage inaccuracies can be overcome," claims Smith.

In the double-deflection tube, the first part of the tube is about 11 in. long and 2 in. in diameter and contains the electron gun, condenser and collimating lenses, and deflection blanker. These are identical to those used in single-deflection tubes, and operate at the same cathode potential—10 kV.

The second half of the tube, about 8 in. long and 4 in. in diameter, includes the coarse deflector, the lens and deflector array, and the silicon target. The coarse deflector is an electrostatic structure, and the array lens consists of three aligned plates, each having a 32 × 32 array of holes plus extra holes around the periphery to preserve field symmetry. Lens tolerances, particularly the roundness of the holes, are tightly controlled to minimize spherical aberrations.

The fine-deflector array consists of two successive arrays of parallel bars at right angles to each other to achieve x-y deflection. Construction stability is important to minimize the memory's sensitivity to vibration, but mechanical tolerances are not particularly stringent because of the nature of the target.

The target is a 4 × 4-cm slab of silicon that is homogeneous in the plane perpendicular to the beam—there is no structure imbedded in the material. Instead, the target has just four layers: p-type silicon, n-type silicon, an oxide insulator, and a metal front surface. Only two leads, one on each side, are required to write and read data.

In operation, positive charge is normally stored in the oxide layer, and this charge is removed by exposure to the beam. Data storage is represented by charge or no-charge states, or transitions between them, and is nonvolatile.

The writing beam also acts as a reading beam. Signals are capacitively coupled through the oxide to a differential sense amplifier. The MOS target acts as an amplifier because each penetrating electron from the incident beam generates several thousand electron-hole pairs.

The first double-deflection tubes will have a capacity of 128 Mbits so that a memory system of 22 such tubes will have a 256-Mbyte capacity. Systems four times as large are already in the conceptual stage, according to Smith, who foresees per-bit prices an order of magnitude less than that of similarly large MOS RAM arrays.

RAM cell promises 64 k with existing rules

A dynamic RAM cell described at the recent International Solid State Circuits Conference promises 64-k dynamic RAMs that can be made with existing fabrication techniques. With this cell, 256-k RAMs should be possible in a couple of years. Today, any RAM larger than 16-k requires special manufacturing techniques.

Each cell, typically 10 × 15 μm, has internal gain, which means that the sense amplifiers can be simple inverters. Not only that, but dynamic RAMs using these cells will need fewer sense amplifiers than current designs, whose cells have output in the millivolts and require fairly elaborate sense amplifiers. Readout in the new concept is nondestructive, and refresh intervals are expected to be comparable with existing dynamic RAMs.

Access time is limited not by cell speed, but by the multiplexing required to use a limited number of address-input pins for a large address.

The cell concept, called the Stratified Charge Memory, was invented by Dr. Darrell M. Erb, of Mountain View, CA. (PO Box 4113, Zip 94040). Dr. Erb, who is currently self-employed, owns the rights to a forthcoming patent.

Erb's structure is like one transistor with two "gates" in series, one for storing the bit, the other for enabling writing and readout.

An array of Erb's cells contains orthogonal polysilicon row and column electrodes that are simply stripes with straight-sided outlines. The array also has diffused n+ source and drain buses, both running parallel to the column electrodes. Sense amplifiers are connected to the ends of the drain buses. The crosspoint between a row electrode and a column electrode is adjacent to the drain bus, and a bit is stored beneath this overlap.

To store a bit, the column electrode for the selected location is made relatively negative for a ONE, and relatively positive for a ZERO. By properly biasing the row electrode for that location, holes will be attracted to the oxide-silicon interface beneath the crosspoint to store a ONE. For a ZERO, no holes are attracted.

Changing the bias on the row electrode "traps" the holes, which become surrounded by a positive electric field. Readout doesn't affect this "trapping," so data aren't destroyed.

To read, the row and column electrodes for the selected location are biased to new values. An n-type inversion layer forms under the row electrode, which behaves like a gate enabling writing and readout. The presence or absence of the stored holes under the column electrode has the effect of the other gate and determines whether or not an electron current will flow from source to drain. Current in the drain bus is picked up by the sense amplifiers.

μC programming easier with ROM interface cards

Two microcomputer-interface cards, one for printer control and another for communication, are the first to have their on-board intelligence in the form of ROMs. The 256-byte ROMs carry the driver and control software in Basic language. Putting this on-board intelligence into the ROMs simplifies programming, because for most other μC cards to run, a machine-language program must be loaded into the microcomputer itself, or perhaps even written.

The cards, from Apple Computer Inc. (Cupertino, CA), are aimed for use with the Apple II microcomputer. While the intelligent ROM is only a 256-byte device, it appears to the computer to be much larger, because it is linked directly to machine-language routines already in the Apple II monitor.

Both Apple cards do more than simplify programming. In fact some of their features are new to the μC field, according to Apple.

For example, the Parallel Printer Interface control board can handle printers up to 255 characters wide at 5000 characters per second. The Communications Interface board, or modem controller, does more than provide a serial link to allow computers to talk to each other—as most modems and controllers do. With its intelligence, the board permits one Apple computer to take control of another—particularly useful for running remote diagnostic programs.

The Apple printer-control card's ROM has all the card's control and driving software in Basic. This software not only handles the printer timing and interfacing to a wide variety of printers, but also handles all of the interfacing to the Basic language in the μC. So for printing, all a user has to do is tell the card how many columns he wants to have printed, and then type in PRINT.

The Communications Interface card, or modem controller, provides full-duplex operation at 110 or 300 Baud, which is selected by software. The Basic program to control the modems or the Apple II computer is contained in on-board ROM. This feature permits a distributed system—say, in a factory —to bring data to a central location. How? By allowing the user to load and control remote units from a central microcomputer.

Dual laser carves out objects of any shape

A two-laser method of chemical machining does what no conventional machine tool can do—readily produce any pattern or shape required. The method promises to prove useful in precision casting and IC technology, and may even lead to 3-D oscilloscopes.

Two laser beams of different wavelengths are projected into a volume of photoresistant material that reacts only where the beams intersect. After the desired shape is created by the coordinated movement of the beams under computer control, solvents or a vacuum can remove the excess unreacted material. Since the dual-laser system can duplicate a solid object sensed by other lasers, it is called a replicator. It has been patented by Omtec Replication, Berkeley, CA.

"As to its usefulness for ICs, it's all a question of the resolution that can be achieved," says research chemist Dr. Robert Schwerzel of Battelle Memorial Institute. Battelle's Columbus Laboratory is now defining the research necessary to make the concept commercially feasible.

In February, inventor Wyn Kelly Swainson, President of Omtec, executed agreements permitting Battelle to obtain industrial sponsors for the research, which may be under way in a few months.

Castings manufacturers large and small have shown very enthusiastic response, says Schwerzel. The laser approach potentially can do in hours or days the complex pattern-making jobs that now require months.

The feasibility of a 3-D oscilloscope display was demonstrated in 1971 by Carl Verber, another research chemist at Battelle. Swainson's concept, notes Verber, would add a hard-copy output.

Estimating the ultimate impact of the concept, Arthur C. Clarke, renowned author of science fact and fiction, told the Congressional Clearinghouse on the Future last October about a machine that could make a copy of anything in its three-dimensional form, in all its detail.

"Imagine my astonishment when I learned that the first patent for the replicator had been put out by a company in California called Omtec."

Minicomputer emulates most minis or micros

A new minicomputer can expand a system's performance by being microprogrammed to run the instruction set of practically all mini or microcomputers.

The T-1000 from Dynamic Sciences, Van Nuys, CA, has an architecture specifically designed for efficient emulation. It uses a variable-size microprogrammable memory to store microinstructions, says Earl Kanter, vice-president for corporate development. This, coupled with the T-1000's architecture and interpretive controls, enables it to emulate computers with 8, 12, 16 or 32-bit word lengths.

Operating typically at 300,000 operations per second, the T-1000 is several times faster than a MOS microcomputer. In addition, up to 65,536 words of memory can be directly addressed, and 262,000 words of extended addressing are available. The T-1000 contains 16 full-word (16-bit) registers and operates off a single +5-V supply.

The basic CPU is contained on a single small printed-circuit board, but much more capability is available on additional boards—extra memory, programmed I/O, various interfaces and a series of data option modules, such as memory management and floating-point arithmetic.

To retrofit an existing system and to upgrade its performance, Dynamic Sciences will fit the T-1000 into the card-cage slot of the less-powerful computer being replaced. "We will customize the boards to fit the mechanical requirements of the customer," notes Kanter. Prices start at $1000 in 100-up quantities.

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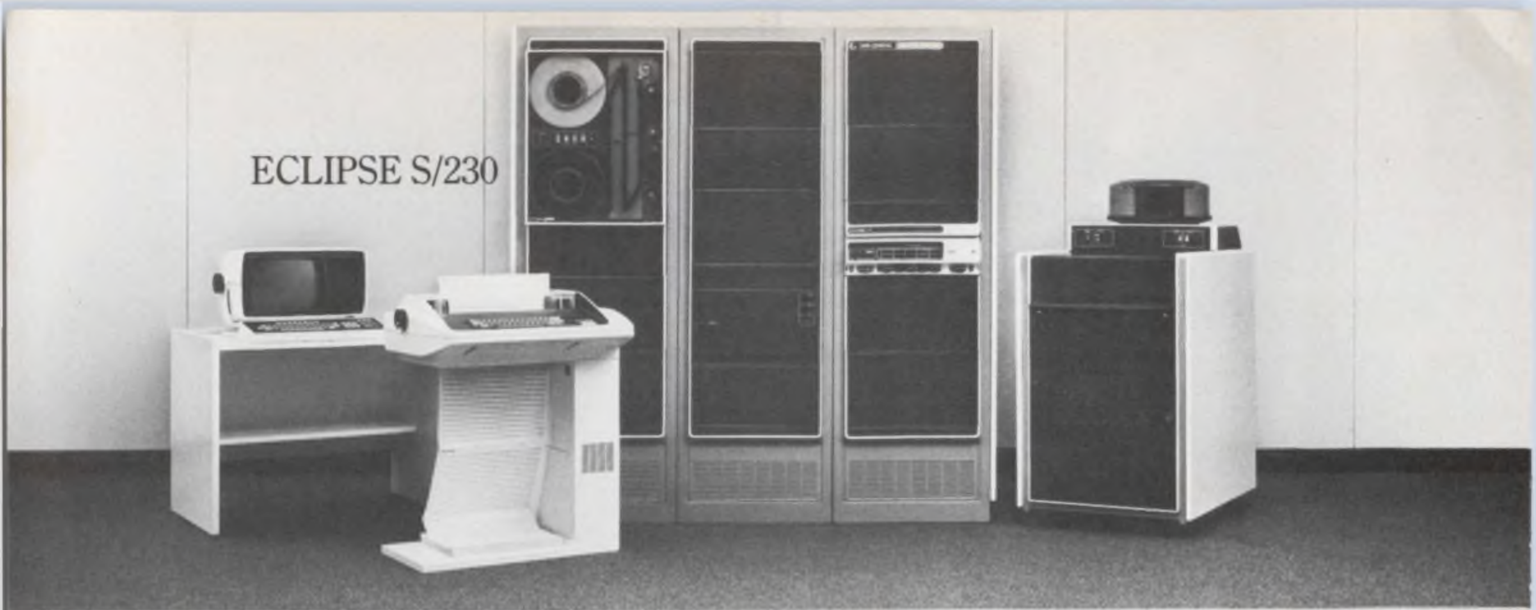
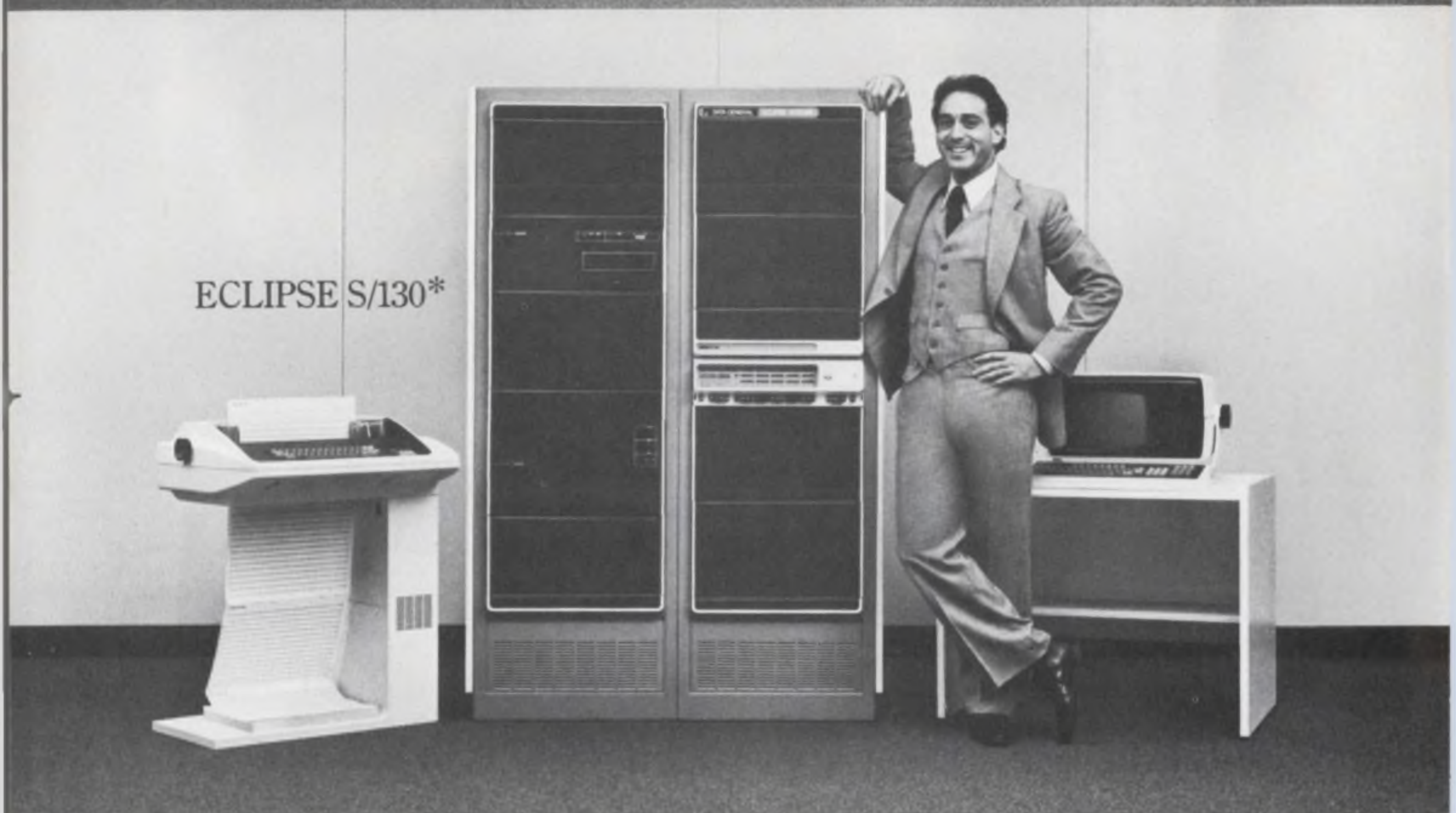

ECLIPSE S/230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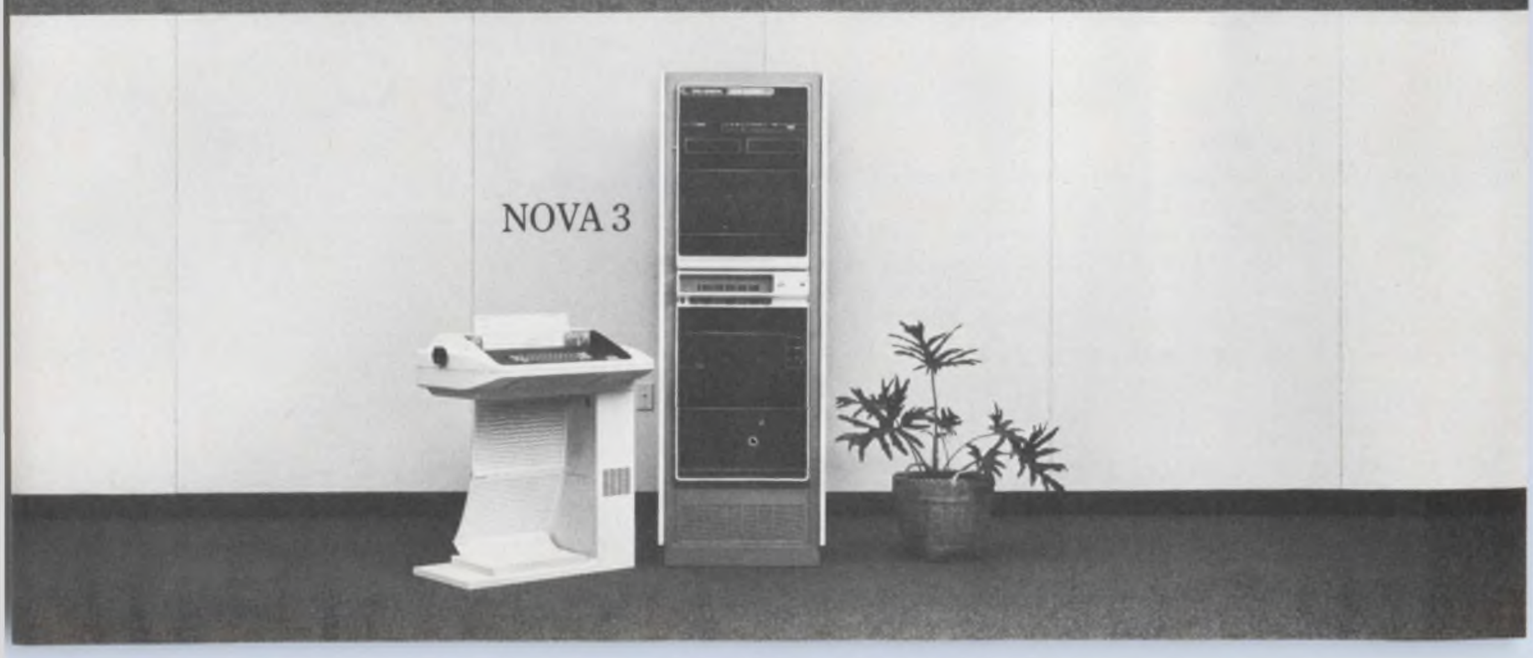
NOVA 3

Minicomputer architecture: advancing, but with caution

Much of the improved data-processing capability of minicomputers stems from architectural changes made possible by advances in semiconductor technology. Yet the basic architectures themselves haven't undergone any tremendous face lifts. For one thing, designers are leery about putting in new devices before their technologies are proven—and that takes time. In addition, manufacturers often cannot get low-enough costs or standardized packaging for new devices.

As a result, minicomputer architecture in several notable cases has not been changed dramatically to improve performance. For sure, minicomputer families are evolving. But each new member first derives benefits from the original architecture, then gains the advantages of improved hardware based on tried-and-true technologies.

The Eclipse S/230 uses high-speed semiconductor and core-memory modules. Read cycle time for the Data General mini's 64-kbyte semiconductor memory is 500 ns, while its 32-kbyte core memory cycles in 800 ns.

Architecture—do not disturb

For example, Data General's Nova family, designed for the standard minicomputer market, has used the same basic architecture since its inception 10 years ago. This has not prevented advanced features like a hardware multiply and divide, a floating-point processor and an increased memory capacity from being built into the newest members.

Meanwhile, the philosophy at Hewlett-Packard is "to enhance the performance without throwing away the architecture," according to David Carver, Products Manager of the Data Systems Division. Thus, the new HP 1000 Series (HP-21MX) minicomputers are architecturally compatible with machines made way back in 1966, while offering much greater processing power.

Compatibility to Vernon Smith, Senior Vice President at Microdata, means that "the hardware evolves under the software, so the customer can continue to use the same software package." This is called "software transparency," and to a user it means that while newer members of a machine family offer better performance, their programming is similar to the older models.

Since up to 50% of the development cost of a minicomputer can be tied up in software, sweeping architectural changes that would affect software don't make sense. On the other hand, computer performance is being upgraded by using software in new ways. One of the most recent innovations, user-accessible microcode or microprogramming, provides powerful instructions that replace many normal programming routines. A microprogramming instruction word can be extremely wide—up to 56 bits—and contain several commands that can be executed in one machine cycle.

Not too surprisingly, then, minicomputers with microprogrammed architecture are becoming more popular than older, hardwired designs. Nevertheless, the basic architectural structures of both types have much in common.

Microprogramming is coming on

To execute machine code, hardwired and microprogrammed computers begin an instruction cycle the same way. Through the control section, an instruction is fetched from main memory, then loaded into an instruction register.

At this point, paths diverge, with a hardwired computer executing the word via its control logic, and a microprogrammed computer operating on microinstructions located in a special memory called a control store.

The contents of a location in the control store are fed to a microinstruction register, which holds the

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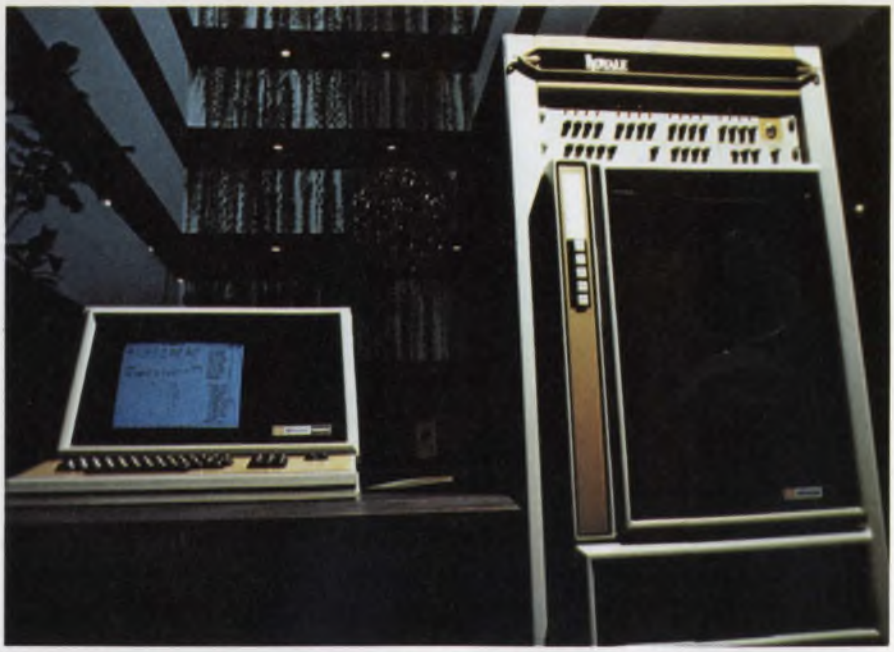
(continued from page 26)

control signals until they are ready for execution. Moreover, control signals to allow execution also come from the control store, under the direction of a simple clock that generates the sequence of operations.

Unlike a hardwired controller's instruction set, the instruction set of a microprogrammed minicomputer can be altered by changing the locations of microinstructions in the control store. To do the same thing, a hardwired machine's control section would have to be redesigned radically.

But for high-performance applications, where execution speed is critical, hardwired logic works faster than software. So machines with logic controllers should be around for some time.

Whatever the architecture, minicomputers must operate at increasingly higher speeds to execute the complex programs that result from sophisticated instruction sets. But the burden doesn't have to fall on their CPUs alone. Microcomputers are coming to the rescue.



The Royale, a data management minicomputer, features a new computer language called ENGLISH. Statements written in dictionary-based form containing verbs, nouns, adjectives and adverbs enable the Microdata computer to identify specific items in a data file.

Microcomputers share the load

A minicomputer designed for speed has a better chance of achieving higher throughput rates if a microcomputer becomes part of its architecture. By giving up control tasks to a microcomputer, the mini's CPU can perform its primary mission processing data, faster and more efficiently. And the burden of I/O operation, by which a CPU controls and communicates with its peripheral units is shouldered effectively by a microcomputer.

But microcomputers aren't restricted to improving speed. Microcomputers can help minis in the field operate reliably by providing diagnostic capabilities to detect malfunctions in both the CPU and its peripherals. For example, a microdiagnostic unit can test the operation of CPU components, and, with a special code indicated on front-panel LEDs, identify the malfunctioning section. Thus, error diagnosis is taken out of the hands of field-service engineers, which means lower mean time to repair failed equipment and lower service costs.

Microcomputers are just one part of the growing semiconductor arsenal that includes large-scale integrated circuits. With greater levels of gate integration available, features that were previously unheard of can now be built into existing architectures. However, putting LSI to work in mainframes leads to some not-so-obvious problems.

LSI pros—and cons

LSI devices offer some clearcut reliability advantages on a system level in minicomputers. But many machines still rely on older medium-scale integration to implement control-section logic. For one thing, it's difficult to break the often complex logic of hardwired control sections into blocks that can be implemented with standard LSI devices. And standard LSI in suitable package configurations is not far enough along to be used in architecture.

One way around this problem—although it's far from an ideal solution—is LSI circuits specifically designed to perform the logic functions of the architecture. Unfortunately, procuring such circuits isn't easy. And the custom LSI circuits won't be cost-effective unless an extremely large batch is needed.

Nevertheless, the attraction of LSI, with its potential for reducing both package count and interconnections between circuits, pulls strongly on manufacturers interested in improving overall system reliability.

Where it's difficult to use LSI devices in control logic, LSI memories pose no such problem. Random-access-memory bit densities have steadily increased from 16 bits in 1970 to the 4-k sizes available today. So memory-oriented microprogramming architectures are gaining popularity. Access times are in the neighborhood of 150 to 300 ns, but newer MOS technologies such as HMOS and VMOS offer the possibility of future RAMs with access times as low as 70 ns.

Old memories not forgotten

On the mainframe-memory front, meanwhile, established technologies will be hard to overtake.

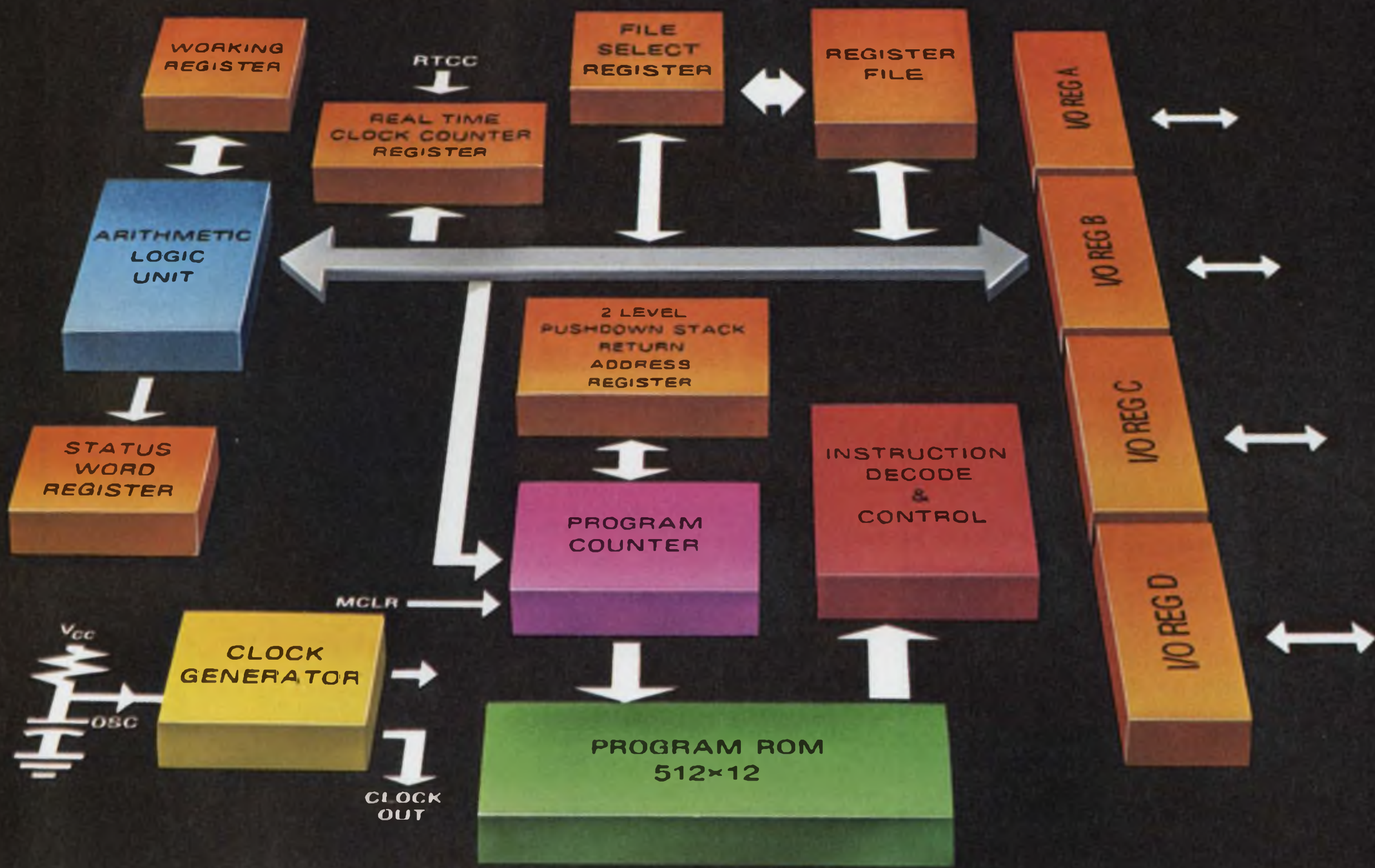
Most minicomputers today use either core memory, or a combination of both. And there's no mystery behind the reasons. Newly developed charge-coupled devices and bubble memories are not yet price-competitive or, in some cases, not commercially available.

Moreover, minicomputer manufacturers place a premium on component reliability—and CCDs and bubbles don't even have a track record. Couple that with the fact that the reliability of established technologies for disc storage isn't standing still, but is approaching 15,000 hours MTBF.

"Another problem facing replacement memory technologies is that they are chasing a moving target in terms of the minimum memory capacity they

(continued on page 30)

PIC 1650



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must replace plus the changing cost of alternate technologies," says Robert Grossman of Data General. Because today's requirements call for sophisticated software and operating systems, the minimum mass memory being ordered is increasing—a trend that will continue. At the same time, the cost per bit of rotating magnetic mass memory is continuing to drop significantly. But CCD add bubble memory costs are roughly proportional to capacity, so increases in minimum memory size makes the cost goals of the emerging technologies harder to achieve.

If cost isn't enough to dampen interest in new memory technology, perhaps the following will: Minicomputer performance can be upgraded by incorporating design techniques into memories that make better use of established technology. Cache memories —fast, bipolar, small-capacity devices that serve as front-ends for the main memory—speed up processing time. The cache contains data that a CPU is most likely to request, and makes the information available faster than if it had come from main memory.

Another reason that caches improve speed performance is that they can read at the same time that the CPU is writing into main memory.

Still, minicomputers have benefited from developments both in basic technology and design innovations. One big result is that minicomputer languages now offer a level of sophistication and data-management capability that grows with the size of memory itself.

Speak to your computer

The proliferation of languages spoken by new minicomputers would tax the abilities of a linguist. Most machines can now execute operations in well-known high-level languages like Fortan, Basic and Algol.

From Microdata comes the Royale, a data management minicomputer that speaks ENGLISH. While it's not exactly spoken English, users can program the Royale with sentences made up of verbs, nouns, adverbs and adjectives, all stored in dictionary-type files.

Data General's Eclipse family understands a host of high-level languages, including real-time Fortran IV, Extended Basic, Business Basic and Extended Algol. To bring these sophisticated languages to the user, instruction sets have been expanded to include words that are considerably longer than the old 16-bit words.

HP's 21-MX minis use an instruction word of 32 bits, as does Digital Equipment's PDP 11/34. And among microinstruction words, bit lengths of 48 and 56 bits are not uncommon. But the old 16-bit word may not be dead yet: Minicomputers still take the longer-bit words and bite them off in 16-bit chunks.■■

Need more information?

Not every manufacturer of minicomputers has been cited in this report, nor are the complete product lines of each supplier included. For additional details circle the appropriate number on the reader service card and consult the GOLD BOOK.

ABC Digital Electronics Inc., Automation Dynamics Div., 25 Charles St., Westwood, NJ 07675. (201) 666-2458 **Circle No. 504**

Applied Computer Systems Inc., 77 E. Wilson Bridge Rd., Worthington, OH 43085. (614) 436-3163. **Circle No. 505**

Applied Systems Corp., 26401 Harper Ave., St. Clair Shores, MI 48081. (313) 779-8700 **Circle No. 506**

Astronautics Corp. of America, 907 S. 1 St., Milwaukee, WI 53204. (414) 671-5500 **Circle No. 507**

Compucorp, 12312 W. Olympic Blvd., Los Angeles, CA 90064. (213) 820-5611 **Circle No. 508**

Computer Automation Inc., 18651 Von Karman, Irvine, CA 92664. (714) 833-8830 **Circle No. 509**

Computer Electronics Ltd., Shirehill Ind Est Saffron, Waldon Essex, Great Britain. 0799 27093. **Circle No. 510**

Control Data, P.O. Box 0, Minneapolis, MN 55440. (612) 853-7600 **Circle No. 511**

Control Logic Inc., 9 Tech Circle, Natick, MA 01760. (617) 655-1170 **Circle No. 512**

CSP Inc., 209 Middlesex Tpke., Burlington, MA 01803. (617) 272-6020. **Circle No. 513**

Datacom Inc., Box 278, Fort Walton Beach, FL 32548. (904) 244-6121 **Circle No. 514**

Data General Corp., Rte 9, 15 Tpke. Rd., Westboro, MA 01581. (617) 485-9100 **Circle No. 515**

Datapoint Corp., 9725 Datapoint Dr., San Antonio, TX 78284. (512) 690-7151 **Circle No. 516**

Digital Communications Assoc. Inc., 135 Technology Park, Norcross, GA 30092 (404) 448-1400 **Circle No. 517**

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Airborne TV systems are jammable, but μPs may be part of a solution

Microprocessors may help the Air Force solve the problem of transmitting video signals from its TV-guided airborne vehicles, missiles and gliding bombs without fear of jamming.

The trouble is that for TV pictures to be sent back to earth with techniques that defeat jamming, the 4 or 5-MHz video signals must be squeezed down to a few hundred kHz. But so far, complex mathematical operations needed for such bandwidth compression cannot be performed without extensive hardware. And the airborne system must be small, light, power-stingy and low-cost.

Analog systems developed to minimize bandwidth suffer from analog-multiplier instability. And custom digital systems generally have proven to be power-hungry, expensive, or too slow to process video signals in real time.

But now, for the first time, off-the-shelf microprocessors have been configured for powerful mathematical capability. Moreover, these low-cost devices have been demonstrated to be feasible for the Air Force's airborne TV application (see Fig. p. 34).

Two microprocessors built around three Advanced Micro Devices 2901 4-bit-slice, low-power Schottky chips are used in a laboratory setup developed for the Air Force by Data/Ware Development Inc. of San Diego to evaluate digital compression-expansion of TV signals. The μPs provide enough mathematical power and speed to perform the necessary complex TV-signal bandwidth-compression transforms and their inverses in real time.

One of the microprocessors simulates an airborne TV system, in which the signal-compressing takes place. The other μP simulates a ground-site receiving system where the signal is expanded for display on a standard TV monitor.

One advantage this setup has over analog systems is that it is digital. Communications between airborne vehicles and base stations are digital, so the system doesn't require additional hardware for conversion to that form. Moreover, it's more stable.

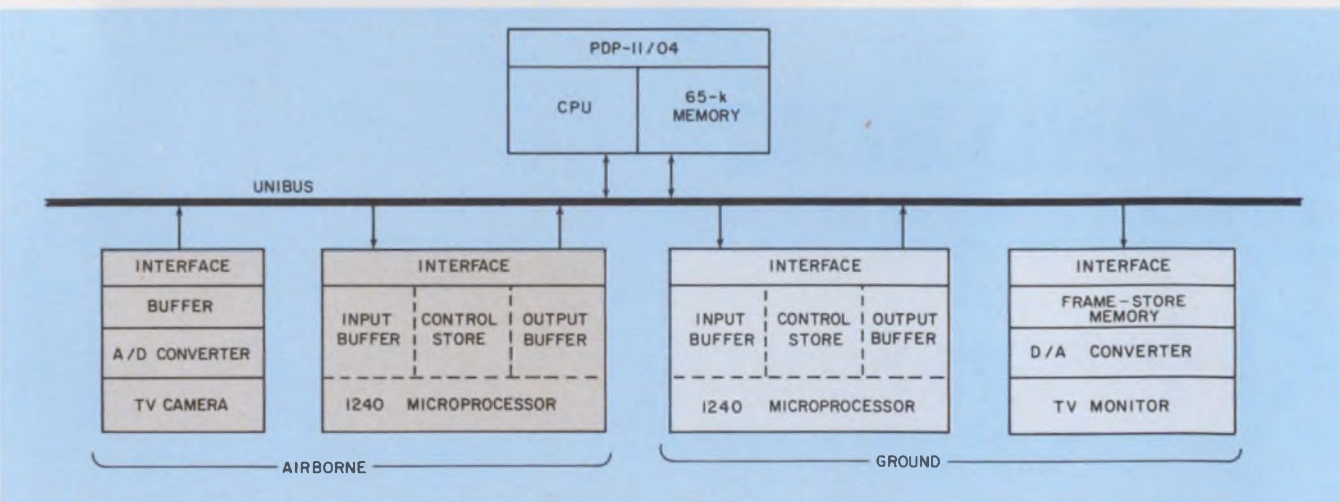
A PDP-11/40 minicomputer simulates the link between airborne and ground systems. Normally, the compressed airborne video signal is fed to a modulator and transmitter, picked up on the ground by the receiver, and demodulated for expansion. The microprocessors performing the compression-expansion are tied to the minicomputer's Unibus (see Fig. below). As a result, the minicomputer can control all subsystem operations for evaluating different configurations.

Redundant data removed

Basically, the TV-picture data are compressed by removing redundant information, explains Richard V. Keeple, vice president of Data/Ware. Keeple is co-author with Ronald A. Belt (USAF Avionics Laboratory, Wright-Patterson Air Force Base) of "Digital TV Microprocessor System," which he presented at the recent National Telecommunications Conference in Los Angeles.

If the compressed video bandwidth can be reduced to some 200 kbits/s, Keeple maintains, the video information can be transmitted over a spread-spectrum link in which the narrowband video is distributed across a broadband spectrum. This makes jamming difficult.

Redundant information in a TV picture can be rejected because it changes



The modems and rf links between the airborne and ground microprocessors are simulated by a PDP-11/40 minicomputer. The DEC machine's Unibus permits a maximum transfer rate of 5 Mbytes/s between the processors. This setup allows the mini to control all subsystem operations for evaluation.

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very slightly, if at all, from frame to frame. Picture data can be compressed by employing only the frequency changes that occur as the camera scanning beam picks up edges such as lines or rapid variations in light levels.

The information is squeezed down further with transforms of the horizontal and vertical-image frequencies. On the receiving end, the information is subjected to an inverse transform and the picture is reconstructed.

Transform algorithm helps

The key to the microprocessors' providing the computing power necessary to perform the transforms and their inverse operations is a transform algorithm that is the most efficient to date. It was developed at Data/Ware by P.J. Erdelsky and G.G. Murray.

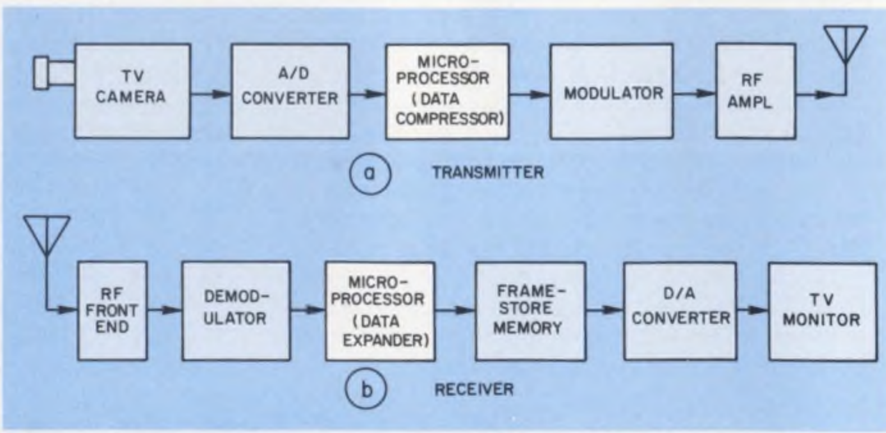
In the Data/Ware system, the standard TV format is modified so that each field consists of 256 lines of 256 picture elements, or pixels. This means that the horizontal pixels are slightly longer than they are wide, so horizontal resolution is slightly, but not noticeably, lower than the vertical. Since odd and even fields are treated as identical, 256 lines of information are obtained from the 525 lines of the standard TV picture. And gray scales are quantized on a 6-bit level.

To reduce the bandwidth even further, the Data/Ware system employs a frame slowdown that dissects and sends the picture out in vertical stripes 32 pixels wide and 256 pixels high—an eighth of a picture frame—at a time. These stripes are stored in a frame-store memory at the receiving site until the full frame is received. Then the frame is sent to a d/a converter and to the video monitor (see Fig. below). A 32-pixel strip is transmitted during one field period. The slowdown is 8-to-1, but the picture produced at the ground station is acceptable for typical airborne applications. The stripes are processed from left to right, and updated 7.5 times a second.

With Data/Ware's encoding method, each line is processed as it is generated by the TV camera. As the information on one line comes into the microprocessor, a discrete cosine transform is performed on it to extract coeffi-

(continued on page 38)

Complex calculations needed to compress and expand TV signals are performed by microprocessors (two top card racks) in this laboratory setup. This demonstration system by Data/Ware simulates TV transmission from an airborne vehicle and reception at a ground station.



The TV signal from a remotely guided airborne vehicle is compressed by an on-board μP in this Data/Ware system (a). On the ground a second μP expands the video information, stores it, and puts it on a monitor (b).

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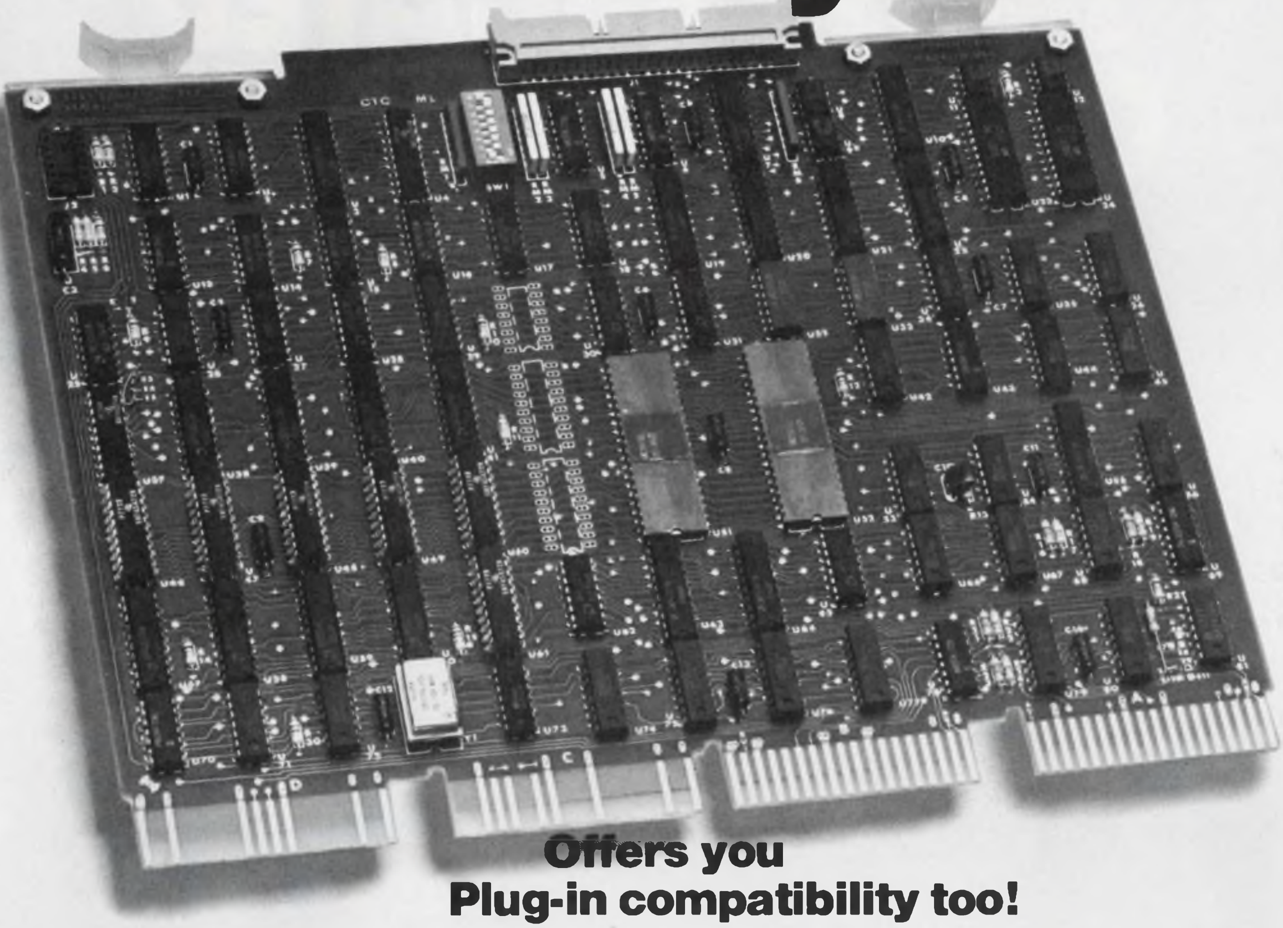

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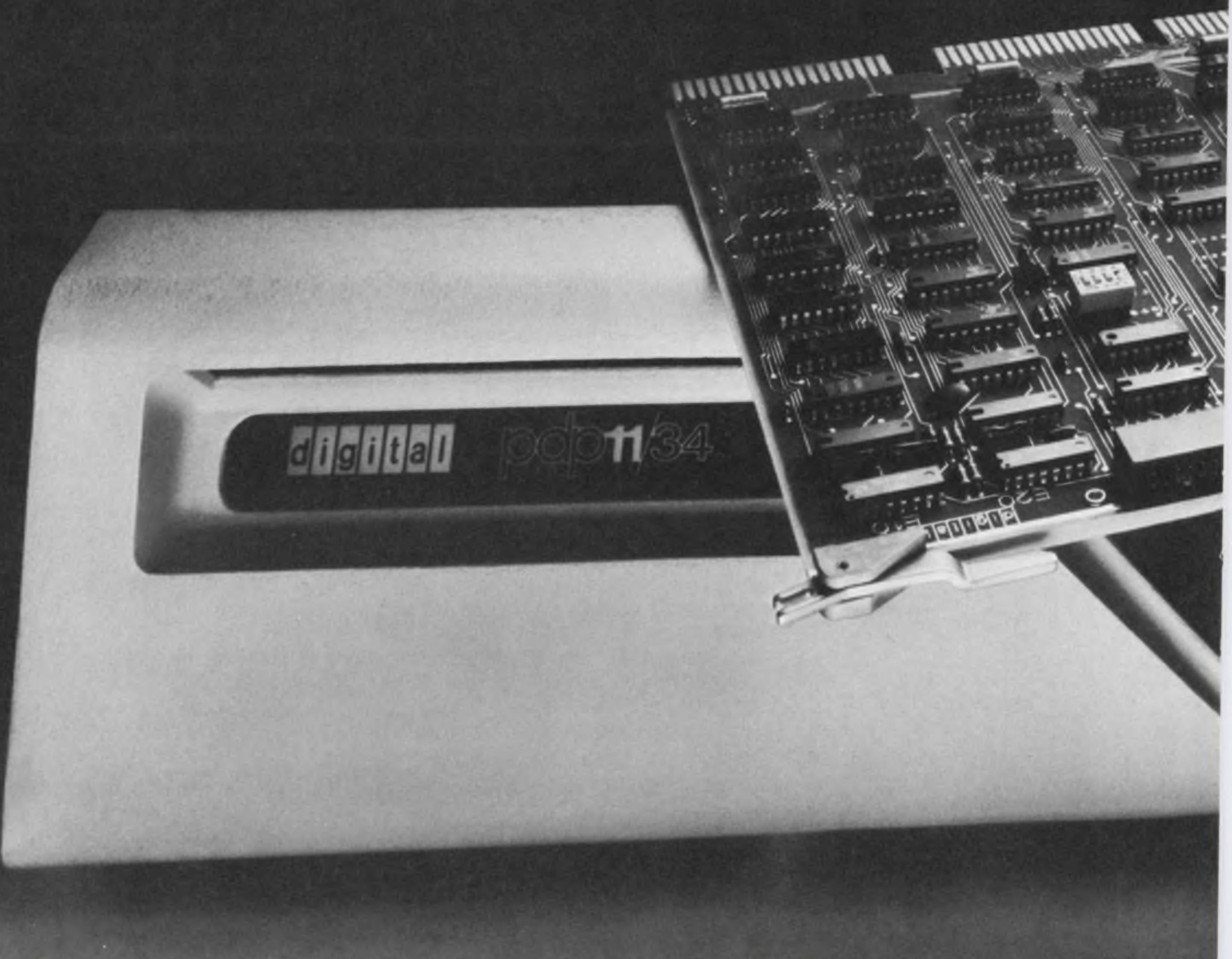

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CIRCLE NUMBER 25

(continued from page 34)
cients of key frequencies. The transform information is saved, and the coefficients obtained from the 32 pixels are stored. This information is compared with (subtracted from) the coefficients generated and stored from the previous line.

After this discrete cosine transform, the frequency-domain coefficients of one TV line-segment are compared with those on the succeeding line by differential pulse-code modulation. The difference obtained for each coefficient is applied to a quantizer table. The output from the quantizer table is a code word to be transmitted. This word can vary from 0 to 4 bits, depending on how much compression is desired.

The over-all bit rate may vary from 1.6 Mbits/s to as low as 200 kbits/s, depending on the contents of the quantizer.

The microprocessor simulating the ground station performs the inverse transforms on the data received, then sends the reconstituted one-eighth-picture-stripe information to the frame-store memory. The stripes are stored until a complete picture arrives in the memory. The picture is then sent to the TV monitor during retrace so that it doesn't disturb the readout of the frame-store memory as it updates the TV picture.

The transform computations on the 32-line pixels and on the vertical-stripe lines must be executed by 63.5 microseconds less in the ground system. The microprocessors have pipelined architecture and a fast instruction time—150 ns—which is more than adequate for the purpose. And both μPs operate under microprogram control from a 48-bit wide RAM microstore to which the PDP-11/40 has access.

The microprocessor speed is achieved not only from its pipelined architecture but also from its low-power Schottky elements. Propagation delays have been matched in the system using data latches. And parallel transfers are possible.

The Data/Ware system can not only compress images, but enhance them as well, according to Richard Keeple. This flexibility can be useful in enhancing low-contrast elements like medical X-ray pictures, among other applications. This has already been proved experimentally.

The PDP-11/40 is interfaced with the microprocessors so that various key registers of the subsystem appear as high-speed core-memory locations in the DEC computer. As a result, the minicomputer can directly modify the control-store contents within each microprocessor and directly interrogate or modify the various microprocessor registers. As a result, the μPs can be controlled directly by the minicomputer for simulation runs.

At present, the microprocessors require about 60 W, which is too much. But a CMOS silicon-on-sapphire equivalent looks like it will be available from at least two companies soon, Keeple says, which would solve the power problem.■■

How fast are you driving? That sign on the overpass knows

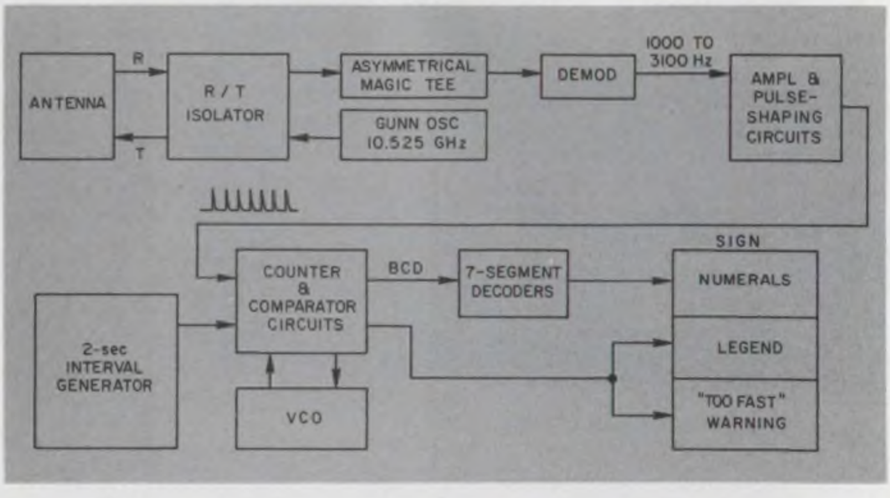
A radar-operated sign flashes on to warn motorists they're speeding—and tells how fast they're going. But to get the sign's X-band Doppler radar to work reliably from overpasses (see photo) or from overhead sign posts, two major problems had to be overcome: fluctuations in the Doppler returns because of multipath cancellations from cars approaching the sign, and interference caused by bidirectional traffic flow. The sign was developed by John B. Flannery, president of Transportation Safety Associates, North Billerica, MA.

A 100-mW, 10.525-GHz radar mounted in the lower end of the sign measures the speed of approaching vehicles up to 800 feet away. Doppler speed signals of 31.5 Hz per mph are converted by special circuitry into BCD signals that turn on 14-in.-high neon numerals, which display the speed.

Radar polices drivers

As a vehicle approaches, the radar takes measurements that are stored and updated every two seconds. If the car's speed is within a preset value, say 55 mph, the sign remains dark—as it does with no traffic. But if the speed exceeds that value by 1 mph or more, the exact speed is displayed for two seconds, turned OFF for two seconds, and then ON for two seconds in a repetitive cycle.

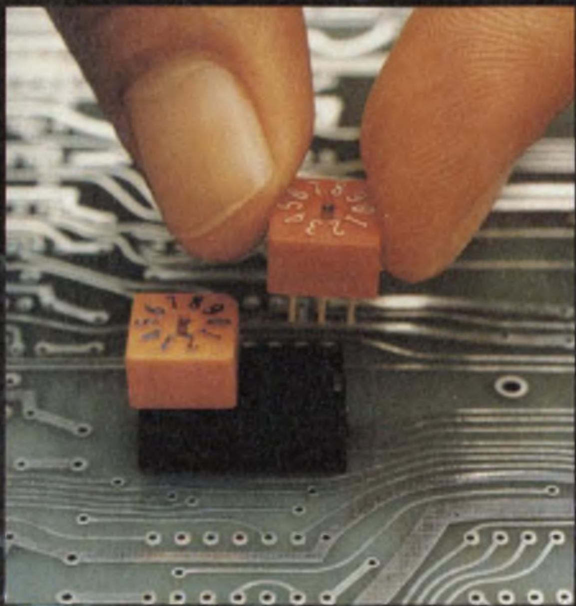
During the "on" portion of the cycle,

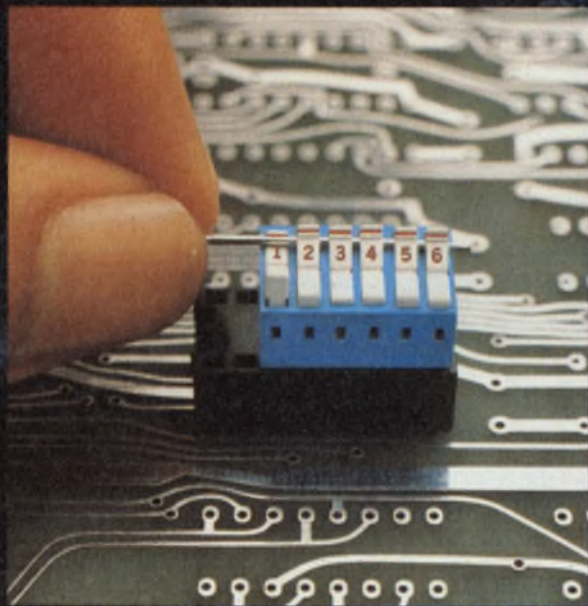


A 100-mW Gunn oscillator provides the CW power for this radar-based speed sign. Doppler signals from approaching cars are selected by the asymmetrical magic tee and passed on to counting and decoding circuits.

MICRO / MINI

DIP SWITCH **DIP SWITCH**





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A car approaching a radar sign installed in New Hampshire is being clocked at 60 mph, five miles over the legal speed limit.

legends in 8-in.-high neon letters also flash on to tell the driver: "YOUR SPEED IS..." and "REDUCE SPEED."

But the speed readings can be wrong —usually low—if multipath cancellations, or fluctuations in the received microwave energy, aren't corrected. These dropouts are caused by the interference of microwave energy reflected from the road with that reflected directly from an auto.

Besides developing the sign, Flannery came up with the solution to the cancellation problem. To begin with, the speed is determined by shaping the sine-wave Doppler output of the radar receiver and producing a string of pulses with it. These pulses are applied to gating circuits and counted for a specific gating period that is crystal-controlled.

When a multipath cancellation causes the Doppler-return pulses to drop out, a voltage-controlled oscillator (VCO) that tracks the Doppler pulses momentarily supplies the missing pulses. When the Doppler pulses reappear, they are compared with the VCO pulses. This comparison takes place at least five times during every two second "off" period. If the rates differ, the display is updated.

Opposing traffic problems

Another problem had to be solved: What to do where the sign is used over a road whose traffic goes in opposite directions. Doppler signals from the cars going away from the sign can interefere with those approaching it.

Because the Doppler signals (1000 to 3100 Hz) are such a small percentage of the 10.525-GHz carrier frequency, they cannot be separated by rf frequency filters. Flannery's solution, originally developed for a vehicle collision-avoidance radar, is to use an asymmetrical magic tee that is inserted between the receive/transmit isolator and the demodulator circuits (see Fig.). This proprietary device separates the approaching and receding signals on the basis of phase difference. It rejects the receding signals, and passes the approaching signals on to the demodulator circuits.

The radar sign is usually placed over high-speed lanes of highways, and the antenna beam width is shaped so that the vehicle in that lane will be the only one whose speed is measured. Amplitude gating is incorporated to ensure that the auto closest to the sign is measured.

The system can measure and display speed from 30 to 99 mph. But, usually the upper limit is set at 75 mph to prevent the hot rodders from checking their speed up to 100 mph. The displayed speed is accurate to ±1 mph. Optional outputs are available, such as printers to give the date, time, and speed of the offenders, and counters to measure traffic density.

The sign is being used effectively in several states. At Dulles Airport in Virginia, drivers have maintained slower speeds for up to five miles after passing a sign. In Iowa this slow-down effect has been measured up to 20 miles.

While the radar sign uses the x-band radar it can be updated with the newer Ku band units. ■■

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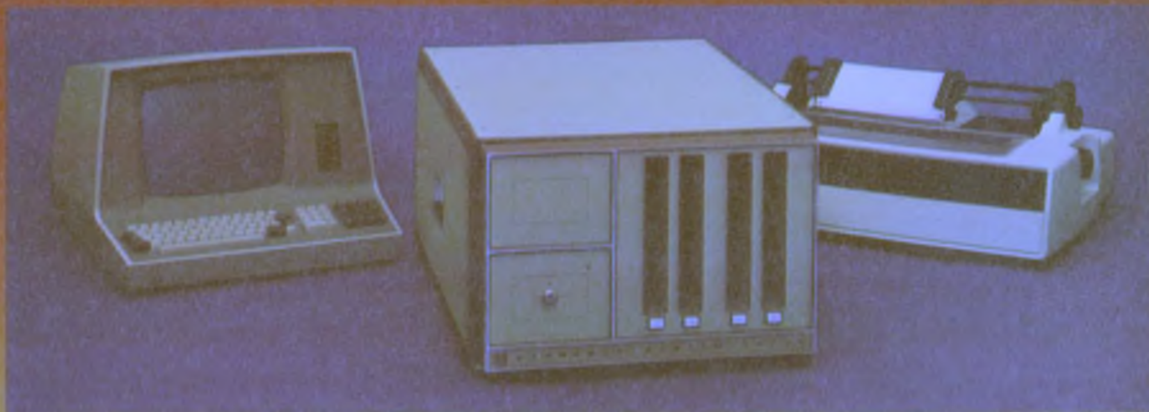

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CIRCLE NUMBER 28

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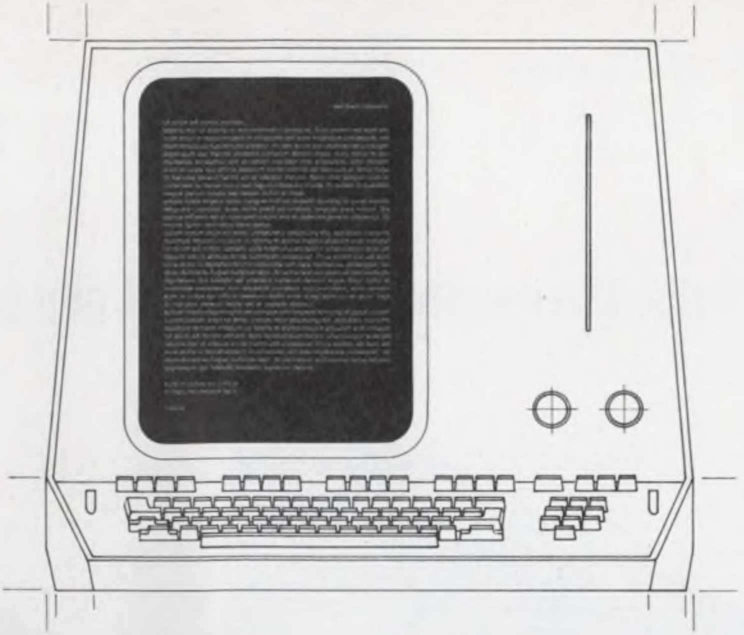

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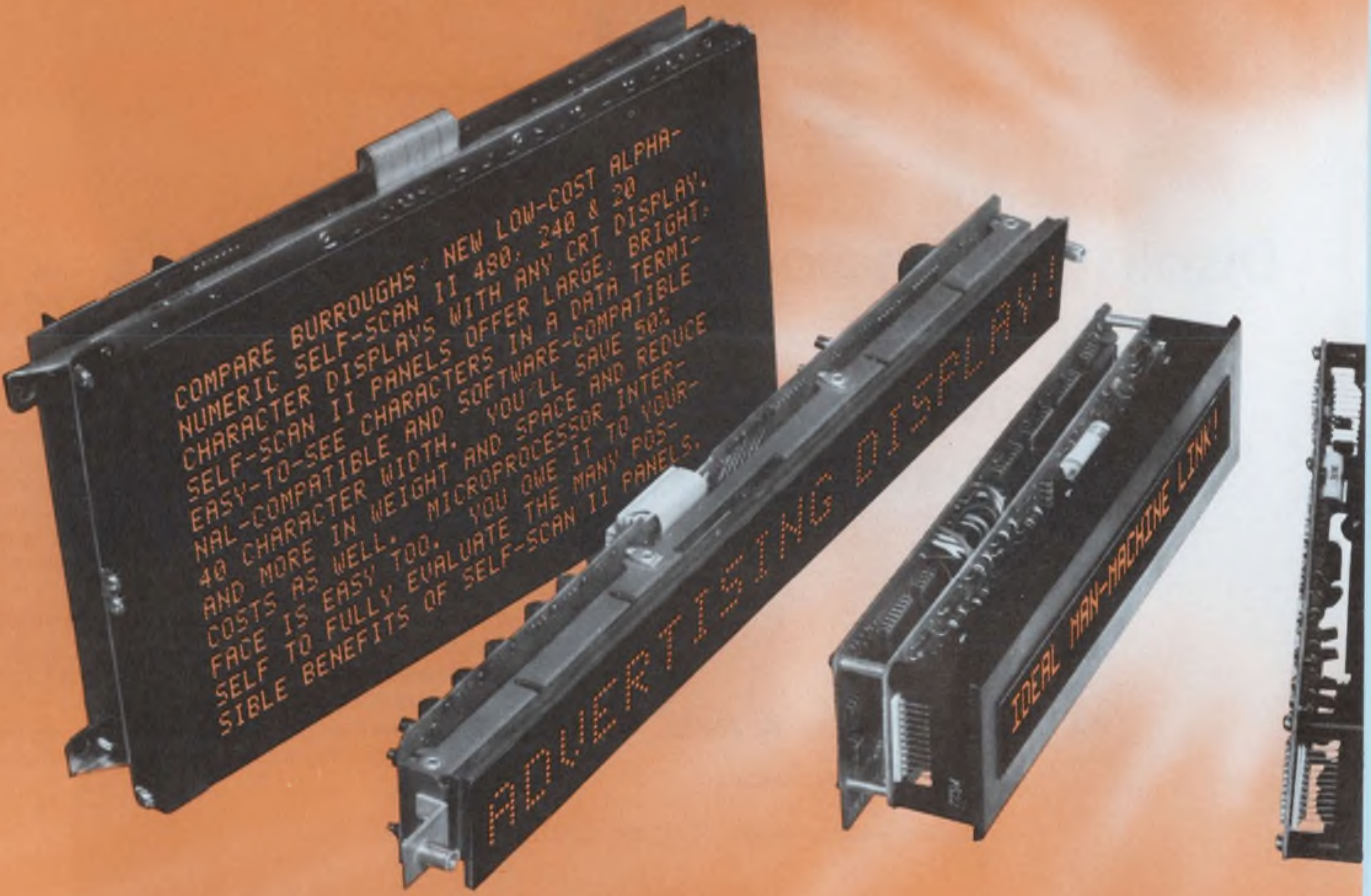

Burroughs SELF-SCAN displays provide bright, easy-to-read alphanumeric readout that will enhance the saleability of your product. Over one-quarter million have been built into everything from word processors to data terminals to paint matching machines.

And now they're easier than ever to use. Optionally available microprocessor-based controllers save you most of the time normally spent to "design-in" a display.

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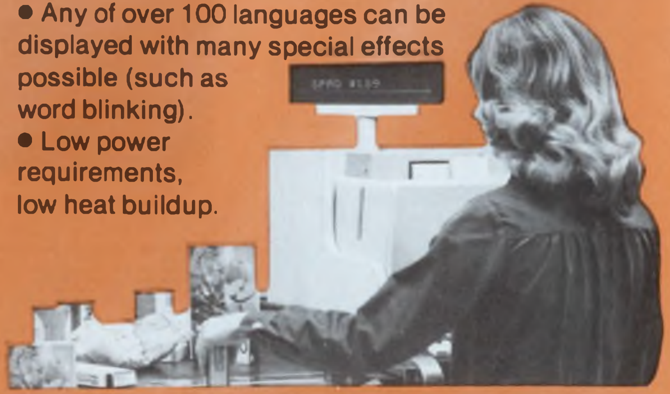
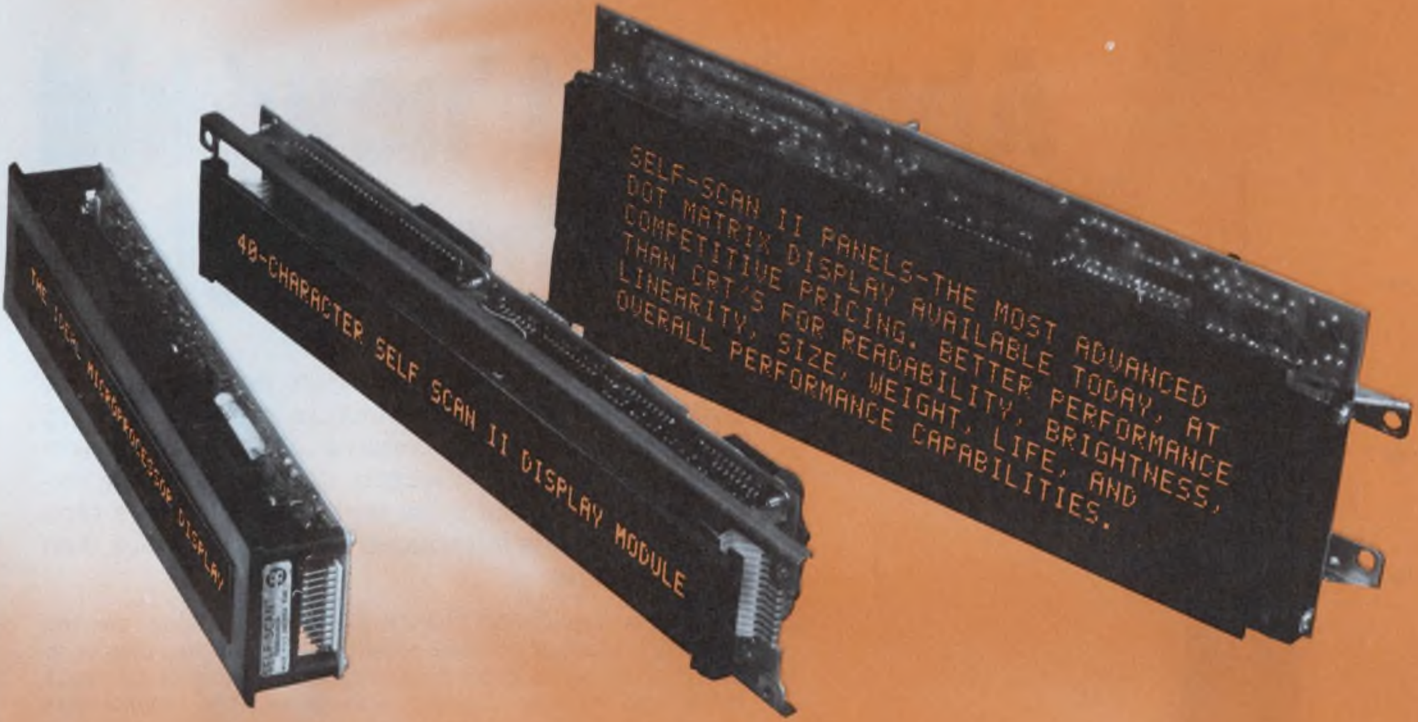
- Thin cross-section (under 2" with electronics) to keep your product's design efficient and low-cost.
- Neon-orange characters are uniformly bright, flicker- and distortion-free, easy-to-read in high ambient light and at night without eye strain.
- Easy interface with microprocessor-based systems.
- Any of over 100 languages can be displayed with many special effects possible (such as word blinking).
- Low power requirements, low heat buildup.



visual superiority

now available with microprocessor control.



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FOR GENERAL INFORMATION CIRCLE 30

FOR DETAILED SPECIFICATIONS CIRCLE 31

About that 'new' kid on the block...

Illustrated approx. 4x actual size

Actually, he's not that new. He's been around for quite a while now. Other vendors keep announcing miniature cylindrical ceramic capacitor 'innovations', but Sprague Electric, the pioneer in layer-built ceramics, can state with pride that this type of capacitor was introduced by Sprague more than ten years ago.

Sprague Type 292C MONOLYTHIC® Capacitors are the industry's best-constructed axial-lead capacitors, thanks to MFT*, a closely-monitored material modification of electrode metal and ceramic reacted with glass. The result—less capacitance change with temperature change, improved stability with life, and improved impedance with frequency characteristic.

These low-cost miniature capacitors feature a dimensionally-precise molded construction and can be ordered taped and reeled for automatic insertion. They are available in body formulations to meet characteristics Z5U (general-application), X7R (semi-stable), and C0G (NP0).

For complete technical data, write for Engineering Bulletin 6250B to: Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247.

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CIRCLE NUMBER 32

Washington report

John Rhea, Washington Bureau

Cruise missiles will cost over $8-billion

The air, land and sea-launched cruise missiles proposed by the Defense Department will cost $8.1-billion, the Department has reported to Congress in its latest Selected Acquisitions Report. The SAR, a quarterly analysis of major weapon-system costs, does not reveal how many cruise missiles will be ordered, but previous estimates have placed their cost at about $1-million each.

The ship-launched Tomahawk and a variation, the Ground Launched Cruise Missile, will be built by General Dynamics Corp., in San Diego, which is competing with the Boeing Co. in Seattle to build the third type, the Air Launched Cruise Missile. The Tomahawk will cost $2.4-billion, according to the latest SAR, while the GLCM, to be launched from combat vehicles, will cost $1.5-billion.

To determine the winner of the Air Force's ALCM, each company will build 18 test missiles for a competitive fly-off in 1979. That program, which is intended to supply strategic cruise missiles to be launched from B-52 bombers, is expected to cost $4.2-billion. The ALCMs must be operational by early 1980, according to the Defense Department, to fill the gap created when the B-1 bomber was canceled.

The McDonnell Douglas Astronautics division in St. Louis is supplying terrain-contour-matching (Tercom) guidance systems for all the cruise missiles.

Defense Dept. eyes new high-energy laser for weapons

The Defense Department has begun experimenting with a new "free electron" laser that is believed to be more lethal than conventional lasers. And it wants more money to develop high-energy laser weapons—from $150-million this year to $184.1-million in fiscal 1979.

Currently, lasers require a solid or gaseous lasing medium. But the essential physical interactions of the new laser occur within a spiraling, relativistic electron beam.

"This could provide a new option for high-energy lasers, with three times the efficiency previously achieved," according to Dr. William J. Perry, undersecretary for defense research and engineering. Speaking before Congress, Perry went on to say that the free-electron laser would be tunable from ultraviolet to infrared —unlike present systems, which are not continuously tunable.

The Air Force has already demonstrated lasing with the new technique. And if potential weapons based on the new laser prove effective, they could be used to defend ships, aircraft and satellites, according to Perry.

New ASW helicopter approved for development

Full-scale engineering development of a new antisubmarine warfare (ASW) helicopter has been approved for the Navy by the Defense Department—despite cost overruns that have driven up the price of one to $18.7-million.

The YSH-60B, also known as the Light Airborne Multi-Purpose System (LAMPS) Mark III, is a variation—with more avionics equipment—of the Army's Blackhawk troop-carrying utility helicopter. One Blackhawk costs $3.26-million.

Besides antisubmarine warfare, LAMPS is expected to be used for over-the-horizon targeting for the Harpoon cruise missile and possibly the Tomahawk. The helicopter will carry the new Control Data AYK-14 standard airborne computer and the Texas Instruments APS-124 long-range radar, as well as two torpedoes and 25 sonobuoys. The Federal Systems Division of IBM is the prime contractor and system integrator.

Development was approved by the Defense Systems Acquisition Review Council (DSARC) despite a report to Congress that program costs had jumped from $2.7-billion to $3.9-billion. The Navy attributes the increased costs to inflation, additional support requirements and schedule slippage.

The DSARC development decision will permit the airframe contractor, the Sikorsky division of United Technologies Corp. (Stratford, CT), to begin building the first prototypes. The company is already building Blackhawks.

The program will remain in the development phase until the fall of 1981, when the DSARC is scheduled to meet again to rule whether or not the LAMPS should be produced. The Navy is requesting funds for 209 LAMPS helicopters (including five prototypes), and the first flight is scheduled for late 1979.

Coast Guard seeks new helicopters

The Coast Guard wants a search, rescue and recovery helicopter, and is evaluating proposals from two American and two European manufacturers under a program expected to be worth $180-million.

Coast Guard officials say they want a helicopter that is already in production in order to eliminate costly research and development, but insist they won't be procuring it "off the shelf." The helicopter must have improved avionics, such as search and weather radars—which current search and rescue helicopters don't have—an area navigation system, and the latest technology autopilot.

One American competitor, the Sikorsky division of United Technologies Corp., is proposing its new S-76 commercial helicopter. The other, Bell Helicopter Co., a Textron division in Fort Worth, TX, is proposing its Model 222. Great Britain's Westland Helicopters is offering its Sea Lynx WG-13 and France's Aerospatiale a version of its Model 365. Whichever helicopter is chosen will have to be modified extensively for the Coast Guard's special requirements, such as the advanced avionics and a hoist for rescue operations.

The Coast Guard expects to make its selection in early 1979 and receive the first fully certified helicopter two years later. Funds for the first 10 have been appropriated in this year's Transportation Department budget, and authority to procure five more is being requested in the fiscal 1979 budget. The Coast Guard expects the procurement to be completed within five years after the initial deliveries.

Capital Capsules: Fairchild Space & Electronics Co., Germantown, MD, has been selected to build **the first two Landsat-D earth-resources survey satellites,** to be launched in 1981. The contact, still being negotiated with the National Aeronautics and Space Administration, is expected to be worth $10.3-million and to include options to produce four additional spacecraft for future programs....**The Air Force now confirms that it plans to buy 20 of the new TR-1 spy planes,** which will fly at 430 miles per hour, with a range of more than 3000 miles and a ceiling described only as "above 70,000 feet." The Air Force will buy them from Lockheed Aircraft Corp., Burbank, CA, as part of its plan to reopen the U-2 production line there (see Washington Report, ED No. 5, Mar. 1, 1978, p. 31). The first six TR-1s will be procured in fiscal 1980, which begins Oct. 1, 1979. To do that, the Air Force plans to seek $97-million in addition to the $10.2-million being requested for fiscal 1979.

Fast Relief for the "Typical Spec" Headache

"Typical Specs" Are a Pain

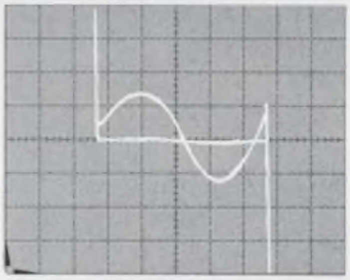
The next time you're searching through component spec sheets for a characteristic best suited to your design, the word to watch out for is "TYPICAL."
Typical specifications can be devilish creatures. Ask any design engineer who has ever believed in them. When you need answers in black and white, they turn gray and disappear in the fog. Until you determine what the MIN., MAX, or typical value really is, you've got headaches. Headaches not just for you, but for everyone on down the reliability line —from QC to your field service people.

Curve Tracer A Quick Cure

There's an age-old cure for the headaches caused by typically elusive specifications. It's called a Curve Tracer. TEKTRONIX Curve Tracers aren't new. We introduced our first one in the days of vacuum tubes.
Since then Curve Tracers have performed wonders for semiconductor manufacturers, component evaluators, incoming QC inspectors and reliability engineers.
We prescribe them for design engineers because the earlier you can diagnose a problem, the less of a problem it will be.

A Picture of Health

If you need to examine a component, it's a good idea to start with its vital signs — current and voltage. And we all know that the best way to understand the voltage/current relationship is to look at a graph.



Two Op Amp gain curves at different sensitivities in the storage mode.

TEKTRONIX Curve Tracers graph voltage vs. current in digital and linear ICs, 2- and 3-terminal devices...transistors, diodes, rectifiers, thyristors, optoisolators and more.
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CAUTION
TEKTRONIX Curve Tracers are mildly habit-forming. Once you use one, you'll wonder how you ever survived without it.

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Dialight is the first place to look. We make just about any kind of illuminated push button switch that anyone could want . . . Single lamp, dual lamp, neon, incandescent, LED lighted, you name it.

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And if you're looking for rear panel or front bezel mounting switches, switches with momentary or alternate actions, or high quality switches for computer applications, we have them.

You'll find that Dialight switches are not only available at a reasonable price, they're also available with some very attractive features. Lamp removal is from the front so you don't have to remove an entire switch just to change a lamp. And you never have to use anything more complicated than your fingers for replacement or installation.

Along with outstanding variety and design, you get superior Dialight quality. Most Dialight switches are Underwriter's Laboratory listed and CSA approved.

And Dialight distributors are widely located throughout the United States, Canada and worldwide.

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CIRCLE NUMBER 35

Editorial

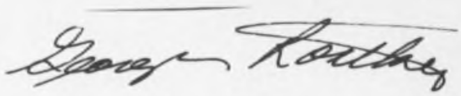
The frozen mind

I was discussing power supplies with Charlie the other day. We were arguing the relative merits of linear and switching supplies, and though he knew, or should have known, that I had been studying power supplies for many years, he remained adamant. He had apparently made up his mind years ago and wouldn't budge. He adhered rigidly to his old opinions and seemed unable to accept my facts.

I had a similar problem with Jack, and we weren't even discussing something that affected us professionally. I don't remember what it was that we argued about. It may have been apartheid in South Africa, the Food and Drug Administration, the value of Vitamin E in treating burns, or the relative merits of Chinese and French cuisine. I do remember that Jack was thoroughly rigid and his mind was closed. He had done some reading on the subject and didn't realize that his authors were biased—despite my showing him that, from *my* reading, I knew the facts.

It's sad to relate that my experience with people who confront my facts with their opinions is not limited to Charlie and Jack. Indeed, I've had such experience with dozens of people on dozens of subjects. And though I would expect them, in time, to develop some humility, they still suffer from the illusion that they are right.

I find the problem particularly rampant in our industry. Engineers frequently make design decisions based on insufficiently considered opinions and faulty evidence. And executives make business decisions the same way. That's unfortunate. Things would be lots better if they'd ask me.



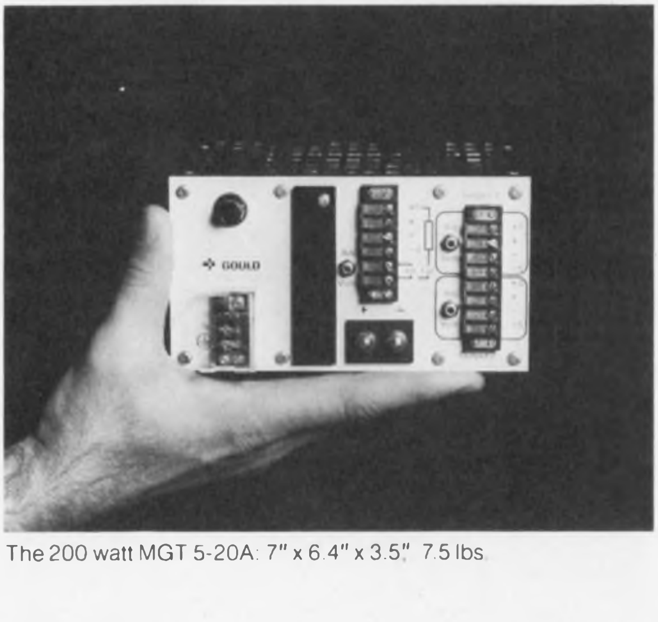
George Rostky
Editor-in-Chief

We're deeply honored that the American Business Press has conferred on George Rostky, for the third year, its coveted Neal Award Certificate for Editorial Excellence. The Neal Awards are considered the business-press equivalent of Pulitzer prizes. Rostky's award was for the "Best Series of Editorials."

Keep those cards

The big switch

...is to smaller lighter switchers.



The 200 watt MGT 5-20A: 7" x 6.4" x 3.5", 7.5 lbs.

Switching power supplies average about ⅓ the size and ¼ the weight of linears. And in many applications that's reason enough to make the switch. But it's not the only reason. Compared to linears, switchers can cut energy consumption in half, generate far less heat, and offer better holdup protection. That's why more than 40,000 Gould switchers are already in use around the world.

Gould offers single and multiple output units with power levels from 8 to 2,250 watts. And custom designs can be provided to meet your exact specifications. You'll be backed by a high volume production capability and worldwide service network that only a $1.5 billion company like Gould could offer.

For more information or to arrange for an evaluation unit contact Gould Inc., Electronic Components Division, 4601 N. Arden Drive, El Monte, CA 91731. Telephone (213) 442-7755.

Gould.
The power in switching power supplies.

GOULD

CIRCLE NUMBER 36

Diagnose computer ills

with an analog monitor. It's inexpensive, very easy to build, and does not interfere with computer operation.

When you want to locate and correct computer-system bottlenecks or look for unused capacity, consider using an analog monitor. It doesn't cost much to build and operate, it monitors the system continuously, and its accuracy isn't as limited as that of other methods. For example, digital simulation techniques require a high level of detail to be accurate, and software monitors are limited by their sampling rate.

Like the monitors in an intensive-care hospital ward, an analog monitor measures vital signs—in this case, a computer's. In fact, the charts it produces, even look very much like electrocardiograms or encephalograms.

The analog monitor's measurements are automatically plotted in real time (Fig. 1). You don't need an expensive minicomputer, nor additional analysis on your host computer. Because the plotter records two traces simultaneously, you can also examine Boolean relationships.

These graphs can help the computer designers in locating and correcting system bottlenecks, and similar problems, as will be demonstrated by six case studies.

A do-it-yourself "encephalograph"

Connect a monitor to your system with a high-impedance, passive probe. It won't affect your "electronic brain's" operation (Fig. 2). Heat-shrinkable tubing (broken lines) protects the external resistors and capacitor.

The selected probe circuit components smooth out high-frequency digital signals. Resistors R_1, R_2 and R_3, along with capacitor C, form a low-pass filter. If the probe is connected across a low-impedance indicator bulb, the chosen component values provide a time constant of about 15 s, which corresponds to a moving average over approximately one minute (4T = 58.67 s). A very high output impedance at the test points increases the averaging time to 88 s. If you prefer a faster response, use lower-value resistors or capacitors in the probe (Fig. 3.) Larger component values expand the averaging interval.

Ronald Zussman, Senior Consultant, Securities Industry Automation Corp., 55 Water St., New York, NY 10041.

Before you assemble the probe, check the ZERO and ONE voltage levels at the connecting points, and use a capacitor rated for the appropriate voltage range. The capacitor in the parts list is rated at 10 V, which is an adequate choice for most applications. You can minimize noise pickup by keeping the probes short and —where feasible—using low-impedance connection points such as indicator bulbs. Test points can be as far as 50 ft from one another, provided you can place the chart recorder midway between them.

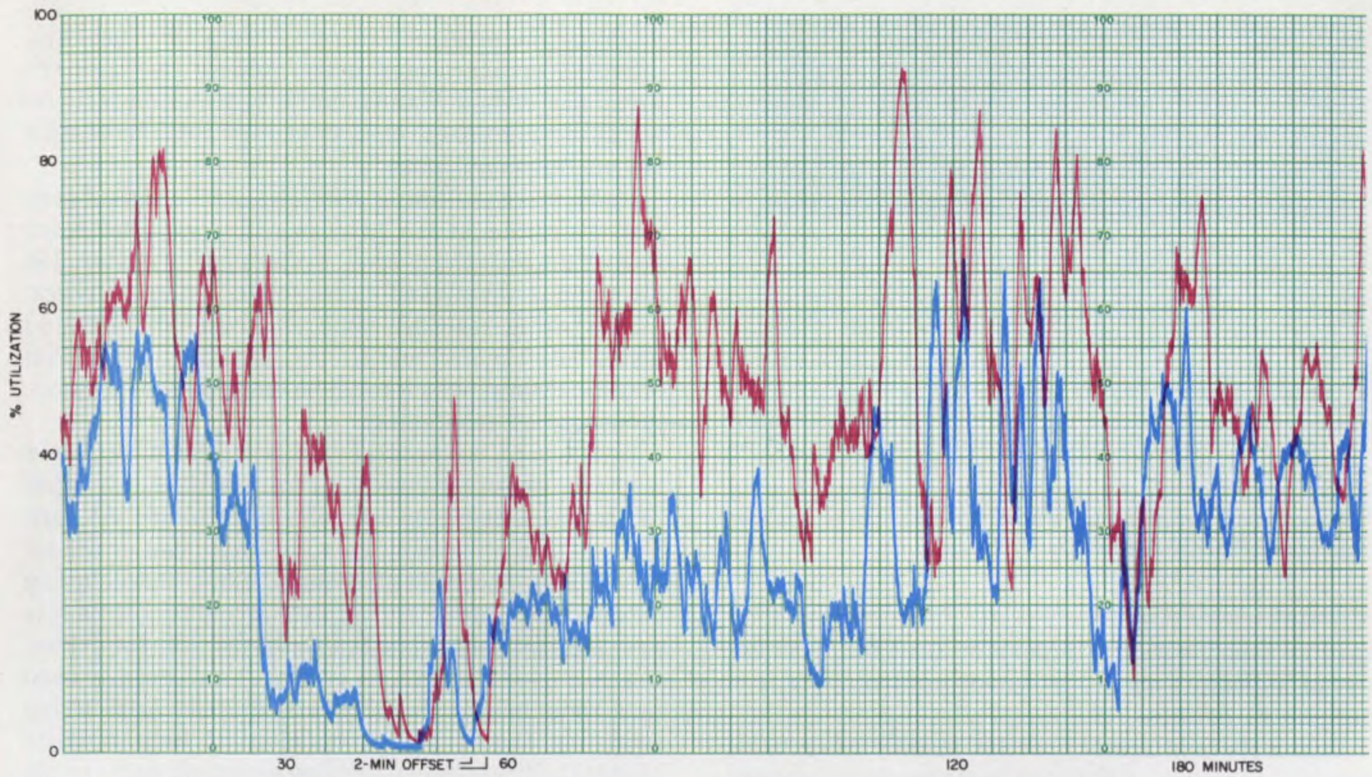
To speed up measurements, connect several sets of probes to the host system simultaneously, and connect the chart recorder periodically to different probes. You can leave the probes connected to the "patient" even when you remove the chart recorder at the other end.

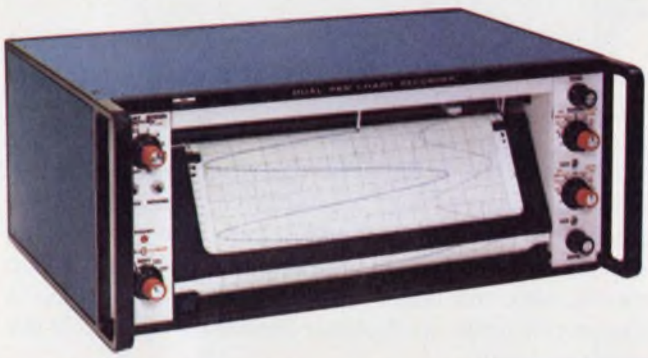
Pick the right recorder

The monitor requires a recorder with high-impedance floating inputs, and zero adjustment as well as sensitivity controls. A Heath-Schlumberger Model SR-206 dual-pen strip-chart recorder or its equivalent works well, because it's versatile, reliable, and reasonably priced. Along its vertical axis the chart is ruled in 5% increments, and chart speed is most convenient at 0.1 in/min.

While the recorder can handle logic levels ranging from millivolts up through several hundred volts, probe-circuit components have to be modified at higher voltage levels. A chart recorder with separate calibration controls and independent floating input for both channels can accommodate both negative (ONE more negative than ZERO) and positive (ONE more positive than ZERO) logic.

To calibrate the monitor, place the chart paper for the correct time reading. If one pen is offset with respect to the other to avoid pen interference, note





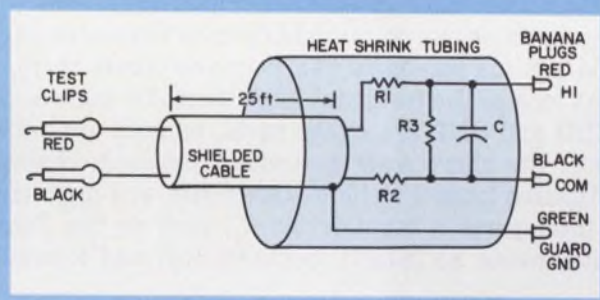
1. **A dual-pen strip-chart recorder** like this Heath SR-206 is the heart of the described analog monitor. The chart plots total CPU utilization (red) and an application program's contribution (blue) to show supervisor overhead (see also Fig. 4f).

to which pen the time scale applies.

Calibrate the two recording channels separately because they may have to be adjusted for different logic levels (e.g. if the probes go to different parts of a system). First check that the polarity is proper for the probe's electrolytic capacitor by making sure the voltage at the red banana plug is always positive with respect to its black companion. If it isn't, reverse the test clip connections.

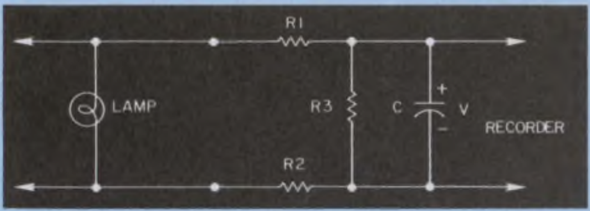
Now adjust the null control at logic level ZERO, and then the gain control to full scale with a logic-level ONE input. Chart-recorder drift is usually small enough so recalibration is needed infrequently.

You're now ready to start with the analysis. The monitor probes can frequently be connected directly across indicator bulbs or light-emitting diodes (LEDs). An IBM 370/155 system-control panel contains almost 500 bulbs, and with the help of dial switches they can display the status of approximately 1500 bits of information. It is very likely that some subset of these indicators will satisfy your monitoring needs. If a computer manufacturer has taken the trouble to provide an indicator lamp for a function, you can



Quantity	Description
	Micro Grabber test clips (ITT, Pomona, CA)
2	black: model 4233-0
2	red: model 4233-2
6	resistors, 100 kΩ, 1/4 W, 1% accuracy (Allen Bradley cermet film)
2	tantalum capacitors, 220 μF, 10 WVdc (Sprague type CSR-13)
50 ft	2-conductor shielded #22 stranded wire conductor size: (Alpha type 3221)
	heat shrinkable tubing:
1 ft	3/16 in.
1 ft	1/2 in. (Voltrex type FPS)
	banana plugs:
2	red
2	black
2	green

2. **The probe schematic and parts list** show how easily the analog monitor can be assembled.



$$T = \frac{(R_1+R_2)R_3}{R_1+R_2+R_3} C$$

If $R_1 = R_2 = R_3 = 100\ k\Omega$, $C = 220\ \mu F$:

$T = 14.67$ s

3. **The equation for the monitor's time constant** is valid if the test-point impedance is much lower and the recorder impedance much higher than 100 kΩ.

assume that function is important. Look for pertinent signal indicators on the processor, control units, and peripheral devices.

Take a spare indicator bulb and modify it to provide a monitor connection that can be conveniently plugged into one of the front panel indicator sockets: Join the electrical connections from its base to a second "piggybacked" indicator lamp, and attach the probes in-between.

If there is no convenient indicator for the desired signal, you may have to access the host system's backplane or logic gates. Your probe connections will frequently be test points used for troubleshooting, and field service personnel can help you locate them.

As long as the test point impedances for logic levels ZERO and ONE are either equal, or both are under 2 kΩ, the chart scale accurately indicates channel utilization from 0 to 100%. Otherwise, you may have to intersperse a lamp-driver IC, such as the Texas Instruments SN75450B, between host and monitor.

Put your system on the couch

The six following examples show how the monitor can diagnose system bottlenecks or imbalances.

CPU waiting for I/O (Fig. 4a): The negative correlation between CPU and channel readings indicates that the CPU waits for I/O completion before it resumes processing. Simultaneous processor and I/O activity would be much more desirable.

Excessive overhead (Fig. 4b): This virtual memory system has a very heavy operating-system overhead and a high paging rate. Turnaround and response times degrade because of contention for real memory and heavy disc activity. Reducing the number of initiators would remove the overload, and increase operating efficiency. Another solution is to disable the system resource management program. Although this program is supposed to optimize system performance by controlling critical resources, it can hog CPU cycles for itself. So when CPU activity gets extremely high, disabling the program entirely lowers CPU use, and improves system performance. Adding real memory would also reduce channel activity, as would restructuring of programs so that associated portions of code are on the same "page."

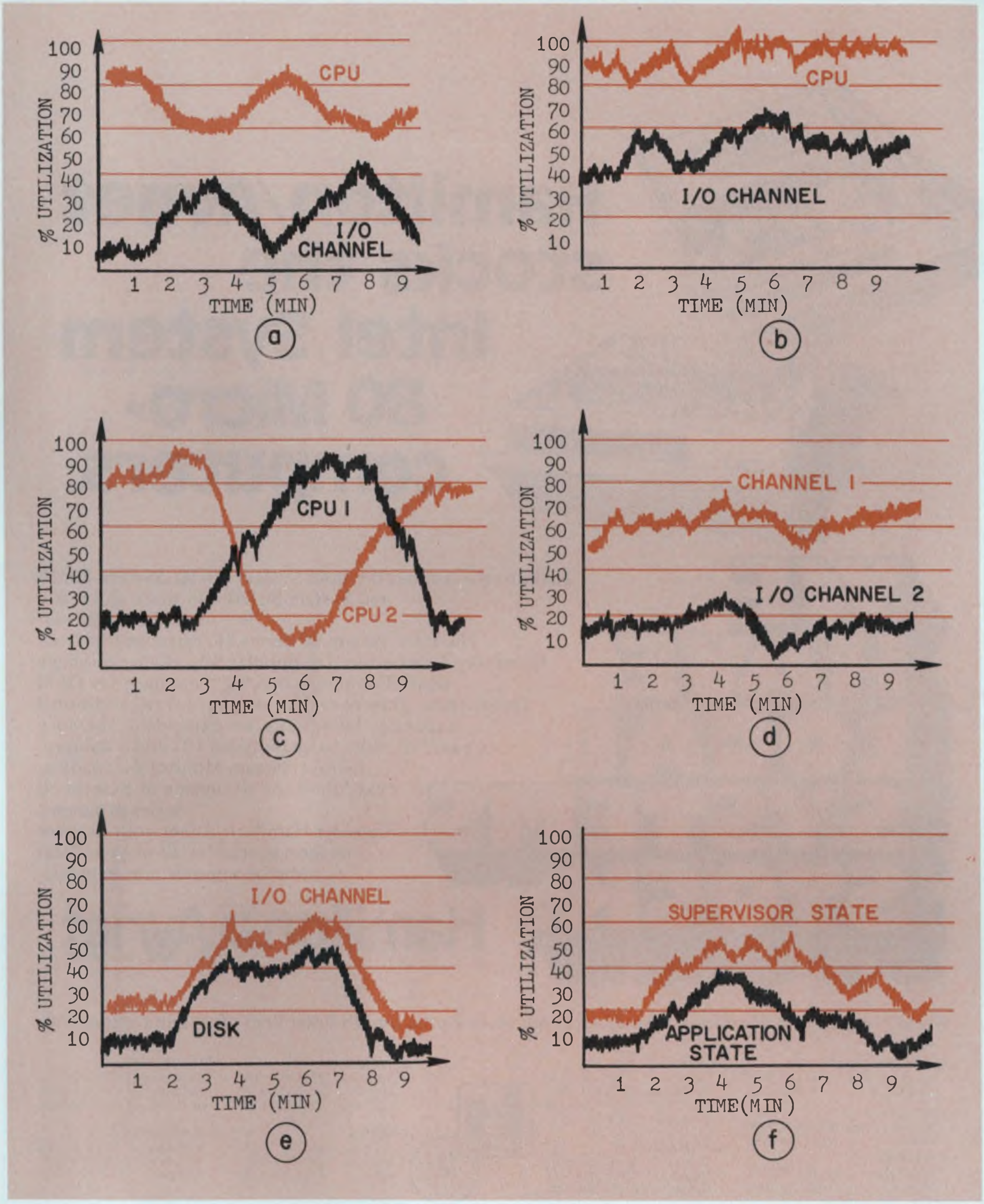
Unbalanced multiprocessor (Fig. 4c): Periods of very high utilization at any processor in a multiprocessor system degrade the over-all system performance. Job throughput drops and turnaround times increase. Time-sharing response time and batch turnaround would both benefit from a more balanced distribution of the workload, which could be accomplished by more judicious job scheduling.

Unbalanced multiplexer (Fig. 4d): Disc multiplexer channels are unbalanced so that the 60% utilization of channel 1 degrades over-all performance. At such high channel utilization, the rotational-position sensor of IBM 3330 discs misses reconnect slots, thus delaying data access for another complete revolution. Data sets and disc packs should be redistributed over the drives, to achieve greater channel overlap. Concurrently used data sets belong on separate drives. And string switching should be implemented to help equalize channel utilization by providing alternate paths to the discs.

Channel hardware problem (Fig. 4e): For efficient operation, disc channels disconnect during seek and latency times. The utilization of a block-multiplexer channel is ordinarily much less than the sum of the utilizations of its discs. In the 10-min time span of Fig. 4e, I/O operations are initiated primarily on the monitored disc. Yet channel and disc utilizations almost coincide because the channel is being tied up during seek and latency times. A hardware problem causes this block-multiplexer channel to operate in the selector mode.

Excessive supervisor overhead (Fig. 4f): Total CPU utilization is the sum of application and supervisor-state processing. In Fig. 4e, total CPU utilization peaks at 90% (40% application plus 50% supervisor). It is often difficult to determine which—if any—application tasks can be attributed to supervisor processing. So make certain that all definitions are clear, and that you know what CPU time is being charged to which program before drawing conclusions. (The actual recording from which Fig. 4f has been extracted is shown in Fig. 1.)

Effective as analog monitoring is, it does not replace more sophisticated measurement techniques. Digital monitors, for example, are much more expensive, but they can perform logic operations and permit connection of many probes to the host system. While you may end up using a digital monitor, it's only sensible to try the inexpensive analog approach first. The greatest dollar improvements in computer performance often occur early in the project, and analog monitoring can pay big dividends by helping you to find and overcome problems. As a bonus, management gets an early indication whether the computer meas-



4. **System problems discovered by the monitor** include: CPU waiting for I/O (a), excessive overhead (b), unbalanced multiprocessor (c), unbalanced channels (d), channel hardware (e), and high supervisor overhead (f).

urement program should be extended. ■■

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Take advantage of powerful instructions

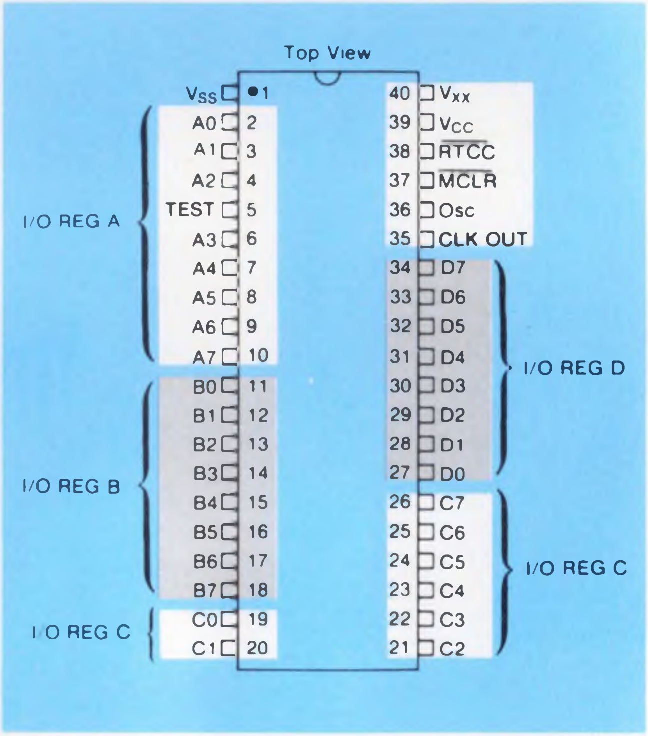
in the PIC-1650 microcomputer chip. Its 12-bit instruction size and the register-file architecture make a potent pair.

Based on register-file architecture, the PIC-1650 all-in-one microcomputer uses a 12-bit instruction word, which gives the processor a powerful instruction set. The processor also has an 8-bit arithmetic-and-logic unit, 31 directly addressable 8-bit registers and a 512-word (12-bit size) ROM space.

Programming the PIC-1650 is both easy and economical—all nonjump instructions can be written in a single line, including both operator and operand, and executed in 4 μs (assuming the processor operates at a 1 MHz clock). Jump instructions take twice as long. There are 30 basic instructions in the processor's command set—18 arithmetic and logic operations, eight literal functions, and four individual bit operations.

Manufactured with General Instrument's n-channel ion-implant process, the 8-bit PIC-1650 requires just a 5-V supply. Packaged in a 40-pin DIP, the chip has 32 user-defined I/O lines, a clock generator that provides all internal timing, and an 8-bit counter/timer. (The PIC-1650's software-compatible smaller cousin, the PIC-1655, has 20 I/O lines and comes in a 28-pin DIP.)

Besides the 32 I/O lines, there are just eight more lines to connect into a system—and three of those are for power and ground. The other five are for an oscillator input, clock output, counter/timer input, master clear, and an unused pin (Fig. 1).



1. **There are few control pins** on the PIC-1650 microcomputer chip. Of the 40 pins, 32 are I/O lines, each of which can act as either input or output lines.

Internal workings of the PIC-1650

The 1650's register-file architecture permits simple commands for bit, byte and register transfer operations. The processor's three major sections—the register file, an ALU and the control ROM—are all linked by an 8-bit bidirectional bus (Fig. 2).

The register file is divided into two functional groups that total 31 8-bit registers. The first eight registers, F_1 to F_8, are operational registers and the rest are general-purpose registers (F_9 to F_{31}). Register F_1 works as the real-time clock/counter and can be incremented by an external signal; F_2 is a 9-bit program counter (the ninth bit comes from one bit of the F_3 register). F_3 is the status-word register; F_4 forms an indirect addressing register; and F_5 to F_8 are I/O registers that function as directly addressable TTL-compatible I/O ports.

The eight operational registers are similar to the general-purpose registers in that they can be loaded, incremented and logically operated on by any instruction servicing any of the registers.

The timer/counter (register F_1) can be used to keep track of elapsed time since it can be updated or read via software control. It accepts external pulse inputs

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The PIC-1650 instruction set

Even though the PIC-1650's instruction set has only 30 basic commands, there are many features that are hidden because of the large word size. For example, most instructions execute in a 4-μs period unless a conditional test is true or the program counter is changed as a result of an instruction. In these two cases, the instruction execution time climbs to 8 μs.

There are two addressing modes available to the 1650—direct and indirect. In the direct mode, the address of the register being addressed is contained in the instruction. For the indirect mode, the program instruction contains the address of a register that, in turn, contains the address of the instruction or data to be acted upon. The indirect mode is handy for operations that must be carried out repetitively to data stored contiguously in memory, since only the contents of the indirect register must be incremented to point to another location.

To use the indirect mode, the FØ file must be accessed (this is the 32-file register). The FØ register is not an actual register in the processor—however, when FØ is specified in an instruction, the instruction decode logic interprets the register number as the register pointed to by the file-selector register (F4).

The 30 instructions of the PIC family of microcomputers are in the accompanying table. Various abbreviations used in the table include k to represent an 8-bit constant or literal value, f to represent a file-register designator, and d to represent a destination designator. If d is zero, the result of an operation is placed in the 1650's W register. If d is one, the result is returned to the file register specified in the instruction. If the d operand is omitted, the f register is assumed to be the destination.

When the PIC assembler is used, f and d may be numbers, characters or symbols. Additional abbreviations used in the table include C, which represents the carry bit; Z, which represents the zero bit; and DC, which represents the BCD-digit carry bit.

General file register operations	
Mnemonic	**Definition**
NOP	No Operation
MOVWF	Move W to f
CLRW	Clear W
CLRF	Clear f
SUBWF	Subtract W from f
DECF	Decrement f
IORWF	Inclusive OR W and f
ANDWF	AND W and f
XORWF	Exclusive OR W and f
ADDWF	Add W and f
MOVF	Move f
COMF	Complement f
INCF	Increment f
DECFSZ	Decrement f, Skip if Zero
RRF	Rotate Right f
RLF	Rotate Left f
SWAPF	Swap halves f
INCFSZ	Increment f, Skip if Zero
Bit level file register operations	
BCF	Bit Clear f
BSF	Bit Set f
BTFSC	Bit Test f, Skip if Clear
BTFSS	Bit Test f, Skip if Set
Literal and control operations	
RET	Return
RETLW	Return and place Literal in W
CALL	Call subroutine
GOTO	Go To address
MOVLW	Move Literal to W
IORLW	Inclusive OR Literal and W
ANDLW	AND Literal and W
XORLW	Exclusive OR Literal and W

at up to 250 kHz. Keeping track of the program flow, program counter (PC) F_2 automatically increments after each program instruction. It is nine bits wide so that it can address the full 512 words of ROM-based control memory. However, aside from being fed directly to the ROM address inputs, the output of the PC cannot be read by the processor.

Holding all the flag information from logic and arithmetic operations in bits 0 to 2, status word F_3 (Fig. 3) has four more bits allotted for future expansion. The eighth bit is used as bit nine of the PC. Bit O stores an arithmetic carry (C) and acts as a link bit on rotate operations. Bit 1 stores the carry-out of the four lower-order bits for decimal arithmetic operations (DC) and is used to simplify operations done with BCD arithmetic. Bit 2 gets set to ONE when the result of an operation is zero (Z). The function of bit 3 has not yet been defined.

Each of the I/O lines on "ports" F_5 to F_8 have a fanout of one standard TTL load, and a sink capability up to 14 mA (which enables them to drive LEDs directly, among other things). However, to provide the high drive, you need a 10-V supply on the V_{XX} line to turn on the chip's drive transistors.

Since the ports are really registers, they can be directly incremented (to provide a counter output), shifted (to do display scanning), or bit set or tested (to provide single-line logic control or sensing). And, of course, they can be operated on by logic and arithmetic commands.

The 512-word ROM on the chip is custom-programmed at the factory according to the pattern defined by the user during program development. For program development, another chip is available, the PIC-1664, which is a ROM-less version of the 1650. Housed in a 64-pin package, the 1664 has ROM address lines for external use, so that programs can be developed with either fusible-link or ultraviolet erasable PROMs.

You can get more addressing capability. Just make I/O lines function as address lines by using the Bit Set and Bit Clear instructions. Instructions pointed to by the program counter are transferred from either the internal ROM or external PROM via a 12-bit-wide bus to the instruction decode and control section of the processor.

Also in the processor is a two-level push-down stack for storing the current value of the program counter before a subroutine is accessed. The subroutine CALL operation code is contained in the first four bits of the instruction and the address of the subroutine in the other eight bits.

Programming the processor

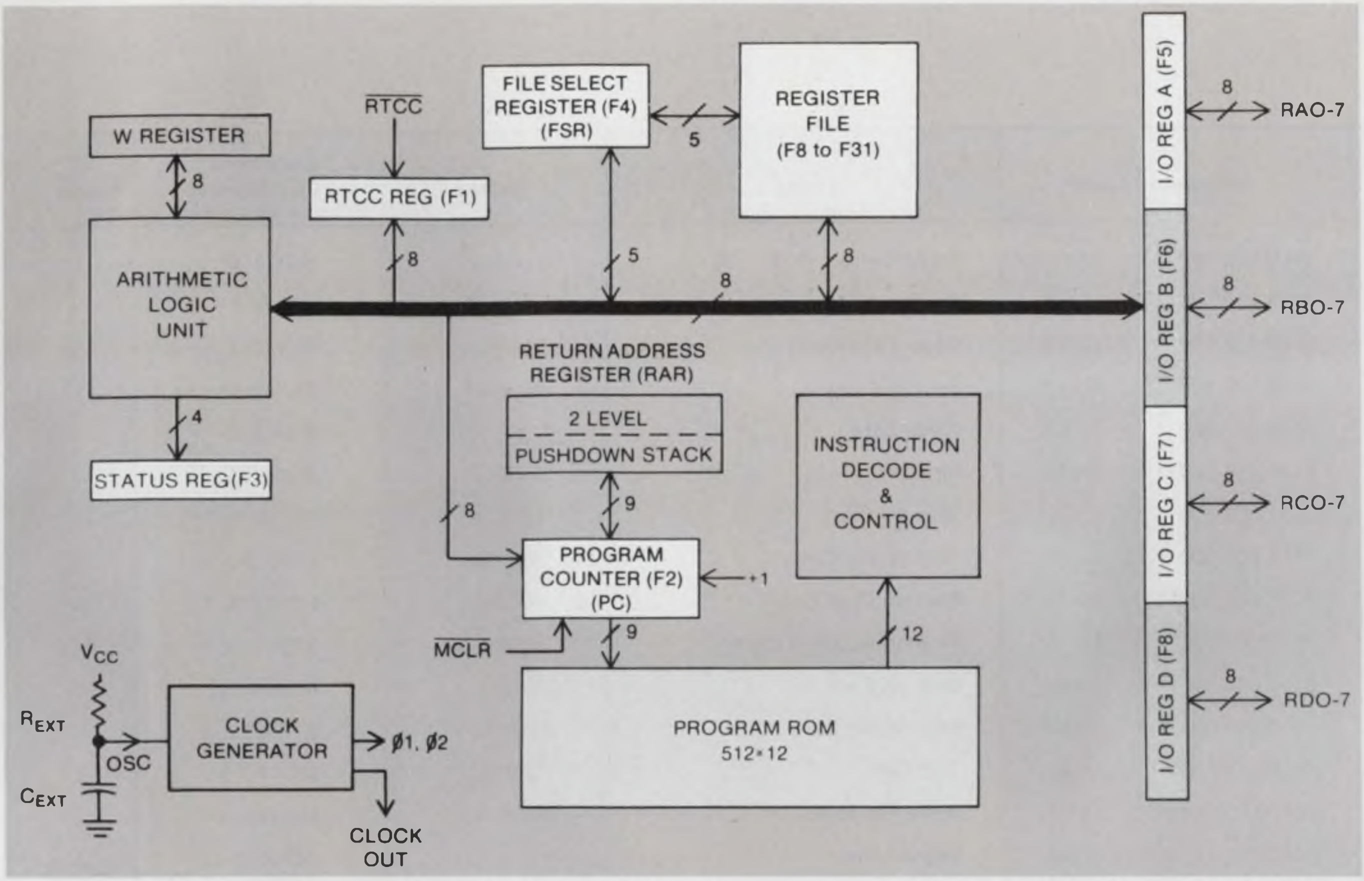
Program development can be supported with an assembler that responds to 26 additional instructions (Fig. 4). For instance, the instruction "BTFSC 3, 2" skips on bit 2 of file 3 in the same way as "BTFSC 30, 2" skips on bit 2 of file 30—except that in the first case bit 2 of file 3 is the zero bit of the status register and the operation is the same as a Skip on Zero. As a result, the assembler uses a SKPZ instruction as the equivalent of the "BTFSC 3, 2" command.

Any operation can be performed with any file, except for the program counter, which can be written to but not read. The result of an operation can go either to the referenced file or to a working register. Thus, the assembler instructions like Test File can be generated by a "MOVF f, F" (Move file f, leaving the result in the file rather than in the working register). The assembler mnemonic "TEST f" is interpreted to mean the same as a "MOVF f, F" instruction.

Available software-development aids (see table) include the PIC 1650 assembler, which permits symbolic source programs to be developed. The assembler translates the source program into object code and produces a binary paper tape that, in turn, can be used to generate the ROM mask pattern to program the chip. Two versions of the assembler are available—one is written in Fortran IV and can run on most popular minicomputers and larger systems; the other runs on General Instrument's Gimini development system for the 16-bit CP1600 MP.

Software and hardware support

Type	Description	Cost
Gimini	16-bit development microcomputer based on CP 1600 — General Instrument microelectronics' 16-bit microprocessor	$2995
PIC assembler	2-pass mnemonic assembler. FORTRAN version available that will run on 16-bit mini computers and large machines	Free with Gimini
PIC simulator	Software simulator of PIC 1650 including mnemonic assembly and disassembly as well as breakpoint and other debug facilities. FORTRAN version available that will run on 16-bit minicomputers and large machines	Free with Gimini
PIC 1664	64-pin version of PIC 1650 with ROM off chip, thus allowing external program to be run from RAM, PROM, or EAROM	$99
Development System (DB 1650)	Machine-code development system with debug facilities	$700
PIC field demo system (FD 1664)	PC card with PIC 1664 and PROM sockets. 40-pin plug emulates PIC 1650	$220



2. **Inside the PIC-1650** are 31 randomly accessible registers, an 8-bit counter/timer, storage space for up to 512 words of program memory, an ALU and a clock-generator circuit. Other versions of the processor are available with more program storage space, fewer I/O lines, or no internal program storage.

(3-7)	(2)	(1)	(0)
not defined	Z	DC	C

3. **File register F3** contains all the status information generated by operations in the processor. Four of the eight bits have not yet been assigned for functions.

Another aid, the PICSIM simulator program, lets you debug programs rapidly by communicating interactively with the processor. Besides simulating the PIC-1650 processor, the PICSIM allows breakpoints to be set and can do comprehensive on-line debugging. It also includes both assembly and disassembly capability to permit programs to be modified at the mnemonic rather than at the object-code level.

PICSIM executes on a Gimini microcomputer with 8 kwords of RAM and a teletypewriter console. It comes as a relocatable load module that can be loaded into the Gimini system with the help of the resident monitor. A Fortran IV PICSIM is also available.

For hardware development, the FD-1664, a printed-circuit card that contains the PIC-1664 chip and provisions for either fusible-link or UV-erasable PROMs, and the DB1650, a fully interactive debug system, are available. The card comes with a ribbon cable that terminates in a 40-pin CIP plug that can plug directly into the socket of a PIC-1650.

The DB-1650 provides in-circuit emulation. Built on a single PC board, the system contains a PIC-1664 with external memory to emulate your processor. A second, preprogrammed, processor on the board, a PIC-1650, acts as the controller. It is programmed with PICBUG, a comprehensive debug program for memory and register examination/modification, single-step tracing, and serial-communications-channel control for communicating interactively with a terminal and paper-tape reader/punch.

Using the PIC-1650

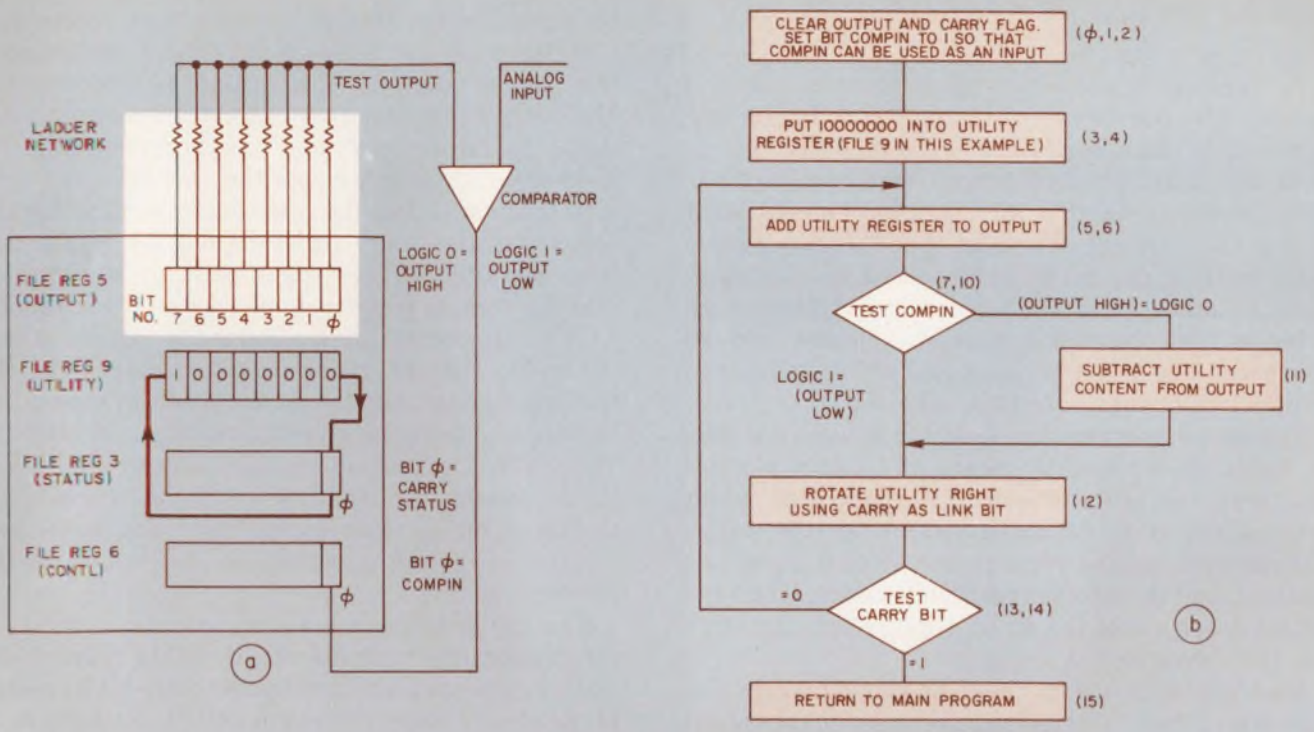
Developing a routine for the PIC-1650 is the same as preparing a program for any other one-chip microcomputer—start with the flow chart, develop the software, and check out the program before committing yourself to a mask version of the chip. One simple example of a program that the 1650 can handle is an analog-to-digital conversion that provides an 8-bit output. All the hardware you need for the operation is a comparator and a ladder network that must be connected to the processor (Fig. 5a).

(continued from page 65)

Instruction (Octal)		Name	Syntax	Equivalent Operation(s)	Status
0100 000 00011	(2003)	Clear Carry	CLRC	BCF 3, 0	—
0101 000 00011	(2403)	Set Carry	SETC	BSF 3, 0	—
0100 001 00011	(2043)	Clear Digit Carry	CLRDC	BCF 3, 1	—
0101 001 00011	(2443)	Set Digit Carry	SETDC	BSF 3, 1	—
0100 010 00011	(2103)	Clear Zero	CLRZ	BCF 3, 2	—
0101 010 00011	(2503)	Set Zero	SETZ	BSF 3, 2	—
0111 000 00011	(3403)	Skip on Carry	SKPC	BTFSS 3, 0	—
0110 000 00011	(3003)	Skip on No Carry	SKPNC	BTFSC 3, 0	—
0111 001 00011	(3443)	Skip on Digit Carry	SKPDC	BTFSS 3, 1	—
0110 001 00011	(3043)	Skip on No Digit Carry	SKPNDC	BTFSC 3, 1	—
0111 010 00011	(3503)	Skip on Zero	SKPZ	BTFSS 3, 2	—
0110 010 00011	(3103)	Skip on No Zero	SKPNZ	BTFSC 3, 2	—
001000 1 f f f f f	(1040)	Test File	TSTF f	MOVF f, 1	Z
001000 0 f f f f f	(1000)	Move File to W	MOVFW f	MOVF f, 0	Z
001001 1 f f f f f 001010 d f f f f f	(1140) (1200)	Negate File	NEGF, f,d	COMF f, 1 INCF f, d	Z
011000 0 00011 001010 d f f f f f	(3003) (1200)	Add Carry to File	ADDCF f, d	BTFSC 3,0 INCF f, d	Z
011000 0 00011 000011 d f f f f f	(3003) (0300)	Subtract Carry from File	SUBCF f,d	BTFSC 3,0 DECF f, d	Z
011000 1 00011 001010 d f f f f f	(3043) (1200)	Add Digit Carry to File	ADDDCF f,d	BTFSG 3,1 INCF f,d	Z
011000 1 00011 000011 d f f f f f	(3043) (0300)	Subtract Digit Carry from File	SUBDCF f,d	BTFSC 3,1 DECF f,d	Z
101× kkkkkkkk	(5×00)	Branch	B K	GO TO K	—
0110 00000011 101× kkkkkkkk	(3003) (5×00)	Branch on Carry	BC K	BTFSC 3,0 GO TO K	—
0111 00000011 101× kkkkkkkk	(3403) (5×00)	Branch on No Carry	BNC K	BTFSS 3,0 GO TO K	—
0110 00100011 101× kkkkkkkk	(3043) (5×00)	Branch on Digit Carry	BDC K	BTFSG 3,1 GO TO K	—
0111 00100011 101× kkkkkkkk	(3443) (5×00)	Branch on No Digit Carry	BNDC K	BTFSS 3,1 GO TO K	—
0110 01000011 101× kkkkkkkk	(3103) (5×00)	Branch on Zero	BZ K	BTFSC 3,2 GO TO K	—
0111 01000011 101× kkkkkkkk	(3503) (5×00)	Branch on No Zero	BNZ K	BTFSS 3,2 GO TO K	—

if × = 0, address is in page 0.
if × = 1, address is in page 1.

4. **The PIC-1650 assembler** can count on these additional commands to simplify substantially programming operations. All these commands are just special cases that merely extend the normal instruction set, as can be readily seen by examining the equivalent mnemonic codes in the "Equivalent Operations" column.

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               GI PICAL V01G        PAGE     1

                     ;8 BIT A TO D SUCCESSIVE APPROXIMATION

                     ;DEFINITIONS OF WORDS USED IN THE PROGRAM.

                     F        EQU      1          ;DEST. DESIGNATOR - SEE TEXT.
                     UTILRG   EQU      .9         ;REGISTER 9
                     OUTPUT   EQU      5          ;REGISTER 5
                     CONTL    EQU      6          ;REGISTER 6
                     COMPIN   EQU      0          ;BIT 0

                     ;A TO D SUBROUTINE

      000 2406 ATOD     BSF      CONTL,COMPIN;BIT SET COMP. INPUT
      001 0145          CLRF     OUTPUT    ;CLEAR OUTPUT, IE: FILE 5
      002 2003          CLRC               ;CLEAR CARRY (BIT 0 OF FILE 3)
      003 6200          MOVLW    B'10000000';MOVE LITERAL TO W REG.
      004 0051          MOVWF    UTILRG    ;MOVE W REG TO UTILREG, FILE 9
      005 1011 CYCLE    MOVFW    UTILRG    ;MOVE UTILRG TO W REG
      006 0745          ADDWF    OUTPUT,F  ;ADD W REG TO OUTPUT, FILE 5
      007 3006          BTFSC    CONTL,COMPIN;TEST BIT 0 OF FILE 6
      010 5012          GOTO     ENDTST    ;GOTO ADDRESS ENDTST, IE: 12
      011 0645          XORWF    OUTPUT,F  ;EXCL. OR W REG WITH FILE 5
      012 1451 ENDTST   RRF      UTILRG,F  ;ROTATE RIGHT FILE 9
      013 3403          BNC      CYCLE     ;BRANCH TO CYCLE IF
      014 5005
                                           ;CARRY BIT NOT SET.
      015 4000          RET                ;RETURN TO MAIN PROGRAM
      015               END

   ATOD      0000  R  IN  UR
   COMPIN    0000  A  EQ
   CONTL     0006  A  EQ
   CYCLE     0005  R  IN
   ENDTST    0012  R  IN
   F         0001  A  EQ
   OUTPUT    0005  A  EQ
   UTILRG    0011  A  EQ

   8 SYMBOLS
   0 ERR(S)
```

c

5. **Using the PIC-1650 to form a successive-approximation a/d converter** simply requires a comparator and resistor ladder network (a). The flow chart for the conversion uses a test word that is shifted right one position every time another bit in the converter's output is filled in (b). Written with the help of the assembler, the program necessary to perform the 8-bit a/d conversion requires just over a dozen instructions (c).

(continued from page 67)

To perform a successive-approximation a/d conversion, the system mu t be programmed according to the flow chart outlined in Fig. 5b. First, set the most significant bit of the output word equal to ONE, then determine whether this word has an equivalent analog value greater or smaller than the analog value being input. If the test bit gives a word that is smaller than the analog value, the bit remains set. If the word is bigger than the analog value, it is cleared, and the next most significant bit is set and tested—and so on until all eight bits have been determined.

The entire program for digitizing is shown in Fig. 5c. Each bit is tested by means of a utility register (F_9), which is initially set to 10000000. The set bit corresponds to the bit under test. After it is tested, the contents of the register are shifted right one position, and the next bit position is tested. When the set bit drops out of the utility register into the carry bit, the conversion is complete.

Each bit is tested in the following manner: The contents of the utility register are added to the output register and a comparison made between the incoming analog signal and the output of the ladder network.

In the conversion program, the first three instructions initialize the PIC-1650 (all instructions are numbered in octal). Instruction Ø sets pin Ø of file control register 6 (called CONTL, COMPIN in the program). This operation is necessary whenever an I/O register is used as an input. If the output were set to 0, the I/O pin would be held at ground by the output latch, regardless of the input value. (This provides a wire-AND capability.)

Instruction 1 sets the contents of register 5 equal to zero, which initializes the trial digitized value. The carry flag, which in this program is used to indicate the end of conversion, is cleared by instruction 2, a Bit Clear command to set bit Ø in register 3 to 0.

Instruction 3 loads the literal 10000000 into the working register, and instruction 4 transfers it from the register into a utility register (F_9) where it will be manipulated by a rotate operation. (Any of the available general-purpose registers, F_9 through F_{31}, could have been selected.)

Before testing the first bit, instruction 5 reads the contents of the utility register back into the working register. The next command adds the contents of the working register to the output register and leaves the result in the output register. A destination-designator bit, d, specifies where the result of this operation will be stored. When it is set to ONE, the result is returned to the file register specified in the instruction. When the bit is set to ZERO, the result remains in the working register. If the d operand is omitted in the assembler, the result is left in the file register.

Instruction 7 takes advantage of the bit-handling capabilities of the PIC-1650 by testing the comparator's output through an examination of bit Ø in register 6. If the comparator output is ONE, the bit under test remains set, and the next instruction, a GOTO command, is executed to direct the program flow to instruction 12. If the comparator's output is ZERO, the digitized output is greater than the analog signal to be digitized and the program skips to instruction 11, which resets the test bit.

Instruction 11 does the resetting by subtracting the contents of the utility register from the output register. Since the utility-register contents were loaded into the working register in instruction 5, instruction XORWF performs an Exclusive-OR operation between file register 5 (the output register) and the working register, and leaves the result in the output register (the destination designator bit is set to ONE). The XORWF instruction was used instead of SUBWF, the subtraction command, since the latter would set the carry bit in two's complement arithmetic and would then require an extra clear instruction for the carry bit.

Now the program is ready to test the next bit. In preparation, the contents of the utility register are shifted right one place through the carry bit by means of the Rotate Right command (RRF). Instruction 13 and 14 prepare to finish the conversion program by first checking to see if the carry bit is set. If the bit is not set, the program branches back to instruction 5. If the bit is set, the program is finished and instruction 15 is executed, which returns program control back to a master program.

The a/d-conversion example makes use of direct program addressing. However, the PIC-1650 also has an indirect-addressing capability that can be useful in mulitdigit display multiplexing and other applications. For indirect addressing, the F_0 register must be called; thus, the next instruction will be carried out with the F_4 register as the address pointer.

The file-select register can be used as any of the other registers, except that the three most-significant bits are always set to ONE. For display scanning, the data for each digit or pair of digits could be stored in consecutive locations that aren't addressed directly, but are pointed to by the address stored in the file-select register.

Two special instructions, DECFSZ and INCFSZ (Decrement and skip if zero, and Increment and skip if zero), help keep timing loops short by performing two instructions in the space of one. Also available is a swap instruction (SWAPF), which permits decimal operations to take place by swapping 4-bit sections of the file registers.

Two other important features, the bit set and test operations, are especially useful when used in conjunction with electromechanical operations such as switch closures. The instruction sPcontains operations that can clear a bit, set a bit, skip if the bit is cleared, and skip if the bit is set. When a switch is polled to detect its state, the bit test or skip instructions can divert the program flow. Or, in the case of setting a bit, the processor can be used to turn on a relay, lamp or display segment.■■

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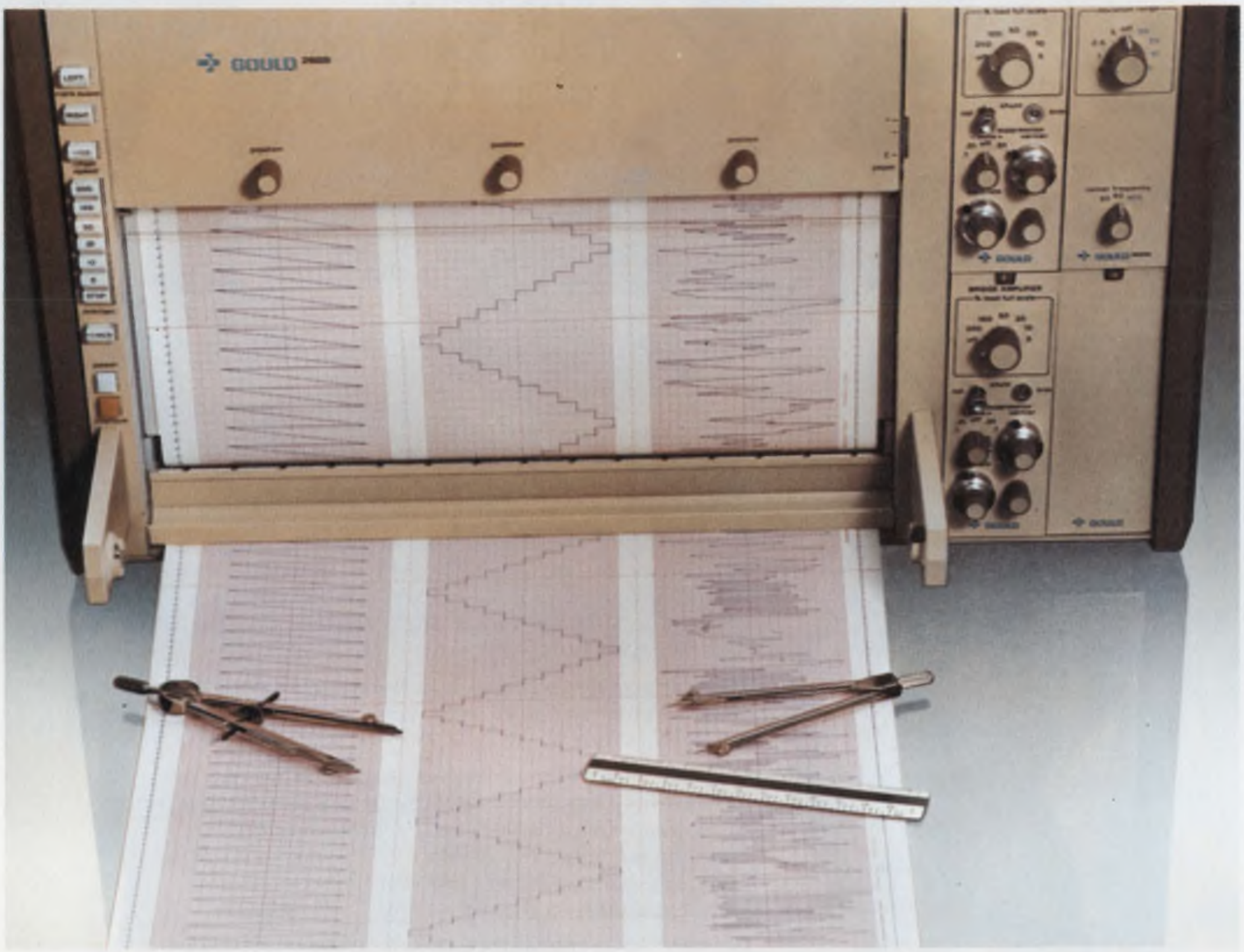

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CIRCLE NUMBER 41

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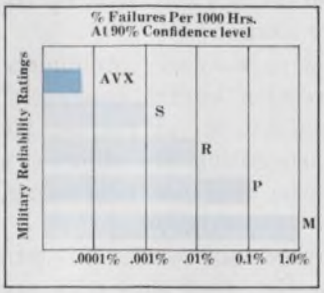

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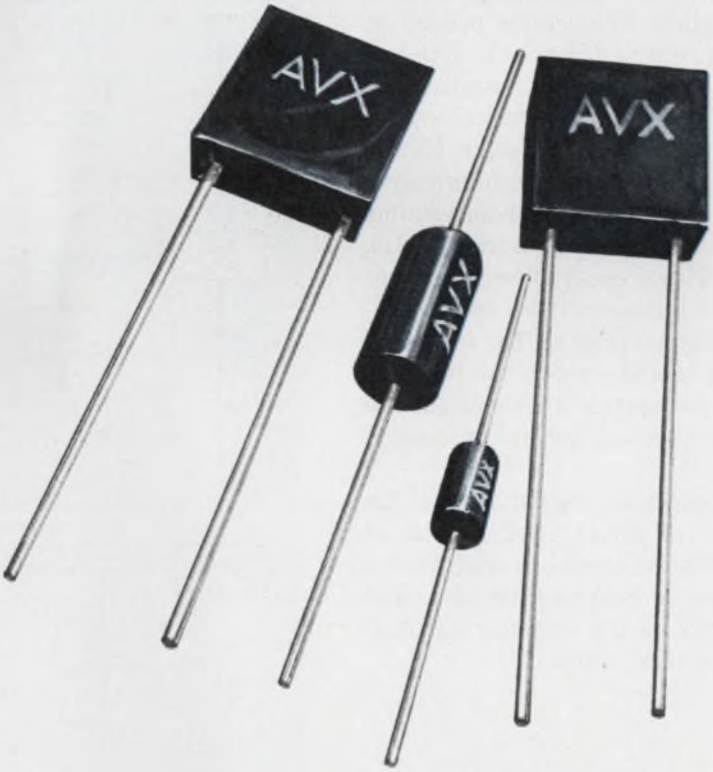

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CIRCLE NUMBER 42

Multiprocessing boosts microcomputer

power dramatically. You can build systems from 8080s and a few other chips. And such systems are expandable, too.

An 8080-based multiprocessor system gives you a powerful architecture when you need fast memory access, enhanced microprocessor performance, extremely large memory, or memory with protected areas. Common memory for all μPs lets you use the latest, 16-kbit memory circuits, self-correcting codes and memory power back-up. And by letting separate μPs handle peripherals, you can later increase throughput without redesigning the whole system.

In a conventional mini or microcomputer system (Fig. 1a) the central processing unit (CPU) interacts with peripheral units (PUs) through a peripheral controller (PC). But because μPs are so inexpensive, they can be used in PCs as well as in CPUs. For example, μP_P is part of the PC in Fig. 1b. This μP works as a controller, by executing a program stored in its own memory, and controlling the peripheral through its I/O ports. The central processor, μP_C, sends data and I/O commands over a data bus to μP_P, which responds by transmitting its status, and data if any are ready. However, the architecture of Fig. 1b suffers at least two serious drawbacks: Memory overhead costs are doubled, and the communication between μP_P and μP_C is complex and time-consuming.

An improved multiprocessing architecture (Fig. 1c), well-known but still not widely used, solves a number of problems. The memory bus serves also as a direct-memory-access (DMA) channel (Fig. 2). The smart PC units execute programs stored in central memory rather than locally. And the system's throughput can be increased by attaching a second "central processor" to the same bus.

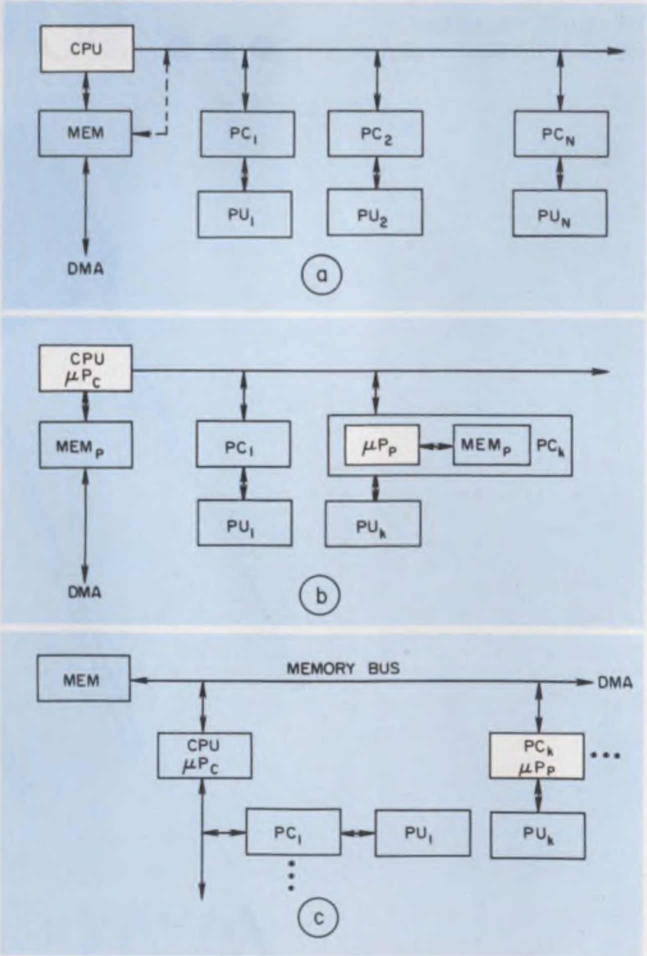
In such a multi-microprocessor system, one μP, for instance, can take care of data manipulation or arithmetic functions, while the other one controls the system's I/O. The number of central processors and allocation of tasks depends on the system's purpose, characteristics, and peripheral units.

Division of labor helps

The tasks to be performed by a system don't depend on how the system is implemented. Before μPs became popular, intelligence was usually concentrated in the central processor, which not only manipulated data but also controlled the I/O devices step-by-step because the peripherals were dumb.

In the architecture of Fig. 2, however, intelligence is distributed, and the expression "central processor" is incorrect, unless it's applied to the μP responsible for data handling and task scheduling. The others μPs are assigned dedicated tasks like file processing, floppy disc control or data transmission.

The data-manipulating processor works on data located in central memory. But when new data are needed, or results must be recorded, the I/O-control



1. **Computer architectures have evolved** from a central processor with individually controlled peripherals (a), to μP-controlled peripherals with local memory (b) to fast peripherals with direct memory access (c).

Kalman Rozsa, Senior Engineer, Facit AB, Data Products Development Dept., Stockholm, Sweden

processor is awakened and manages the data flow to or from I/O devices. This processor either directly controls slow peripherals, or tells a PC unit what to do by assembling an I/O command. The μP in the PC unit then acts as a controller and handles the peripheral device on the character or bit level.

Processors communicate by mail

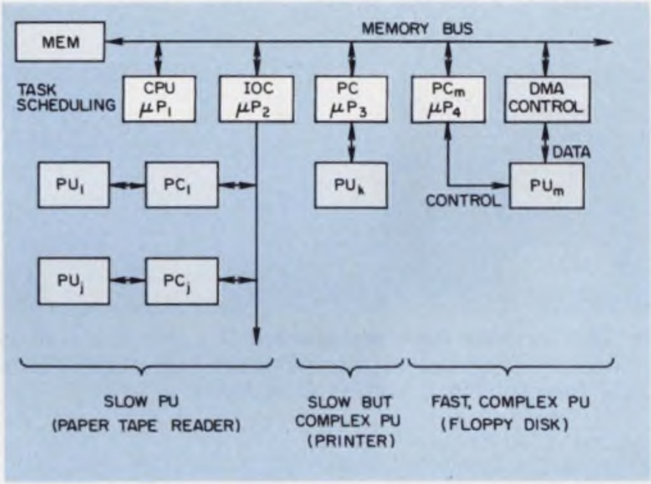
The central memory not only provides program and data storage, but also serves as the communications link between the microprocessors. An assigned part of the memory becomes the "mailbox" where the sending processor places information. The receiving processor then executes the task specified by the message in the mailbox. When the task is completed, the receiving processor responds by leaving a new message.

The simplest way to initiate μP operation is by polling. The receiving μP looks at a mailbox flag, which is either a hardware device (flip-flop) or the content of a memory location. Polling works well if there aren't too many μPs, or if only one of them may initiate an action. But you can get higher efficiency if any μP is allowed to activate any other. For this method, the software must be able to manage priority among processors, as well as multiple requests and queue handling.

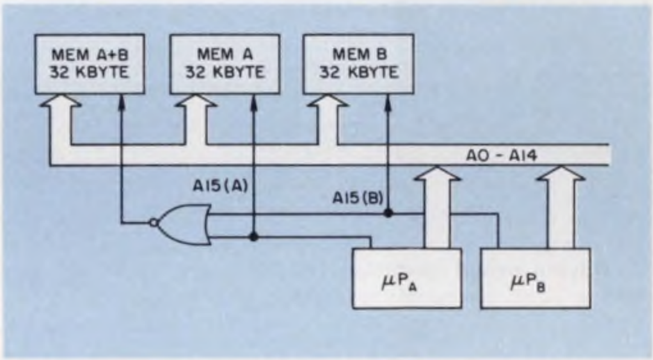
The hardware naturally gets to be more complex in this system. Interrupts, though not always desirable, are commonly used to notify the receiving μP that the mailbox contains a message. Several interrupt levels with various priorities must be reserved for interprocessor communication. The microprocessors form a matrix: If N is the number of processors, in theory every μP must have N-1 interrupt levels. In practice, some combinations of sending and receiving μPs never occur, so the number of interrupt levels required is lower.

The processors' ability to prompt each other improves the system's throughput substantially. For example, the contents of a CRT display can be printed out while a file-searching program is in progress. A star or matrix configuration describes the μPs' behavior and the logical data flow. Physically, however, every μP is connected to a common bus.

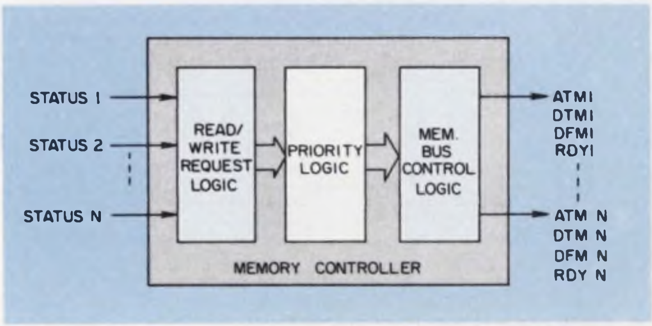
How many μPs can work together effectively in a



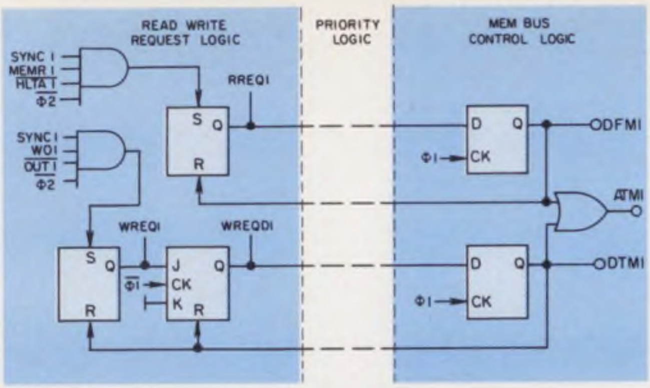
2. **In a multimicroprocessor system,** intelligence is distributed, but one μP is assigned to task scheduling. Peripherals are grouped by speed and complexity.



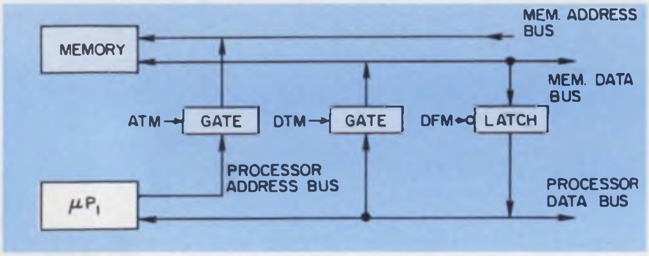
3. **When two μPs share CPU functions,** each can have its own memory, in addition to the common A+B sector.



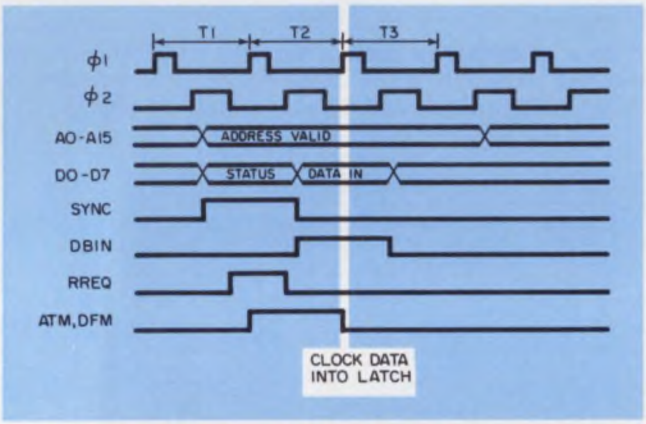
4. **A memory controller interprets the status** signals and synchronizes the data flow to the processors.



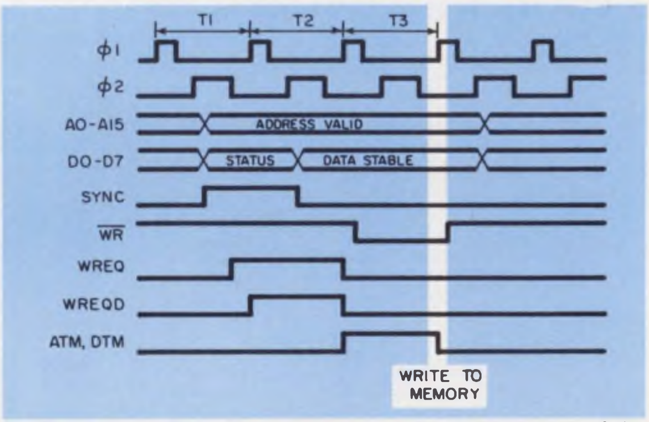
5. **The functioning of the memory controller** is easier to understand when you bypass the priority logic.



6. **With priority logic disregarded** (Fig. 5), every μP is connected to central memory with two rows of gates (one gate for each line), and an 8-bit latch.



7. **During a read operation,** the ATM signal gates the data into a latch because the DBIN signal is too late.



8. **Data are written into memory** under the control of the DTM signal, which occurs when both address and data are valid.

given system depends primarily on the number of clock cycles per machine cycle. For the 8080A, every instruction needs two to five machine cycles, each consisting of two to five "states," or clock cycles. The first cycle of an instruction is always a fetch cycle, during which the instruction code is read out from the memory. Some instructions access the memory again, when data are written or read.

Statistical analysis of a large number of programs shows that on average 3.5 states elapse for each memory access. That means that, if the memory can be accessed within one state, it can serve at least three μPs without slowing down much. Nonetheless, some speed reduction is unavoidable. If two devices request memory access at the same time, one of them will have to wait.

Connecting more than three 8080s to the same memory bus decreases the average speed of each μP, but because most of the time each μP works independently, the over-all speed of the system is still higher than that of a single-CPU system.

A trinity of buses

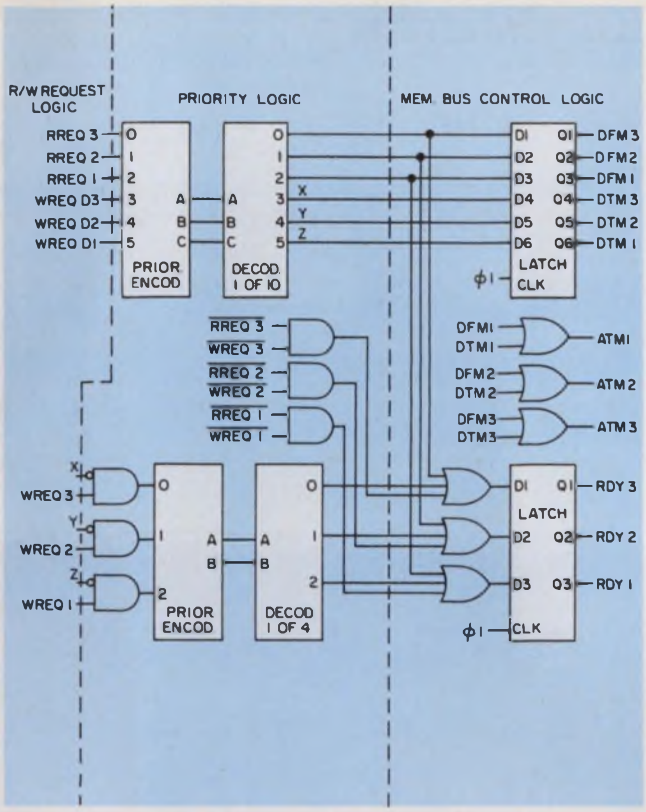
The memory bus combines a data bus, address bus and control bus. The data bus is a two-way, 8-bit-wide data path, but the width of the address bus depends on the size and configuration of the memory. While the number of address lines usually equals the number of address bits, it can be lower or higher. Thus, the addressable memory is virtually unlimited. In Fig. 3, both μP_A and μP_B access 64 kbytes of memory but only their lower halves (memory A+B) overlap. This part holds the common data areas as well as the mailbox. Memories A and B are accessible only by μP_A or μP_B, respectively, and they serve as their program or data storage. A wider address bus not only provides access to a larger memory, it also allows protected areas, accessible to only one μP.

The control bus synchronizes the data flow between memory and processors. Since there is only one memory bus, the processors must obey certain rules when accessing the memory. Each μP is provided with four signals which control when a μP:

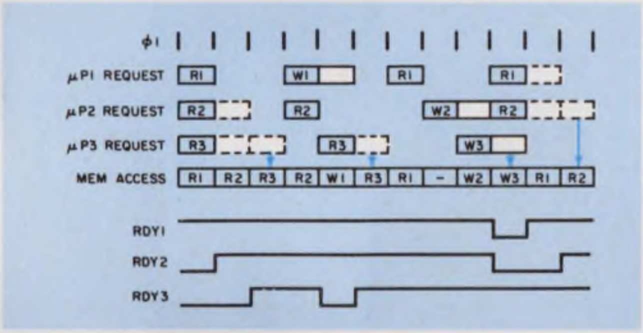
1. Must put an address on the address bus (ATM, address to memory),
2. Fetch data from the data bus (DFM, data from memory)
3. Gate out data onto the data bus (DTM, data to memory).
4. Suspend the data bus's activity when the memory bus is busy filling requests from a higher-priority device (RDY goes low).

The control signals are derived from the microprocessors' status signals. The memory-controller network interprets the status signals as memory-access requests and synchronizes the data flow by generating ATM_n, DFM_n, DTM_n and RDY_n (Fig. 4). The suffix n identifies the μP.

If two devices request a memory bus operation at



9. **In this priority logic for three μPs,** the highest priority is assigned to μP_1, the lowest to μP_3.



10. **Timing for the priority logic** of Fig. 9 clearly shows that read (R) and write (W) requests by μP_1 are rarely delayed, while those of μP_3 wait every time. The delay time between request and realization is highlighted.

the same time, the device with higher priority gets immediate service while the other one has to wait. So, analyze your needs thoroughly before you assign priority to different processors.

Priority can be variable or fixed. Variable priority is either "rotating," or assigned by hardware or software in some other way. Fixed priority is easiest to implement, but in some cases more complex arrangements are necessary. A very fast device like a rigid disc requires the highest priority, but only while reading or writing. Head positioning, on the other hand, doesn't depend on immediate memory response, and deserves only low priority.

Very high priority can be used to disable all the other devices. If the read circuits in the disk controller are directly connected to the memory bus under top priority, you can achieve very high transfer rates, up to 2 Mbytes per second.

An 8080-based system

Intel's 8080A is not really designed for multiprocessing, but by adding a few circuits you can design very powerful architectures with it. While other μPs are better suited for multiprocessing systems, the 8080A's availability and low price often outweigh its drawbacks.

While neither task allocation nor communication between μPs depends on the μP model used, you should choose a μP with a suitable number of interrupt levels to avoid complex interrupt-handling hardware outside the μP. The 8080A's interrupt handling capability is fairly good, though some third-generation μP's are better. Communication between μP and memory, on the other hand, is very device dependent, and warrants thorough analysis.

The most crucial part of any multiprocessing system is the memory controller. Its performance must be matched to the system's purpose, speed and projected cost. Usually, it is built from random TTL circuits and some MSI circuits.

The memory controller's main purpose is to time-multiplex the memory bus, making the memory available to all μPs. Time-multiplexing is done by defining one machine state (clock cycle) as the memory-access cycle, and assigning it to a μP that asks to write or read.

The memory controller contains three blocks: read/write request logic, priority logic, and memory-bus control logic. The R/W request logic interprets the μP's status and generates three signals: RREQ (Read request), WREQ (Write request) and WREQD (Write request delayed).

The memory-bus control logic contains latches and a few gates; it distributes the memory bus control signals to the three-state gates that isolate the μP from the memory bus. Assume for the moment a single-μP system which doesn't need priority logic (Fig. 5). The μP runs at full speed, and is never stopped by a low RDY. The interrelationship between the μP and the memory is then as in Fig. 6.

Fig. 7 illustrates the timing of a read operation. The ATM signal gates the address onto the address bus and data is clocked into a latch by DFM's trailing edge. The latch is necessary because the μP's DBIN signal occurs somewhat later. Fig. 8 shows how data to be written pass the DTM gate. The gates are standard three-state bus drivers and the 8-bit latch is an 8212 with three-state output.

Priority logic allows several μPs to share the same memory bus (Fig. 9). It collects the request signals, determines the highest priority, outputs ATM, DFM or DTM to the selected μP, and stops the others by setting RDY_n low. In the solution for three processors shown in Fig. 9, μP_1 has the highest priority and μP_3 the lowest. The timing is shown in Fig. 10. ■■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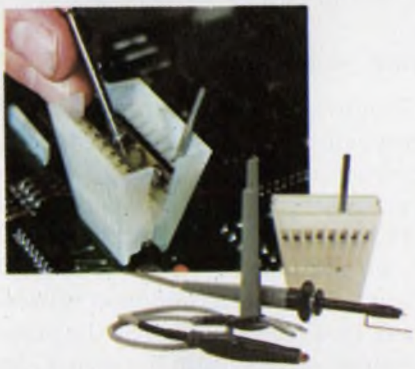

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CIRCLE NUMBER 43

Choosing a scope to measure time? Look at some relative pulse-width and delay measurements, and you'll see that wider bandwidth doesn't necessarily mean better results.

When you select an oscilloscope to make time-interval measurements, don't just look for the scope with the widest bandwidth you can afford. Although bandwidth is related to time-interval accuracy, larger bandwidth doesn't necessarily mean more accuracy.

The need to measure time intervals at varying duty cycles and with different logic families places increasing emphasis on resolution and accuracy. Obviously, the more reliable the timing measurements, the faster or more reliable the end system.

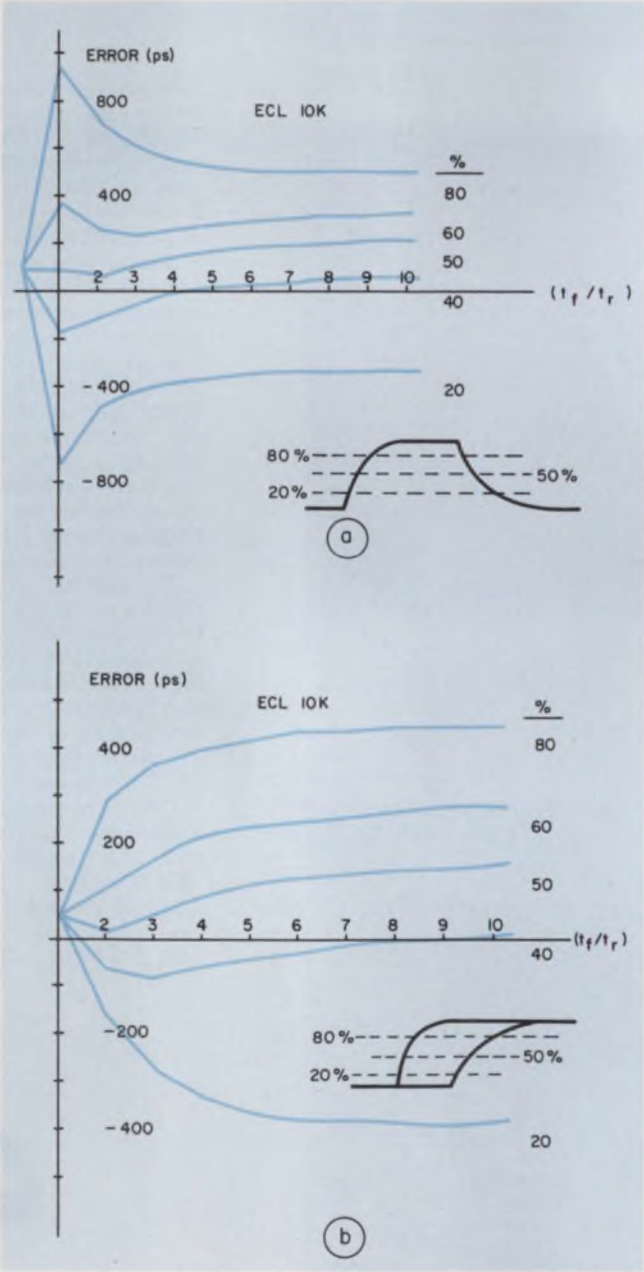
Know your scope's limitations

Bandwidth is certainly a major source of scope errors in timing measurements. But so is time-base accuracy. When rise and fall are considerably slower than a scope's response, errors are negligible and determined primarily by the time base, usually 3 to 6% for standard scopes, 1% for delta-time units and about 0.002% for a time-interval-counter scope. As the transition times approach the scope's response time, however, errors begin to creep in. But to what degree?

Luckily, scopes tend to have many very-high-frequency poles, with the dominant ones determined by the CRT deflection amplifiers. Therefore, a scope can be approximated by a shunt-peaked amplifier. The time-interval accuracy achievable with, say, a 100-MHz unit can be analyzed, along with its induced distortion, with an exponential input signal having different fall and rise times (see box). With that signal, it is easy to vary the transition times, and—as shown by the scope's amplitude response derived in the box—the mathematics is simplified.

To compute the time-interval error of a 100-MHz scope when measuring pulse width, use a pulse with a fixed rise time and a fall time that can be adjusted from one to 10 times the rise time. Select leading-edge rise times corresponding to major logic families: ECL pulse t_r is 2 ns, so t_f varies from 2 to 20 ns; Schottky TTL (STTL) pulse t_r is 4 ns, so t_f varies from 4 to 40 ns; and low-power Schottky (LPSTTL) rise time is 7 ns, so fall time varies from 7 to 70 ns.

Now compare the actual interval of the input signal,



1. **Errors in measuring pulse widths** on a scope (a) depend on the relative rise and fall times of the pulse and your definition of width. If, for example, an ECL 10 k gate's output pulse has a 2-ns rise and 10-ns fall, and a width of 12.4 ns at the 50% points, the actual width equals 12.4−(0.10), or 12.3 ns. At the 20% points, the actual width would be 12.4−(−0.46)=12.86 ns. Similar propagation-delay errors occur for identical slopes (b).

Walt Fischer, Oscilloscope Engineering Manager, Hewlett-Packard, P.O. Box 2197, Garden of the Gods Rd., Colorado Springs, CO 80901.

Analyzing the oscilloscope as a shunt-peaked amplifier

$$Z(s) = \frac{1}{C} \cdot \frac{s + R/L}{s^2 + s\frac{R}{L} + \frac{1}{LC}}; \quad i(s) = \frac{\gamma}{s(s+\gamma)}$$

$$\text{If } K \equiv R\sqrt{\frac{C}{L}}; \ \tau_o = RC,$$

$$Z(s) = \frac{1}{C} \cdot \frac{s + \frac{K^2}{\tau_o}}{\left[s^2 + s\frac{K^2}{\tau_o} + \frac{K^2}{\tau_o^2}\right]};$$

$$e_o(s) = i(s) \cdot Z(s) =$$

$$\frac{1}{C} \cdot \frac{\left(s + \frac{K^2}{\tau_o}\right)\gamma}{s(s+\gamma)\left[s^2 + s\frac{K^2}{\tau_o} + \frac{K^2}{\tau_o^2}\right]}.$$

$$\text{If } a_o \equiv \frac{K^2}{\tau_o}, \ \alpha \equiv \frac{K^2}{2\tau_o},$$

$$\gamma \equiv \frac{1}{\tau_s}, \ \beta_o \equiv \frac{2}{\tau_o}, \ \beta = \frac{K^2}{2\tau_o}\sqrt{\frac{4}{K^2} - 1},$$

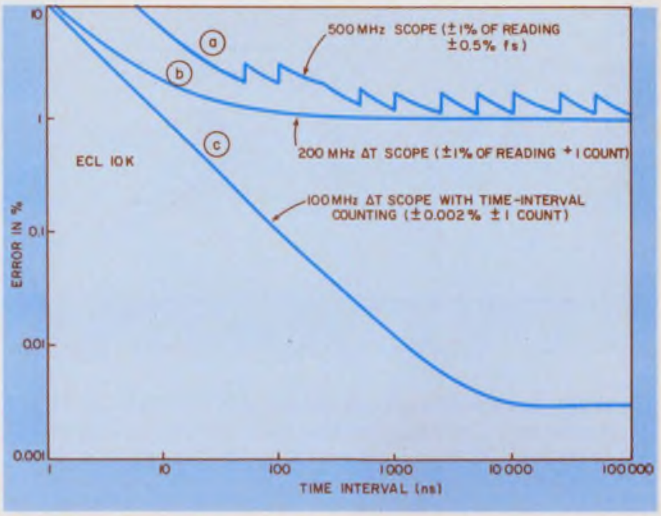
$$e_o(s) = \frac{\gamma}{C} \cdot \frac{s + a_o}{[(s+\alpha)^2 + \beta^2]\, s(s+\gamma)},$$

If $K<2$,

$$\pounds^{-1}[e(s)] = e(t)$$

$$e(t) = \frac{1}{C\tau_s}\left\{ \frac{a_o}{\beta_o^2} + \frac{(\gamma - a_o)\,\epsilon^{-\gamma t}}{\gamma[(\alpha-\gamma)^2 + \beta^2]} + \frac{1}{\beta\beta_o}\left[\frac{(a_o-\alpha)^2 + \beta^2}{(\gamma-\alpha)^2 + \beta^2}\right]\epsilon^{-\alpha t} \sin(\beta t + \psi) \right\}$$

$$\psi = \tan^{-1}\frac{\beta}{a_o - \alpha} - \tan^{-1}\frac{\beta}{\gamma - \alpha} - \tan^{-1}\frac{\beta}{-\alpha}$$



2. **Errors contributed by a scope's** time base depend on the time interval being measured. Accounting for bandwidth adds more inaccuracy.

measured at the 50% points, with the interval measured on the scope at the 50% points. The difference is the error. Next measure the errors at the 20, 40, 60 and 80% points. The resulting error curves (Fig. 1) reveal slight errors for pulse width and propagation delay, when rise and fall times are different—however, the error is about an order of magnitude less than expected from a 100-MHz scope.

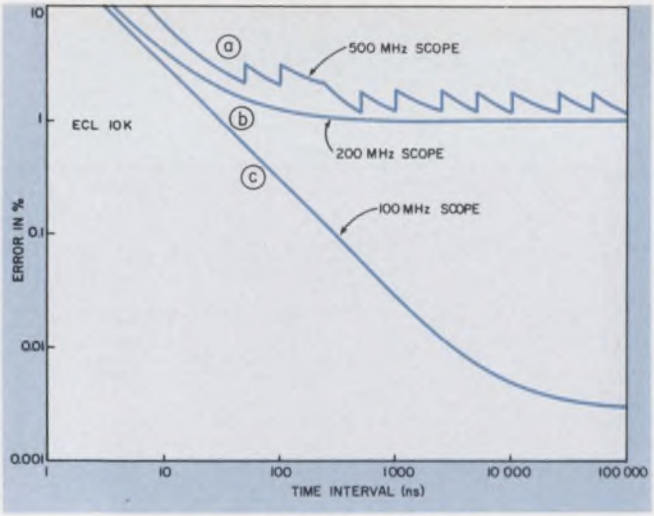
How the 100-MHz scope stacks up

Measurements made at the 50% points are within ±150 ps for ECL 10 k and STTL and within ±100 ps for LPSTTL and slower logic families, TTL and MOS. And, if the rise and fall times differ by less than 5:1, the 100-MHz unit can achieve an accuracy of ±100 ps on ECL 10 k and STTL as well as LPSTTL.

Since most devices and pulse widths are specified at the 50% points, the 100-MHz scope is entirely satisfactory for timing measurements in logic families up to and including ECL 10 k, and offers accuracies better than ±200 ps (Fig. 2). But compare time-base errors, and you'll see that if bandwidth is considered for the 100-MHz scope, you must add 200 ps for ECL 10 k and STTL and 100 ps for LPSTTL (Fig. 3).

Figs. 2 and 3 compare pulse-width measurements on ECL 10 k with bandwidth limitations for 500, 200 and 100-MHz scopes. The 500 and 200-MHz instruments, using an analog time base, provide delta-time measurements while the 100-MHz scope offers a time-interval averaging counter that ties measurement accuracy and resolution to a crystal oscillator.

So what good is a wide bandwidth? In general, it provides more fidelity—important for viewing unwanted narrow pulses and glitches. Obviously, a 1-ns-



3. **When bandwidth errors are added** to time-base errors, and intervals are taken at the 50% points, add errors of 50, 150 and 200 ps, respectively, for curves a, b and c.

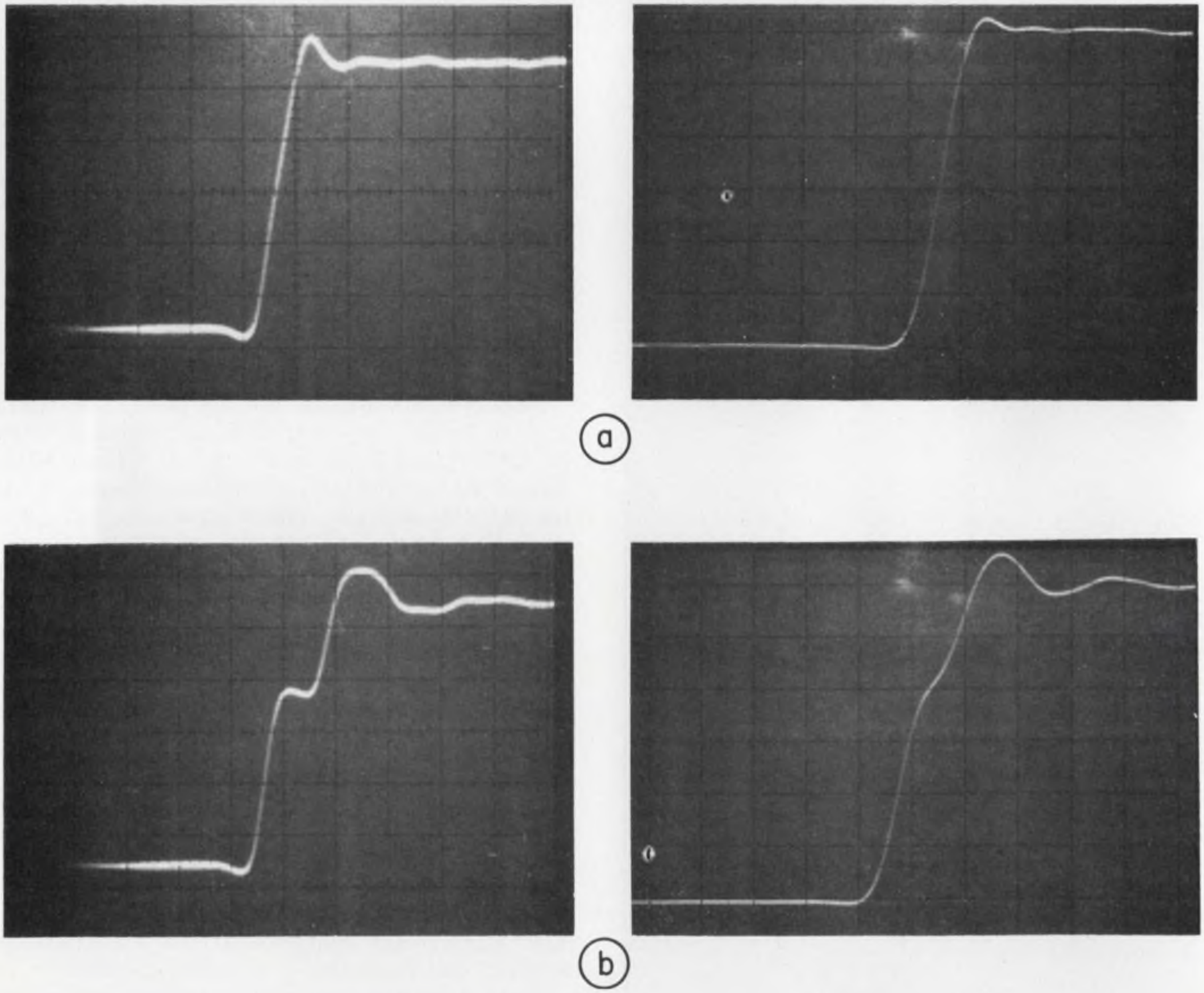
wide impulse displayed by a 500-MHz scope will have more amplitude than an impulse displayed by a 100-MHz unit. But can your system generate impulses as narrow as that? And will the logic family you're using respond to them?

Looking at impulses

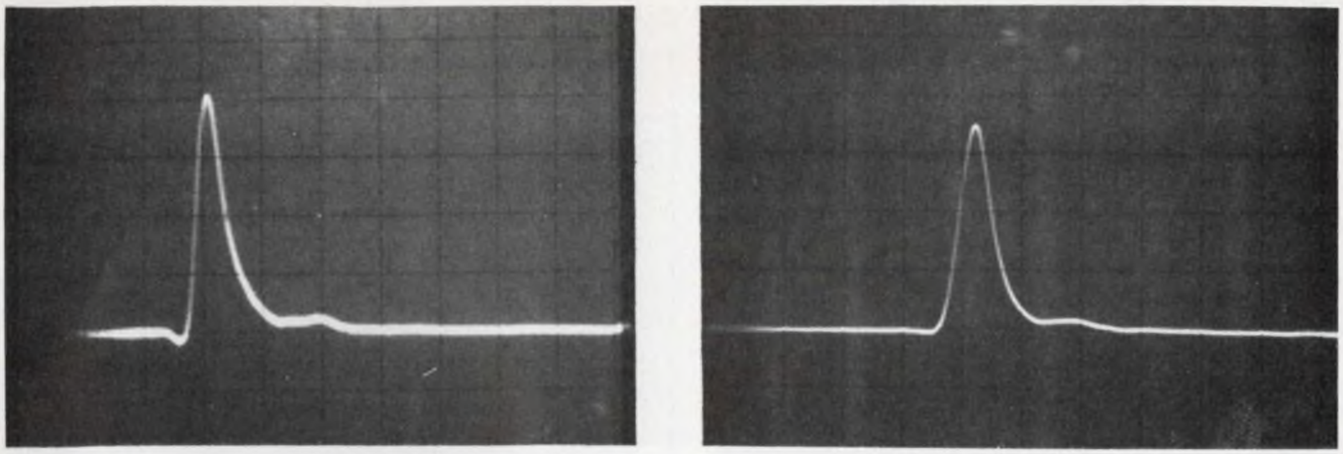
Most narrow impulses come from system reflections created by poor or unterminated coaxial or printed-circuit connections. See what happens when an ECL gate drives two open, printed-circuit traces, one 15.2 cm (6 in.) long and the other 45.7 cm (18 in.) long. The waveforms are shown in Fig. 4.

The 15.2-cm trace should show a reflection approximately 2 ns after the gate output starts to rise. Because the rise is slew-rate-limited, the reflection returns while the gate output is still rising. The result is a slight slope error on both the 500 and 100-MHz

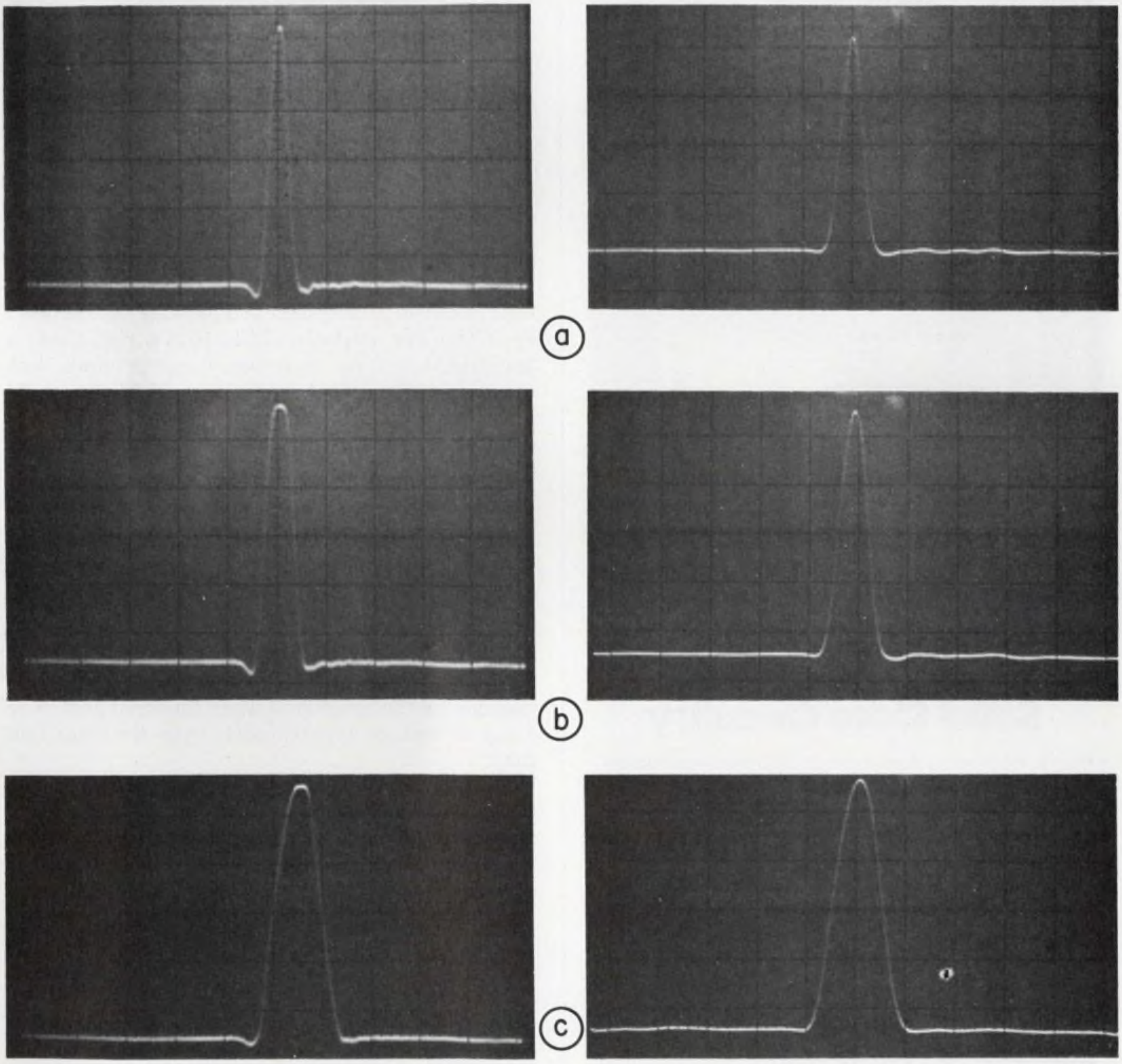
(text continued on page 82)



4. **See how two scopes of different bandwidths** respond to identical pulses generated on ECL-driven, open transmission lines of 15.2 cm (a) and 45.7 cm (b). The response for a 500-MHz scope is shown on the left, while that for a 100-MHz unit is on the right. Sweep speed is 5 ns/div. Note the reflections.



5. **Although an impulse shows up** a bit larger on a 500-MHz scope (left) than it does on a 100-MHz unit (right), the latter's display is good enough for many purposes. Here an ECL 10 k gate drives a shorted transmission line.



6. **Bandwidth isn't always crucial for pulse measurements.** 500-MHz displays (left) are of the narrowest impulse responded to by (top to bottom) ECL 10 k, STTL and LPSTTL. 100-MHz scope photos are at right.

(continued from page 80)

displays. With the 45.7-cm trace, the reflection should occur approximately 6 ns after the gate output starts to rise, and produce a step on the leading edge.

The step is more pronounced on the 500-MHz scope, but the 100-MHz unit, if nothing else, shows that a reflection exists. Notice that the interval between the 10% and 90% points is close enough to indicate the relative delay of the pulse top caused by the reflection.

With a 45.7-cm open trace driven by an STTL gate, the displayed differences between the 100 and 500-MHz scopes are very small. Even if a short impulse were to be generated, the slew rate of the logic limits the amplitude. The resultant distortion, even with ECL 10 k, can be viewed adequately with a 100-MHz scope.

Now consider the shortest impulse that can be generated and still have enough amplitude to pass through the ECL 10 k threshold. The 100-MHz display, even with less amplitude than the 500-MHz, adequately shows the impulse and certainly calls attention to a potential problem (Fig. 5).

The narrowest observable pulse

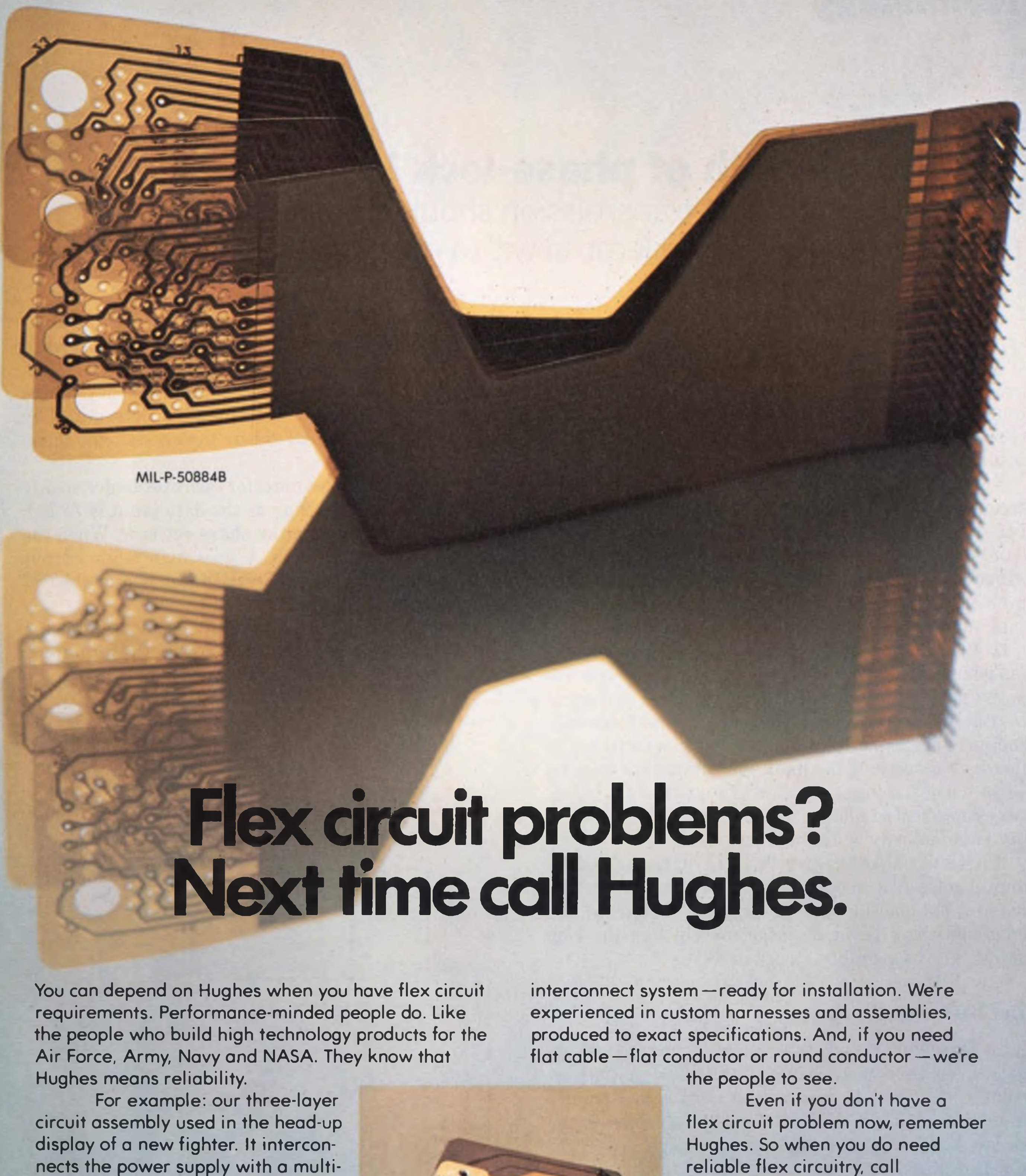
To determine a minimum pulse width, rule-of-thumb says to note the transition time of the fastest logic family in your system and increase that number by 100%. For example, ECL 10 k's rise time is approximately 2 ns; therefore, it can generate 4-ns impulses—large enough to pass through the threshold levels of other 10 k components in the system.

Keep in mind that this rule-of-thumb is for minimal output loading, that is, fanouts of one or two. As the fanout increases to four or six, the transition times can increase to 3 or 4 ns for minimum pulse widths as wide as 6 to 8 ns.

To determine if a logic family can respond to a very narrow input pulse, consider an ECL 10 k gate, which acts as a slew-rate-limited linear amplifier when driven by signals that last only a few nanoseconds. As the input pulse width is varied, the output passes through the threshold level when the input gets to be 3 to 4 ns wide, or approximately twice the transition time.

Therefore, the answers to "Can a system generate extremely narrow impulses?" and "Will the logic family respond?" revolve around the transition-time specifications of the fastest logic family in your system. With ECL 10 k, you will observe impulses of 3 to 4 ns, with STTL, impulses of 4 to 5 ns, and so on.

Trace photos taken on 100 and 500-MHz scopes show displays of ECL 10 k, STTL and LPSTTL impulses for each scope (Fig. 6). The differences in the photos between each scope are so small, you should ask yourself: Is wider bandwidth really worth the additional cost?■■



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CIRCLE NUMBER 241

The bandwidth of phase-lock loops

for synchronous data transmission should first be wide, then narrow. Solve the dilemma with a modified loop.

If you want to recover the timing signal in synchronous data systems with a phase-lock loop[1] (PLL), you need a filter bandwidth around 10 Hz for good noise rejection. But in the search mode the filter must be wide enough to accommodate the pulling characteristics of the oscillator crystal. This sounds contradictory, but there are three ways to do it:

1. Divide both the input frequency and VCO output-frequency by N, ahead of the phase comparator (see box for PLL basics). This method reduces noise bandwidth by a factor of N, and increases the lock range by the same factor. Unfortunately, it also multiplies the steady-state error by N, and the acquisition time by N^2, which may be unacceptable.

2. Replace the phase comparator by a phase-frequency comparator that gives different steady-state outputs for input frequencies below, above, and equal to the VCO frequency. However, phase-frequency comparators using digital gates fail to operate satisfactorily if some of the input transitions are missing —i.e. when the input consists of random data.[2] Only very complicated phase-frequency comparators operate satisfactorily with random data.[3]

3. Use variable bandwidth PLLs implemented by digital gates. The normal loop bandwidth is extremely narrow; but once out-of-lock condition is detected, the bandwidth can be made large to help lock the loop as quickly as possible.

The best of both worlds

To implement the third—and preferred—alternative, you can use a voltage-controlled crystal oscillator, designed to recover the clock signal from a random PCM data channel. To operate properly, the circuit has to meet the following criteria:

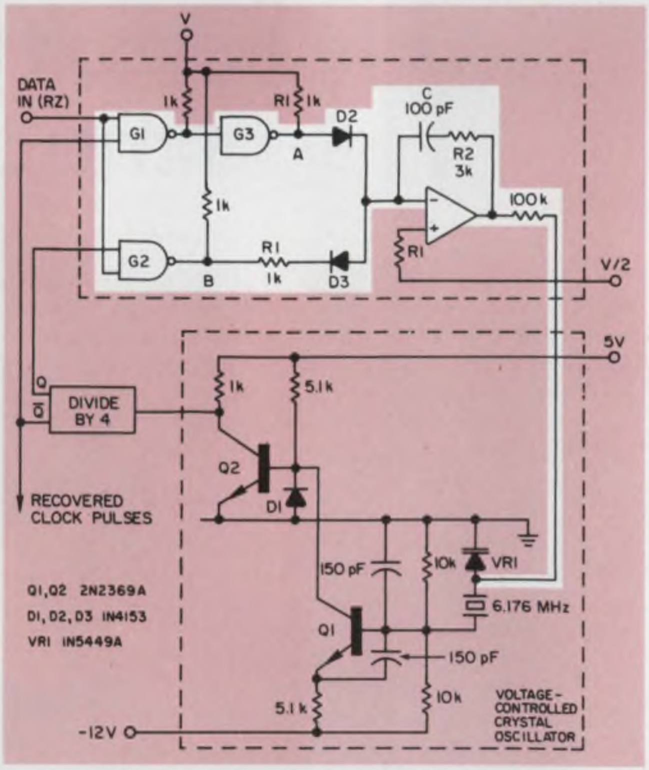
- The input data rate must be within the lock-in range of the loop. The filter bandwidth should be large enough so that the lock-in range is essentially determined by the pulling characteristics of the crystal and its associated circuitry.
- The input signal must contain a sufficient number of data transitions per second.
- The input data must be return-to-zero binary.

The oscillator and the integrator filter are designed conventionally. A crystal oscillator is shown in Fig. 1, but an LC oscillator of the same frequency can be used instead. The PLL performance is determined by the loop bandwidth and not by the crystal characteristics.

In Fig. 2, the phase detector operates under steady state conditions.[2] As long as the data input is ZERO, there is no output from the phase detector. When the input is one, gate output A goes high while output B goes low. So the input to the filter is a doublet of current pulses (Fig. 3).

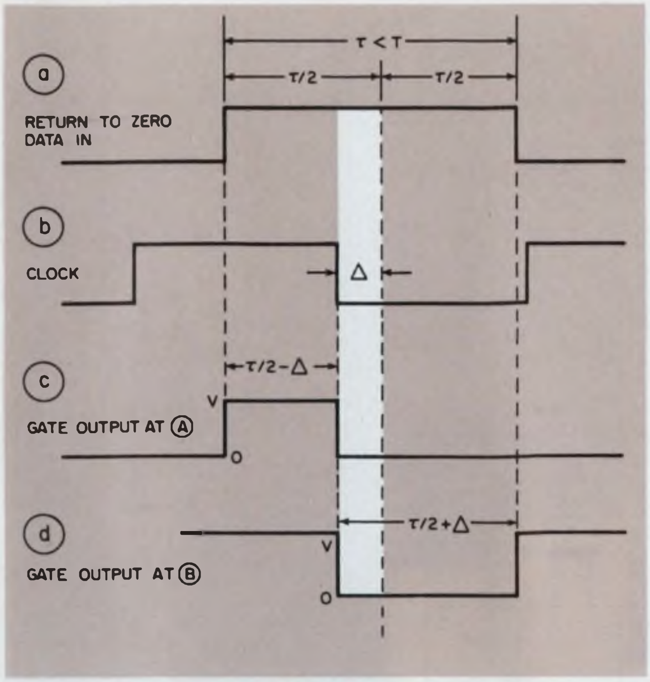
If you ignore component variations and assume the gates' LOW voltage to be ZERO, then the amplitude of the current pulse is given by

$$I = \frac{V/2 - V_d}{R},$$

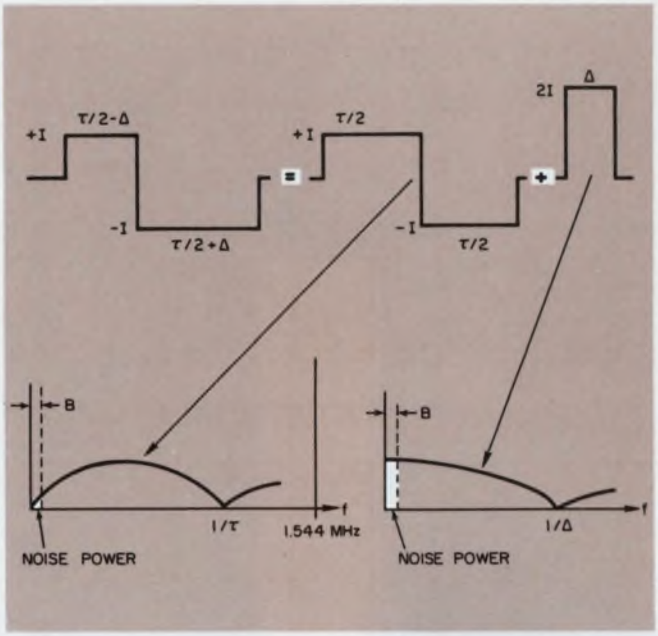


1. **A practical PLL circuit** uses a crystal-controlled VCO that is fed by a phase comparator and filter. The active filter's bandwidth remains constant.

S. Ghosh, Engineer, TRW Vidar Div., 77 Ortega Ave., Mountain View, CA 94040.



2. **A phase detector's output** is determined by the status of the NAND gates. The currents are measured at points A and B in Fig. 1 before they are combined.



3. **The output current from the phase detector** is an asymmetrical doublet composed of a symmetrical doublet and a variable pulse (a). Within the filter's bandwidth, the spectrum of the pulse contributes most of the power.

Loop circuit fundamentals

The basic schematic of a second-order phase lock loop contains a phase comparator, an active filter, and a voltage controlled crystal oscillator. The first basic loop equation is the transfer function:[1]

$$H(S) = \frac{\theta_o(s)}{\theta_i(s)} = \frac{2\rho\omega_n S + \omega_n^2}{S^2 + 2\rho\omega_n S + \omega_n^2} \qquad (1)$$

where ω_n is the natural frequency and ρ is the damping factor of the loop. Furthermore,

$$\omega_n^2 = K_o \cdot K_d/\tau_1,$$
$$\rho = \tau_2 \cdot \omega_n/2$$
$$\tau_1 = R_1 C_1, \text{ and}$$
$$\tau_2 = R_2 C.$$

The steady phase error

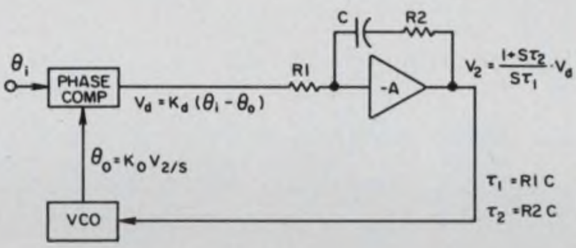
$$\theta_e = \theta_i - \theta_o = \Delta\omega/K_v, \qquad (2)$$

where $\Delta\omega$ is the difference between input frequency, f_i, and the free-running frequency, f_o, of the local oscillator, and $K_v = A\ K_o\ K_d$ is the dc gain of the loop.

A fundamental loop parameter is the noise bandwidth. If the input to the loop has phase noise of uniform density Φ, then the output noise power for that input is given by

$$e_{no}^2 = \frac{\Phi_2}{2\pi}\int_o^\alpha |H(j\omega)|^2 d\omega \qquad (3)$$

The integral in the equation is defined as the noise bandwidth B of the loop:



$$B = \frac{1}{2\pi}\int_o^\alpha |H(j\omega)|^2 d\omega$$
$$\simeq \omega_n\rho/2 \qquad (4)$$

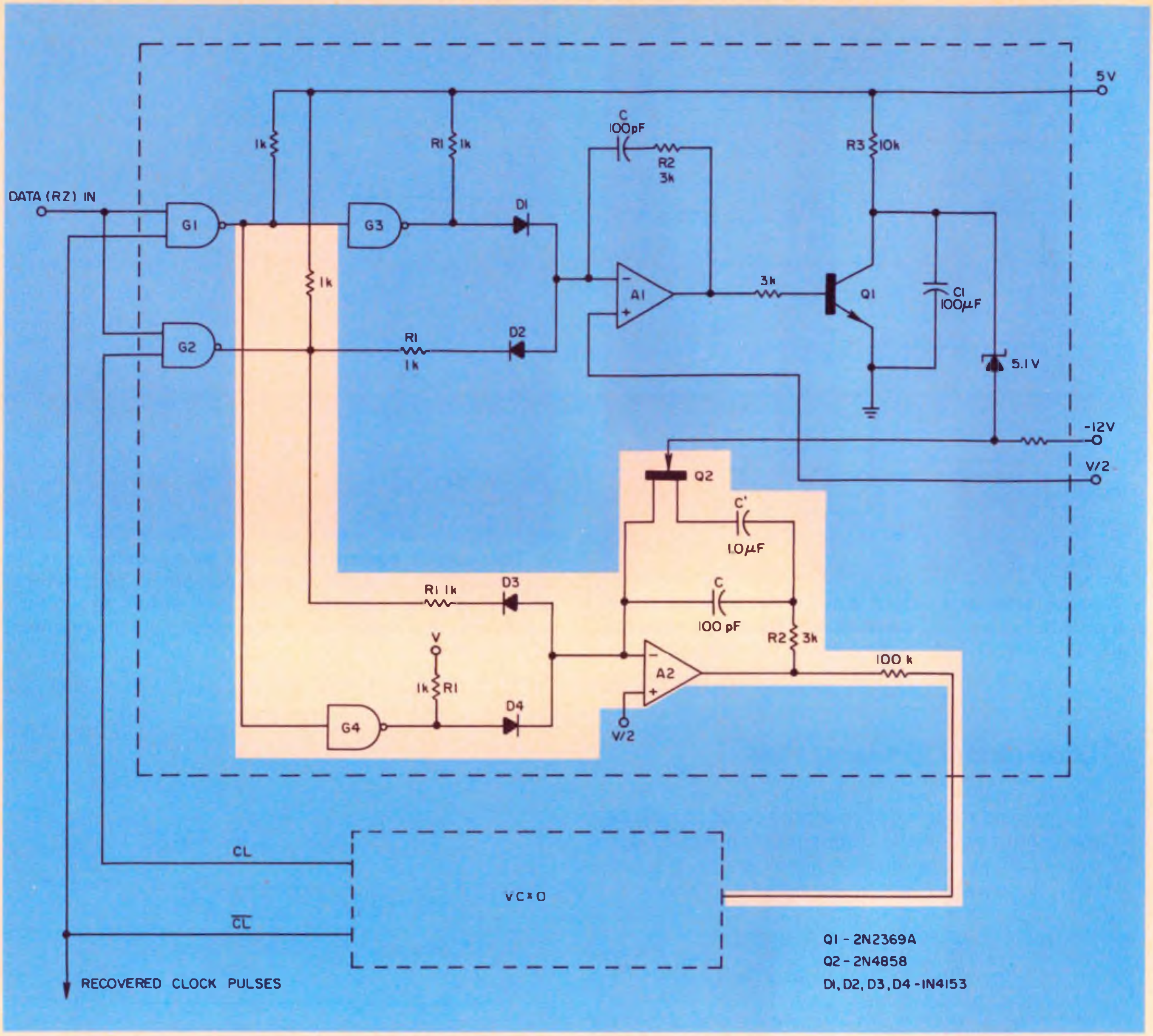
The value chosen for ρ is usually from 0.5 to 1 to ensure good transient behavior of the loop.

Another parameter, equally important, is the lock-in range, given by:

$$\Delta\omega_L = 2\ \rho\ \omega_n \qquad (5)$$

The lock range indicates the largest difference permitted between f_i and f_o at which the loop will lock-in rapidly. Equations 4 and 5 show conflicting requirements: For a wide lock-in range, ω_n should be large; on the other hand it should be small for maximum rejection of input jitter.

The problem in designing a phase-lock loop, then, is to keep the noise bandwidth as small as possible, yet maintain a wide lock-in range for the loop.



4. **A modified PLL circuit** controls the VCO through a new gate and filter (highlighted area). The original gates and filter now serve only to switch a 1-μF capacitor, which changes the filter's bandwidth.

where V is the gate supply voltage for gate B, V_d is the diode forward drop, and R is the current-determining resistance.

Normally, the clock transitions should be in the middle of a pulse. If τ is the length of the input pulse, and Δ the steady-state time deviation from nominal, then the positive current pulse lasts for $\tau/2-\Delta$, and the negative pulse $\tau/2+\Delta$.

You can interpret the asymmetrical doublet to be a symmetrical doublet plus a narrow unipolar pulse with duration Δ and amplitude 2I. These narrow pulses produce the correction voltage that maintains lock. Proper servo operation requires that

$$\tau = K_1T,\ K_1 < 1,$$

where $$T = \frac{1}{f_r},$$

and f_r = the data bit rate.

Thus, return-to-zero (RZ) data are needed. If the input data are nonreturn-to-zero (NRZ), they must be converted to RZ by generating a pulse of duration τ for every data transition, because NRZ data contain no timing information.[4]

Reducing the phase error

To predict the steady-state phase error, you first must convert the phase computation ($\theta_e = \theta_i - \theta_o$) to time:

$$\Delta = \frac{T}{2\pi}\frac{\Delta\omega}{pK_v}$$

where p is the probability that ONEs occur.

You can make the phase error as small as you want by increasing K_v. The equation for Δ also shows that the phase error is inversely proportional to the proba-

Table 1. Performance of three clock extraction circuits

Parameters	Resonant circuit*	Conventional PLL	Modified PLL
Realizable Q	100	1500	>15,000
Noise BW	15 kHz	1 kHz	<0.1 kHz
Steady state error	12°	≃0	≃0
Long term stability	0.5%	Excellent	Excellent
Necessity for manual alignment during manufacturing	Yes	No	No
Shop cost	$5	$6	$7.50

*Mistuned by 0.1%

bility of transitions in the input data. If you use an op amp for the integrator, the phase error has to supply only the bias current of the op amp. If the input data were periodic, the power spectrum at the filter input would consist only of discrete lines, namely the harmonics of the bit rate. Random data, however, produce a continuous power spectrum in addition to the discrete lines.

You can separate the continuous spectrum into a component produced by the symmetrical doublet, and one by the unipolar pulses of width Δ. The doublet has very little energy in the passband of the loop filter; the output jitter of the PLL is primarily caused by the low-frequency power in the spectrum due to the time error, $\Delta = K_2T$.

Over the bandwidth B, the input spectrum is nearly uniform and is proportional to K_2^2/f_r. The output noise is given by

$$e_{no}^2 \; \alpha \; \frac{K_2^2}{f_r} B \; \alpha \; \frac{K_2^2}{Q_e}$$

Variable Q_e is the "quality factor" of the loop:[5]

$$Q_e = \frac{f_r}{B}.$$

The output noise, or jitter, originates from:

1. The randomness of the input data; you can reduce the effect of this source by making Δ very small.
2. Modulation of the input phase, hence of Δ, due to input timing-jitter; eliminate noise from this source by reducing the noise bandwidth of the loop.

The modified PLL circuit (Fig. 4) has a bandwidth that is wide when out-of-lock, but drastically reduced after lock-in. Two phase detectors and filters operate in parallel: Phase detector 1 senses only the in-lock condition. Phase detector 2, inside the loop, has an associated filter with two time constants, determined by C and C_1. Capacitor C_1 is switched into the circuit by FET Q_2 only when the loop is locked in.

Should phase lock be lost, the output of the first filter amplifier is designed to swing from extreme positive to extreme negative. As soon as the output is positive, transistor Q_1 switches on quickly to turn Q_2 off. When the lock is regained, the amplifier output is negative and Q_2 is switched off slowly because of the large time constant R_3C_1.

Balancing the loop

Except for C_1 and its associated circuitry, the two phase detectors and the filters are identical. You may have to adjust one of the current-setting resistors, R_1, to compensate for bias-current differences in the two op amps.

The time constants of the loop filter may be changed either by adding resistance in series with R_1, or capacitance in parallel with C. But adding resistance will increase the phase error for any given amplifier bias current. Adding capacitance leads to redistribution of charges in the integrator. But, because the capacitor is switched in very slowly through a FET acting like a time-varying resistor, this should not cause any problems.

Under steady-state conditions, the signal-to-noise ratio at the output of the loop is determined by the input S/N, reduced by the loop bandwidth (which can be as small as you want). However, when the input noise is very large and at low frequencies, the output of the monitoring phase detector may become positive, and switch off C_1. This will cause sudden output jitter increase, and require a divider chain in front of the phase comparator to reduce the jitter.

To see whether the modified PLL method is worth the trouble, a comparison of three clock extraction methods is made in Table 1, which assumes an input bit rate of 1544 ±0.25 kb/s, and a required lock range of 300 b/s. "Shop cost" includes hardware (using only commercially available components), and manual alignment for the resonant circuit.

Although Q should be large to minimize noise power, resonant circuits can only realize a Q of 70 to 100. Regular PLLs surpass even the best resonant circuit by a factor of 15, and a modified PLL is superior by at least another order of magnitude. The same ratios are reflected in the noise bandwidth.■■

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3. Bellisio, J. A., "A New Phase Locked Timing Recovery Method for Digital Regenerators," *ICC Conference Records*, June, 1976, p. 10.
4. Bennet, W. R., "Statistics of Regenerative Digital Transmission," *Bell System Technical Journal*, November, 1958, p. 1501.
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CIRCLE NUMBER 245

Modulo-N counter speed

is limited by the counter module's propagation delays. But asymmetrical clock inputs can raise the speed substantially.

Because the modulo-N counter has many uses, learning how to push its operating frequency to the maximum can return dividends. The modulo-N counter is found in such important applications as frequency synthesizers, phase-lock loops and many logic-system timing circuits.

Although a bidirectional synchronous counter such as a 74193 has a typical maximum count-frequency rating of 32 MHz, in a modulo-N circuit the frequency is no better than about one-fifth of this value. But you can break through this limitation by using asymmetrical clock inputs.

Modulo-N circuit revisited

In a simplified modulo-N counter (Fig. 1a), the input clock causes the 74193 modules to count down, toward zero.[1] When zero is reached, a borrow pulse propagates to the last module's borrow output on the negative-going edge of the clock. The borrow pulse then loads the counters with the number N from the data-input bus, and the cycle repeats. The over-all result is an output pulse train of narrow, negative spikes occurring at a frequency of 1/N times the input clock.

Note in the timing-diagram sequence (Fig. 1b) for a single-stage modulo-3 counter that the loading operation quickly resets the borrow pulse to form a sharp spike. However, this simplified timing sequence doesn't contain the information that can tell you the speed limitations of Fig. 1a. The propagation delays detailed in Table 1 must be taken into account. Note the wide spread of delays an individual 74193 counter unit can have.

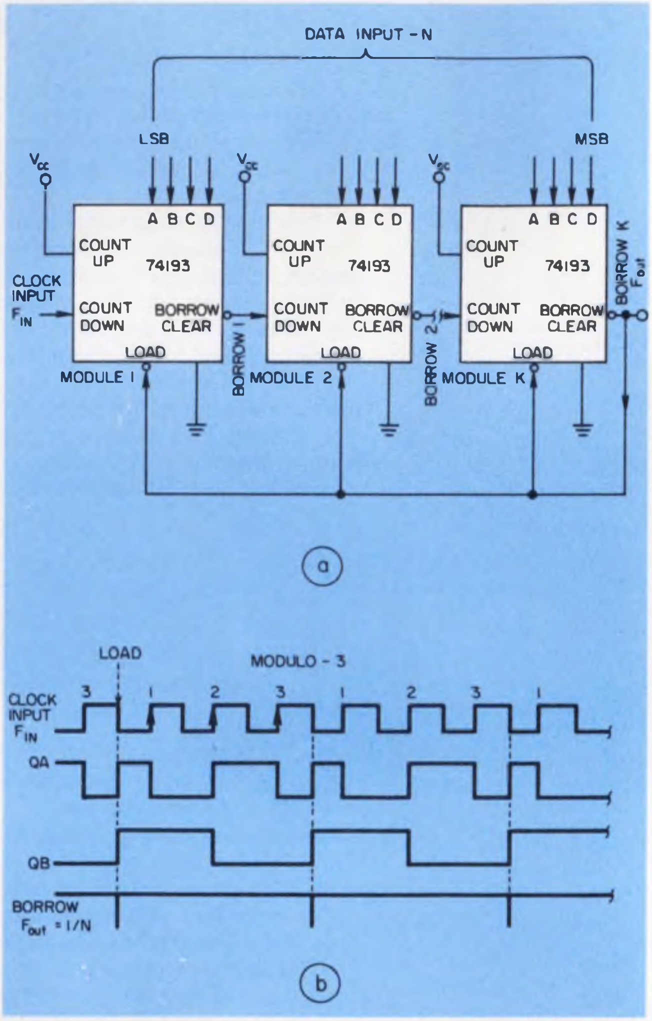
To determine maximum operating frequency for a symmetrical input clock, examine the negative-going portion of the clock pulse that generates a borrow/load signal. Fig. 2 shows a two-module counter with a set of worst-case propagation delays.

For a counter to perform reliably, the circuit must provide a minimum 20 ns between the trailing edges of the load and a clock signal. The minimum T_N is (24 + 24 + 55 + 20), or 123 ns. Therefore, for a symmetrical clock signal, the total clock period is 246 ns, which corresponds to a maximum operating frequency of 4.07 MHz. Generally, the minimum clock period for any number of counter modules is expressed by the following equation:

$$T = 2[K(T_{PCB}) + T_{PBL} + T_{LC}], \qquad (1)$$

where

T = Total minimum symmetrical-clock half-period.



1. **The simplified block diagram of a modulo-N counter chain** (a) shows how borrow outputs propagate through the chain, when the chain counts down from N and reaches zero. The final borrow-output signal, K, then reloads the counter modules with N, which quickly resets the borrow signal so that the borrow signal is seen as only a narrow spike (b).

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Table 1. Switching characteristics of a 74193

Parameter	From input	To output	Min	Typ	Max	Unit
f_{max} (clock)			25	32	50	MHz
t_{PLH} t_{PHL}	Count-down	Borrow	8 8	16 16	24 24	ns
t_{PLH} t_{PHL}	Either count	Q	13 16	25 31	38 47	ns
t_{PLH} t_{PHL}	Load	Q	14 15	27 29	40 40	ns
t_{PHL}	QA (output)	Borrow	5	10	15	ns
t_{PLH}	Load	Borrow	20	40	55	ns
*t_W (width of any input pulse)			8	15	20	ns
*t_{LC} (time between rise of load and rise of clock)			8	15	20	ns

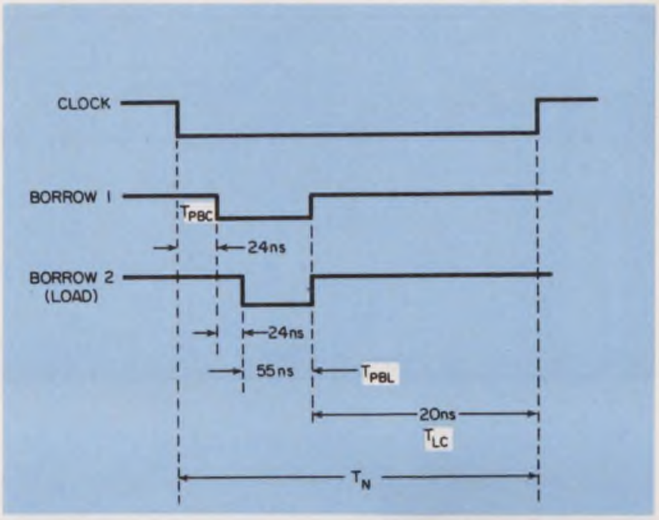
*to guarantee operation
t_{PHL} = propagation delay for high-to-low level
t_{PLH} = propagation delay for low-to-high level

Table 2. Maximum operating frequency of a symmetrical input clock

Number of counter modules (K)	Maximum operating frequency (MHz)		
	Minimum delays	Typical delays	Maximum delays
1	13.89	7.04	5.05
2	11.36	5.75	4.07
3	9.62	4.85	3.70
4	8.33	4.20	3.40
5	7.35	3.70	3.14
6	6.58	3.31	2.92

Table 3. Maximum operating frequency with 20-ns positive clock pulses

Number of counter modules (K)	Maximum operating frequency (MHz)		
	Minimum delays	Typical delays	Maximum delays
1	17.86	10.42	7.30
2	15.63	8.93	6.21
3	13.89	7.81	5.41
4	12.50	6.94	4.78
5	11.36	6.25	4.29
6	10.42	5.68	3.89



2. **Studying the timing details of the negative clock-signal interval** reveals the series of delay times that limit the counting speed of a modulo-N circuit.

K = Number of modules.
T_{PCB} = Propagation delay, high-to-low level, of borrow output with respect to clock input signals.
T_{PBL} = Propagation delay, low-to-high level, of borrow output with respect to load-input signals.
T_{LC} = Minimum period between rise of load and rise of clock signals to guarantee operation.

Table 2 shows the results of solving Eq. 1 for minimum, typical and maximum values of the delays, but only the maximum-delay values can guarantee that all counter modules operate.

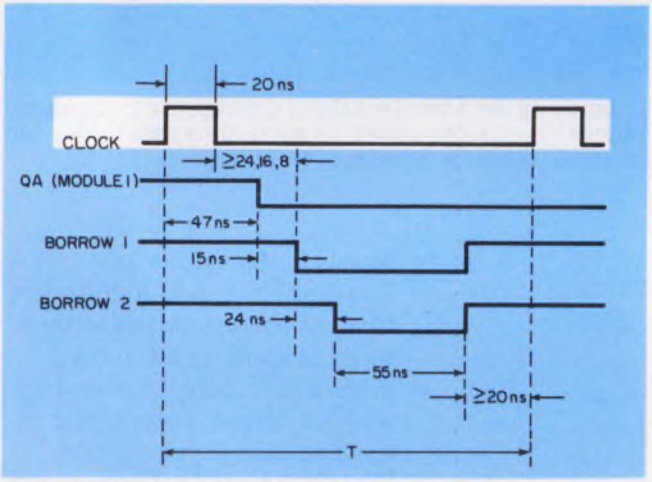
A test circuit for a one-module, modulo-8 divider built by this author operated properly up to an input clock rate of 13 MHz. From 13.7 to 24.8 MHz, however, the circuit consistently divided by 9. And between 13.0 and 13.7 MHz, the circuit divided by almost anything, with 11 and 15 predominating. The test was repeated for modulo-7 and achieved similar results. The 74193 used in this test apparently was faster than units classified as typical according to Tables 1 and 2.

The modulo-8 test results suggest that you can reliably operate a multimodule circuit in an N+1 mode at frequencies above the maximum. Unfortunately, by the time a minimum delay module starts to operate in an N+1 mode, Table 2 implies that another slower module would operate in an N+2 mode. So don't try to operate above the values in the maximum column in Table 2 for truly reliable performance.[4]

Another note of caution: Frequently, a symmetrical output pulse is required in modulo-N applications. Obviously, you should set the data inputs to N/2 and feed the Borrow/Load output signal to a flip-flop. Note in Table 1, however, that the width of a borrow/load

Table 4. Maximum operating frequency with maximum circuit delays

Number of counter modules (K)	Maximum operating frequency (MHz)			
	Symmetrical input	40-ns positive pulses	30-ns positive pulses	20-ns positive pulses
1	5.05	7.19	7.30	7.30
2	4.07	6.14	6.21	6.21
3	3.70	5.35	5.41	5.41
4	3.40	4.74	4.78	4.78
5	3.14	4.26	4.29	4.29
6	2.92	3.86	3.89	3.89



3. **An asymmetrical clock signal** allows you to operate a modulo-N circuit at a higher frequency than with a symmetrical clock.

pulse can range from 20 to 55 ns. The 20-ns value restricts the choice of flip-flops to high-speed units.

For still higher frequencies

But "shaping" the input clock signal can improve speed significantly over the values determined by Table 2 and Eq. 1. The high-level portions of the clock pulses needn't be as wide as the low—merely equal to, or greater than, 20 ns. However, when driving the modulo-N counter with 20-ns positive going pulses, the propagation delay from the QA output to the Borrow output of a module—15 ns max—must be considered. Fig. 3 shows a timing chart for a 2-module counter with a 20-ns positive-going pulse clock input and worst-case delays.

Fig. 3 shows that the total worst-case clock period, T, is (47 + 15 + 24 + 55 + 20), or 161 ns, which is a maximum operating frequency of 6.21 MHz. In general, the minimum clock period for a 20-ns positive-going clock pulse and maximum circuit delays is computed by

$$T_{max20} = 137 + (K-1)24 \text{ (ns)}, \qquad (2)$$

where

$$137 = 47 + 15 + 55 + 20.$$

A similar analysis for typical and minimum delays results in

$$T_{typ20} = 96 + (K-1)16 \text{ (ns)}, \qquad (3)$$

where

$$96 = (31 + 10 + 40 + 15).$$

Also,

$$T_{min20} = 56 + (K-1)8 \text{ (ns)}, \qquad (4)$$

where

$$56 = (20 + 8 + 20 + 8).$$

The results of applying Eqs. 2, 3 and 4 are shown in Table 3. Again, only the maximum-delay column will guarantee operation for all modules.

Clock pulses generated by a 74121 one-shot can produce pulses in the 30-to-40-ns range. If used to drive a modulo-N counter, the equations for operating with these one-shot pulse widths are as follows:

For maximum circuit delay in nanoseconds,

$$T_{max30} = 137 + (K-1)24,$$
$$T_{max40} = 139 + (K-1)24.$$

For typical circuit delays,

$$T_{typ30} = 101 + (K-1)16,$$
$$T_{typ40} = 111 + (K-1)16.$$

For minimum circuit delays,

$$T_{min30} = 66 + (K-1)8,$$
$$T_{min40} = 76 + (K-1)8.$$

Applying these equations with maximum circuit delays, you get the results summarized in Table 4. The values listed guarantee that all the modules will operate. For reliable performance at higher frequencies, you must use faster counters, such as the ECL types, or you can use logic circuits that incorporate look-ahead-borrow techniques.■■

References

1. Morris, R.L. and Miller, J.R., *Designing with TTL Integrated Circuits*, McGraw-Hill, New York, 1971, p. 272.

2. "The TTL Data Book for Design Engineers, CC-411" First Edition, Engineering Staff of Texas Instruments, Components Group, Dallas, 1973, p. 333.

3. Some of the specifications were furnished by Ron Natali of Texas Instruments, Stafford, TX.

4. Buhler, O.R., "Stop Counter Errors," *Electronic Design*, Jan. 4, 1977, pp. 104-106.

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CIRCLE NUMBER 49

Collect data via pulse-code modulation

in your next data-acquisition system. PCM handles bandwidths of 5 kHz, has a high s/n ratio and permits data manipulation.

In a data-acquisition system, analog signals with bandwidths below 5 kHz are often best handled with pulse-code modulation (PCM) techniques. Above 5 kHz, other ways to handle analog data, such as direct recording and frequency-modulated recording, have their own advantages, depending on the number of channels, the frequency range of the signals and the required accuracy of the recorded data.

Below 5 kHz, however, PCM offers many advantages: data are stored in digital form, thus guaranteeing accurate reproduction of recorded signals; the signal-to-noise ratio is better than 70 dB (about double that of many FM or direct recording methods); and the accuracy of recorded information is within 0.1% (about an order of magnitude better than most other methods).[1]

PCM requires that analog signals be sampled at regular, discrete intervals and that the signal amplitudes be coded into a digital format (Fig. 1). Even though most data-acquisition applications are analog, to maintain accuracy and ease data manipulation, you are better off encoding the data digitally before recording. You also ensure that the desired signals are truly recorded and regenerated. PCM systems are typically 0.1 to 0.025% accurate—or even better, depending on the converter used.

PCM permits data manipulation

Since the data are stored digitally, a great deal of manipulation and control can be performed via digital techniques. Thus, a complete data-acquisition system, possibly microprocessor controlled, will contain the following features:

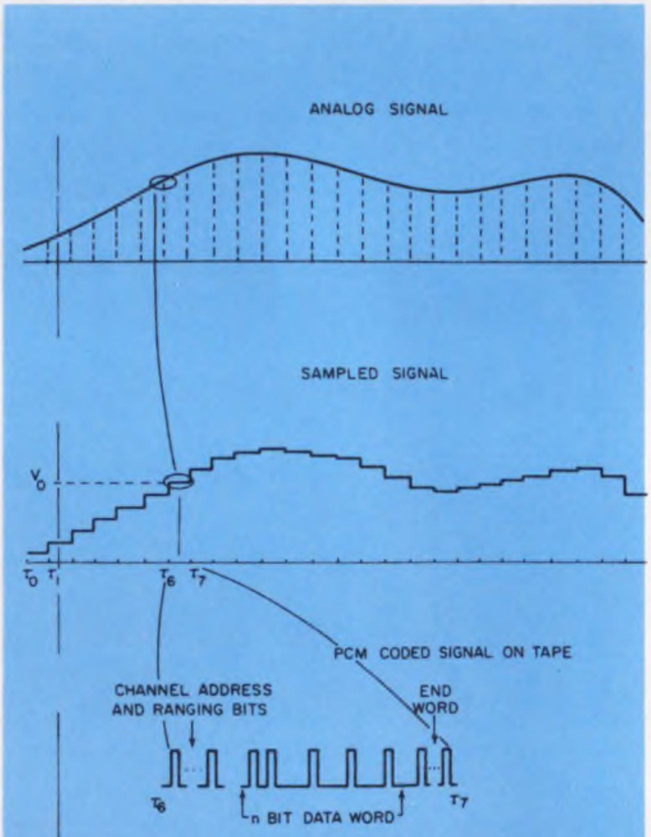
- Automatic or manual operation.
- Autoranging for analog inputs.
- Basic accuracy of at least 0.1%.
- Input capacity of at least four channels, but preferably more. (Channel capacity should be expandable.)
- Accurate timing to keep track of data.
- Incremental or continuous recording for good I/O capability.

The circuits that handle and control data flow can be broken down into four major building blocks:

1. Analog-signal handling, which includes the multiplexer.
2. Digitizing, which includes sample/hold amplifier (if used), a/d converter and autoranging circuits.
3. Addressing and timing, which includes clock and parity generation circuits.
4. Recording and transmitting, which includes the tape-drive and line drive circuitry and the motor control.

A basic data-acquisition system is outlined in Fig. 2. Many different companies offer subsystem compo-

Stan Yalof, President, and **Don Gregg,** Principal Engineer, Tetrahedron Associates, 7605 Convoy Ct., San Diego, CA 92111.



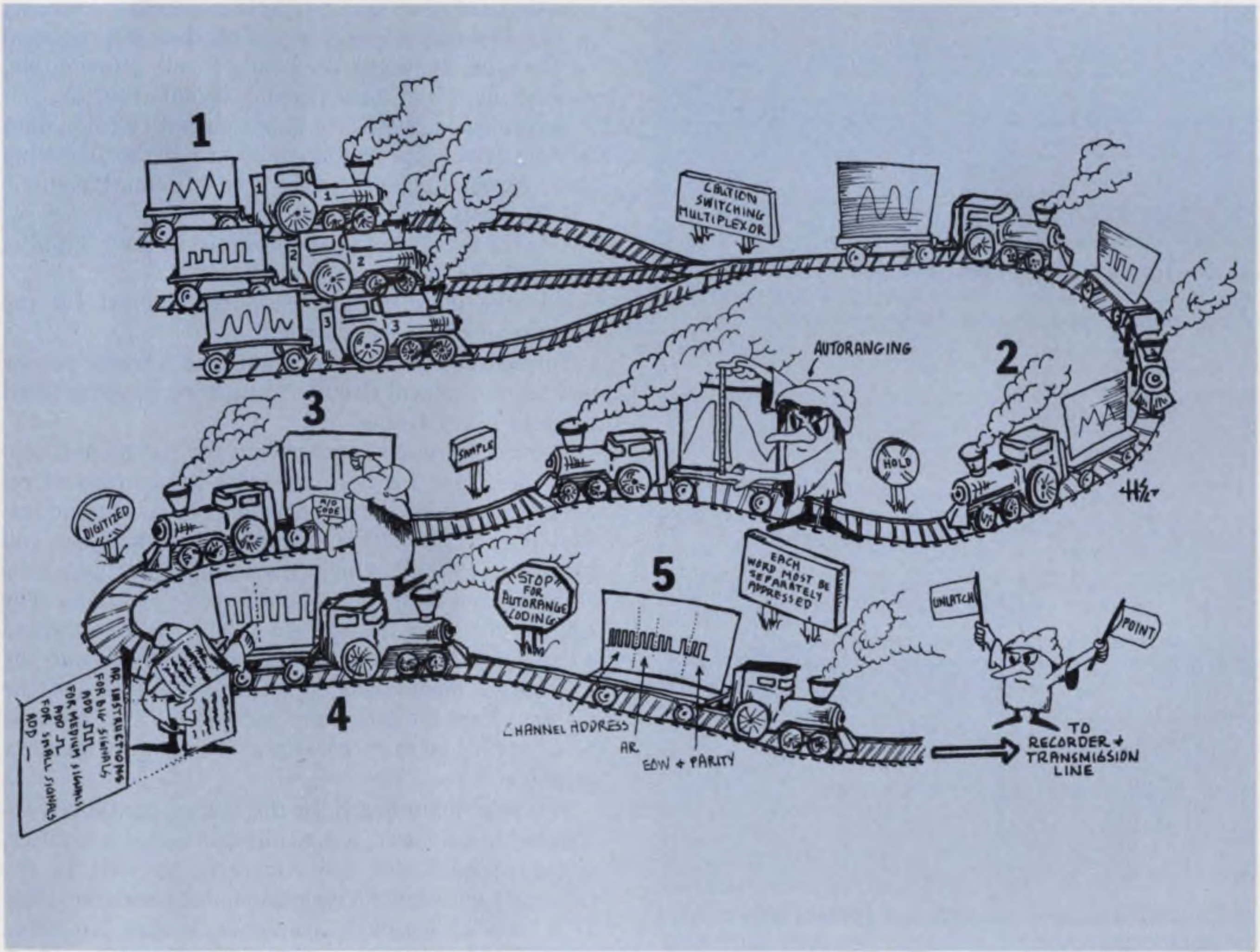
1. **Encoding an analog signal into digital form,** PCM techniques provide the accuracy necessary to guarantee true reproduction of the analog signal when it's played back. Digital encoding also permits the data to be manipulated easily for expansion or compression.

nents such as input amplifiers, analog signal multiplexers, sample/hold amplifiers, a/d converters and digital logic, therefore the design to be discussed will only be covered in general form—specific devices must be selected by individual performance requirements.

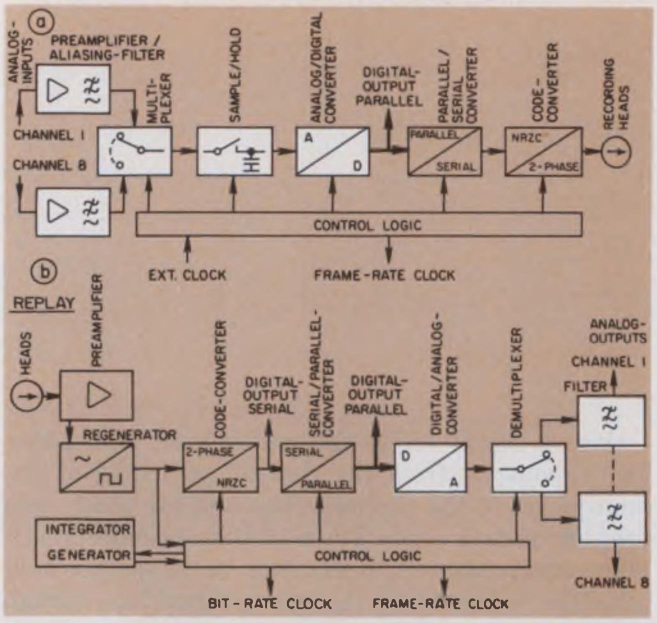
Each input line actually consists of a signal-conditioning amplifier combined with a 2 to 12-pole aliasing filter. Each filter prevents signal components above the maximum transmission frequency (often 5 kHz) from getting through the multiplexer to form ghosts —lower-frequency signals caused by the periodic sampling of the data—that appear as real signals.

Once a signal enters the multiplexer, it is under digital control—from the channel switching of the multiplexer to the timing pulses and the parity bits used on the data words. The multiplexer connects each of the input channels, in sequence, to the sample/hold amplifier, which holds the analog signal long enough for the analog-to-digital converter to digitize the analog value.

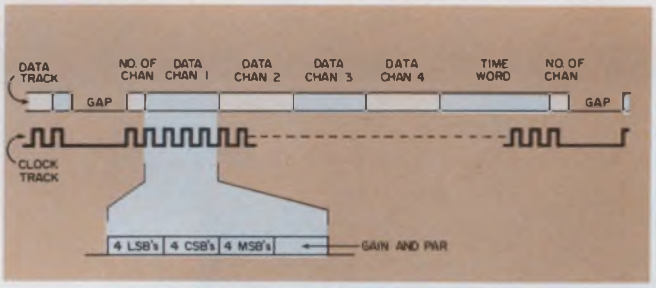
There are several methods of formatting PCM, depending on individual objectives and available equipment—serial, parallel, two-phase and others. During formatting the data word is given its



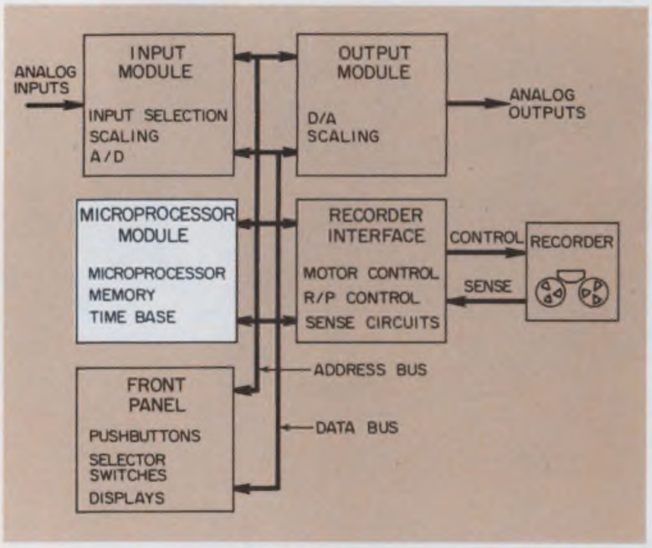
2. **A complete PCM-based data-acquisition system** combines multiple analog input channels and digitizes the channels sequentially. The data train covers a lot of ground en route to its tape-storage destination.



3. **Converting the analog input data to serial digital format,** the input circuitry of the data-acquisition system (a) multiplexes the inputs, samples them, converts them to digital form, then serializes and encodes the data. To decode the data stored on magnetic tape, the entire recording process must be done in reverse (b).



4. **One frame of digital data** consists of a header to define the number of channels, the time code, a data word from each channel, and an end-of-frame indicator.



5. **Organized around the data and address buses** of the microprocessor-based controller, all sections of the data-acquisition system are treated as memory locations to simplify access and reduce hardware.

automatic-ranging code label. Once labeled, the word gets a timing-address code, a parity bit and if necessary, an end-of-word label.

The entire recording process is shown in Fig. 3a. Each completed word is sent on to the recording circuitry where it is placed on tape usually in the form of flux reversals. Again, there are many ways to format data, but one way to keep the circuitry simple is to record four bits at a time and use a separate clock track for timing.

To recover the data, reverse the process

Recovering data is almost the exact reverse of recording, except that the clock is sensed to synchronize the reading of data (Fig. 3b). Flux reversals on the clock track are sensed and used to synchronize detection and storage of data on each track. If a flux reversal is sensed on a data track, a ONE is stored; if no reversal is sensed, a ZERO is stored—at least, that's the scheme used by Tetrahedron in the Data Manager data-acquisition system.

For data to be read from the tape, the gap between frames must first be sensed. This gap, just an absence of a clock signal over a short section of tape, indicates that no data are stored in that section of the tape and must be used when performing incremental recording. A frame is a complete sweep of all channels recorded on the tape, including the header, time information, channel data and end-of-frame signal (Fig. 4).

Before being passed on to the output circuits, data in each frame are examined to see if the following three questions can be answered affirmatively:

- Is parity met?
- Is the number of channels listed at the beginning the same as the number at the end?
- Is the number of clock pulses correct for the number of channels recorded?

To recover the data you want, use a frame sensor and set the control circuits to capture, say, the third word of every frame.

A microprocessor can perform the timing and control operations for both the data-recording and recovery sequences. For one possible μP-based organization, check Fig. 5. This system is bus-organized and based on a 6800 μP, which treats the I/O sections, tape recorder and front panel as memory locations. The control panel for the system (Fig. 6) is also treated as memory—the status of all switches read into the μP control module under software control and the displays that indicate time and other functions can be controlled by the processor as if they were memory locations.

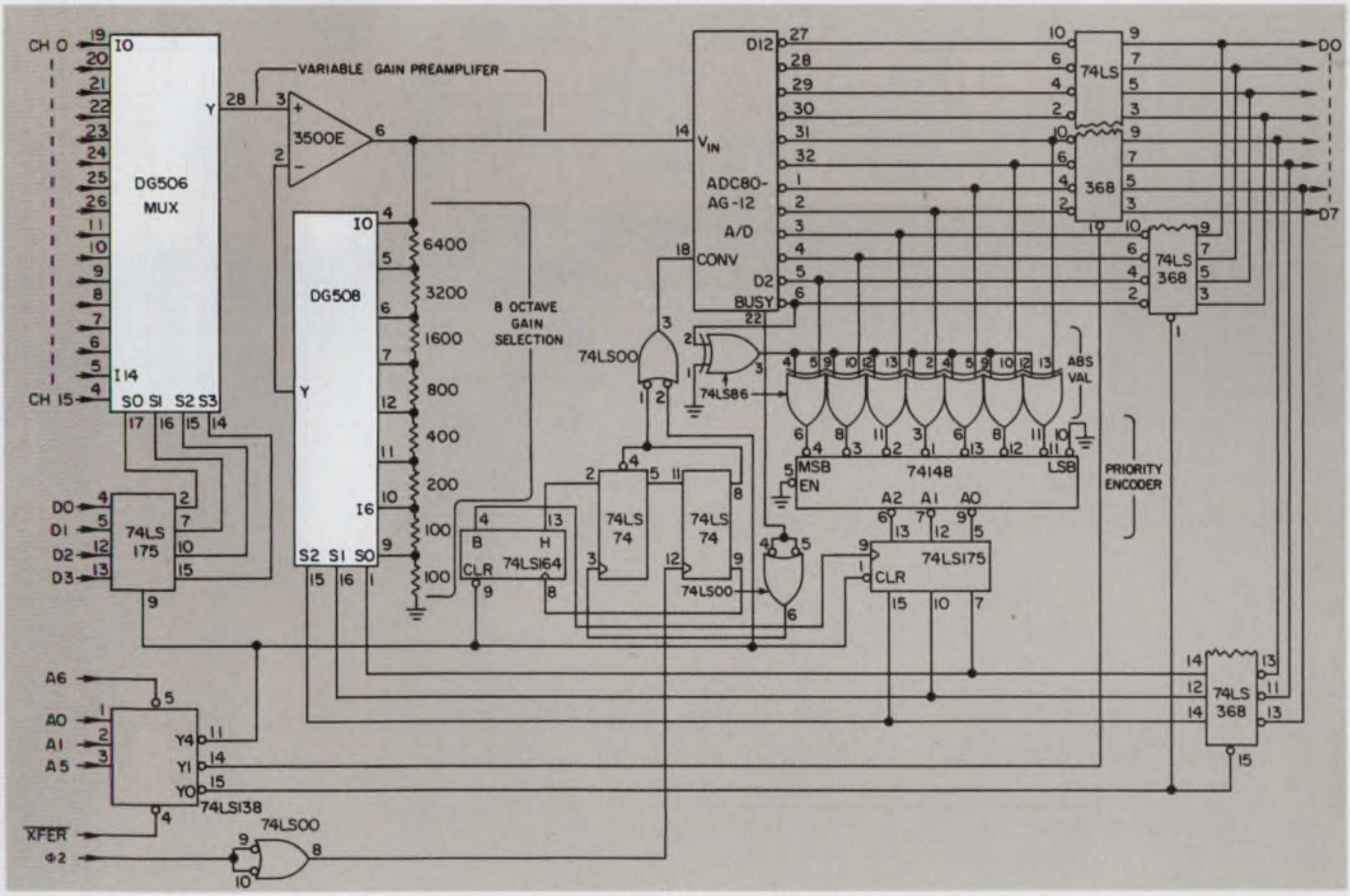
A typical input board for the system contains a 16-channel multiplexer, a digitally controlled amplifier, a high-speed 12-bit a/d converter as well as the necessary gain-control logic and output registers (Fig. 7). A 74LS138, acting as an address decoder, initializes the gain to 1, selects the proper input channel, enables the output data bus and starts the a/d conversion.

6. **The front panel for a data-acquisition system** typically has control switches to define the number of channels, the scan rate, the step time and many other control functions such as those for the recorder.

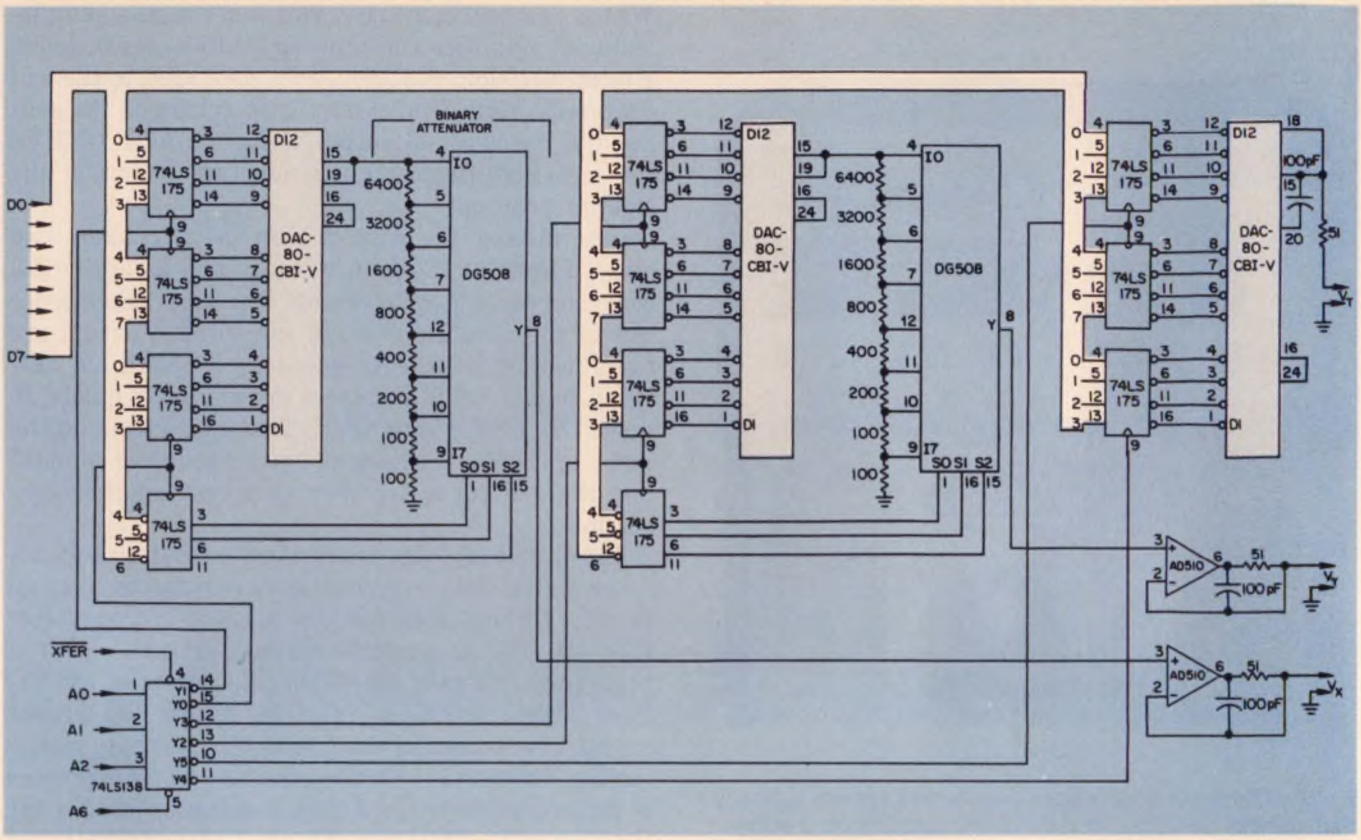
With a fast a/d converter, you won't need a sample-and-hold amplifier since the signal to be converted is a relatively slow changing level compared to the a/d conversion time. The correct gain setting is the gain causing the encoded output to have a logic ONE in the most-significant-bit position (not including the sign-bit position).

Determining the correct gain usually takes two steps: First, set the gain to unity and have the a/d converter perform a conversion. Then the higher-order bits of the absolute value of the encoded output are examined by a priority encoder to determine how many binary (× 2) increases in gain are required to make the MSB a logic ONE. The gain setting on the input amplifier is changed by the required amount and the a/d converter then performs another conversion.

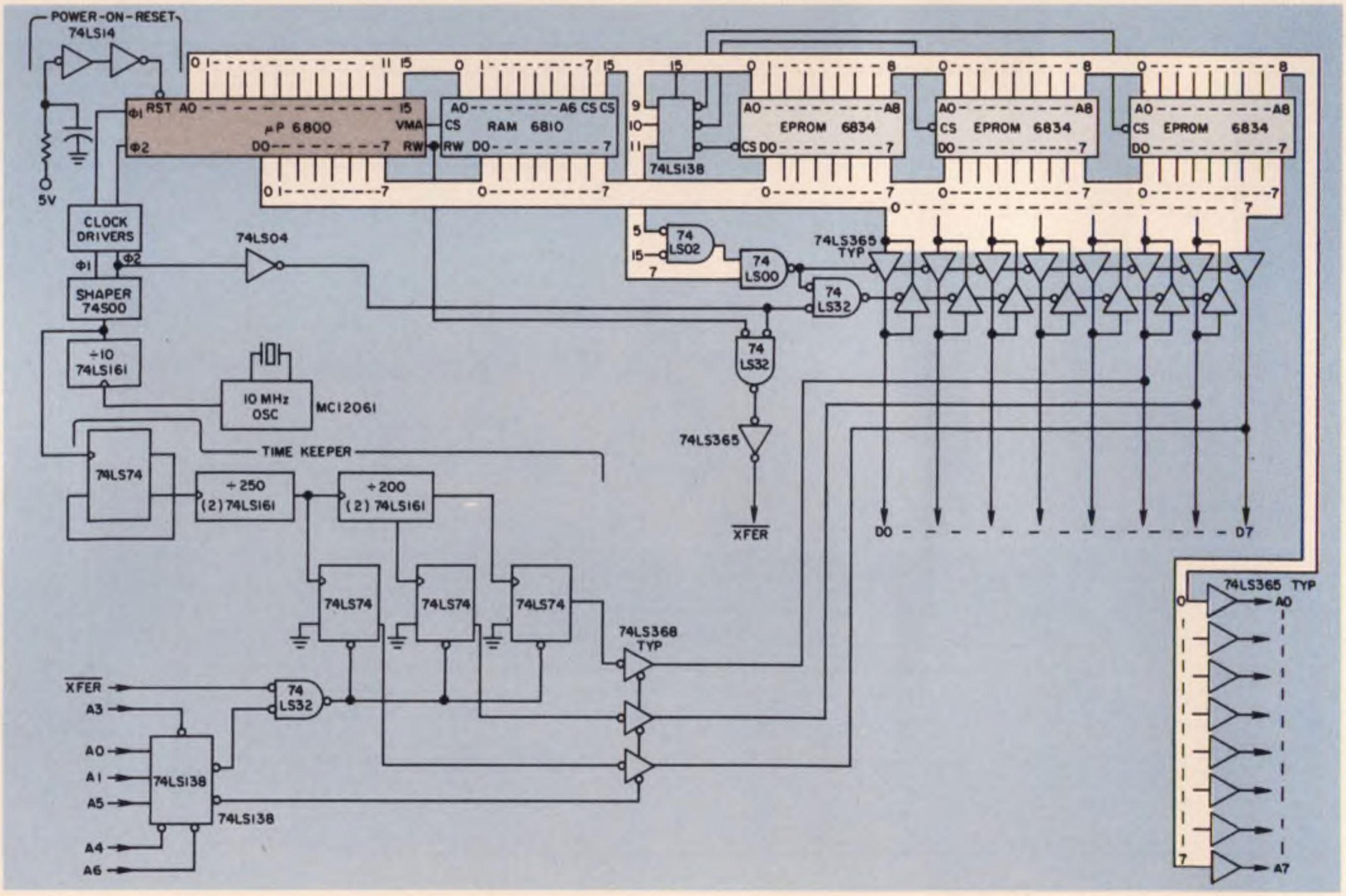
The output module operates in the reverse sequence—the digital data from the tape are restored to a full parallel format, then fed into a 12-bit d/a converter (Fig. 8). The converter's output, in turn, feeds a programmable-gain amplifier that provides the desired signal levels. A 74LS138 selects the proper register for accepting data, with the first byte selecting the MSBs and the scaling coefficient. This process is performed for both X and Y outputs, but not for the time scale, which has only the LSB and MSB bytes but no scaling coefficient.



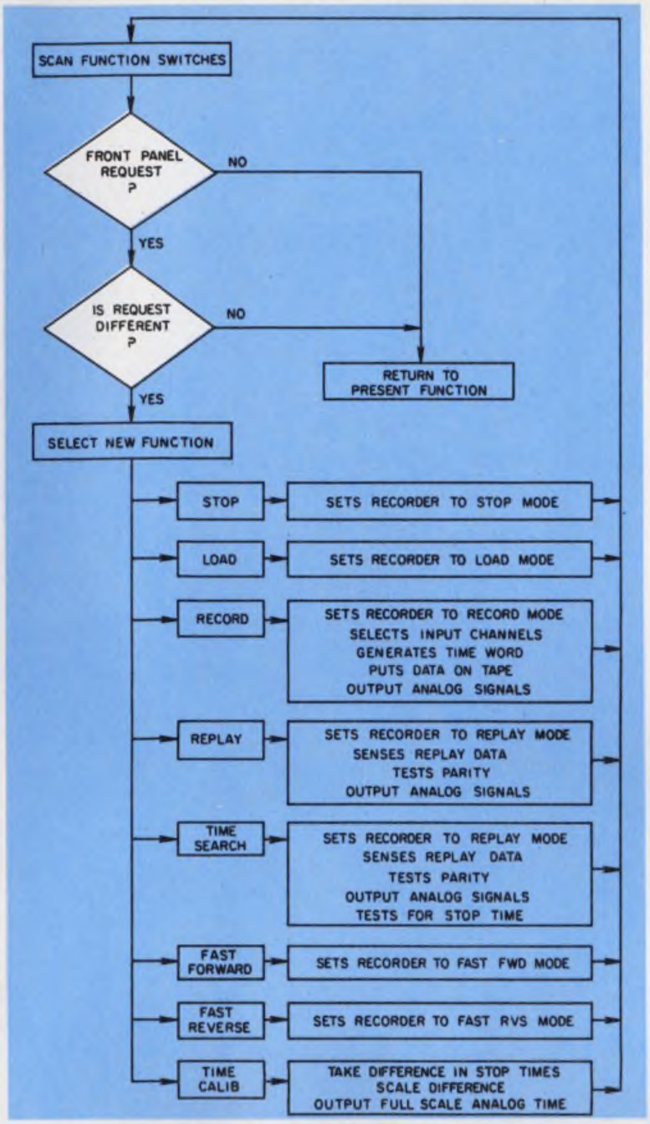
7. **Handling analog inputs from microvolts to volts,** the 14-channel analog input module contains a programmable-gain amplifier, a high-speed 12-bit a/d converter and, of course, the multiplexer.



8. **The analog output module** contains three d/a converters, one for the X output, one for the Y drive and one for the TIME drive. The X and Y converters deliver signals to programmable-gain amplifiers.



9. **Based on a 6800 μP,** the controller includes all the timing and I/O circuitry that is necessary to manipulate and coordinate the various sections of the complete data-acquisition system.



10. **To control a data-acquisition system,** the 6800-based controller must follow a routine like this one to examine the front panel and follow the commands.

Coordinating all the functions of the data-acquisition system, the μP control section contains the control memory, the processor, the serial and parallel control lines and all the timing circuitry (Fig. 9).

A complex task becomes routine

Under ROM control, the 6800-based system performs the complex task of monitoring the front-panel controls and performing the indicated functions (Fig. 10). Each switch and display on the front panel has a unique address and can be accessed by the μP when an address is loaded onto the address bus. When a switch is accessed the setting is loaded onto the data bus for the μP to read. When addressing a display, the μP loads the contents of the data bus into the respective display register that, in turn, feeds a driver.

The system front panel should contain all controls and displays necessary for complete manual operation. On the Data Manager, the front panel is divided into three primary functions: Record, Replay and Time Search, and three secondary functions: Time Display, Offset and Time Calibrate. The Record function samples the selected number of analog input channels at the selected scan rate, autoranges the sample, digitizes the sample and records the data on tape. The signal is also reconverted into an analog signal that is available on a rear-panel jack.

The Replay function runs the magnetic tape in the direction selected, reads a block of data at the selected replay rate, tests the parity bit, and checks for an error. Then it outputs the data to the converter section for restoration to the analog form, and the time information to the time display. For the Time Search function, which is similar to the Replay, the tape is read at maximum R speed. Replay will stop when the corresponding selected stop time is read from the tape.

Additional control is supplied by the secondary functions. The Time Display shows the time word corresponding to each update of analog output signals. The time word represents the time each sample was taken, in seconds, during a Record operation. Initialization of the time to zero occurs when a Record operation is initiated, and increments occur at the selected scan rate.

To add a voltage offset to an analog signal, the Offset adjustment can be used to set a predetermined level to the output jack. Even time can be scaled—the Time Calibrate function scales the time analog output to the difference between the forward and reverse stop times. This "scaling" permits the operator to fit the data within the selected time interval for a particular recorder. The scaling also sets the reverse stop time to 0 V, and the forward stop time to between +5 and +10 V dc.

The processor section also controls the tape-unit interface. Two sets of signals are fed to the tape mechanism—the basic control sense lines and, of course, the date lines. Control signals activate the stepper motor, tension motors, solenoid and indicator lamps. Signals generated by the mechanism include status flags to the μP controller (file protect, cartridge in place, solenoid lifted, and end of tape) to help the processor in its decision-making routines.

Information can be collected, collected, and collected. But then what do you do with it? By taking advantage of PCM's high accuracy and reproducibility, data stored in one channel can be compared, scaled and compared, or reproduced at any time and compared with previously collected data without any errors. Fast or slow data can be replayed at either low or high speeds, for time expansion or compression, without sacrificing any accuracy. For example, the stress profile of a tanker ship, taken over several months, versus all pertinent collected variables can be compressed into a single graphic presentation within minutes.■■

References

1. Yalof, Stan, "Curb Analog Data Errors with PCM," *Electronic Design*, June 7, 1974, pp. 124-127.

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CIRCLE NUMBER 48

UNITRODE

IN SEMICONDUCTORS, UNITRODE MEANS POWER.

Multilayer coil design is made easy with a programmable calculator. Not only are AWG numbers provided, but also wire material and tempco can be changed.

Multilayer coil design is laborious when done with tables, charts and complicated formulas. [1,2,3] But now a programmable calculator like the TI-59 can handle the large number of steps needed to provide comprehensive calculations for rectangular and circular multilayer coils. Although the equations (Fig. 1) relating inductance to number of turns, dimensions, wire size, resistance and temperature are complicated, the program makes them easy to implement.

With its 795 steps, the TI-59 program can design a coil of a desired inductance, resistance or number of turns, given its dimensions. Also, the program selects the American Wire Gauge (AWG) number for the wire that will fill the coil's window and yield the maximum inductance possible for a given resistance, or the minimum resistance for a given inductance. In addition, the program can compute temperature effects on resistance and the effect of using wire materials other than copper.

The program's easy to use

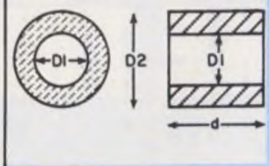
To run the program, just enter the dimensions of the bobbin as in step 3 of the sequence (see table). Enter the known item—the inductance, the number of turns or the resistance—into labels A, B or C, respectively. After a few seconds the calculator displays the first of the three unknowns. The remaining answers are obtained, thereafter, by pressing R/S (steps 4a, 4b or 4c) until you have solved all the unknown parameters, including the AWG number.

Note that circular and rectangular coils have the same sequence, but rectangular calculations are performed with labels *A′ , *B′ , and *C′ . And when the calculator is connected to a PC-100A printer, all values are printed and identified by name.

Furthermore, you don't have to press R/S to obtain the next answer; R/S is activated automatically as answers are printed. The program "knows" when the calculator is attached to the printer, and consequently doesn't halt after each intermediate answer. This programming sequence, which incidentally can be helpful in other TI-59 programs, is contained in steps

Thomas B. Gross, Consultant, T.A.O. Gross and Associates, Lincoln, MA 01773.

CIRCULAR COILS



N = number of turns

$K_n = \dfrac{1}{1+.9(r/d)+.32(t/r)+.84(t/d)}$

$r = (D_1+D_2)/4 \qquad t = D_2-D_1$

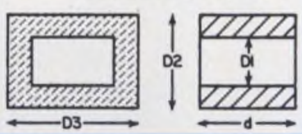
D_1 = inner diameter in cm

D_2 = outer diameter in cm

d = length of coil in cm

$$L = K_n \frac{4\pi^2 r^2 N^2}{d} 10^{-9} \text{ (henrys)}$$

RECTANGULAR COILS



$g = \sqrt{D_2^2 + D_3^2}$

$c = D_2 - D_3$

D_1 = shorter length (cm)

D_2 = shorter length (cm)

D_3 = longer length (cm)

$$L = 0.00921(D_2+D_3)N^2 \left[\log_{10} \frac{2D_2D_3}{c+d} - \frac{D_2}{D_2+D_3}\log_{10}(D_2+g) - \frac{D_3}{D_2+D_3}\log_{10}(D_3+g) \right] + 0.004(D_2+D_3)N^2 \left[\frac{2g}{D_2+D_3} - \frac{1}{2} + 0.447\frac{(c+d)}{(D_2+D_3)} \right] \text{ (henrys)}$$

Wire resistance in ohms at 20 C is

$R = \rho L/A$ | L = length in cm, A = area in cm^2, ρ = resistivity (Ω-cm at 20 C)

Resistance of a wire at a temperature other than 20 C is

$$R_t = R_{20}\,(1 + \alpha\,(t - 20))$$

α = temperature coefficient of metal at 20 C.

The American Wire Gauge number is related to wire cross-sectional area by

$$(\text{AWG}) \approx -10\left(\log\frac{\text{C.M.}}{100{,}000}\right)$$

C.M. = cross-sectional area in circular mils

1. **Multilayer-coil inductance equations** for round and rectangular coils are too complicated and time-consuming to solve manually. The work becomes even more difficult if you also calculate coil resistance for any metal at any temperature, and then get answers in AWG numbers. But a calculator makes it all easy.

Sequence of operations

1. **Partition calculator**
   Enter 2 Press 2nd *Op 17 Display 799.19
2. **Load both cards:** all four sides
3. **Enter bobbin dimensions** in cm:
   Enter D_1 Press D Display D_1
   Enter D_2 Press 2nd *D' Display D_2
   Enter d Press E Display d
   (and for rectangular coils:)
   Enter D_3 Press 2nd *E' Display D_3

4a. **Enter inductance** (L) in henrys:
   For circular coils Press A
   For rectangular coils Press 2nd *A'
   Display (N)
   **Press R/S Display (AWG)
   **Press R/S Display (OHMS)

4b. **Enter number of turns** (N):
   For circular coils Press B
   For rectangular coils Press 2nd *B'
   Display (L) henrys
   **Press R/S Display (AWG)
   **Press R/S Display (OHMS)

4c. **Enter resistance** in ohms:
   For circular coils Press C
   For rectangular coils Press 2nd *C'
   Display (AWG)
   **Press R/S Display (N)
   **Press R/S Display (L) henrys

**Performed automatically when used with PC-100A printer

Program constants and codes

Registers	Contents	Comments
00	0.4	space factor
01	D_1	
02	D_2	
03	D_3	
04	d	
05	(used)	
06	(used)	
07	1.	relative resistivity of copper
08	1.724137931	resistivity of copper at 20 C ($\mu\Omega$-cm)
09	0.00393	temperature coefficient of copper
10	20.	temperature °C.
11	16021530.	"D1CM"
12	16031530.	"D2CM"
13	16041530.	"D3CM"
14	27001530.	"L CM"
15	32233036.	"OHMS"
16	55275623.	"(L)H"
17	134322.	"AWG"
18	(used)	
19	(used)	

280 through 289 of the program.

To enter the program into the calculator, you first partition the calculator. In the calculator's notation, 20 registers for data (00 to 19) and 800 registers for the program (000 to 799) appear as 799.19 on the calculator's display. You obtain this partitioning by pressing keys 2, 2nd, *Op 17, in that order. A space factor is put into data register 00, and the other constants and alphanumeric codes used in the program are put into registers 07 to 17 (see table of

000	98	ADV	055	12	B	110	01	01	165	91	R/S	220	71	SBR
001	98	ADV	056	71	SBR	111	13	13	166	71	SBR	221	06	06
002	98	ADV	057	03	03	112	91	R/S	167	07	07	222	31	31
003	91	R/S	058	07	07	113	71	SBR	168	62	62	223	81	RST
004	76	LBL	059	65	×	114	05	05	169	81	RST	224	76	LBL
005	13	C	060	71	SBR	115	77	77	170	76	LBL	225	14	D
006	71	SBR	061	04	04	116	81	RST	171	18	C'	226	42	STO
007	03	03	062	17	17	117	76	LBL	172	71	SBR	227	01	01
008	65	65	063	87	IFF	118	17	B'	173	03	03	228	25	CLR
009	53	(	064	07	07	119	71	SBR	174	65	65	229	43	RCL
010	43	RCL	065	00	00	120	06	06	175	43	RCL	230	11	11
011	02	02	066	68	68	121	31	31	176	03	03	231	69	OP
012	33	X^2	067	91	R/S	122	87	IFF	177	65	×	232	04	04
013	75	-	068	71	SBR	123	07	07	178	43	RCL	233	43	RCL
014	43	RCL	069	05	05	124	01	01	179	02	02	234	01	01
015	01	01	070	54	54	125	27	27	180	65	×	235	69	OP
016	33	X^2	071	87	IFF	126	91	R/S	181	43	RCL	236	06	06
017	54	)	072	07	07	127	71	SBR	182	04	04	237	91	R/S
018	65	×	073	00	00	128	07	07	183	75	-	238	76	LBL
019	89	π	074	76	76	129	62	62	184	43	RCL	239	19	D'
020	65	×	075	91	R/S	130	81	RST	185	01	01	240	42	STO
021	43	RCL	076	71	SBR	131	76	LBL	186	65	×	241	02	02
022	04	04	077	05	05	132	16	A'	187	43	RCL	242	25	CLR
023	55	÷	078	77	77	133	71	SBR	188	04	04	243	43	RCL
024	04	4	079	81	RST	134	03	03	189	65	×	244	12	12
025	65	×	080	76	LBL	135	93	93	190	53	(	245	69	OP
026	71	SBR	081	11	A	136	55	÷	191	43	RCL	246	04	04
027	04	04	082	71	SBR	137	53	(	192	03	03	247	43	RCL
028	28	28	083	03	03	138	71	SBR	193	75	-	248	02	02
029	87	IFF	084	93	93	139	06	06	194	71	SBR	249	69	OP
030	07	07	085	55	÷	140	59	59	195	03	03	250	06	06
031	00	00	086	71	SBR	141	85	+	196	31	31	251	91	R/S
032	34	34	087	04	04	142	71	SBR	197	54	)	252	76	LBL
033	91	R/S	088	85	85	143	07	07	198	95	=	253	15	E
034	71	SBR	089	95	=	144	32	32	199	65	×	254	42	STO
035	03	03	090	34	$\sqrt{X}$	145	54	)	200	71	SBR	255	04	04
036	39	39	091	95	=	146	65	×	201	04	04	256	25	CLR
037	55	÷	092	22	INV	147	01	1	202	28	28	257	43	RCL
038	71	SBR	093	52	EE	148	52	EE	203	87	IFF	258	14	14
039	03	03	094	58	FIX	149	09	9	204	07	07	259	69	OP
040	56	56	095	00	00	150	95	=	205	02	02	260	04	04
041	87	IFF	096	42	STO	151	34	$\sqrt{X}$	206	08	08	261	43	RCL
042	07	07	097	05	05	152	95	=	207	91	R/S	262	04	04
043	00	00	098	69	OP	153	58	FIX	208	71	SBR	263	69	OP
044	46	46	099	06	06	154	00	00	209	03	03	264	06	06
045	91	R/S	100	87	IFF	155	22	INV	210	39	39	265	91	R/S
046	71	SBR	101	07	07	156	52	EE	211	55	÷	266	76	LBL
047	03	03	102	01	01	157	69	OP	212	71	SBR	267	10	E'
048	07	07	103	05	05	158	06	06	213	03	03	268	42	STO
049	65	×	104	91	R/S	159	42	STO	214	56	56	269	03	03
050	71	SBR	105	71	SBR	160	05	05	215	87	IFF	270	25	CLR
051	04	04	106	05	05	161	87	IFF	216	07	07	271	43	RCL
052	17	17	107	54	54	162	07	07	217	02	02	272	13	13
053	81	RST	108	87	IFF	163	01	01	218	20	20	273	69	OP
054	76	LBL	109	07	07	164	66	66	219	91	R/S	274	04	04

Program Constants and Codes). They are permanently recorded, along with program steps 000 to 794, in banks 1 to 4 of two magnetic cards.

Unless instructed otherwise, the program assumes that the coil is wound with annealed copper having double-film insulation. Also, the program assumes that the resistance entered is the value at 20 C. But you can easily adjust the program from the keyboard for other types of metal and change the space factor or temperature simply by storing new values in the

275	43	RCL	330	92	RTN	385	06	06	440	55	÷	495	85	+
276	03	03	331	53	(	386	25	CLR	441	01	1	496	43	RCL
277	69	OP	332	43	RCL	387	43	RCL	442	00	0	497	01	01
278	06	06	333	02	02	388	17	17	443	00	0	498	54	)
279	91	R/S	334	75	-	389	69	OP	444	95	=	499	55	÷
280	53	(	335	43	RCL	390	04	04	445	34	√X	500	04	4
281	02	2	336	01	01	391	54	)	446	65	×	501	54	)
282	00	0	337	54	)	392	92	RTN	447	04	4	502	42	STO
283	69	OP	338	92	RTN	393	53	(	448	55	÷	503	18	18
284	07	07	339	53	(	394	42	STO	449	89	π	504	33	X²
285	69	OP	340	71	SBR	395	05	05	450	95	=	505	55	÷
286	19	19	341	03	03	396	71	SBR	451	34	√X	506	43	RCL
287	25	CLR	342	31	31	397	02	02	452	54	)	507	04	04
288	54	)	343	65	×	398	80	80	453	53	(	508	55	÷
289	92	RTN	344	05	5	399	43	RCL	454	53	(	509	01	1
290	53	(	345	00	0	400	16	16	455	53	(	510	52	EE
291	53	(	346	65	×	401	69	OP	456	42	STO	511	09	9
292	01	1	347	43	RCL	402	04	04	457	06	06	512	55	÷
293	85	+	348	04	04	403	43	RCL	458	55	÷	513	53	(
294	43	RCL	349	65	×	404	05	05	459	93	.	514	01	1
295	09	09	350	43	RCL	405	52	EE	460	00	0	515	85	+
296	65	×	351	00	00	406	69	OP	461	02	2	516	93	.
297	53	(	352	55	÷	407	06	06	462	05	5	517	09	9
298	43	RCL	353	89	π	408	25	CLR	463	04	4	518	65	×
299	10	10	354	54	)	409	03	3	464	54	)	519	43	RCL
300	75	-	355	92	RTN	410	01	1	465	33	X²	520	18	18
301	02	2	356	53	(	411	69	OP	466	55	÷	521	55	÷
302	00	0	357	43	RCL	412	04	04	467	01	1	522	43	RCL
303	54	)	358	06	06	413	43	RCL	468	52	EE	523	04	04
304	54	)	359	33	X²	414	05	05	469	05	5	524	85	+
305	54	)	360	55	÷	415	54	)	470	54	)	525	93	.
306	92	RTN	361	04	4	416	92	RTN	471	28	LOG	526	03	3
307	53	(	362	95	=	417	53	(	472	65	×	527	02	2
308	42	STO	363	54	)	418	71	SBR	473	01	1	528	65	×
309	05	05	364	92	RTN	419	04	04	474	00	0	529	53	(
310	71	SBR	365	53	(	420	85	85	475	94	+/-	530	71	SBR
311	02	02	366	42	STO	421	95	=	476	95	=	531	03	03
312	80	80	367	05	05	422	22	INV	477	22	INV	532	31	31
313	03	3	368	71	SBR	423	58	FIX	478	52	EE	533	55	÷
314	01	1	369	02	02	424	69	OP	479	58	FIX	534	02	2
315	69	OP	370	80	80	425	06	06	480	00	00	535	54	)
316	04	04	371	43	RCL	426	54	)	481	69	OP	536	42	STO
317	43	RCL	372	15	15	427	92	RTN	482	06	06	537	19	19
318	05	05	373	69	OP	428	53	(	483	54	)	538	55	÷
319	69	OP	374	04	04	429	43	RCL	484	92	RTN	539	43	RCL
320	06	06	375	43	RCL	430	08	08	485	53	(	540	18	18
321	25	CLR	376	05	05	431	65	×	486	04	4	541	85	+
322	43	RCL	377	55	÷	432	43	RCL	487	65	×	542	93	.
323	16	16	378	71	SBR	433	00	00	488	89	π	543	08	8
324	69	OP	379	02	02	434	55	÷	489	33	X²	544	04	4
325	04	04	380	90	90	435	43	RCL	490	65	×	545	65	×
326	43	RCL	381	95	=	436	05	05	491	53	(	546	43	RCL
327	05	05	382	48	EXC	437	65	×	492	53	(	547	19	19
328	33	X²	383	05	05	438	43	RCL	493	43	RCL	548	55	÷
329	54	)	384	69	OP	439	07	07	494	02	02	549	43	RCL

appropriate data registers.

For example, to design a coil wound with aluminum wire, change either the relative resistance in register 07 to 1.64, or the resistivity to 2.62 $\mu\Omega$-cm in register 08, but not both. And you can change the temperature in register 10 to investigate the effects of temperature changes.■■

References

1. Welsby, V. G., *The Theory and Design of Inductance Coils*, Macdonald & Co., London, 1960, pp. 42-44.

2. *Circular of the National Bureau of Standards C74*, Washington, 1937, p. 265.

3. "Copper Wire Tables," *National Bureau of Standards Handbook 100*, 1966, pp. 7 and 14.


```
550 04 04      605 54 )       660 09 9       715 54 )       770 91 R/S
551 54 )       606 33 X²      661 93 .       716 28 LOG     771 43 RCL
552 54 )       607 55 ÷       662 02 2       717 75 -       772 15 15
553 92 RTN     608 89 π       663 01 1       718 43 RCL     773 69 OP
554 53 (       609 65 ×       664 65 ×       719 03 03      774 04 04
555 25 CLR     610 43 RCL     665 53 (       720 65 ×       775 22 INV
556 43 RCL     611 07 07      666 53 (       721 53 (       776 58 FIX
557 17 17      612 65 ×       667 43 RCL     722 43 RCL     777 53 (
558 69 OP      613 43 RCL     668 02 02      723 03 03      778 43 RCL
559 04 04      614 08 06      669 85 +       724 85 +       779 03 03
560 53 (       615 55 ÷       670 43 RCL     725 43 RCL     780 85 +
561 71 SBR     616 01 1       671 03 03      726 19 19      781 43 RCL
562 03 03      617 52 EE      672 54 )       727 54 )       782 01 01
563 39 39      618 04 4       673 42 STO     728 28 LOG     783 54 )
564 55 ÷       619 95 =       674 18 18      729 54 )       784 65 ×
565 43 RCL     620 65 ×       675 65 ×       730 54 )       785 02 2
566 05 05      621 71 SBR     676 53 (       731 92 RTN     786 65 ×
567 54 )       622 02 02      677 02 2       732 53 (       787 43 RCL
568 34 √X      623 90 90      678 65 ×       733 04 4       788 05 05
569 65 ×       624 95 =       679 43 RCL     734 65 ×       789 55 ÷
570 02 2       625 22 INV     680 02 02      735 53 (       790 71 SBR
571 95 =       626 52 EE      681 65 ×       736 02 2       791 06 06
572 71 SBR     627 69 OP      682 43 RCL     737 65 ×       792 00 00
573 04 04      628 06 06      683 03 03      738 43 RCL     793 54 )
574 53 53      629 54 )       684 55 ÷       739 19 19      794 92 RTN
575 54 )       630 92 RTN     685 53 (       740 75 -       795 00 0
576 92 RTN     631 53 (       686 43 RCL     741 43 RCL     796 00 0
577 53 (       632 71 SBR     687 04 04      742 18 18      797 00 0
578 25 CLR     633 03 03      688 85 +       743 55 ÷       798 00 0
579 22 INV     634 07 07      689 71 SBR     744 02 2       799 00 0
580 58 FIX     635 65 ×       690 03 03      745 85 +
581 43 RCL     636 71 SBR     691 31 31      746 93 .
582 15 15      637 06 06      692 54 )       747 04 4
583 69 OP      638 59 59      693 54 )       748 04 4
584 04 04      639 85 +       694 28 LOG     749 07 7
585 89 π       640 43 RCL     695 75 -       750 65 ×
586 65 ×       641 05 05      696 43 RCL     751 53 (
587 53 (       642 33 X²      697 02 02      752 43 RCL
588 43 RCL     643 65 ×       698 65 ×       753 04 04
589 01 01      644 71 SBR     699 53 (       754 85 +
590 85 +       645 07 07      700 43 RCL     755 71 SBR
591 43 RCL     646 32 32      701 02 02      756 03 03
592 02 02      647 95 =       702 85 +       757 31 31
593 54 )       648 55 ÷       703 53 (       758 54 )
594 55 ÷       649 01 1       704 43 RCL     759 54 )
595 02 2       650 52 EE      705 02 02      760 54 )
596 65 ×       651 09 9       706 33 X²      761 92 RTN
597 43 RCL     652 95 =       707 85 +       762 53 (
598 05 05      653 22 INV     708 43 RCL     763 71 SBR
599 55 ÷       654 58 FIX     709 03 03      764 05 05
600 53 (       655 69 OP      710 33 X²      765 54 54
601 43 RCL     656 06 06      711 54 )       766 87 IFF
602 06 06      657 54 )       712 34 √X      767 07 07
603 55 ÷       658 92 RTN     713 42 STO     768 07 07
604 02 2       659 53 (       714 19 19      769 71 71
```

The Complete Solution to your F3870 and F8 Design-In Problems

The Formulator Development System

The Formulator family is designed to allow easy, efficient software development and real time hardware simulation of F8 or F3870 based systems. It is supported by a complete line of functional modules including memory, I/O and simulation cards that plug directly into the Formulator cardframe.

The Formulator can, itself, be used as the system breadboard. It provides microprocessor hardware, plus card slots for breadboarding your system. Thus the entire system may reside within the Formulator or in a combination of external and internal configurations.

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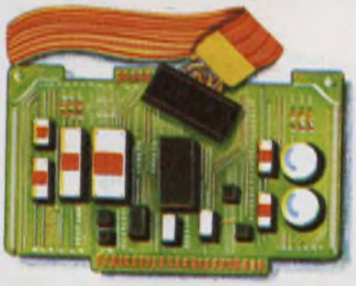
To develop, test and debug F8 and F3870 based products, Fairchild offers simulation options that extend the functional features of the microprocessor from the Formulator to the 40-pin socket on your breadboard. This allows complete ROM firmware development, real-time symbolic debugging of your breadboard and freezing of ROM codes during the breadboard stage.



PROM Prototypes

The 3870 Emulator is a PROM-based substitute for the F3870 microprocessor. The Emulator measures 5" x 7" and contains two 2708 or 2716 EROMs in place of the F3870 so ROM codes can be verified and easily changed if necessary.

The F3870 Emulator plugs directly into the F3870 40-pin socket in the production prototype via a short cable.

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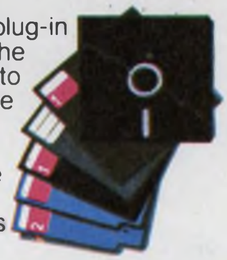
The software consists of an operating system, utility programs and diagnostic routines; a monitor, text editor, assembler and debug package. It includes linking loader and relocating assembler and will operate in interactive or batch mode. The result is an easy to use, reliable, fast and extremely efficient capability for microprocessor based system development.

The Formulator-Floppy Disk Marriage



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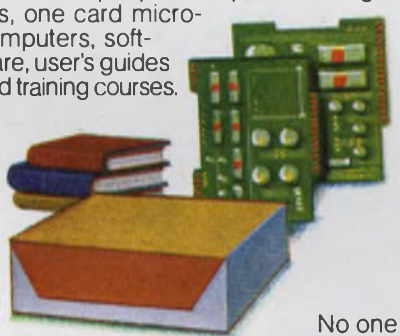

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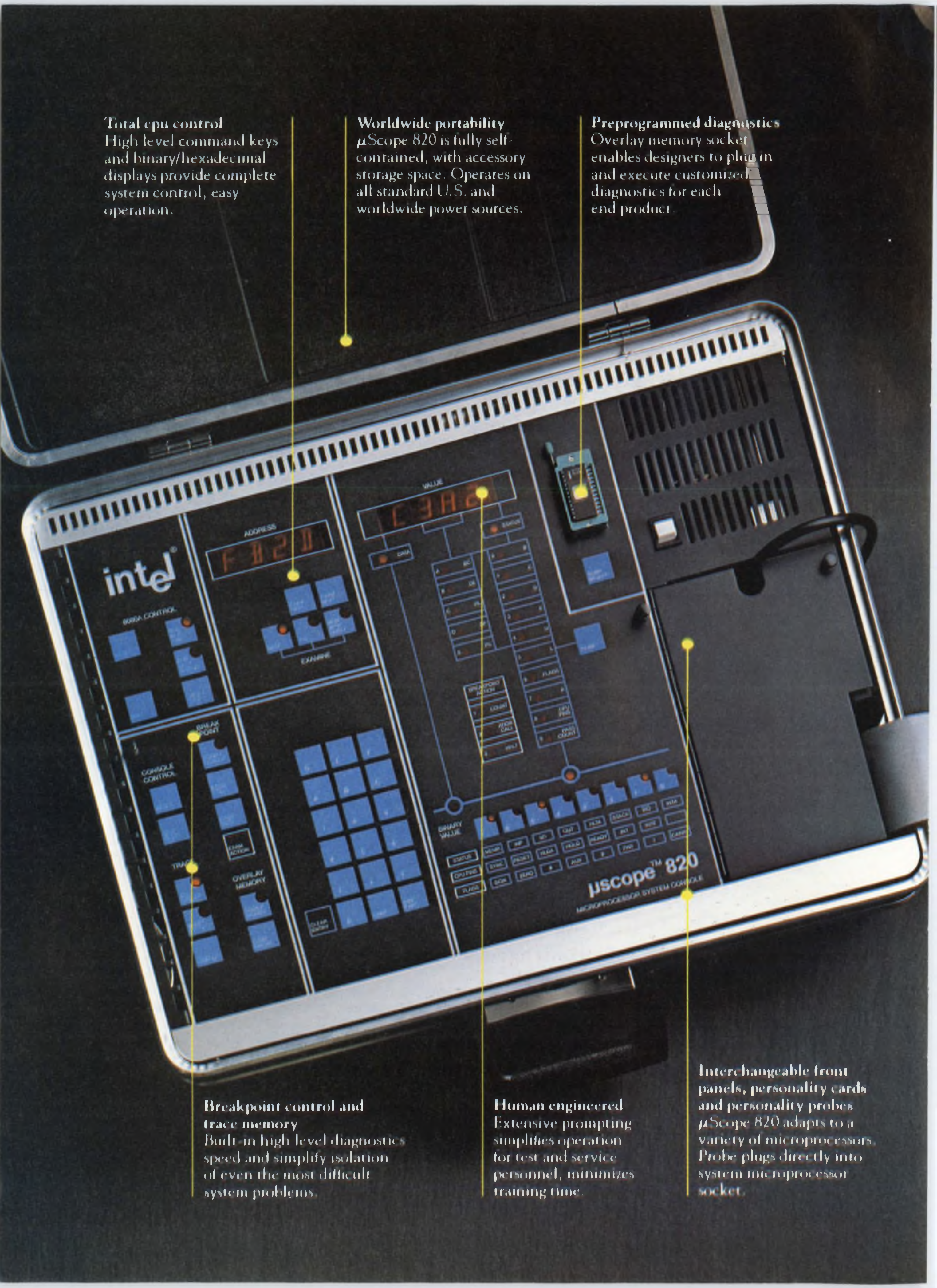

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Quantize the feedback in a/d converters.

With microprocessor control, you trade inexpensive program-storage space for crucial speed and accuracy.

If you're designing a microprocessor-based a/d converter, you should try to benefit from quantized feedback. This can provide 18-bit resolution and half-second conversions in a two-chip system. Considering the 14 bits most two-chip systems strain for, or the 16 seconds that some dual-slope converters need, the 500-byte program required for quantized feedback doesn't seem too much of a drawback.

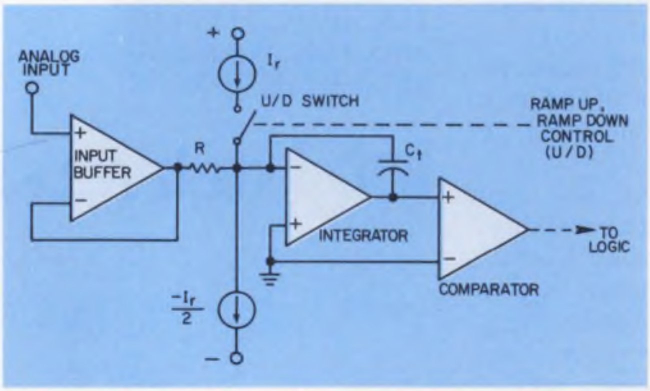
For quantized feedback, a digital control system feeds fixed-charge packets (pulses of reference current) to an integrator. The number of pulses that bring the integrator back to a reference voltage in the presence of the input, is the conversion result.

The fundamentals are illustrated by the simplified schematic of Fig. 1. The processor examines the comparator at intervals and operates the up/down (U/D) switch appropriately. Thus, a current of $\pm I_r$ is gated to the integrator for a fixed interval. As a result, a specific number of counts can either be added to or subtracted from the counter (U/D switch open or closed, respectively). The flow chart of Fig. 2 describes the quantized-feedback process for one complete measurement interval.

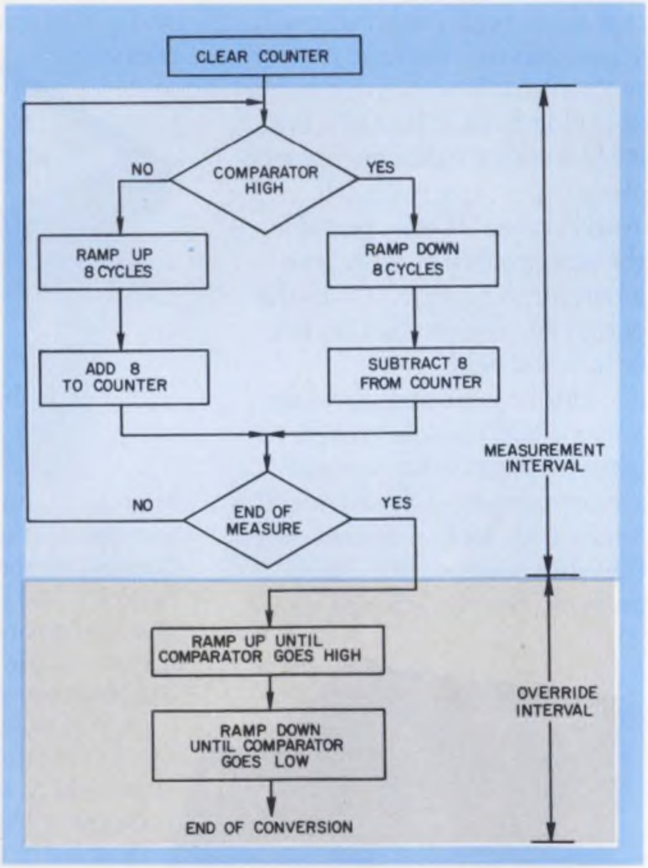
Gary Grandbois, Precision Monolithics, Inc., 1500 Space Park Dr., Santa Clara, CA 95050. (Formerly Manager of Digital Applications, Siliconix.)

The integrator sums it all up

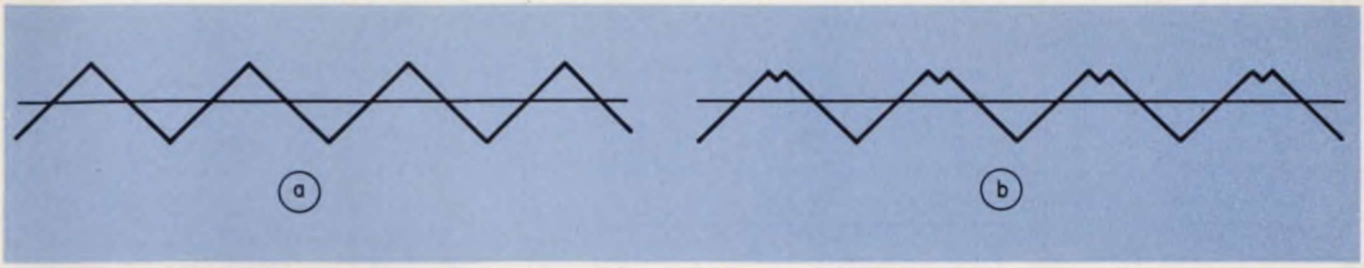
Fig. 3a shows the integrator output during a measurement interval. Here, for simplicity, the converter is digitizing a zero voltage input. The waveform implies that eight-count blocks from the counter



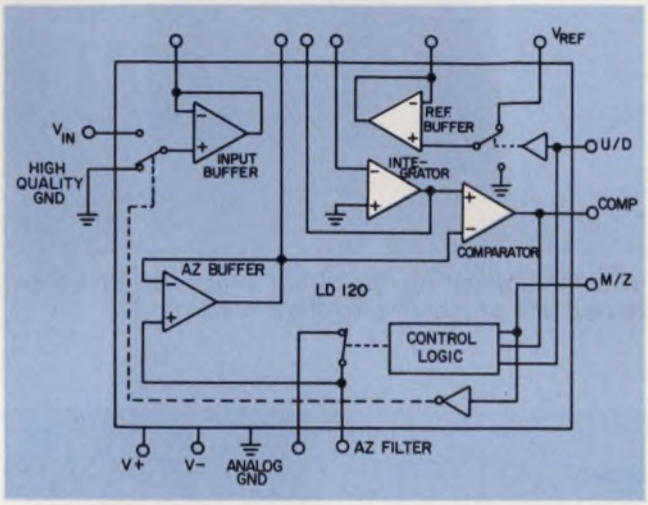
1. **The functional components of quantized-feedback** systems are a current-to-voltage converter (buffer amplifier), an integrator, a comparator and a switch. With two current sources—one having half the magnitude of the other—a single set of contacts can switch the reference current polarity to measure either polarity input.



2. **In a basic quantized-feedback system,** a comparator controls the conversion, which once started, proceeds for eight clock intervals. During the measurement (coarse) interval, eight-count bundles—whose total is proportional to the analog input—are accumulated. This approximation is corrected in the override (fine) interval, during which the comparator always goes from high to low. This eliminates the chance of hysteresis errors.



3. **Integrator waveforms for no voltage input** are simple triangles (a) in a 100% duty-cycle (basic) system. An LD120 under F8 control divides each eight-clock-time set into up and down ramps (b) lasting one-and-seven or seven-and-one clock times each. This 87.5% duty cycle fixes the number of switching transitions and eliminates offset errors that would result from differences in charge injection, turn-on-time and turn-off-time.



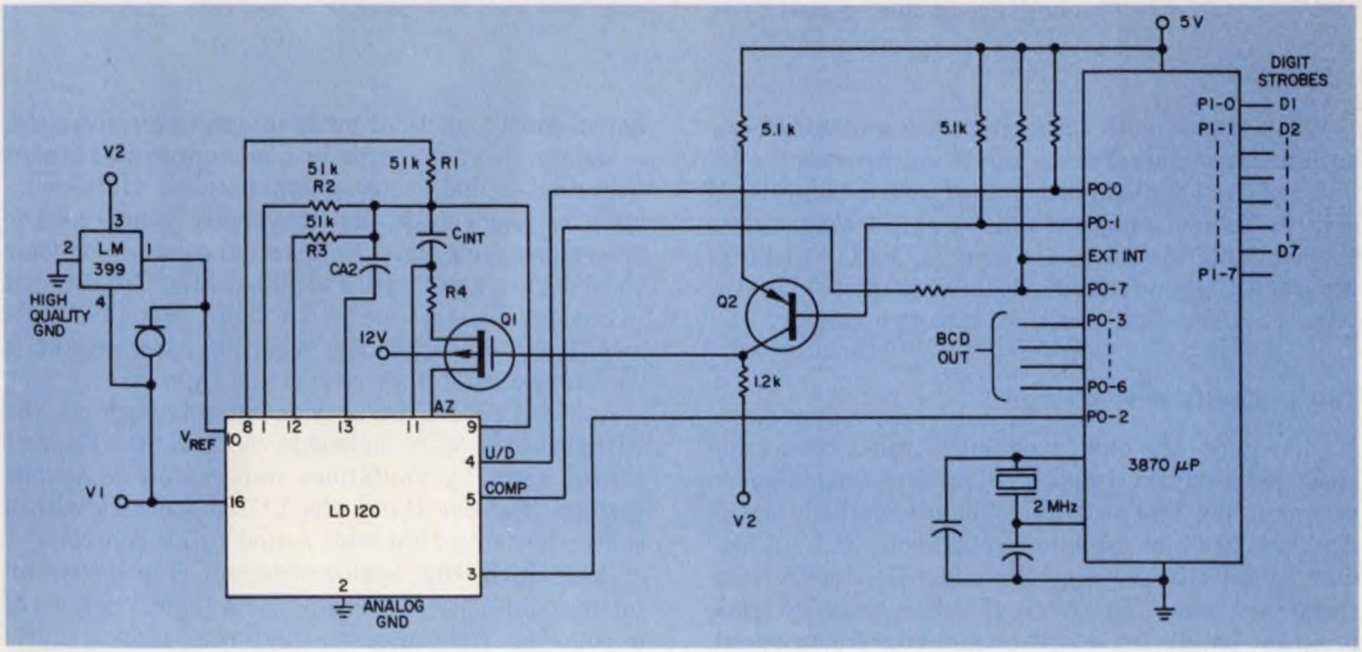
4. **An LD120 chip has all the analog blocks** for quantized feedback: integrator, comparator, voltage-to-current converter and reference switch. Also included: a reference buffer amplifier that lowers tempco, an auto-zero buffer amplifier that nulls offset errors, and analog switches that generate the negative reference with the auto-zeroing.

alternately charge and discharge the integrating capacitor. The integrator keeps adding and subtracting these eight-count blocks from the counter, so the net count ends at zero—corresponding to the input.

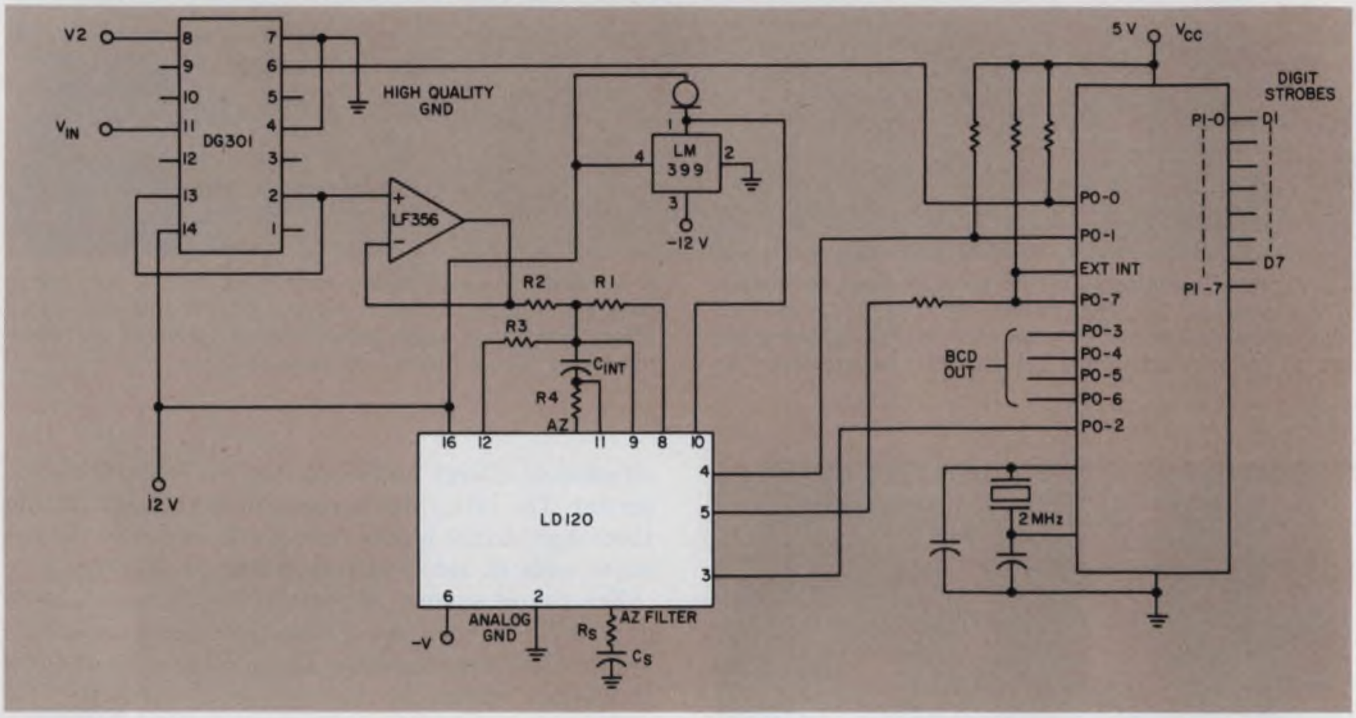
The simple system implicit in Fig. 3a uses a 100% duty cycle in each ramp direction. But this simple system has a disadvantage: The number of up or down transitions varies. At the expense of simplicity, if a duty cycle were to contain both an up and down phase, the number of transitions would be constant.

With a constant number of transitions, U/D switching transfers a fixed quantity of charge to the integrator. Also the difference between the turn-on and turn-off times of the U/D switch causes a constant offset. Being constant, charge-switching and transition-time offsets can be nulled automatically.

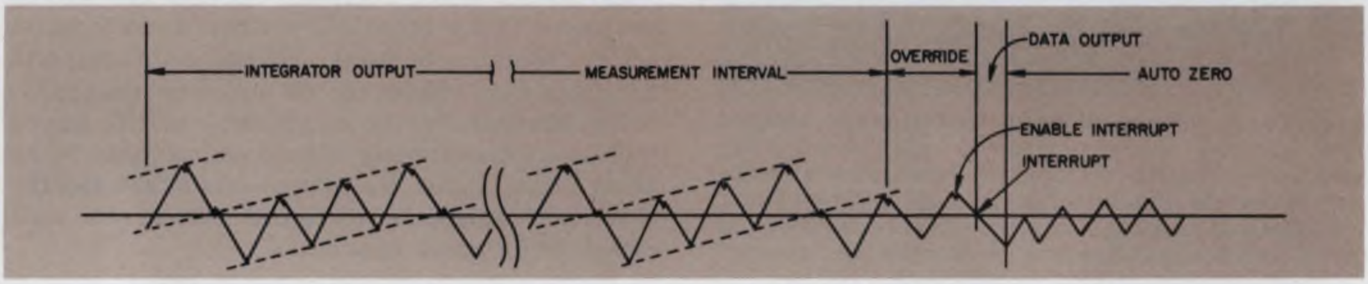
For example, in the single-chip, LD120 analog processor from Siliconix, offsets are cancelled by an auto-zeroing system. But nonconstant offsets fool the converter's automatic correction system and this makes performance nonlinear.



5. **Converting analog inputs to 5½ BCD digits** uses every functional block of the LD120, plus Q_1 for zero-offset correction. The 3870, a single-chip F8, puts out a single scan of multiplexed data in BCD format.



6. **This high-performance 5½-digit DVM** reduces last-digit jitter by replacing the LD120's input buffer wih a lower-noise BiFET amplifier. The DG301 switch performs auto-zeroing and improves zero-offset correction.



7. **In the complete conversion sequence,** the analog input is coarsely digitized in the measurement interval. Fine-tuning to the correct number occurs during override as the integrator ramps down. With an F8 microprocessor, override ends when the processor is interrupted. Digit-scan and auto-zero precede a new conversion start.

When mated with an appropriate microprocessor such as Fairchild's F8, the LD120 can provide the 18-bit resolution and stability needed for a 5½ digit DVM (Fig. 4). Though many one and two-chip a/d converters are available for 2½ to 4½ digit DVMs (10 to 14-bit accuracy), only quantized feedback or dual-slope systems pack 5½-digit precision into two chips.

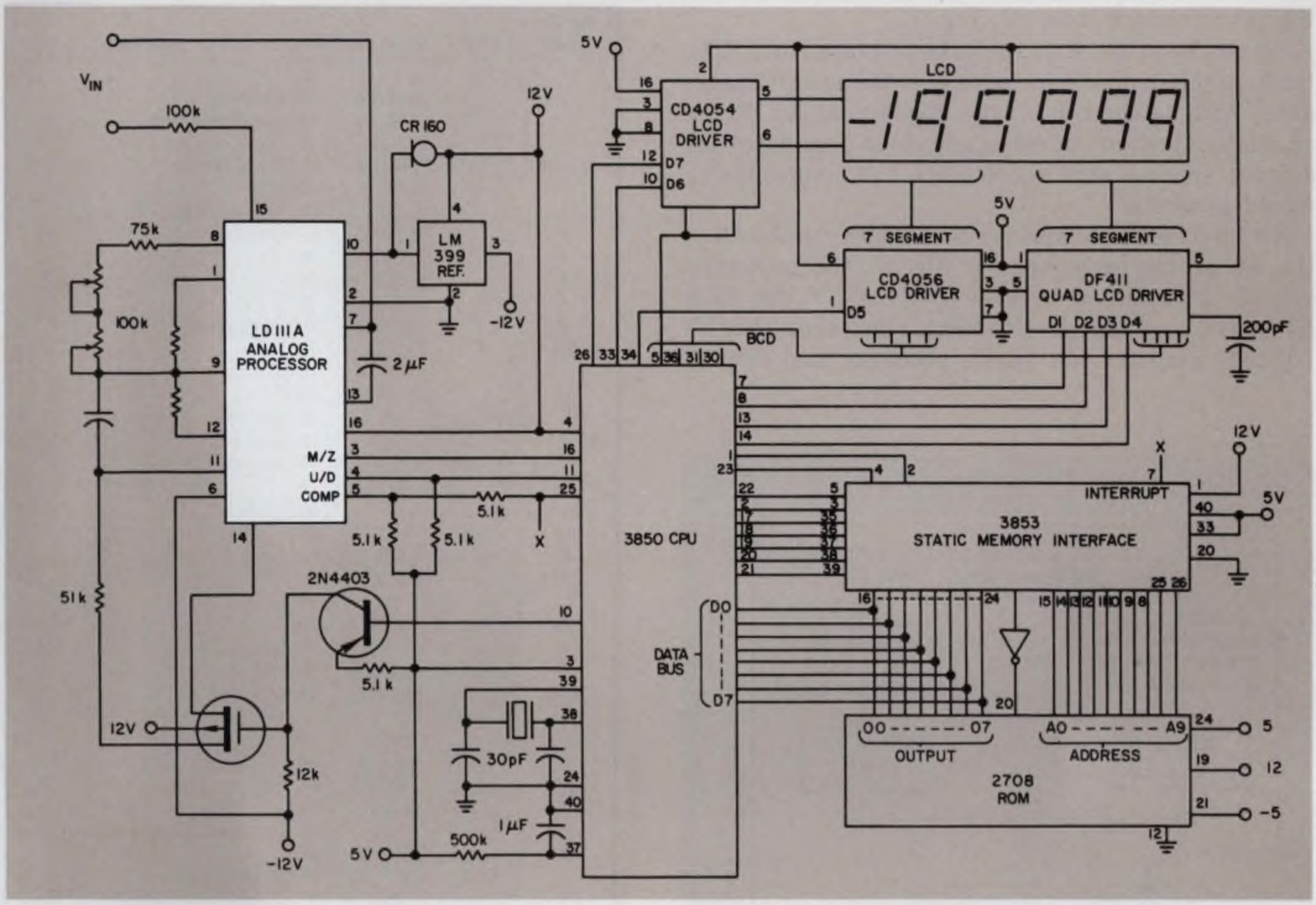
The tradeoffs have changed

Dual-slope, the older technique, trades conversion speed for program simplicity. This is no longer a good exchange now that program bytes are relatively cheap. And the 20 to 40 machine cycles required by a 5½-digit Add routine, severely limit dual-slope conversion speed (see table). Therefore, it's often better to trade program length for accuracy and conversion speed. And this is what quantized feedback does—while retaining all the noise-averaging properties and inherent monotonicity of other integrating converters.

Mainly, the easy control by a microprocessor makes quantized-feedback converters feasible. Here, software counters take the conversion count at the processor's cycle time. No external counters or logic elements are used. Pulses for integration are counted in groups—six at a time for 3½ digits, 14 for 4½ digits and 78 for 5½ digits. The resulting coarse count is corrected during a short override interval.

A quantized-feedback two-chip set, such as the LD120 and the 3870 single-chip version of the F8, isn't slowed down by limitations imposed on dual-slope systems. For one thing, the LD120 operates with a conversion algorithm well suited to μP control.

In addition, this analog-processor chip boasts an intrinsic linearity of 0.0025% and a typical tempco of 5 ppm/°C. The converter performs zeroing automatically and needs only one reference voltage to accept both positive and negative inputs. All this



8. **Reprogramming this 5½-digit DVM** development system is easy. The 2708 ROM can be erased under ultraviolet light. The system, including the liquid-crystal display, operates from ±5 and ±12-V power supplies.

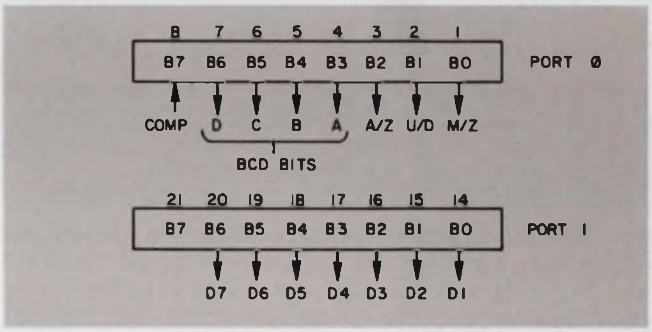
performance is crammed into one chip, thanks largely to 2-picocoulomb charge-injection input switches.

For control, one simple I/O-oriented microprocessor, either the two-chip F8 or its single-chip counterpart, the 3870, provides the LD120 with a 64-byte internal RAM, a crystal-controllable clock, four 8-bit bidirectional I/O ports and a vectored and maskable interrupt system. Moreover, the 3870 operates from a single +5-V supply and contains 2 kbytes of mask-programmed ROM.

The LD120 does require some additional hardware to interface with the 3870, as shown in Fig. 5. Nevertheless, this DVM system is simple. The MOSFET switch, Q_1, allows a digital-zeroing period to be added to the software. And external control of the input switch helps simplify the 5½-digit counter's auto-zeroing (AZ) system.

This zeroing routing dedicates an interval every 15 conversions to measuring the system offset with the input switch grounded. Succeeding conversions are corrected by subtracting this measured value.

Zero drift is minimized by combining, in one a/d system, the offset-correction technique and the analog-AZ system. The digital system corrects for such analog-error sources as auto-zeroing system leakage and comparator drift.



9. **Only two of the F8's four I/O ports** handle the basic DVM. The two other 8-bit ports and 1500 unused bytes of the 3870 ROM are spare.

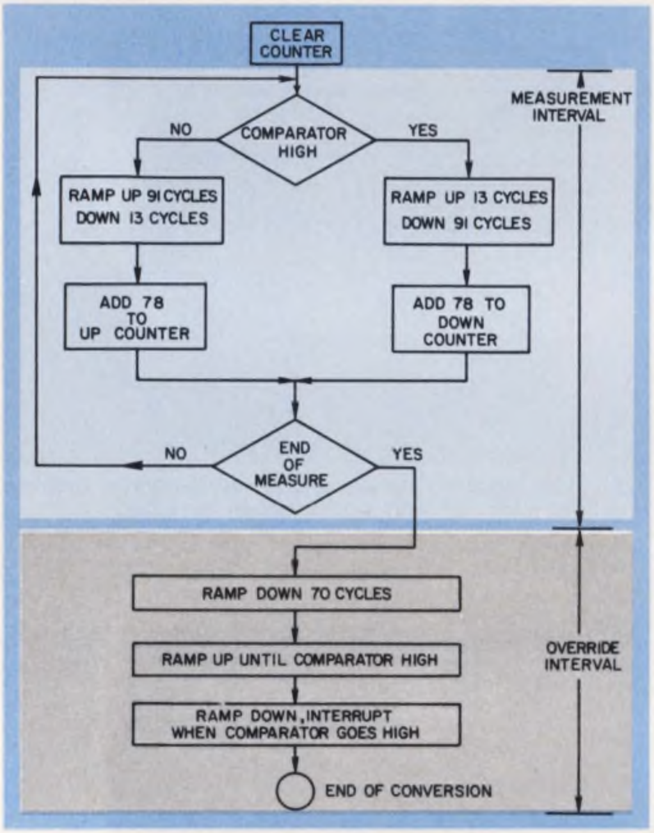
Circuit stability is ±1 count on a 2-V scale. A modified circuit (Fig. 6) has less internal noise, hence better performance. An LF356 BiFET op amp replaces the chip's internal buffer amplifier, and lowers the noise to ± one half of the LSB.

It's BCD at the display interface

At the output side, the data format from the processor is a strobed single scan of multiplexed BCD, which occurs after each conversion except during the digital-correction interval (Fig. 7).

When the output data are to be displayed on LEDs, latching the strobed data helps keep the noise manageable. With latched data, the display can be driven statically. And, of course, static drive eliminates the current spiking and interference that multiplexing would generate.

An interface to a liquid-crystal display is shown in the F8 prototype system of Fig. 8. The prototype system is complex because it provides the 2708 EPROM for system development. Fig. 9 shows the F8 I/O-port map for the analog processor and display



10. **This F8 quantized-feedback algorithm** retains the 87.5% duty cycle, but the steps are multiplied by 13 (13 and 91, or 91 and 13). The comparator is polled during the measurement interval and generates the interrupt during override, when the final downward ramp occurs.

signals. Since only two of the four available ports are used for the basic DVM, the two additional ports (plus 1500 bytes of ROM) are spares.

Still, software is the key to the converter's operating efficiently. Fortunately, F8 software can closely model the quantized-feedback algorithm used with single-chip analog processors, like the LD 110/111 and LD 120/121, which use 1-of-8 (12.5%) and 7-of-8 (87.5%) duty cycles. The instruction sequence for the 12.5% section of the algorithm takes at least 13 machine cycles. Since the 87.5% section takes 91 cycles, the total operation takes 104 cycles.

The single machine-cycle time of the Increment

Machine cycles	Label	Mnemonic	Hex	Comments
1	Oct:	LR A, 7	47	
		OUT S 0	B0	Ramp up
		INS 0	A0	Comparator High
		INC	IF	
3.5/3.0		BM Low	91	Branch if low
			24	
1		LISL 2	6A	Address down
1		LISU 2	62	Counter
1		COM	18	
1		NOP	2B	
1		LR A, 6	46	
2		OUT S 0	B0	Ramp down
2.5		LI 78	20	
			78	
3.5		BR DADD	90	
			02	Add 78
1	DAD:	CLR	70	to down
1	DADD:	LNK	19	counter
2.5		AI 66	24	
			66	
2.0		ASD C	DC	
1		LR E, A	5E	
2.5/2.0		BR 7 DAD	8F	
			F9	
2.5		LI F9	20	
			F9	Use up
1	TMD:	INC	IF	rest of
3.5/3.0		BNZ TMD	94	91 cycles
				FE
2.0		INS 0	A0	
1		LISL. 4	66	
2.0		INS 0	A0	
1.0		LIS 01	71	
2.5		ADC	8E	Increment measure interval timer
4		LR Q, DC	0E	
1	MCK:	LR A, QU	02	Measure over
1		INC	IF	
3.5/3.0		BM OVRD	91	If so, branch to override
			21	
2.5/2.0		BR 7, OCT	8F	If not, repeat
			D8	
1	LOW:	COM	18	
1		LISL, 2	6A	Address up counter
1		LISU 3	63	
2.5		LI 78	20	
			78	
3.5		BR UADD	90	Add 78 to up counter
			02	
1	UAD:	CLR	70	
1	UADD:	LNK	19	
2.5		AI 66	24	
			66	
2.0		ASD C	DC	
1		LR E, A	5E	
2.5/2.0		BR 7 UAD	8F	
			F9	
1		LIS 01	71	Increment measure interval timer
2.5		ADC	8E	
4		LR Q, DC	0E	
2.5		LI F9	20	
			F9	Use up rest of 91 cycles
1	TMU:	INC	1F	
3.5/3.0		BNZ TMU	94	
			FE	
		NOP	2B	
		NOP	2B	
		LISL 4	6C	
		LR A, 6	46	
		OUT S 0	B0	Ramp down
		BR 7, MCK	8F	Branch to measure timer check
			DD	

11. **This F8 routine takes 104 machine cycles** and adds 78 counts to either the up or down counter. During the measurement interval, the routine loops 3280 times. All possible branches must take the same time for the program to function properly.

Accumulator instruction fixes the count time. So, the net count is 78 per duty cycle (91 − 13). This measurement routine is shown in the flow chart of Fig. 10, and as you can see, it is much like that in Fig. 2. The principal difference is that in Fig. 10 an up counter and a down counter replace the single counter that performs both addition and subtraction in Fig. 2. In the two-counter system, the up and down counts are subtracted at the end of each conversion (net count equals up minus down). For an F8 program that uses this measurement algorithm, see Fig. 11.

The errors go out fast

With this algorithm, a measurement interval lasts 3280 duty cycles (341,120 machine cycles) before the override interval starts. The converter's maximum coarse-counting error is 156 counts (2×78). Therefore, the correction that occurs during the override interval is completed in less than 500 μs.

At the end of the override, the down count is subtracted from the up count. The result, the uncorrected count, is then adjusted by a number that represents the offset. The corrected count is then multiplexed out by a Digit Scan routine.

The single Digit Scan output is followed by the AZ interval. During AZ, the U/D line operates at a 50% duty cycle, the input buffer is grounded and the AZ switch closes. Also, the AZ capacitor stores a voltage representing the various amplifier offsets for nulling later. A second reference current is generated, which has the opposite polarity and half the magnitude of

Table : Dual slope vs quantized feedback for 5½-digit a/d converters with F8 μP control.

	Quantized Feedback	Dual Slope
machine cycles	1 (increment instruction)	40[1]
Count Time (μs/count)	2	80
Conversions length (counts)	200 k	200 k
Conversion time (s)	0.5	16
Program length (bytes, approx.)	500	100
Comparator Resolution	1 part in 78	1 part in 200 k

Note 1: Dual-slope counter-increment routine

```
Wait:  LI00
       INC          Set carry
       LISL 2
Loop:  CLR
       LISU 2
       AI 66
       LNK
       ASD C        add to digits
       LR E, C
       BR 7, LOOP
       BR WAIT      wait for interrupt
```

5½-Digit DVM Instruction Set for the F8 (HEX)

M0000=2B	74	55	70	54	53	B6	BC
M0008=20	FF	BD	29	01	18	2B	2B
M0010=62	6A	20	02	B0	20	FB	1F
M0018=94	FE	24	69	90	02	70	19
M0020=24	66	DC	5E	8F	F9	63	6A
M0028=70	B0	70	24	49	90	02	70
M0030=19	24	66	DC	5E	8F	F9	39
M0038=A0	22	00	91	EB	72	B0	71
M0040=BE	1B	1F	1F	1F	1F	1F	1F
M0048=1F	1F	1F	1F	1F	1F	1F	1F
M0050=1F	1F	1F	1F	1F	1F	1F	1F
M0058=1F	1F	1F	1F	1F	1F	1F	1F
M0060=1F	1F	1F	1F	1F	1F	1F	1F
M0068=1F	1F	1F	1F	1F	1F	1F	1F
M0070=1F	1F	1F	1F	1F	1F	1F	1F
M0078=1F	1F	1F	1F	1F	1F	1F	1F
M0080=1F	1F	1F	1F	1F	1F	1F	1F
M0088=1F	1F	1F	1F	1F	1F	1F	1F
M0090=1F	1F	1F	1F	1F	1F	1F	1F
M0098=1F	1F	1F	1F	1F	1F	1F	1F
M00A0=1F	1F	1F	1F	1F	1F	1F	1F
M00A8=1F	1F	1F	1F	1F	1F	1F	1F
M00B0=1F	1F	1F	1F	1F	1F	1F	1F
M00B8=1F	1F	1F	1F	1F	1F	1F	1F
M00C0=1F	1F	1F	1F	1F	1F	1F	1F
M00C8=1F	1F	1F	1F	1F	1F	1F	1F
M00D0=1F	1F	1F	1F	1F	1F	1F	1F
M00D8=1F	1F	1F	1F	1F	1F	1F	1F
M00E0=1F	1F	1F	1F	1F	1F	1F	1F
M00E8=1F	1F	1F	1F	1F	1F	1F	1F
M00F0=1F	1F	1F	1F	1F	1F	1F	1F
M00F8=1F	1F	1F	1F	1F	1F	1F	1F
M0100=1F	1F	1F	1F	1F	1F	1F	62
M0108=6A	18	18	90	02	70	19	24
M0110=66	DC	5E	8F	F9	28	01	AA
M0118=70	E5	84	7E	44	E3	94	13
M0120=6A	65	4C	62	5C	64	4C	63
M0128=5E	8F	F7	70	51	28	01	AE
M0130=90	04	28	01	E0	72	B0	71
M0138=50	6A	64	4C	15	12	18	22
M0140=06	B0	40	18	B1	18	13	50
M0148=20	F0	1F	94	FE	4E	12	18
M0150=22	06	59	20	FF	58	B1	49
M0158=B0	40	18	B1	18	13	50	20
M0160=F0	1F	94	FE	48	B1	8F	D4
M0168=44	18	22	06	B0	40	18	B1
M0170=20	F0	1F	94	FE	48	B1	29
M0178=02	52	2B	2B	2A	75	FF	74
M0180=B0	B0	20	F6	1F	94	FE	76
M0188=B0	20	FA	1F	94	FE	26	06

(continued on page 116)

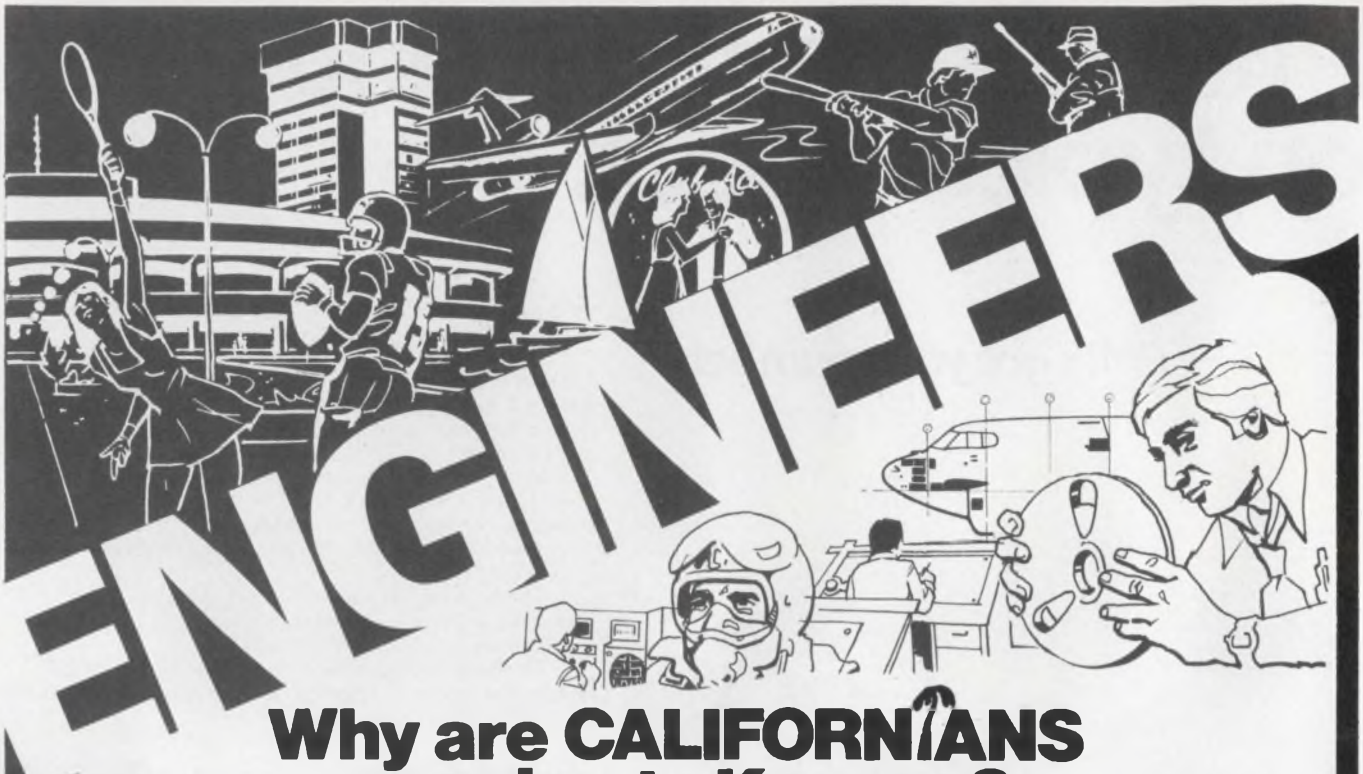
(continued from page 115)

M0190=71	8E	0E	02	1F	91	6E	90
M0198=E7	6A	64	4C	65	5E	8F	FB
M01A0=44	53	20	0F	55	90	D1	2B
M01A8=2B	2B	2B	70	51	54	6A	20
M01B0=66	52	71	58	62	4C	18	63
M01B8=DC	1E	C8	D2	64	5E	49	1E
M01C0=E9	21	02	12	58	8F	EE	70
M01C8=E8	94	15	E1	94	12	6A	64
M01D0=4C	62	5C	63	70	5E	8F	F8
M01D8=44	18	54	71	51	90	D0	1C
M01E0=6A	18	1E	64	1D	70	19	C2
M01E8=DC	1E	65	C2	DC	64	5E	49
M01F0=1E	E9	21	02	59	8F	ED	1C
M01F8=70	6A	54	62	5C	63	5E	8F
M0200=FA	29	01	7B	2A	73	20	2B
M0208=47	B0	A0	1F	91	24	6A	62
M0210=18	2B	46	B0	20	78	90	02
M0218=70	19	24	66	DC	5E	8F	F9
M0220=20	F9	1F	94	FE	A0	6C	A0
M0228=71	8E	0E	02	1F	91	21	8F
M0230=D8	18	6A	63	20	78	90	02
M0238=70	19	24	66	DC	5E	8F	F9
M0240=71	8E	0E	20	F9	1F	94	FE
M0248=2B	2B	6C	46	B0	8F	DD	29
M0250=00	10	35	94	07	72	56	70
M0258=57	90	05	73	56	71	57	29
M0260=01	F8	B5	8A	11	7B	DD	23
M0268=FD	FC	FB	FD	FB	FB	FD	FB

the U/D current through R_1 when the U/D switch is connected to the reference, V_{ref}.

The U/D duty cycle during AZ is set at 52 machine cycles up and 52 down. Besides generating the negative reference voltage on the AZ capacitor, this duty cycle provides U/D switching transitions at the same rate as during the measurement. Fixing the transition rate, effectively nulls the effects of charge injection due to U/D switching or skew that exists between the U/D turn-on and turn-off delays.

Quantized-feedback can be used in other than precision DVMs. For instance, with minor modifications, the conversion systems for the 5½-digit DVMs in Figs. 5, 6 and 8 can provide a 700-μs 8-bit conversion, a 2.5-ms 12-bit conversion, or a 50-ms 4½-digit conversion, respectively. In these conversion systems, the microprocessor can add digital linearization, data reduction and programmed limits. It can also automate ranging and function or multiplexer-addressing. ■■



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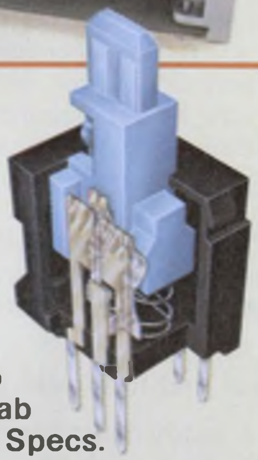

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To make your timing generator even more flexible, use an electrically alterable ROM, or EPROM, as the memory device. Then you'll only have to change programming to change timing. An EPROM timing generator can even serve as a system debugger, since it can be reprogrammed many times to emulate various time sequences.

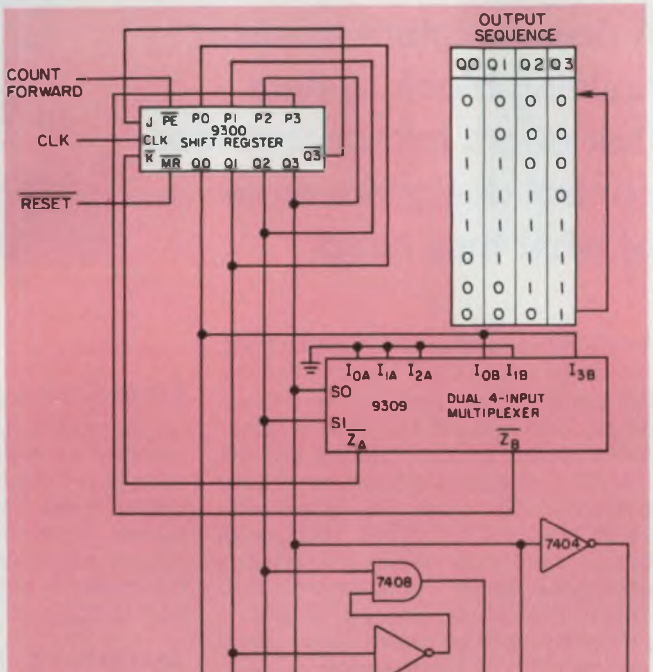
Since a universal timing generator can emulate any timing sequence, you can compare operation of a ROM-based circuit with hardwired logic. The comparison, of course, should use the same timing sequence for each generator.

Back and forth with a ring counter

A hardwired timing generator with a reversible-time sequence is shown in Fig. 1a. This circuit uses a shift register such as the Fairchild 9300 as a twisted-ring counter, a configuration which allows for reversibility of the output pulse sequence. Also included is a dual four-input multiplexer (Fairchild 9309) and SN7400 output-decoding gates.

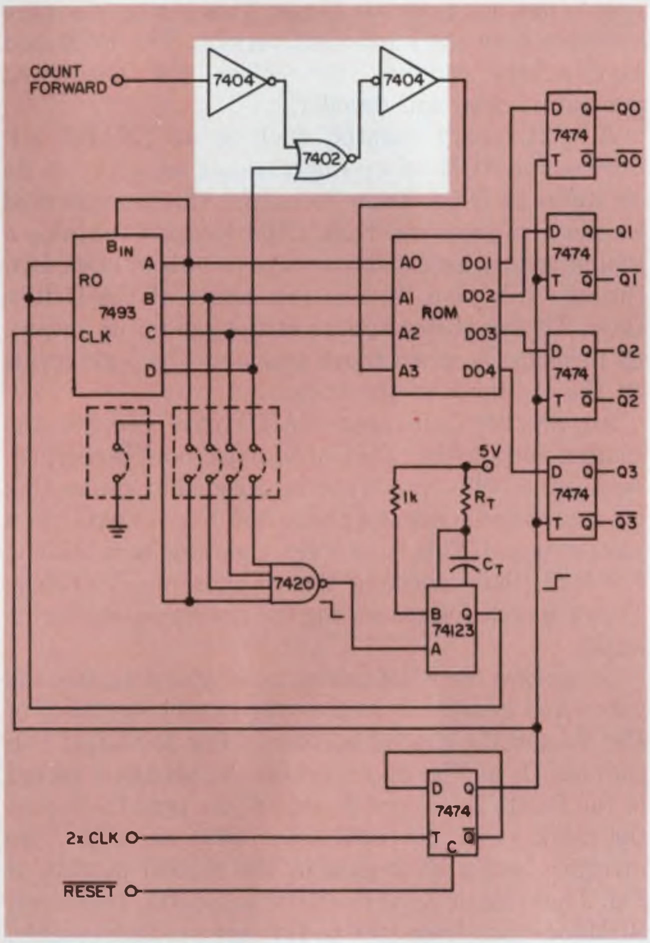
The decoding gates in Fig. 1a produce only four time pulses, A, B, C and D shown in Fig. 1b. However, you may want to design the generator for many more outputs, thereby increasing the complexity of the decode bus and circuitry. But, then, should timing changes be required, you would spend a lot of time redesigning the decode logic, not to mention cutting up the buses on your PC board.

The 9300 shift register in Fig. 1a is controlled by the state of the Count Forward line. With Count Forward at ONE (+5 V), Parallel Enable, $\overline{PE}$, on the shift register is disabled, and the Clock line steps the

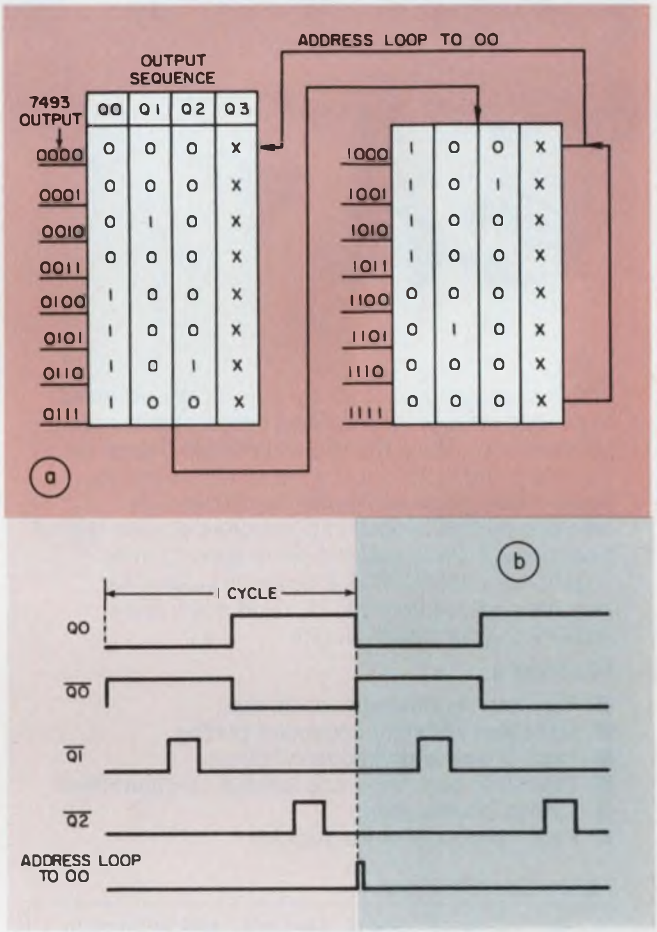


1. **Connecting a shift register as a twisted-ring counter** allows this timing generator (a) to produce the output sequence, signals A through D in (b). And with a ring counter, the output sequence can be generated in either the forward direction (t_0 to t_1) or the reverse (t_1 to t_0).

Robert J. Stetson, Engineer, Storage Technology Corp., 10 Clay Ct, Aurora, IL 60538.



2. **To change the output sequence of a firmware timing generator,** all you have to do is change the ROM since no decode bus or logic is required. However, if you use an EPROM, you can remove and reprogram it many times.



3. **The timing sequence programmed into the ROM-based generator** is tabulated (a). The ROM circuit generates a reversible pulse pattern (b) that is identical to that for the circuit of Fig. 1.

register in its forward count mode under the control of the J and $\overline{K}$ inputs. Starting with an output count of 0000, ONEs are loaded into the register until a count of 1111 is reached, as shown in the output sequence table of Fig. 1a. When both Q_2 and Q_3 are at ONE, output $\overline{ZA}$ of the multiplexer is driven to ZERO, so that ZEROs are loaded into the register. The output sequence then cycles back to all ZEROs and is ready to begin again. Fig. 1b shows the output timing sequence generated by the decoding logic.

To reverse the output sequence, Count Forward must switch to a ZERO, and enable the $\overline{PE}$ input. Multiplexer inputs S_0 and S_1 are held low by Q_2 and Q_3, which allows $\overline{ZB}$ to go high. The register, now in its parallel-operation mode, transfers the contents of P_0 through P_3 to Q_0 through Q_3. The output sequence is generated in reverse, that is, from 0001, 0011 back to 0000. And pulses A through D in Fig. 1b will appear in reverse order via the bus and decode logic.

Of course, few applications require just the four timing signals generated by this simple hardwired scheme. A ROM-based generator, by contrast, can produce the same timing sequence as its hardwired counterpart, and, in addition, can be easily changed or expanded to fit your needs.

Off the bus, onto the ROM

A 16-word ROM is the primary component of the firmware timing generator of Fig. 2. "Firmware" refers to the unique program stored in the ROM for generating a particular timing sequence. Except for the ROM, the ICs in this generator are universal, and the output sequence can be easily changed by inserting a new firmware package.

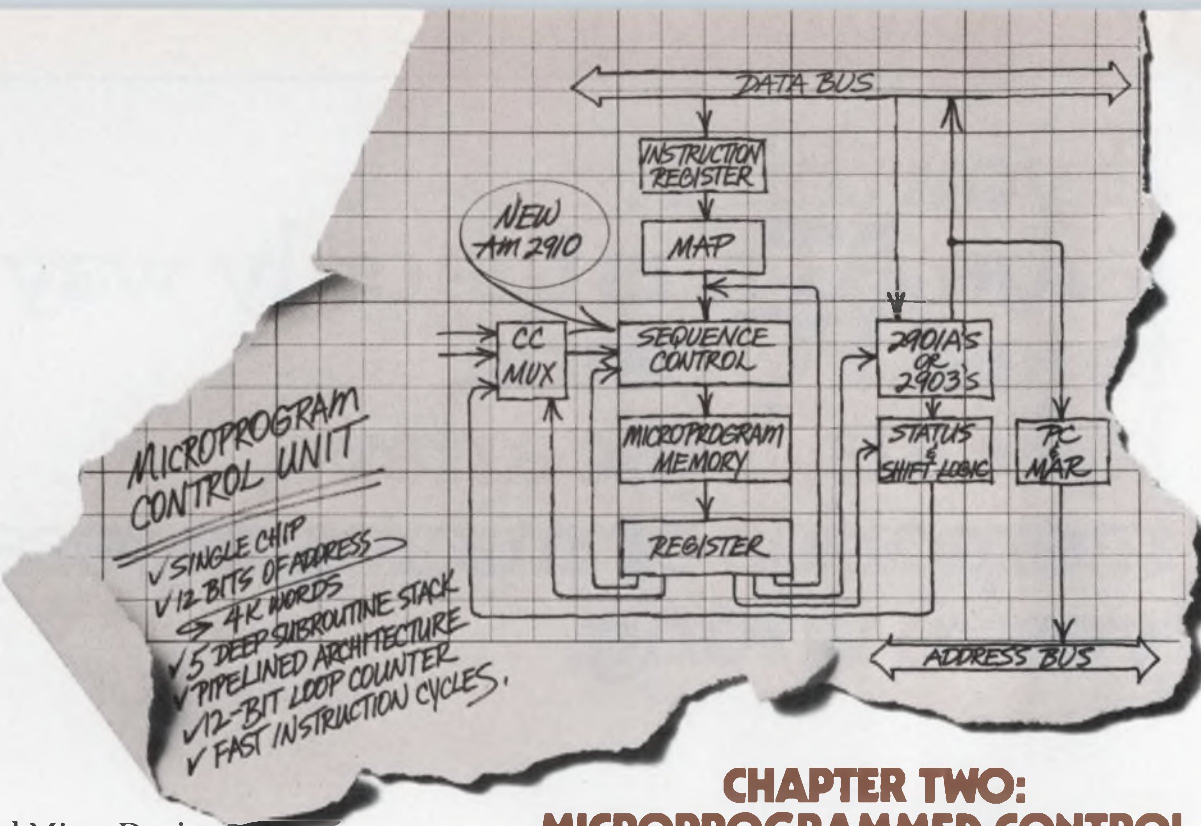
Notice, that this firmware generator has neither a decode bus nor associated logic. This is why it's more versatile than the hardwired version. The ROM and D flip-flops combine to replace the hardwired generator's bus and decoder.

A 4-bit binary counter, such as an SN7493, addresses the ROM by cycling through as many of its 16 states as is necessary to output the programmed locations in memory. Each ROM location contains a unique code, which is delivered to its output lines, DO_1 through DO_4, and then to the inputs of the D flip-flops. Timing pulses appear at the generator output, Q_0 through Q_3, when Clock transfers the logic levels on the D inputs to the output.

An SN7420 four-input NAND gate decodes the counter output when the last address count is reached. Any of the 7493's counts can be decoded by connecting its appropriate output lines to the NAND gate via a jumper board. This fires a retriggerable monostable, SN74123, thus resetting the counter to all ZEROs. Then the cycle for generating the timing pulses begins again.

To see how the ROM timing generator emulates the hardwired generator, look at the output sequence of Fig. 3a and the shaded portion of Fig. 2. Outputs Q_0 through Q_2 in Fig. 3a represent the program stored in the ROM. The Count Forward line is at ONE, and the clock steps the 7493 from 0000 to 0111. Two inverters and a NOR gate in the shaded portion of Fig. 2 hold input A_3 of the ROM at ZERO. Therefore, ROM locations from 1000 to 1111 are not addressable, and the generator produces the output pulses shown in Fig. 3b. Notice that they make up the same time sequence as the one shown in Fig. 1b. But to emulate the hardwired generator completely, the ROM generator's time sequence must also be reversible.

At count 1000, the 7420 NAND gate is enabled, and the monostable fires, which resets the counter to all ZEROs. The Count Forward line then switches to ZERO, which makes A_3 high. Now, locations 1000 through 1111 of the ROM can be addressed as the 7493 counts from 0000 to 0111. The program stored in this second group of locations is the exact opposite of the program in the first group. So the timing sequence is repeated, but in reverse order from the original. Thus the hardwired timing generator is emulated completely.■■



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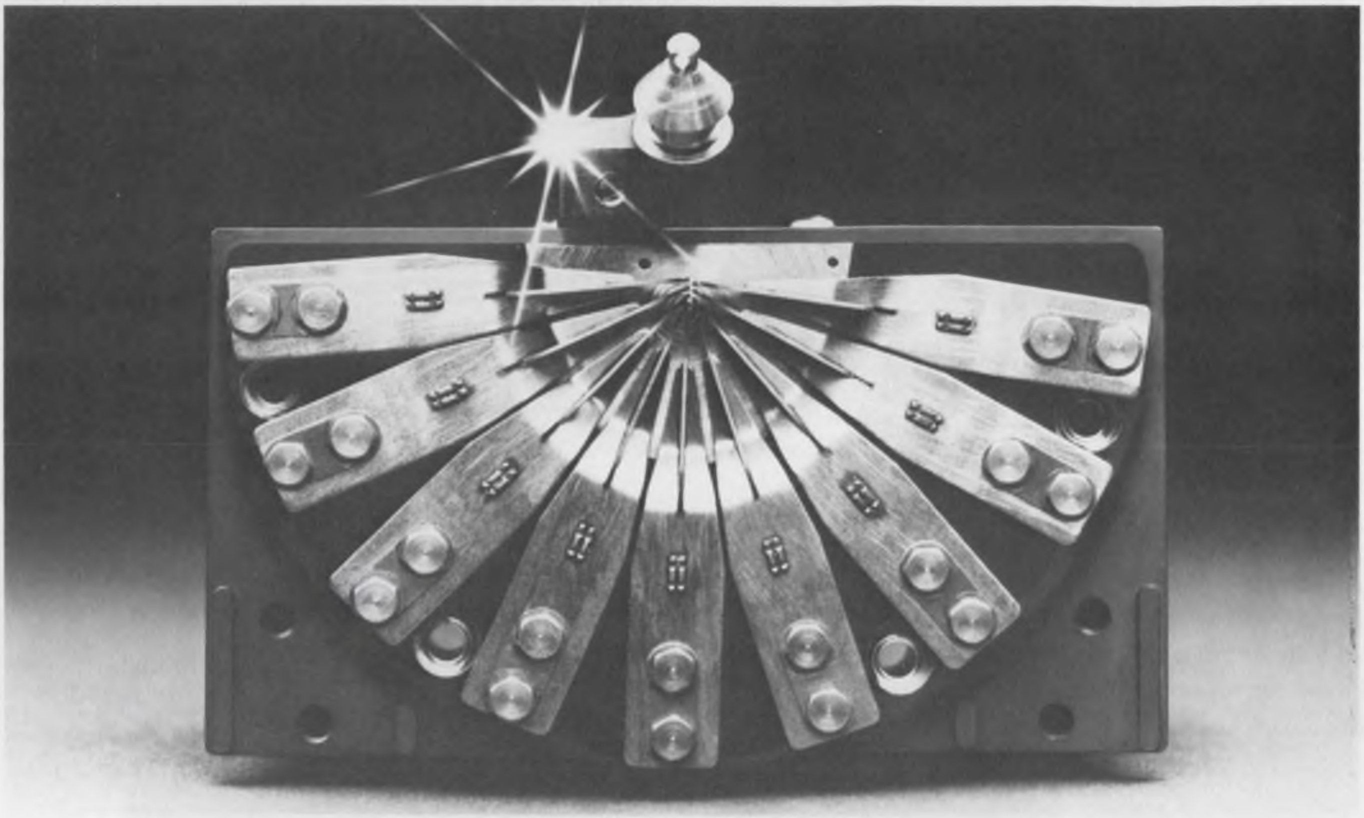

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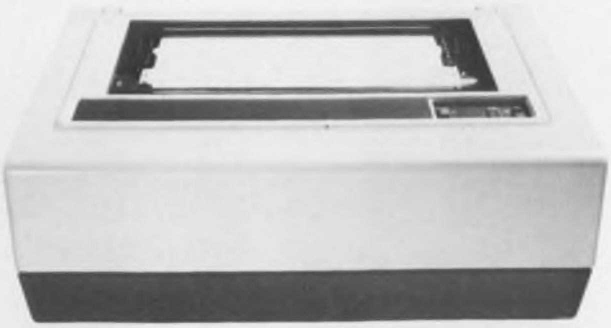

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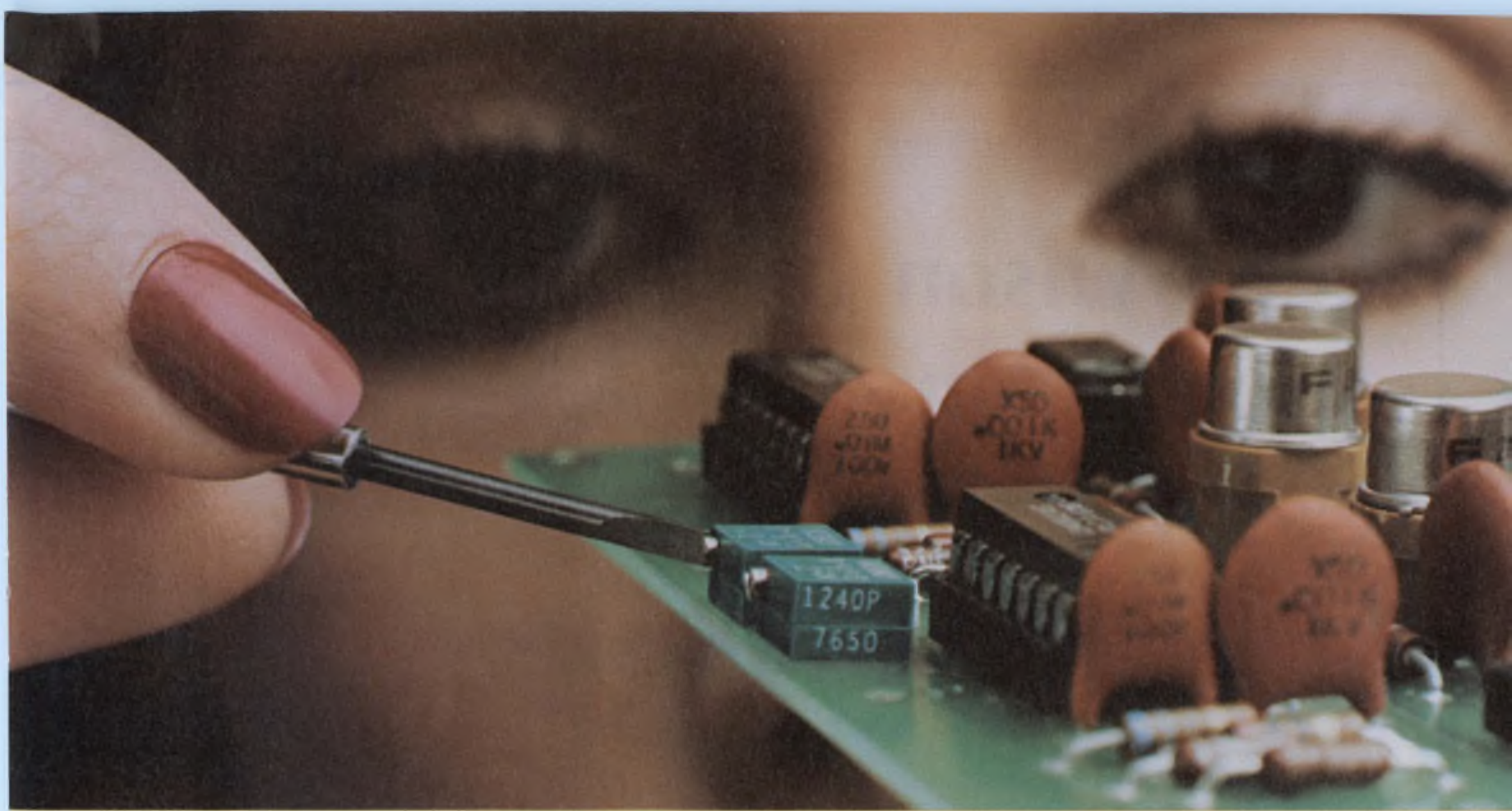

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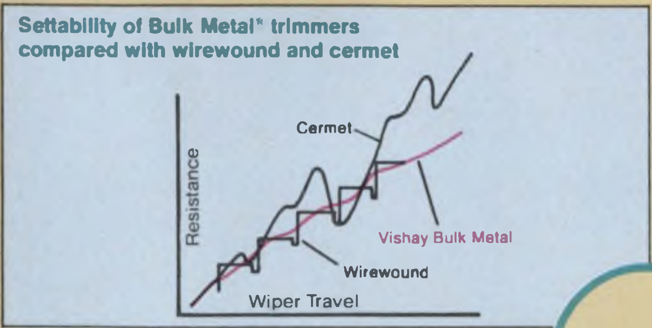

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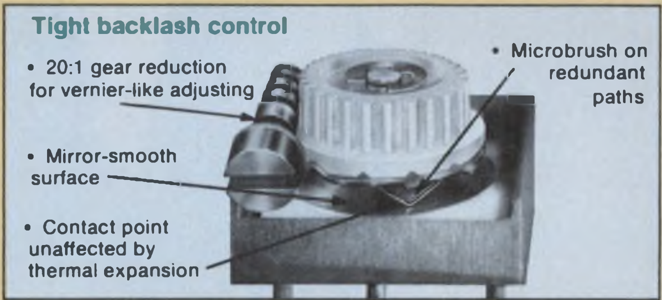

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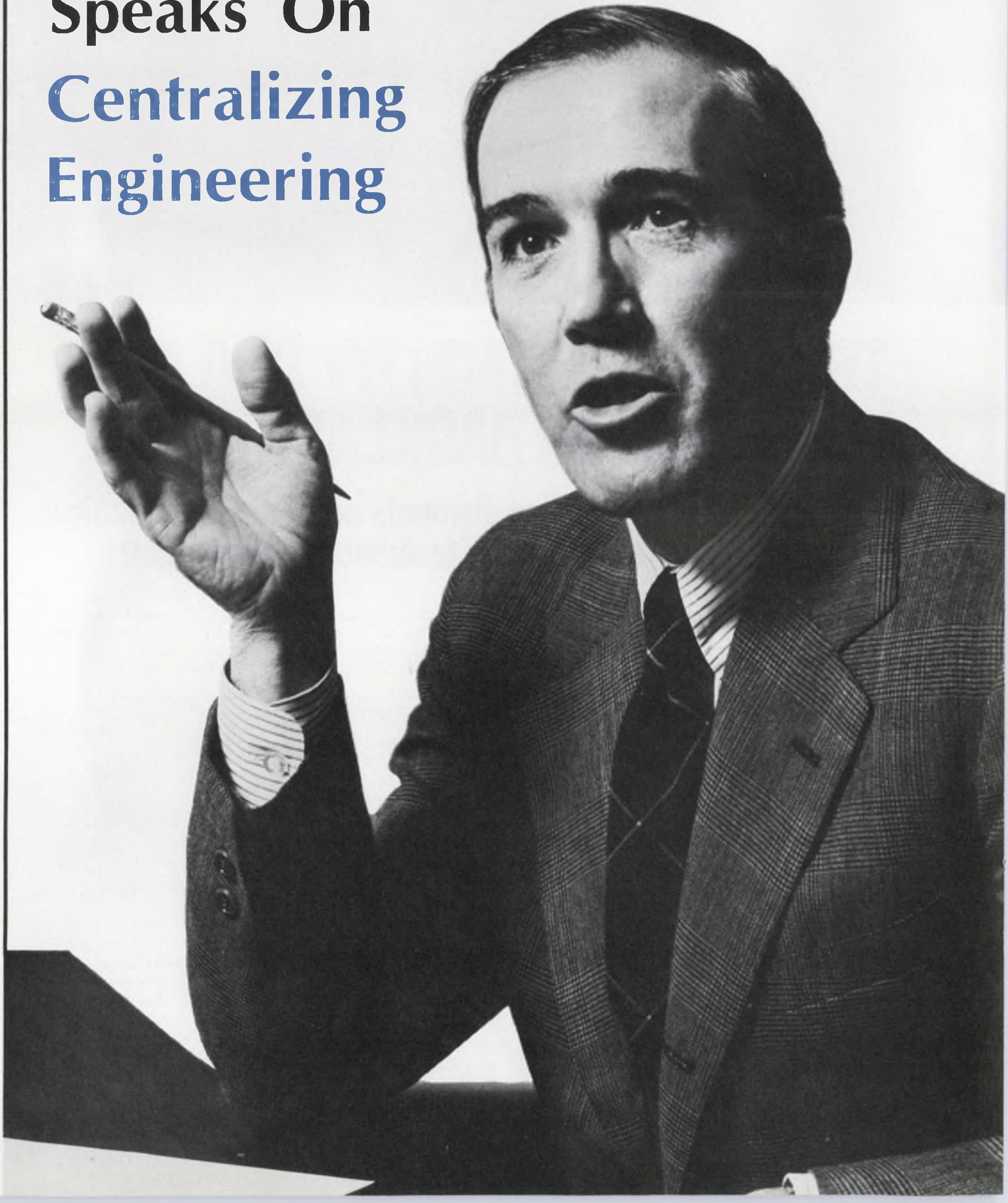
7032

Lee Wilson of Corning Speaks On Centralizing Engineering



In these days of worldwide markets, there's a popular notion that the way to respond to those markets is to decentralize your engineering—to have your engineers in the local plants, right where the markets are—so you can respond quickly to changing market needs. A further advantage of such decentralization—so the theory holds—is that the engineers can respond to local manufacturing problems quickly and effectively instead of having to overcome communications barriers that geography, national and social differences conspire to create.

Well, we disagree, especially if your business is multinational. We tried that method for a long time, and found that centralization works a lot better. A few years ago our electronic-components business was organized as a domestic and an international business. We had two companies in Europe—Electrosil in Sunderland, England, and Sovcor in LeVesinet, France. Each had a managing director who reported to a general manager, who reported to the area manager for Europe, who reported to the vice-chairman of the company here in Corning, NY, who happened to be the president of our international operations. He reported to our chairman of the board.

So we had two homogeneous businesses, one in Europe and one here, both making components that were largely identical. But product planning, budgeting procedures and almost everything else were different, no matter how hard we tried to coordinate.

And that's understandable, because the European companies had a different boss to satisfy, and he was looking at the components business as just a little piece of Corning's total European business, which includes television bulbs, dinner plates, ophthalmic blanks, Pyrex beakers, and what have you. And that made it really difficult for us to coordinate two distinct sections into what should have been one worldwide business enterprise.

Then we changed the structure so that the European plants now report on a functional basis, rather than a geographical one, just as the plants in the States do. So the two European managing directors, while they have corporate responsibility and are more than just plant managers, also report to the manager of manufacturing of the Electronic Products Division here in New York, as do the U.S. plant managers.

Now we have worldwide programs, not just American or British or French programs. This means we can centralize our engineering here in Corning. This, in turn, means that we can standardize our manufacturing processes and technologies.

These all came from Corning in the United States originally. But after many years they began to drift apart, with changes being made locally in the equipment and with new designs being developed that were clearly local in character. So we would end up with different processes in Britain, France and the U.S. One plant might be using a vertical cut-off machine, another a horizontal. One might use one kind of laser for spiraling resistors, and another might use a different kind of laser.

Well. . .so what? What's so terrible about having somewhat different processes or machinery in different locations? The answer is that invariably they perform differently. They impart somewhat different product characteristics. Or one set-up is faster than another, or provides higher yield.

Now this could mean that one plant chose equipment better than another did, for whatever historic reason. But without a central point for working on such matters, we might never find out. And that's not merely a problem of operating worldwide. We can find the same problem in different plants in the United States. As a matter of fact, a machine in one plant might perform better or worse than an identical machine in another plant.

What's more, if everybody's using different machinery, nobody can develop improvements that can prove useful to everybody. If you have a decentralized organization, people in one place never know what's been done someplace else that can raise the performance of similar equipment. If you have a central group, even a small one, you can bring all your machines up to the level of the very best one in the corporation. You can develop useful liaison between your division manufacturing engineering and your corporate engineering group.

And that's what we did.

Here in Corning, New York, we established a new position, Division Manufacturing Engineer, and gave that position to a man with broad international experience. He pulls all our programs together, international and national, and decides which ones to focus on with both capital and manpower. By focusing on the best opportunities, we get best total impact.

Now this doesn't mean we don't do any engineering in the individual plants. We do a lot. But we centralize the direction, especially for major programs like cost reduction and product development. Of course we recognize that regional markets have different needs. And that's why there's still lots of engineering in the individual plants. But those regional differences are

Who is Lee Wilson?

Except for a stint in the Army from 1954 to 1956, Leroy Wilson has been a one-company man. He joined Corning Glass Works as a technical trainee after he got his BS in mechanical engineering from Purdue in 1950. Then he got an over-all view of the company by going through one department after another—manufacturing, then engineering, then sales—before he worked in a branch plant. Then he went into product engineering as a permanent assignment until he went into the Army. When he returned, Wilson went to the Electrical Products Div., where he was given product engineering responsibility for developing the 110-degree television bulb.

A year later, he was selling TV bulbs in Chicago, and three years after that he returned to Corning in New York as sales manager of the Communication Products Dept., where he remained for four years, till 1965.

Then on to Europe as general sales manager for five years, then back to New York as area manager for Latin America and Canada. In 1975 he became vice president and general manager of the Electronic Products Div.

Lee and his wife, Claudie, have two children away at college and three still at home. The couple travel a lot, particularly to Brittany in France. They both dabble in tennis, cross-country skiing and sailing on Keuka Lake, where they have a cottage. And both are avid readers.

less prevalent than you would think because many of our important customers are worldwide customers that manufacture in Europe as well as in the States.

Naturally, some customers have special needs, perhaps to meet local safety requirements or to meet other demands. We make sure the needs of various areas are considered by having engineers from the local plants represented on our central planning task forces. And our engineers visit each other frequently. There are people from France and England here all the time and U.S. people are over there. Interaction is close among all of them.

Of course, for minor changes, say different lead lengths for a component, the local engineers don't have to consult the central organization at all.

But some problems that appear to be merely regional idiosyncrasies and very simple may not be at all.

For example, take a "simple" thing like lead diameter. Some customer wants lead diameters different from the standards you offer. But a difference in lead diameter could affect the way a component holds a lead bend and the way it is inserted into a PC board. So it's wise, even on something apparently trivial, to have local representation on the central organization.

But it's not wise to involve the central organization on matters that can be taken care of entirely locally.

Product definition, for example, must be taken care of locally. We don't have *one* catalog. We have different catalogs in different countries. But as much as we can, we try to standardize products. That's to be expected because, as I said, many of our customers are multinational. A computer manufactured in Detroit is going to be very much the same as one manufactured by the same company in Scotland, so it's going to need the same components. The people in both plants are going to want the same specifications, the same body color and the same markings. They want things to be the same and to look the same.

So we try very much to standardize—starting with the raw materials and manufacturing processes. I think, in the end, you get better quality. And once your standardized processes are tuned up and running well, you can maintain an even higher standard.

If a component is standardized, a multinational systems manufacturer will feel more assured that the one he buys in Europe will be the same as the one he buys in the States. And it's much easier for an individual customer to qualify different plants making that product.

A European purchaser will feel more confident about qualifying us. He knows, not only that we make the same product elsewhere, but that we make it the same way wherever we make it.

There's also a personal element. If the chief engineer of a major customer in the United States begins to manufacture in Europe, he faces the unwelcome task of finding new vendors in Europe.

We can relieve him of that burden to some extent by letting him know that the vendor he's using here is the same vendor in Europe. Life will be easier for him if he knows that the same people designed the processes for the European and American plants and that the same person has the line responsibility for the quality of engineering in both plants.

Still another advantage to standardization is that if a natural tragedy—say a flood or fire—or a strike shuts down one plant, we can deliver from another plant. Fortunately, we've never had a strike. But a strike by somebody else could also affect us.

There's another advantage to having the same component available from different factories. You can solve problems stemming from local social customs. In France, for example, it's almost impossible to lay off people. You can do it, but it's always very costly. So you have practically zero flexibility in adjusting the size of your work force. And that's becoming more prevalent everywhere.

With standardized components, we can go a long way toward keeping our work force stable. If, for example, the market for resistors suddenly expands in France, and we suspect that the expansion is temporary, we'd be nervous about adding to our French labor force since we couldn't reduce it later.

But we could supply that surge demand from England or someplace else where we have idle capacity. And that can help avoid the old problems of double-ordering, followed by cancellations. This tends further to stabilize the work force, and it reduces capital investment. We're not yet at the stage where we can ship readily from alternative plants, mind you, but that's our direction. It would be impossible if each plant were working on its own.

And there's another point. It's a lot easier to increase the output from another plant to meet surge demand than it is to hire and train new workers.

For all those reasons, we try to standardize, while trying to recognize and accommodate regional differences. Even if these differences were much stronger, we'd still benefit overwhelmingly from our centralized organization—not only for product planning, but also for developing manufacturing equipment and processes.

Though all our plants got most of their equipment designs from Corning, there was no central group to make sure that each plant used its equipment most effectively. Each plant had its own cost-reduction program and its own process-development activity. The problem, of course, was the old one of everyone wanting to please his own boss. We found that it's much easier if everyone has the same boss.

We tackle this problem by having somebody from the division manufacturing engineering group visit all the plants. He focuses on a relatively small number of objectives. So he can get a great deal done.

If one plant improves a process, our manufacturing engineer can communicate that to all the other plants. He can bring them all up to the highest level.

Another very important advantage of a centrally directed engineering effort, especially for Corning, is access to the central corporate engineering group.

This large and very professional organization can accomplish engineering projects that no plant, or even division, engineering group could do on its own. And with a centralized division engineering group, major projects can be organized and undertaken with the corporate engineers much more easily.

For example, the central corporate engineering group can set up a whole line, get it working smoothly and optimally, then order the same equipment for all the other plants. If we tried to have each plant develop its own equipment, we would end up with an awful lot of duplicate effort.

In addition, our central corporate engineering group can concentrate on developing new equipment and processes without having to worry about keeping a plant running at the same time. Our people in the various plant locations can't do that because their engineers are busy running factories.

Finally, no local plant can bring to bear the level of engineering that we can offer from Corning. We have engineering manpower and resources that no individual plant can afford to carry. We have several hundred engineers in our central engineering group and they have an enormous range of disciplines. ■■

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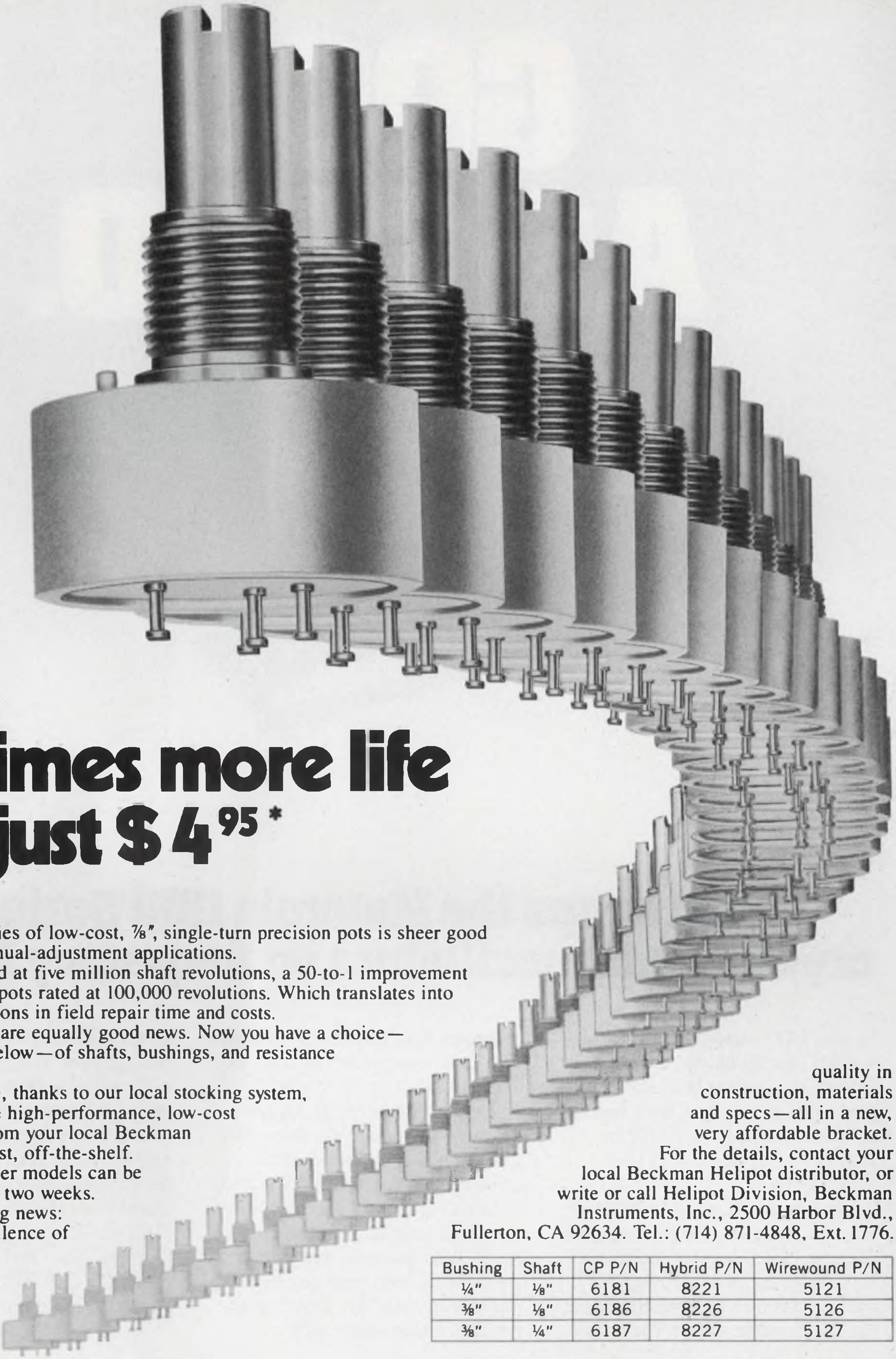

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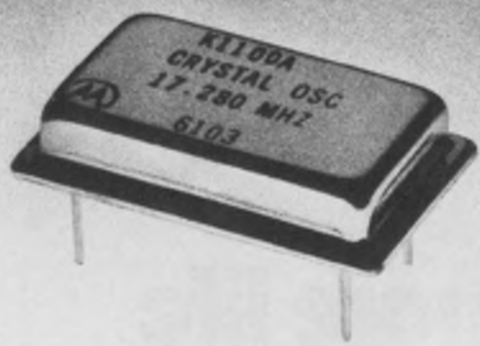

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Constant-current feedback loop improves photodetector performance in optical sensors

Improve your beam-interrupt optical system with a constant-current feedback loop to bias the photodetector, and use both the dc and ac gain of a high-gain op amp in the feedback loop. The circuit (see figure) provides Class-A biasing for the phototransistor, a Motorola MRD 360 Darlington. Not only can you use the circuit for beam-breaking applications, but it's good enough for light-measuring.

A phototransistor is often called upon to distinguish between low-energy light pulses in the infrared region and ambient light, which may be strongly modulated by 60-Hz light sources. With Class-A biasing, the phototransistor's threshold is easily exceeded, which puts ambient light variations and fast rise time light pulses in the phototransistor's linear region. And ac coupling of the signal (via the specially selected $R_{12}C_5$ combination) helps attenuate 60-Hz components, but not the desired signals.

In the circuit, a dc reference voltage is established at A_1's inverting input by voltage divider R_8 and R_9. Phototransistor Q_3, a Darlington arrangement, provides dc inverting to hold A_1's noninverting input, through feedback, at a voltage which differs from the reference by a very small offset. Constant voltage drops across R_6 and R_7 provide constant Class-A current to the phototransistor. Photon overloading of the photosensitive base of Q_3 is minimized by R_{10}, a 10-MΩ resistor. And to control the op amp's dc output to a desired level of pulse clipping, R_{10} can be a selected value. The photo-Darlington and op amp together produce a switching time of 25 μs.

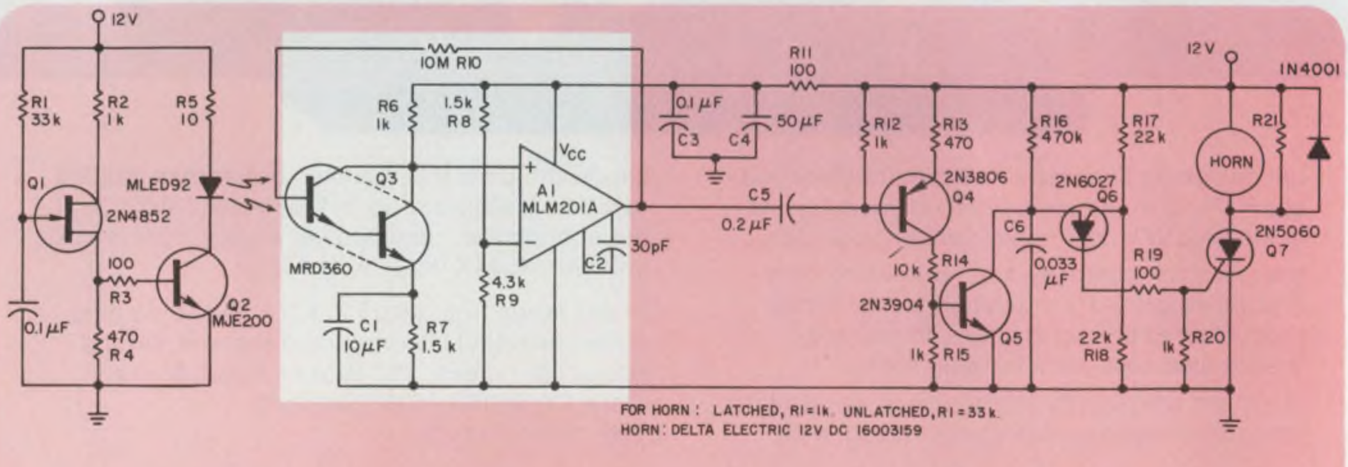
In addition to the closed-loop circuit between Q_3 and A_1, the circuit contains a LED pulser, an inhibited trigger circuit and an alarm-horn driver. The pulser consists of Q_1, a 300-Hz unijunction relaxation oscillator feeding Q_2, the LED driver. Current pulses through the LED are about 1-A peak with a pulse width of 40 μs, giving a duty cycle of about 1%.

After a pulse is detected and amplified, the pulse is capacitively coupled (which rejects 60-Hz modulation) to pulse amplifier Q_4, and then fed to clamp transistor Q_5. Since Q_5 clamps the timing capacitor C_6 of the 100-Hz programmable-unijunction oscillator PUT Q_6, periodic pulses keep C_6 below the firing potential of the PUT. But if the infrared beam is broken for more than four pulse times (about 12 ms), Q_6 conducts, triggering horn-driver Q_7. A steady stream of pulses inhibits triggering, so the four-pulse feature provides false-signal immunity.

An interrupter-contact-type horn turns off Q_7 after initial triggering, if R_{21} is large enough. A lower value of R_{21} would allow Q_7 to latch, and the horn would sound continuously until the circuit is externally opened. A prototype system using a simple flashlight reflector behind the LED can respond at distances to 3.5 ft.

Al Pshaenich, Senior Application Engineer, Motorola Semiconductor Products, Inc., Phoenix, AZ 85008.

CIRCLE NO. 311



Constant-current Class-A biasing of the phototransistor, Q_3, allows this optical sensor to operate in a linear region, which improves the performance of the circuit on fast rise-time pulses. The circuit also includes a LED pulser, inhibited trigger circuit and an alarm-horn driver.

Field-programmable logic array decodes keyboard without a debounce circuit

A field-programmable logic array (FPLA) can be programmed with hexadecimal code to load keyboard data into an 8-bit processor (Fig. 1). Not only that, but use of the FPLA and a one-shot makes key debounce-circuitry unnecessary.

Each of the FPLA's 16 inputs is assigned a unique key (Fig. 2). When a key is depressed, the FPLA immediately generates the 4-bit hex code (B_0 through B_3 in Fig. 2), and a fifth bit, B_4, which first passes through time delay R_{18}, C_2, then fires one-shot U_2. Depending on the state of flip-flop U_6, the FPLA's contents are loaded into either buffer U_3 or U_4. The one-shot's trailing edge toggles U_6, which sets up the empty buffer to be loaded.

An 8-bit hex byte is available on the output lines, ready to input to the processor. Releasing a key presents an all-zeros input to the FPLA, which holds B_4 at ZERO. As a result, the buffers cannot be loaded on a key bounce.

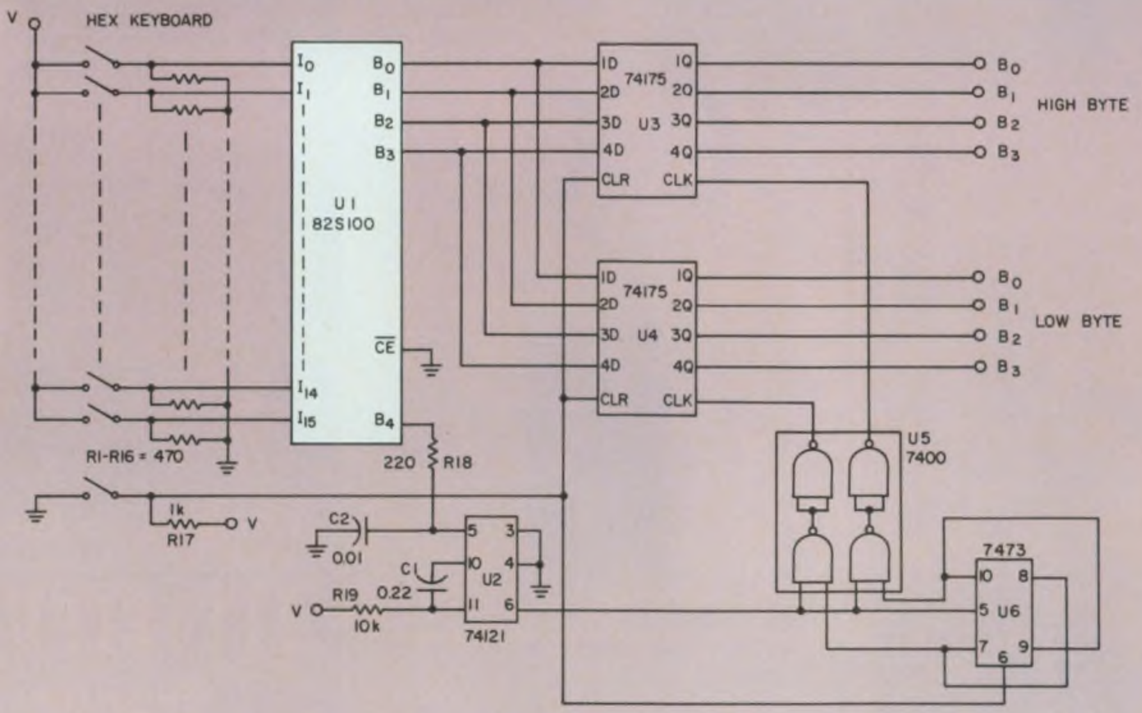
John A. Glaab, Electronic Systems Engineer, National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, MD 20771.

CIRCLE NO. 312

82S100 Program																					
	Inputs																Outputs				
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	B4	B3	B2	B1	B0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0
3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1
4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1
6	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0
7	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	1
8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0
9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1
A	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
B	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1
C	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
D	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
E	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Key release																					
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: All outputs are programmed active low.

1. **An 82S100 field-programmable logic array** is basic to this hex keyboard decoder. Hexadecimal code is programmed into the device; a single one-shot allows debounce circuits to be eliminated.



2. **Hexadecimal coding of an FPLA** provides a unique address to each key on a keyboard. The hex output code is stored in B_0 through B_3. A ONE on the B_4 line allows output buffers to be loaded.

No more square tails in round holes.

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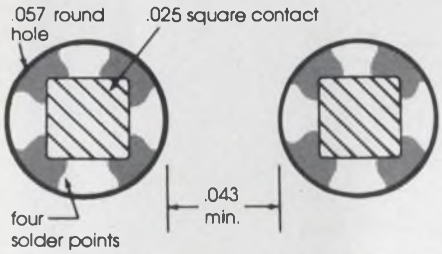
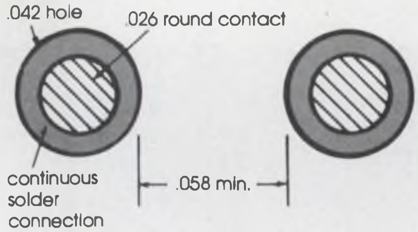
What an electronic design engineer will make-do with in a pinch is astonishing. For example – converting wire wrap* PC connectors to wave solder.



How it's done: you saw off the square .025" tail and push it through a .057" round hole in the PC board. You get only 4 contact points for solder. And there's room for only one tracing between holes. But, so what... it works.

At last – The obvious answer



Our own design engineers, not afraid of doing the obvious and simple thing, have done just that. They've taken a series of our PC wire wrap connectors – and given them .026" round tails. Everything else stays the same: the insulator, semi-bellows contacts, pin and row spacing.

So what?

So – the .026" round pin slips into a .042" round hole in your PC board for an excellent solder connection. So – you can now get multiple tracings between rows.

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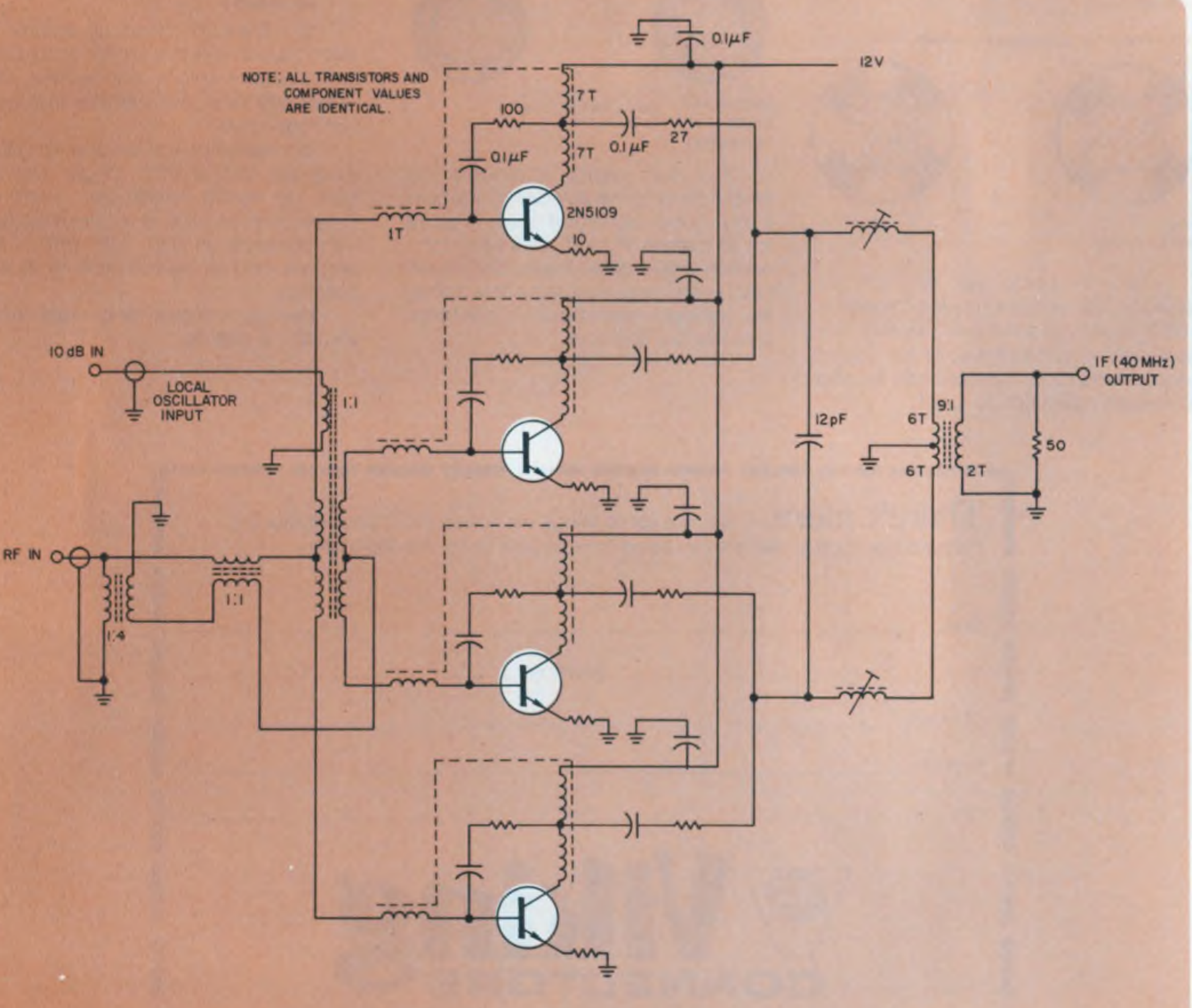
CIRCLE NUMBER 66

Improve double-balanced mixer response with an active-circuit design

With four 2N5109 CATV transistors in the active double-balanced mixer of fig. 1, you can use impedance-stabilized feedback in a transformer-coupled configuration. As a result, the mixer has lower intermodulation distortion than conventional field-effect or diode mixers at the same drive level, and a low-noise figure as well as stable gain. The circuit's 10-Ω emitter resistors reduce the amount of flicker noise. Furthermore, the circuit can achieve a 40-dBm intercept point with a local oscillator drive of 13 dBm. Even a reduced drive of 10 dBm still gives good circuit performance and low distortion.

The available gain of the specialized CATV (community-antenna television) transistors taken to-



1. **An active double-balanced mixer** uses 2N5109 transistors for stable gain and low noise.

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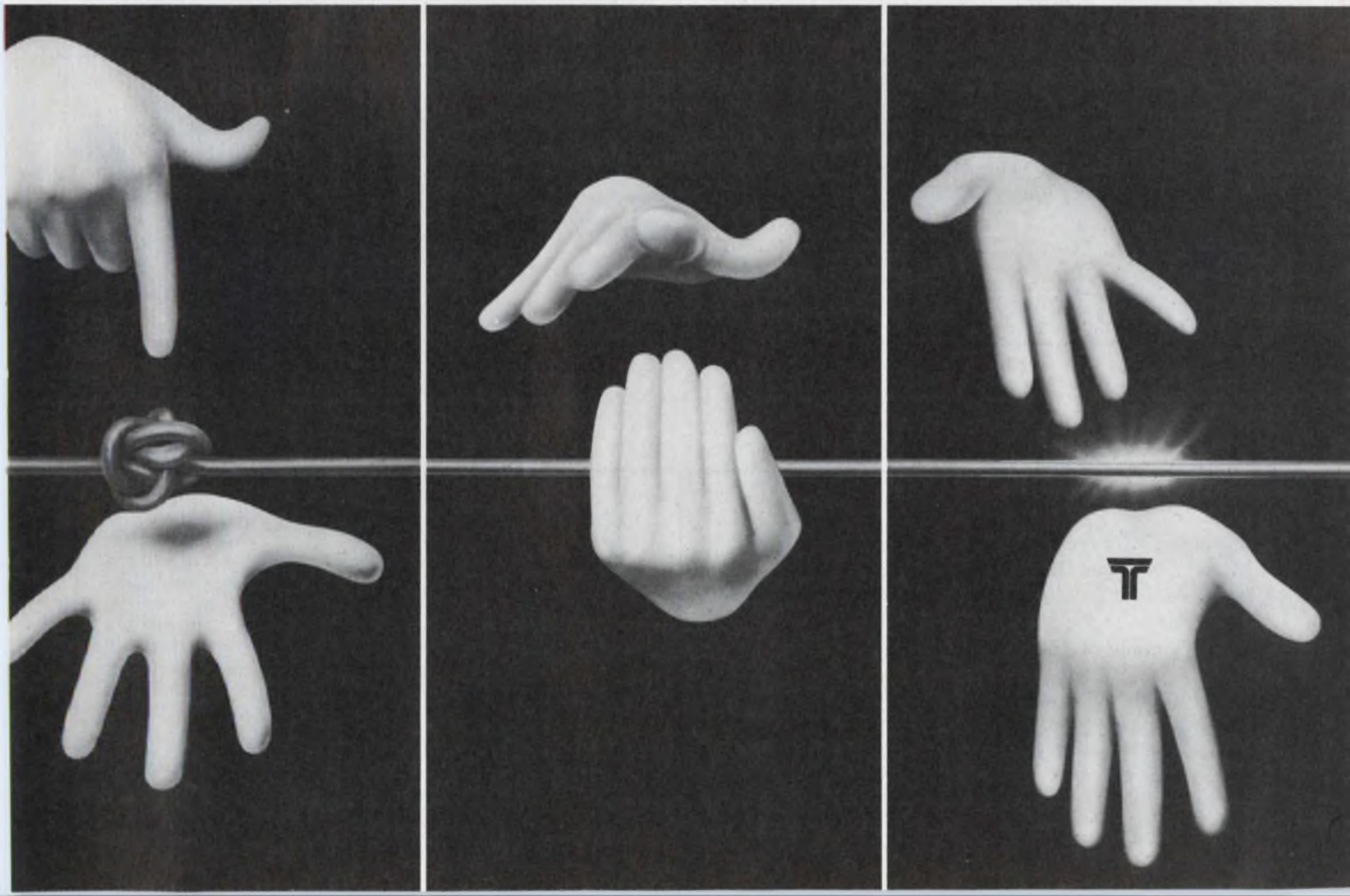
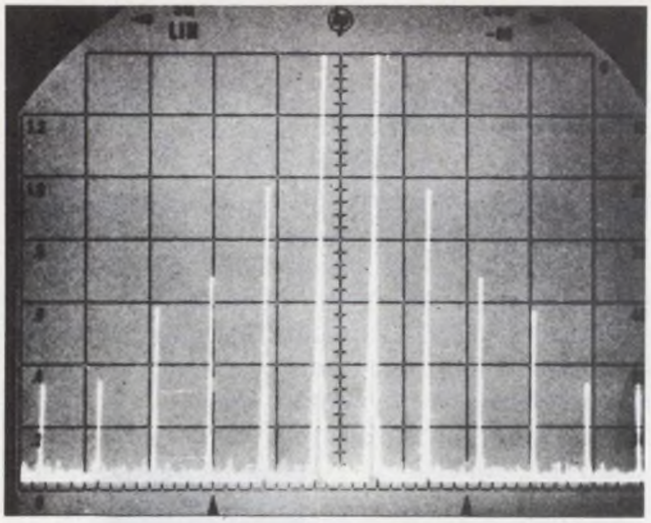
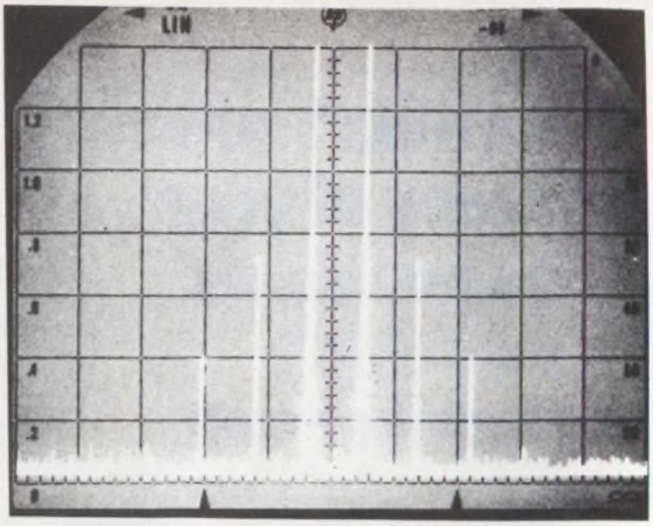
DIVISION OF TIMES FIBER COMMUNICATIONS, INC.

CIRCLE NUMBER 67

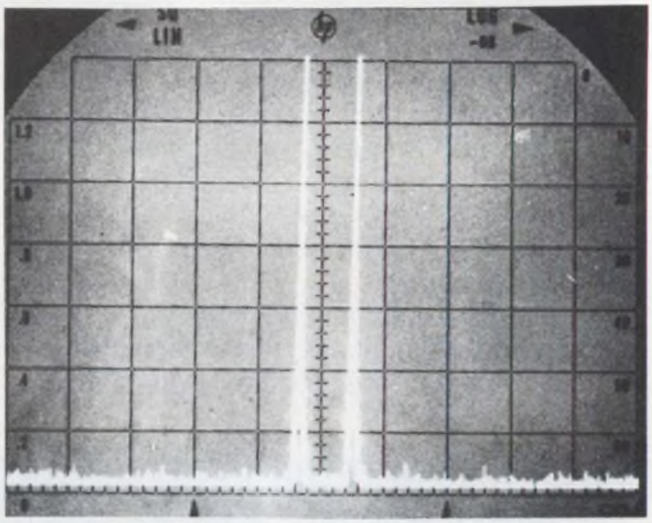




(a)



(b)



(c)

2. **Mixer response benefits from active circuits.** A passive, hot-carrier diode mixer's response (a) is improved with a grounded-gate quad FET circuit (b). But the best response occurs when CATV transistors are used as the active elements in the circuit (c).

gether with their low-noise figure and improved gain-bandwidth product allow you to use the impedance-stabilized, current/voltage rf-feedback technique, where previous mixers were passive circuits that used hot-carrier diodes or grounded-gate silicon FETs.

An ordinary double-balanced mixer that uses just four hot-carrier diodes produces the response plot of Fig. 2a. A mixer constructed with a Siliconix quad FET (U 350) generates the plot of Fig. 2b. Note the significant improvement over Fig. 2a—third-order intermodulation distortion is suppressed by 35 dB. However, the circuit of Fig. 1, with CATV transistors, suppresses third-order distortion by 65 dB (Fig. 2c) for about the same component cost as a quad-FET circuit.

Ulrich L. Rohde, President, Rohde and Schwarz Sales Co., 14 Gloria Lane, Fairfield, NJ 07006.

CIRCLE NO. 313

IFD Winner of November 8, 1977

Raymond K. Ferris, Supervisor, Program Support, Actron, 700 Royal Oaks Dr., Monrovia, CA 91016. His idea "Constant Bandwidth PLL Tone Decoder Accepts Wide Range of Input Voltages" has been voted the Most Valuable of Issue Award.

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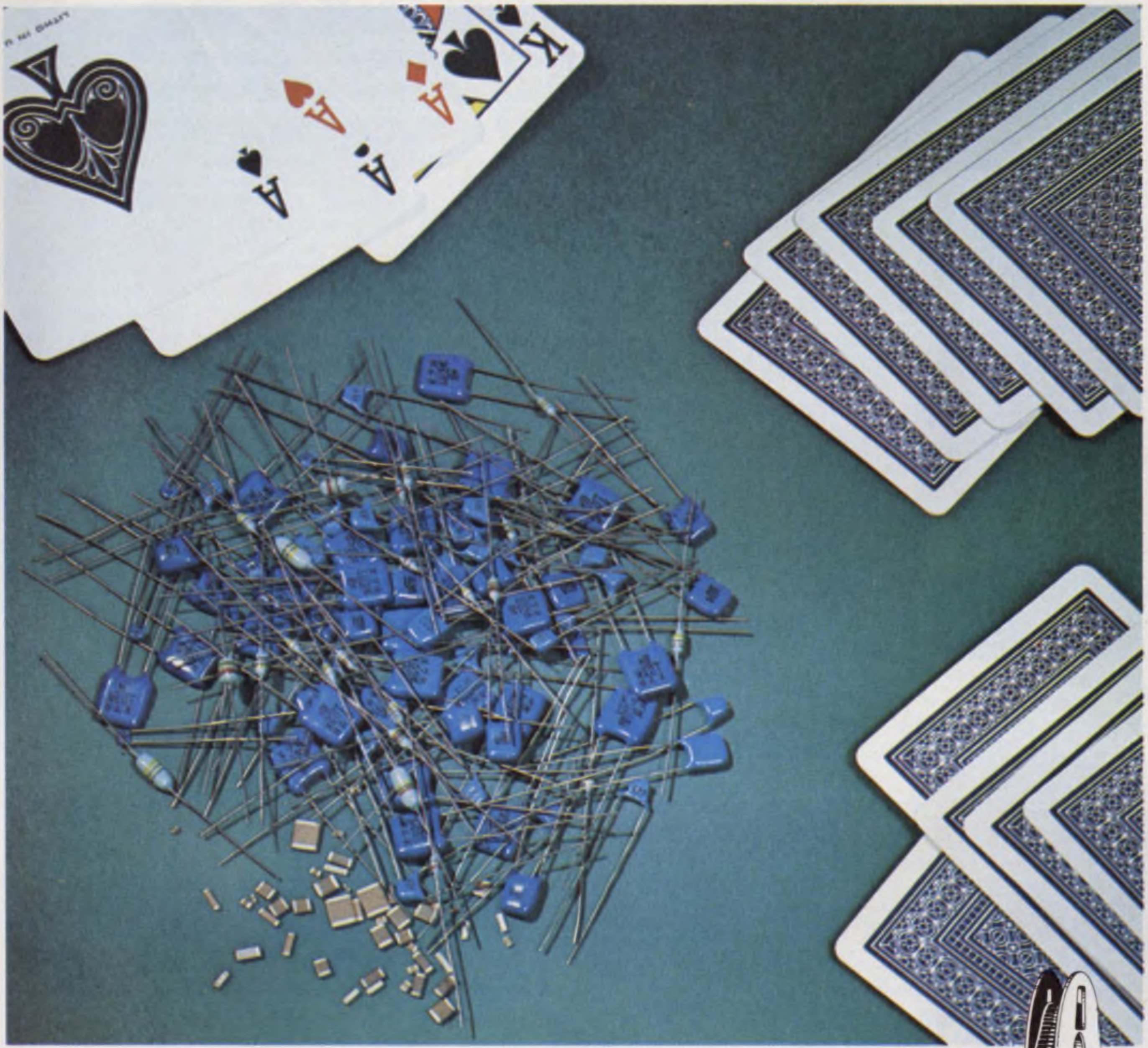

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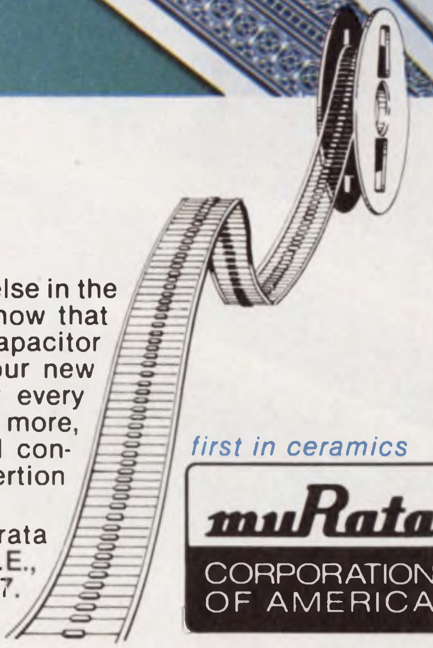

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The low-rental rates on Mini Bee 2 will make you happy if you need a TTY-compatible terminal with cursor control and a detachable keyboard. Beehive's Mini Bee 2 is a stand-alone, operator/computer accessible remote display terminal with a detachable keyboard. You use Mini Bee 2 to transmit and receive data serially through an RS232C interface at any of several preselected transmission rates to a maximum of 9600 baud. Mini Bee 2 has a 12" rectangular monitor which displays 25 lines with 80 characters per line. It has a total page memory of 2000 characters, and each character is generated from a 5x7 dot matrix with two dot spacing between adjoining characters. Communications mode can be full duplex, half duplex, 10 or 11-bit asynchronous word. Mini Bee 2 also features character-by-character transmission, an escape sequence mode for unique CRT functions, and an erase mode. It's also available off-the-shelf from REI immediately.

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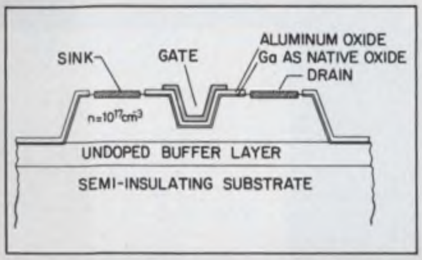
GaAsFET may solve NMOS transistor memory problems

Silicon NMOS transistors, when used as nonvolatile-memory storage devices, are hampered three ways. Their data-storage lifetime leaves room for improvement; they are not radiation-hardened; and their access time is relatively slow. But these limitations may be overcome by a nonvolatile GaAsFET transistor, developed at the Dept. of Electrical and Electronic Engineering, University of Newcastle upon Tyne, England.

The new transistor uses a double-oxide gate-insulator structure consisting of aluminum oxide (Al_2O_3) and gallium arsenide anodic native oxide. The charge is stored at the interface between the two oxides (see Fig.).



The double-oxide structure is made by evaporating 450 Å of aluminum onto the gallium arsenide device and then anodizing through the aluminum layer. The final structure is 700 Å of Al_2O_3, with some 10 or 20 Å of GaAs underneath the aluminum oxide.

The interfaces between the oxides are charged by three-second pulses as high as 30 V. The ability of the structure to retain charge was measured with the gate disconnected after charging and with the gate grounded and the device operating. With the gate disconnected, saturation current of 5.2 mA decays at the rate of 0.17 mA per decade of time, measured over 2000 minutes.

Stepping motor's angular stability can be increased

With a new technique called "pole interpolation," the angular resolution of a stepping motor can be greatly improved. Indeed, a 200-pole stepping motor can be made to operate with up to 12,800 discrete mini-steps per revolution—and, an angular stability of better than 0.001°.

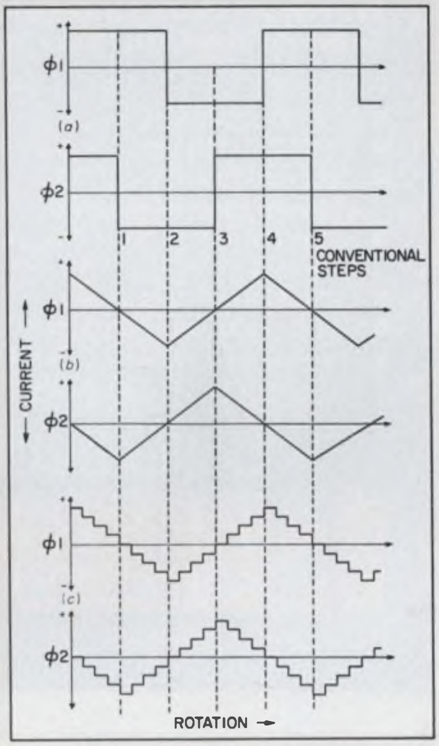
Developed at Great Britain's National Physical Laboratory, pole interpolation replaces the motor's on-off current pulses with currents of either suitably phased analog waveforms or digitally-generated, modified staircase waveforms.

Conventional two-phase step waveforms are applied to the stator windings as in Fig. 1a. When triangular waves are applied (Fig. 1b), the motor can be moved continuously between pole positions.

Angular stability depends on the accuracy of the analog waveforms, but these may present design problems. Should that happen, staircase waveforms can be used instead (Fig. 1c). Each step of the staircase represents a stable motor position.

Detailed measurements of the motor's motion have revealed that the angular velocity is not constant as the motor turns—the motor accelerates as it moves away from one conventional pole and decelerates as it approaches the next one. This nonlinearity can lead to unwanted resonances at high stepping speeds.

By using a PROM to generate unequal staircase steps—whose sizes are obtained by measuring the motor's performance with perfect staircase drive—the nonlinearity can be removed.



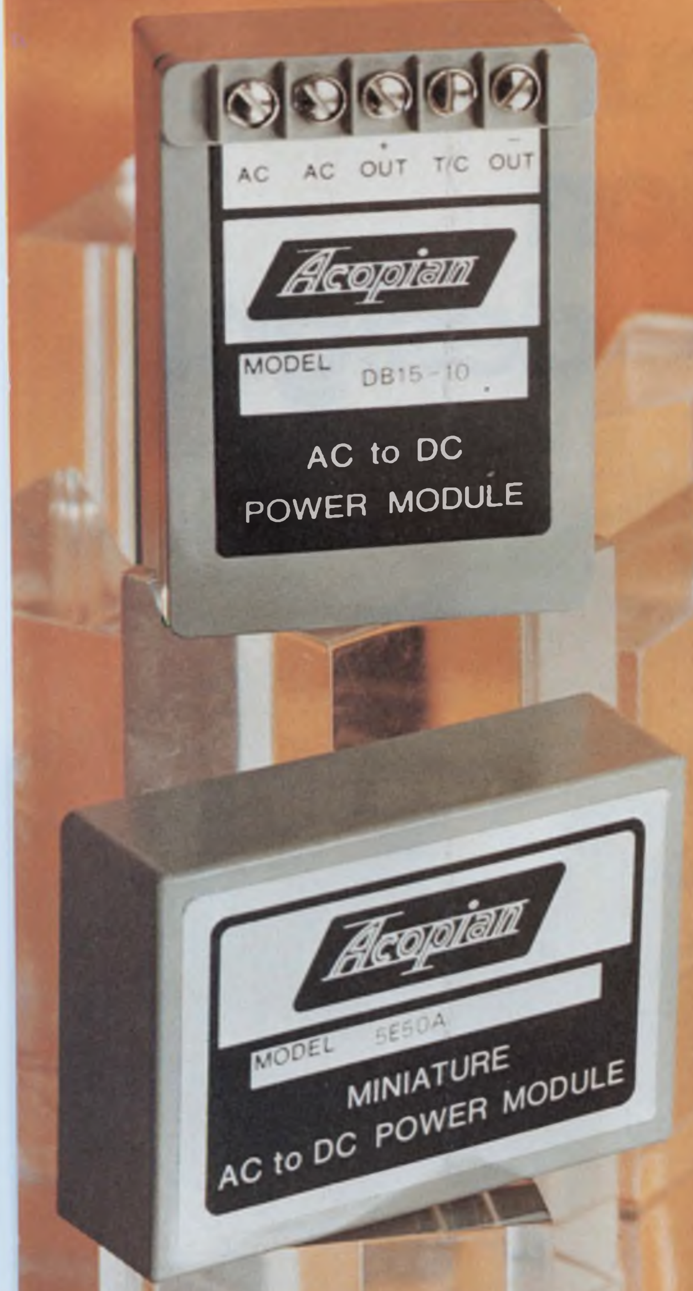
Laser crystal produces high spectral purity

A new semiconductor lasing element has almost ideal characteristics for fiber-optic communications systems. The laser, a neodymium aluminum-borate crystal between 10 and 100 μm long, emits a single spectral line of unusual purity, at 1.06-μm.

The key to the crystal's development is the process used for doping the aluminum compound. By varying the doping, the laser can be tuned to radiate at a wavelength where an optical fiber has minimum absorption loss. As a result, attenuations in the order of 1 dB/km or less are possible.

The doping process is, as yet, being kept secret. The crystal was excited by researchers at the Institute of Applied Physics, at Hamburg University in West Germany, using a krypton gas laser operating at 0.8 μm.

MINIATURIZED POWER SUPPLIES



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5	1.0	.25	.05	1	75	5EB100	EB-13
5	1.5	.35	.1	1	105	5EB150	EB-13
5	2.0	.25	.05	1	115	5EB200	EB-20
5	2.5	.25	.05	1	130	5EB250	EB-20
±12	.100	.05	.05	1	55	DB12-10	EB-10
±12	.150	.05	.05	1	65	DB12-15	EB-10
±12	.200	.05	.05	1	75	DB12-20	EB-10
±12	.300	.05	.05	1	105	DB12-30	EB-13
±12	.350	.05	.05	1	110	DB12-35	EB-13
±12	.500	.1	.05	1	135	DB12-50	EB-20
±15	.100	.05	.05	1	55	DB15-10	EB-10
±15	.150	.05	.05	1	65	DB15-15	EB-10
±15	.200	.05	.05	1	75	DB15-20	EB-10
±15	.300	.05	.05	1	105	DB15-30	EB-13
±15	.350	.05	.05	1	110	DB15-35	EB-13
±15	.500	.1	.05	1	135	DB15-50	EB-20

PCB Mounting

Nominal Output Voltage	Output Current Amps.	Regulation Load ±%	Regulation Line ±%	Ripple mv RMS	Price	Model	Case Size
5	.250	.05	.05	0.5	$ 39	5E25	ES-10
5	.500	.1	.05	1	49	5E50A	EL-10
5	1.0	.2	.05	1	69	5E100	EL-13
5	1.5	.3	.1	1	98	5E150	EL-13
5	2.0	.15	.05	1	110	5E200	EL-20
5	2.5	.15	.05	1	125	5E250	EL-20
±12	.025	.1	.05	1	24	D12-03	ES-10
±12	.050	.1	.05	1	39	D12-05	ES-10
±12	.100	.05	.05	1	49	D12-10A	EL-10
±12	.150	.05	.05	1	59	D12-15A	EL-10
±12	.200	.05	.05	1	69	D12-20	EL-10
±12	.300	.05	.05	1	98	D12-30	EL-13
±12	.350	.05	.05	1	105	D12-35	EL-13
±12	.500	.1	.05	1	130	D12-50	EL-20
±15	.025	.1	.05	1	24	D15-03	ES-10
±15	.050	.1	.05	1	39	D15-05	ES-10
±15	.100	.05	.05	1	49	D15-10A	EL-10
±15	.150	.05	.05	1	59	D15-15A	EL-10
±15	.200	.05	.05	1	69	D15-20	EL-10
±15	.300	.05	.05	1	98	D15-30	EL-13
±15	.350	.05	.05	1	105	D15-35	EL-13
±15	.500	.1	.05	1	130	D15-50	EL-20

Input Voltage: 105-125 Vac, 47 to 420 Hz, single phase.

Output Voltage Setting: Single output models are factory preset to within ±2% of nominal output voltage, and may be more precisely trimmed to the nominal voltage rating with an external trim resistor. Dual models are set to within ±1% of their nominal ratings, and are not trimable.

Polarity: Either positive or negative terminal of a single output module may be grounded. Dual output modules have a positive/common/negative output terminal configuration.

Ambient Operating Temperature: −20 to +71°C. (Model 5E150 and 5EB150, 0 to +71°C.) No derating required.

Temperature Coefficient: 5-volt models, .03%/°C; dual output models, .015%/°C.

Impedance: 0.07 ohm at 1 kHz, 0.2 ohm at 10 kHz (approx.).

Optional 230 Volt Input: To order, add suffix "-230" to model number and $10.00 to price.

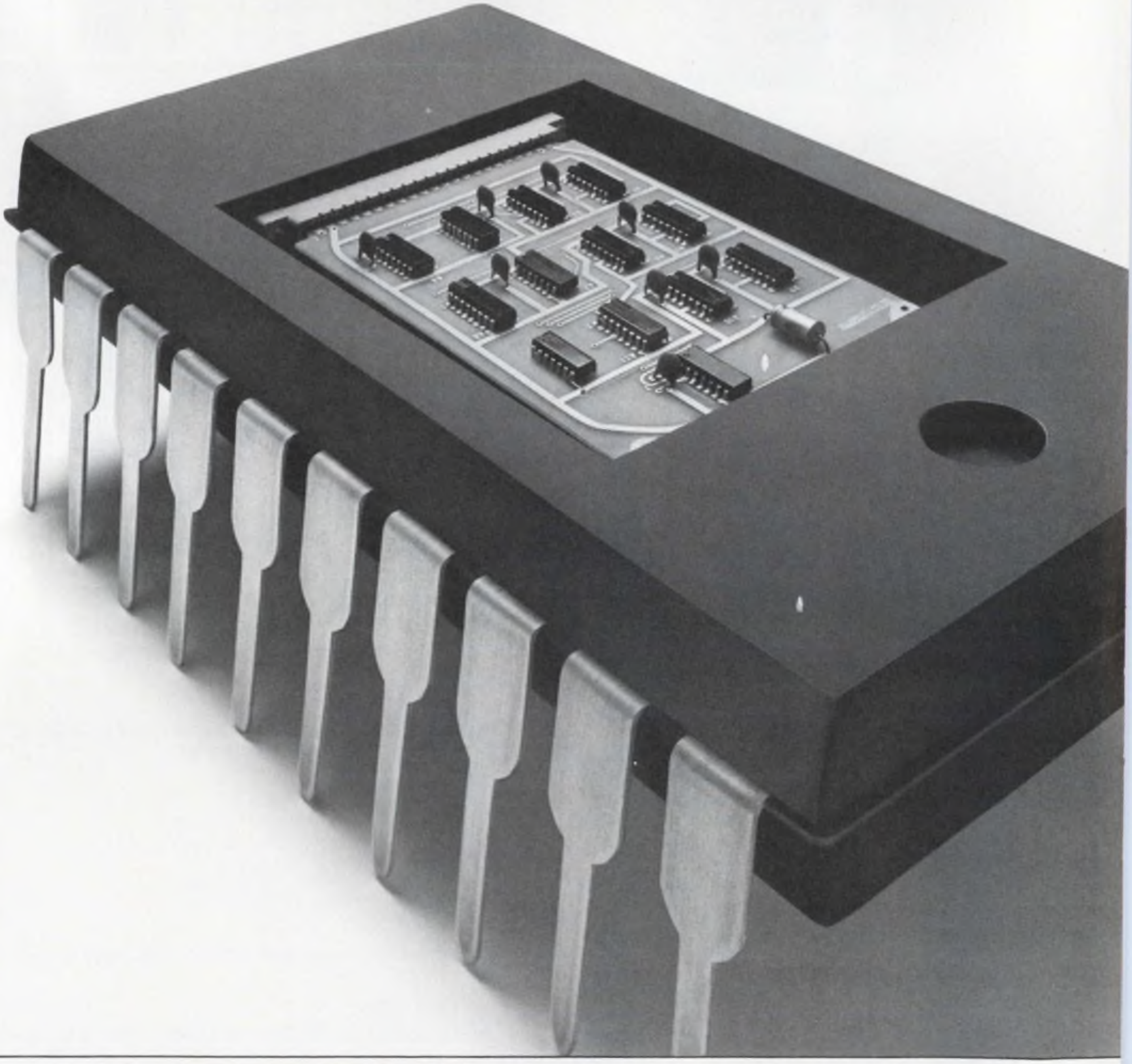
Case Sizes and Weight:
EB-10: 3.5" x 2.5" x 1.375" (1 lb)
EB-13: 3.5" x 2.5" x 1.625" (1 lb 5 oz)
EB-20: 3.5" x 2.5" x 2.375" (2 lb 1 oz)
EL-10: 3.5" x 2.5" x 1" (15 oz)
EL-13: 3.5" x 2.5" x 1.25" (1 lb 3 oz)
EL-20: 3.5" x 2.5" x 2" (2 lb)
ES-10: 2.3" x 1.8" x 1" (7 oz)

Other models available from 1 to 75 volts. Send for complete information.

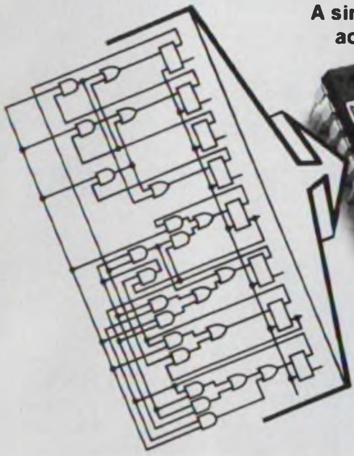
Acopian Corp., Easton, Pa. 18042 Tel: (215) 258-5441

CIRCLE NUMBER 211

Monolithic Memories announces: a revolution in logic design!

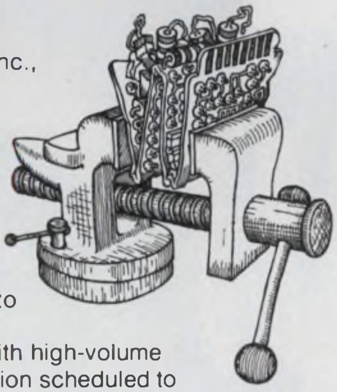


PAL™ will save you money, space and sweat.



A single PAL16R8 (package shown actual size) can be programmed to perform all the logic functions shown here. Other devices in the PAL family offer comparable efficiencies.

Programmable PAL logic will reduce random logic chip count by 4-to-1.



Monolithic Memories, Inc., the company that invented the modern bipolar PROM, soon will bring you PAL (Programmable Array Logic)—a family of monolithic LSI circuits which allows you to program your own logic on a chip, from random gates to arithmetic functions. We have samples now, with high-volume production scheduled to begin mid-year, and the entire family to be in full production by year's-end.

The fifteen devices in the family will each contain a programming network which interconnects various types of gate arrays, consisting of AND/OR and AND/NOR gates, exclusive-OR gates, registers, optional three-state outputs and feedback connections.

The PAL family will replace 90% of 7400S/LS Series functions.

When you use PAL, you'll be designing functions on-chip that are ordinarily performed by conventional TTL logic, and realizing tremendous efficiencies of time, space and cost. PAL replaces 9 out of 10 standard functions now provided by ordinary SSI/MSI TTL logic gates and flipflops.

Use PAL to interface your microprocessor—or maybe even replace it.

To the designer faced with implementing his logic with microprocessors, PAL will offer special blessings. It's ideal for interfacing peripheral devices to any microprocessor system, with minimum time and cost. And for those less complex logic system designs that don't really require a microprocessor, PAL will offer the ideal answer.

Programmability simplifies design and saves dollars in production.

PAL will let you structure your logic by programming fusible-link connections identical to those used in PROMs. All PAL programming will be handled by standard PROM programmers, simply, quickly and efficiently.

If your PC board layout should prove difficult or awkward, PAL can help. You can program the same logic functions into PAL a number of different ways, thereby eliminating jumper wires and crossed conductors, with sunbstantial improvement in reliability, plus savings in space and power.

PAL's unit cost will be lower than that of microprocessors, custom logic and FPLAs. Compared with conventional TTL logic, you'll save in system cost, because PAL reduces parts inventory as well as parts on your board. It also simplifies production and saves in testing.

Every PAL will be packaged in a 20-pin "Skinny DIP," saving additional board space every time it replaces TTL, microprocessors, FLPAs or custom logic. Result: often you'll get your entire circuit on a single board, resulting in fewer boards per system. Ask for product details from Monolithic Memories, 1165 East Arques Ave., Sunnyvale, CA 94086, or call (408) 739-3535.

How they stack up. Only PAL offers across-the-board advantages over all other types of logic.

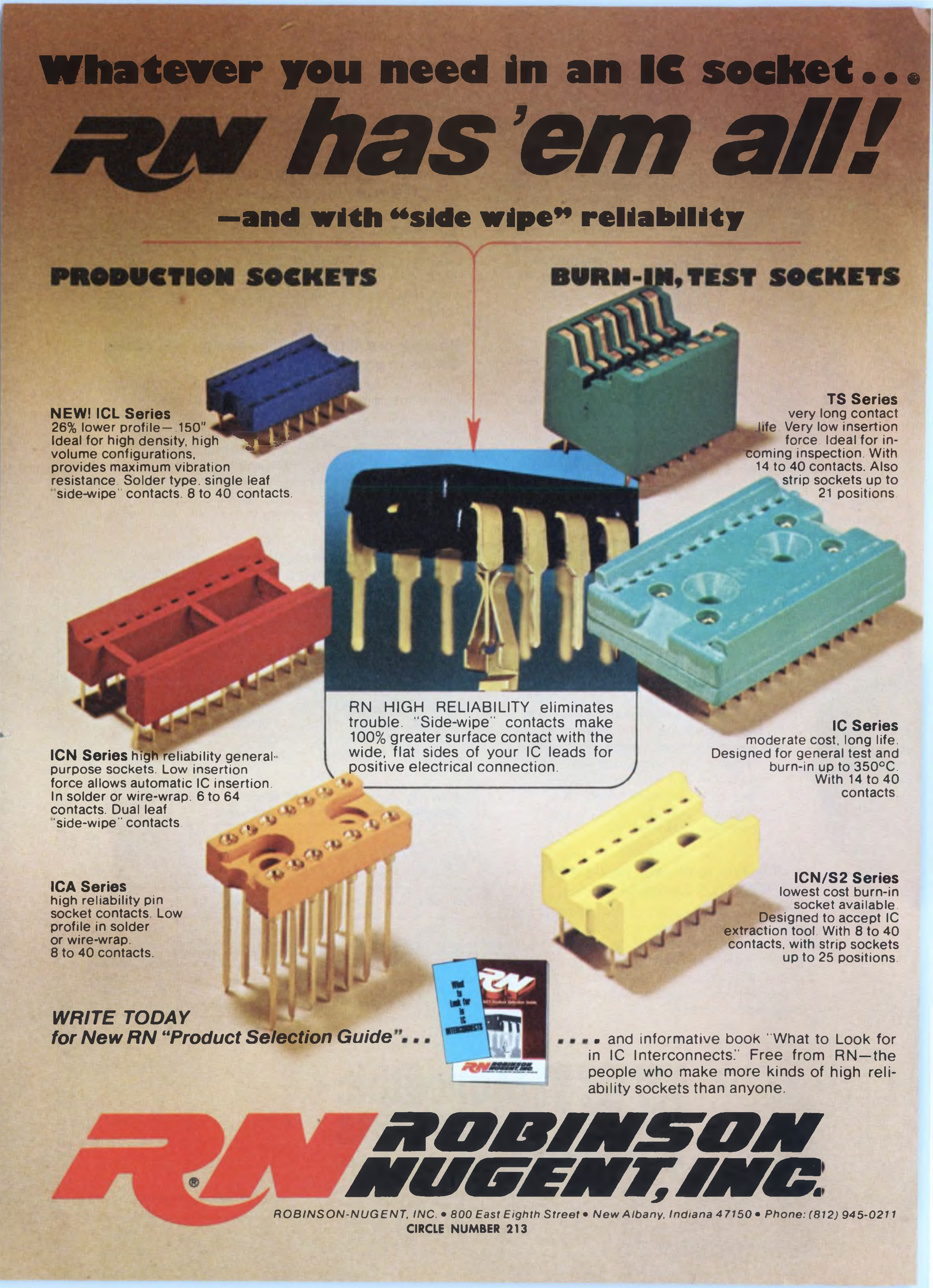
	PACKAGE COUNT	UNIT COST	INVENTORY COST	FLEXIBILITY	SPACE SAVINGS	POWER SAVINGS	SPEED	RELIABILITY	EASE OF PROGRAMMING	DESIGN CYCLE TIME
TTL LOGIC	POOR	GOOD	POOR	GOOD	POOR	POOR	GOOD	FAIR	——	FAIR
FPLA	EXCELLENT	POOR	GOOD	GOOD	EXCELLENT	EXCELLENT	FAIR	GOOD	POOR	FAIR
PAL	EXCELLENT	GOOD	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	GOOD	EXCELLENT	EXCELLENT	EXCELLENT
CUSTOM LOGIC	GOOD	POOR	POOR	POOR	EXCELLENT	EXCELLENT	FAIR	GOOD	——	POOR
MICRO-PROCESSOR	EXCELLENT	POOR	GOOD	EXCELLENT	EXCELLENT	EXCELLENT	POOR	EXCELLENT	POOR	FAIR

Monolithic Memories

Bipolar is our business.

TM—Trademark, Monolithic Memories, Inc.

CIRCLE NUMBER 212


Whatever you need in an IC socket...
RN has 'em all!
—and with "side wipe" reliability
PRODUCTION SOCKETS
BURN-IN, TEST SOCKETS
NEW! ICL Series
26% lower profile—.150" Ideal for high density, high volume configurations, provides maximum vibration resistance. Solder type, single leaf "side-wipe" contacts. 8 to 40 contacts.
TS Series
very long contact life. Very low insertion force. Ideal for incoming inspection. With 14 to 40 contacts. Also strip sockets up to 21 positions.
RN HIGH RELIABILITY eliminates trouble. "Side-wipe" contacts make 100% greater surface contact with the wide, flat sides of your IC leads for positive electrical connection.
ICN Series high reliability general-purpose sockets. Low insertion force allows automatic IC insertion. In solder or wire-wrap. 6 to 64 contacts. Dual leaf "side-wipe" contacts.
IC Series
moderate cost, long life. Designed for general test and burn-in up to 350°C. With 14 to 40 contacts.
ICA Series
high reliability pin socket contacts. Low profile in solder or wire-wrap. 8 to 40 contacts.
ICN/S2 Series
lowest cost burn-in socket available. Designed to accept IC extraction tool. With 8 to 40 contacts, with strip sockets up to 25 positions.
WRITE TODAY
for New RN "Product Selection Guide"...
What to Look for in IC Interconnects
.... and informative book "What to Look for in IC Interconnects." Free from RN—the people who make more kinds of high reliability sockets than anyone.
RN ROBINSON NUGENT, INC.
ROBINSON-NUGENT, INC. • 800 East Eighth Street • New Albany, Indiana 47150 • Phone: (812) 945-0211
CIRCLE NUMBER 213

A "Special" reminder.

We don't stock this one.

We put it together to demonstrate Cutler-Hammer's unique capability to produce custom—and even proprietary—switch "specials" to satisfy virtually any end-product requirement.

We offer "specials". . . toggle, rocker, paddle, rotary, slide, key, lever-lock or pushbutton. Both illuminated and non-illuminated.

. . . ac or ac/dc. For one-hole, flush, sub-panel, snap-in or nest mounting. In all sizes. With special circuits that can be ampere or horsepower rated . . . or both.

. . . with screw, spade, pc, solder lug, wire wrap, wire lead and integrated wire terminations.

For "special" assistance on commercial, industrial and MIL-Spec applications, call your Cutler-Hammer sales office or distributor.

And for the many "non-specials" we *do* stock—write Milwaukee for your copy of our new 144-page catalog.

Switch to No.1

CUTLER-HAMMER

SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

CIRCLE NUMBER 214

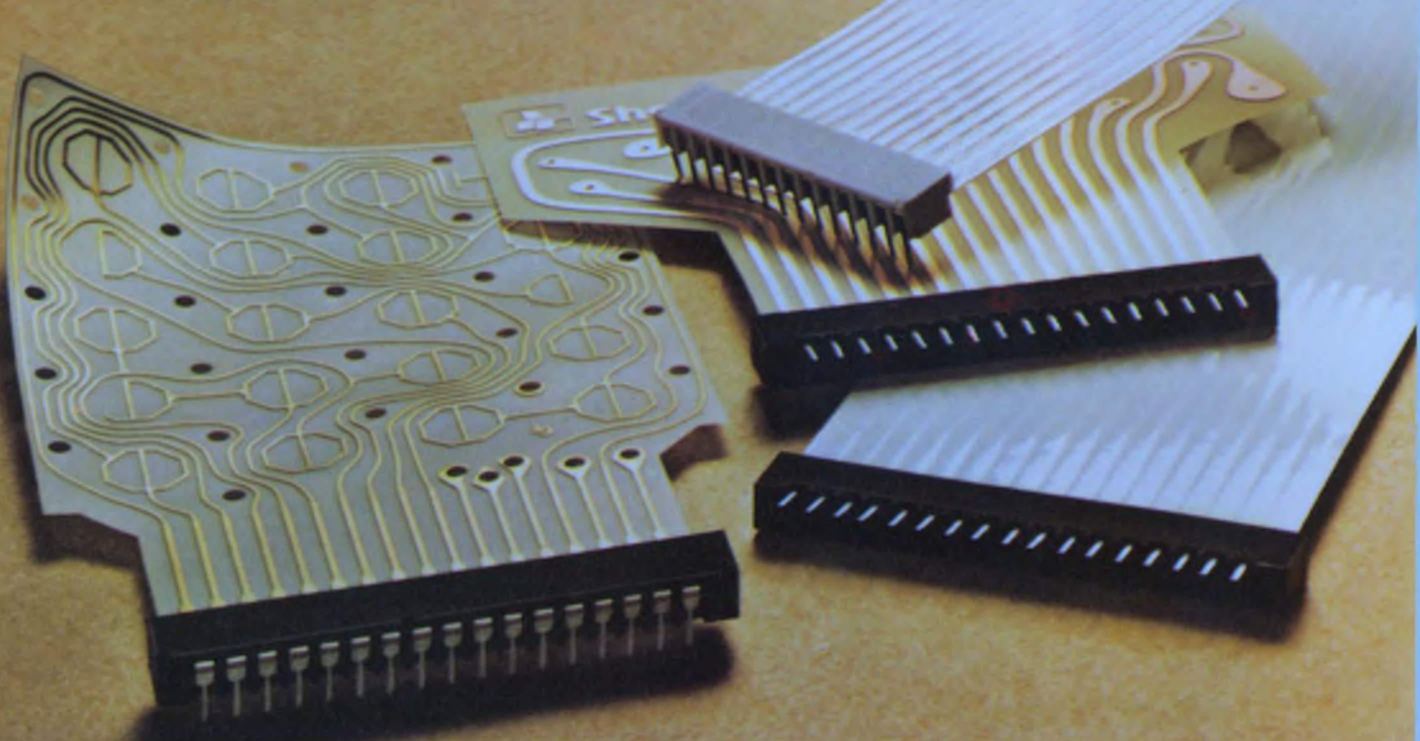
We've just terminated your flexcircuit connector cost problems... without sacrificing reliability.

Burndy Flexlok™ connectors combine high-reliability with low-cost design to slash installed costs 66%.

Now, for less than 1¢ per contact, you can enjoy all of the design and production benefits of flexible circuitry and flat cable.* That's a lot less than the 3¢ to 10¢ you'd normally expect to pay with other connectors.

But Flexlok not only costs less initially, it costs less to install. That's because it comes fully assembled, inspected and ready for soldering and cable insertion. *No separate handling. No loose contacts to assemble. No assembly machines or tools. No special operator training.*

What's more, these savings are all yours without sacrificing reliability. That's because Flexlok connectors feature Burndy's patented GTH™ contact design that delivers gas-tight, high-pressure, good-as-gold contact even under adverse environment. Hard to believe? The proof is in the cost comparisons and performance data shown below.



*Flat-flat and flat-round types.

Here's proof!

FLEXLOK COST COMPARISON

	GTH Flexlok FC & RC	Clamp Type Pressure Tin	Insulation Displace-ment	Insulation Piercing	Solder Connections
Piece Price* (per line)	1¢†	2¢-3¢	3¢-5¢	5¢-10¢	5¢-10¢
Special Conductor Preparation	None	Required	None	None	Required
Installation Tooling (Purchase/Rental)	None	Yes	Yes	Yes	Yes
Operator Training Required	None	None	Skilled	Skilled	Skilled

*In Quantity †Average price.

FLEXLOK DESIGN FEATURE COMPARISON

Design Simplicity	1 piece	2 pieces or more	2 pieces or more	2 pieces or more	2 pieces or more
Conductor Types Accommodated	Round Flat Flex. P.C.	Flat Flex. P.C	Round	Round Flat	Round Flat Flex P.C.
Top or Side Entry Available	Yes	No	No	No	No

FLEXLOK PERFORMANCE DATA

	Contact Resistance Test Data	MILLIOHMS MIN.	MAX.	AVG.
Test Group 1	Initial Contact resistance	7.00	7.60	7.26
	After thermal shock	7.10	7.50	7.25
	After durability (5 cycles)	7.10	7.80	7.39
	After moisture resistance (10 days)	7.20	8.70	7.68
	After vibration	PASSED		
	After mechanical shock	8.20	25.20	12.30
	Insulation resistance (megohms X 10^6)	.002	9.50	5.26
	Dielectric withstanding voltage No breakdown @ 500V AC	PASSED		
Group 2	Initial contact resistance	7.00	7.50	7.25
	After thermal shock	7.20	7.90	7.46
	Ammonium Sulfide exposure (3 min.)	7.20	8.00	7.59
Grp. 3	Initial contact resistance	7.10	7.50	7.25
	After gas tightness	7.00	7.60	7.24

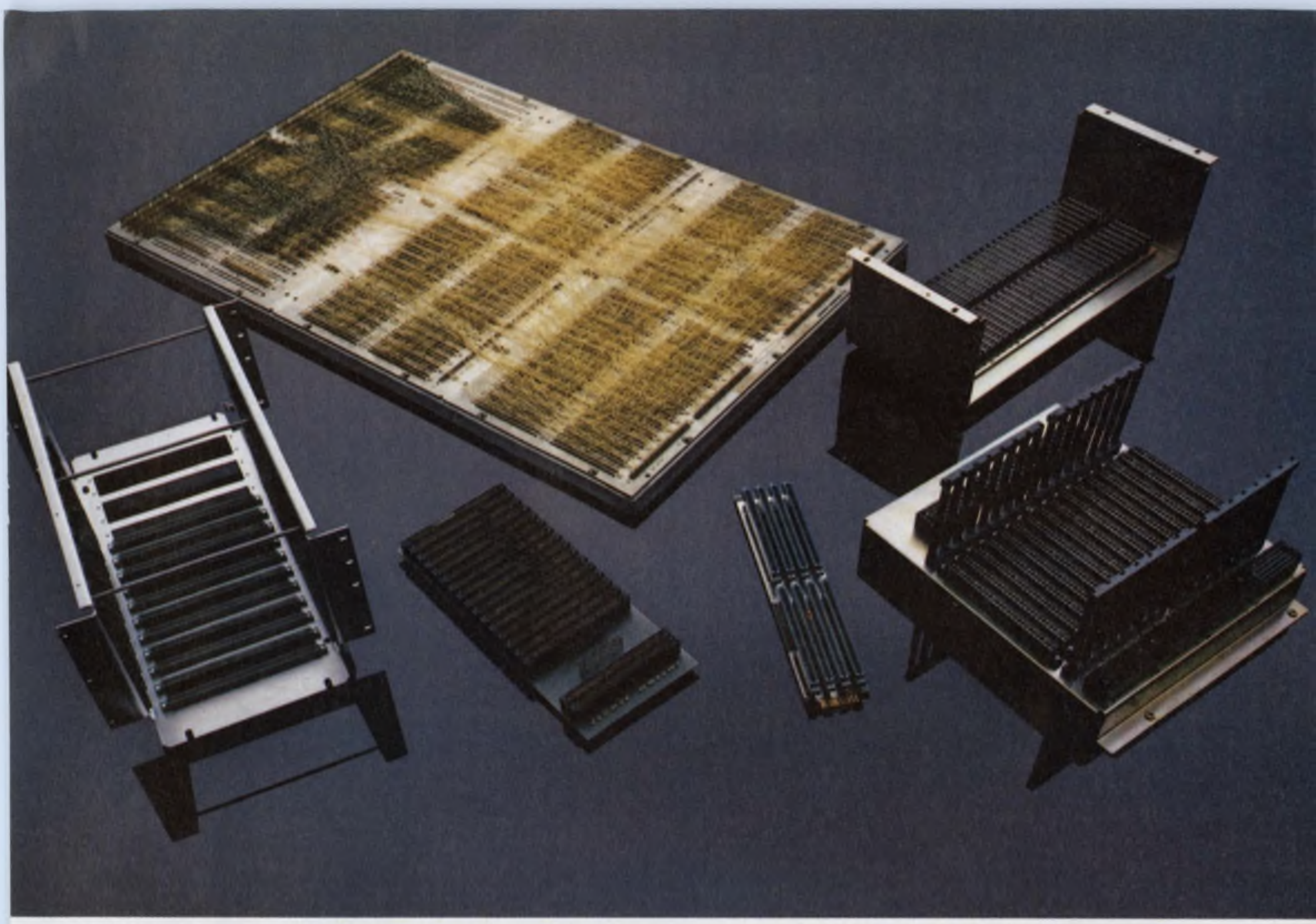
Report No. G7515-755 (Summary) Mated with tin/lead plated flexible printed circuitry.

For details, call or write: Burndy Corporation, Norwalk, Connecticut 06856 (203-838-4444).

BURNDY

Offices in principal cities throughout the United States

CIRCLE NUMBER 215



The MC² from Pyle gives you more design flexibility than any connector in history.

Until the development of the MC²™ (Modular Concept/Multi-Cell) connector system, you either had to design around existing connectors or buy expensive tooling for specialized applications. The former was a nuisance; the latter time-consuming and costly.

We solved the problem by developing a "family" of components consisting of 4 shell sizes and a series of insertable, contact-carrier modules available in a variety of removable, crimp-type contact sizes and arrangements. You simply insert the appropriate modules into the shells and you have, in effect, designed your own connector. And should you choose to interchange male and female components in the same shell, you can do that, too.

The MC² provides you with the capability to design any of 36,936 different connectors.

But, all connectors are not created circular.

The MC² concept can be applied to whatever shape suits your particular purpose. If you will simply tell us what you need to solve your system-component interconnect problems, we'll come up with the economical answer.

And you and we together will continue to advance the state of the art through design innovation.

Write us for our MC² catalogue now, or call our toll-free number.

DIAL PYLE:
800-621-6027*

**Illinois respondents call 312-342-6300.*

pyle-national company

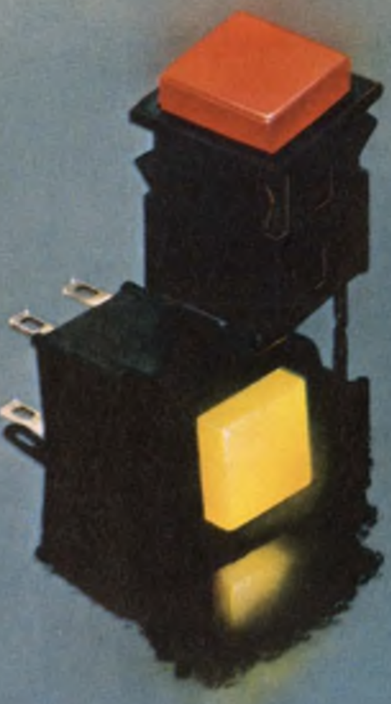
A Division of Brand-Rex Company

The problem solvers.

Pyle-National Company, 1334 N. Kostner Ave., Chicago, Ill. 60651. In Canada: Pyle-National of Canada, Ltd., 2560 S. Sheridan Way, Mississauga, Ontario, In Europe: Pyle-National (U.K), Ltd., The Octagon, 143 Derby Road, Nottingham, England.

CIRCLE NUMBER 218

Licon has more economical ways to light and control switch action.



If you sat down . . . took the best features of all low cost, low energy lighted pushbutton switches . . . you'd come up with the same thing we did . . . the LICON® Series 05 Lighted Pushbutton Switches. These are the switches you asked for.

Here are the ideal LPB switches for office machines, computers, appliances, home entertainment, etc. wherever requirements dictate low level switching, economy and high reliability. The Licon Series 05 Switch is available in momentary and maintained action plus lighted, non-lighted versions. The maintained action style offers "dual indication", light and lens position. Available in both double and single pole styles – single pole N.O., double pole N.O. and SPDT styles. Exclusive design offers smooth, pleasing "feel" plus snap-in bezel mounting that assures rigid retention. These amazing little switches also feature bifurcated, silver plated contacts, .110 quick disconnect or PC board terminals, a rainbow of colored lens cap choices and U.L. Listing.

05 Series Switches fit .625 square panel hole size; accept low cost T 1¾ wedge base lamp. Relamp from front panel. .25 Amp., 125 VAC rating. In addition, all these features are available in a compatible L.E.D. version complete with L.E.D. display lens.

05-6 Series Switches mount in a .750 square panel cutout. Use versatile front panel replaceable T 1¾ flange base lamp. Offered in .25 or 3 Amp versions, 125 VAC rating. Lens barriers are available.

We've got more to talk about too. Ask for full details, contact your local Licon Distributor, or call or write for our Switch Catalog: LICON, 6615 West Irving Park Road, Chicago, Illinois 60634. Phone (312) 282-4040 TWX: 910-221-0275.

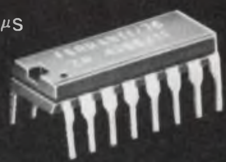
LICON
A DIVISION OF ILLINOIS TOOL WORKS INC.

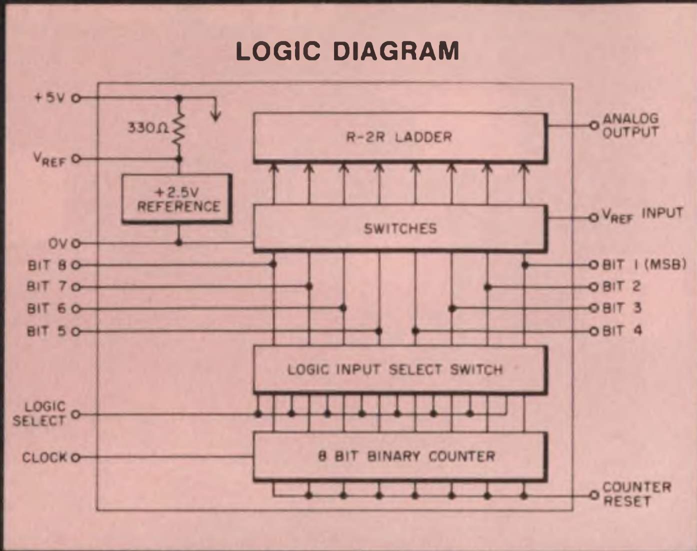
For Full Details CIRCLE NUMBER 219
To Have Salesman Call CIRCLE NUMBER 220

8 Bit A to D/D to A Converter— the first priced at only $4.50*

The Ferranti Model ZN425E—an 8 bit dual mode analog to digital/digital to analog converter features:

- Single chip monolithic construction
- Typical settling time 1.0 μs for 1 L.S.B. step
- 8 bit binary counter, R-2R ladder network and switches
- On-chip precision voltage reference
- Self-contained, precision ramp generator
- TTL and CMOS compatible





better by design

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*1000 piece price

FOR COMPLETE SPECIFICATIONS, CONTACT: FERRANTI ELECTRIC, INC. / SEMICONDUCTOR PRODUCTS EAST BETHPAGE ROAD, PLAINVIEW, NEW YORK 11803 PHONE: (516) 293-8383 / TWX: 510-224-6483

CIRCLE NUMBER 221

CLASSIC

Essex/Stancor transformers have that special quality, that classic quality.

From our miniature transistor transformers to our power transformers, we engineer them for performance and doublecheck them for dependability. And our products are available off-the-shelf from electronic distributors everywhere. For super performance at a basic cost, see your local distributor or write us for our free catalog: **Essex/Stancor,** 3501 W. Addison St., Chicago, IL 60618, 313 / 643-7400.

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CIRCLE NUMBER 222

Fast Relief
for digital troubleshooting headaches

Banish those troubleshooting headaches with signature analysis, the new technique from Hewlett-Packard that lets you troubleshoot microprocessor products right down to the faulty component. In production. In the field.

With signature analysis, that enormous floating inventory of expensive boards and modules moving in and out of service can be cut dramatically.

Signature analysis is positive. There is no hit or miss about it. Conceivably you could even eliminate the need to partition your product for modular service.

A simple concept.

The HP 5004A Signature Analyzer converts lengthy bit streams at any node in the circuit into short, four-digit, hexadecimal "signatures."

Just activate a digital exercise routine in the circuit under test and compare the bit stream signature at each data mode with the known good signatures previously written into your manual.

Digital signal tracing becomes as simple as analog tracing used to be. But more accurate. So accurate that it catches almost every possible fault, including many that can be detected in no other way. It once again becomes realistic to think of field or production troubleshooting to the component level by technicians.

Design it in or retrofit.

The savings in service costs and inventory are well worth the effort of designing with signature analysis in mind. In some cases, it could even pay you to "retrofit" by developing a signature manual for your existing equipment.

It's a fascinating—and very workable—concept. Amazingly the price of the HP 5004A Signature Analyzer that makes all this possible is a low $990*

To help you take advantage of this breakthrough we've prepared Application Note 222—"A Designer's Guide to Signature Analysis." It's yours for the asking. Just contact your nearest HP field sales office or write.

*Domestic U.S. price only.

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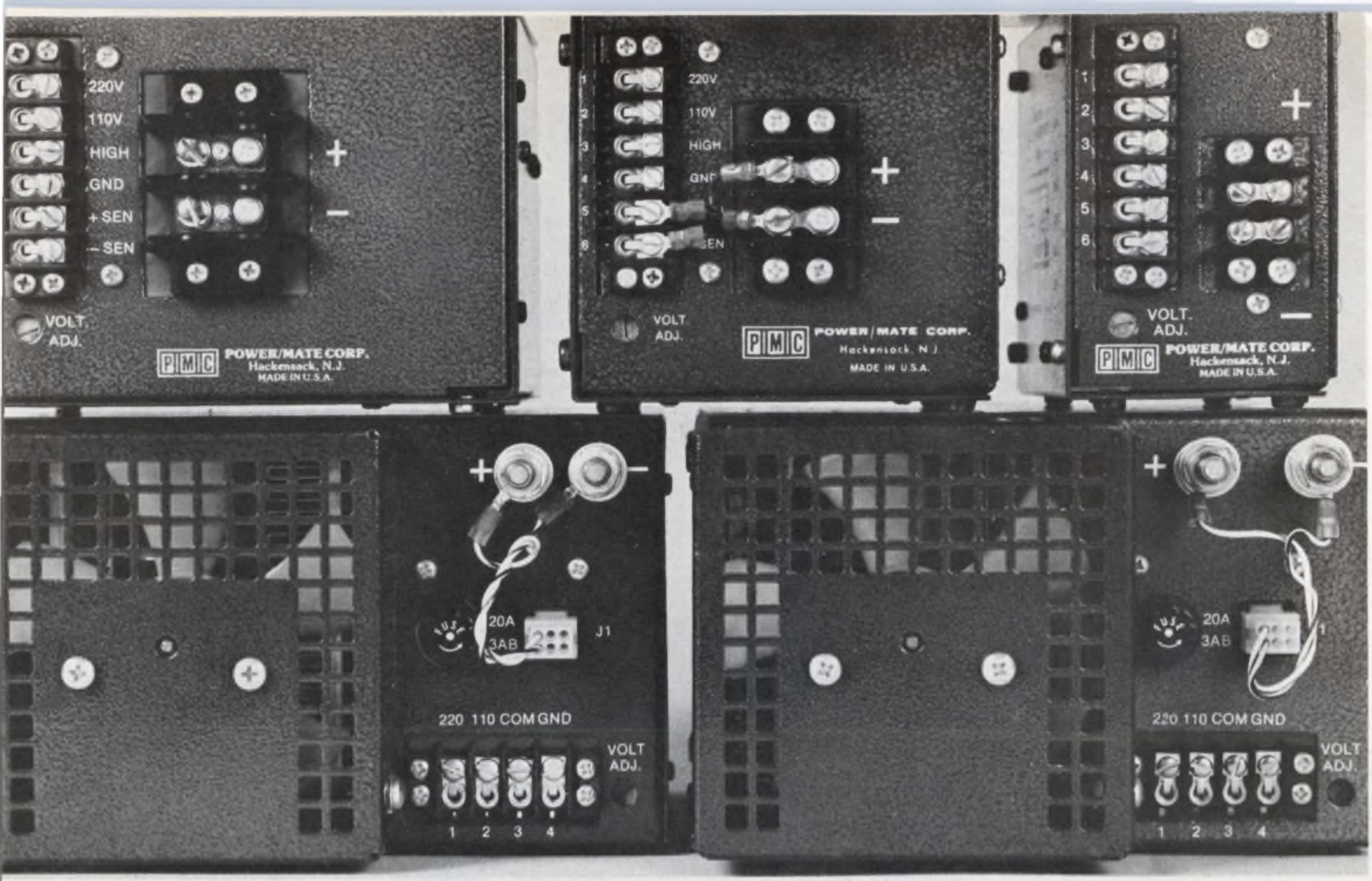
02813

For assistance call: Washington (301) 948-6370, Chicago (312) 255-9800, Atlanta (404) 955-1500, Los Angeles (213) 877-1282

CIRCLE NUMBER 62



With 87 different switching supplies to choose from, no wonder people are switching to Power/Mate.

But at Power-Mate we know it's not enough to offer you 87 different switching models in 10 different case sizes.

From 2 volts to 28.

In currents all the way up to 200 amps.

And we know it's not enough to build them to the highest quality standards in the industry.

Standards you've come to expect from Power-Mate.

When you need a switcher fast, your entire business could depend on ours.

So Power-Mate stocks all models for immediate delivery on every switching model we make from both our East and West Coast plants.

The same goes for our open frame, modular and miniature models, as well as our laboratory supplies.

Whether starting from scratch, updating your system, or in need of emergency service, it's good to keep Power-Mate's name and number in mind.

Because knowing where to get the switchers you want isn't much good, unless you can get them when you want them.

PMC

POWER/MATE CORP.

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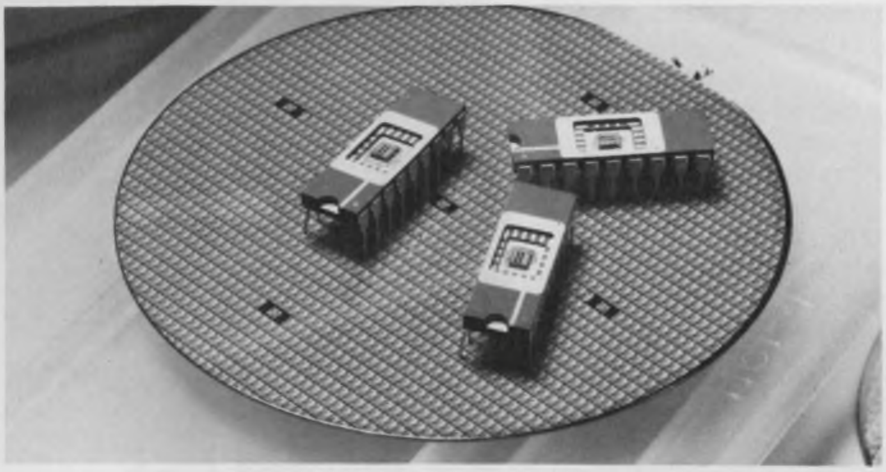
17942 Skypark Circle/Irvine, California 92714/(714) 957-1606/TWX (910) 595-1766

The world's largest supplier of quality power supplies.

CIRCLE NUMBER 73

New products

True 12-bit CMOS multiplying d/a converter is low-priced



Analog Devices Semiconductor, 829 Woburn St., Wilmington, MA 01887. Jeff Riskin (617) 935-5565. P&A: Stock; see text for price.

Twelve bits for twelve bucks is now available in the first monolithic CMOS multiplying d/a converter to have linearity consistent with its 12-bit resolution. The AD7541 from Analog Devices features a low power consumption (below 32 mW) and nonlinearity error (±0.01% of full-scale range at 25 C). In a plastic DIP, and an operating temperature range of 0 to 70 C, the AD7541 goes for $12 each in quantities of 1000 or more.

The reference-voltage input to the converter may be steady dc of either polarity, or ac of either constant or varying amplitude. This versatility encourages such applications as digitally programmed power supplies, digital-to-synchro converters and digitally controlled attenuators.

The AD7541 contains a precision thin-film R-2R ladder network and CMOS switches. The network is connected—inverted—to generate binary-weighted currents. Each switch sends its current to one of two output current-summing buses; this provides a "push-pull" output. Having both of these outputs available, as well as a reference input that accepts either polarity, permits four-quadrant multiplication to be done with a relatively simple circuit that uses two external operational amplifiers.

To maintain the AD7541's linearity, the voltages at the output terminals must be kept very close to ground. Op amps at the output(s) must be chosen for low bias current (less than 75 nA, or so) and low offset voltage (less than about 0.5 mV). The digital inputs, which are TTL and CMOS-compatible, are zener-protected, but still require typical CMOS design and handling precautions.

The AD7541 has no digital-input buffer register. Although this complicates microcomputer interfacing, it simplifies the converter, reduces its cost, and increases its versatility.

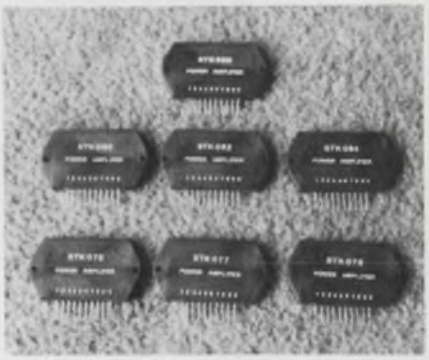
Two linearities are available: ±0.01% of full-scale as mentioned, and ±0.02% of full-scale, which costs less. Both are available in three temperature ranges: 0 to 70 C, −25 to +85 C, and −55 to +125 C. The first range is provided in a plastic DIP, while the latter two come in ceramic DIPs.

Linearity is affected slightly by temperature, and becomes ±0.012% and ±0.024% of full-scale over the rated temperature ranges.

Prices for the three temperature ranges, respectively, are $12, $16, and $49 for 0.01% linearity, and $11, $15 and $44 for 0.02%. In addition, the AD7541 is pin-compatible with its less-accurate predecessor, the AD7521, and all versions are in stock.

CIRCLE NO. 301

Hybrid IC audio amps deliver 25 and 90 W

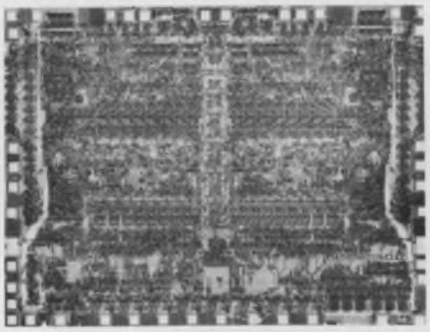


Sanyo Semiconductor, 1360 Roadrunner Terrace, Sunnyvale, CA 94087. Tsuyoshi Taira (408) 732-7902. P & A: See text.

The STK-075 hybrid IC audio amplifier delivers 15 W into 8 Ω or 25 W into 4 Ω at a cost of $4.80 (1000 quantity). The STK-086 delivers 70 W into 8 Ω and 90 W into 4 Ω at a cost of $16.00. The output has a specified, 0.3%, total harmonic distortion and a 20-Hz to 20-kHz frequency range. Since the device uses a dual power supply, it does not require a speaker coupling capacitor.

CIRCLE NO. 320

Multiprotocol chip formats data



Zilog, 10460 Bubb Rd., Cupertino, CA 95014. Jim Gibbons (408) 446-4666. $49 (plastic), $54 (ceramic); stock.

The single-chip Z80-SIO is a serial I/O controller that controls communications peripherals and formats data in data communication networks. The chip works with the interfaces of most 8 and 16-bit processors and supports the "daisy-chain" interrupt structure of the Z80 CPU. Each of the SIO's full-duplex channels has four control lines for most commonly used modems. For systems with 2.5-MHz CPU clock rate, the SIO's data rate goes up to 550 kbits/s, while in a 4-MHz system, it is up to 880 kbits.

CIRCLE NO. 321

AMP component sockets are sealed with silicone rubber. And can be inserted at up to 7,000 an hour.

You can't beat that.

AMP component sockets. They're the ones that come in strip form. You can insert them at high speed and cut your costs. Use a bench press or, for really fast loading, a N/C machine. AMP can furnish the applicator and interface module for compatibility with most N/C machines.

And AMP keeps your product out of trouble by sealing its component sockets with silicone rubber. Which ends solder flux contamination and solder flooding.

Of course, they provide easy pluggability with either rectangular integrated circuit leads or .016 inch-.019 inch diameter leads. Their small head diameters permit .100 inch center-to-center mounting. Our sockets help you save on board costs too, as they seat securely in wide tolerance holes.

For more data on AMP component sockets, ask your AMP Sales Engineer. He's ready to help you in any way possible.
Or write or call AMP Incorporated,
Harrisburg, PA 17105.
(717) 564-0100.

AMP has a better way.

**SEE US AT
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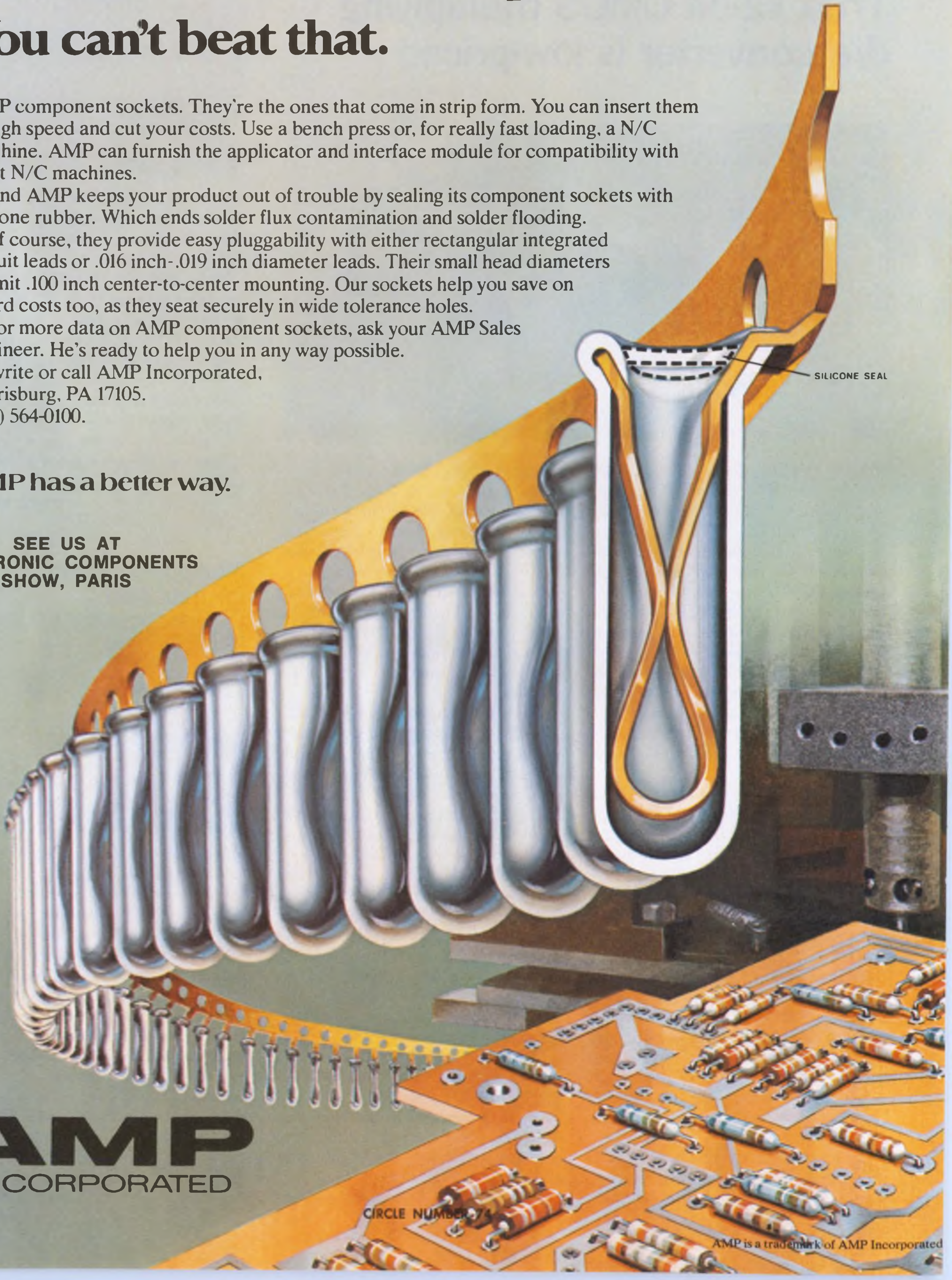


AMP
INCORPORATED

CIRCLE NUMBER 74

200-A transistor turns on/off in 0.5 μs

Westinghouse Semiconductor, Youngwood, PA 15697. (412) 925-7272. $200; 10 to 12 wks.

The D60T is a high-current, high-voltage and fast-switching transistor with turn-on and turn-off times of less than 0.5 μs. Rated at 200 A peak, 450 to 550 V, the transistor has a gain of 10 at 50 A.

CIRCLE NO. 310

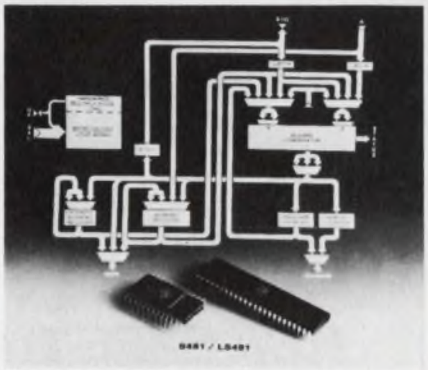
High-power SCRs operate at 150 C

International Rectifier, 233 Kansas St., El Segundo, CA 90245. (213) 322-3331. $44.85 to $87.65 (100 qty); stock to 4 wks.

The 325PAH series of high-power SCRs are for 150-C operation and have a nominal rms current rating of 510 A. The average current level is 325 A. Peak-reverse voltages are from 500 to 1200 V. The SCRs have a junction operating temperature range of −40 to +150 C and a maximum internal thermal resistance, junction to case, of 0.085 C/W. Packaged in a 1.6-in. diameter "hockey puck."

CIRCLE NO. 322

4-bit-slice processors operate at high speed

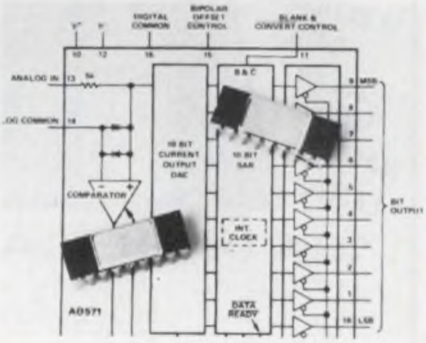


Texas Instruments, P.O. Box 5012, M/S 308 (Attn: S481), Dallas, TX 75222. Rex Meek (713) 491-5115. $29.25; stock.

The S481 set of 4-bit-slice processors can select and operate on two operands, generate status and store results in a single 100-ns cycle. The chips provide built-in computational algorithms for automatically sequenced iterative, signed or unsigned multiplies and divides and cyclical-redundancy character calculations. The chip set consists of LS/481s, 54S/74S482 4-bit-slice controllers and either the 54S/74S330 or S331 field-programmable logic arrays.

CIRCLE NO. 323

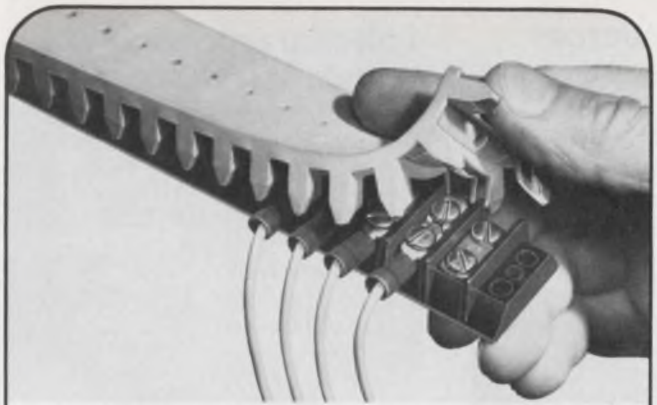
A/d chip mixes linear and digital



Analog Devices, 829 Woburn St., Wilmington, MA 01887. Jeff Riskin (617) 935-5565. $24 to $60; stock.

The AD571 10-bit monolithic a/d converter combines linear and digital circuitry on a single IC chip. The device is a successive-approximation converter and includes a d/a, voltage reference, clock, comparator, successive-approximation register and output buffer on a 120 × 150-mil chip. A complete conversion to 10-bit accuracy is executed in 25 μs.

CIRCLE NO. 324



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CIRCLE NUMBER 75

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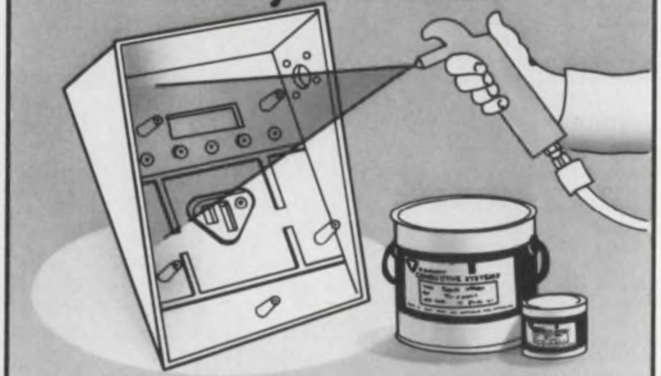

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CIRCLE NUMBER 242

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CIRCLE NUMBER 243

200 MHz DC-Coupled Wideband Amplifier

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- **2.5 V/nsec slew rate**
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- **±0.1% integral linearity**
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LeCroy Research Systems, leading supplier of fast electronics for particle physics research, now offers its unrivaled expertise in high-speed circuits to other original equipment manufacturers. The Model VV100B Wideband Amplifier, offering excellent linearity, speed, stability, and noise characteristics, is just a sample of LeCroy's creative technology and experience.

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CIRCLE NUMBER 244

HV rectifiers have 2-μs or 250-ns recovery

High Voltage Devices, 7485 Avenue 304, Visalia, CA 93277. Ken Corsetti (209) 733-3870. $6.90 to $23.93 (100 qty); 1 to 4 wks.

The KXS and KX Powerstack series of medium (2 μs) and fast (250 ns) recovery high-voltage, high-current silicon rectifiers are mini-sized. The body is 0.39 in. long with a max diameter of 0.515 in. Peak inverse voltages are 1.5 to 10 kV with average rectified currents at 50 C of 3, 2.2 and 1.5 A depending on PIV. Max reverse leakage is 1 μA at 25 C and 25 μA at 100 C. Forward surge current ratings are up to 200 A for 8.3 ms.

CIRCLE NO. 325

Controller gives memory transfer of 2 Mbytes/s

Advanced Micro Devices, 901 Thompson Pl., Sunnyvale, CA 94086. E. Sopkin (408) 732-2400. $18.25 (100 qty); stock.

The Am9517 controller has memory-transfer speeds up to 2 Mbytes/s. Four independent channels are available and these can be increased through cascading. Three transfer modes are provided: single word, demand and block. The device is available in molded and ceramic hermetic DIPs.

CIRCLE NO. 326

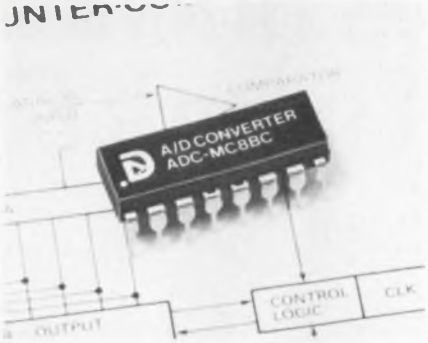
MOS memory is fully static

Motorola, 3501 Ed Bluestein Blvd., Austin, TX 78721. (512) 928-2600. (100 to 999 qty) from $12.25, stock.

The MCM2114 MOS memory is a 1024 × 4-bit static RAM that requires no clocks, no timing strobes, nor refreshing because of fully static operation. Data-out and data-in are of the same polarity and no address set-up time is required. Four speed ranges are offered: 200, 250, 300 and 450 ns. Two power versions are the MCM2114 at 550 mW and the MCM21L14 at 385 W. Two 18-pin packages are available; plastic and lid-seal ceramic.

CIRCLE NO. 327

Converter can be used a/d or d/a



Datel Systems, 1020 Turnpike St., Canton, MA 02021. Eugene Murphy (617) 828-8000. $8 to $14; stock.

The ADC-MC8B is an 8-bit multifunction d/a converter that can be configured as an a/d, using the internal binary counter and two external ICs. The converter is available in temperature ranges of 0 to 70 C and −55 to 125 C. The device consists of eight current switches, a diffused-resistor ladder network, a precision reference, an 8-bit binary counter and a logic input-select switch. Output settling time is 2 μs for a full-scale change. Using the device as a counter-comparator a/d gives a converson time of 500 μs. 14-pin plastic DIP.

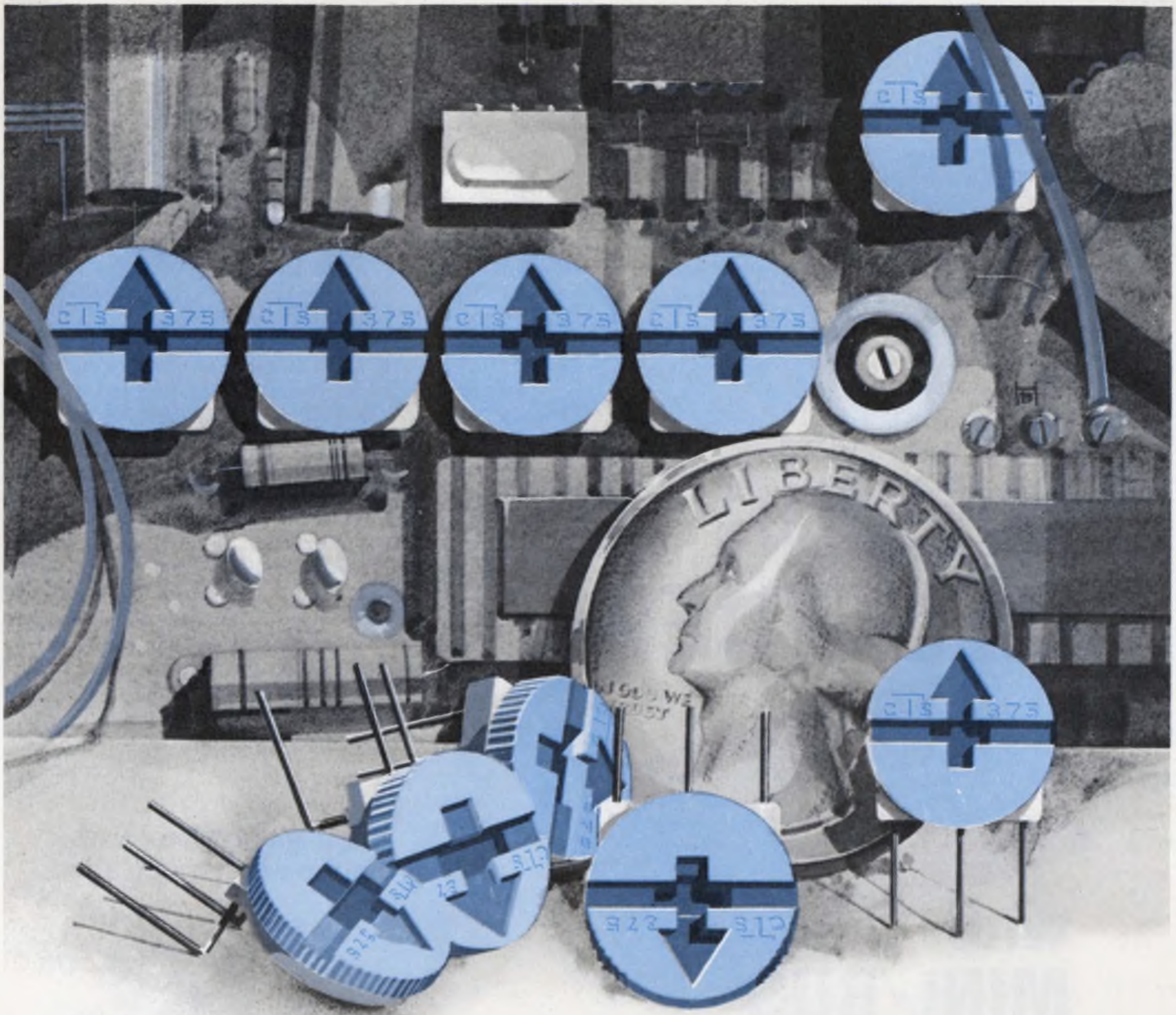
CIRCLE NO. 329

Rectifiers supply up to 16 kV

Solid State Devices, 14830 Valley View Ave., La Mirada, CA 90638. Dee Peden (213) 921-9660. $0.66 to $7.29 (100 qty); stock to 4 wks.

Two types of high-voltage rectifiers combine high peak-reverse voltage and moderate current characteristics. An axial-lead series, 1N2372 through 1N2385, has PRVs from 420 V to 10 kV with average rectified currents from 250 mA to 70 mA. Forward voltage drops, at 100 mA, range from 3 V for the 420-V units to 39 V for the 10-kV units. Case dimensions are from 0.5 × 0.363-in. diameter up to 2 × 0.5 in. The ferrule series, 1N1133 through 1N1149, has PRVs from 1.5 kV at 100 mA to 16 kV at 45 mA. Forward drops are 7.5 to 60 V at rated current. The 0.5625-in. diameter cases go from 1.813 to 6.025-in. long.

CIRCLE NO. 328



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Fantastic! Small 3/8" dia. (10mm), great performance and CTS reliability are only three reasons you should use our NEW series 375 single turn cermet trimmers. The low 25¢ price tag is still another.

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And the serrated adjustment knob doubles as a dust cover to protect the element from dirt, oil and other contaminants. It's a lot for so little. But you expect that from a company that's put millions into electronics for industry. For complete information, write **CTS OF WEST LIBERTY, INC.**, 6800 County Road 189, West Liberty, Ohio 43357 or phone (513) 465-3030.

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CIRCLE NUMBER 78

ICs & SEMICONDUCTORS

Complex-sound generator is I^2L linear IC

Texas Instruments, P.O. Box 84, M/S 812, Sherman, TX 75090. Lowell Chambers (214) 893-5166. $1.65 (100 qty); stock.

The SN76477N is a complex-sound generator that can be used to generate the sound of a siren, gun-shot, jet engine, whistle, pin-ball and others. Since it is an I^2L linear IC with low-power consumption, it is suited for battery powered devices. The IC contains a voltage-controlled oscillator, super-low-frequency oscillator, white-noise generator, noise filter, one shot, mixer and an attack/decay envelope generator. The desired sound is externally programmed through logic and analog inputs. The device is housed in a 28-pin plastic DIP.

CIRCLE NO. 330

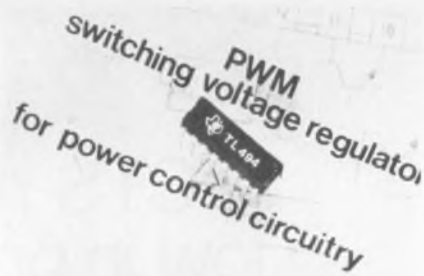
Power transistors handle up to 10 A and 300 V

TRW Power Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260. John Power (213) 679-4561. $14.20 to $45.00 (100 qty); 4 to 8 wks.

The SVT300-3, 300-5 and 300-10 are npn power-switching transistors that feature a minimum dc current gain of 15 at currents of 3, 5 and 10 A. Max collector voltage is 300 V. At 25 C, the SVT300-3 dissipates 116 W; the SVT300-5 and SVT300-10, 146 W. Operating and storage temperature is −65 to +200 C. The transistors are available in TO-3 or TO-61 isolated packages and can be made to meet JAN and JAN-TX military specs.

CIRCLE NO. 331

Voltage regulator uses pulse-width modulation



Texas Instruments, P.O. Box 5012, M/S 308 (Attn: TL494), Dallas, TX 75222. Dale Pippenger (214) 238-5908. $2.88 (plastic), $3.31 (ceramic); stock.

The TL494 is a switching voltage-regulator IC that provides all the functions required for pulse-width modulation (PWM) control circuits. The chip contains a 5-V regulator, error amplifier, current-limit amplifier, adjustable oscillator, dead-time-control comparator, pulse-steering flip-flop and output-control circuitry. Uncommitted output transistors may be operated as common-collector or common-emitter. The trigger for the pulse-steering flip-flop is derived from the PWM circuit to prevent double pulsing of either output.

CIRCLE NO. 332

Speed total harmonic distortion measurements.

With HP's newest distortion analyzer.

Automatic frequency nulling and auto set level features of the 339A Distortion Measurement Set speed your total harmonic distortion measurements (THD). And true-rms detection means accurate measurements as low as 0.0018% (−95 dB) from 10 Hz to 110 kHz. Whether you're testing signal sources or amplifiers, here's how the 339A, priced at $1,900*, can help you make quick and precise measurements.

Speed your set-up. Just select the frequency of the built-in oscillator and the 339A's "turn signal" indicators show you how to make the proper input range setting. This means you have a low-distortion source for testing high-performance amplifiers and you tune one instrument instead of two. If you're using an external source, "turn signal" indicators show you which direction to turn frequency controls for quick manual nulling.

Save test time. The 339A's auto set level feature automatically sets the 100% reference level, within a 10 dB capture range, every time you change frequency or level. Again, visual indicators show you which way to turn the input range switch if your signal is outside of the capture range. You not only save time, you also minimize operator errors.

Standard features even make the 339A suitable for checking broadcast equipment for FCC compliance. And for measuring frequency response, you can quickly read relative measurements in either percentage or dB.

Contact your local HP field engineer for further details.

* Domestic U.S.A. price only

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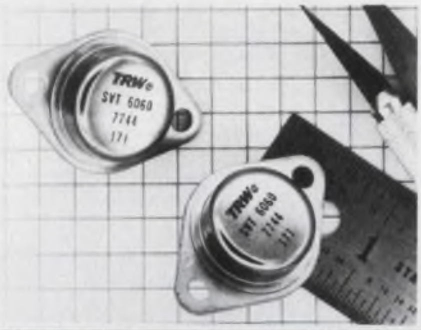
098/41

CIRCLE NUMBER 80

Darlingtons can sustain 400 V when switching



TRW Power Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260. (213) 679-4561. $5 to $6 (100 qty); 4 to 8 wks.

A series of monolithic Darlington transistors, for motor controls and switching power supplies can sustain 400 V. With a rise time of 0.4 μs and a fall time of 1 μs, the devices are suited for high-speed switching circuits (10 kHz). Three transistors, SVT 6060, 6061 and 6062, have a dc current gain of 30 at 15 A and a peak collector current of 25 A. Junction-temperature range is −50 to +150 C.

CIRCLE NO. 333

Dynamic RAM suits low-cost uses

Motorola, 3501 Ed Bluestein Blvd., Austin, TX 78721 (512) 928-2600. From $5.75 (100 qty); stock.

The MCM4096 is a 4 k × 1-bit dynamic RAM. All inputs are TTL compatible and the output is three-state TTL compatible. Each of the 64 row addresses requires a memory cycle every 2 ms to refresh the RAM. Max power dissipation is 445 mW in the active mode and 19 mW for standby. Three speeds are available: 250, 300 and 350 ns (max access time). Package types are 16-pin ceramic or frit-seal ceramic.

CIRCLE NO. 334

32-k ROM for M6800 bus is fully static

Motorola, 3501 Ed Bluestein Blvd., Austin, TX 78721. (512) 928-2600. $13.10 (plastic, 250 qty).

The MCM68A332 is a 32,768-bit programmable ROM that is fully static and can be used with bus-oriented systems such as the M6800 or other 8-bit microprocessors. The memory uses a single 5-V supply, dissipates less than 440 mW with an access time and cycle time of 360 ns. The 24-pin package is available in either plastic (P suffix) or ceramic (L suffix).

CIRCLE NO. 335

SCRs have grounded cathodes

Texas Instruments, P.O. Box 5012, M/S 308 (Attn: TIC101/102), Dallas, TX 75222. Keith Renard (214) 238-3041. $0.26 to $0.57 (1000 qty); stock.

The TIC101/TIC102 series of grounded-cathode SCRs are pnpn silicon reverse-blocking triode thyristors with the cathode in electrical contact with the mounting tab. Electrical insulation of the SCR tab is thereby eliminated. Repetitive peak off-state voltages and repetitive peak reverse voltages range from 30 to 600 V. Surge on-state current is to 30 A with up to 600-V capability. Continuous on-state current at or below 80-C case temperature is 5 A dc.

CIRCLE NO. 336

BergLance™ Wire-Wrapping Posts give a classic performance on the Lowrey Organ.

The BergLance System assures rapid staking of miniature thru-lugs for solid or stranded wire terminations. It's an approach that offers high quality and reliability . . . and is economical, too.

Lowrey likes it, and has used millions of BergLance posts throughout the past decade. Lowrey has found it can rely on Berg Electronics . . . to supply the product and the application machines that precisely meet its interconnection needs.

Berg is experienced. We read interconnection needs like Lowrey reads music. We have the products, the background and the back-up to do the job. Your job. Let's work on it, together. Berg Electronics, Division, E. I. du Pont de Nemours & Co., New Cumberland, Pa. 17070—Phone (717) 938-6711.

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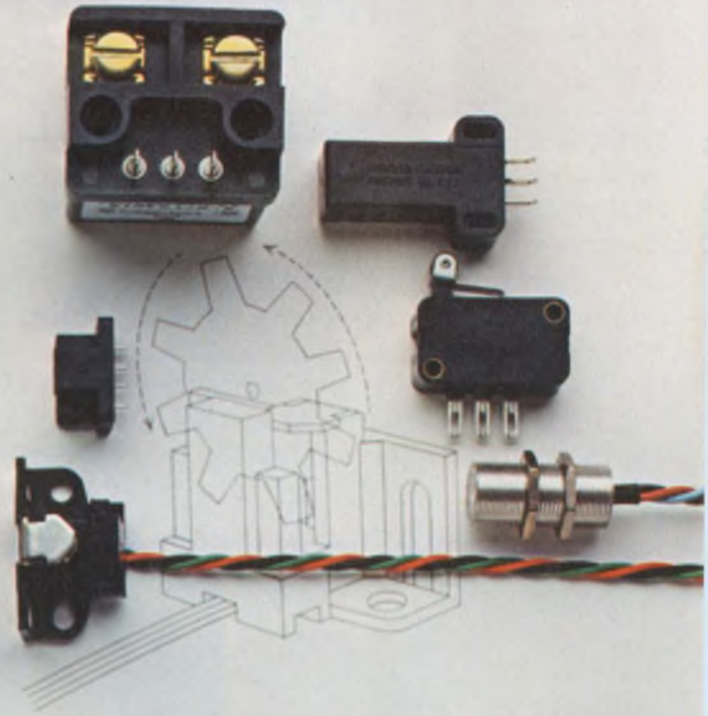
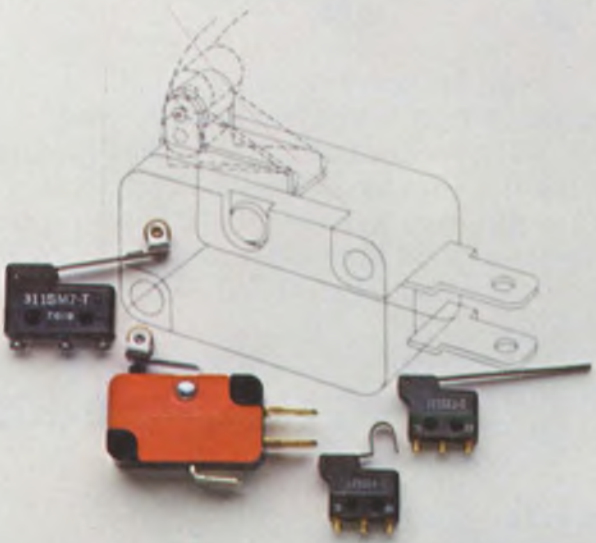
CIRCLE NUMBER 82

We serve special interests—yours!

Some of these components will probably never The others will just come close.

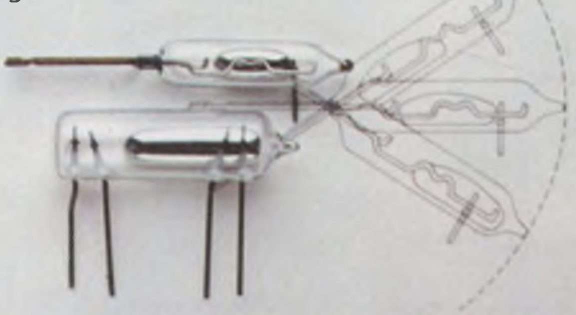
The SR, XL, XK and AV are solid state position sensors featuring almost infinite life. All offer zero speed operation with some up to 100 Khz. ES current sensor utilizes Hall-effect IC and protects against damage from short circuits or overcurrent conditions.

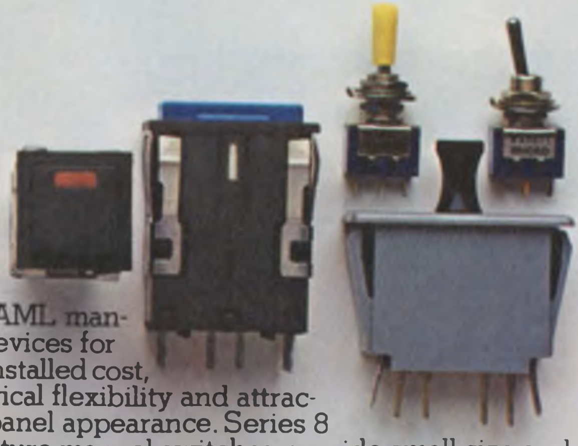




Snap-action V3, SM and SX switches offer wide variety of actuators, electrical capacity and termination.

Mercury switches offer hermetic sealing, a variety of electrical capacity and broad temperature ranges at a low cost.

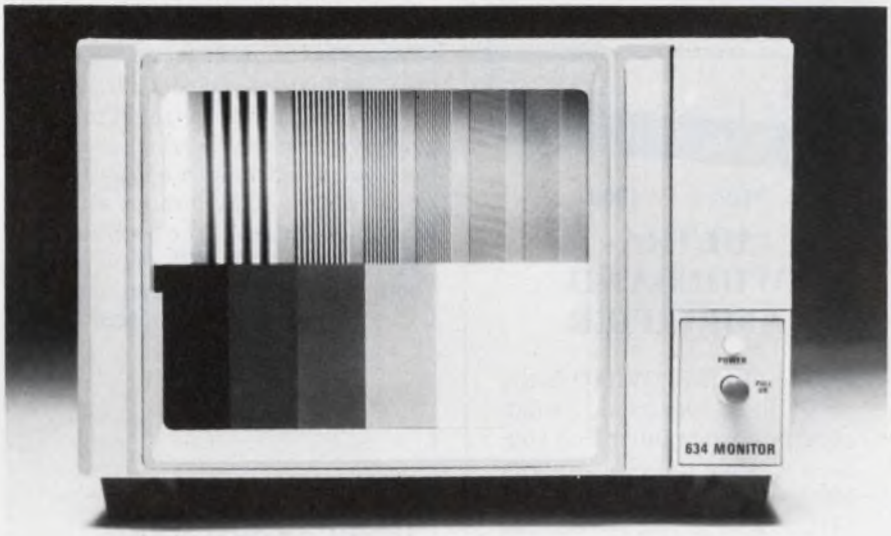




AML manual devices for low installed cost, electrical flexibility and attractive panel appearance. Series 8 miniature manual switches provide small size and wide variety of operators. DM offers inexpensive snap-in panel mount design.

Solid state keyboards provide high reliability no mechanical keyboard can offer. Panel sealed versions also available.

Video monitor takes the lead in resolution and distortion



Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077. Bob Down. (503) 644-0161. P&A: See text.

Need high resolution, low distortion and uniform brightness in a video display? You can get the best of all three in the Tektronix 634, a 10 × 12-cm, flat-screen monitor.

Resolution is guaranteed to be 1100 lines minimum at a brightness of 100 candelas/m^2 (30 footlamberts). Distortion stays under ±0.5%—without calibration—over a 9-cm circle at the center of the screen, and it remains below 1% elsewhere. And brightness doesn't vary more than 20% over the entire screen.

The best resolution until now was about 800 lines with the Conrac VF-02, a popular 10 × 12-cm display. But even that resolution isn't guaranteed, nor is the VF-02's brightness variation specified. However, the VF-02's distortion is adjustable to 0.5 to 1%.

The maximum brightness of both competing displays is over 150 ft-L.

Tektronix measures the 634's worst-case resolution of 1100 lines—the nominal value is 1400 lines—with the shrinking-raster method at a 60% modulation index. At a 90% index, resolution falls to 840 lines, nominal, and 660 lines, worst case. Distortion is measured with a superimposed, transparent linearity chart, and brightness is read at the center and four corners of the chart by Tek's J-16 photometer.

With the 634's improved performance, the black-and-white range is so wide, you get better gray-scale images than ever before. Moreover, you don't need any calibration time for accurate on-screen image measurements. Also, you get more uniform reproduction of equivalent gray shades over the screen area.

With the Tek unit's modular construction, the various controls for contrast, focus and brightness can be connected at the 634's top or side, or elsewhere in your equipment arrangement. Or functions can be controlled remotely via an optional connector.

The 634 operates from a standard 110 or 220-V line, but unregulated dc operation (21 to 25 V, −21 to −25 V, 8 to 10 V) is available optionally.

The 634 goes for $1125 (just about a buck a line). If resolution isn't important, you can get a 650-line unit for $900. Either way, delivery takes 12 weeks.

Tektronix **CIRCLE NO. 302**
Conrac **CIRCLE NO. 303**

Pulse generator has true/complement outputs

Dytech, 2725 Lafayette St., Santa Clara, CA 95050. (408) 241-4333. $385; stock to 4 wks.

The Model 801 pulse generator provides true and complementary outputs with amplitude control from 0 to +10 V. Rise and fall times are 5 ns or less while delays of from 50 ns to 1 s are available. The unit accepts external triggering as well as internal automatic and manual modes and produces pulse-pair bursts over the entire delay range. A single-cycle switch also generates any fixed number of pulses of any pulse width for any duration within the min-max ranges of the generator. The unit accepts DTL, TTL or ac input at both the external and gate inputs.

CIRCLE NO. 337

Tester locates shorts in multilayer PC boards

Idlewild Associates, Box 41, McMinnville, OR 97128. Larry Lockwood (503) 472-6605. $275; stock to 2 wks.

A fault finder, called Model 911 Short Sniffer, locates shorted runs buried in multilayer circuit boards. The instrument enables technicians to locate and patch around defective runs and acts as a diagnostic tool to aid in circuit-board failure analysis. The device indicates the direction of shorted conductors as well as pinpointing the location of the short. Indication is by audible clicks that increase in frequency as the short is approached. Meter indication is also provided.

CIRCLE NO. 338

Thrifty function gen spans 0.1 Hz to 1 MHz

B&K Precision, 6460 W.Cortland Ave., Chicago, IL 60635. (312) 889-9087. $175; stock.

Model 3010 function generator spans 0.1 Hz to 1 MHz in six ranges, with each range providing linear 100:1 frequency control. The unit generates sine, square, TTL square and triangle waveforms. Frequency generation is by a stable voltage-controlled oscillator (VCO) that can be varied on each range by a front-panel control or the VCO external input. If a 0-to-5.5-V ramp is applied to the VCO, the unit will provide a 100:1 output frequency change. With an audio signal in place of the ramp, the unit will produce a direct FM output. Variable-output, square-wave rise or fall time is 100 ns; TTL square-wave rise/fall time is 25 ns.

CIRCLE NO. 339

Word generator delivers up to 50 MHz

Tau Tron, 11 Esquire Rd., North Billerica, MA 01862. Jim Hanley (617) 667-3874. $4400; 6 to 8 wks.

Model MG-3 programmable word generator module has speeds up to 50 MHz. The device contains 1024 bits of RAM, programmable from front-panel controls or via an optional remote bus. The bits are arranged in a matrix of 128 words by 8 bits. An auxiliary ninth channel is used as an additional data channel or auxiliary sync channel. Data outputs may be in either 8-bit parallel or serial, RZ or NRZ-selectable. The output word or bit length in either mode is controllable in integer steps.

CIRCLE NO. 340

Introducing the Incredible DATALOGGER 2000

. . . an easy-to-operate . . . simple to understand . . .

DATA INFORMATION CENTER

that speaks your language!

It's incredible but . . . the Datalogger 2000 can measure 4 parameters that you've chosen . . . offer 2000 internal alarms . . . manage your data collection and report it in your language . . . and still remain 'pushbutton-simple' to operate.

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  Combine up to 4 of the 38 field interchangeable signal conditioning modules for measuring:
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  AC Voltage, True RMS
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- **Up to 20 channels internal—expandable to 1000.**
- **±25,000 count display (4¾ digits) of measured data.**
- **Alphanumeric printout.**
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- **Pushbutton programming.**

And these options can make your DATA INFORMATION CENTER even more versatile!

- **Internal alarms**
  Up to 2000 individual set-points.
  4-level limits assignable per channel.
- **English messages**
  6-character message assignable to each limit which eliminates the need for translation codes and look-up tables.
- **Data outputs**
  Isolated BCD.
  Isolated RS-232-C, TTY compatible, with selectable baud rates from 110 to 9600.

From the leaders in data acquisition, the Datalogger 2000 delivers all the traditional Digitec qualities—premium components, designer styling and reliable performance.

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FOR INFORMATION CIRCLE 84

FOR DEMONSTRATION ONLY CIRCLE 85

IC thermal resistance checked in 7 seconds

Sage Enterprises, 1080 Linda Vista Ave., Mountain View, CA 94043. B. Siegal (415) 969-5111. $5600; 8 wks.

The thermal resistance of ICs can be measured quickly (in accordance with MIL-STD-833A Method 1012) with the THETA 400. Using the forward-biased substrate-isolation-diode junction voltage as the temperature-sensitive parameter, the instrument applies a repetitive pulse that heats the test device. Sensing the change in isolation junction voltage, the device automatically divides the change by the applied heating power to produce a direct full-scale reading of 199.9 C/W. Accuracy of 6% max is made possible by the use of multiwire Kelvin contacts.

CIRCLE NO. 341

8-digit freq counter sells for $135

Continental Specialties, 44 Kendall St., New Haven, CT 06509. (203) 624-3103. $134.95.

The MAX-100 frequency counter operates from 20 Hz to 100 MHz and reads out on an 8-digit display. The crystal-controlled time base offers 3-ppm accuracy and the counter updates every second. The input is preamplified to work with 30 mV of signal and is diode protected up to 200 V. The display has a 0.6-in. digit height. No range switch is necessary since the least significant digit always represents 1 Hz. The unit can be operated on internal rechargeable batteries or from wall power using a charger.

CIRCLE NO. 342

How fast can you accurately measure period or frequency of this wave form?

The old way.

(About 5 minutes)

1. Find a scope and voltmeter.
2. Connect signal to scope.
3. Determine proper trigger points.
4. Connect signal to counter.
5. Select period or frequency function.
6. Select time base.
7. Set input voltage range.
8. Set input coupling to DC.
9. Connect voltmeter to trigger level output – if counter has output. (If not, good luck.)
10. Set desired trigger level.

The easy way.

(About 5 seconds)

1. Connect signal to Racal-Dana 9000 counter.
2. Push P or FA button.
3. Push TL button.
4. Push AU button.

The rest is automatic.

Now it's up to you.

You can continue to struggle along the old way. Or you can find out about the Racal-Dana 9000 Microprocessing Timer/Counter. The patented Auto-Trigger capability makes it the fastest and most accurate instrument in the world for the precision measurement of wave forms. Give us a call and we'll tell you how Racal-Dana systems technology can solve all your measurement problems the easy way.

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FOR PRODUCT INFORMATION CIRCLE 88 FOR LITERATURE ONLY 89

Featherweight Miniature Panel Mount Thermal Printer

DPP-7 QUICK SPECS

Printing Rate:
3 lines per second

Inputs
Full parallel BCD
TTL logic inputs, selectable positive or negative true

Printouts:
Six digits and sign, 99±9999, ±999999 or 9±99999
(Hexadecimal optional)

Input Storage
BCD data must be valid only 1.5 microseconds during print command

Data Capacity
9000 lines on 150 foot x 1.75 inch (44.5mm x 45m) thermal paper rolls

Power Supply:
Choice of: +5VDC, or 100, 115 or 230VAC, 47 to 440 Hz

Size Case:
4.50" wide x 2.72" high
(115mm x 69mm)

Depth:
5V Models
6.2" (158mm)
28V, 12V or
AC Models: 8.7"
(221mm)

New! Datel's Model DPP-Q7
Whisper Quiet
5 Lines/sec.
$495

COVERED BY
GSA CONTRACT
NO. GS-00S-27959

Datel's new model DPP-7 Digital Panel Printer uses only 2 moving parts for OEM reliability. At only 2.3 Lbs, (1,1Kg) it is one of the lightest panel-mounting recording instruments available.

Includes all electronics.
The $475* single quantity price includes everything required for full parallel BCD/TTL data inputs *plus* an input storage register for multiplexed bus applications *plus* an AC power supply! There are no extra boards to design or bulky cables and power supplies needed. The DPP-7 is ready to use.

Thermal printing means no messy inks, banging hammers or twirling print-wheels. Nothing to jam or run out of ink.

Use the miniature DPP-7 for simple data logging systems, automatic test fixtures or with a digital panel meter for accurate unattended data measurement.

The **small size** of the DPP-7 makes it ideal for panel-mounting in analytical instruments and compact data systems. Up to six digits and sign may be printed to identify channel number and data.

The DPP-7 uses +5VDC power in a very short 6.2" (158mm) deep version or 100, 115 or 230 VAC power in an 8.7" (221mm) deep version.

*U.S.A. domestic price only

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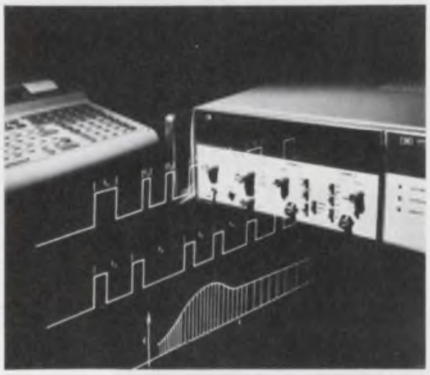
TEL. (617) 828-8000 / TWX: 710-348-0135
- Santa Ana, CA (714) 835-2751
- LA Exchange (213) 933-7256
- Sunnyvale, CA (408) 733-2424
- Gaithersburg, MD (301) 840-9490
- Houston, TX (713) 932-1130, 1132
- Irving, TX (214) 256-4444
- Tokyo, Japan 793-1031; Osaka, Japan (06) 354-2025 • Andover, UK (0264) 51055 • Paris, Fr. 620-06-74
- Muenchen, W. Ger. (089) 776095

Send for your FREE Brochure

CIRCLE NUMBER 247

Data aquisition system measures time intervals



Hewlett-Packard, 1507 Page Mill Rd., Palo Alto, CA 94304. Larry Shergalis (415) 493-1501. $17,500; 12 wks.

The Model 5391A is a compact data acquisition system capable of high-speed, high-volume measurements of time interval and frequency. Measurements of successive pulse widths or periods as short as 2 ns can be made at rates over 50,000/s. The system measures frequency from 50 μHz to 500 MHz or intervals from 2 ns to 20,000 s in either of two input channels. Up to 8 kbytes of measurement data can be acquired and temporarily stored in the plug-in memory per run. By pressing a single key on the Computing Controller keyboard, all of the specified measurements are automatically made and stored. Pressing another key causes previously-specified statistical analyses to be performed.

CIRCLE NO. 343

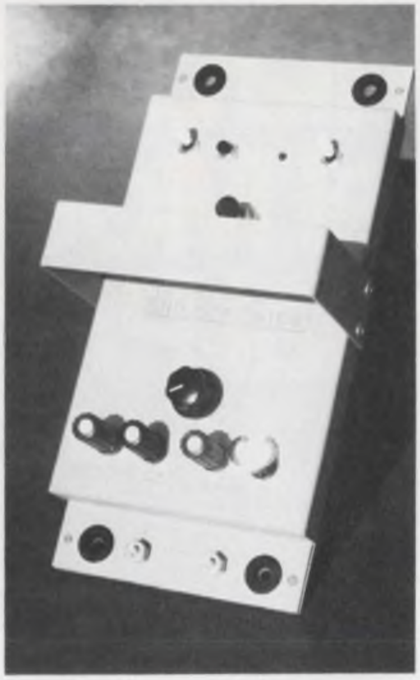
Triggered scope has 20-MHz bandwidth

Leader Instruments, 151 Dupont St., Plainview, NY 11803. Pat Redko (516) 822-9300. $500.

The LBO-507 oscilloscope has automatic-triggered circuitry and a 20-MHz bandwidth. Pushbutton switches select all functions. Vertical sensitivity is 10 mV/cm, and calibration is in 11 steps, up to 50 V/cm, with variable control. Rise time is 17.5 ns. Sweep speed ranges from 0.5 μs/cm to 500 ms/cm in 18 steps. Magnification of ×5 delivers 100 ns/cm maximum speed. The unit has a 5-in. CRT with an 8 × 10 effective area.

CIRCLE NO. 344

Transient detector holds spikes



Industrionics, 115 Pleasant St., Millis, MA 02054. Joe Hersey (617) 376-8147. $125; stock.

The Zap-Trap is a portable battery-operated transient voltage detector that senses and holds voltage spikes for up to 30 minutes with only 10% decay. If necessary, the unit can be operated unattended, with connection made to any dc meter on the 10-V scale. Pulse widths ranging from 2 μs to 1.1 ms in both positive and negative directions can be sensed. Voltage range is from 10 to 1000 V, but a special adaptor allows you to detect pulses up to 10 kV. The instrument mounts directly on two 12-V #1463 batteries, or can be powered by 16 C-cells mounted in an optional carrier.

CIRCLE NO. 345

Freq synthesizer spans 20 to 160 MHz

Syntest, 169 Millham St., Marlboro, MA 01752. (617) 481-7827. $699; stock to 4 wks.

The SI-160 is a 5-digit frequency synthesizer that provides ECL signals into a 50-Ω load over the range of 20 to 160 MHz with a resolution of 1 kHz. Temperature stability is ±1 ppm from 0 to 50 C. Options include external BCD programming with latching for computer control, sine-wave output at 13 dBm into a 50-Ω load and a standard RETMA 19-in. rack-mounting adapter.

CIRCLE NO. 346

Audio gen and monitor checks received signals

International Data Sciences, 100 Nashua St., Providence, RI 02904. (401) 274-5100. $810; 4 wks.

The Model 8508 audio generator and monitor allows the operator to listen to and measure received analog signals appearing at a modem-telephone line interface. The instrument generates a 1-kHz tone, variable from 0 to −16 dBm, patched into a telephone line. The monitor portion has an audio speaker and a dBm meter to monitor and measure line signals from −20 to +3 dBm. The input signals may be amplified to a level up to 50 dB.

CIRCLE NO. 347

Logic tester checks general-purpose ICs

E.I.S., 1617 E. 17 St., Santa Ana, CA 92701. Hal Horrocks (714) 541-0445. $2495; 4 wks.

The Model 500 Functional Logic Tester is a general-purpose IC logic tester that can be used by non-technical personnel. The instrument can be operated manually, testing one device at a time, or can be connected to an automatic handler since it contains built-in interface and control circuitry. Three internal test frequencies are 100 Hz, 250 kHz and 500 kHz. Also available is one external test frequency ranging from 50 kHz to 6 MHz. There is a selection switch for either TTL or CMOS devices. IC packages of 6, 8, 14, 16 and 18 pins can be handled.

CIRCLE NO. 348

New, 16 Bit Microcircuit D/A Converter

Datel has it...

Two versions to choose from:

DAC-HP16BMC
- 16 Bit Binary Resolution
- 15 ppm/°C Max. Tempco
- ±0.003% Linearity
- 0 to +10V, ±5V Output
- 35 μsec. Settling Time

DAC-HP16DMC
- 4 Digit BCD Resolution
- 15 ppm/°C Max. Tempco
- ±0.005% Linearity
- 0 to +10V Output
- 15 μsec. Settling Time

77^{50}* (100's)

Price, both versions: $119.00* (1-24)

*U.S.A. domestic prices only

When high resolution and stability are demanded, Datel's DAC-HP series provides the performance — applications such as precision signal reconstruction, automatic test systems, and ultra-linear ramp generation. DAC-HP's excellent performance results from special low tempco nichrome thin-film resistors, laser trimmed for optimum linearity, and a low tempco zener reference circuit. Operating temperature range is 0 to 70C, with models available for −25 to +85 and −55 to +125C operation.

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CIRCLE NUMBER 180

Lab rf amplifier yields preset constant level

Instruments for Industry, 151 Toledo St., Farmingdale, NY 11735. Ralph Logan (516) 694-1414. $4910; 4 wks.

The Model 2600 rf amplifier is for use where a load may be damaged by excessive power. Either the power or voltage delivered to the load can be maintained at a preset constant level, regardless of impedance changes in the load. In addition, the unit turns itself off if power or voltage reaches a predetermined level. Two meters monitor forward and reflected power. The amplifier covers 0.5 to 35 MHz and is rated at 130 W output. The unit is solid state and operates into any load impedance from a short to an open circuit.

CIRCLE NO. 349

General-purpose scope handles 15 MHz

Philips Test & Measuring Instruments, Mahwah, NJ 07430. (800) 631-7172. $875; stock.

Model PM3211 portable, 15-MHz/2-mV oscilloscope features comprehensive triggering facilities. The unit has an 8 × 10-cm screen in a 300 × 135 × 445-mm case. Its weight is 7.5 kg. Triggering can be in "Auto" or level-set modes and multisourced. Channel B can be used as an X input to facilitate X-Y displays, with calibrated attenuation of both X and Y inputs. Channel B can be inverted, and with the ADD function, can display A ± B.

CIRCLE NO. 350

Current probe measures peaks up to 500 A

Tektronix, P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. $665.

The P6303 probe measures peak pulse currents to 500 A and steady-state currents to 100 A within the frequency range of dc to 15 MHz. A 1 × 0.83-in. jaw accommodates large conductors. Because inductive coupling is used, no electrical contact or circuit break is required. The probe operates as a part of a system with the AM503 current probe amplifier, any TM500 power module and an oscilloscope.

CIRCLE NO. 356

New technique measures power for fiber optics

Hewlett-Packard, 1507 Page Mill Rd., Palo Alto, CA 94304. John Kane (415) 493-1501. $500; 5 wks.

The 84801A thermistor sensor, when used with any HP 432 power meter, measures optical power from 1 μW (−30 dBm) to 10 mW (+10 dBm) over the wavelength range of 600 to 1200 nm, with an absolute accuracy as low as 7%. Using an optical fiber as its input, the system is a high-efficiency device designed for single-fiber power measurement. Absolute calibration is provided by the calibration factor adjustment on the 432. The power sensor is a thermistor bead that is attached to one meter of fiber-optic "waveguide." The fiber diameter is 200 microns, maximizing the amount of light detected by the sensor and assuring high accuracy of measurement.

CIRCLE NO. 357

Dial-A-Voltage

SHOWN ACTUAL SIZE

0.005% Calibrator

only $450 (SINGLES)

Datel's Digital Voltage Calibrator, DVC-8500 comes in a mini-benchtop package, at a mini-price ($450 in singles*), but provides very big performance. DVC-8500 offers 4½-digit resolution and a ±19.999 volt full scale output range with ±1 millivolt accuracy (±0.005% of full scale.)

Use your DVC-8500 to calibrate A/D and D/A converters, DPM's, DVM's, Op Amps, V/F converters, and Data Acquisition Systems. A short-proof, buffered output gives up to ±25mA output current with an LED overload warning signal. The ±1.5 millivolt front panel vernier allows fine tuning of A/D and D/A bit steps.

Included are rear PC sense terminals and a choice of 100, 115, or 230 VAC inputs. A panel mounting kit is optional.

Contact Datel, or your nearest Datel Representative listed in Gold Book or EEM.

* U.S.A. Domestic Price only.

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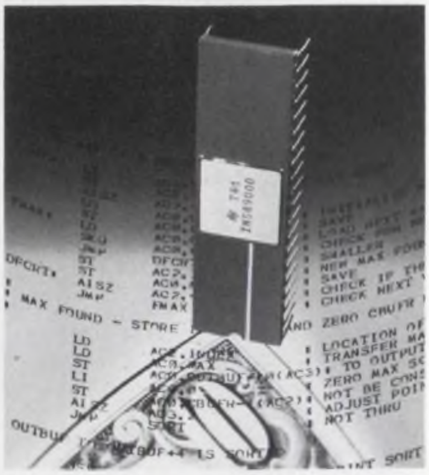
CIRCLE NUMBER 94

16-bit μP outperforms most 8-bit CPUs



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Howard Raphael (408) 737-5956. $10; stock.

The INS8900, a 40-pin, 16-bit microprocessor, sports an interrupt structure, addressing modes and logical capabilities associated with minicomputers. Instruction execution times for most commonly used routines are equivalent to those on advanced 8-bit designs and 10 to 30% faster than on present generation designs, such as the 2-μs 8080. The 8900 is a true 16-bit CPU. It uses 16-bit instruction words and 16-bit data words and has a flexible set of 45 instruction types. The chip contains status and control circuitry, conditioned branch-sense circuitry, interrupt logic and a portion of the clock generation circuitry. By adding a ROM and one to four RAMs, a complete microprocessor system can be implemented.

CIRCLE NO. 358

Single-chip μP has four 8-digit RAMs

Western Digital, 3128 Red Hill Ave., Newport Beach, CA 92663. (714) 557-3550.

The WD/40 microprocessor, for dedicated control uses, has four 8-digit RAM data storage registers and 400 or 512 10-bit words of ROM. The chip directly drives seven-segment displays through a ROM programmable decoder.

CIRCLE NO. 359

One Mallory THF capacitor can replace up to four CSR types in a switching power supply.

These small, solid-tantalum capacitors give you a per-unit substitution factor as high as one for four and can by-pass 4.5 amp rms at 100kHz. So by using these high ripple performance capacitors you save in space, weight and cost.

Specially designed for low equivalent series resistance, at frequencies from 1 kHz through 1 M Hz. They're ideal for high frequency power supply switching, for regulator switching, or for bypassing or filtering unwanted ripple currents.

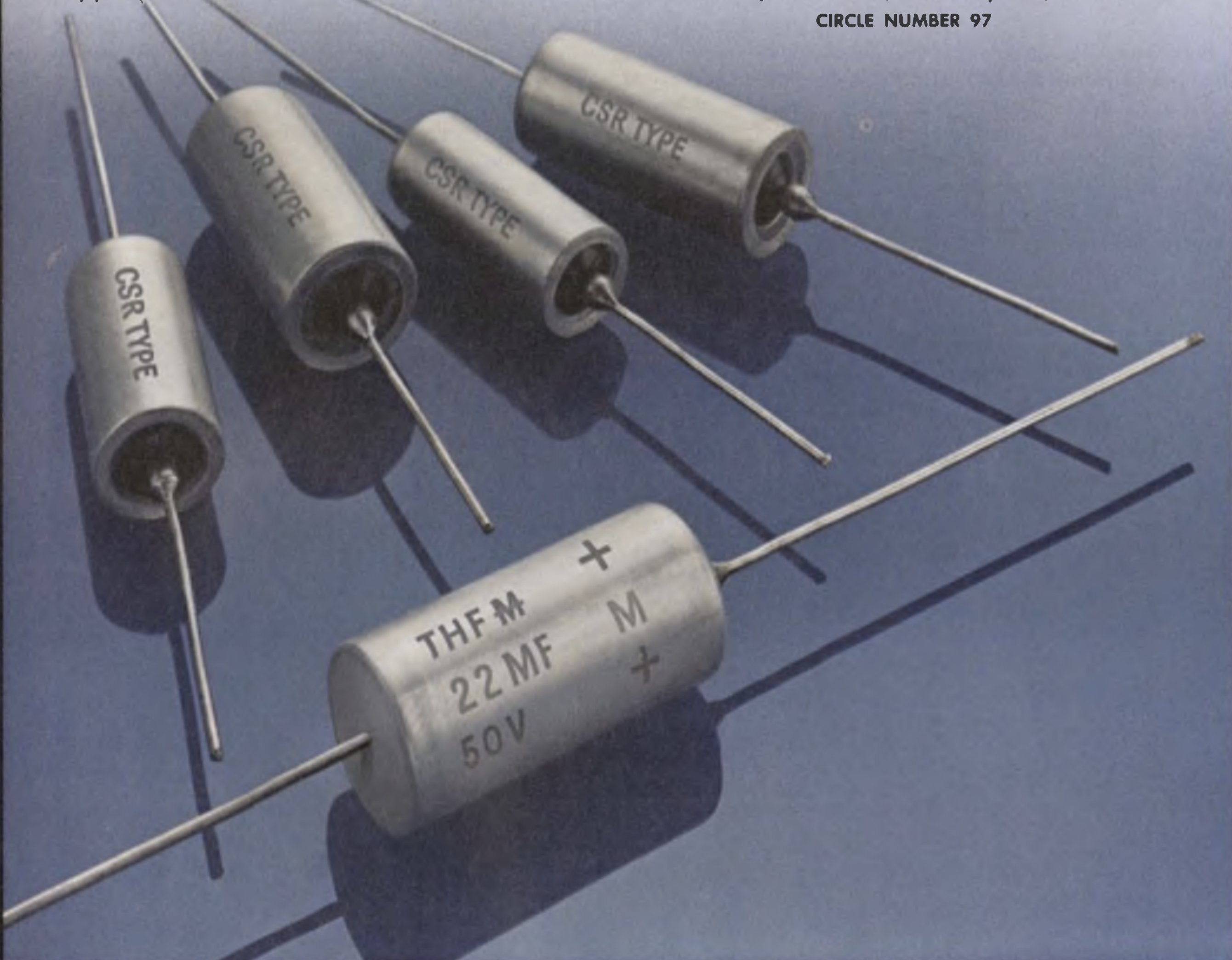
Because ESR is low, power losses are low. With the solid electrolyte and hermetic seal, long life is inherent. Electrical characteristics are very stable over a temperature range of −80°C through 125°C. Two case sizes: .29 x .69 and .35 x .79 inches.

Mallory THF capacitors are available in a wide range of ratings: 5.6 to 330μF, 6 to 50VDC.

They're the result of Mallory's engineering program that's finding ways to produce high performance type capacitors at less cost to you.

Just ask your Mallory representative. Available direct, or through authorized Mallory Distributors in U.S. or overseas. Or call Help-Force Headquarters at (317) 856-3731. Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Box 1284, Indianapolis, IN 46206.

CIRCLE NUMBER 97



MALLORY

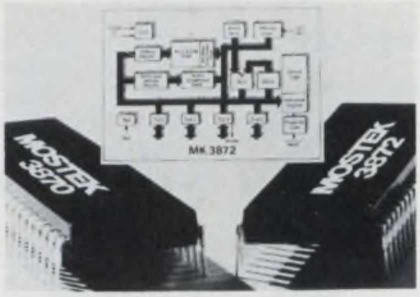
CRT terminal handles 9600-baud data

North Star Computers, 2547 Ninth St., Berkeley, CA 94710. (415) 549-0858. $995.

Soroc Model IQ 120 is a CRT terminal that can be connected to North Star's Horizon computer and handle data rates up to 9600 baud. The terminal displays 24 lines × 80 characters and has an addressable cursor, upper and lower-case ASCII character set and a numeric key pad.

CIRCLE NO. 360

μC chip includes 4032 × 8 bytes of ROM



Mostek, 1215 W. Crosby Rd., Carrollton, TX 75006. Jim Vittera (214) 242-0444. See text; 8 to 10 wks.

The 3872 single-chip microcomputer includes 4032 × 8 bytes of mask programmable ROM, 64 bytes of scratchpad RAM and an additional 64 bytes of executable RAM. Supporting the executable RAM is a stand-by power mode for battery backup. The chip requires just a 5 V supply, and includes 32 bits (four ports) of bidirectional I/O; a programmable binary timer and external interrupt capability. The 3872 costs $25 in 1000-unit quantities with a refundable masking charge of $3000.

CIRCLE NO. 361

Data-acquisition system is programmable

Signal Lab, 202 N. State College Blvd., Orange, CA 92668. Bill Chidester (714) 634-1533. $3495; 4 wks.

UPDAS (user programmable data acquisition system) includes a microcomputer, analog and digital I/O, and the integrating software in a single chassis. The system provides real-time computation in multiple process and control loops. The unit accepts analog and digital inputs; performs real-time computation; outputs in analog and digital form; displays, prints and accepts commands from the front panel. All functions can be programmed by the user.

CIRCLE NO. 362

Data coupler delivers date, time or messages

Chrono-Log, 2 W. Park Rd., Havertown, PA 19083. (215) 853-1130. $272/$312.

Series 70,000 digital clock/calendars interface with the communications port of a computer, CRT terminal or recording device and deliver date, time and messages with up to 31 ASCII-coded characters. Up to 31 ASCII-coded characters. Up to 16 of these characters can come from variable sources such as digital time and front-panel thumbswitches. The remainder are fixed and stored in a PROM. Each character can include 7 or 8 data bits. Speed can be selected from 75 to 9600 baud.

CIRCLE NO. 363

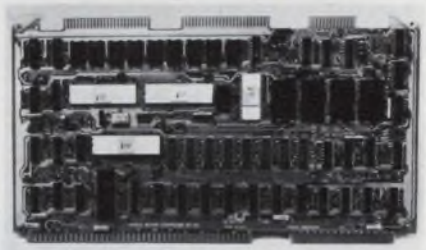
Cross-assemblers mate with PDP-8 systems

Sierra Digital Systems, 13905 Rancheros Dr., Reno NV 89511. (702) 329-9548. $400; stock.

Four microprocessor cross-assemblers have been added to the X8 Series for the DEC PDP-8 minicomputer. The series covers the Z80, 1802, SC/MP and 8048 μPs in addition to the previous 6502, 6800, 8080, F8 and 2650 versions. The cross-assemblers run in 8 kwords of memory under the OS/8 system and are written in PDP-8 assembly language. Pseudo-ops and run-time options provide for conditional assembly and extensive listing control. Generated object code may be output in the μP's standard loader format, or BNPF for ROM generation. The cross-assemblers are distributed in PDP-8 binary format on paper tape, Dectape or DEC floppy diskettes.

CIRCLE NO. 364

Single-board computer ups its ROM capacity



Intel, 3065 Bowers Ave., Santa Clara, CA 95051. Don Schare (408) 987-7253. $495.

The iSBC 80/10A single-board computer is an enhanced version of the 80/10 and gives up to twice the ROM capability of the older 80/10. With the 80/10A, the user can store the program in either a type 2716, 2048-byte EPROM or smaller 8708 or 2758, 1024-byte EPROM. With the 80/10, the user could only use the 8708.

CIRCLE NO. 365

Model 178

Now... the next generation of bench DMMs!

Two New Keithley Models offer uncompromising performance and outstanding value.

- Accuracy 3½'s can't match: 0.04% + 1 digit on dc volts and ohms.
- Large, bright, 20,000-count LED display that's quick and easy to read.
- Convenient bench size that won't get "lost" yet doesn't crowd.
- Exceptional reliability.

Model 178 offers functions and ranges for most measurements: 100μV to 1200V dc, 100μV to 1000V ac, 0.1Ω to 20MΩ. At $199* it is a remarkable value!

Model 179 is a full-function, multi-feature model offering the same advantages as the 178. Plus TRMS AC; 10μV Sensitivity; Hi and Lo Ohms; AC and DC Current. Yet it's still half the price you'd expect. Only $289*!

Model 179

Both models feature designed-in reliability.

Rugged circuits use a minimum of parts – high quality, off-the-shelf parts – carefully assembled and tested by Keithley (we've been making sensitive laboratory instrumentation for more than 30 years.)

Outstanding overload protection and rugged mechanical design keep both units going even after severe abuse. One-year accuracy specifications minimize recalibration costs. Local assistance keeps downtime to a minimum should service ever be needed.

A battery option, user installable, gets you off "line" for critical measurements or for field use. Nine other accessories add versatility.

Keithley's 178 and 179 are designed, built and supported to provide continuous usability at the lowest total cost of ownership.

Need autoranging, more accuracy or sensitivity? See Keithley's complete line of DMMs.

For complete specifications and immediate delivery on the 178 and 179, call your local Keithley representative (see adjoining list). Or, call or write: Keithley Instruments, Inc., 28775 Aurora Road, Cleveland, Ohio 44139. (216) 248-0400. In Europe: D-800 München 70, Heiglhofstrasse 5, West Germany. (089) 7144065.

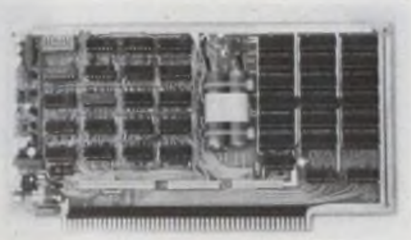
KEITHLEY

The measurement engineers.

*U.S. domestic price only.

CIRCLE NUMBER 99

High-speed RAM is nonvolatile



ElectriCom, P.O. Box 1235, Hawthorne, CA 90250. Pat Patterson (213) 676-6576. $287.

Model 4020 nonvolatile high-speed semiconductor RAMs have size and word widths of 2 k × 8/9 or 1 k × 16/18, which are jumper selectable. Data is maintained for a minimum of three months (six months is typical) after the primary board power is removed. Constructed on a 5 × 10-in. card, the memory has a 450-ns access time, bank selectable by DIP switches within 64 k, phase-programmable operating controls, separate data inputs and outputs that can be bussed together, S100 bus compatability, on-board address registers for A0 through A9 and LS-type TTL interfacing. On-board NiCd batteries, battery charger and power-state monitors are also included.

CIRCLE NO. 366

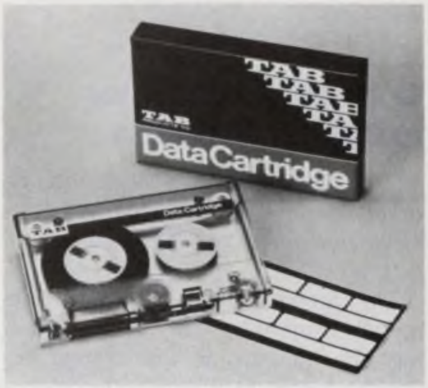
Disc storage unit adds 10 Mbytes to computer

Diablo Systems, 24500 Industrial Blvd., Hayward, CA 94545. (415) 783-3910. See text: 8 wks.

Disc-storage capacity of Model 3200 small business computer systems have been increased to 10 Mbytes with the addition of a fixed/removable disc-drive. The Model 3200-14 disc system has a 5-Mbyte fixed disc and an additional removable 5-Mbyte disc cartridge that can be used in place of, or in addition to, the 630,784-byte diskette drives currently available on the computer. The disc subsystem achieves a data transfer rate of 312,000 bytes/s with an average access time of 50 ms. A typical 3200 system with the 1-Mbyte disc drive is priced at $29,000.

CIRCLE NO. 367

Data cartridges use 1/4-in. tape

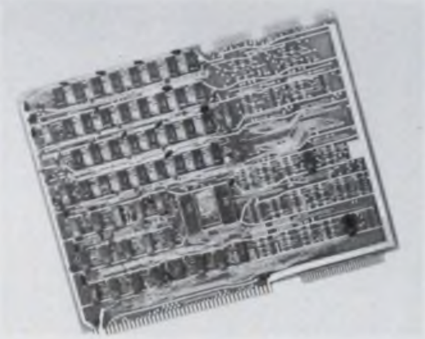


TAB Products, 2690 Hanover St., Palo Alto, CA 94304. Jim Snyder (415) 493-5790.

The Model 1040 quarter-inch magnetic-tape cartridge is compatible with the ANSI, ECMA, ISO and IBM standards. Features include ceramic edge guides for extended cartridge life, interchangeability with IBM 5100 and 3M DC300A units, manually operable internal file protection, endless drive belt, roller and hub retaining system that reduces skew and bit-to-bit jitter, a polycarbonate cover and precision-machined metal base.

CIRCLE NO. 368

64-k RAM mates with SBC 80/10



GSI Systems, 223 Crescent St., Waltham, MA 02154. Ed Letscher (617) 899-6688. $179; stock.

The Model 10046, 64-k RAM board is a direct replacement for four SBC 80/10, 16-k RAM boards. Providing 475-ns access and 650-ns refresh times, the board is compatible with a standard SBC 80/10 backplane. The memory can be driven by any 80/10 CPU board, and its 64-k address starts at 0000, page selectable.

CIRCLE NO. 369

Unit allows computer to control ac outlets

Mountain Hardware, P.O. Box 1133, Ben Lomand, CA 95005. (408) 336-2495. $189 (controller), $149 (remote); stock to 4 wks.

The Introl controls ac devices remotely from any S-100 bus over existing 110-V-ac wiring. The system impresses a code-modulated 50-kHz control on the ac wiring and then decodes the signal at any outlet to switch appliances on and off. A single ac-controller board plugs into the computer bus and connects to the ac interface adapter, which, in turn, is plugged into any 110-V-ac outlet. The controller can address as many as 64 channels remotely. When polled, the remote unit sends a signal back indicating the status of each device.

CIRCLE NO. 370

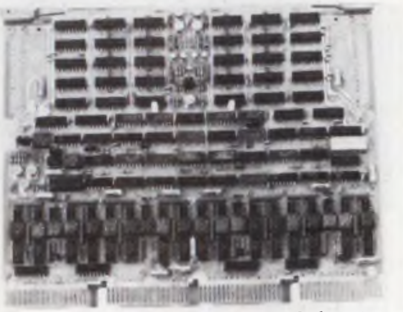
ROM/RAM simulator tests software

Electro-Design, 7364 Convoy Court, San Diego, CA 92111. (714) 277-2471. $1495.

To test software when developing μP systems, the ED5000 simulator can be plugged into any standard ROM or RAM socket to verify new programs under actual operating conditions. Programs entered into its standard 2-k x 8, 45-ns memory can then be edited. Also, programs already stored in PROMs can be loaded into the system. The display serves as a memory map.

CIRCLE NO. 371

16 k × 16 core memory plugs into LSI-11 micro



Micro Memory, 9438 Irondale Ave., Chatsworth, CA 91311. (213) 998-0770. $1181; 3 wks.

The MM-1103/16, 16 k × 16 core memory system plugs directly into the DEC LSI-11 microcomputer. Access time is 400 ns. The memory is plug-compatible with the DEC MMV-11A and may be installed in any location in the LSI-11 chassis. By using slot four of the chassis, two spare slots are provided. The memory has byte control and has module selection in 4-k increments up to 32 kwords.

CIRCLE NO. 372

NOW

A magnetic circuit breaker that proves LESS is MORE!

The Airpax T11 is a single pole, single throw, series trip magnetic circuit breaker that combines power switching and accurate, reliable protection in one aesthetically pleasing package. It features a patented snap-action that assures immediate and positive opening or closing of the contacts. This snap-action results in an increase in operational life of up to 5 times that previously available. It also eliminates possible operator "teasing" of the contacts and minimizes arcing.

Airpax T11 Snap-Action Magnetic Circuit Breaker.

LESS COST. The T11 costs less than any other magnetic circuit breaker on the market today . . . under $5.00 in small quantites. Even less as the quantity increases. And the traditional Airpax Five-year warranty.
Result: MORE protection for your money.

LESS SPACE. The T11 combines power switching and current protection in one tiny package about 1 cubic inch in size. That's smaller than any other magnetic breaker. In addition, the T11 offers a choice of six attractive paddle handle colors and a variety of mounting hardware.
Result: MORE design flexibility.

LESS INSTALLATION COST. The T11 does the job of a power switch, fuse and fuse holder — all in one easy-to-mount unit. This means only one item to be installed instead of three, less assembly time, and one-third the inventory.
Result: MORE Productivity . . . and profit . . . for you.

LESS SERVICE REQUIRED. The T11 is immediately resetable to check if a fault has been removed. There's nothing to burn out. Nothing to replace. No annoying service calls.
Result: MORE happy customers for you.

LESS GUESSWORK. Airpax has a bulletin fully describing the T11 snap-action magnetic circuit breaker, including rating, delays, complete specifications, and a handy how-to-order chart.
Result: MORE information for you.

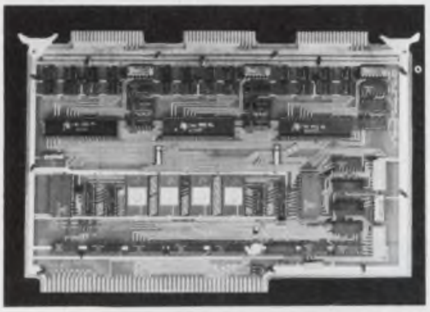
To get your bulletin, call your local Airpax representative or contact Airpax Electronics, Cambridge Division, Cambridge, MD 21613. Phone: (301) 228-4600. Telex: 8-7715. TWX: 865-9655. Other factories in Europe and Japan.

AIRPAX™

THE PRO IN PROTECTION

CIRCLE NUMBER 101

Board expands memory and I/O for TI μC



Digital Interface Systems, P.O. Box 1446, Benton Harbor, MI 49022. Mahesh Seth (616) 926-2148. See text; 8 to 12 wks.

The Model 990-110 memory and I/O expansion board is compatible with the Texas Instrument TM990/100M microcomputer. The board provides 2-k, 16-bit words of EPROM (expandable to 4 k), (1-k and 16-bit words of static RAM. Memory addresses are selectable on 1-k boundaries for RAM and 4-k boundaries for EPROM. Also, three TMS 9901 chips for input, output and interrupt lines are provided. Prices range from $395, for a board with unbuffered inputs and outputs and no memory, to $635, for a buffered and fully populated board.

CIRCLE NO. 373

Memory/disc controller meets Euro standards

Zilog, 10460 Bubb Rd., Cupertino, CA 95014. Vince Schlezes (408) 446-4666. $895.

The Z80-MDC/E is a memory and disc-controller board that meets the standard specs commonly adopted in West Germany, United Kingdom, France and Switzerland. The board provides 12 kbytes of dynamic RAM plus a floppy-disc controller capable of handling up to eight floppy-disc drives. The MDC/E has a strapping option for setting the start address of each 4-kbyte memory page. Also, disc read/write accuracy is ensured by 16-bit cyclic-redundancy-check-code circuitry.

CIRCLE NO. 374

8-kbyte static RAM mates with S-100 bus

Pacific Digital, 2555 E. Chapman Ave., Fullerton, CA 92631. (714) 992-5540. See text.

The 8KRS is an 8-kbyte static RAM for use on an S-100 bus. The memory is organized as two independently addressable 4-k blocks with address selection by jumper and plug, which can be changed while the board is plugged in. Write protection for the entire board is provided by an on-board toggle switch, and memory disable is via a phantom line. Also, 0, 1 or 2 wait states are plug and jumper selectable. All bus lines are buffered with one LS-type TTL load per line. Prices are $199.95 for 450-ns-speed units and $219.95 for 250 ns.

CIRCLE NO. 375

Single-board computer is disc based

Altos Computer Systems, 4340 Stevens Creek Blvd., San Jose, CA 95129. (408) 244-5766. $3394.

The Z8000 is a full-sized disc-based business system with all electronics on one plug-in 8 × 12-in. board. The desktop package contains two Shugart floppy discs for IBM compatability. The system uses the Z80 CPU and the CP/M random access disc operating software together with extended commercial basic.

CIRCLE NO. 376

Flexible-disc drives store 6.4 Mbits

Pertec Computer, 9600 Irondale Ave. Chatsworth, CA 91311. Neil McElwee (213) 999-2020.

The FD410, 5XO, 511A and 514 are flexible-disc drives that boast a maximum storage capacity of 6.4 Mbits (unformatted). The drives have ferrite read/write heads that are IBM compatible. The disc's positioner uses a three-step track-to-track movement for track-positioning accuracy, and a retractable-head system contacts the recording media only when reading or writing data. The different models offer a selection of interfaces.

CIRCLE NO. 377

Talk to a computer and it talks back

Digital Group, P.O. Box 6528, Denver, CO 80206. (303) 777-7133. $595.

With a Votrax voice synthesizer card, you can verbally command your Z80 microcomputer and it will answer. The card plugs into any I/O slot of a Digital Group microcomputer system. Other computers require some extra hardware and software programming. The developed software assumes a Z80 system with at least 18 k of memory, a 1024-character TV and cassette interface card. A high-impedance microphone is required for voice input and an external 8-Ω speaker for voice output.

CIRCLE NO. 378

Data cassettes handle short tape lengths

Avdex, 2280 Grand Ave., Baldwin, NY 11510. (516) 546-2272. $4.95 to $6.35.

The CDC line of data cassettes are loaded with only 1 to 5 min of tape. These cassettes use computer shells, polyolefin slip sheets, machined guide rollers, stainless steel pins, oversized pressure pads and oversized hubs for smooth, uniform tape transport. Extra-short leaders do not come in contact with the recording head, which allows instant-start operation, eliminating lost data.

CIRCLE NO. 379

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And now a neat new way to definitive display performance.

DOT MATRIX

Consider the new Noritake-Ise dot-matrix line-up—9, 10, 16, 20 and 40-character line displays. Variety aimed at giving you more design potential. Or consider our unique 400-dot graphics display with 17m/m depth and low 35V drive rating. It's aimed at helping you think low voltage, portability and economy all at the same time.

In short, consider Noritake-Ise period for dot matrix (or segmental) displays. Itrons always help you design more competitively.

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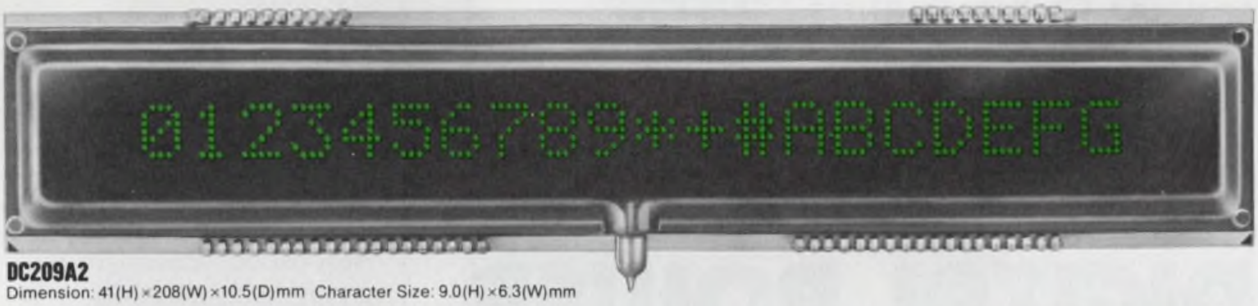
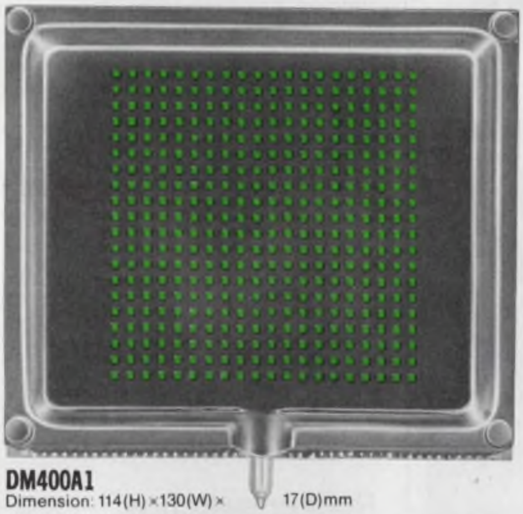


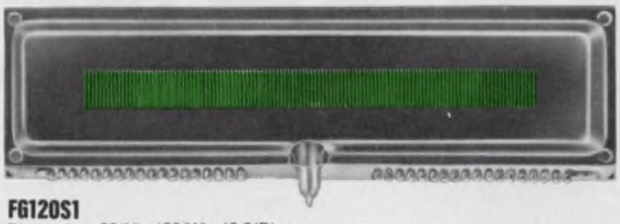
DC209A2
Dimension: 41(H)×208(W)×10.5(D)mm Character Size: 9.0(H)×6.3(W)mm



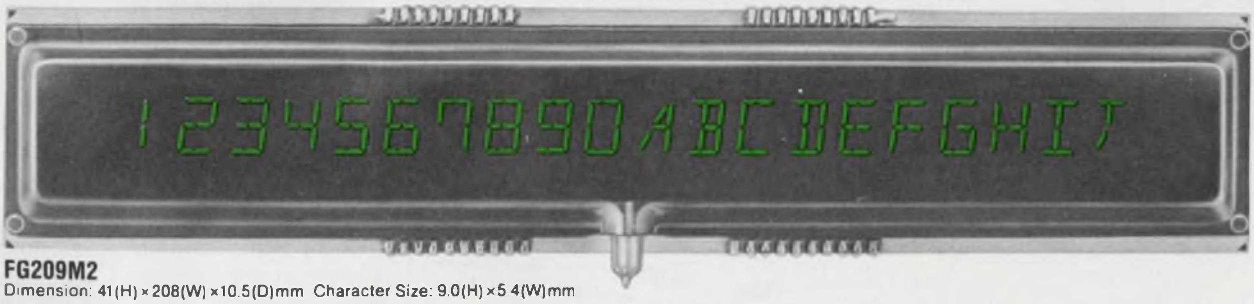
DM400A1
Dimension: 114(H)×130(W)×17(D)mm

DC95A2
Dimension: 24(H)×75(W)×7.2(D)mm
Character Size: 5.05(H)×3.55(W)mm

FG48D6
Dimension: 25.5(H)×56.5(W)×7(D)mm
Character Size: 8.0(H)×4.2(W)mm



FG120S1
Dimension: 39(H)×138(W)×12.5(D)mm



FG209M2
Dimension: 41(H)×208(W)×10.5(D)mm Character Size: 9.0(H)×5.4(W)mm

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Electronics Division
1-1 Noritake-Shinmachi, Nishi-ku, Nagoya-Shi, Japan
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Essex, U.K.
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72-9 SEC 2, JEN AI RD., Taipei
Phone: 351-0293 Telex: 11176

Manufacturer:
ISE ELECTRONICS CORP.
P.O. Box 46, Ise-shi,
Mie-Pref., Japan
Phone: (0596) 39-1111
Telex: 4969523

Europe Office
Rue De la presse 3-5 1000
Bruxelles, Belgium
Phone: 2178360, 2178460
Telex: 25327, 26962

New York Branch
19C NY MDSE MART
41 Madison Ave. New York, N.Y. 10010
Phone: (212) 481-3300
Telex: 230125469

CIRCLE NUMBER 102

Keyboard allows many uses

Cherry Electrical Prod., 3600 Sunset Ave., Waukegan, IL 60085. Frank Amendola (312) 689-7702. $88.00 (100 qty); 2 wks.

The PRO keyboard, for users who don't want to work around a totally dedicated unit, features an alpha-lock key that changes outputs from typewriter keyboard to teletypewriter code, and also five unassigned keys whose legends you can change. The keyboards daughter-board circuit can be easily piggy-backed. Alterable options that permit rapid customizing of the unit include negative logic, which can be derived by substituting SN7400N ICs for SN7408Ns and three-state positive logic, which can be obtained by using two SN74126Ns. Additional options include CMOS-compatible output, encoded or nonencoded outputs, an automatic repeat function, optional parity bit, varied strobe pulse width, output latch and shift-control mode.

CIRCLE NO. 380

Rocker switches are sealed

Cutler-Hammer, P.O. Box 463, Milwaukee, WI 53201. (414) 442-7800.

Commercial environmentally sealed rocker switches resist dust, dirt and liquid contaminants found in harsh environments. The switches are available in either snap-in bezel, flush or sub-panel mounting; in 1, 2 and 4-pole configurations. The switches have flame-retardant mineral-filled melamine bases, die-cast frames, high-impact nylon rockers and screw-type terminals. The units have a seal around the bushing and a seal between the base and frame.

CIRCLE NO. 381

Audible alarms blast 70 to 86-dB sound alerts

Cybersonic, P.O. Box 151, Glenside, PA 19038. F. Coller (215) 885-2244. $6.50; stock.

Models of the Bleeptone audible signalling device provide a compelling 70-to-86-dB audible alerting signal at 1 meter. All models come with either a 2.5 or 1-kHz (nominal) frequency. Driving voltages are 3, 6 or 24 V dc ±30%, compatible with DTL, TTL or HTL logic.

CIRCLE NO. 382

Double-balanced mixers use Schottky diodes

Vari-L, 3883 Monaco Pkway, Denver, CO 80207. Carol Kiser (303) 321-1511. $15.95 to $35.00; stock.

A series of high-level doubly-balanced mixers cover 0.5 MHz to 1 GHz and are designed around beam-lead Schottky diodes. Model CM-1H4 and CM-1H8 cover 0.5 to 500 MHz and are rated at +13 and +17dBm (LO) respectively. Models CM-2H4 and CM-2H8 cover 5 MHz to 1 GHz and are also rated at +13 and +17 dBm. Typical conversion loss is 6 dB and typical isolation is 40 dB. The 1-dB signal compression point for models CM-1H4 and CM-2H4 is +7 dBm. For CM-1H8 and CM-2H8 the compression point is +12 dBm.

CIRCLE NO. 383

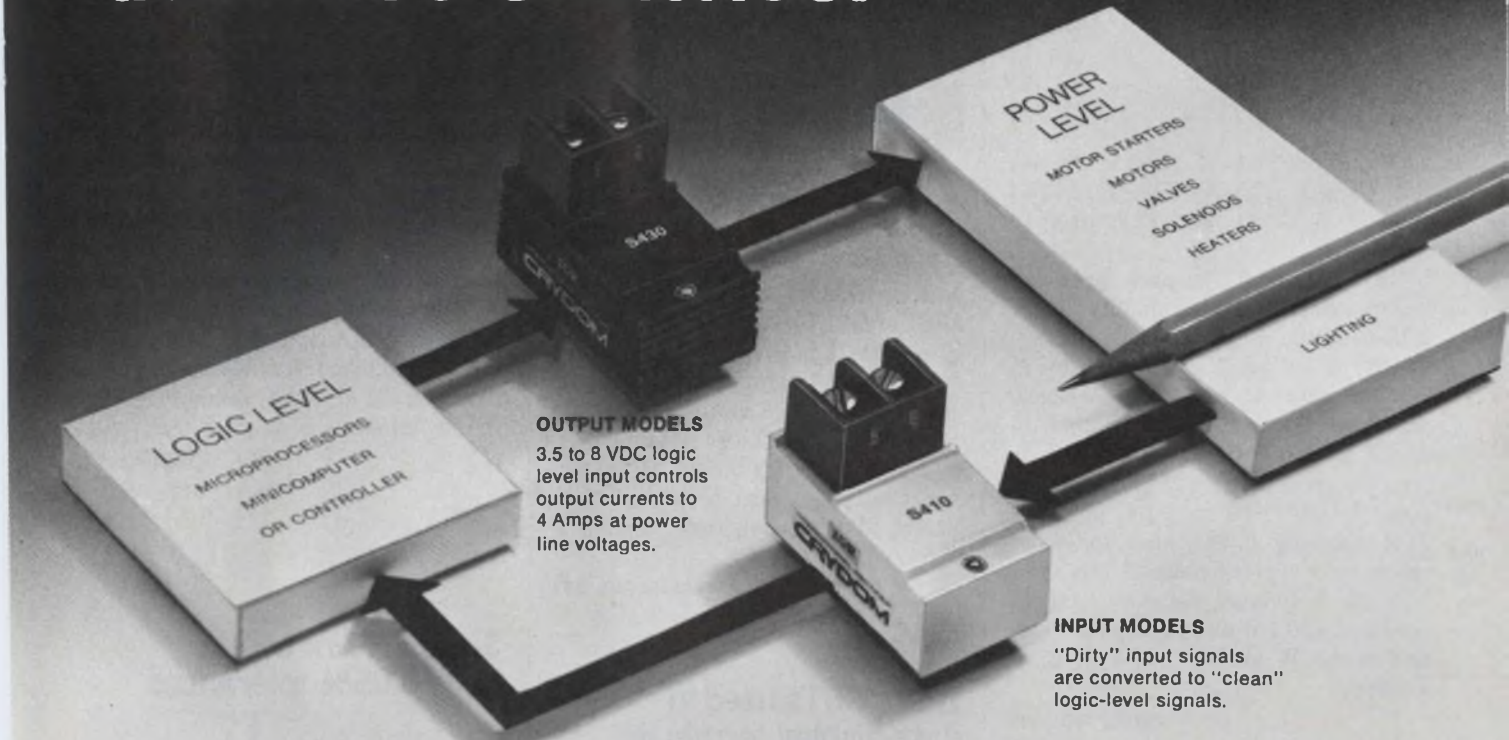
Illuminated switch has multiple legends

Industrial Electronic Engineers, 7740 Lemona Ave., Van Nuys, CA 91405. Helen Sands (213) 787-0311. $29; 6 to 8 wks.

The Proswitch is a multi-legend, illuminated pushbutton switch with 12 different selectable messages. Up to three lamps can be energized at one time to yield a maximum of 64 possible compound legends. The switch contains 12 lamps, an optical system, a 12-legend film chip, viewing screen and switch. The viewing screen is pivot mounted and doubles as the pushbutton to operate a snap-action switch.

CIRCLE NO. 384

From Crydom... A totally new design in microprocessor interface switches!



OUTPUT MODELS
3.5 to 8 VDC logic level input controls output currents to 4 Amps at power line voltages.

INPUT MODELS
"Dirty" input signals are converted to "clean" logic-level signals.

AC and DC Solid-State Input Switches and companion Output Switches that deliver 4 Amps at 40° C, 2.75 Amps at 70° C Ambient . . . without added heat sinks.

Very simply, Crydom's new family of solid-state Input-Output switches give you the highest current capability and highest transient immunity in the industry, with all of the advantages of photo isolation and zero voltage switching. Electrically clean, isolated and noise-free interface switching between logic-level "smart" circuitry and the brawny power level equipment it controls.

But there is much more to the Series 4 design, including models available to NEMA Part ICS-2-230 specifications.

These all-new switches include such quality features as: gold plated logic-level PC board pin terminals; screw-type, color coded power level terminals; and a LED status indicator, all environmentally sealed by solid encapsulation.

Most important, the output devices have their own highly efficient heat radiators, plus a unique and proprietary thermo/mechanical output power construction designed to provide unequalled current handling capability. That's why the Series 4 output models can handle 4 amps at 40°C and 2.75 amps at 70°C with an extra margin of safety.

And there are other space-saving advantages. Like internal transient suppression in the DC models and internal snubber networks in the AC models. It's all there!

These single-package devices offer you a better and cost-competitive way to switch from logic-level to power levels . . . and vice versa. They're bound to simplify your designs and increase your reliability.

Contact your local Crydom distributor or representative for immediate response to your product and/or technical data needs.

And, find out why it will pay you to switch to — and with — Crydom Series 4 Input/Output devices.

International Rectifier Crydom, 1521 E. Grand Ave., El Segundo, CA 90245. (213) 322-4987. TWX 910-348-6283.

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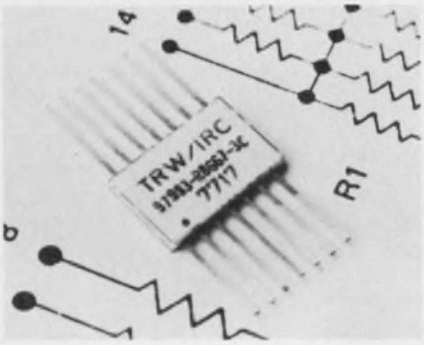
CIRCLE NUMBER 108

Resistor network meets MIL-R-83401



TRW/IRC Resistors, 4222 S. Staples St., Corpus Christi, TX 78411. Bill Wagner (512) 854-4872. $7.70 to $8.40 (1000 qty).

TRW's 14-lead flat-pack precision resistor networks now qualify under MIL-R-83401, Style RZ030. Package density is either 7 or 13 resistors in 0.07-in.^{2} ceramic sandwich packages. Standard resistance range is 150Ω to 51 kΩ, with 0.1 to 2% tolerance. Four tempcos are offered: ±25 ppm/°C, ±50 ppm/°C and −50 to −150 ppm/°C. TCR tracking is ±5 ppm for most values and current noise is less than −25 dB. Individual resistor elements are rated at 0.1 W and package dissipation is 0.5 W at 70 C, 1 W at 25 C ambient.

CIRCLE NO. 385

PC relays allow immersion cleaning

Potter & Brumfield, 200 Richland Creek Dr., Princeton, IN 47671. Roy Stewart (812) 386-1000. $1.74 up; stock.

Immersion-cleanable PC-board relays, Type R50, are rated to 5 A and accept full immersion in cleaning solvents for 2 min. The low-profile relays are available as 1 and 2 A versions for 28 V dc or 120 V ac in SPDT and DPDT models, and as 5-A SPDT model. Standard and sensitive-coil ratings range from 5 to 48 V dc. Sensiti ve coils can be driven by ICs capable of sinking 80 mA (TTL) and 40 mA (MOS at 12 V dc). The smallest model is 0.46 × 0.595 × 1.09 in.

CIRCLE NO. 386

DIPs switch 2 to 10 circuits

Waldom Electronics, 4301 W. 69 St., Chicago, IL 60629. (312) 685-1212. See text; stock.

Rocker or lever actuated multi-position DIP switches feature SPDT, SPST or DPST switching for 2 through 10 circuits. The switches handle 30 V dc at 50 mA. Contact resistance is 100 mΩ max at 10 mA and voltage breakdown is 500 V dc. The terminals, on 0.1-in. centers, are tin plated for ease of soldering. A typical price for an 8-circuit SPST switch (type DSL-8) is $5.55.

CIRCLE NO. 387

12-in. CRTs used in data-display terminals

Panasonic, 1 Panasonic Way, Secaucus, NJ 07094. Bill Parkin (201) 348-7271. $21 (1000 qty); 12 wks.

Two 12-in. cathode ray tubes, the 310JKB4 and 310JLB4 for data display use, feature sharp corner focus and high resolution characteristics. The 310JKB4 offers 100° deflection and 1500-line resolution, and the 310JLB4, 90° deflection and 1200-line resolution. The tubes employ electrostatic focusing, electromagnetic deflection and most standard phosphors are available.

CIRCLE NO. 388

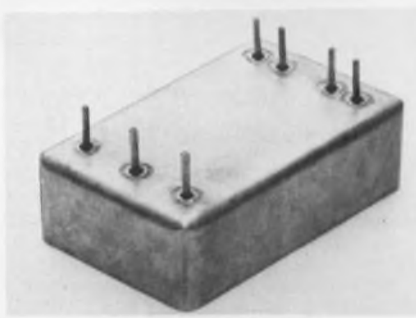
Keyboard allows typing with one hand

NewO, Palo Alto, CA 94303. Sid Owen (415) 321-7979. $98; stock to 2 wks.

Writehander is a keyboard on which you can type all 128 ASCII characters with one hand. The typist places four fingers on four press switches and the thumb on one of eight press switches. The four finger-operated switches actuate the four least-significant bits of a seven-bit ASCII code. The thumb then selects a desired character from a choice of eight groups. The keyboard's hemispherical shape comfortably accomodates the hand, and the fingers naturally locate themselves on the switches.

CIRCLE NO. 389

Sealed RC networks have 0.05% tolerances



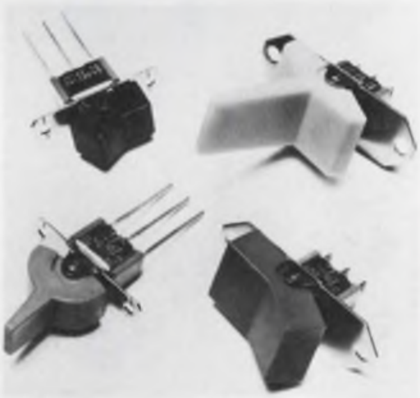
PFC, 100 Community Dr., Great Neck, NY 11022. Tom Cary (516) 487-9320. $20 up; 8 to 10 wks.

RC networks with tolerances as close as ±0.05% for the RC product come hermetically sealed in metal containers. The accuracy is guaranteed for one year. Variation of the RC product from −55 to 85 C is maintained within ±10 ppm/°C. Several packaging styles are available, including a flat-pack for PC mounting. Two or more networks can be supplied in a single package, with tracking to within 5 ppm/°C.

CIRCLE NO. 390

COMPONENTS

Miniature switches have four actuator options



Dialight, 203 Harrison Pl., Brooklyn, NY 11237. (212) 497-7600. $1.12 to $2.68 (1000 qty); stock.

The 572 series of subminiature rocker and lever-operated switches offer panel designers a variety of actuator, electrical, mechanical and functional options. The series includes two sizes of rockers, 0.365 × 0.648 in. and 0.595 × 1.036 in.; and two of levers, 0.365 × 0.74 in. and 0.595 × 1.174 in. Molded-nylon actuators are available in black, white and any of seven colors. Other options include six types of terminals, nine different switching functions and standard, low-level or combination standard/low-level contact rating.

CIRCLE NO. 391

Mini relays latch magnetically

Gould, 100 Relay Rd., Plantsville, CT 06479. (203) 621-6771.

MPCL miniature relays latch magnetically and need only 0.6-in. spacing between boards. A permanent magnet provides the armature holding force in the latch position. Two isolated coils (each 5 to 48 V dc, with 500-mW sensitivity at max latch or reset) have identical construction, eliminating the need for polarity reversal for release. A hingeless armature construction ensures a life of more than 10^6 mechanical operations.

CIRCLE NO. 392

Mini delay timer provides to 900-s delay

Artisan Electronics, 5 Eastmans Rd., Parsippany, NJ 07054. Alan Seman (201) 887-7100. $9.00; 2 to 3 wks.

Model 437 timer is a delay-on pull-in fixed timing device having delays of 0.025 to 900 s. The timer is an axial-lead series device that delays current to a load for a pre-selected time. Available for operating voltages from 6 to 172 V dc, the output is rated at 2 A.

CIRCLE NO. 393

Capacitors have low ESR for switcher supplies

Sangamo, P.O. Box 128, Pickens, SC 29671. (803) 878-6311.

Type 139R thermal-pack aluminum electrolytic capacitors have ESR values as low as 0.003 Ω at 20 kHz, and capacitance tolerance of ±20%. They handle 20-A ripple current at 85 C and 20 kHz and operate from −55 to 85 C with 2000 h of operating life at max temperature.

CIRCLE NO. 394

Low-profile heat sink fits TO-220 devices

Thermalloy, 2021 W. Valley View Lane, Dallas, TX 75234. (214) 243-4321. $0.045 (5000 qty); stock.

Type 6073 low-profile heat sinks fit TO-220 and Motorola Case 90 and 77 packages. For Case 90 use, heat sinks can be mounted above or below the device. Thermal resistance is 21 C/W in natural convection. Heat sink size is 0.75 × 0.75 × 0.375 in.

CIRCLE NO. 395

Quartz crystals cover 1-to-60-MHz range

Marden Electronics, P.O. Box 277, Burlington, WI 53105. Bob Rubach (414) 763-6093. $1.50 to $2.75 (1000 qty); stock to 4 wks.

Precision quartz crystals with wire leads or in plug-in holders cover the 1-to-60-MHz range. Accuracy is 0.002% at 25 C, with a temperature coefficient of 0.002% from −10 to +85 C.

CIRCLE NO. 396

Intel introduces the first JAN-qualified microprocessor, the 8080A. It's available now, and listed in QPL-38510 as M38510/42001BQB.

Now you can build your military projects with the most popular microprocessor ever, and avoid special approval procedures and reliability documentation.

In addition to our JAN-qualified 8080A, Intel's military ic-38510 program includes 26 LSI components manufactured in full compliance with the testing and screening requirements of MIL-M-38510D and MIL-STD-883B. For details on the JAN8080A, and our other military products, write Intel Corp., Military Program Manager, 3065 Bowers Avenue, Santa Clara, CA 95051.

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CIRCLE NUMBER 111

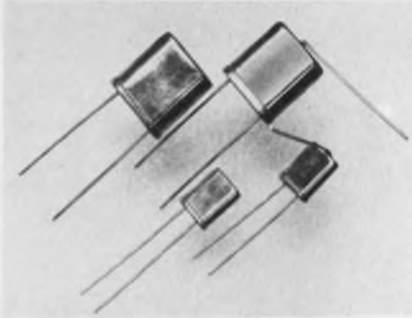
LEDs illuminate pushbutton switches

Dialight, 203 Harrison Pl., Brooklyn, NY 11237. (212) 497-7600. $1.96 (1000 qty); stock.

Switches and indicator lights in the 554 Series use a 5/8-in.-square, Series 332 caps in which rectangular LEDs are flush-mounted as integral components. The caps can replace incandescent-lamp caps on existing 554 Series units. Seven cap colors and three LED color options give a choice of 21 color combinations. In addition, caps can have hot-stamped or engraved legends. Current-limiting resistors are built into the caps for operation at 5 V dc, 15 mA.

CIRCLE NO. 397

μP crystal line covers 1 to 48 MHz



Bulova Electronics, 61-20 Woodside Ave., Woodside, NY 11377. Bob McComb (212) 335-6000. $6.00 to $11.75; stock to 6 wks.

Type BU quartz crystals cover from 1 to 48 MHz. The crystals are AT cuts and packaged in hermetically sealed HC-18 holders. Low-frequency units are available also in the HC-33 holders. Frequency tolerance is ±0.0005% at 25 C and stability from −20 to 75 C is ±0.003%.

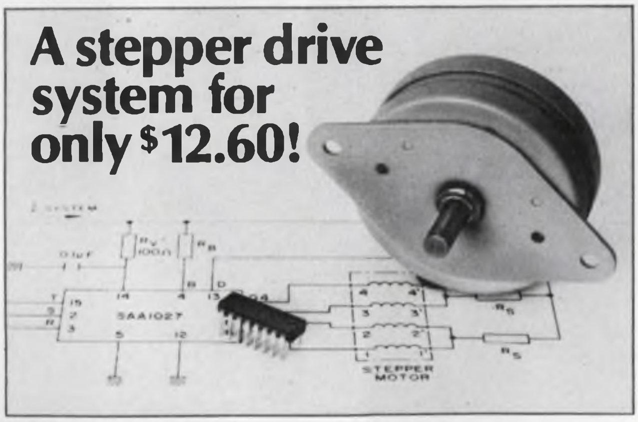
CIRCLE NO. 398

Pushbutton switches sealed in rubber boots

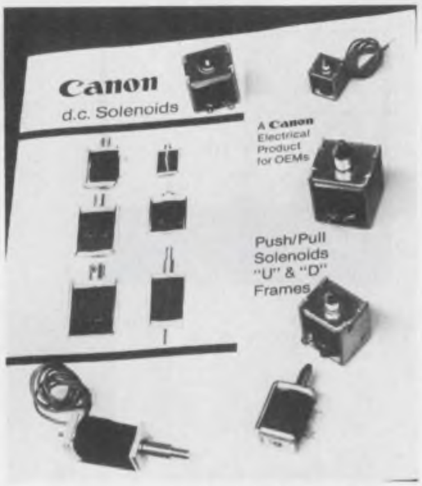
Standard Grigsby, 920 Rathbone Ave., Aurora, IL 60507. (312) 844-4300. $0.25.

TL360 miniature pushbutton switches are completely sealed in silicone-rubber boots that prevent contact contamination by water, oil and dust and fluids during cleaning. Just 0.16 × 0.36-in diameter, the switches mount easily on PC boards.

CIRCLE NO. 399



Linear solenoids use 1.7 to 14.5 W



Canon USA, 10 Nevada Dr., Lake Success, NY 11040. Phil Spector (516) 488-6700. $0.67 to $5.00; stock to 10 wks.

A line of 20 models of linear solenoids with maximum continuous power ratings from 1.7 to 14.5 W are available in push, pull or push-pull versions. Both C and D frames are included. Max force ratings at rated power range from 0.30 kg to 7 kg and up to about 13 kg at 10 times rated power for intermittent duty. Stroke length in the largest standard unit is 1.25 in.

CIRCLE NO. 403

Time-delay relay has delayed-on mode

Master Electronic Controls, P.O. Box 25662, Los Angeles, CA 90025. Shirley Wilkerson (213) 393-3177. $25.40 (100 qty); stock.

The D10 and D11 solid-state time-delay relays provide a delayed-on mode of operation with fixed, local and remote-adjustable time ranges from 100 ms to 1800 s. Available input voltage ratings are 24, 48, 115, 230 V ac and 12, 24, 48, 110 V dc. Voltages may vary ±10%. The timers feature polarity and false-output transfer protection. Repeat accuracy is as high as ±1%.

CIRCLE NO. 404

Low-pass audio filters allow choice of specs

Sprague Electric, 347 Marshall St., North Adams, MA 01247. (413) 664-4411.

Series JW33-4000 low-pass audio filters are available in a choice of attenuation characteristics (Cauer or Chebyshev), cut-off frequencies (1 to 50 kHz), and operating impedances (250 to 10,000 Ω). The filters mount on PC boards on 0.2-in. centers. The max seated height is 0.562 in. Hermetically sealed cases prevent crosstalk and unwanted pickup, and allow operation under extreme environmental conditions.

CIRCLE NO. 405

Large LED display readable at 33 ft

Hewlett-Packard, 1507 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $1.80 (1000 qty); stock.

HDSP-3400 series, 0.8-in. numeric displays are readable in bright light at distances to 33 ft. Made from GaAs phosphide, these LED displays come in standard 0.6-in. DIPs that mount on PC boards or plug into standard IC sockets. Models in the series include the 3400 with a common-anode left-hand decimal; the 3401 with a common-anode right-hand decimal; the 3403 with a common-cathode right-hand decimal; and the 3406 with a universal overflow (±1) right-hand decimal.

CIRCLE NO. 406

Solid-state relay boasts 10^{12} operations

Solid State Electronics, 15321 Rayen St., Sepulveda, CA 91343. Ed Politi (213) 785-4473.

The Model SSR-1285-5050 solid-state relay has no moving parts and is capable of over 10^{12} operations. "Contact" rating is 50 V, 50 mA; actuation time is 2 μs and dropout time is 5 μs. Actuation frequency can be as high as 50 kHz. The relay is epoxy encapsulated and operates from −55 to 125 C.

CIRCLE NO. 407

Stackpole Ceramag® gives you more of what you buy an inductor core for.

Transformer designs a la Stackpole toroids
Contain no air gaps or efficiency voids.

Need a good Q? Check our cups and our pots.
They'll adjust to your problems, be they ohms, hertz or watts.

Stackpole ferrite cores, both U and E,
Can take lots of power with a high Curie.

Three vowels to remember: Ceramag E's, U's, and I's
For fluorescent light ballasts and switched mode supplies.

Our sleeves, baluns, beads help to shut out the sound
From extraneous EMI that is buzzing around.

Stackpole ferrite slugs give car radios strength.
If you're into perm tuning, we're on your wavelength.

And speaking of autos, you will never be sore
Knowing ferrite core sensors watch your carburetor.
Showing up "EGR" on your auto dashboard.

When it comes to TV's, we've got quite a selection.
From CRT circuits for info collection
To round ferrite yokes for TV deflection.

For adjustable tuning and good Q circuitry,
Stackpole threaded cores offer just what you need.
And without even costing an arm and a knee.

If you'd like to devise a test for your peers,
Our name and address are featured right here.
We'll send you our folder to make it all clear
And we never would give engineers a bum steer.
So send us your name and where you are near.

We'll get back to you and we're sure you'll be pleased with our Ceramag Bulletin 59-103.

Stackpole Carbon Co.
Electronic Components Div.
St. Marys, Pa. 15857

CIRCLE NUMBER 118

Ceramag. The right ferrite. STACKPOLE

Rotary switches qualify under MIL-S-3786

Cole Instrument, 2034 Placentia Ave., Costa Mesa, CA 92627. Phil Hanson (714) 642-8080.

Type 3600 1-in. enclosed rotary switches are fully qualified under MIL-S-3786. Up to twelve decks of switching are available. Each deck can have one to six poles per deck with 30, 36 or 45-degree steps and 8, 10 or 12 positions. Both shorting and nonshorting contacts that handle 6 A can be combined in the same deck.

CIRCLE NO. 408

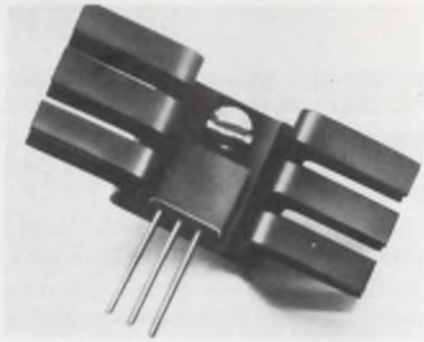
Surge shunts protect solid-state devices

Morel International, 21583 Castleton St., Cupertino, CA 95014. (408) 257-2414. $0.39 to $0.42 (OEM).

Carbon-film surge-shunt protectors have a discharge lag of less than 0.1 μs when installed across ac input lines. They protect solid-state devices from damage by lightening or high-voltage surges. The protectors can be supplied for high-voltage surges from 180 to 3000 V. For 120-V-ac operation, the shunts are made to arc over at 205 V. They withstand 2000-A impulse currents. Their glass capsules, filled with inert gas, are 5.5-mm diameter by 2-mm long.

CIRCLE NO. 409

Heat sinks fit plastic SCRs and transistors

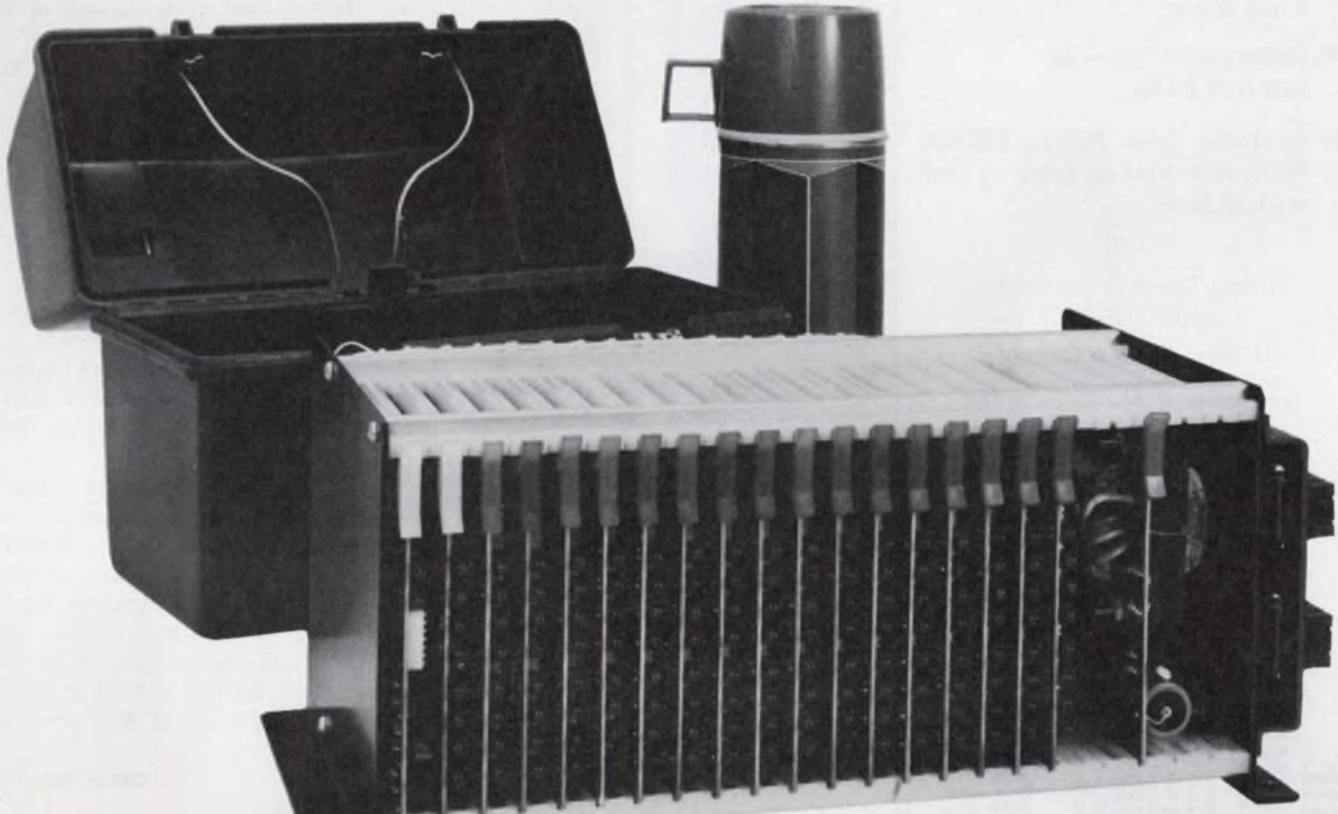


Aavid Engineering, 30 Cook Court, Laconia, NH 03246. (603) 524-4443. Free samples; stock.

A series of low-profile heat sinks for cooling plastic power SCRs and transistors is adaptable for use on PC boards with 0.5-in. spacing between boards. Part numbers 5070 and 5072 have a total height of 0.375 in. Part number 5071 is for high-power use and can be used with either the 5070 or 5072 heat sinks as a cap to provide double-sided cooling of TO-220 devices.

CIRCLE NO. 410

The IMP* Controller: It doesn't take breaks, It gives them.



Patented

The IMP gives you a break on initial cost, economically accommodating systems from 8 to more than 500 I/O's. It gives you a break in performance too, handling control functions not normally associated with programmable controllers. IMP incorporates patents to give you additional breaks on reliability—more than any other controller. And, if service is necessary, IMP gives you more good breaks. It can be demounted in minutes. Modular circuit boards are interchangeable and they simply plug in, as does the power supply. Your local ASI representative has spares on hand. Give yourself a break by contacting us today. Write or call and we'll see you get all the facts.

*Industrial Modular Programmable

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AUTOMATION SYSTEMS, INC.

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CIRCLE NUMBER 121

Mini power relay switches 15 A

Omron Electronics, 233 S. Wacker Dr., Chicago, IL 60606. Don Nelson (312) 876-0800. $8.30 to $9.90; stock.

Model G2H miniaturized power relays meet UL and CSA standards for switching high-capacity ac loads. Rated at 240 V ac with resistive loads of 15 A or inductive loads of 10 A, the relays have DPDT contacts. The units are enclosed in transparent polycarbonate-resin cases and are equipped with an arc barrier that provides a dielectric strength of 2000 V at 50/60 Hz for 1 min.

CIRCLE NO. 411

Photo scanner detects material at a distance

MEKontrol, 56 Hudson St., Northboro, MA 01532. Dean Percival (617) 393-2451. $134 (qty discount); stock.

LED proximity scanner, MEK-55-SC85, doesn't need a reflector, but still detects any material at a distance. Its small size—only 3.25 × 3.8 × 1 in.—makes it easily mountable. The sensor is immune to electrical noise and ambient-light and uses a phase-locked-loop circuit built into the amplifier. A choice of plug-in output and timing modules is available.

CIRCLE NO. 412

Yellow LED arrays readable in sunlight

Plessey Optoelectronics & Microwave, 1641 Kaiser Ave., Irvine, CA 92714. R.G. Millett (714) 540-9934.

The GPD 420 family of GaP solid-state LED arrays are legible in 100,000-lux (lm/m^2) light levels (equivalent to illumination from direct sunlight above clouds). The displays consist of four, seven-segment digits, each 4-mm high, mounted in a hermetically sealed package. Typical LED intensity is better than 2 mcd at a current of 20 mA/segment.

CIRCLE NO. 413

Mini toggle switch mounts on PC boards

Alco Electronic Products, 1551 Osgood St., North Andover, MA 01845. Clem Czapinski (617) 685-4371. $1.20 (100 qty).

A family of miniature toggle switches for use on PC boards can withstand flow-soldering temperatures. Four types are available: upright PC with silver or gold contacts; right-angle PC with side toggle motion; and vertical right-angle types with up-down action. Ratings are 5 A at 125 V ac (silver) or 0.4 VA at 20 V ac or dc max.

CIRCLE NO. 414

Single/dual-element pots are side actuated

Carter Mfg., Sugar Rd., Bolton, MA 01740. (617) 779-5501. $10 up; stock.

Series ST477 single and dual-element plug-in wirewound potentiometers are side-actuated and housed in polycarbonate cases. They can be stacked on 1-in. centers and are supplied with matching receptacle boards. The pots have 3-in.-stroke slider action. Resistance values to 100 kΩ are available in a 0.5-W rating, with or without switch and pilot lamp. Basic size is 1 × 0.875 and 6.25 or 4.5 in. long. A pilot lamp provides lighting for the strip.

CIRCLE NO. 415

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CIRCLE NUMBER 123

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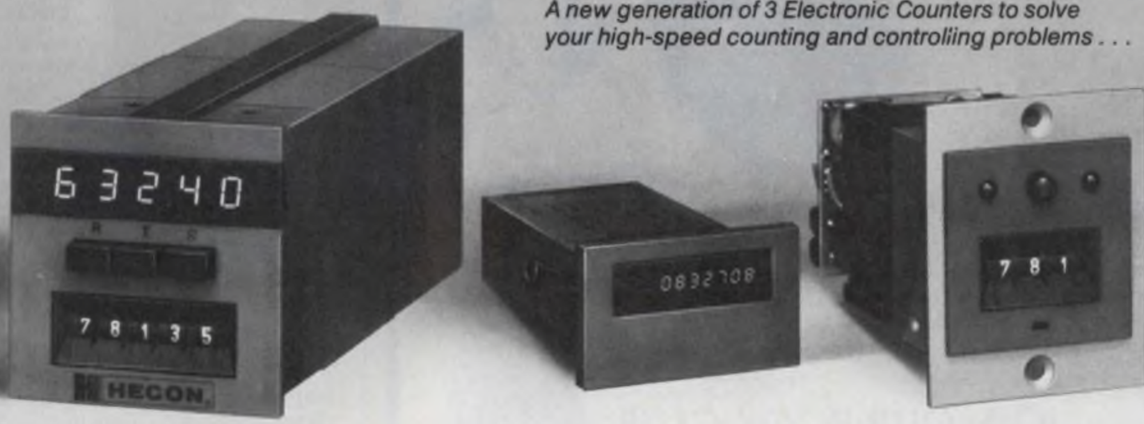

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Your Hecon Distributor is listed in the Yellow Pages under Counting Machines.

CIRCLE NUMBER 124

Floppy-disc system uses IBM 3740-type diskettes

Sykes Datatronics, 375 Orchard St., Rochester, NY 14606. Bruce Paton (716) 458-8000. See text.

Comm-Stor II is a communications floppy-disc system that uses IBM 3740-compatible diskettes and interfaces with all RS-232 communications devices. The system is μP-based, enabling the user to store and retrieve files by file source. Variable length files give increased file storage capacity and maximum usage of the diskette. Merging files provide the capability of merging and creating new files composed of existing files. The system provides buffering at the terminal and/or modem port to allow commands and data to be stacked. A single drive system lists at about $3000 and a dual system at about $4000.

CIRCLE NO. 416

Mini-controller expands from 1 to 8 displays

Trivex, 3180 Red Hill Ave., Costa Mesa, CA 92626. R.J. Martin (714) 546-7781. $3950; 6 to 8 wks.

The Model 0712M is a minicontroller that is expandable from one to eight displays and is plug-compatible with IBM's 3271 remote controller. The system operates up to 19.2 kbaud at switch-selectable speeds. The Model 0772M display, used to expand the 0712M cluster, features self-test, OCR wand, light pen, prompting line, cursor position indicator, local display to print, upper and lower case, character indicators in unprotected fields and a 10-key numeric pad.

CIRCLE NO. 417

Multiuser computer has 1-Mbyte memory

Data General, Route 4, Westboro, MA 01581. Howard Steiner (617) 366-8911. $160,000 to $395,000.

The M/600 computers contain semiconductor memory capacity up to 1 Mbyte and a demand paging facility to optimize memory use in large on-line applications. A three-level I/O management system features an independent I/O processor with 64 kbytes of local memory, a standard data channel and a burst multiplexer channel with a 10-Mbyte/s transfer rate. The I/O management system provides hierarchical control for low, medium and high-speed peripherals. A typical system would include 512 kbytes of main memory, 4 Mbytes of fixed-head disc storage, 760 Mbytes of disc file storage, two 9-track 1600-bits/in magnetic tape drives, a 600-line/min printer, a 600-card/min card reader, synchronous communications and 32 terminals.

CIRCLE NO. 418

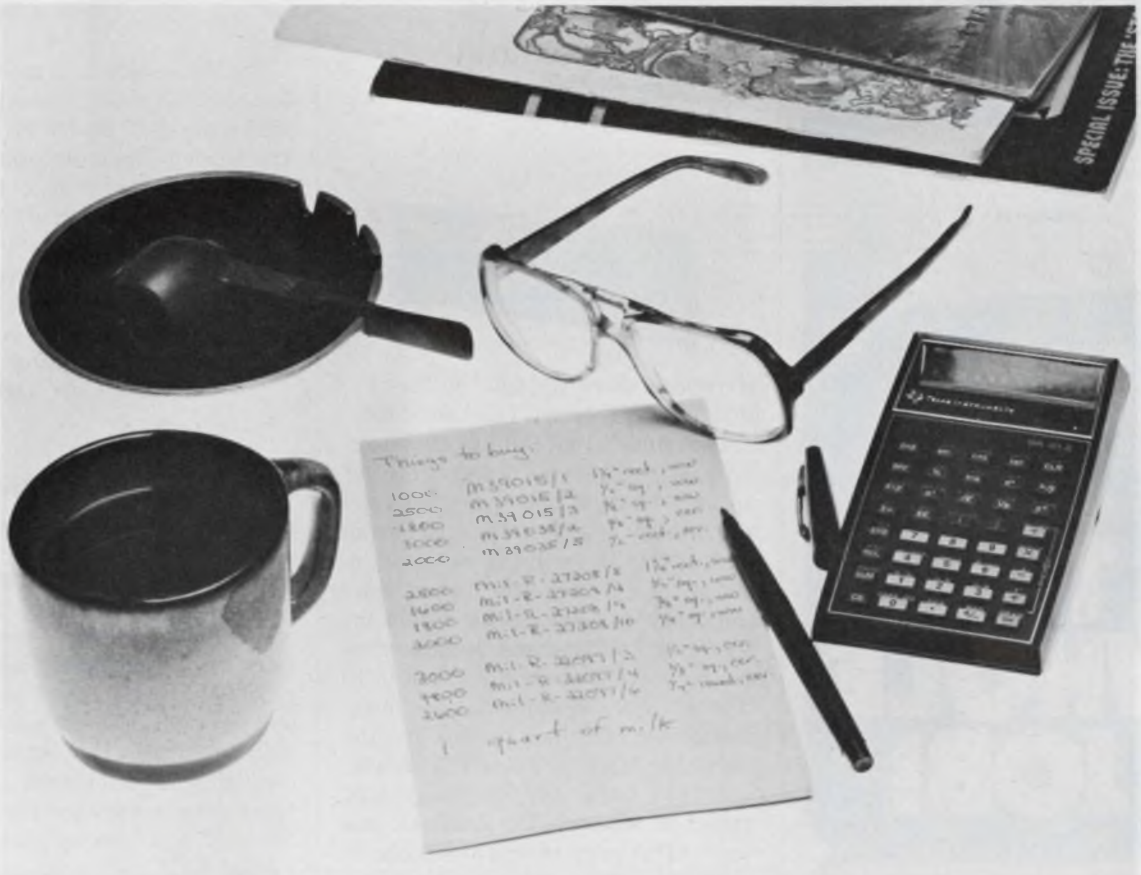
Modem originates and auto answers

U.S. Robotics, P.O. Box 5502, Chicago, IL 60680. (312) 528-9045. $160 to $195; stock.

The USR-300 series of originate and auto-answer modems operate asynchronously, full or half duplex at data rates up to 300 baud. The stand-alone modems are compatible with the Bell 103 and 113 lines. Connection to the public telephone network requires a CBS-1001F data-access arrangement (DAA).

CIRCLE NO. 419

Specifier's QPL Shopping List.



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RTR24	M39015/3	L.P.W.X	⅜" Square, Wirewound
RJR24C,F	M39035/2	P.W.X	⅜" Square, Cermet
RJR28C	M39035/5	P	½" Rectangular, Cermet
RT12C2	Mil-R-27208/8	L.P.Y	1¼" Rectangular, Wirewound
RT22C2	Mil-R-27208/4	L.P.W.X	½" Square, Wirewound
RT24C2	Mil-R-27208/9	L.P.W.X	⅜" Square, Wirewound
RT26C2	Mil-R-27208/10	P.W.X	¼" Square, Wirewound
RJ22C	Mil-R-22097/3	L.P.W.X	½" Square, Cermet
RJ24C,F	Mil-R-22097/4	L.P.W.X	⅜" Square, Cermet
RJ50C	Mil-R-22097/6	P	¼" Round, Cermet

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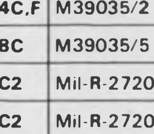
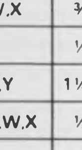
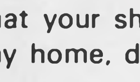


RTR12

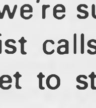


RTR22

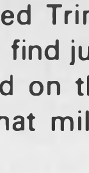
RTR24



RT22C2



RT26C2



RJ50C

CIRCLE NUMBER 132

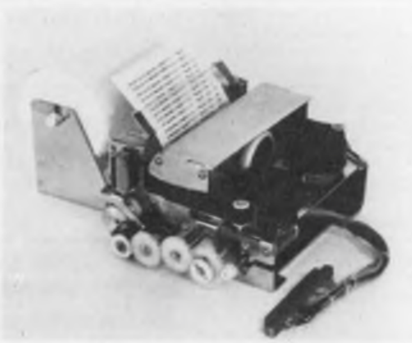
Modems operate in satellite FM systems

American Modem, 160 Wilbur Pl., Bohemia, NY 11716. (516) 567-6800.

The Model 1260 QPSK data-over-voice or group-band modems are for use in terrestrial microwave links and satellite FM systems. The modems interface directly with the baseband input of the FM above the highest voice frequency or at any place within the operating FM baseband. Data services can be provided from 1.2 kbaud to 10 Mbaud. The equipment has interchangeable interface options for the use of RS-232, Bell 303 or V35 devices. Operating modes are full duplex, half duplex or simplex. The transmit and receive frequency ranges are 60 kHz to 50 MHz with a minimum carrier-to-noise ratio of 14 dB.

CIRCLE NO. 420

Journal printer yields 3 lines/s on 40 columns



C. Itoh Electronics, 280 Park Ave., New York, NY 10017. (212) 682-0420. $225.

The Model 512 serial-entry dot-matrix printer prints 3 lines/s on 40 columns. The character set is 64 ASCII. The print-out is 3.5-in. wide friction-fed fan-folded or rolled paper, inked by ribbon or impact. The size is 6 × 7 × 9.6 in.

CIRCLE NO. 421

Modem mounts directly into teletypewriter

Omnitec Data, 2405 S. 20th St., Phoenix, AZ 85034. (602) 258-8244. $625; stock.

The Model 4500 data modem mounts directly into a teletypewriter and replaces the Bell Model 101C data set. The modem operates over the DDD telephone network at a rate of 110 baud. The principal mode of operation is two-wire, half-duplex over the dial network. The unit interfaces to the telephone line via a DAA type CBT and provides full auto/answer capability for unattended operation.

CIRCLE NO. 422

Interactive software creates business reports

Control-Data, Box O, Minneapolis, MN 55440. Ken Thompson (612) 853-3053.

IPS Report Writer is an interactive software package that allows simple reports to be generated quickly using only a few basic terminal commands. More sophisticated reports can be created with mimimum effort. Features include command file processing, "what if" and "look up" commands and virtual field and scroll report-writer processing functions.

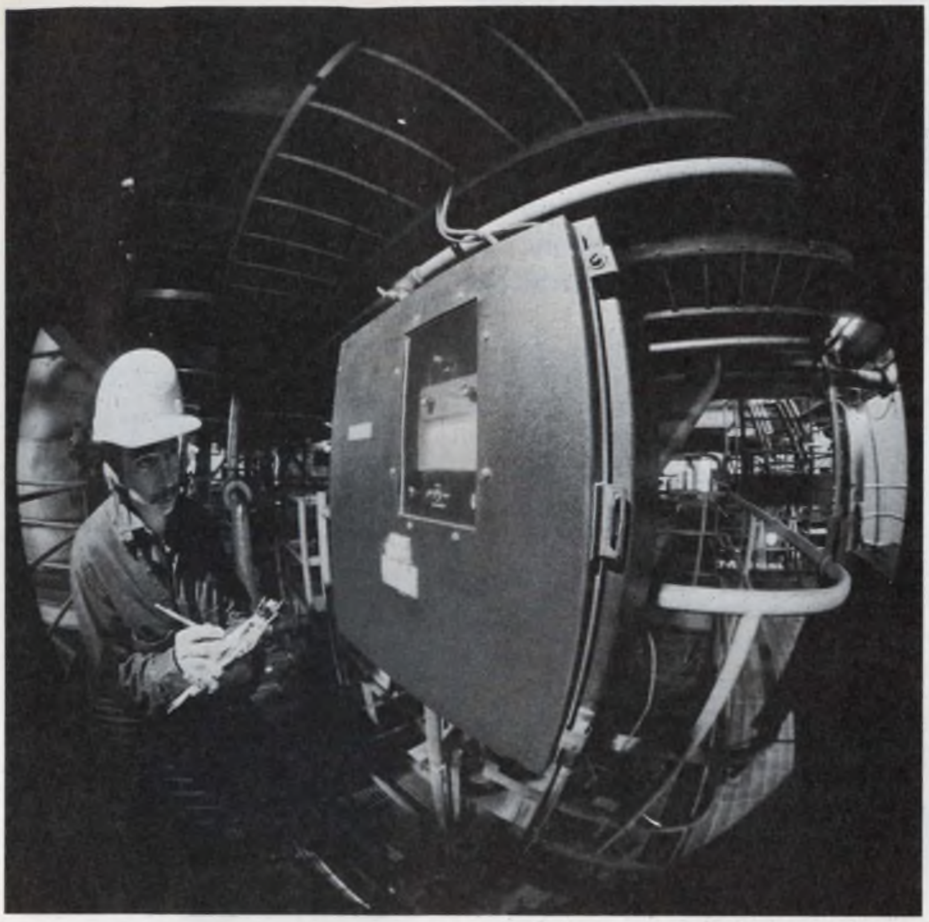
CIRCLE NO. 423

Software lets OS/8 talk to remote computers

Menlo Computer Associates, 801 E. Charleston, Palo Alto, CA 94303. (415) 494-3170. See text.

CMU, a software product, permits communications between two OS/8 systems and provides a method for the system to reduce time-sharing service charges. CMU provides full duplex bidirectional terminal communications as well as real-time reception and transmission of OS/8 files with a time-sharing mainframe or another mini-computer. It operates with all PDP-8 systems as well as the PDP-12 and the DECstation-78. All that is required is a minimal OS/8 operating system and an interruptible device handler. The software allows an OS/8 system to perform like a remote terminal with local storage and editing capabilities. The single-system binary license costs $350, and the binary and source license costs $700.

CIRCLE NO. 424



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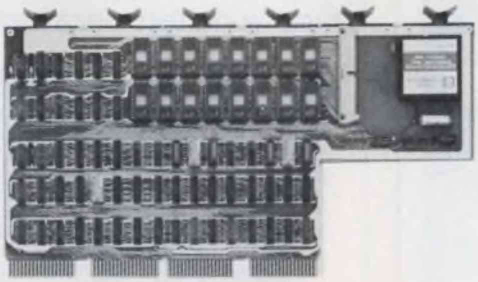
THE RMP-116 INTRODUCES A NEW DIMENSION TO SOLID STATE SOFTWARE FOR THE PDP-11



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CIRCLE NUMBER 135

Switchers yield four independent outputs

Gould, 4601 N. Arden Dr., El Monte, CA 91731. (213) 442-7755. $695.

The Model MGQ-300 offers switching-regulated isolated outputs of +5 V at 30 A, −5 V at 5 A and ±15 V at 2 A. Overvoltage and current protection are provided on all outputs. All outputs remain within voltage regulation at full load for 28 ms after the removal of nominal line voltage. The size is 12.25 × 3.9 × 7.5 in.

CIRCLE NO. 427

Regulated supplies work over wide temperatures

Tecnetics, P.O. Box 910, Boulder, CO 80302. Vern Garrison (303) 442-3837. $200 to $365.

The Type 400 compact, low-power, encapsulated, ac to dc regulated power supplies operate at a baseplate-temperature range of −55 to 100 C. Included in the line are units with 3, 6, 10, 15 and 20-W outputs, each with single, dual or triple outputs. Input voltage is 115 V, 400 Hz, single phase per MIL-STD-704A. Regulation is 30 mV, line plus load. The use of military-type parts yields 70,000-h MTBF.

CIRCLE NO. 428

A/d converter delivers high accuracy

Phoenix Data, 3384 W. Osborn Rd., Phoenix, AZ 85021. Srini Iyer (602) 278-8528. $2190; 8 to 12 wks.

The Model ADC 1215L analog-to-digital converter has an accuracy of ±0.004%, a 5.5-μs conversion time, 15-bit binary output resolution and ±0.002% linearity. The a/d converter requires no external reference voltage. Power consumed is 2.2 W. The size is 5 × 4.5 × 0.92 in.

CIRCLE NO. 429

Data acquisition units come in matched pairs

ILC Data Device, Airport International Plaza, Bohemia, NY 11716. (516) 567-5600. $255 (amplifier), $310 (converter); stock to 8 wks.

A matched pair of 8-bit data-acquisition components consists of a hybrid video sample-and-hold amplifier, SH-8518, and a hybrid a/d converter, ADH-8512. The pair is capable of word rates up to 900 kHz. The SH-8518 has a 25-ns acquisition time, a 60-ps aperture uncertainty and a 20-MHz sampling rate. Linearity error is 0.05% and droop rate is 1 mV/μs. The ADB-8512 employs successive approximation with linearity of ±0.2% and a conversion time of 1 μs.

CIRCLE NO. 430

Op amp in DIP has low offset

Precision Monolithics, 1500 Space Park Dr., Santa Clara, CA 95050. Don Soderquist (408) 246-9222. $3.25 (100 qty); stock.

The OP-07CP op amp, housed in a plastic DIP, maintains an input-offset voltage below 250 μV over an ambient range of 0 to 70 C. Max long-term input-voltabe drift is 2 μV. Input noise voltage is 0.65 μV from 0.1 to 10 Hz.

CIRCLE NO. 431

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H8 Kit $375.00

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Heathkit computers are designed to fit right into your home. No matter what your computer application, we have the unit for you. Our H8 is an 8080A-based machine with an "intelligent" front panel that is ideal as a programming trainer and instruction tool. The powerful H11 is based on the most successful commercial computer in the world, the Digital Equipment Corporation® PDP-11. These two computers, along with a complete line of peripherals and I/O devices, make Heath your home computing system headquarters.

Heathkit computer systems provide the documentation you need to get up and running right – complete step-by-step assembly manuals, comprehensive operating procedures and complete and thorough rundowns of software programs. What's more, Heathkit computer systems include the systems software you need to start programming right away. The H8 includes a front panel monitor program, Benton Harbor BASIC, assembly language, text editor and console debugger. The H11 includes editor, relocatable assembler, link editor, absolute loader; debug, executive and dump programs plus BASIC and FOCAL.

Heathkit computer systems are designed to give you home computing at its very best. And since they're backed by Heath's 54-year reputation for honesty, reliability and quality, you know that a Heathkit computer system is one of the best investments you can make!

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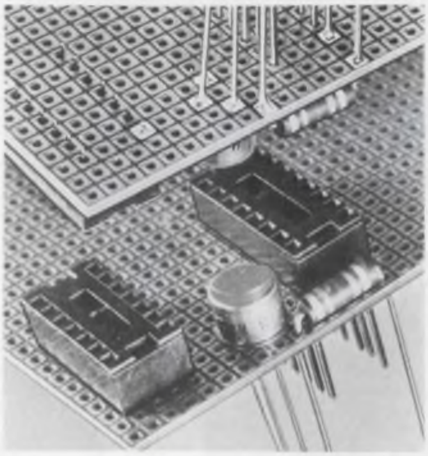
CIRCLE NUMBER 141

Large-area boards take DIPs and irregular pins



Vector Electronic, 12460 Gladstone Ave., Sylmar, CA 91342. Floyd Hill (213) 365-9661. $9.96 to $19.95; stock.

A family of large-area "pad-per-hole" plugboards permit breadboarding of either custom circuits or S-100 bus-compatible boards. All boards have an isolated array of square solder pads surrounding 0.1-in. spaced holes. Two are made without card-edge connectors and may be cut to any desired shape. The 45P80-1 is 4.5 × 8.08 in.; the 106P106-1 is 10.6 × 10.6 in. Model 8801 is compatible with the S-100 bus system, accommodates DIP devices, modules and discrete components. All boards accept DIP packages from 8 to 64 leads as well as special modules with leads spaced on irregular multiples of 0.1 in.

CIRCLE NO. 432

Epoxy bonds optic fibers, has thermal stability

Epoxy Technology, 14 Fortune Dr., Billerica, MA 01821. (617) 667-3805. $16.60 (1-lb kit); stock.

Epo-Tek 330 is a two-part epoxy formulated for bundling optic fibers. Thermal stability results in less than 5% weight loss at 300 C. At 2.65 microns, spectral transmission is 84.9% with a 0.0015-in. sample thickness. Pot life is 8 h and the curing cycle is 5 min. Curing is indicated by a change in color from clear amber to bright red.

CIRCLE NO. 433

Edge connector allows removal of contacts

Methode Electronics, 1700 Hicks Rd., Rolling Meadows, IL 60008. (312) 392-3500.

Term-Acon Series 1500 card-edge connectors provide 0.1-in. centers cable-to-board interconnects and allow field contact removal or replacement. The connectors' crimp contacts are rated at 3.5 A and accept board thicknesses of 0.062 in. Connector housing material is 94V-2 or 94V-0. Polarizing features, with or without strengthening flanges for extended PC boards, are available.

CIRCLE NO. 434

Teflon TO-5 socket installs with 1/4 turn

Sealectro, Mamaroneck, NY 10543. G. Antonion (914) 698-5600. $0.72 (100 qty); stock to 8 wks.

A Teflon-insulated transistor socket, P/N 027-1700, for four-lead TO-5 transistors installs with only a 1/4 turn in an unchamfered "D" hole in a 0.02 to 0.06-in.-thick chassis.

CIRCLE NO. 308

Fiber-optic cable uses single large core

Valtec, West Boylston, MA 01583. Rich Cerny (617) 835-6082. $1/meter; stock.

The general-purpose fiber-optic communication cable, PC10, consists of a single, large-core silica fiber clad in a rugged plastic dielectric jacket. The cable can be used for high-bandwidth optical transmission over distances ranging from a few centimeters to 2 km. The maximum cable attenuation is 20 dB/km at 800 nm. Pulse spreading is 40 ns/km. Over-all diameter is 4 mm.

CIRCLE NO. 435

Kit mounts TO-220 devices

Thermalloy, 2021 W. Valley View Lane, Dallas, TX 75234. (214) 243-4321. $0.098 (10,000 qty); stock.

Type 4880 mounting kit for TO-220 devices provides fast, uniform mounting and maximizes thermal performance. Mounting hardware includes a stainless steel 4-40 nut, lock washer, flat washer and 4-40 × 1/2-in. screw. In addition, a polyphenylene-sulphide shoulder washer is provided to fit inside the device tab to electrically insulate the device from the mounting screw. A plastic film provides electrical insulation as well as low thermal resistivity (2.25 C/W).

CIRCLE NO. 436

Desolder connections with vacuumized wick

Multicore Solders, Westbury, NY 11590. (516) 334-7450. Stock.

A vacuumized wick for desoldering has improved capillarity and shelf-life. The vacuumization technique deoxidizes the copper braid while applying a smooth, adhering coating of noncorrosive flux. To use, place the wick on the connection and apply the soldering iron to the wick. The solder is absorbed almost instantly. Wicks are available in 1/16, 3/32, and 1/8-in. widths, on plastic dispenser spools each 66 in. long.

CIRCLE NO. 309

Circular connector mates blindly

ITT Cannon Electric, 666 E. Dyer Rd., Santa Ana, CA 92702. R.L. Harmon (714) 557-4700. See text; 15 wks.

The KJL miniature circular connector has a "scoop-proof" feature that eliminates the possibility of contact damage in blind mating use. The connector meets MIL-C-38999 and operates from −65 to 200 C. As many as 58 crimp snap-in contact arrangements take from 3 to 128 contacts in wire sizes 16 through 28. Contacts are of high-conductivity copper alloy with a gold-plated finish. The price of a mated pair (type OF shell) 5-contact plug and receptacle is $45.54 in lots of 50.

CIRCLE NO. 437

WE KNOW A LOT ABOUT A LITTLE.

Silicon-iron alloys, for instance.

Magnetics offers you fast delivery on silicon-iron alloy coils in 1- to 7-mil thicknesses, either coated or uncoated. And we're the only source for 5- and 7-mil nonoriented types. You can count on them for uniformity in magnetic properties —in fact, we make and use them for our own magnetic devices, so they have to be right. In widths to 15".

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Magnesil materials provide low core losses.

Very special specialists in specialty alloys.

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A DIVISION OF SPANG INDUSTRIES INC

CIRCLE NUMBER 142

WE KNOW A LOT ABOUT A LITTLE.

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When it comes to tape wound cores, we offer thousands of choices—900 sizes, eight materials, seven gauges. Our Supermalloy tape cores feature high permeability and low loss for such applications as precision current and ratio transformers, high-perm inductors, bridge lifters, etc.

We also make bobbin cores from Permalloy 80 and Orthonol® ultra-thin tape. These cores are wound on nonmagnetic stainless steel bobbins, with core diameters down to 0.050".

For more information on tape or bobbin cores, write Magnetics, Components Division, Butler PA 16001.

In addition to catalog items, we offer a custom core service.

Very special specialists in tape wound cores.

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CIRCLE NUMBER 143

FOR INFORMATION CIRCLE NUMBER 144 ▶
FOR INFORMATION AND DEMONSTRATION CIRCLE NUMBER 145 ▶

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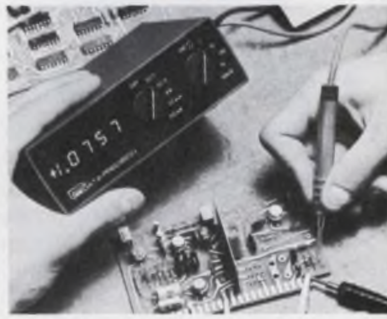

No other 4½-digit portable multimeter gives you 10μV DC and AC sensitivity, True RMS AC voltage and current measurement along with unsurpassed ±0.05% basic DC accuracy, guaranteed for one year—in a truly portable, easy-to-read instrument.

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DC Volts ±10μV to ±1KV,
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Extras Included
You also get these standard accessories: a rechargeable NiCd battery module, a pair of test leads, line cord with charger, carrying case, and full instruction manual and test data. A full range of optional accessories is also available.

Price: $295* complete.
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New literature

Test instruments

A 20-page catalog features test instruments, including frequency counters, universal counter-timers, digital volt/multimeters, sweep generators, spectrum analyzers, microwave components and a new instrumentation controller for IEEE bus applications. Systron-Donner, Concord, MA

CIRCLE NO. 441

PROM matrix

A compact, space-saving, programmable-read-only-memory matrix for switching, testing and programming applications is described in a catalog from the Programming Devices Division. Sealectro, Mamaroneck, NY

CIRCLE NO. 439

Microwave components

A storehouse of standard and custom components for microwave and electronics engineers, designers and specifiers is detailed in a revised and updated 40-page handbook. Premier Microwave, Port Chester, NY

CIRCLE NO. 440

Snap-action switches

Operating and dimensional data on hermetically and resiliently sealed snap-action switches are given in a 16-page catalog. Haydon Switch & Instrument, Waterbury, CT

CIRCLE NO. 438

Indicator lamps and LEDs

Descriptions of LEDs, lamps, lampholders and indicators are included in an 88-page catalog as well as the company's complete line of products. Mouser Electronics, Lakeside, CA

CIRCLE NO. 442

Centrifugal blowers

An 84-page catalog describes an extensive range of centrifugal blowers. The catalog also contains sections on technical notes and standard connection diagrams. IMC Magnetics, Westbury, NY

CIRCLE NO. 443

Rectifiers

Over 1600 rectifiers, rectifier assemblies, zener voltage regulators, high-voltage rectifiers, Klipvolt surge suppressors and selenium rectifiers are covered in a 20-page catalog. ST-Semicon, Bloomington, IN

CIRCLE NO. 444

7-1/2 digit DVM

A 7-1/2 digit precision digital voltmeter that is the only DVM with a displayed scale length of 14-million counts is the feature of an 18-page catalog, whose full-color photos highlight each function and control. Guildline Instruments, Elmsford, NY

CIRCLE NO. 445

Open-frame switchers

Photos, dimensional drawings, features, and specifications on open-frame switchers are included in a catalog. LH Research, Irvine, CA

CIRCLE NO. 446

Connectors

A 40-page catalog describes miniature PC-card and cable-to-cable connectors. Featuring a graphic-selector chart, the catalog offers designers photos of actual application-board mountings as well as line drawings, dimensional and specification charts. Methode Electronics, Rolling Meadows, IL

CIRCLE NO. 447

Assembled instruments

An entire line of electronic test instrumentation is covered and displayed in a 32-page catalog, which carries complete listings of oscilloscopes, laboratory-grade strip and X-Y recorders, power supplies, various signal and function generators, counters, a full line of multimeters (analog and digital), and a complete selection of associated accessories such as probes and interconnecting cables. Heath, Benton Harbor, MI

CIRCLE NO. 448

Power FETs

The VMOS Power FET brochure covers general VMOS power FET benefits, markets and new design possibilities previously not achievable with bipolar transistors. It works in conjunction with the VMOS Power FET Design Catalog consisting of a device/application selector, data sheets, geometry characteristics, application notes and design aids. Siliconix, Santa Clara, CA

CIRCLE NO. 449

Transistors

More than 1000 types of transistors are covered in a 28-page catalog. Kertron, Riviera Beach, FL

CIRCLE NO. 450

Electronic kits

Nearly 400 electronic kits and products are featured in a 104-page catalog. Heath, Benton Harbor, MI

CIRCLE NO. 451

12-bit data acquisition

Two complete 12-bit data-acquisition systems, one with eight differential-input channels and one with 16 single-ended input channels, are presented in an eight-page brochure. Datel Systems, Canton, MA

CIRCLE NO. 452

Automatic testing

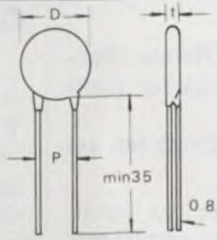
A 12-page brochure describes computerized automatic test equipment for functional testing of loaded printed-circuit boards, electronic assemblies, and electromechanical devices. S.I.R. Atlanta, Atlanta, GA

CIRCLE NO. 453

QUALITY FABRICATION

Zenamic
(Metal Oxide Varistor)

This varistor is fabricated from Metal Oxide and mainly use for absorption of lightning surge, protection of all varieties of semi-conductors, suppression of switching surges and contactor protection. Following types are available.



Type No	Z7L	Z10L	Z15L	Z21L
D	Max10	Max13	Max18	Max24
t	Max 8	Max 8	Max 8	Max 9
P	6.8	8.3	8.3	10.8

Z 10 L 221

Zenamic — Element diameter — Lead type — Zenamic voltage

Code	Diameter	Surge Current
7	7φ	8 × 20μ Sec 250A
10	10φ	500A
15	15φ	1000A
21	21φ	2000A

22V at 1mA
120V ±15%
150V at 1mA
1000V ±10%

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TYPE OF
Glass tubular capacitors, temperature range of —50° to 85° C, offer continuous operation at 85° for 10,000 hours. Standards thru 60 KVDC.

TYPE LK
CP70 style. Unusually good electrical characteristics in a very small unit. Used for filters, bypass and coupling. Temperature range, —55° to 105° C, 10,000 hours life at 85° C. Standards thru 50 KVDC.

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Frequency Response Analyzers For Every Application

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Take the low-cost, easy-to-use Model 1312. It's ideal for production testing and basic measurements of phase and amplitude to 20 kHz. Or choose the Model 1410, the full capability, single-channel instrument that has become the industry's standard for most engineering applications. Then there's the Model 1172, the ultimate Frequency Response Analyzer featuring all-digital signal processing, fully-isolated dual measurement channels and a computer-type keyboard entry. With the Model 1180 Plotter Interface, you can plot Bode, Nyquist, or Nichols diagrams with a conventional analog XY recorder.

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SANGAMO WESTON
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CIRCLE NUMBER 148 ▶

Vendors report

Annual and interim reports can provide much more than financial position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

Gulf + Western. Manufacturing, natural resources, consumer and agricultural products, apparel, financial services, leisure time, automotive replacement parts and paper and building products.

CIRCLE NO. 459

Dataram. Core memories.

CIRCLE NO. 466

Cubic Corp. Defense electronics, mass transit, elevator industry/electronic controls, two-way radio communications and medical/industrial equipment.

CIRCLE NO. 460

Youngwood Electronic Metals. High-precision metal stampings for semiconductor components.

CIRCLE NO. 461

Penril. Data-communications equipment, digital panel meters, test instruments and power supplies.

CIRCLE NO. 462

Computer Communications. Equipment and systems for the processing and switching of data.

CIRCLE NO. 463

Spartek. Industrial ceramic, plastic and powdered-metal products.

CIRCLE NO. 464

Tech Ops. Radiation monitoring, industrial radiographic equipment, solid-state controls and broadcasting.

CIRCLE NO. 465

Design aids

D/a, a/d resolution

What resolution (number of bits) a/d is required to resolve 15 mV in 20 V? What is the output-step size of a 14-bit d/a in ppm? The answers to these and other common d/a and a/d-resolution questions can be quickly and conveniently found on a card. Micro Networks.

CIRCLE NO. 454

Plating process

Easy to use and in full color, a guide lists and describes copper, nickel, electroless nickel, tin/lead, tin, and indium-plating processes. A brief description with suggested applications, operating parameters, and deposit characteristics is given for each of the processes. Sel-Rex Div.

CIRCLE NO. 455

Magnetic-media guide

A comprehensive magnetic-media-compatibility guide for digital cassettes, disc packs, disc cartridges, diskettes and MCST magnetic cards gives an instant cross-reference to hundreds of products by dozens of manufacturers. Wabash Tape Corp.

CIRCLE NO. 456

Frequency spectra

Using the acoustic noise and vibration of an electric fan as illustrations, an eight-page application note shows how to interpret frequency spectra with the company's Model 444A FFT computing spectrum analyzer. Nicolet Instruments.

CIRCLE NO. 457

Electromagnetic interference

A three-part kit includes information on electromagnetic-interference shielding and static-discharge theory and formulas, shielding methods and efficiencies, applications and bibliography. TAFA Metallisation.

CIRCLE NO. 458

E-Z-MICRO HOOK ■ E-Z-MINI HOOK X100W AND XL1 ■ E-Z-MACRO HOOK XH AND XHL ■ E-Z-NAILCLIPS

E-Z-PROBES XP AND XPL ■ TEST LEADS AND JUMPERS ■ ADAPTORS

PATCH CORDS ■ COAXIAL JUMPERS ■ E-Z-HOOK CLIP 61-1 AND 61-2

OUR NEW MICRO TROUBLE SHOOTER SOLVES YOUR IC TESTING PROBLEMS

The XM Micro Hook is designed for difficult IC test connections. Light weight (less than 1 gram) and Finger-eze Hypo Action permit direct hookup to delicate wires where weight and leverage may damage component. Fully insulated to a single contact point for true readings.

Construction: One-Piece Beryllium Copper, Gold-Plated Conductor and Hook, made for connections over leads up to .025" diameter. Durable Heat and Chemical Resistant Nylon Body. Stainless Steel Spring. Available preconnected to a wide variety of interface connectors.

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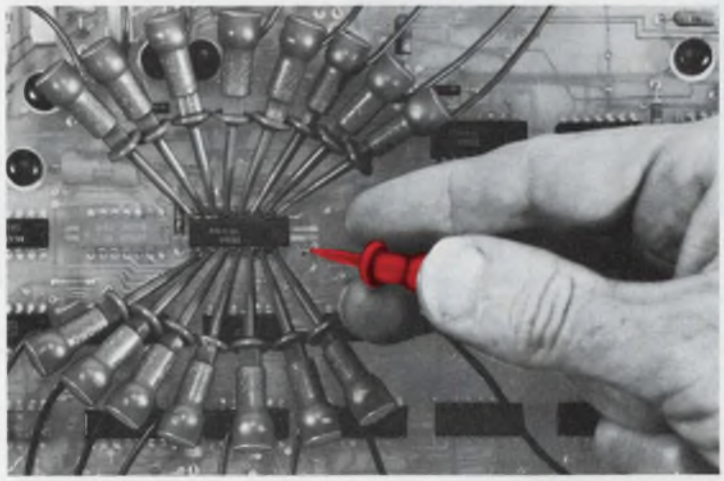
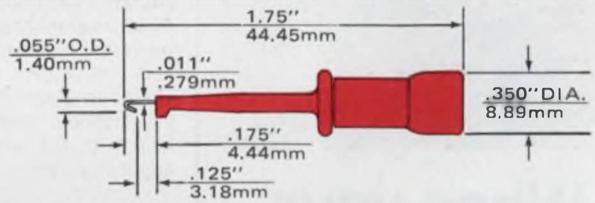


MODEL XM SHOWN ACTUAL SIZE WITH HOOK EXTENDED.



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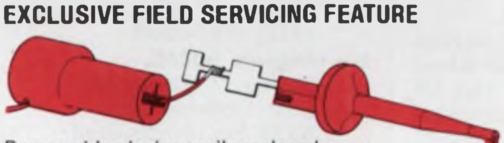

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Vinyl Encased Polyurethane Foam

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Suggested uses include:

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Vibration Dampener	Airflow Stoppage
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CIRCLE NUMBER 151

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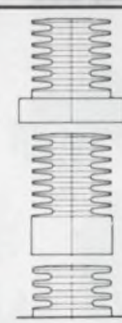

FREE SAMPLE and DESIGN CATALOG write:
Servometer Corporation
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MINIATURE METAL BELLOWS
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CIRCLE NUMBER 152

Electronic Design

ELECTRONIC DESIGN's function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
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- To provide a central source of timely electronics information.
- To promote communication among members of the electronics engineering community.

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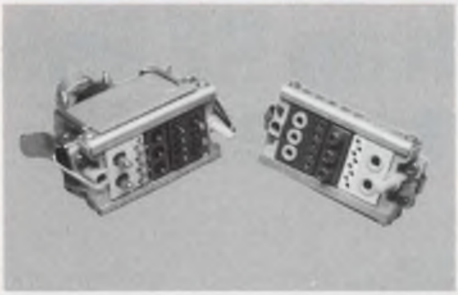
CIRCLE NUMBER 155

quick ads

New and current products for the electronic designer presented by their manufacturers.



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VARIAC® REGULATORS 184

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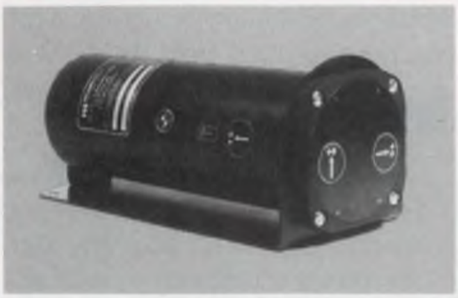

GYRO STABILIZED, 3-AXIS ACCELEROMETER for precise acceleration measurements free from the disturbing element of earth's gravity vector. Model SA09 has accelerometers on inner gimbal of a vertical gyro which is maintained with a verticality within ±0.2° of local gravity. Wirewound potentiometers provide continuous pitch and roll outputs. Angular freedom of ±85° pitch and 360° continuous roll. 3.13" x 10.0" long, 3.5 pounds. AC/DC. Humphrey, Inc., 9212 Balboa Ave., San Diego, CA 92123. (714) 565-6631

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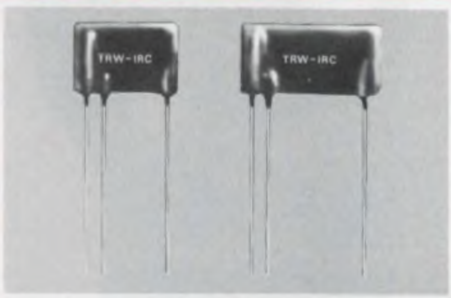
REGULATED DC POWER SUPPLY 185

Free Catalog contains complete line of Power Supplies from Computer Products, Inc. Miniature encapsulated models from 3.6 to 28V, 25mA to 2A. DC/DC Converters, 5 to 12 Watt models, single and dual outputs. High-efficiency supplies, single and dual output, models to 100 Watts. Attractive OEM discounts. Computer Products, Inc. 1400 N. W. 70th Street, Fort Lauderdale, FL. 33309 305/974-5500

POWER SUPPLY CATALOG 188

NEW DESKTOP TAPE READER—all you do is plug this Smart Box in. Up to 300 cps—RS232C, Current loop, parallel I/O —and quality built. State-of-the-art fiber optics, photo transistor read head, dual-sprocket drive. Outstanding for flexibility and simplicity. Low cost. Decitek, 250 Chandler Street, Worcester, MA 01602 (617) 798-8731.

NEW DESKTOP TAPE READER 183



Thick-Film High Voltage Dividers are the latest line of high-voltage resistors from TRW. Each device consists of a high-voltage thick-film resistor circuit deposited on a high alumina ceramic substrate. The circuit can be encapsulated in a high-temperature epoxy coating with printed circuit leads or it can be made as a substrate for customer assembly into an integral high-voltage function. Available in various sizes and configurations. TRW/IRC Resistors, 401 N. Broad St., Phila, Pa. 19108. (215) 922-8900.

HIGH VOLTAGE RESISTORS 186

ALPHANUMERIC KEYBOARD, based on screened mylar switch technology, represents *lowest cost alphanumeric style keyboard on market today.* Standard keyboard consists of 59 keys plus space bar. Encoding and termination, as well as keytop colors and legends, can be produced to customer specification. Technical Bulletin No. 984 provides details. CHOMERICS, INC., 77 Dragon Court, Woburn, MA 01801. (617) 935-4850.

KEYBOARDS 18

PROGRAMMABLE MOS/CCD DRIVER plug-in for Tektronix TM-500 series mainframes. Primarily a level shifter, the PI-451 converts a TTL input signal into a ±25V output signal for driving MOS-type devices. Independ. output Hi/Lo levels man. adjustable or voltage prog. Digital programming option also available. Output transition times variable from <2.5ns/V to $>2.5\mu$s/V. Max rep-rate >10MHz for 10V output and 40pf load. $324. PLUSE INSTRUMENTS CO., 1536 W. 25th St., San Pedro, Ca. 90732. (213) 541-3204

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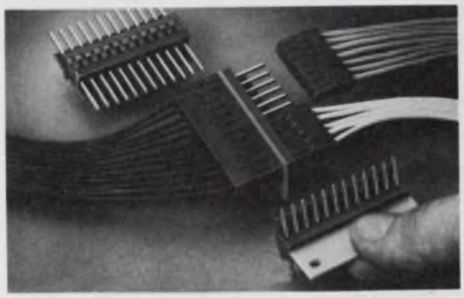

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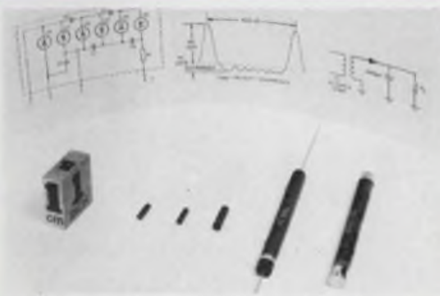

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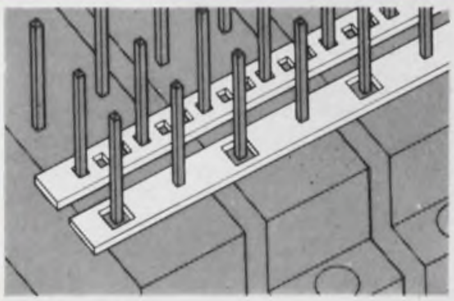

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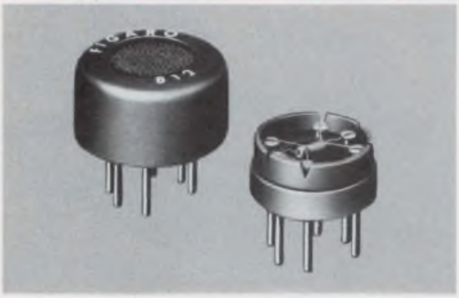

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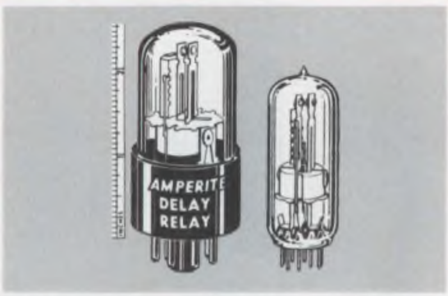

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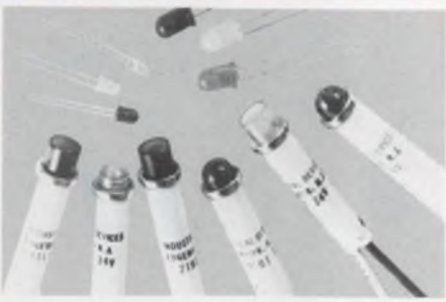

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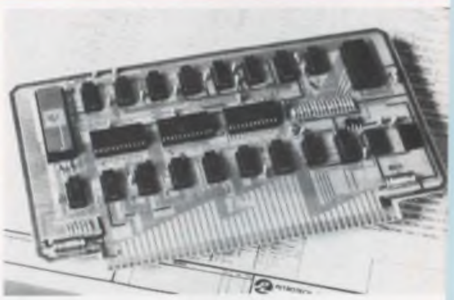

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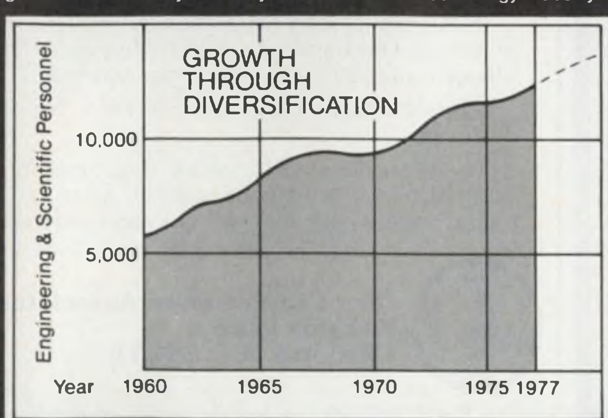

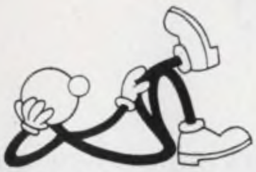

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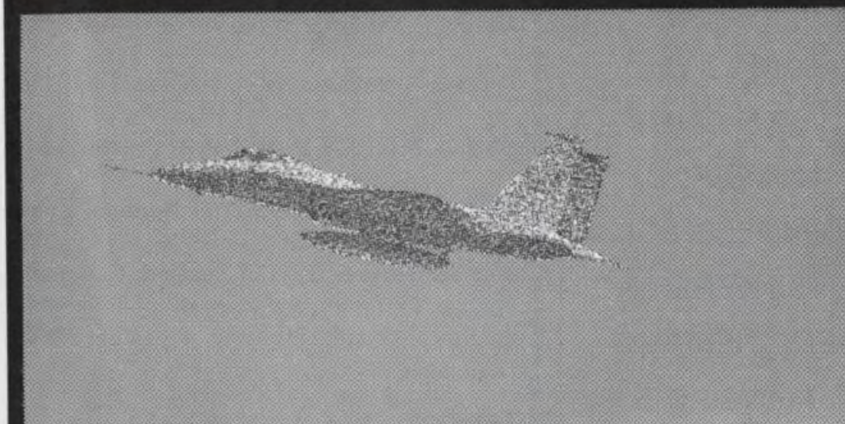

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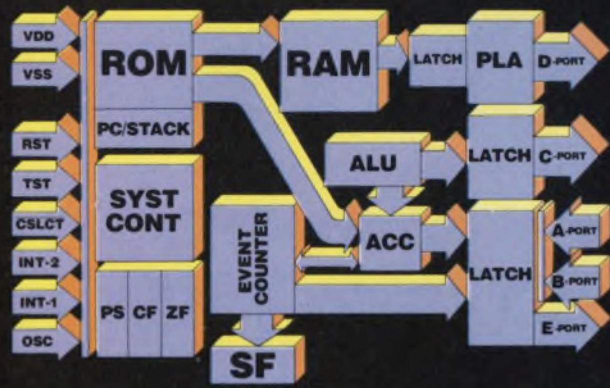

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The Panasonic family of one-chip microcomputers.

Package		MN1400 40-Pin Plastic DIP	MN1402 28-Pin Plastic DIP	MN1498 40-Pin Plastic DIP	MN1499 64-Pin Ceramic DIP
Power Supply		+5V	+5V	+5V	+5V
Instruction Cycle Time		10μs	10μs	10μs	10μs
Instruction Set		75	57	68	75
Instruction Memory	Instruction ROM	Internal 1024 x 8 bits (8192 bits)	Internal 768 x 8 bits (6144 bits)	External 1024 x 8 bits (8192 bits)	External 2048 x 8 bits (16384 bits)
Total on Chip RAM		64 x 4 bits (256 bits)	32 x 4 bits (128 bits)	64 x 4 bits (256 bits)	64 x 4 bits (256 bits)

16-bit microprocessors, too.

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