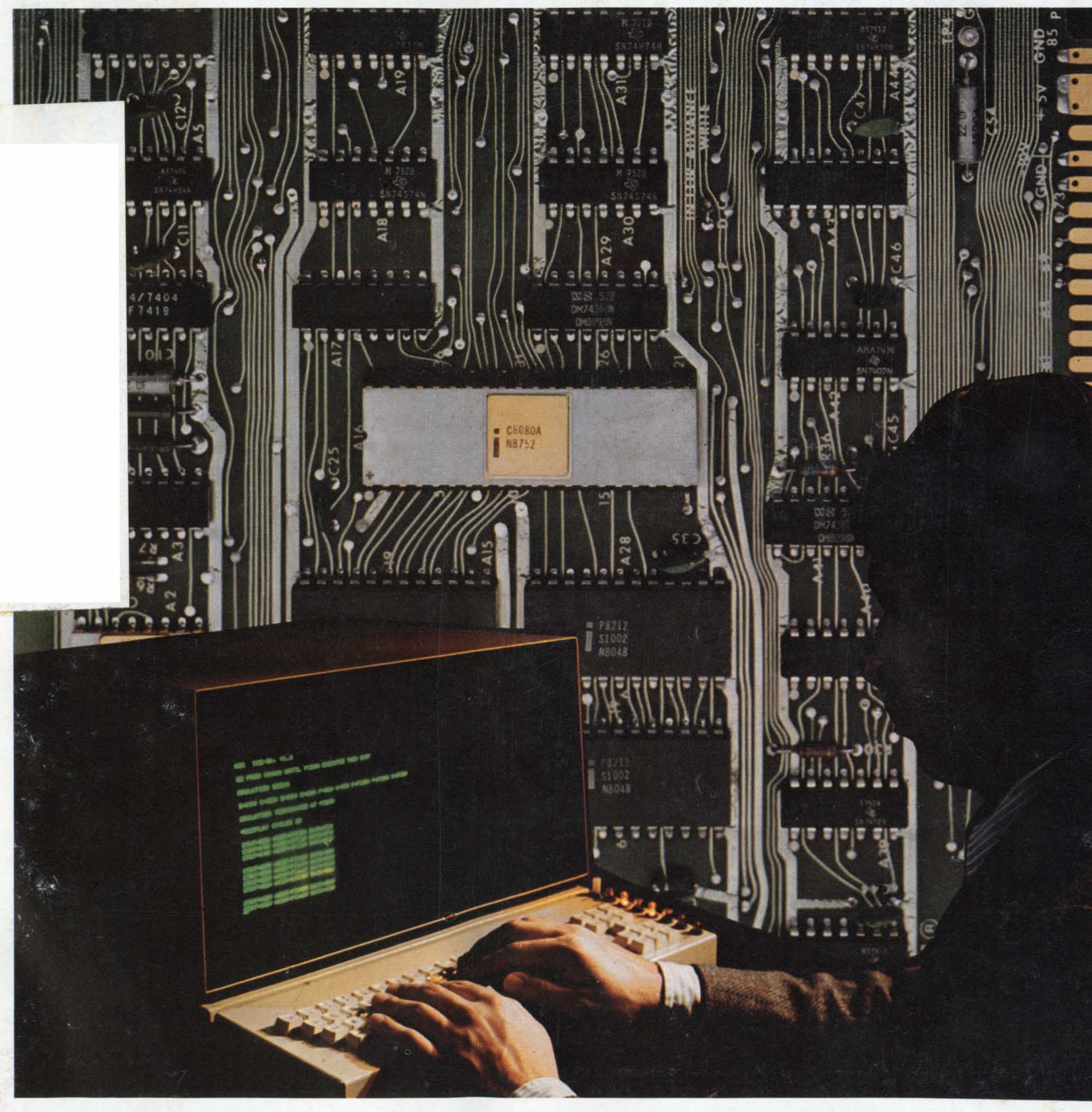
VOL. 23 NO.

Electronic Design 26

FOR ENGINEERS AND ENGINEERING MANAGERS

DEC. 20, 1975

Microcomputer software costs can vary widely. Much depends on the design approach used. The hardware designer, drafted as a software expert, faces unfamiliar choices like type of language and whether to use in-house or outside development aids and services. For a detailed look at μP software, turn to page 20.



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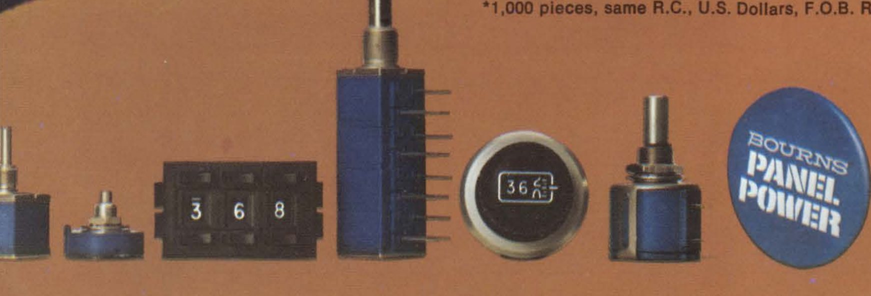
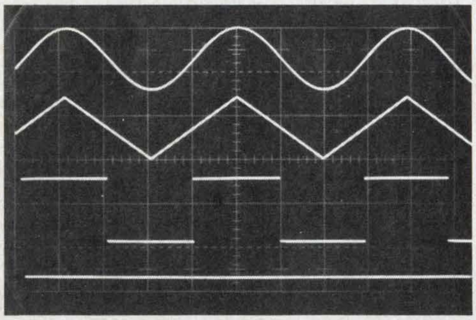
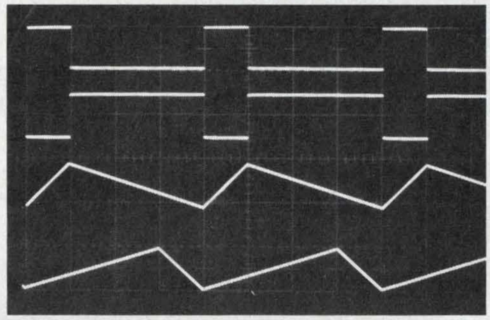
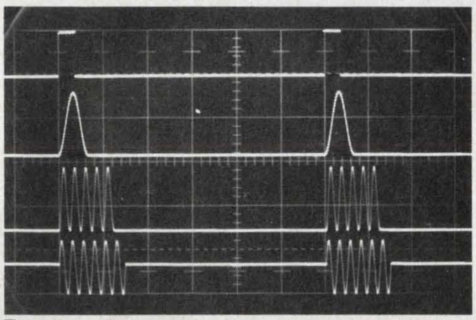


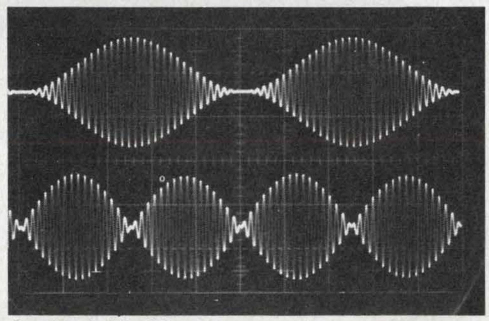
BOURNS®

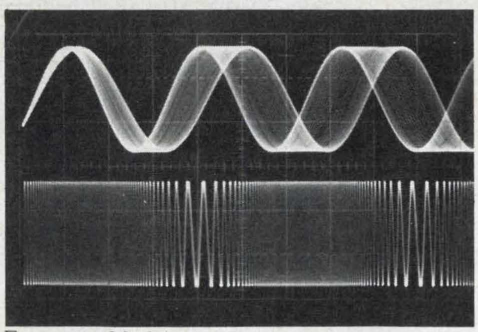
The Model 186 art gallery.

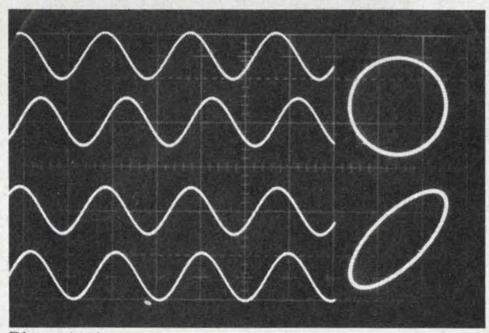

Sine, square, triangle and dc.


Pulse and ramp.

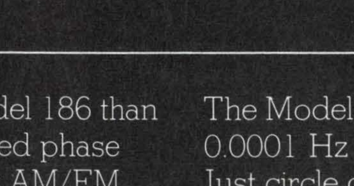

Trigger and gate


Amplitude Modulation


Frequency Modulation


Phase lock.

There's a whole lot more to the Model 186 than just pretty pictures. Like its calibrated phase lock and built-in oscillator for 1 kHz AM/FM capabilities. It also has 30 v p-p output plus continuous, triggered and gated modes. And it's the only generator that gives you the combination of AM and phase lock.



The Model 186 has a frequency range of 0.0001 Hz to 5 MHz and sells for just $795. Just circle our bingo number and we'll send you the complete picture.

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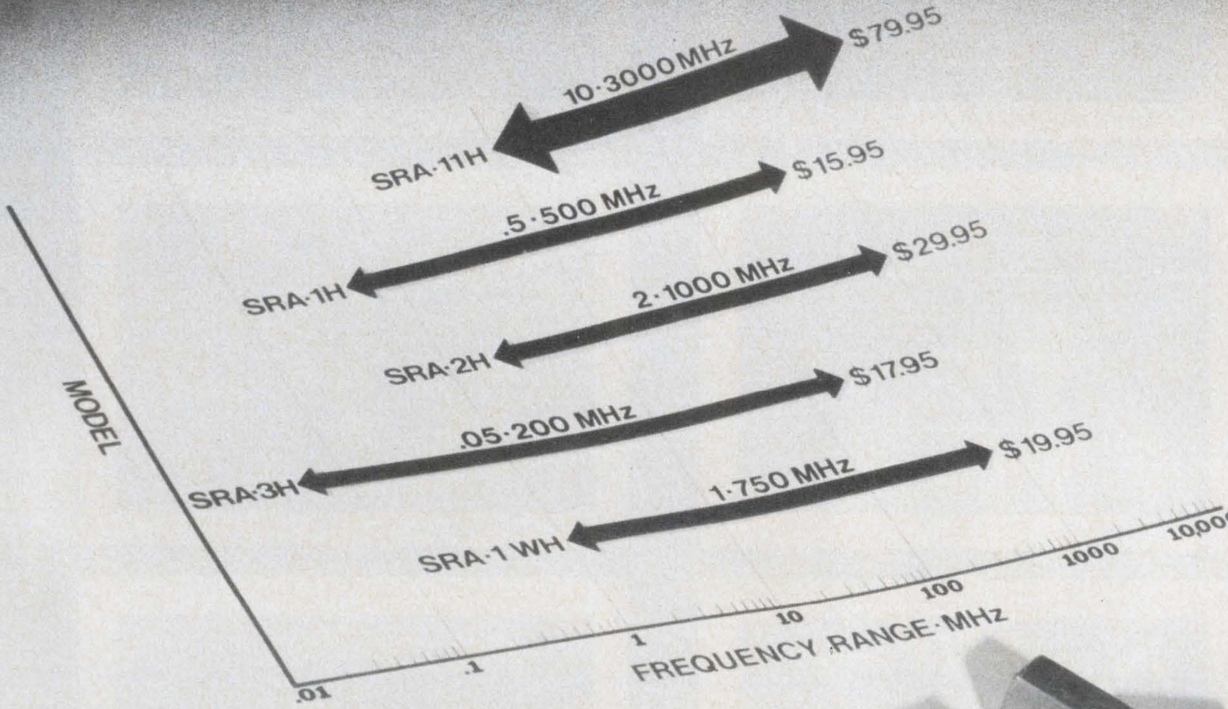

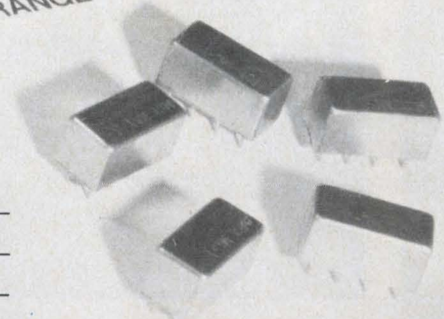

Model	Frequency Range (MHz)	Conversion loss (dB) Total Range	Isolation, dB						Price Quant.
			Lower band edge to one decade higher		Mid range		Upper band edge to one octave lower		
			LO-RF	LO-IF	LO-RF	LO-IF	LO-RF	LO-IF	
SRA-11H	RF, LO-10-3000 IF - DC-1000	9.5 typ. 12 max.	27 typ. 20 min.	27 typ. 20 min.	25 typ. 18 min.	25 typ. 18 min.	23 typ. 16 min.	23 typ. 16 min.	$79.95 (1-24)
SRA-1H	RF, LO-.5-500 IF - DC-500	6.5 typ. 8.5 max.	55 typ. 45 min.	45 typ. 35 min.	45 typ. 30 min.	40 typ. 30 min.	35 typ. 25 min.	30 typ. 20 min.	$15.95 (5-24)
SRA-2H	RF, LO-2-1000 IF - DC-1000	7.5 typ. 9.5 max.	50 typ. 40 min.	45 typ. 35 min.	45 typ. 25 min.	40 typ. 25 min.	35 typ. 25 min.	25 typ. 20 min.	$29.95 (4-24)
SRA-3H	RF, LO-.05-200 IF - DC-200	5.5 typ. 7.5 max.	55 typ. 45 min.	45 typ. 35 min.	45 typ. 30 min.	40 typ. 30 min.	35 typ. 25 min.	30 typ. 20 min.	$17.95 (5-24)
SRA-1WH	RF, LO-1-750 IF - DC-750	5.5 typ. 7.5 max.	50 typ. 40 min.	45 typ. 35 min.	45 typ. 25 min.	40 typ. 25 min.	35 typ. 25 min.	30 typ. 20 min.	$19.95 (5-24)

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INFORMATION RETRIEVAL NUMBER 3

Electronic Design 26

VOL. 23 NO. 26

FOR ENGINEERS AND ENGINEERING MANAGERS

DEC. 20, 1975

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by Patrick S. Tchrakian, courtesy of Intel Corp.

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The TMS 9900 single-chip, 16-bit microprocessor.

Powerful enough to be the heart of a full minicomputer, the TMS 9900 is also the best microprocessor going for terminals, machine monitoring and control, and a host of OEM applications.

All in the Family

The same company . . . Texas Instruments . . . makes every member of the family, and makes every member software compatible, from the bottom up. The new Model 990/4 microcomputer and Model 990/10 minicomputer use the instruction set of the TMS 9900 microprocessor. This means that software developed for the low-end computers will be compatible with the higher performance models. And, users can expand their systems with a minimum of interface and software adaptation.

The TMS 9900 Microprocessor

The TMS 9900 is a 16-bit, single-chip microprocessor using MOS N-channel silicon-gate technology. Its unique architecture permits data manipulation not easily achievable in earlier devices. With its repertoire of versatile instructions and high-speed interrupt capability, the TMS 9900 microprocessor provides computing power expected from a 16-bit TTL computer.

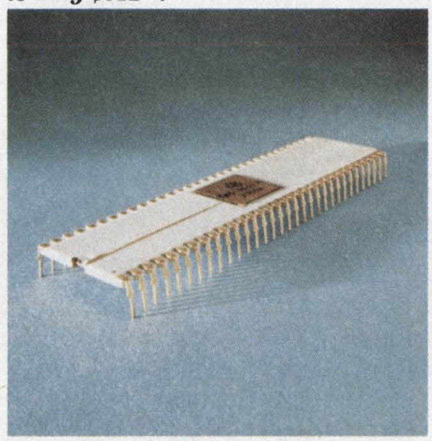
The Model 990/4 Microcomputer

It's a complete computer on a single printed circuit board using the TMS 9900 as its central processor. The 990/4 is ideally suited for terminal control, peripheral device interface control, and as a CPU for OEM customers.

In addition to the TMS 9900 microprocessor, the 990/4 microcomputer contains up to 8K bytes of dynamic RAM, up to 2K bytes of static RAM and/or PROM, eight vectored interrupts, front panel interface, real-time clock input, two I/O buses for low- and high-speed devices, and optional ROM utilities.

With the 990/4, you can select a low-cost OEM package, a 7-inch or 12¼-inch rack-mountable chassis, or a table-top enclosure . . . and memory expansion to 58K bytes.

Price: The Model 990/4 microcomputer with 512 bytes of memory is only $368* without chassis and power supply. This same model with 8K bytes of memory is only $512*.



State-of-the-art TMS 9900 microprocessor . . .16-bit, single-chip CPU with minicomputer instruction power.

The Model 990/10 Minicomputer

The most powerful member of the family is the Model 990/10 general-purpose minicomputer. The 990/10, a TTL implementation of the 990 architecture, provides the high-performance speeds demanded in many applications.

A memory mapping feature providing memory protection and privileged instructions supports memory expansion to two million bytes. And TILINE**, an asynchronous high-speed I/O bus, supports both high-speed and low-speed devices. Chassis options are the same as those for the 990/4.

Price: With 16K bytes of memory, chassis, power supply and programmer's panel, the Model 990/10 minicomputer is only $1968*.

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In addition to the family of compatible hardware, Texas Instruments backs you with complete software and support. ***Standard software packages include memory-resident and disc-based operating systems;*** FORTRAN, COBOL, and BASIC compilers; and program development packages with utilities. And, for you to develop application programs for the 990/9900 family, we offer ***cross support on timesharing networks*** and standalone software development systems. One is a low-cost system using the 990/4 . . . the other is a disc-based system using the 990/10. And, a ***prototyping system*** is offered for TMS 9900 users to develop custom software and firmware modules.

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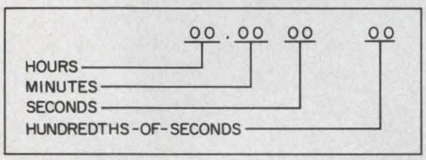
INFORMATION RETRIEVAL NUMBER 4

Across the Desk

How to turn an HP-45 into a stop watch

Readers of ELECTRONIC DESIGN who are also the owners of Hewlett-Packard HP-45 calculators may be interested to know they can use their machines as a digital stop watch and elapsed-time indicator, similar to the functions found on the HP-55 programmable version.

To gain access to the clock function, first clear the machine, using the gold alternate-function key. Then press the RCL key, and then simultaneously press the CHS key and the digits 7 & 8, or 4 & 5, or 1 & 2. The machine now displays the format:



To start the clock function, press the CHS key. Pressing the CHS key again will stop the clock without resetting the display to zero. (To reset the display to zero, press the CLx key.)

To save power during battery operation, you can turn off the last two digits (hundredths of seconds) by pressing the EEX key; depressing the EEX key will again turn on the last two digits.

The clock function can also be used as an elapsed-time indicator for timing and storing the elapsed-time measurements of up to nine separate events (assuming all events started from the same point in time). This function can be quite handy for measurement of physical phenomena, chemical reactions or even at a race track. While the clock is running, depressing any digit key (1 to 9) stores the displayed time up to that point in the respective register, the clock keeps running and is not otherwise affected.

After the clock is stopped by pressure on the CHS key, pressing any of the digit keys recalls to the display the time displayed in the respective register. Note that the STO key (while the clock is running) and the RCL key (after the clock is stopped) need not be pressed; the "store" and "recall" functions are automatically executed, depending on whether the clock is running or stopped. (The CLx key should again be pressed after the last measurement is recalled, as the clock, when started again, will resume counting from the number on the display.)

After the clock function is no longer needed, you can return the machine to normal operation by pressing the ENTER key (which returns the machine to fixed-point, 2-decimal operation) or by turning the machine OFF and then ON again. (The latter method is preferred, as the registers are cleared before the machine is used; however, the registers do not need to be cleared if the user wishes to store new elapsed-time data, as the registers are overwritten with new data any time the clock is running and one of the digit keys is depressed.)

While the clock function is operating, the only keys having any effect are the CHS, EEX, CLx, ".", and the digit keys. All other keys, including the −, +, ×, and ÷, are nonoperating.

Accuracy? It seems the HP-45 was designed with the HP-55 in

(continued on page 13)

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

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Our AMI 6800 Kit is a big step forward in simplifying your design, evaluation and test programs. For example, our intelligent CRT is simple to operate with either resident or remote software. It really is smart, because it contains an S6800! And it's planned to have an in-circuit emulator added later.

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Now why don't you call your nearest AMI sales office or distributor, and ask them for the whole Kit and Caboodle. Or write AMI, 3800 Homestead Road, Santa Clara, CA 95051. What could be easier?

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Hardware Reference Manual.
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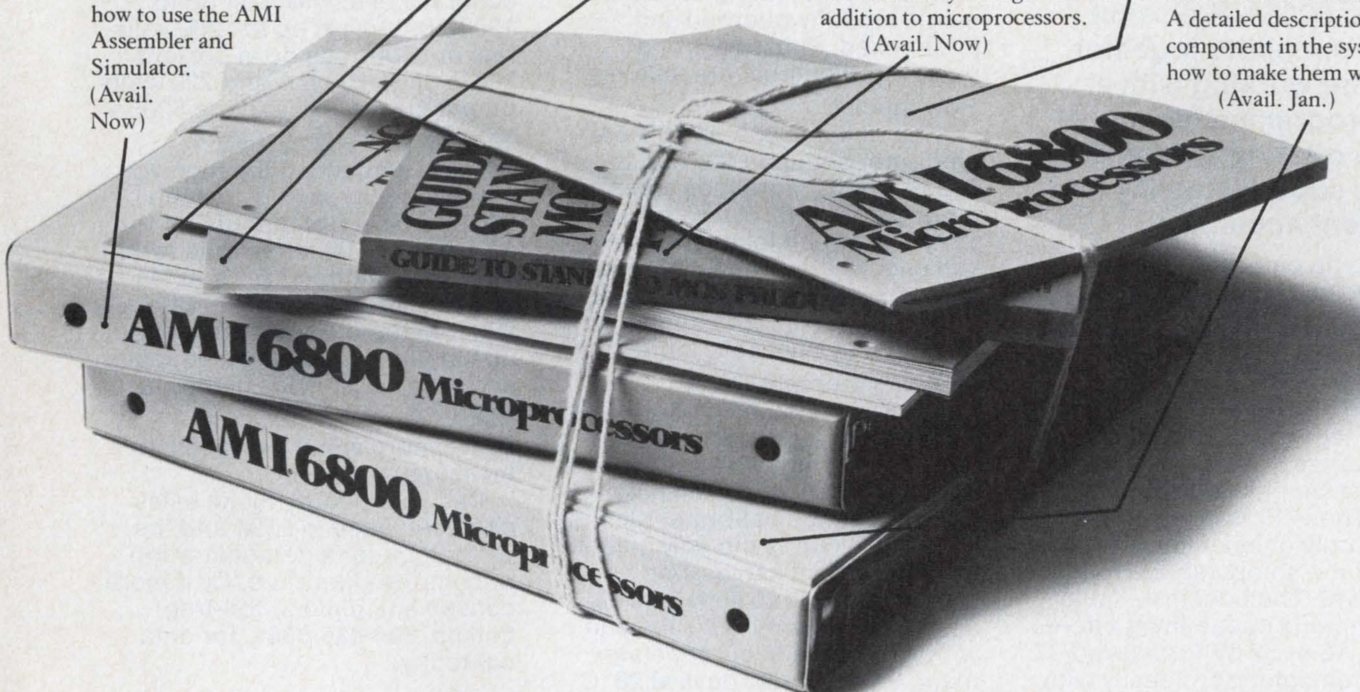

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Midband accuracy is 0.02% overall and long term stability 200 ppm for six months. Instruments are fully guarded and interlocked. Phase lock and quadrature outputs are featured.

How much?

Cost of the 5200A and 5205A calibrator set-up in the U.S. is $8990. That's more than some other calibrators. But with Fluke, the short circuit feature alone will give you lower cost of ownership. Your Fluke sales engineer can point out other features that make our system your better buy.

Or use either unit alone

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Gain is 100 with a midband accuracy of 0.04%. Get dc to 120 KHz and get up to 1200 volts rms or 1600 volts dc at current levels up to 200 mA and 220 watts output power. Price of the 5205A alone is $3995 (U.S. price).

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Learn more about using full ac measure power.

Call your nearby Fluke sales engineer listed in EEM and the Gold Book for a demonstration or complete literature. Or if more convenient, dial our toll-free hotline, **800-426-0361,** for data out today.

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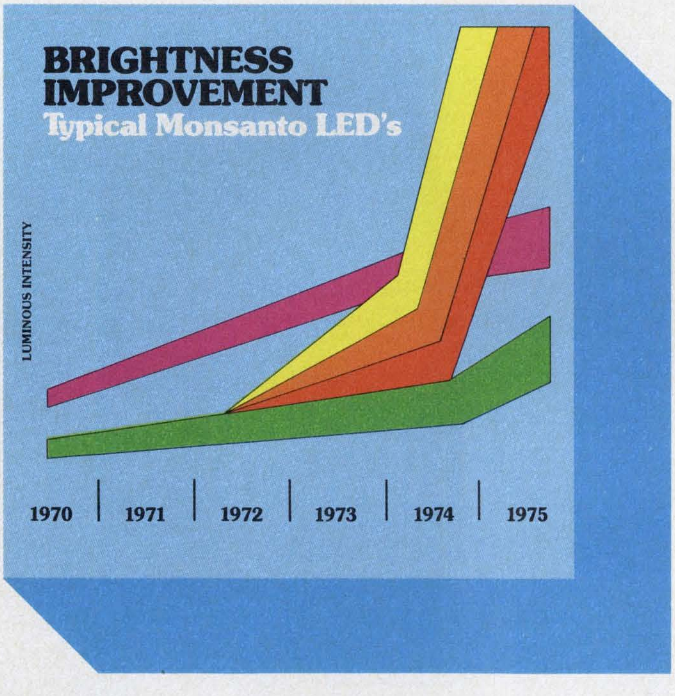
Monsanto has T-1 and T-1¾ replacement lamps in standard red color (improved significantly over last year's red LEDs) and new bright red which is *unbelievably* bright. Red. Plus green, yellow, and a dazzling new orange. In two lens choices and two lead lengths. And all improved, as you can see on the chart.

Model Number	Color	Size	Luminous Intensity	Viewing Angle
5174B*	Orange	T-1	5.0 mcd	90°
5274B*	Green	T-1	1.0 mcd	90°
5374B*	Yellow	T-1	4.0 mcd	90°
5774B*	Red	T-1	5.0 mcd	90°
5152**	Orange	T-1¾	40.0 mcd	28°
5252**	Green	T-1¾	15.0 mcd	28°
5352**	Yellow	T-1¾	45.0 mcd	28°
5752**	Red	T-1¾	40.0 mcd	28°

*Also available with 1″ lead lengths, low profile (.138″ high) lens, and 180° viewing angle.
**Also available with 24° and 65° viewing angles.



Last year there were some sockets that demanded filament lamps, despite their inherent failure-and-replacement problems. *Bright* was needed, and damn the torpedos.

This year you just might find the bright you need in a shake-rattle-and-roll-proof LED lamp. Come and see.

If you can take the time, you just might be able to add a lot of T to your MTBF.

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For product information, circle the service number or call your local Monsanto man. Or write Monsanto Electronics Division, 3400 Hillview Avenue, Palo Alto, CA 94304.

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INFORMATION RETRIEVAL NUMBER 9

They're good... no matter how bad

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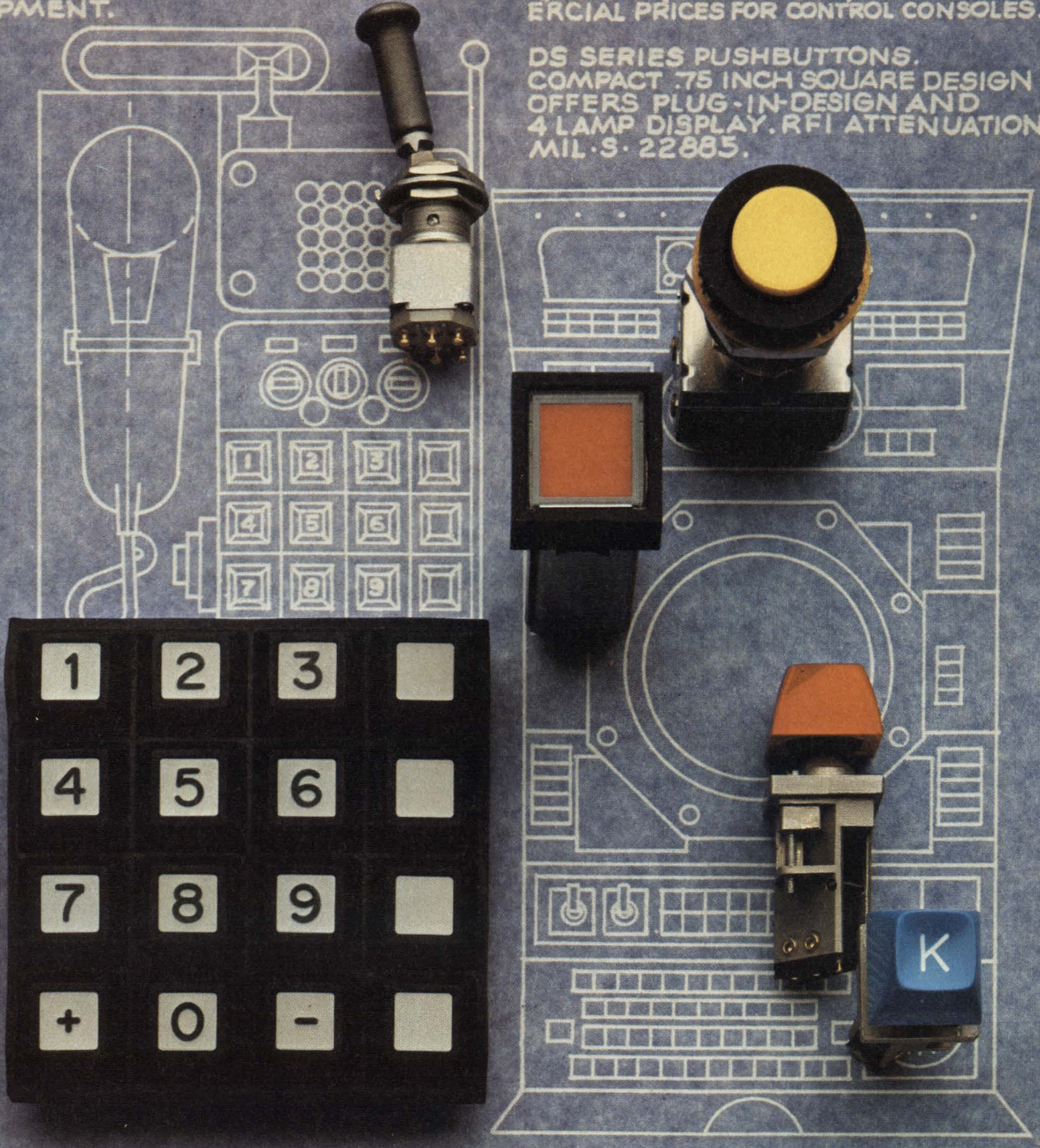
OFFERS SWITCHING VERSATILITY OF LARGER TOGGLES WITH ADVANTAGE OF SMALL SIZE, PANEL SEALING. IDEAL FOR APPLICATIONS LIKE ON/OFF SWITCH IN THIS MANPACK EQUIPMENT.

SERIES 1 ROUND LIGHTED PUSHBUTTONS OFFER FLUSH MOUNTING, PANEL SEALING AND VERSATILE SWITCH CIRCUITRY, INCLUDING SOLID STATE. MIL SPEC QUALITY (MIL-S-22885) AT COMMERCIAL PRICES FOR CONTROL CONSOLES.

DS SERIES PUSHBUTTONS.
COMPACT .75 INCH SQUARE DESIGN OFFERS PLUG-IN-DESIGN AND 4 LAMP DISPLAY. RFI ATTENUATION. MIL-S-22885.



PX KEYBOARDS. TOTALLY SEALED WHEN MOUNTED, WITH ZERO DEPTH BEHIND PANEL, PX IS A NATURAL CHOICE FOR MANPACK EQUIPMENT SWITCH MATRICES.

PANEL SEALED KS KEY SWITCHES. USE OF SPDT SNAP-ACTION SWITCHES (MIL-S-8805) AND FRONT-OF-PANEL REPLACEMENT, MAKE KS IDEAL FOR RUGGEDIZED CONTROL PANEL KEYBOARD APPLICATIONS.

(continued from page 7)

mind, and consequently it uses some of the circuitry of the HP-55. However, the HP-55's internal oscillator is apparently "trimmed" for the required frequency, while that of the HP-45 is not. At any rate, the HP-45 should exhibit reasonable accuracy as is. (My own HP-45 measures about 5.3% slow when compared with a known time standard; I have used my machine on internal battery pack and on external power pack, and obtained similar accuracy results both ways.)

Owners of the HP-45 can compare their machines against a known time standard and use the resulting correction factor as required in future measurements. And although the absolute accuracy of the HP-45 may not equal that of the HP-55, the time function used during relative measurements—and particularly the storing of up to nine elapsed-time measurements—can be very, very useful indeed.

Paul E. Miller
Engineering Technician
AMF Electrical Products
Development Div.
1025 N. Royal St.
Alexandria, VA 22314

Jobs, anyone?

In the April 1, 1975 issue we published an editorial in which we offered to try to match out-of-work engineers with potential employers. As one might expect, we received far more applications for jobs than announcements for job openings. We were successful in effecting a few matches but we're still overstocked on resumes of engineers sprinkled around the country (and one in Germany who would like to come back to the U.S.). Some of the credentials look awfully impressive.

If you have some jobs available, get in touch with our Evelyn Morris (ELECTRONIC DESIGN, 50 Essex St., Rochelle Park, NJ 07662). Good engineers are going to be a lot tougher to find a few months from now.

Misplaced Caption Dept.

"We've got to clear out of the cafeteria for the next shift."

Sorry. That's Pierre-Auguste Renoir's "The Luncheon of the Boating Party at Bougival," which hangs in the Philips' Memorial Gallery in Washington.

Calculator errors and how some arise

In the Sept. 27 issue, a letter from Peter A. Stark discussed two types of alleged mistakes made by some calculators that employ algebraic notation with parentheses. I would like to point out that his second example actually gives the correct answer. It is his lack of understanding of the sequential operations of such calculators that causes the apparent error.

Algebraic calculators perform complex chain calculations in the order in which they are entered, rather than according to the standard mathematical hierarchy (in which exponentiation is done first, then multiplication and division, then addition and subtraction). For example, most users are aware that AB & CD must be entered as

$$A \times B + (C \times D) =.$$

Entering it as

$$A \times B + C \times D =$$

gives the erroneous answer $(AB + C)D$.

The calculation that tripped up Mr. Stark was of the general form A^3B^3, for which he should have entered

$$A \times^y 3 \times (B \times^y 3) =.$$

The incorrect answer was obtained by entering it as

$$A \times^y 3 \times B \times^y 3 =,$$

which gives $(A^3B)^3$.

George Fergus
3341 W. Cullom Ave.
Chicago, IL 60618

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Devices tested: Monolithic or Hybrid Operational amplifiers.
Tests performed: E_{OS}, I_{B-}, I_{B+}, DC open loop gain, DC CMRR, oscillation detection.
Remarks, 3-digit direct reading digital display which enables go-no-go testing.

MODEL 1234

For demo circle Reader Service #271
For literature only circle #272

DIGITAL IC TESTER
$580.

Devices tested: 14 and 16 pins. TTL, DTL and CMOS @ 5V.
Tests performed: Fixed pattern functional test.
Remarks: Performs 2^{20} inspections per test in from 1 to 5 seconds. No comparison with a "good" IC is necessary. 4-digit display gives absolute test results. Can also be used to check continuity of resistor network.

MODEL 1248

For demo circle Reader Service #273
For literature only circle #274

DIGITAL IC TESTER
$1195.

Devices tested: TTL, DTL @ 5V, HTL @ 15V, CMOS @ 5V, 10V, 15V.
Tests performed: Same as 1248.
Remarks: Interfaces with manual and automatic handlers. Multiple voltages for CMOS.

MODEL 1249

For demo circle Reader Service #275
For literature only circle #276

DECEMBER 20, 1975

East German computer proves better than expected

Tests and studies by Control Data Corp. show that East European data-processing machines are much more advanced than most U.S. experts have believed, while the peripheral equipment lags behind that produced in this country.

For example, the Robotron ES-1040 medium-to-large-scale computer, made in East Germany, is three to four times faster than the IBM 370/145 in processing scientific calculations, but in commercial applications the speed of the two machines are comparable, according to the CDC report.

However, when the memory speed of the German ES-1040 was tested along with that of the IBM 370/145 and the CDC Cyber 73, the ES-1040 took twice as long as the IBM machine and about six times longer than the Cyber 73.

Together, the two tests—that of arithmetic speed and memory speed—reveal that the ES-1040 is approximately twice as powerful as the IBM 370/145 in internal computing power.

Other findings by CDC:

The core memory of the ES-1040 is somewhat slow compared with the processor's speed—performance could be enhanced considerably with a faster memory.

- The ES-1040 executes the IBM 360 instruction set.
- The system could be improved through the use of more modern peripherals, chiefly in the mass storage area.
- In general, the East German machine is "very reliable."

The ES-1040 is constructed from ICs made in East Germany that are identical in logic to those produced in the U.S. by Texas Instruments, Motorola and Fairchild. The appearance of the ES-1040 prototype in late 1972 indicates a technology lag of three to four years in the IC area.

The logic design of the CPU is also very advanced, CDC says.

The processor employs microprogram control, a technique not too different from that used in the IBM 370 series. The processor includes a "lookahead" instruction feature, which allows various processor functions to be overlapped.

The memory is composed of 21-mil cores, has an access time of 450 ns and a system level cycle time of 1350 ns. The memory is composed of two to four independent modules, allowing memory interleaving. The path to memory is eight bytes wide. The theoretical memory transfer rate is about 142 million bps. CDC testing on a two-module memory showed that the memory speed was not well matched to the speed of the CPU.

The input/output channels operate under microprogram control and are compatible with the IBM multiplexer and selector channels. These channels are fast enough to allow connection of most modern U.S. peripherals, CDC says.

The two disc drives that came with the ES-1040 can store about seven million characters. The Control Data disc drives now connected to the ES-1040 have four times that capacity, and can also transfer data at twice the speed.

The tape drives that came with the East German machine were found to be equivalent in performance to U.S. units, but bulkier.

The East German printer offers a feature not provided by any U.S. manufacturer, CDC says. It allows different forms to be printed simultaneously. However, CDC points out that its printer outperforms the East German product in other ways: better print quality, slightly higher speed and an interchangeable character set.

Both the card reader and the punch were built in the Soviet Union and use standard 80-column cards.

Soft-recovery test cuts cost of diodes 30%

A new procedure for characterizing power diodes that removes ambiguities and cuts costs by 30% is reported by General Electric, Schenectady, NY.

GE says it has achieved this by finding an easy way to test the soft-recovery characteristics of these devices. Until now, this characteristic has been hard to test, and even the results of the tests were open to many different interpretations, notes Ralph Locher, a product engineer for GE.

High-current diodes (over 100 A), when used in an antiparallel connection with SCRs in large switching supplies, prevent spikes caused by collapsing magnetic fields from destroying the SCRs. However, these diodes must have peak inverse voltages that are high enough to withstand the spikes.

By being able to measure the soft recovery time of the diodes accurately, Locher says, the more efficient units can be picked and thus diodes with lower PIVs can be used. And the lower the PIV, the lower the cost of the diode.

For example, GE says, where a 250-A, 1000-V device had to be used at a cost of $26 in 10-to-99-piece lots, a 250-A, 600-V diode can now be used at a cost of about $20 for similar quantities. Diodes are available with current ratings of 100 to 1000 A rms and with PIVs from 50 to 1500 V.

3-D radar improves target resolution

A monopulse tracking radar capable of providing three-dimensional target information and range resolution down to 1.5 ft is under development at the Naval Research Laboratory, Washington, DC.

Other features include the following:

- Ability to counteract enemy repeater-type countermeasures.
- Improved low-angle multipath tracking.

- Increased resolution of multiple targets.
- Improved target tracking in chaff and clutter.

The experimental radar uses a very narrow pulse width of 3 ns in conjunction with wideband monopulse processing to obtain azimuth and elevation information of each resolved part of the target.

Present high-range-resolution radars provide only one dimensional range-amplitude profiles. The 3-D radar, according to two of its developers, Dean Howard and David Cross, extends this capability, in that a target aircraft can be resolved into its major structural parts. Prominent features such as engines, tail surfaces, and wings can be located precisely in both range and angle. This is accomplished by processing the high-speed return pulses through special sampling and holding circuits, which convert the pulses to digital form for display, storage and analysis by computer pattern-recognition methods.

According to Cross, the next step in the program is to improve the radar performance and extend its range. This will be done by pulse-compression techniques to increase average transmitted power.

A similar radar, developed at Lincoln Laboratory, Lexington, MA, has been in use since 1968, primarily for long-range tracking. The Naval Research Laboratory radar differs in its method of processing and using target angular information.

Speed of CCD memory is boosted tenfold

A tenfold increase in speed—from about 20 MHz to over 230 MHz—has been achieved for a CCD dual-speed, shift-register device. The development by Rockwell International's Autonetics Group in Anaheim, CA, is aimed at a transient recorder application.

According to Dr. Barry French, CCD research group leader: "The device can operate in two modes. In the first mode it accepts data at up to 234 Mb/s and transfers it out at up to 86 Mb/s. We call this the fast-slow mode. In the second mode it operates in a continuous way with up to 86 Mb/s data in and up to 86 Mb/s data out."

This device has 130 cells and uses a two-phase overlapping gate approach—that is, there is a separate gate for transfer and a separate gate for storage associated with each cell. Charge transfer efficiency per cell is 0.999 at a 230 Mb/s transfer rate.

French notes that the device has a ion-implanted epitaxial n-channel that is deeply buried. It also has a gate length of 0.2 mil in the direction of charge propagation. Each cell has a 10-mil-wide channel that allows the full cell to contain about 0.76 picocoulombs of charge.

Laser 'thermometer' to detect 80 million C

A laser "thermometer" to measure temperatures as high as 80 million degrees centigrade is being developed at the Massachusetts Institute of Technology, Cambridge, for thermonuclear fusion research.

The temperature-measuring system, being designed at MIT's Francis Bitter National Magnet Laboratory, consists of a new high-power, methyl fluoride gas laser and an infrared detection system. The laser wavelength is 500 μm —in the far infrared.

The system, being developed under a $350,000 contract with the Federal Energy Research and Development Administration, will measure the temperature of deuterium ions in a plasma confined by strong magnetic fields inside a tokomak—a structure shaped light a hollow doughnut.

The thermal measurements will monitor the ion temperatures, according to Dr. Daniel R. Cohn, who is in charge of plasma physics research at the Magnet Laboratory.

"Measurements of ion temperatures are a crucial indicator of progress towards self-sustained thermonuclear fusion," says Cohn. "The hotter the ions, the more often they will fuse into helium ions, giving off energy in the process."

Fusion occurs at 80 million C, he notes.

Ion temperature is measured by use of a phenomenon called Thomson Scattering, Cohn explains. The laser beam is directed at the plasma, and as the beam hits and bounces off the ions, the laser frequency is shifted. By measurement of this shift, both ion temperature and concentration of impurities in the plasma can be determined.

ROM capacity cut in voice synthesizer

A digital coding system used in a new electronic voice synthesizer reduces the required ROM capacity to only 2% of that needed in competitive voice systems, according to John E. Stork, president of Speech Technology, Inc., system developer.

"Conventional voice digitizing requires at least 50,000 bits/s to reproduce telephone-grade speech," Stork points out. "With our coding method, we compress that down to 1000 bits/s."

The Speech Technology synthesizer—the Model 200—uses a standard approach, Stork explains, in that it produces an electrical analog of the voice tract. It duplicates the resonances and other characteristics of speech.

"We take voice recordings—words or statements—and digitize them at a 100,000 bits/s rate. But our trick is to extract from the recording features that can be stored in the digitizer and recalled upon command.

"We do that by running the voice data through a computer analysis that compresses and transforms the data into unique code sequences that control the sound-generation portion of the synthesizer.

"To produce a particular sound, you send a 24-bit code to a control register in the synthesizer. The code—it is transferred in and out of the register in microseconds—programs the resonances, pitch frequencies and other sounds needed.

"For example, a sound like the vowel 'aah' in the word fox lasts for some 100 or 200 ms in normal speech. So the code directs the synthesizer to make that sound for 100 to 200 ms.

"Upon termination of that period, the code is replaced in the register by another code group, which is sent in for, say, 10 to 50 ms, until it is replaced by still another code, and so on."

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James Zaros
Vice President of Sales
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Datel carries 10 short-form catalog pages in the 1975-76 GOLD BOOK. They feature, among other products, Datel’s line of A/D and D/A converters, wideband operational amplifiers and analog multiplexers. The pages are packed with detailed specs, data and price information. Datel makes it easy for engineers to talk business over the phone.

Because the GOLD BOOK is primarily distributed to *Electronic Design’s* audience, Datel gets the best of both worlds — 78,000 engineers and engineering managers, purchasing agents and distributors throughout the U.S. *plus* 13,000 in key markets abroad. These are the men who have the authority to specify and *buy.*

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News

REPORT ON MICROCOMPUTER SOFTWARE

Experts tell how to hold down high cost of processor programs

The hardware designer, enticed by ads for low-cost microprocessor boards, has several surprises in store when he embarks on his first micro-systems design.

First, he'll learn that for a simple microprocessor control system, he'll wind up with at least 25 additional chips surrounding the basic processor. For fairly complex systems, the number can rise substantially above 100.

But the big shock comes when the designer gets into microcomputer software. It can cost from hundreds of dollars to thousands for the finished system. For a $30 microprocessor, software has been known to cost $65,000 to $70,000.

Like it or not, the designer will have to become involved in programming to produce effective designs at minimum cost. And he'll find himself in a design team that includes a specialized programmer.

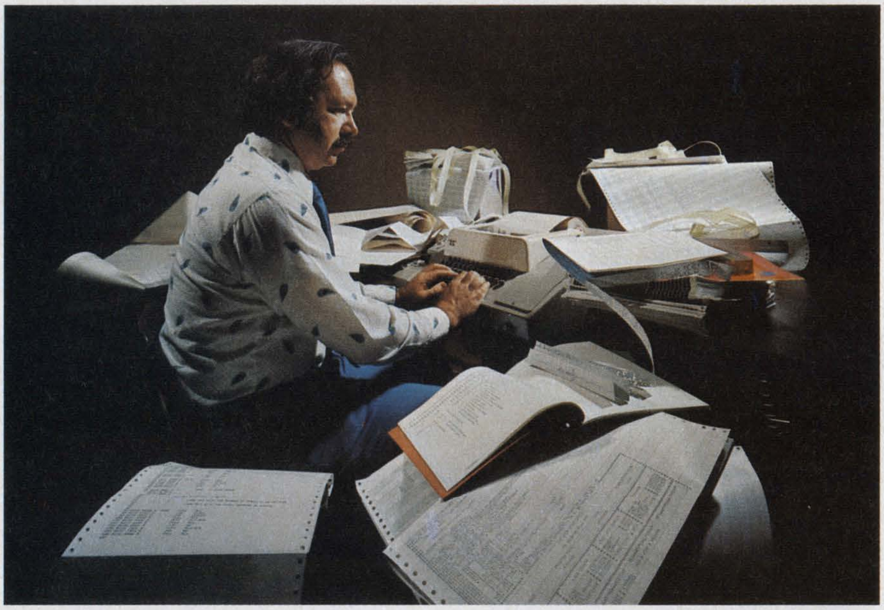
A two-man team

You need at least two people on the microprocessor team," says Gordon Gould, hardware designer for Advanced Electronics Development, Chester, CT, who has several successful micro-systems designs to his credit.

"You need the hardware man and the programmer. But the hardware man, to be effective, must have a good knowledge of programming language.

Software is more an integral part of microcomputer design than it is for a large computer, Gould notes, because much of the processing is related to the outside world rather than number crunching.

Jim McDermott
Eastern Editor



Microprocessor software programs can cost orders of magnitude more than the hardware. Programs can be generated using only a teletypewriter and a time-sharing service (top). But the slow speed of this system limits the lines of instruction code produced per hour. Fast, cost-effective software generation requires an investment like that of the National Development System (bottom) that incorporates an IMP-16P, an interactive CRT, a high-speed printer, a floppy-disc system and a teletypewriter.

Costs of software development can vary widely, Gould points out, depending upon which of several approaches is taken and the skill of the programmer. A skillful programmer can reduce hardware costs by assigning hardware functions to software.

"Our initial discussions on a design," says Tony Matthews, the programmer teamed with Gould, "are based on the assumption that software does everything. Then we back off from it when we find we can't.

"We use this attack because once the software is completed, there is no more design work to do."

Gould notes: "The more functions you can delegate to software, the better off you are, because you have more flexibility. For example, as changes come along, you can revise the software —on paper—and leave the hardware alone. Also, the less hardware, the lower the cost and the more reliable the system is."

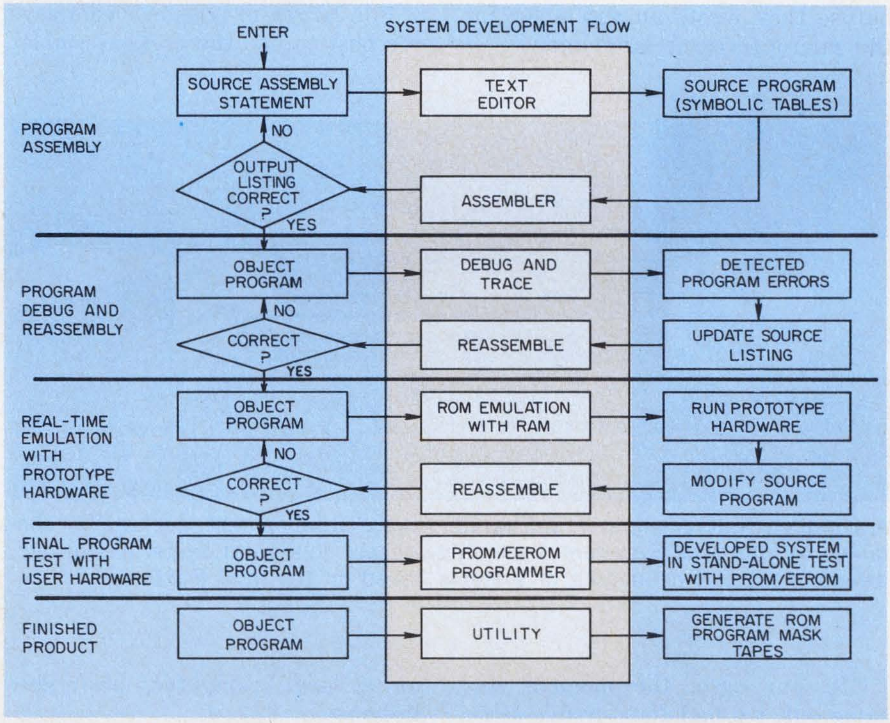
Decision-making in microprocessor hardware and software design can be a confusing experience. Some 60 or 70 vendors—semiconductor manufacturers, independent microprocessor hardware and software design houses and microprocessor hardware distributors—are marketing microprocessor design courses as well as software and development aids. The aids range from 4-bit microprocessor kits that are programmed by manual operation to extensive emulation systems, like Intel's MDS or National's IMP-16.

In addition time-sharing houses are available for running cross-assembler programs provided by the microchip manufacturer. And many of these programs can also be run on in-house computers.

Kits and courses help

For the hardware designer digging into microprocessor system design for the first time, the purchase of a kit or attendance at one of the many courses now given throughout the country can be of substantial advantage.

"Kits are extremely useful as a primary learning tool," says Robert K. Lowry, executive vice president of Technology Marketing, Inc., a design house for computer based systems.



Microprocessor system software development—assembly, test, debug, reassembly and verification—requires a series of organized steps. The final step puts the program in a ROM.

Just what microprocessor course to take depends upon how well the course presentation fits the designer's approach to study. For example, Jerry Ogden, president of Microcomputer Technology, Inc., Reston, VA, who conducts seminars and is also responsible for the training at the 13 Cramer Microprocessor Design Centers, points out that "our courses are an intellectual exercise.

"We're different from others," he says, "in that we don't teach in terms of hands-on experience. We don't believe that you need hands-on work in the initial stages."

On the other hand, Edwin Lee, president of Pro-Log, Monterey, CA, insists on a hands-on approach in his courses. And he's dead set against the usual course approach that considers the microprocessor a "baby computer." He uses "a very simple documentation approach" to software.

One reason for the high cost of microprocessor software is that the languages are still fairly new. This software has not yet reached the high degree of refinement and power that software for minicomputers and large machines has achieved.

Once a microcomputer is in hand, the tendency is great for a user to develop his own instruction set. But this, according to Robert Richards, president of Megadata, Bohemia, NY, a microcomputer design house, "is the biggest mistake the designer can make.

"While instruction sets and documentation are getting better," he says, "they're still not as good as anything from a company like DEC or Data General."

For minimum software costs, Richards advises the designer to follow Megadata's procedure.

"We evolve our microprocessor technology about well-known minicomputer systems," he notes. "For example, we're using Intersil's IM 6100 because it uses the DEC PDP-8/E instruction set.

"Software cost problems arise when you throw capable programmers into a new and totally unfamiliar instruction set. Finding programmers who can program by the pound—and that's the way to look at it—is a lot easier for us, because there are so many available with experience on the DEC machine."

A. Thampy Thomas, manager of microprocessor development at Intersil, Cupertino, CA, agrees with that philosophy.

"About two years ago we decided to build a microprocessor that emulated an existing instruction set, so we could use the software already developed for it," Thomas says.

The reason for that decision, he notes, is that "microprocessors usually take about two years to develop a resident assembler.

"For example," Thomas continues, "both Intel and National supported their microprocessors for two years on a Fortran processor before they wrote an assembler in the microprocessor language.

"In our case, the moment we came out, we had four or five self-assemblers available from DEC. We have compilers that recognize Fortran, Basic, Cobol and other high-level languages. And all this software was available without any development effort."

Minicomputer manufacturers are beginning to reduce microcomputer software costs by marketing new microprocessor boards and chip sets that are compatible with their own software.

One such manufacturer is General Automation. It is providing a one-board GA-16/110 and a two-board GA-16/220 microprocessor set. Both use the software developed over the last six years for the General Automation SPEC-16 minicomputer. In addition the micros are also compatible with the latest GA-16/330 and GA-16/440 minicomputer software.

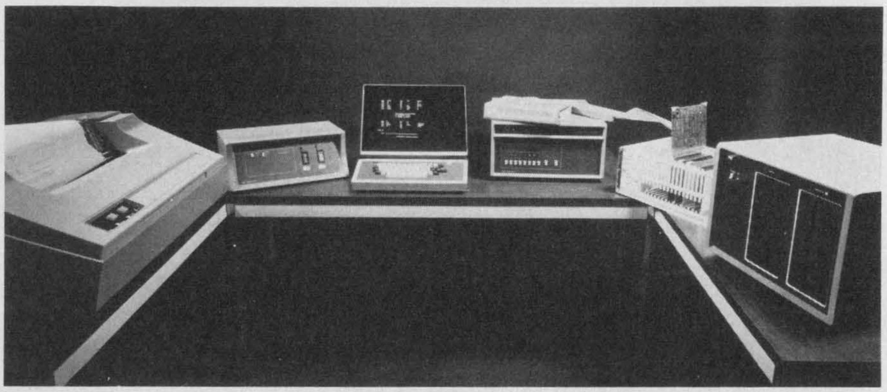
Designers disagree on how much equipment is needed to program a microprocessor satisfactorily.

Chuck Pedal, marketing director for microcomputers at MOS Technology, Norristown, PA, suggests that for a small program, such as debugging a printer or a piece of hardware, the use of a Teletype can be satisfactory.

For a larger program, on the order of 1 to 2 k, he recommends a resident assembler that has some kind of file structure.

"You can probably use a cassette and perhaps use a paper tape," Pedal says. But, in any event, a printout is mandatory, he notes.

For larger programs, Pedal says it's best to use the cross-assembler on a large computer, preferably in-house.



A complete microcomputer software-hardware development package is contained in Intel's MDS system. Its multiprocessor configuration permits design, development and debugging of systems based on the Intel 8080.

Richard Lee, manager of engineering development at Boonton Electronics, Boonton, NJ, has a different view. He says:

"There are only two reasonable approaches to software development. One is to go with a time-sharing house to do your program development, and the other is to buy either a resident operating system device or a cross-assembler operating system with a minicomputer."

Needed: two capabilities

"You must have, in a productive system, file-handling and file-editing capability in order to get the job done in any reasonable length of time. It is possible to write programs in machine language, but your productivity is small. And even the little resident assemblers found in some of the development kits—the stand-alone processor, like the Intellec 8—is not a very productive machine because its editing capability is minimal.

"In particular, the data input-output program gets to be enormous. You read paper tape forever for one cycle of a program development. And when you find you made a mistake, you do it again and again.

"When you think of the time you're spending and of the value of the time, you have to realize that software is a substantial investment in any microprocessor-based system. I think Intel is on the right track with its MDS system, where you can use a floppy disc and put through program changes in a realistically small amount of time.

"We have a PDP-8/E system, which has a dual mag tape drive and a line printer. I've been looking at 8-bit processors, and so far I haven't found any instruction set that I can't trick the DEC PAL8 assembler into assembling for me.

"Another thing you need is a reasonable rate of creating hard copy. You can run with a Teletype, but to do a 4-k listing means that you walk away from it and let it run for the morning.

"So you have to size the development equipment to suit the job you're running. My own impression is that people sadly underestimate the amount of software they're going to wind up wanting to have. You usually wind up with three times the program you expected in terms of added functions. And that's liable to be five or six times as big in memory locations."

In-house development backed

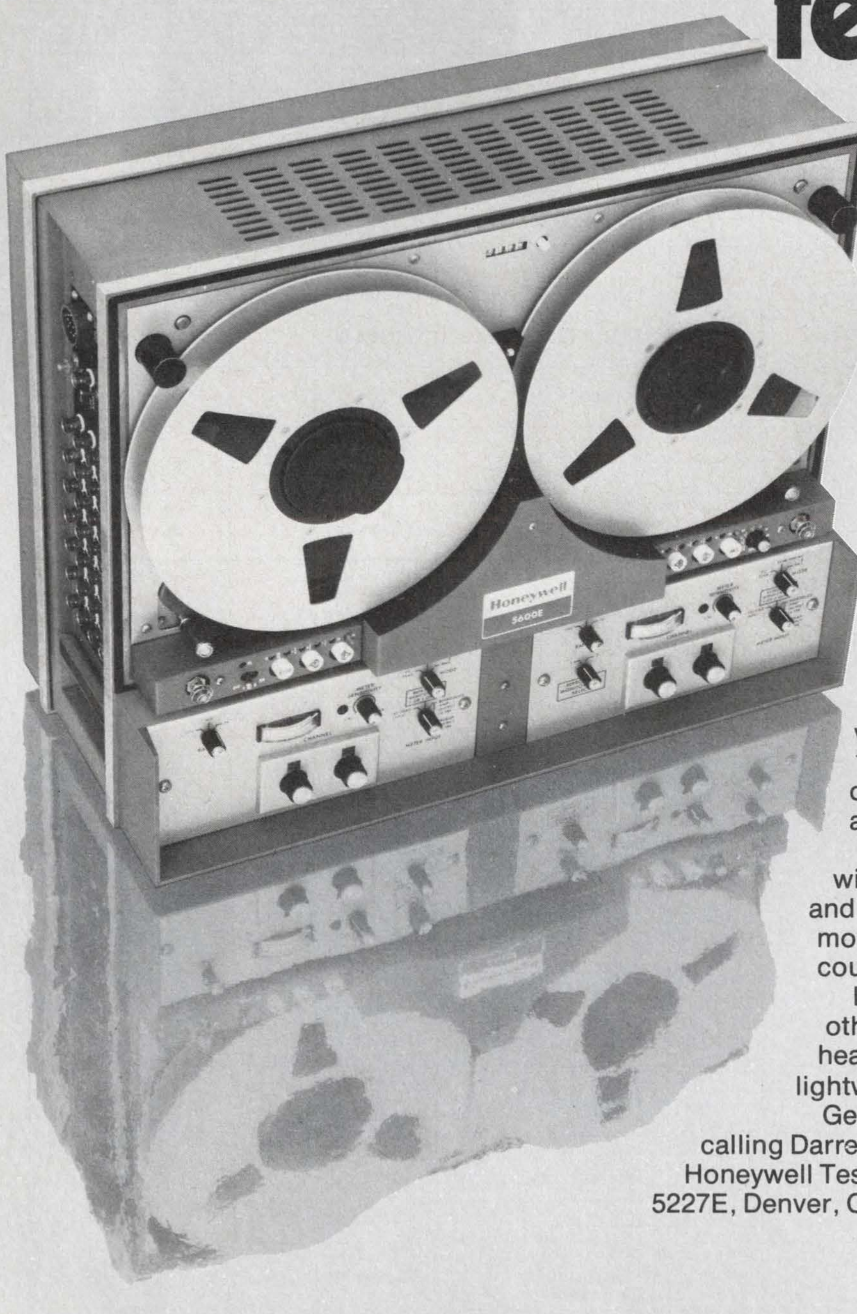
George F. Martin, vice president of Advanced Electronics Development, favors an in-house development system for producing new designs.

"A company that's just designing one or two systems can't usually justify the cost of a full development system," he says.

"We started with just a microprocessor and a Teletype for editing, but it took a 12-hour day to edit and assemble one large program.

"If you're a small manufacturing

New Honeywell portable packs 28 channels, meter monitoring and solid ferrite heads all into one small, superb unit.



If you've been waiting for better features and more capability in a portable tape recorder — you've got it. The Model 5600E from Honeywell!

Our new portable gives you up to 28 tracks, 7 speeds, field-convertible intermediate or wideband, solid ferrite wideband heads and 10 1/2-inch reel capacity. There's also a variety of rack and shock mount configurations and an integral dc power supply option.

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Microprocessor manufacturers and software support

Manufacturer	Microprocessor and architecture	Microprocessor system on a card	Hardware/ software development systems	Emulator to test system in place	Manufacturer's software support					
					Cross assembler	Resident assembler	Simulator	Debug program	Diagnostic program	Editor
Advanced Micro Devices	2901 4-bit slice	—	—	—	—	—	—	—	—	—
	9080 8-bit CPU	—	—	—	√	√	√	√	√	√
American MicroSystems	S6800 8-bit CPU	√	—	—	Fortran IV	—	Fortran IV	—	—	—
Electronic Arrays	EA9002 8-bit CPU	√	—	—	Fortran IV Time-share	√	√	—	—	—
Fairchild	F8 8-bit CPU	√	√	—	Fortran IV	√	Fortran IV	√	√	√
General Instrument	CP-1600 16-bit CPU	√	√	—	Fortran IV	√	Fortran IV	√	√	√
Intel	4004 4-bit CPU	√	√	—	Fortran IV	√	Fortran IV	√	√	√
	4040 4-bit CPU	√	√	—	Fortran IV	√	Fortran IV	√	√	√
	8008 8-bit CPU	√	√	√	Fortran IV	√	Fortran IV	√	√	√
	8080/A 8-bit CPU	√	√	√	Fortran IV	√	Fortran IV	√	√	√
Intersil	IM6100 12-bit CPU	√	√	PDP8/E	Fortran IV	√	√	√	√	√
Monolithic Memories	6701 4-bit slice	√	√	—	—	√	—	√	√	√
MOS Technology	6501/2/3 8-bit CPU	√	√	√	Fortran IV	√	Fortran IV	√	√	—
Mostek	F8 8-bit CPU	√	√	√	Fortran IV	√	Time-sharing	√	√	√
Motorola	M6800 8-bit CPU	√	√	√	Fortran IV	√	Fortran IV	√	√	√
National Semiconductor	IMP-4/8/16 4-bit slices	√	√	—	Fortran IV	√	—	√	√	√
	INS4004 4-bit CPU	—	—	—	—	—	—	—	—	—
	SCAMP-ISP500A 8-bit CPU	√	√	—	Fortran IV Time-sharing	√	√	√	√	√
	PACE-IPC-16 16-bit CPU	√	√	√	Fortran IV	√	—	√	√	√
NEC Microcomputers	μPD8080A 8-bit CPU	√	√	√	Fortran IV	√	Fortran IV	√	√	√
Plessey	MIPROC 16-bit CPU	√	√	—	Time-share DEC10	—	Time-share DEC 10	—	—	—
RCA	CPD 1800 8-bit CPU	√	√	√	Fortran IV	√	√	√	√	√
Rockwell	PPS-4/2 4-bit CPU	√	√	√	Fortran IV Time-share	√	√	√	√	√
	PPS-8 8-bit CPU	√	√	√	Fortran IV Time-share	√	√	√	√	√
Signetics	2650 8-bit CPU	√	√	√	Fortran IV	—	Fortran IV	√	√	√
Texas Instruments	TMS 1000/1200 4-bit μComp.	—	√	—	Time-share	√	Time-share	√	√	√
	TMS8080 8-bit CPU	—	—	—	Time-share	—	Time-share	√	√	√
	TMS 9900 16-bit CPU	√	√	√	Time-share	—	Time-share	√	√	√
Western Digital	MCP1600 9-bit CPU	√	—	√	Time-share	—	Time-share	√	√	—

It's good to know that in low power dividers you don't have to be constantly comparing which is best, which is new, on and on.

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Most important, you get an incredibly low power drain. For example:

	Type	Description	Power Consumption
Motorola	MC12012	÷10/11 at 200 MHz	95 mA typical
Plessey	SP8695	÷10/11 at 200 MHz	20 mA typical
Fairchild	95H90	÷10/11 at 200 MHz	70 mA typical
Plessey	SP8690	÷10/11 at 200 MHz	14 mA typical

Other examples of Plessey's extremely low power devices with no competition:

Type	Description	Power Consumption
SP8667	÷10 at 1.2 GHz	80 mA typical
SP8602	÷ 2 at 500 MHz	12 mA typical
SP8685	÷10/11 at 500 MHz	45 mA typical
SP8655	÷32 at 200 MHz	10 mA typical
SP8660	÷10 at 200 MHz	10 mA typical
SP8790	÷ 4 at 200 MHz	10 mA typical

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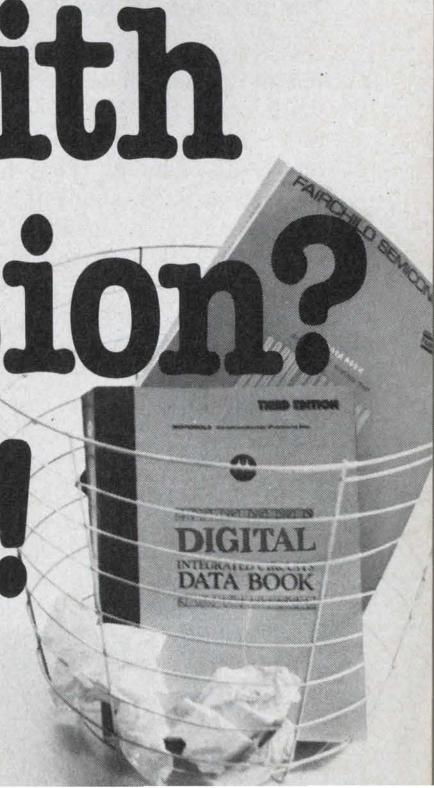
INFORMATION RETRIEVAL NUMBER 17

Compare Plessey's low power, high-speed dividers with the competition? Rubbish!



company and you want to automate your product, you can live with that, because in three months you'll have a system that you'll be selling for the next five years. So you don't want a lot of expensive prototyping equipment around.

"But in our business—designing microprocessor systems under contract—the initial $3000 for the prototype was a good investment."

In fact, each additional dollar invested, until we got up around $12,000, bought us more speed. For example, part of our system is an expensive high-speed card reader.

"But above $12,000 it takes considerably more dollars to get more programming output per hour. We believe that Intel has taken the right approach for our kind of need with its MDS system."

But Martin's advice is to go slowly and carefully before you make a large investment, "because once you start with a microcomputer that has its own unique software and development hardware, the investment in the software grows so rapidly that to convert to another system is usually a prohibitive expense."

The extent of development and software support provided by semiconductor manufacturers is very important in holding down software cost. A look at the table shows that for some microprocessors, across-the-board software support is provided.

The case for 16 bits

Another point that has been made is that in some cases software costs can be lower with use of a 16-bit processor, instead of an 8-bit device. The hardware price is usually about the same.

One reason for lower 16-bit software costs is that in some applications it may take more than 8 bits to define one instruction. In the 8-bit machine the machine must read in and fetch from two memory locations to get the instruction.

In one example, a system using a 16-bit processor took 1800 lines of coding in 1800 memory locations. Use of the 8-bit machine for the same job would have taken 5000 to 6000 memory locations. For, although the microprocessor is only 8 bits wide, the number of locations could have been divided by 2, but the software would still have come out with 2500 to 3000 lines of coding. And this would have required the debugging of 700 to 1200 lines more than necessary with the 16-bit machine.

High-level languages useful?

There has been much argument about the usefulness of high-level languages for microprocessor system development. So far four high-level languages for microprocessors have been offered.

The first entry, introduced two years ago, was Intel's PL/M. Motorola has just announced a new language: MPL. Plessey has a high-level language called PL-MIPROC, which is a super-set of Algol. And a "super-enhanced industrial Basic" has been generated by MITS, Inc., Albuquerque, NM, for the company's Altair 8800 microcomputer.

Microcomputer emulators, like this Rockwell PPS-8MP, shorten the time and reduce costs required for software design and system debugging.

Phil Roybal, microprocessor marketing manager of National Semiconductor, Santa Clara, CA, feels that most high-level languages are not good for bit manipulation or I/O instructions.

"That is why," he says, "almost no minicomputers or large-scale machines use these languages for writing the operating systems and the drivers or anything normally done with microprocessors.

"If you can intermix high-level and assembly languages, it helps. Unfortunately, some are attracted to the high-level languages because it looks so easy to program. But they're wrong."

James Lally, manager of systems products for Intel, Santa Clara, CA, notes that "you use languages like Basic or Fortran or Cobol or Algol to do programming in which there is a lot of numerical analysis."

But Lally points out that the operating system itself is generally written in assembly language. Intel's PL/M language, he insists, is different from Fortran and the others, in that it is a systems oriented, rather than an applications oriented, language. The best indication of the effectiveness of a systems language is its use by the manufacturer, Lally says.

"We've used PL/M exclusively in the development of all of our software," he notes. "We've written our disc operating system, the ICE 80 executive, all of our assemblers and our text editors—everything—in PL/M."

Language merger

Robert Albrecht, a Basic language expert and an executive of the People's Computing Co., a nonprofit organization in Menlo Park, CA, likes MITS' unique merger of Basic and machine language.

"The enhanced Altair Basic can load in octal machine-language instructions as part of data statements in Basic, and then position them in memory," he notes.

And Altair Basic has a potential for teaching machine-language programming, Albrecht points out.

The language can also be used to control output devices and perform bit manipulation, according to Paul Wasmund, programming specialist at MITS.

"You can directly address any I/O port with the IN and OUT instructions that correspond to the IN and OUT instuctions of the machine itself," Wasmund says.

"It also has 'peek and poke' functions for recalling any memory location desired. In addition there's a WAIT function that gives you a bit mask. For example, if you use a bit mask for ONE, the computer waits for that ONE to go either high or low, depending upon what else you tell it in the WAIT statement.

"With this function you can wait on a port until it inputs, and as a result the computer can handle devices like a/d's." ■■

Sensor-minicomputer network tells when lightning will strike

Because Sandia Laboratories conducts many tests of military ordnance in the sands at Albuquerque, NM, atmospheric static discharges and lightning are a constant hazard. They might trigger explosions, with resulting damage to telemetering cables and instrumentation at the test sites. Sandia asked: Why not predict when static discharges and lightning strikes might occur?

The result has been a minicomputer-controlled network called the Lightning Early Warning System. It collects and processes atmospheric and potential-gradient data from 14 sensors placed from two to 30 miles from a main station, reports William W. Shurtleff, project leader. The data are interpreted at the main station and then retransmitted to test sites that store explosives.

The computer controlling the system—a Hewlett-Packard 2114B with a 20-k memory—also obtains weather data from four remote stations located in known paths of lightning and dust storms.

Although the Sandia application for the early-warning system is unique, Shurtleff sees the basic long-line acquisition and monitoring functions applied to other uses, such as in solar energy experiments and intruder detection.

He points out that the weather station acquisition system, in particular, is a general-purpose, long-distance system that can be adapted to other applications.

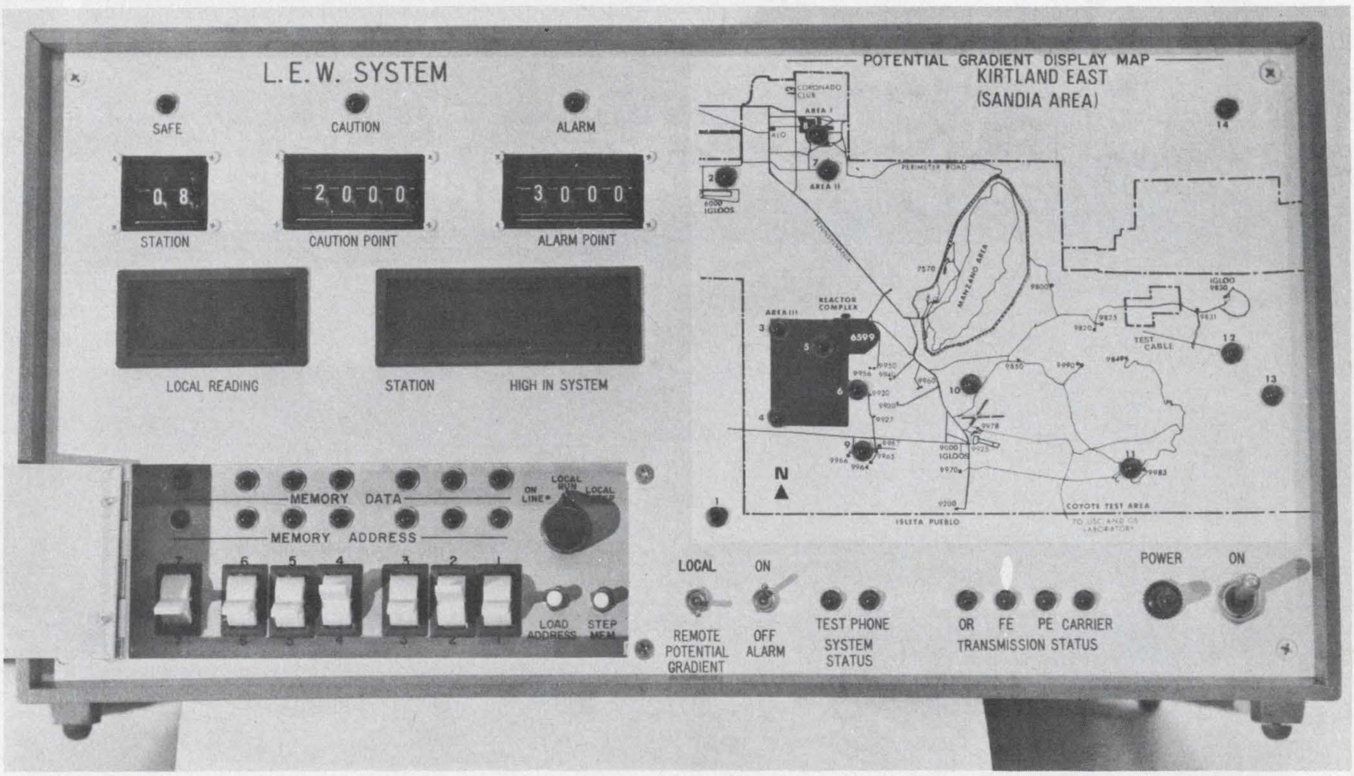
The potential-gradient sensors are laid out in a grid system. Data are fed to the main station, analyzed and retransmitted to users at the various test sites. If the potential gradient at any sensor reaches 2000 V/m, visual and audible alarms are sounded. The explosives are then stored until the danger is past.

The user, or test site operator, can adjust the potential level at which an alarm sounds. He may, says Shurtleff, reduce the level to as low as 500 V/m when he is monitoring tests that employ particularly sensitive explosives.

The test-site equipment has, as part of its display, a potential-gradient map with 2000 V/m warning lights. The observer can follow the path of a storm by watching the sequence in which the lights go on and off (see photo).

Sensors are radioactive

The key element of the system, Shurtleff explains, is the potential-



Display panel of on-site early-warning system equipment has a map with sensors pinpointed by warning lights. Storms can be traced by watching the lights go on. The system is installed at Sandia Laboratories test sites.

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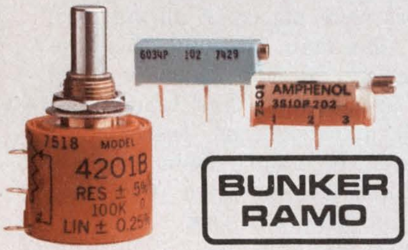

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BUNKER RAMO **AMPHENOL**

(continued from page 28)

gradient sensor. Eleven of these probes are linked to the central station by telephone wires and three by an rf telemetering system. Designed by Sweeney Manufacturing, Denver, each sensor contains a small amount of radioactive tritium, which ionizes the air surrounding the probe. The output ionization signal, which is detected by an electrometer FET amplifier, increases with an ambient, positive potential and decreases with a negative.

The FET output is detected, amplified and converted to a frequency by a Sandia-designed voltage-controlled oscillator. With a zero ambient atmospheric potential at the probe, the VCO output is 1000 cycles. For a positive 2000 V/m gradient, the frequency increases to 1500 Hz; for a negative 2000 V/m voltage, the frequency decreases to 500 Hz.

The probe signal is sent over phone lines or an rf transmitter. The transceiver is powered by a solar-energy panel.

As Shurtleff explains the rf-probe operation, the main station, under computer control, sends out a tone that is unique to a field station. Upon receiving the tone, the field unit switches from standby to full power, takes a reading and sends back a tone frequency that is proportional to the gradient measured. The field transceiver unit then returns to standby power status to wait for the next interrogation signal.

At the main station, the rf signal is received, detected, amplified and filtered to produce a pure af tone. The tone is multiplexed into a frequency-to-voltage converter, which translates it to a dc voltage that is proportional to the measured potential gradient.

The dc voltage is fed to an a/d converter having 11 bits plus a sign bit. The a/d output is computer-compatible.

System needs maintenance

Experience with the rf system has shown that the batteries must be recharged once every six months, despite the constant charge from the solar panel.

Shurtleff points out that recalibration and maintenance are performed at the same time and that the system has worked well through snow, rain and dust storms.

Signals received at the main station via remote-probe telephone lines are converted, in the same way as the rf signals, to digital data that can be fed into the computer.

In addition to the probes, the four remote weather stations transmit, over phone lines and upon computer command, wind speed, wind direction and temperature. The weather system has 16 channels at each station, thus providing 13 spares that can be used for additional meteorological data or weather-related experiments.

The computer requests a weather station to transmit data by sending a 360-Hz tone over its telephone line. The tone resets an a/d converter at that station to the first channel, and a reading is taken locally. The reading is converted to a series of digitally encoded FSK tones that contain the station and channel numbers, and 10 bits of data that are sent back down the line to the computer.

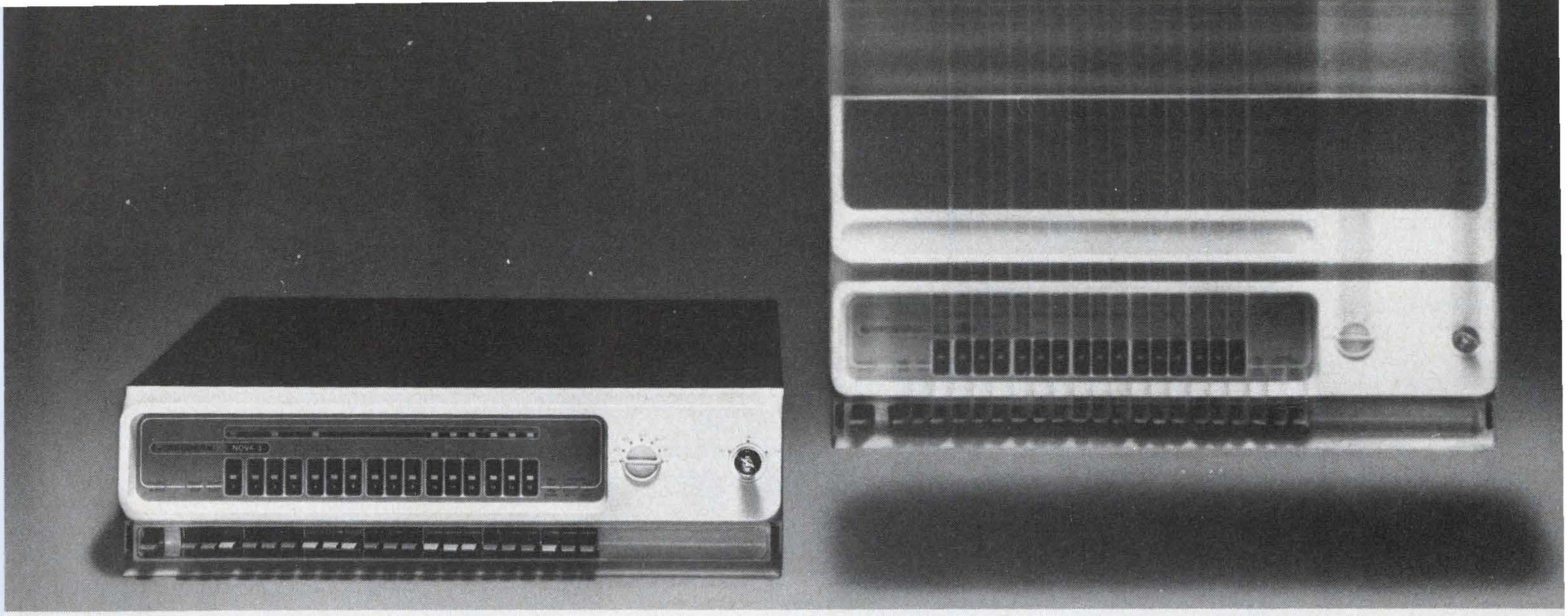
In like fashion, the readings of the other weather channels are converted, encoded and transmitted to the computer, until all active channels are interrogated and have replied. The system is then automatically reset and ready to start over again.

At the main station, the data tones are converted to digital levels, checked for errors and presented to the computer. Once the computer request has been satisfied, the 360-Hz tone is turned off and the process stops.

The remote stations have their own self-test features, Shurtleff points out, including test points, LED displays of critical levels and manual cycling capability.

After a weather station was struck by lightning, destroying a wind-direction sensor and translator circuitry, lightning surge arrestors were placed at all stations.

At the main station, the programming support consists of a high speed paper-tape reader and punch and a Texas Instruments operator terminal. Twin cassette tapes are available for recording data and programs. ■■



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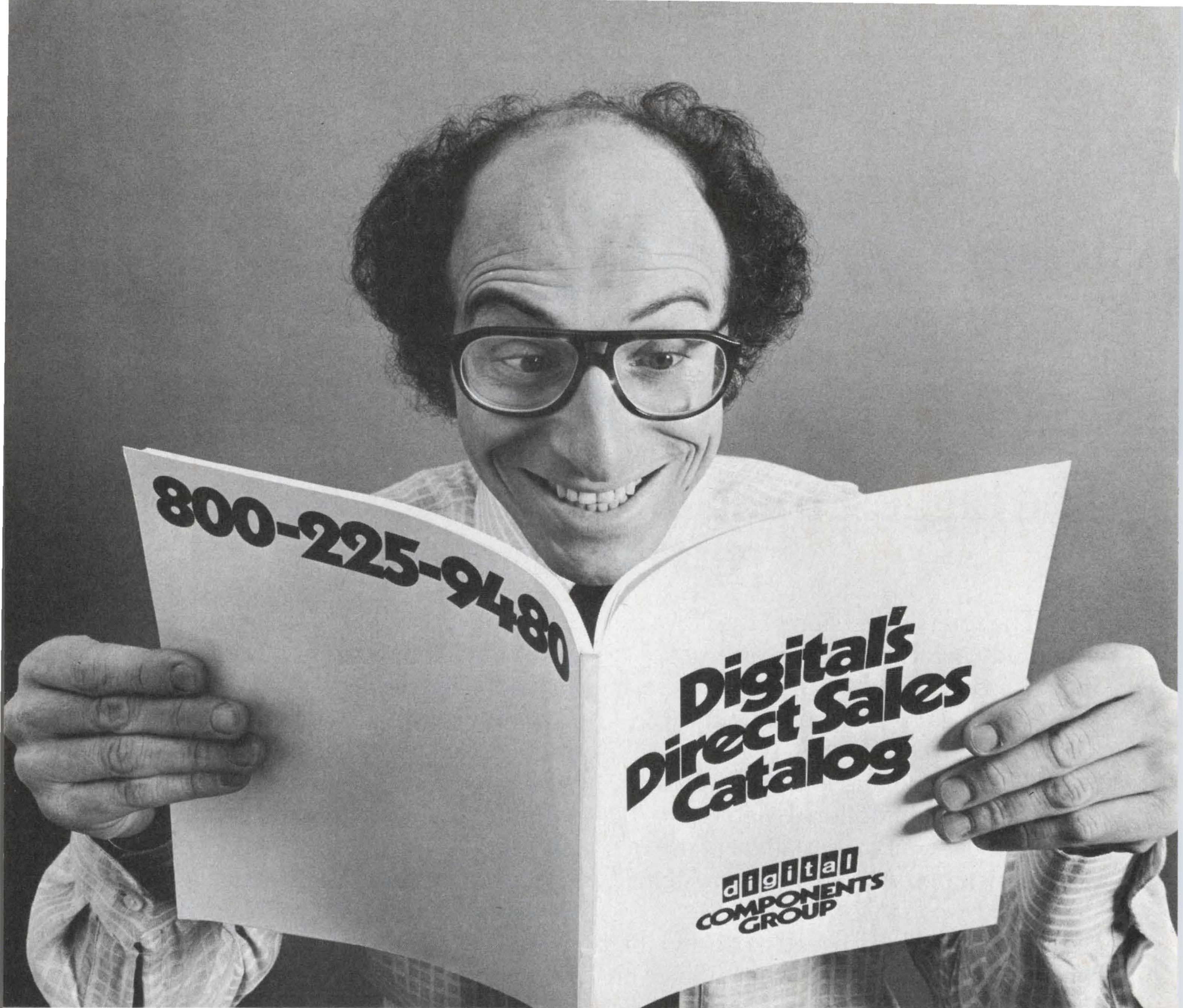

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INFORMATION RETRIEVAL NUMBER 22

Compiler for 6800 offers a high-level language to speed μC programming

No longer does Intel have the only high-level language, and associated compiler, for microprocessors. Motorola now offers a compiler for its language, called MPL, that works with systems based on the company's 6800 μP. Thus 6800 users have many of the benefits hitherto available only to users of the 8080 and 8008. But in addition the MPL (short for Microprocessor Programming Language) compiler contains such features as the ability to accept assembly-language statements, to manipulate bits, and to handle and reference data structures—collections of different kinds of data.

Both Intel's PL/M and Motorola's MPL languages are based on IBM's PL/1. The Intel compiler has been the sole microprocessor-compatible entry for the past two years or so. Similar compilers are expected next year from Fairchild and National Semiconductor among others, though at least one manufacturer—Texas Instruments—plans to introduce Cobol, Fortran and Basic for its new μP (see "Processor Family Debuts," *Electronic Design* 22, Oct. 25, 1975, p. 137).

Like Intel's PL/M, the MPL compiler from Motorola (Phoenix, AZ 85036. 602-244-3466) can be used to reduce programming costs, increase software reliability and simplify program maintenance and documentation when compared with an assembly-language approach. But a program written in assembly language typically requires less memory space than one written in a high-level language.

(continued on page 34)

Floppy-disc systems speed program development

The most time-consuming part of a microcomputer design—program development—can be slashed by a factor of 10 or more by the use of the floppy-disc operating system, or FDOS, from Icom (6741 Variel St., Canoga Park, CA 91303. 213-348-1391). With FDOS, a typical edit and assembly sequence takes 5 to 10 minutes, compared with 3 hours for a teletypewriter and 45 minutes with a high-speed paper-tape reader.

FDOS works in conjunction with the company's FD360 floppy-disc. Versions of the combined hardware/software system are offered for use with Intel's MDS-800 development tool and the Micropac 80A design aid from Process Computer Systems (Flint, MI). However, the basic FDOS/FD360 system can be applied to most microprocessors with the aid of standard interface circuitry.

Contained in FDOS are such single-command operations as disc-to-disc program editing and assembling, disc-to-memory program loading, and file transferring between paper tape and disc or between discs. Also, the operating system allows variable-length named files. The storage area on each diskette is available for any number of files of any length from a single sector of 128 bytes up to an entire diskette, or 256-k bytes. The files may contain program source data, program object data or user-generated data.

Prices for the MDS-compatible version start at $2650 for a single-drive system, including all software and an MDS-interface card. The corresponding price for the Micropac-compatible unit is $2400. Delivery is 2 to 4 weeks.

CIRCLE NO. 501

(continued from page 33)

An important difference, however, between PL/M and MPL is that the Motorola compiler produces assembly language as an output, rather than going directly to machine code as PL/M does. MPL works in conjunction with the 6800's assembler. Thus MPL takes slightly longer for compilations because of the additional step.

But this provides several direct benefits. First, assembly-language statements can be embedded in a compiler-language program. Thus, you can optimize portions of a program by writing them in assembly language, without the entire program written that way. Another benefit is that assembly-language subroutines from, say, a user's library can be applied directly within a program otherwise written in the compiler language.

In addition, program debugging can be greatly simplified. You can more easily see what the computer is doing. If necessary you can use Motorola's Exorciser development system to insert breakpoints in the program, follow the processor's execution step-by-step and actually see the instructions in the assembly-language output as they are to be executed.

Further, portions of the program already written in the compiler language can be shortened somewhat if, say, available memory space is slightly less than that called for by the program. Motorola's MPL allows programs that occupy memory space as large as 65-k bytes, as does the latest PL/M versions.

In another difference, MPL permits data structures, like those found in Cobol. A particular data structure can include 8-bit and 16-bit integers, as well as, alphanumeric characters such as might exist in an inventory system or anywhere that data isn't homogeneous. Data structures contrast with the more common data arrays—like those of Fortran—in which data must be of the same type.

The types of data that can be handled by MPL include bit, binary (1 or 2 bytes long), decimal, and label. The compiler's ability to manipulate individual bits overcomes one of the major drawbacks of existing high-level languages. Micros spend much of their time talking to the "outside world" in terms of bits, but earlier languages don't permit bit manipulation.

Another feature of MPL is that it can perform an automatic conversion of two binary numbers of different length or a binary and decimal number for arithmetic operations. And it allows three-dimensional arrays of data. Thus three levels of data can be stored and indexed.

Other improvements include signed integer arithmetic—the language allows the representation of negative numbers. Also subroutine arguments may be passed in internal registers, thereby saving program steps and memory space for subroutine calls.

Presently the MPL compiler is available on GE time-share services. Beginning during the first quarter of next year, versions priced at $1250 will be available in Fortran on standard cards or magnetic tapes. Portable versions will run on any computer that has a word length of 16 bits or more. Thus many popular minis as well as large computers will be able to run the compiler. For more information

CIRCLE NO. 502 MOTOROLA, 503 INTEL.

(continued on page 36)

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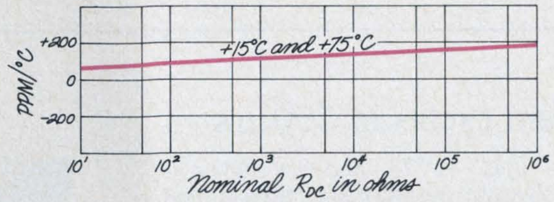

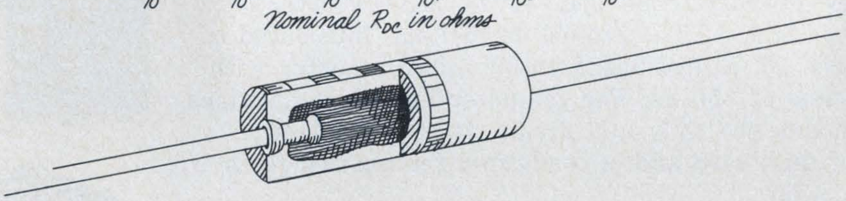

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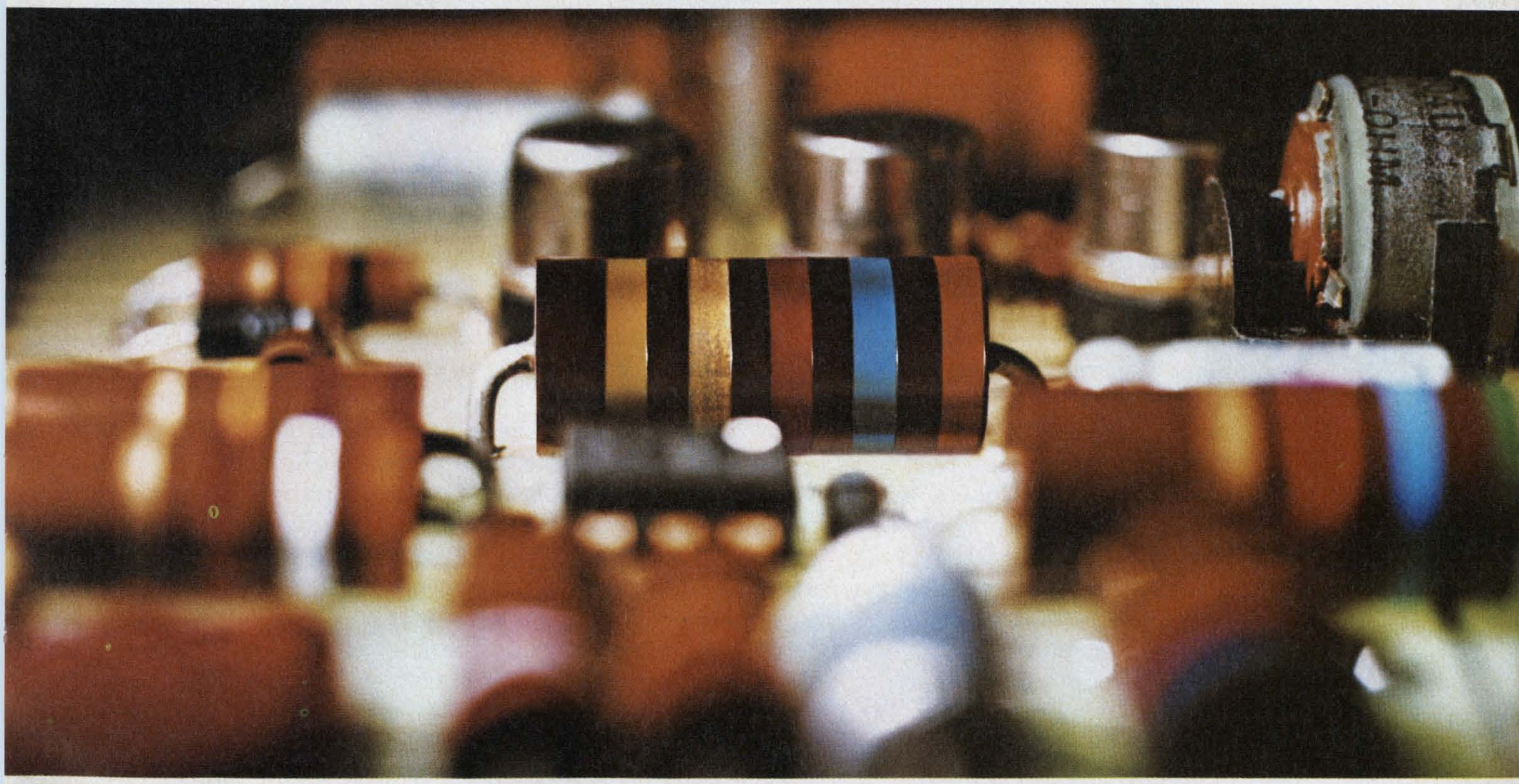

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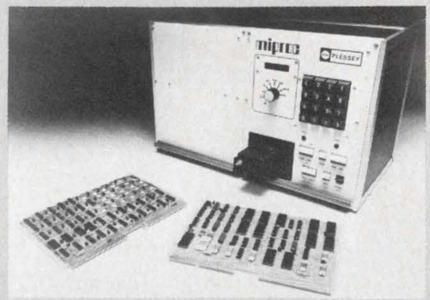
INFORMATION RETRIEVAL NUMBER 24

Next in kits: do-it-yourself gas-discharge displays

Look for Burroughs to enter the rapidly growing microcomputer design-aid field with a display kit that will make it easier to monitor and check a developing micro system. The Plainfield, NJ, manufacturer is rumored to be working on a kit to be used with do-it-yourself processor systems to be offered by Intel, Motorola and others. The Burroughs' entry will have a single-line Self-Scan display with 16 or 32 characters, and it will contain a dc-to-dc converter to translate the low μP voltage levels to the 180 V or so needed for the gas-discharge displays.

16-bit microcomputer system cycles in 350 μs



Plessey Microsystems, Inc. (1674 McGaw Ave., Santa Ana, CA 92705. 714-540-9945) has introduced the Miproc 16, a high-speed 16-bit microcomputer with a cycle time of 350 ns. The computer has 82 instructions, which include multiply and divide. It is a complete processor on a card and is configured for parallel fetch and execution.

Included in the Miproc 16 are two separate program memory and data memory architectures, so most instructions take a single cycle. Conditional branches take 700 ns, and multiply or divide times are 5.6 and 11.2 μs, respectively. The system is supported by a versatile prototype development system and a Fortran IV cross-assembler simulator for use on the Tymshare and GE Mark III networks.

The price of the CPU board is between $700 to $800 for large quantities, and delivery is 30 days.

CIRCLE NO. 504

Security field turns to micros for monitoring and control

The security electronics field, long dominated by the relay and battery, is taking on new sophistication with the introduction of microprocessor-controlled monitoring and scanning equipment. The microprocessor is starting to do a good portion of the job once done exclusively by either hard-wired logic or manual control.

For years, large apartment complexes and office buildings have used guards, sitting at panels of video monitors, to detect trouble. Today these monitors are still used, but added to their effectiveness are μP-controlled scanners that can monitor alarms in up to 1000 locations. In addition card readers controlled by microprocessors are permitting selective access to restricted areas.

Whether the system application is scanning or selective access, microprocessors are ideal as control elements because of their inherent flexibility, says Victor White, vice president of Receptors, Inc., Torrance, CA. "We presently use the Digital Equipment Corp. LSI-11 microcomputer to handle the data from our Model 300 multiplex monitoring and control system," he notes. The LSI-11 is built around a custom microprocessor.

Microprocessor systems developed by Keltron, Waltham, MA, are based on the Intel 8080. These systems can monitor up to 1000 points and provide visual and audible alarms. Two basic systems are being offered by Keltron: the DM-600, a 100-zone system, and the DM-700, a 1000-zone system. The smaller system, complete with all zone circuits, costs about $3500 and can connect to an optional printer, if hard-copy printout of conditions is needed. The larger system costs about $6000 when equipped with 100 zone circuits and a printer, but it is expandable to 1000 zones.

(continued on page 38)

The real test for a display's readability is direct sunlight. Most of them are washouts.

By comparison, Beckman displays stand out. With wider viewing angles and more brightness by the foot. Important factors when you're looking at critical readouts in the air or on the ground.

The reason for most of our product advantages can be summed up in two words: Neoptic™ displays. Combining neon and advanced electronics for a feat in human engineering.

Besides outstanding visibility, Beckman Neoptic displays give you letter-perfect numbers. No breaks or gaps. Natural, flowing lines to the eye. In any number. And in pleasing oranges you can filter to bright reds. Perfect for the designer who wants his numbers to look like numbers. Not like jigsaw puzzles.

Beckman Neoptic displays are the designer's designs. Modular. In character heights from 1/3" to 1." Arranged on one- to four-digit, plug-in building blocks that save space and assembly time.

Reliability is part of the Beckman Neoptic display picture. Assured by extensive in-process testing and 100% burn-in. As a result, we can give you a warranty that's good for 1 year. (Or you may qualify for our Warranty Plus Option.)

To top it all, Beckman Neoptic displays can give you a visible edge in your market—a simple case of product differentiation.

This is how Beckman displays beat the daylights out of all others. Point for point, digit by digit. Clearly and decisively. And if you're not convinced, just plug in one of ours. Then compare it to theirs. The difference will show up day or night.

For complete details, write: Beckman Instruments, Inc., Information Displays Operations, P.O. Box 3579, Scottsdale, Arizona 85257, or call: (602) 947-8371.

Beckman®
INFORMATION DISPLAYS OPERATIONS

INFORMATION RETRIEVAL NUMBER 25

Beckman beats the daylights out of all other displays.

This photo of our model SP-101 was taken in actual daylight.

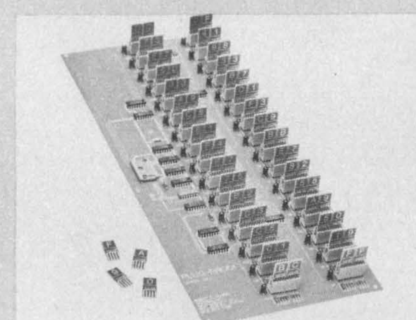
(continued from page 36)

Selective entrance or exit in large company stock rooms, data-processing centers and vaults can be critical. To keep track of who enters and leaves, microprocessors and other dedicated processors are being used to control the opening and closing of doors and gates.

Encoded pass cards, about the size of plastic credit cards, contain data that are keyed back to a central controller or used by a "smart lock" to open doors. The controllers can usually check the code against a list of stolen and defunct cards and either generate an alarm if an illegal card turns up or open the door if the card holder is authorized.

On large processor-controlled systems entry codes can be changed at the flick of a switch. Smart locks, on the other hand, must either be rewired or all the pass cards must be changed. Processor-controlled system prices start at $10,000 for a system that can handle 1000 remote readers and 20,000 individuals. Smart readers cost about $650 each.

PC-board PROM permits easy word changes



The Plug-Prom ROM uses small, 0.5 × 1-in. plug-in printed-circuit boards to program half an 8-bit word. Two plugs are needed for each memory word. Each plug is labeled with a hexadecimal value (0 to 9, A to F) that programs a diode matrix.

The Plug-Prom connects easily to any system using a short cable with a 24-pin plug on the end and is electrically equivalent to a type 1702 PROM. A LED option, a helpful tool, lights a LED in every word position when that word is selected. If the execution time is slowed or single-cycled, the LED indicators will visually show every fetch, jump, jump-to-subroutine and return-to-subroutine in the program.

Brent Olson (1950 Colony St., Mountain View, CA 94043. 415-326-2000) offers eight models, with dimensions ranging from 15 × 8 to 15 × 30 in. Organizations of 8 × 32 to 8 × 256 are available, and prices range from $250 to $1995. The plugs cost extra. Delivery of standard units is from stock to 60 days. **CIRCLE NO. 505**

16-bit processor system has multiple-sourced software

Execution times of less than 1 μs and multiple-sourced software are offered by the Micromini System 300, a 16-bit microprocessor from Monolithic Memories (1165 E. Arques Ave., Sunnyvale, CA 94086. 408-739-3535). The μP system is based on the company's Model 6701 bipolar bit-slice processor.

The system comes in a variety of forms. It is available as a fully tested kit of components, as a set of PC cards, as a stand-alone six or 12-slot card file, or as a chassis-mounted computer with power supply and programmer's front panel.

The System 300 is software compatible with Data General's NOVA series. Compatible mass-storage operating systems with full software-development support are available from both Xebec Systems (Sunnyvale, CA) and Educational Data Systems (Newport Beach, CA).

Versions of the System 300 come in two performance ranges, as well as, in a militarized

(continued on page 40)

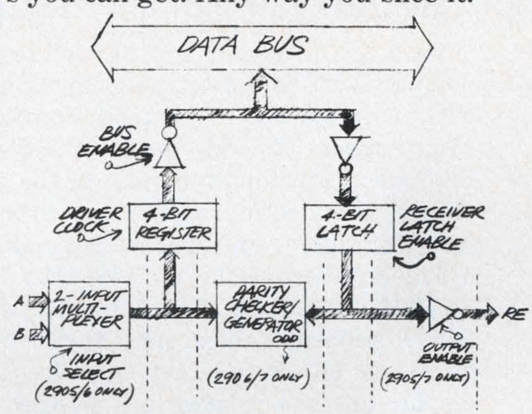
I/O To Go.

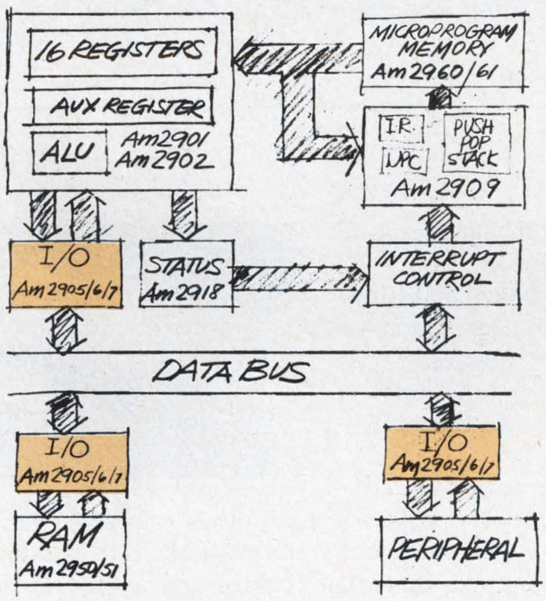
The Am2905/6/7 Bus Transceivers: High-speed I/O for your microprocessor any way you want it. Three versions of the same superb low-power Schottky LSI slice. Yours. Off the shelf. Now.

Single or dual driver input ports. With or without parity checking and generation. With or without three-state receiver outputs.

The Am2905/6/7 have open collector outputs that drive 50-ohm loads on terminated long lines. They store driver and receiver data for pipeline operation. And, with a bus-to-receiver delay of just 17 nanoseconds, they're ideal for any microprocessor, bipolar or MOS.

The Am2905/6/7 are the best microprocessor I/O's you can get. Any way you slice it.





Bye bye, MSI.

Say bye bye to your complicated, costly MSI systems. The Am2900 family is here!

We started with the world's fastest, most powerful LSI microprocessor, the Am2901.

And went on from there until now we have eleven large scale, low-power Schottky circuits that combine the architectural simplicity and functional flexibility of MSI with the performance and cost advantages of LSI. Check the block diagram of a typical high-speed microcomputer, and you'll find everything you'll ever need for computation, control, communications and storage in any high-speed microprogrammed application.

If you like the picture, you'll love the book. Send for the Am2900 story, and wave bye bye.

Bye bye, MSI!

Advanced Microprocessors

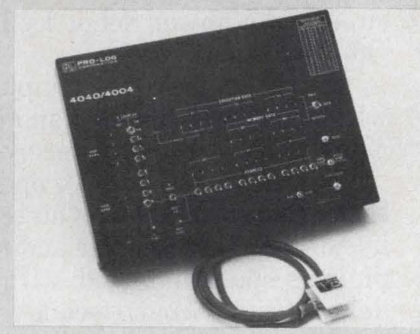
Advanced Micro Devices • 901 Thompson Place, Sunnyvale, California 94086 • Telephone (408) 732-2400 •
Distributed nationally by Hamilton/Avnet, Cramer and Schweber Electronics.

INFORMATION RETRIEVAL NUMBER 26

(continued from page 38)
form. The 301 CPU ($1250 in unit quantities) allows instruction execution time of 900 ns, and the 304 CPU ($625 in unit quantities) permits 1800 ns. The 302 CPU operates over the −55-to-100-C temperature range.

CIRCLE NO. 506

Portable analyzers design and test μP systems



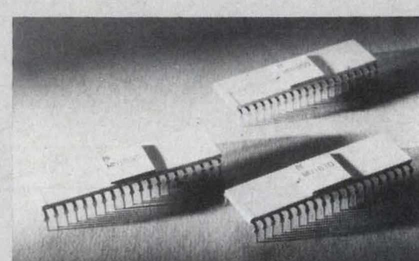
Both the program and hardware for systems using popular 4-bit and 8-bit μPs can be designed and tested with a new series of portable analyzers from Pro-Log (852 Airport Rd., Monterey, CA 93940. 408-372-4593). The new instruments eliminate the need for control panels, diagnostic routines or other data-processing tools for testing microprocessor-based systems.

The series consists of units that test systems based on 4004, 4040, 8008, 8080 and 6800 μPs. Used in conjunction with standard oscilloscopes, they can test program and hardware either together or individually. The analyzers display all data related to a selected instruction cycle and generate a scope sync pulse. They interface to the system under test through use of a DIP connector that clips onto the microprocessor.

Prices range from $550 to $750, and all analyzers are available from stock.

CIRCLE NO. 507

16-bit μP chip set includes DMA chip



The latest microprocessor entry is a 16-bit, three-chip set from Panafacom (P.O. Box 4637, Mountain View, CA 94040). It features a CPU IC that can perform 16-bit parallel operations in 3 μs or less. The two other chips—the Subchannel Adapter (SCA) and Direct Memory Access Controller (DMAC)—provide the I/O functions for the new PFL-16A chip set and permit data-transfer rates up to 1 Mbit per second.

The CPU chip responds to 33 basic instructions, allows six addressing modes and has five 16-bit registers. Like other processor chips, it contains control logic, arithmetic and index registers and stack pointer. But in addition the new CPU has three levels of program-maskable interrupt control and a type of software interrupt called program-status-word switching. And its auto-start feature ensures startup from a specified address whenever power is turned on.

The SCA chip operates in a program-control mode if used alone and in a DMA mode when used with the DMAC. Up to eight DMA channels, each with four subchannels, can be accommodated by the PFL-16A. The total subchannel capacity is 32, and up to 256 input and 256 output device addresses can be connected. Further, the chip set operates with either 8 or 16-bit data; external systems using either can be interfaced directly.

Each of the three chips in the set is a silicon-gate NMOS circuit requiring 12, 5 and −3-V supplies. Each chip features TTL compatibility and comes in a 40-pin DIP.

The PFL-16A system is available on preassembled, standard-sized cards. Thirteen cards are offered, and their use simplifies hardware development. For software development, Panafacom provides three complete debugging and program-maintenance systems. Other software support includes resident and cross-assemblers, editors and loaders.

CIRCLE NO. 508

INFORMATION RETRIEVAL NUMBER 28

Washington Report

Competition sought in common-carrier communications

An inquiry by the House Subcommittee on Communications into regulations affecting domestic common-carrier communications is setting the stage for regulatory reforms that could shake up the communications industry.

The White House policy on the communications industry emerged loud and clear in testimony: Market competition should be the rule and regulated monopolies the exception.

One beneficiary of competition would be the Federal Government, the nation's largest customer of telecommunications, with a current investment of $50 billion and an annual expenditure of $10 billion. Government procurement has largely been sole-source from monopoly common carriers, and a competitive market would ostensibly result in savings.

"We still have today a kind of presumption in favor of regulated monopoly," says John Eger, acting director of the Office of Telecommunications Policy in the White House. "This means, in practice, that any would-be provider of a new or improved service must bear the onus of justifying his entry into the market and must undergo the accompanying burden of regulatory delays—and must usually accept the added cost of some kind of regulations."

The Ford Administration contends that the burden of proof should be shifted in favor of competition and that those opposing it should be obliged to show concretely that the detriments outweigh the benefits.

Rise in defense budget spending planned in '77 budget

The Ford Administration's tentative budget estimate for fiscal 1977 calls for $11.5 billion more for defense than was authorized for 1976. Defense budget authority would increase from the current $103 billion to $114.2 billion, and outlays from $91.5 billion this fiscal year to $103 billion in fiscal 1977.

Procurement of defense items again takes a back seat to personnel costs, which would account for over $6 billion of the increase. Budget authority for procurement would rise from the current $22.2 billion to $24.4-billion. Actual outlays would increase from this year's $16.2 billion to $18.3 billion.

The Defense Dept.'s research and development budget authority would increase to $10.6 billion from $9.7 billion, and outlays are expected to be $10 billion, compared with $9.3 billion this year.

Almost no change is projected for general science and technology, which includes the National Aeronautics and Space Administration budget. That category will climb $300 million to a total of $4.6 billion, and all of the hike is for manned space flight in connection with the space-shuttle program.

The President will officially transmit the 1977 budget to Congress early next month.

FAA landing and beacon programs pushed

The Federal Aviation Administration has a green light from Congress to move ahead with three systems: microwave landing, discrete-address beacon and aeronautical satellite. This approval came with passage of the Dept. of Transportation money bill for fiscal 1976, in which $67.5 million was earmarked for FAA's research, engineering and development.

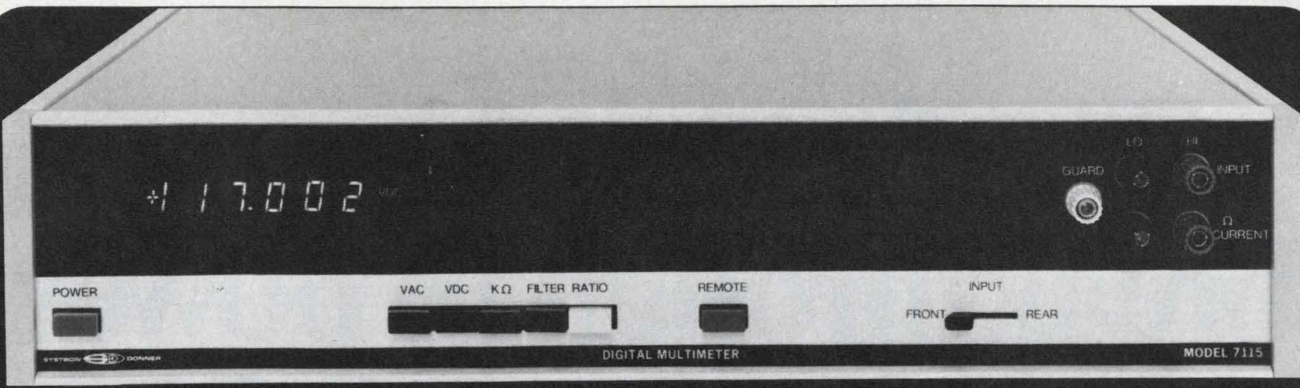
Congress didn't specifically break out the allocations for the programs, leaving that to the agency, but it did say that the funds were intended to provide sufficient capital to ensure essential progress in the microwave landing and beacon systems. In restoring funds for Aerosat, Congress said it expected the FAA to test both L-band and vhf capabilities and to present findings to the Congress to acceptance of either frequency.

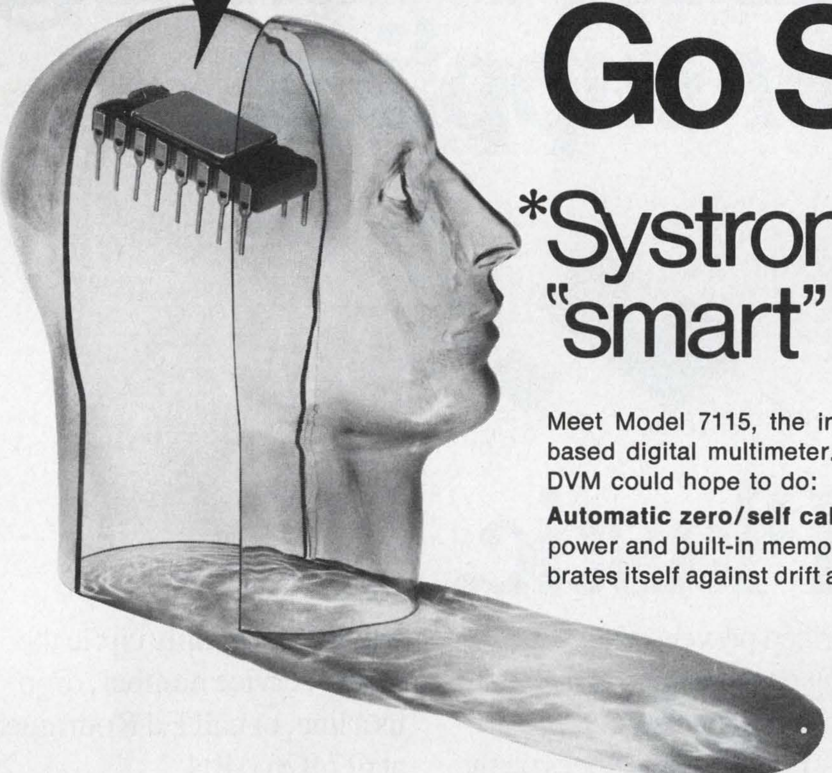
Minimum altitude control sought by military

In the near future air controllers and military control centers are going to be alerted instantly when aircraft are below minimum safe flying altitude. This capability will come from a programmable indicator data processor system now under development by the Air Force, which plans to buy 91 units under a contract to be awarded in the spring of 1976. Navy flying fields will also get the units.

The heart of the new system is a programmable digital minicomputer which will generate alphanumerics to indicate flight density, ground speed and message data. Radar scopes will either have to be modified or replaced to accommodate this more detailed presentation of flight information.

Capital Capsules: The Dept. of Transportation has authority in its budget **to begin deployment of a Loran C navigation network** in the Gulf of Mexico and along the Atlantic Coast. . . . **The Air Force is testing a new electronic security system in a variety of terrains.** Tests have been made at sandy Eglin AFB in Florida, and Fort Drum in northern New York State is to be the next site. The transducers under development are said to be so sensitive that they can detect ground vibration caused by air waves from a helicopter flying overhead. The object of the tests is to program the system's logic so it can tell the difference between a man crossing a field of sensors and, for example, a rabbit. . . . The Air Force Systems Command **wants a source to develop a low-cost high-performance integrated circuit capable of amplifying photodiode signals** at data rates to 10 Mbits/s. The Directorate of R&D Procurement (ASD/PPM-1) at Wright-Patterson Air Force Base also is looking for low-cost fiber-optic transmitter and receiver modules for those data rates. . . . Congressional pressure is reportedly one reason why the **Energy Research and Development Administration has deferred to next month or later that issuance of guidelines for submission of proposals for the Solar Energy Research Institute.** Southwestern states are on record as saying their area would be ideal for such a facility.





Go SDVM*

*Systron-Donner "smart" DVM

Meet Model 7115, the industry's first **microprocessor-based** digital multimeter. It does what no conventional DVM could hope to do:

Automatic zero/self calibration. Using its computing power and built-in memory, Model 7115 continually calibrates itself against drift and component aging. Similarly, it detects and corrects for zero drift and offset error. Result: accurate readings all the time!

Self-diagnosis. Microprocessor power again. Out-of-limit conditions or failures are signalled on the front panel; internal LED's direct the operator to their location inside.

High-speed autoranging. A rapid new S-D autoranging technique finds the correct range, goes there immediately and reads. It's not only a big improvement for bench use, but systems users can now use autoranging.

Command performances. An optional keyboard for programming the Model 7115 allows it to linearize and normalize, run comparison programs for checking out-of-tolerance conditions, multiply by a constant, average readings . . . and much more.

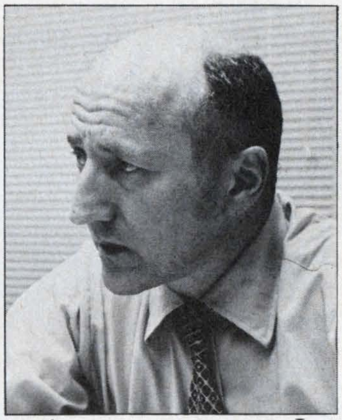
These features, too. Up to 100 readings/sec. • DC accuracy of ±0.002% rdg. • Parallel programming or ASCII option • True RMS AC volts option • High accuracy resistance measuring option.

Get the full story on the first SDVM from Scientific Devices, or contact us at 10 Systron Drive, Concord, California 94518. Phone (415) 676-5000. Overseas, contact Systron-Donner in Munich; Leamington Spa, U.K.; Paris (Le Port Marly); Melbourne.

SYSTRON DONNER

INFORMATION RETRIEVAL NUMBER 29

Delegating authority



Joe's a great manager. If you don't believe it, ask him. He's read just about every book anybody has ever written on management and he subscribes to all the management publications. He has probably read everything Peter Drucker has written 16 times.

One of the cornerstones of his success, he confides, is that he knows how to delegate authority. Just about everybody working for him is authorized to do something. But if you ask his people, they offer a different view.

"Sure he delegates authority," Stan will tell you, "but he gives it to you with one hand and takes it away with the other." If one of Stan's engineers screws up, Joe will be in there chewing him out. And if one of Stan's engineers does a sensational job, Joe will promise him a raise—often forgetting to mention this to Stan.

So Stan has all the authority he wants and needs to do his job properly, but Joe frequently takes it away without telling him. Under pressure of a deadline, Stan gives one of his engineers a time-sensitive assignment, only to discover later that Joe has stopped by to chat and asked the engineer to run through some tests on a different project. The engineer, unfortunately, hadn't read all the management books so when his boss' boss asks him to do something, he does it.

I'm particularly sensitive to this problem because, eleven years ago, I lost a fine editor, who resigned one day because he never got the fantastic raise promised him by my boss, who never bothered to tell me about it.

It's unfortunate that our industry has bred so many hundreds of well-intentioned Joes for whom thousands of Stans must bear a double burden. It might make a major contribution to improving the way we operate if they could teach themselves, when speaking to their subordinates' subordinates, to restrict their conversations to: "Good morning," "How are things going?," "Did you hear about these two guys in a saloon who. . .?"

George Rostky

GEORGE ROSTKY
Editor-in-Chief

THIS YEAR...

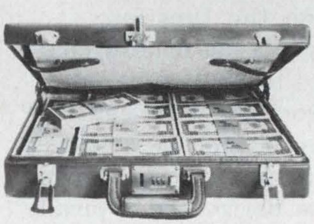
LET ELECTRONIC DESIGN PAY FOR YOUR VACATION

ENTER OUR JAN. 5, 1976

TOP TEN CONTEST

WIN THE POPULAR CARIBBEAN WINDJAMMER CRUISE FOR TWO

Once again, by reader demand, a week's Windjammer Cruise for two in the fabulous blue Caribbean is waiting for the lucky winner of *Electronic Design's* annual TOP TEN CONTEST. Think of it . . . a complete vacation absolutely FREE! Spend easy carefree days sailing among the Bahama Out Islands, the U.S. and British Virgin Islands, or the exotic Windwards and Leewards. Shop in the free ports, sun, swim, snorkel, help sail the ship or just relax by the rail. It's truly the cruise of a lifetime.



PLUS A COOL $1,000 CASH AND PRE-PAID AIR TRANSPORTATION FOR TWO

In addition to the cruise, the first prize winner gets $1,000 cash, plus air transportation for two to and from the cruise ship's point of departure.

PLUS FREE AD RERUNS FOR YOUR COMPANY

If your company has an ad in *Electronic Design's* Jan. 5, 1976 issue, and you are one of the top three reader or advertiser winners, you earn a free ad rerun* that can be worth up to several thousand dollars for your firm.

100 PRIZES IN ALL

READER PRIZES

1st Prize: Caribbean Windjammer Cruise for two, $1,000 cash, air transportation for two, free ad rerun*.

2nd Prize: Portable color TV set, free ad rerun*.

3rd, 4th, & 5th Prizes: Digital wristwatch, free ad rerun* (3rd prize only).

6th through 100th Prizes: Technical books.

SEPARATE CONTEST FOR ADVERTISERS AND THEIR AGENCIES

Advertisers, marketing men, and advertising agencies can enter too. Duplicate awards are given to the top three winners (cruise, cash, air transportation, free ad rerun*, color TV and digital watch). Remind your advertising people it's the issue of the year to build business for your company *and* win valuable prizes at the same time.

HERE'S ALL YOU HAVE TO DO TO ENTER

Examine the January 5, 1976 issue of *Electronic Design* with extra care. *Read the Rules.* Then:

(1) Select the ten ads you think will be best seen and read.

(2) List the ten ads by company name and inquiry number on the contest entry card.

(3) Fill in your name and address and mail before midnight Feb. 15, 1976.

*The top ten ads will also receive free reruns. Only one free rerun per company. The first three prize winners in the reader contest and the first three prize winners in the advertiser contest awarded reruns only if their companies have an ad in the Jan. 5, 1976 issue.

COMPLETE RULES AND ENTRY BLANKS IN JAN. 5 ISSUE

Technology

Employ μP software tools properly,

and you'll shorten development time and reduce errors. Get to know the three types of design aids offered by vendors.

Software provided by microprocessor vendors is an invaluable tool for the digital system designer. Properly used, it can greatly speed the development and reduce the errors in a program design. For these reasons, logic designers ought to be aware of what software packages are available and how they can be used effectively.

There are three types of computer software: operating, program-development and diagnostic (Fig. 1). This is true for microprocessors as well as for minicomputers and large mainframe computers.

Operating software is the group of programs that runs on the computer under normal use. In a dedicated computer system, the programs are in the read-only memories (ROMs) that come with the machine. For example, in a microprocessor-controlled automatic weighing system, the operating software is the program that calculates and displays the weight. Usually operating software combines user-written and vendor-supplied programs.

Program-development software refers to design tools that help in the creation of operating software. It is a computer-aided-design package, and the tools range from simple assemblers to complex high-level-language compilers.

Diagnostic programs test the computer hardware and verify that the system is operating properly. Typical programs test the central processing unit, memory and selected I/O devices. There are also software diagnostic programs, such as simulators and debuggers. These test for proper program sequencing and functioning.

Who does what in software?

The user must write his own operating software, since this represents the logic design of the system or product being built. The computer vendor can supply some prepackaged items, such as binary loaders and mathematical subroutine packages, but the rest is created by the user for his application. On the other hand, diagnostic software is a fixed package of programs supplied by the μP vendor.

Program-development software represents the largest investment on the part of the computer supplier. It is this type of software that is usually referred to when one speaks of a vendor's software support, and the degree of support can vary markedly from one vendor to another.

If you are a logic designer using microprocessors for the first time, you may ask: "What does all this software do for me?" You have to answer this question to know what you need for your design and how to evaluate what the microprocessor vendor is supplying. The three types of software may be needed even for very simple systems.

A computer system design for, say, an automatic meat scale typically goes through the following steps:

1. State the problem. (Create an automatic meat-weighing scale with digital readout.)
2. Analyze the problem into a sequence of operations that will perform the function.
3. Arrange the sequences in a list or flow chart that will show how they are to be performed.
4. Write the program from the flow chart of operations. If the definition of the operations is detailed enough, this should be a simple conversion. Each operation will be performed typically by a few instructions.
5. Enter the instructions into the computer-system memory. Let us assume that we enter it manually through the computer front panel.
6. Test the program. This will probably be done first by stepping the computer through the program, instruction by instruction, and then at full speed. This corresponds exactly to testing a hard-wired logic system, clock-step by clock-step, and then at full speed. When the program and system have passed these tests, the program design is complete.

Small systems can be designed easily

For a simple program of, say, 20 words, the design is straightforward. Instructions, address-

David C. Wyland, Microprocessor Design Manager, Monolithic Memories, 1165 E. Arques Ave., Sunnyvale, CA 94086

es and data can be generated as binary bit patterns. These bit patterns are entered through the front panel, and the program is then tested. Programs of 100 words or larger, however, create the following problems:

1. Instructions are hard to remember as binary numbers.

2. Addresses are difficult to remember as binary numbers. Also, addresses change when the program changes. It is often hard to remember what the address locations are being used for.

3. It is difficult to follow the program flow with binary addresses and data during debugging.

4. The program must be entered into the computer memory. Programs of over 100 words are impractical to enter manually through the front panel.

5. If you have a system failure during debug-

Operating software:

- Customer application programs
- Binary loaders
- Relocatable binary loaders
- Operating systems
- Miscellaneous utility programs:
  - Math subroutines
  - I/O control subroutines
  - Paper tape copy and list programs
  - Etc.

Program development software:

- Assemblers
- Relocatable assemblers
- Paper tape editors
- Macroassemblers
- Compilers
- General-purpose microassemblers

Diagnostic software:

- CPU diagnostics
- Memory diagnostics
- I/O device diagnostics
- Software diagnostics:
  - Debuggers
  - Simulators

1. Three types of software—operating, program-development and diagnostic—exist for all computers, from micros to large mainframes.

Source Tape Listing:

```
                    Sample Program
        . LOC   2       ; First Word to Location 2
Start:  DIA     0, 15   ; Load Reg 0 From Device
                          15, Reg A
        LDA     1, X    ; Load Reg 1 From Location
                          X
        ADD     1, 0    ; Add Reg 1 to Reg 0
        STA     0, Y    ; Save Result In Location Y
        DOB     0, 15   ; Output Result To Device
                          15, Reg B
        JMP     Start   ; Loop Back To Start
X:      30              ; Octal Data
Y:      0               ; Result: Initial Value = 0
        . End
```

Assembler Program Printout:

```
                  Sample Program
000002          . LOC   2      ; First Word To Lo-
                                 cation 2

060415  Start:  DIA   0, 15    ; Load Reg 0 From
                                 Device 15, Reg A
024010          LDA   1, X     ; Load Reg 1 From
                                 Location X
123000          ADD   1, 0     ; Add Reg 1 To Reg
                                 0
040011          STA   0, Y     ; Save Result In Lo-
                                 cation Y
062015          DOB   0, 15    ; Output Result To
                                 Device 15, Reg B
000002          JMP   Start    ; Loop Back To Start

000030  X:      30             ; Octal Data

000000  Y:      0              ; Result: Initial Val-
                                 ue = 0
                . END
```

Binary Tape Contents:

```
000002
060415
024010
123000
040011
062015
000002
000030
000000
```

2. **An assembler generates this sample program.** Each line of the source-tape listing contains one or more symbols that define a binary word.

Command	Description
Y	Read in a tape. Tape is terminated by a special end-of-page character.
P	Punch the contents of the buffer with an end-of-page character.
Pn	Punch (n) lines of the buffer with an end-of-page character. Begin at line pointer.
W	Punch the buffer without an end-of-page.
Wn	Punch (n) lines without an end-of-page.
T	Type the contents of the buffer.
Tn	Type (n) lines of the buffer.
I	Insert text following (I) at the line pointer location. Terminate with Escape character.
C	Change line: Find (within the current line) the text string between (C) and the first Escape character. Replace with the text string between the first and second Escape character following (C).
Kn	Erase (n) lines following line pointer.
B	Set line pointer to beginning of buffer.
Ln	Move line pointer down (n) lines. (n) can be negative.

Command Formats: A, A_n
A = alphabetic command character
n = modifier number, as required

A paper-tape editor employs various commands to read alphanumeric characters into a buffer area in memory, modify the buffer's contents and punch a new tape from the modified buffer. Modifications are performed on lines of text, and each line consists of a string of characters terminated by a carriage return.

"Ready" symbol from editor program

"Escape" character (not visible in printout)

	COMMENTS
* Y □	Read a tape into the buffer
* T □	Type out buffer contents
BEWARE OF GREEKS BEARING GIFTS	Buffer contents (two lines)
* B □	Set line pointer to beginning of buffer
* L 1 □	Move down one line
* T 1 □	Type one line
GREEKS BEARING GIFTS	
* CGREEKS □ GIFTS □	Change GREEKS TO GIFTS
* CG GIFTS □ G GREEKS □	Change GIFTS TO GREEKS. Note use of extra characters to avoid ambiguity
* T 1 □	Type one line
GIFTS BEARING GREEKS	
* T □	Type all lines
BEWARE OF GIFTS BEARING GREEKS	
* P □	Punch out new tape

An example of a paper-tape editor's operation employs a Ready symbol and an Escape character.

ging, you need to know what is failing, the program or the hardware.

Program-development software packages attack the first three problems. They make instructions, addresses, and data easier to remember and manipulate by the program designer. Operating software, such as loaders and operating systems, attacks the fourth problem of entering and running the program. Diagnostic software for both hardware and software functions attacks the fifth problem by providing tools that help the designer locate the problem.

Assemblers: Simple, but powerful

Assembler programs represent the lowest level of program-development software. But though an assembler provides but a few basic bookkeeping functions, it allows a programmer to design programs of up to several thousand words.

An assembler provides three functions to the programmer: It allows him to specify instructions by name, to specify addresses by name, and to specify data in several forms other than binary. Instead of writing down a list of binary numbers for instructions, addresses, and data words, the programmer lists shorthand symbols for the instruction words and names for the address words, and he specifies data constants in more convenient decimal, octal, or hexadecimal data formats. The assembler program then processes this list to create a corresponding list of binary numbers.

The list of symbols that an assembler processes to create the binary program is called the source program. Each line of the list contains one or several symbols to define one binary word. A line in the source program may also provide information to the assembler program, such as indicating the start and the end of the source program, as well as where the binary program is to be placed in memory. A small assembly-language program illustrates these features (Fig. 2).

Each assembler has its own list of shorthand symbols or mnemonics for instructions. This list may be either fixed or expandable, depending on the design of the assembler. It is possible to write a general-purpose assembler in which all of the instruction mnemonics are defined by the user. These mnemonics are usually three to five characters long.

Memory locations are named by writing the name, followed by a colon, before a line that specifies an instruction, a data constant or another address. The assembler associates the address value for that location with that name. Names are usually restricted to five or fewer characters. There may be other restrictions about numbers and nonalphabetic characters in the names.

Once a location has been named, it can be referred to by that name throughout the rest of the program. This is very convenient, because if the program is changed and the named location becomes a different address, the assembler will automatically use the new number. The programmer does not have to perform any calculations to determine the new address. Likewise he does not have to scan the program to find all of the places where that address may be used and then update them.

The ability to specify data in other than binary form is also a useful feature. It is very time-consuming for a programmer to convert decimal data to binary if he needs to specify a decimal constant. And manual conversion is prone to error.

Microprocessors and small minicomputer systems use paper-tape assemblers. These programs accept the source data on paper tape and also produce the binary program output on paper tape. In the source paper tape, one line of teletypewriter data is interpreted as one line of source code. A paper-tape assembler assumes the existence of a small operating program called a binary loader. The binary loader reads the binary paper-tape output from the assembler and generates the corresponding binary words in the memory of the computer.

The binary loader program, although small, may itself be too long to be loaded into the computer by hand. A second, smaller paper-tape loader program, called a bootstrap loader, is used to load the binary loader into memory. This bootstrap loader is designed for minimum size and easy entry from the front panel.

A paper-tape assembler package usually includes a program called a paper-tape editor whose primary purpose is to overcome a problem that occurs when source tapes are generated. It is difficult to add or delete characters or a line of characters in the middle of a paper tape. The editor overcomes this problem by reading the source tape into a buffer area in memory. It allows the user to add and delete lines and characters to and from this buffer. It punches out the new source tape when additions, deletions and modifications are complete.

Diagnostic programs determine whether a system failure is caused by hardware or software. Hardware diagnostic programs are usually supplied with each machine. Typically one diagnostic program is supplied for the CPU, memory and each I/O device. When a user designs a custom I/O interface, he must also write the corresponding diagnostics. Software diagnostics are called debugger programs. These tend to be loosely classified under the heading of program development software, although, in fact, they are a type of operating software. Obviously, debugger software is considered a marketing tool by the computer vendor in the same category as program development software.

The software debugger program is a collection of useful functions. A simple, teletypewriter-based debugger program will include the ability to load memory from paper tape, dump a section of memory to paper tape, and dump a section of memory to the teletypewriter printer in readable format. It will also include the ability to examine and modify memory locations and to execute a program starting at a specified address.

Debugger permits breakpoints

A debugger has another important feature, called breakpoint. This allows the programmer to stop the program when it reaches a specified point. To use the feature, the programmer inserts a breakpoint at an address in the program. The debugger program then goes to that address, removes and saves the instruction and inserts an instruction that causes the computer to jump back to the debugger program. After returning to the debugger, the original instruction is replaced. Thus the program can be executed up to a point and then stopped. The programmer can then examine the memory to see if failures have occurred.

The debugger program duplicates many of the functions of the computer front panel. But while the computer front panel directly controls computer hardware and is useful for debugging hardware problems, the debugger program focuses on software problems. Its use assumes that the hardware is working well enough for the debugger program itself to run.

More powerful tools

The amount of support software required by the logic system designer depends on the size of the program he intends to write. If the program is less than 200 words, support software may not be required. It may be practical to create the program directly in binary or hexadecimal form, enter it through the front panel and debug it manually through the front panel.

For common programs of approximately 200 to 4000 words, a paper-tape assembler and debug package are sufficient. But for larger programs, systems of programs and programs of a high degree of complexity, more extensive software support packages have been developed. These include (in order of increasing sophistication) relocatable assemblers and loaders, macroassemblers and high-level-language compilers.

A relocatable assembler is the same as a simple assembler, except that it produces its binary tape in a format that is compatible with a relocatable loader. This loader allows the programmer to load several programs at the same time and to stack them automatically in memory. It also provides any necessary communication between programs, such as in a program that calls several common mathematical subroutines. The relocatable loader must modify all addresses used by a given program, since these addresses depend on where the program finally ends up in memory. Thus a relocatable loader is considerably larger and more complex than a simple binary loader.

A macroassembler allows the programmer to create and specify blocks of instructions. Suppose a programmer uses a three-instruction sequence for any call to an I/O device. A macroassembler allows the programmer to define this three-instruction sequence and to assign a special mnemonic to it. When this mnemonic is encountered by the macroassembler during processing of a source program, it will create the corresponding three binary words. These user-defined multiple-word instructions are called macroinstructions.

High-level-language compilers, such as those for Fortran and PL/1, are somewhat like macroassemblers. A high-level language provides these four features:

1. The ability to specify mathematical operations in algebraic form and have them converted to a series of instructions.

2. A convenient method of handling real numbers in floating-point notation. This is the same as adding a floating-point feature to a fixed-point calculator, since most computers are binary fixed-point machines in operation.

3. The ability to specify data in a matrix or subscript form. Data can be identified by row and column location within a matrix. This is convenient for handling large amounts of data and data arranged in matrix or table form.

4. Indexing macros for a loop sequence. Program loops are very common and typically require several instructions in the beginning and end of each loop.

Programming vs debugging time

These sophisticated software packages have a disadvantage, though. Because of their size and sophistication, they create a distance between the source code and the binary object code. This is inherent in any program-development tool, from a simple assembler up to the most complex compiler, and it's easy to understand why this is so. The more a program does for you automatically, the less aware you are of what it is doing in the resulting binary code. A programmer using the simple paper-tape assembler creates a source program that is very close to the resulting binary code. The symbols used are one-for-one representations of the binary code.

A programmer writing in a high-level language like Fortran may never see the binary code except when he is debugging the program. This distance from the machine code is significant only during program debugging, which requires dealing with the binary instructions being executed by the machine. Debugging a simple assembly-language program is fairly straightforward. Usually the assembler will print a listing of the source-language statement, the resulting binary data and the address where that data will be loaded by the binary loader.

A program written with a relocatable assembler forces you to find out where the relocatable loader put the program in the memory and mentally change all of the addresses on the listing. A program written in Fortran will give you no listing of the binary data that is loaded in the memory, but it will give you the addresses for the data and subroutine packages used. You must

Command	Description
An	Examine/modify accumulator register (n)
En	Examine/modify memory location (n)
Gn	Go to location (n) and execute program
Il,m,n	Initialize: load (n) into all memory locations between (l) and (m)
Dm,n	Dump memory to teletypewriter printer, locations (m) through (n)
R	Read in program from teletypewriter paper tape reader (binary loader function)
Om,n	Punch out memory contents from locations (m) through (n) in binary loader format on teletypewriter paper tape punch
B	Breakpoint examine/set
C	Continue from last breakpoint

Command Formats: A, An; Am,n; Al,m,n
A = Alphabetic command character
l,m,n = modifier number as required by command

Commands for a debugger program allow the isolation of software errors. The debugger has a breakpoint capability that permits the program to be stopped when it reaches a specified point.

then know or learn how the Fortran compiler generates the resulting binary code from its source-statement input.

The use of program-development software tends to result in fewer program errors, because these tools do many things automatically and provide many design-checking features. But if the program doesn't work, sophisticated debugging techniques may be needed.

Special techniques for special problems

Several other program packages commonly available represent solutions to special problems. One of these is the "microassembler," which is actually a misnomer. A microassembler is really a general-purpose assembler that allows the programmer to define the word size of the machine, the instruction mnemonics, and their corresponding binary bit patterns. A microassembler can therefore be used to generate an assembler for a specific machine.

Operating systems are similar to debuggers. They can load and run programs and dump the contents of the memory to a printer or other output device. Often they provide software-diagnostic features. Unlike a debugger, the operating system contains a relocatable loader and can load programs from different sources, such as paper tape, magnetic tape and disc.

An operating system is typically used in conjunction with a disc file or other storage medium and provides a library function as well. This means that the user can specify a program by name, load it, and execute it. The operating system includes facilities for program filing on the storage units. These facilities include program loading, dumping, copying, renaming and deleting.

The operating system also provides a standard set of I/O control subroutines. These allow all programs to use the same method of calling I/O devices. The system can then provide various I/O utility features, such as stopping the program to add paper to the printer.

Simulators are diagnostic tools for the debugging of software. A simulator creates a software model of a hardware computer. Each step of the internal operation of the simulated CPU is visible to the programmer. Complex problems of hardware and software interaction can often be solved with this tool, but it runs 10 to 1000 times slower than the hardware it simulates. This means you cannot use it to solve timing-related problems. ■■

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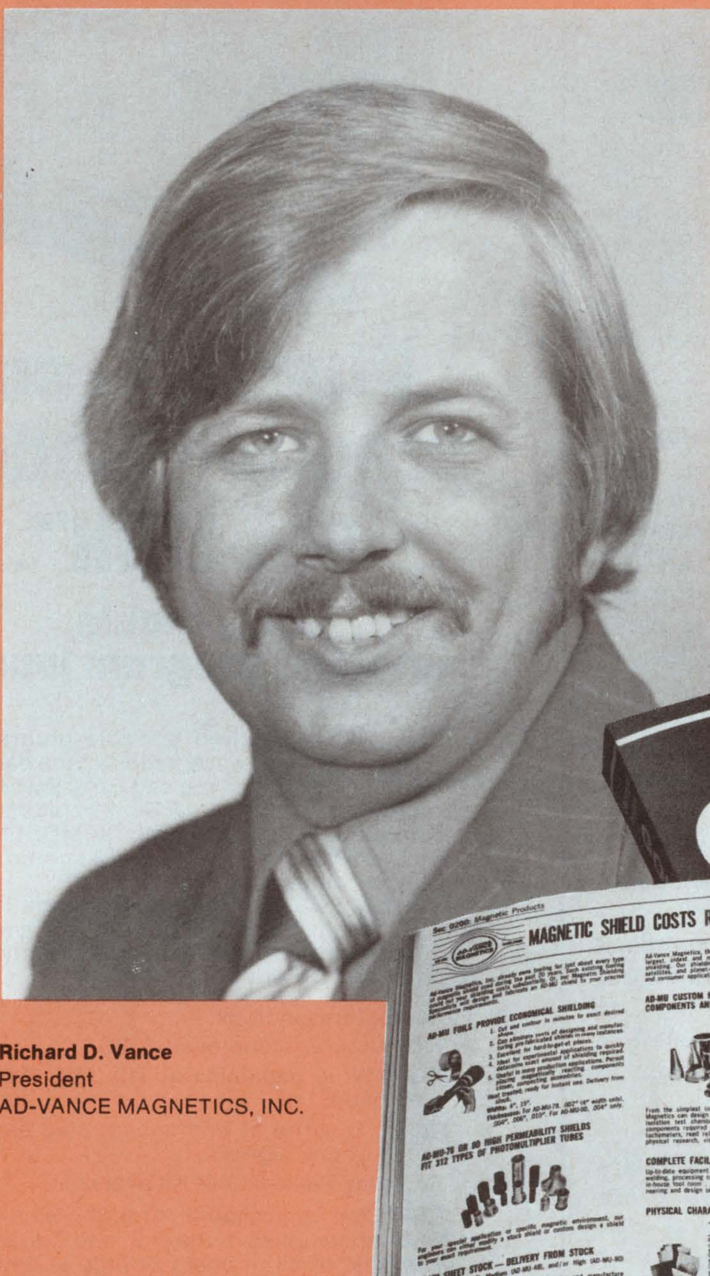

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Assembly language for μPs: Mnemonic programming isn't hard once you learn the coding. Here's how to organize and write a program.

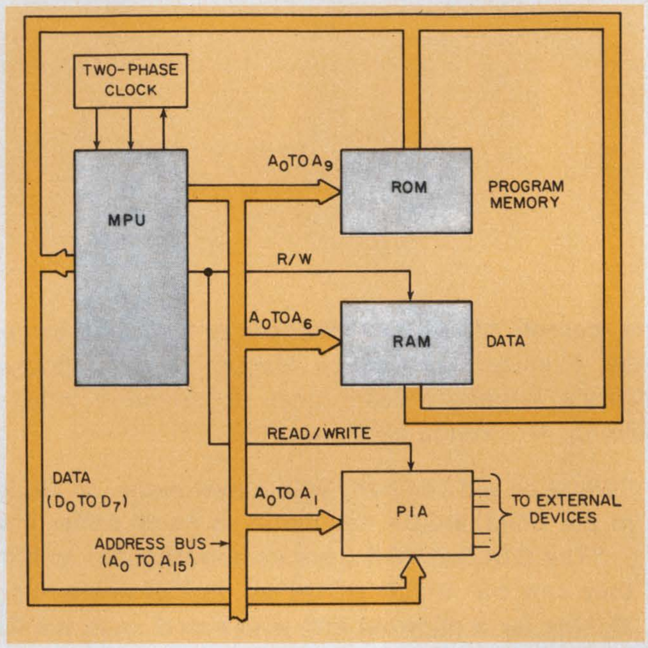
Learning assembly language programming isn't hard. All an assembly language program consists of is a list of mnemonic commands that tell the microprocessor what to shift, pull from memory, which registers to clear, where to store data, etc. To do any work with microprocessor systems, programming is a necessity.

All μP manufacturers use a form of mnemonics, but unfortunately they are different from one vendor to the next. Therefore, to learn the basics of assembly-language programming, we will use the Motorola M6800 μP and its software as an example, since its structure is fairly generic and since it is now available from more than one source.

A μP can be viewed as a group of registers that, upon command, extract data from a memory bank, perform the programmed operations and then return the data to the memory or to an output device. To do all these operations, the μP-based system must contain these main sections (Fig. 1):

- MPU—the main processing unit. This houses the registers, control gating and counters needed to manipulate and keep track of the data.
- ROM—the read-only memory. It usually contains the binary equivalent of the assembly-language program that gives the MPU all of its instructions.
- RAM—the random-access memory. This can be used to hold the active part of the program and any other data that are being inputted or generated. It usually is very volatile and is only for temporary storage.
- PIA—the peripheral interface adapter. This lets the MPU and memories talk to external devices, such as terminals, printers and tape drives in parallel data words.

Communication between the various sections of the μP system is done over a multi-line communications bus. One part of this bus is unidirectional—from the ROM to the MPU and contains mainly instructions and perhaps key



1. **All major functional blocks are connected** by a 16-bit address bus and an 8-bit data bus in the M6800 μP-based system.

constants. The rest of the bus is bidirectional—the MPU can communicate with the RAM and PIA, and the PIA can talk to the RAM directly as if all of these were simply read/write memory.

In large systems the computer words are usually long enough to obtain the entire data word or instruction at once. In the smaller μP systems the words are only about half the size, and in some cases two or more words (of 8 bits each) must be used to supply data or give instructions. One prime example of this is when the data needed for the MPU to complete an instruction is external to the MPU.

When this happens, the MPU must reach out to successive locations where the data are stored and bring them to the registers within the MPU. To do this, address words must be issued to direct the data into the register.

Since all the MPU consists of is a bunch of registers connected by a complex gating arrangement and a controlling set of counters, let's examine these sections a little closer. The MPU

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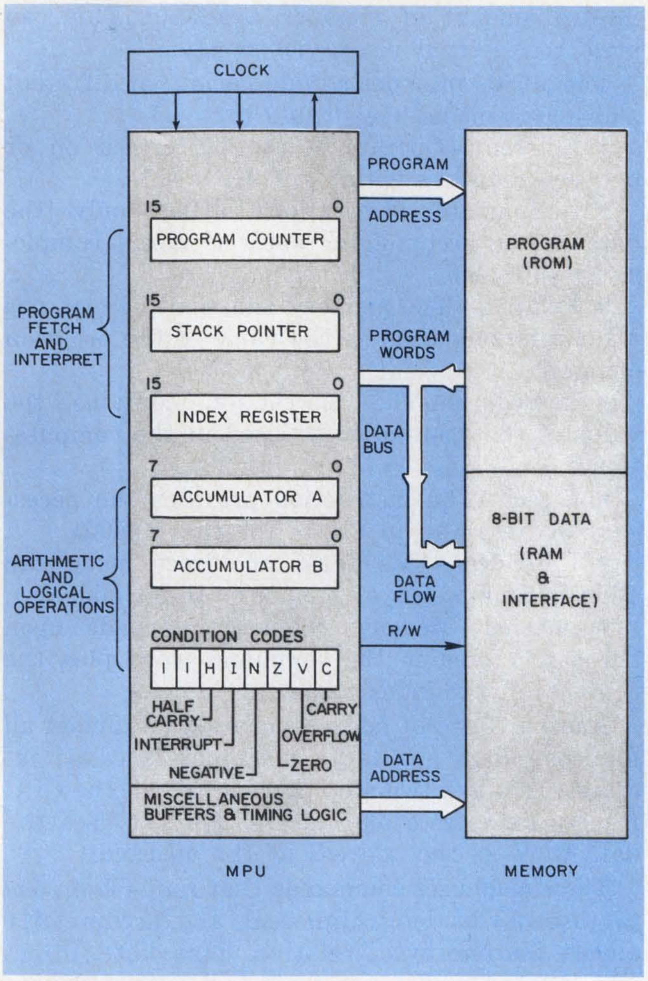


2. **Inside the MPU** are the different counters and registers that let you separately keep track of both the program and data. And, correspondingly, the programmer treats memory as if it were composed of two parts—a data or variable section and a command or instruction section. Also included are the logic circuits and control gates needed to do all the arithmetic operations.

can be divided into two main blocks (Fig. 2): (1) Program fetch and decode, and (2) The arithmetic/logical processor.

Separate the commands and data

The first steps of the processing cycle depend on the data within the program counter of the MPU. These data determine which operation the computer is to perform. Subsequent cycles may generate read or write commands to the data or variable section of the memory in order for the processor to manipulate the data.

As a rule, the clocked program counter (PC) generates sequentially increasing addresses to pull control words from the ROM or other control block. The PC controls the entire operation of the processor, unless commands are encountered in the program flow that cause the counter to depart from sequential operation. The next value of the PC may then depend upon commands for conditional branching (similar to Fortran IF statements) or direct branching (like GO TO in Fortran). The PC value may also be forced to a specific location by the presence of an external interrupt.

Data addresses depend on the type of command and can be modified by the value stored in the index register. The read/write control line of the MPU tells it whether it should fetch or store data.

Although the MPU operates under binary control, the chance for an error, should the program or data be entered manually, is enormous.

Assembly language is a shorthand way of writing the binary instructions that can be converted into binary form by an assembler. And, as a rule, a single statement generates a single storable command. These shorthand statements are grouped into fields and are designated by the following four names: Label, Operator, Operand, Comments.

The four elements when combined on a single line are separated from one another by some form of delimiter, such as one or more blank spaces, a slash or a comma. The Comments field is used only to help others understand what the programmer intends; it will not generate any instructions for the computer.

A sample working instruction for the M6800 might appear as follows:

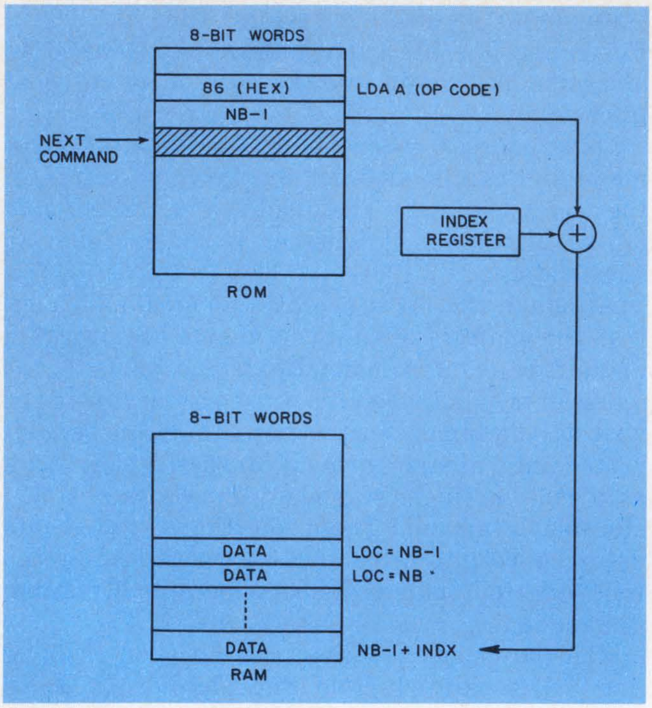
UPDAT	LDA A	NB	BEGIN THE LOOP
Label	Mnemonic	Operand	Comment

Labels help the programmer use branching commands, since he can then write the equivalent of a GO TO statement just by associating it with the label. The mnemonic command LDA A instructs the μP to load the accumulator known as A with the data that will come from the location described by the operand. The operand, NB, instructs the μP to fetch data from the location called NB. This pseudo English tells the MPU that the binary data in the byte following the LDA instruction names or points to the address from which the MPU is to fetch the desired data (Fig. 3).

Assign values to the symbols

Once an assembly language program is written, you must systematically determine the locations in which the program is stored in ROM or RAM. First, concentrate on the commands and store each command in sequentially ascending order of memory locations.

Whenever a label is noted, write the address of the memory location presently associated with that label. Since the mnemonic operation codes have unique binary descriptions assigned by the manufacturer, there is no difficulty in storing them. This process is usually done in most larger systems by the assembler, which converts the



3. **When the op code LDA A is given,** the byte of binary data following the instruction is added to the index register information to supply the address of the data needed by the op-code instruction.

mnemonic into binary and assigns numbers to all labels.

After the commands are all located, you must provide unique locations for storing the operands or data. These locations don't have to be in any particular sequence, except that arrays usually receive consecutive assignments. Once fixed, these addresses provide the data to fill in some of the missing command words when the assembler assigns location and sequence numbers.

Returning to the sample instruction given earlier, we could have chosen the location FFF (hexadecimal notation) for NB. Assemblers let the user specify the origin or starting address for his commands and the locations for his data.

These addresses are referred to as directives (to the assembler), and while they influence the final values selected for the numerical data other than operation codes, they do not result in any extra instructions. But they can be confusing, since the format of the directives often resembles the actual assembly code. Similarly directives to insert constant values at certain locations in ROM resemble MPU commands. Fortunately most assemblers sort them out and arrange them in columns.

Address the data properly

When you specify the address of data, use the most direct way—too long an address and the computer slows down, too short and you have a limited amount of memory available. This can break a system if you're not careful.

The M6800 provides a wide variety of different addressing modes (see Table 1):

- Inherent—Operations are performed on or between registers within the MPU chip.
- Accumulator—Operations affect only the data in the accumulator such as clear, complement, shift, etc.
- Relative—The memory address to which the MPU refers depends on the value of the program counter.
- Immediate—The instruction contains the value of the operand to be used in the computation.
- Direct—The instruction provides the necessary address (up to 8 bits for the M6800).
- Extended—This form of direct mode can address 64 k words of memory (16-bit address).
- Indexed—Memory reference depends upon the data stored in the command word plus the contents of the index register.

Another form of addressing used on almost all minicomputers and large machines is called indirect. This is a two-step process: First, the CPU fetches data from an address. Then it uses the data word as the address of the operand.

The M6800 uses commands that range from one to three bytes long: Inherent and accumulator modes use one byte; relative, immediate, direct and indexed modes use two; and extended uses three.

Motorola has developed a program that accepts symbols and mnemonics to assemble a program. The symbols that indicate the address mode include the asterisk, period, pound and single alphabetic characters. These are used in the operand field.

The asterisk indicates that the relative address mode is to be used, and it has been accepted as the de facto standard for this mode by many companies. Another way of looking at this symbol is to think of it as the present value of the program counter.

The pound character, #, designates the use of the immediate addressing mode. An alphabetic character (X for Motorola) indicates that indexed addressing is to be used. Each of the symbols is, of course, mutually exclusive—only one addressing mode can be used at a time. The Motorola assembler will select either extended or direct addressing by default if the other modes are not specified. If the numerical address lies within the range 0 to 255, default is to direct addressing, while if the address specifies a location out of that range, extended addressing is used.

The relative addressing mode, though, is restricted to branching instructions, such as BSR (branch to subroutine).

Table 1. Explanation of various addressing modes

Addressing mode	Processing required to load address into internal address register	Byte appearance of instruction	Comments
Immediate	Current value of PC indicates the op code and the digital information represented by PC + 1 is the data the op code is to perform its operation on.	op code K data K + 1 see comments K + 2 bit 0.......7	Only one data byte is used except for mnemonic instructions CPX, LDS and LDX which use a second byte.
Direct	The current value of the PC indicates the op code. Increment the PC and then move the data from the location specified by PC + 1 to the address register.	op code K address K + 1 0.......7	Two data bytes are used.
Extended	The current value of the PC indicates the op code. Increment the PC by 1 and transfer the data from the location specified by PC + 1 to the address register. Increment the PC again to PC + 2 and transfer the data from the location specified by PC + 2 to the address register.	op code K address K + 1 } 16 bits address K + 2 } 0.......7	Two data bytes are used.
Relative	The current value of the PC indicates the op code. Increment the PC by 1 and add the contents of the location specified by PC + 1 to the value of the PC after it is incremented again (PC + 2)	op code K displacement K + 1 0.......7	One data byte used. This applies only for branch instructions.
Indexed	The current value of the PC indicates the op code. Increment the PC by 1 and add the contents of the location specified by PC + 1 to the index register.	op code K data from K + 1 memory location K + 1 0.......7	One data byte used.

When you write programs for the M6800, they can be done in modular form and then strung together. To do this, though, you must make use of the stack pointer (SP) within the μP chip. The SP register provides an address that is used for subroutine jumps, or if the program is interrupted, it holds data from some of the other registers.

The stack is a set of memory locations that are addressed and sometimes modified when interrupts or subroutine jumps are invoked. A jump-to-subroutine (JSR) command orders the μP to increment and store the program counter value in the next empty stack location and then jump to the new (subroutine) location. The stack pointer is also set to the next empty location, just in case another subroutine or interrupt command is given.

The return-from-subroutine (RTS) instruction decrements the stack pointer and places the contents of the register specified by the pointer back into the program counter. Two additional instructions—mnemonics PSH (push data) and PUL (pull data) allow transfer of accumulator data to and from the stack.

An interrupt command causes the μP to react as if indirect addressing is in effect. After the MPU completes its current instruction, it initiates the following sequence of operations:

- Stores the contents of the program counter, accumulators and condition code registers into the interrupt stack registers.
- Generates a 16-bit address that points to locations n-2 and n-3.
- Follows instructions starting at a location prestored by the user in locations n-2 and n-3.

The last eight memory locations of the stack should be reserved for interrupt vectoring (another name for such indirect addressing). This allows for four 16-bit words to redirect the MPU. For instance, beginning with location FFF8 (hex), you could have:

FFF8	MS	Hardware interrupt
FFF9	LS	
FFFA	MS	Software interrupt
FFFB	LS	
FFFC	MS	Nonmaskable interrupt
FFFD	LS	
FFFE	MS	Restart
FFFF	LS	

The software interrupt lets you develop an over-all systems executive or monitor. Thus if a program module has some data to send through the asynchronous communications interface adapter (serial data port)—ACIA—it could execute a software interrupt and vector the MPU to the appropriate input/output routine.

Let's look at a sample program

To write a program without the aid of an assembler, start with a list of the commands you

Table 2. Program to clear 10 registers

ROM Location (decimal)	ROM Content	
	(hex)	comment
000	7F	op code
001	8 bits	address of
002	8 bits	buffer (1) in binary
003	7F	
004	8 bits	address of
005	8 bits	buffer (2)
.	.	
.	.	
.	.	
.	.	
027	7F	
028	.	address of
029	.	buffer (10)

Table 3. Rewritten clearing program

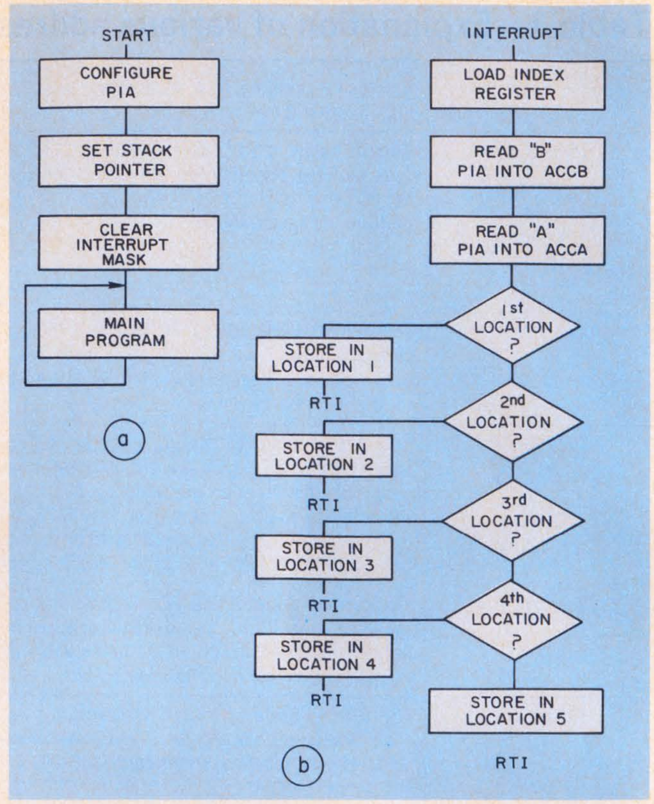
Label	Op code	Operand or location
	LDX	#BUFFR*
	LDA A	# 1
BEGIN	CMP	A # 11
	BEQ	PROC
	CLR	O, X
	INC	A
	INX	
	BRA	BEGIN
PROC	. . . .	New program section

*The pound sign shows that immediate addressing is to be used for the first three commands.

Table 4. Assembled clearing program

Label	ROM location (decimal)	Op-code (hexadecimal)	Description or name of op code
	000	FE	LDX
	001	two binary	extended address to first location of
	002	bytes	data-symbol BUFFR
	003	86	LDA A
	004	01	with literal 1
BEGIN	005	81	CMP A
	006	0B	with literal 11
	007	27	BEQ
	008	06	relative address to location 015
	009	6F	CLR (see note 2)
	010	00	indexed by 0
	011	4C	INC A
	012	08	INX
	013	20	BRA
	014	see note 1	
PROC	015	XX	Any op code
		.	Subsequent instructions
		.	and literals
		.	.
			.
			.

Notes:
1. Use hex equivalent of −10 in location 14 to get a relative branch back to location 005 which continues the loop.
2. This is an indexed address command with 0 shift that refers to one of the locations in the array BUFFR.



4. **The interface program** has an executive portion (a) with only a few steps and an interrupt subroutine (b) with many steps.

will use to process the data. Remember, the program will reside in the ROM until needed, and the RAM will be used to hold the active part of the program.

Let's start with a simple program that will clear a set of data locations named BUFFR. We will assume that BUFFR consists of 10 consecutive locations and exists in the RAM data space. The program could then consist of the clear command (CLR) given 10 times, with the location in the operand field:

```
CLR    BUFFR(1)
CLR    BUFFR(2)
 •
 •
 •
CLR    BUFFR(10)
```

The location of BUFFR was chosen so that extended addressing is used. The resulting hex characters appear in ROM as shown in Table 2. The contents of the op-code byte—in this case, 7F—informs the MPU that extended addressing is to be used. Use of an index register, though, can replace the repetition of the same command with a short program loop. The same program to clear 10 locations can be rewritten as shown in Table 3.

The program operates as follows: Before the main program loop begins, the program loads the

Table 5. Complete interface program

```
00100                      NAM    BA
00120 0000                 ORG    $0
00130 0000 0005    DATLOC  RMB    5
00140 0100                 ORG    $100
00150 0100 0001    PIA1AD  RMB    1
00160 0101 0001    PIA1AC  RMB    1
00170 0102 0001    PIA1BD  RMB    1
00180 0103 0001    PIA1BC  RMB    1
00190 FF00                 ORG    $FF00
00200 FF00 86 07   START   LDA A  #7          ┐
00210 FF02 B7 0101         STA A  PIA1AC      │
00220 FF05 86 04           LDA A  #$04        ├ CONFIGURE
00230 FF07 B7 0103         STA A  PIA1BC      │
00240 FF0A 8E 007F         LDS    #$7F        │
00250 FF0D 0E              CLI                ┘
00260 FF0E 01      MAIN    NOP                ┐ MAIN PROGRAM
00270 FF0F 20 FD           BRA    MAIN        ┘
00280 FFF8                 ORG    $FFF8
00290 FFF8 0500            FDB    INTER
00300 FFFE                 ORG    $FFFE
00310 FFFE FF00            FDB    START
00315 0500                 ORG    $500
00320 0500 CE 0000 INTER   LDX    #DATLOC     ┐
00330 0503 F6 0102         LDA B  PIA1BD      │
00340 0506 B6 0100         LDA A  PIA1AD      │
00350 0509 49              ROL A              │
00360 050A 25 0C           BCS    STO1        ├ LOCATE WHERE TO
00370 050C 49              ROL A              │   STORE DATA
00380 050D 25 0C           BCS    STO2        │
00390 050F 49              ROL A              │
00400 0510 25 0C           BCS    STO3        │
00410 0512 49              ROL A              │
00420 0513 25 0C           BCS    STO4        ┘
00430 0515 A7 04           STA B  4,X         ┐
00440 0517 3B              RTI                │
00450 0518 A7 00   STO1    STA B  0,X         │
00460 051A 3B              RTI                │
00470 051B A7 01   STO2    STA B  1,X         ├ STORE DATA
00480 051D 3B              RTI                │
00490 051E A7 02   STO3    STA B  2,X         │
00500 0520 3B              RTI                │
00510 0521 A7 03   STO4    STA B  3,X         ┘
00520 0523 3B              RTI
00530                      END
```

address of BUFFR(1) into the index register and sets location A to 1. At the command labeled BEGIN, the program compares A to 11 (decimal notation) and if $A \neq 11$, the program performs the next instruction, CLR. As the program continues in the loop, A will increase to 11, and when the program reaches the BEQ command it breaks out of the loop into the next program.

The entire program that must either be put on paper tape or into ROM is shown in Table 4. This type of programming is fine for small programs where you can keep track of variable locations, but for larger programs some sort of assembler is needed. Assemblers can refer to unnamed locations as a numeric expression that involves a label name. Thus BRA = BEGIN + 1 would refer to location 5—that of the next instruction.

Commercial assemblers let you locate the origin of programs anywhere in ROM through the ORG directive. For example, ORG 100 states that the given program segment is to start at ROM location 100. The EQU directive equates a symbol with a numerical value, another symbol or an expression. The RMB command reserves memory bytes. These and other directives assign values and addresses in data memory.

Interface instruments with software

To interface anything to the μP, you must make connections through a form of PIA or ACIA. The PIA handles parallel data, while the ACIA handles serial. Let's look at the complex problem of interfacing an instrument to the μP.

As a starting point, assume the instrument delivers a parallel digital data word. The PIA would then be used to interface the instrument. Inside the PIA are enough interface circuits to handle two peripherals. The PIA is internally divided into two symmetrical (noted as A and B), but independent, circuits that consist of three registers each. Each half contains a data direction register, a control register and an output register.

The registers are eight bits wide and are externally controllable. To define the operation of the PIA A or B side, an 8-bit word is loaded into the control register, and to define the data lines as inputs or outputs, an 8-bit word is loaded into the data direction register. Finally the actual data to be transferred goes into the output register.

The instrument we want to interface has data and a data ready line that can be used to signal an interrupt of the processor. Both halves of the PIA must be used to move the data from the instrument to the memory. The B side of the PIA holds the data word, and the A side identifies that word.

Basically the PIA and μP operate together as follows: When the interrupt occurs, the B side of the PIA is read into the B accumulator of the μP. Then the A side of the PIA is read to define the memory location of where the data stored in accumulator B should be placed. Next the data are transferred from the accumulator to the memory location, and then the μP goes back to waiting for another interrupt.

The MSB of the A side data word specifies the first location, the next bit the next location, and so on. If a ONE is not present in any of the four MSBs, the data are to be stored in the fifth location. These data locations are contiguous, with the first at an address we'll call DATLOC and all others in increasing sequence. When any of these locations receives a data word, the new data wipe out the old.

The CA1 terminal of the PIA can accept the interrupt signal generated by the rising edge of a waveform. This configures all the data ports as inputs, while the other interrupt lines CA2, CB1 and CB2 are not used. The flow charts for the system program to pull in data are shown in Fig. 4.

When started, the program configures the PIA, sets the stack pointer and clears the interrupt line and can proceed to do any program it has in memory. When an interrupt comes, present values of the last instruction and program counter and registers are stored in the stack, and the interrupt program is set in the program counter. When the interrupt routine is finished, the μP registers are reset to their values just before the interrupt and the main program continues along.

Table 5 shows the complete instrument interface program developed by Motorola Semiconductor Products to do the job. ■■

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Let a μP keep track of your process.

Built around a central processor, this analog monitor samples and displays transducer outputs.

You can keep an eye on various physical parameters or monitor a number of other analog voltages with a microprocessor-based system. Built around the 6800 μP and an a/d converter subsystem, the system can monitor and display any of four switch-selected voltages or various software-controlled functions (see table).

The monitor can interface to a main control system or operate as a stand-alone system. And, if necessary, a large number of parameters—with certain restrictions—can be monitored. These restrictions stem from the finite scan frequency, which is inversely proportional to the number of parameters.

Also, the scan frequency affects the type of parameter to be monitored since, for reliable conversion, the sensed quantity should not vary appreciably between conversion periods. Usually, though, physical quantities like temperature and pressure vary so slowly that a single a/d converter can monitor a large number of sensors.

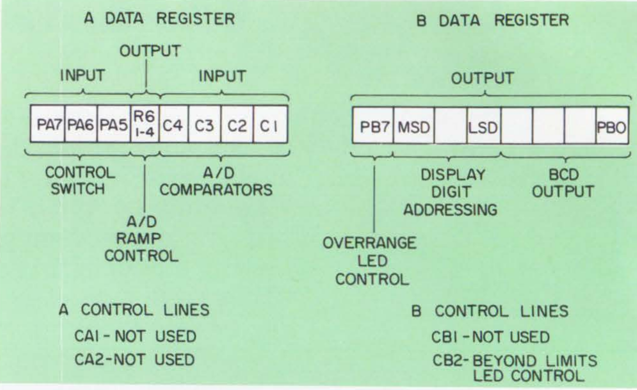
In addition to the basic CPU, the system uses a peripheral interface adapter (PIA), such as the MC6820, and memory for the control program. Fig. 1 shows the allocation of the PIA register and control lines. To interface all the required operations of the display board through one PIA, the BCD inputs to the display decoder/drivers are multiplexed.

Also, all the ramp control lines for the a/d subsystems are tied to a single line in the register that interfaces the comparator outputs of the a/d to the CPU. This configuration allows up to seven a/d subsystems per PIA register to be interfaced to the CPU.

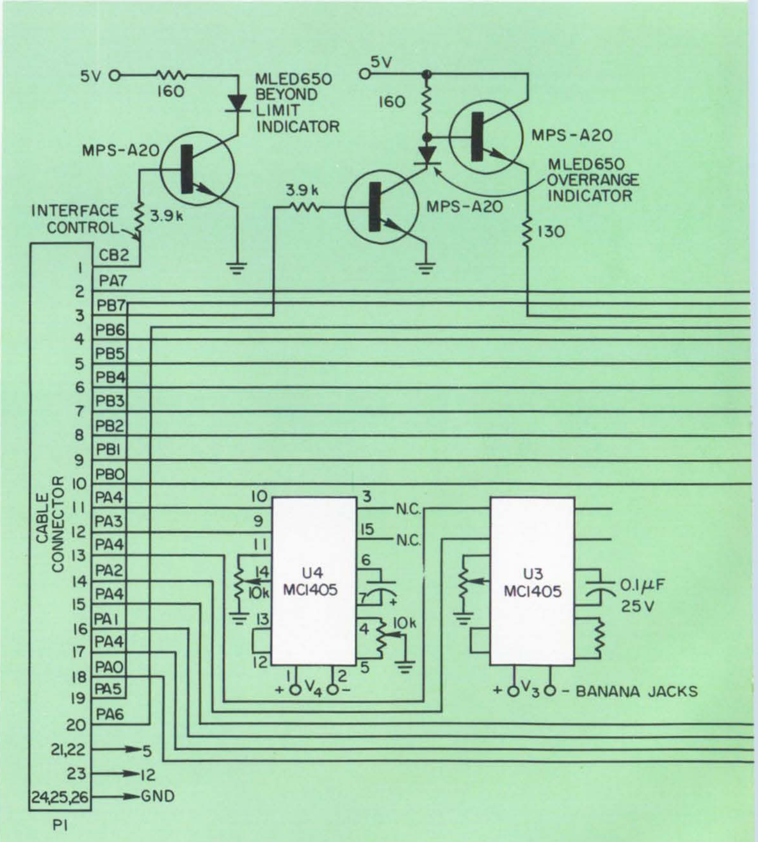
Higher voltage improves S/N

Hardware external to the CPU mounts on the display board. Included are the display select switch, the a/d subsystem chips (MC1405), dis-

John Kaufmann, Software Engineer, Motorola Semiconductor Products, 5005 E. McDowell Rd., Phoenix, AZ 85008.



1. **With multiplexing,** just one PIA is needed to couple the display board to the μP. PIA allocations are shown.



NOTE: PA0 TO PA7 FORM I/O PORT 1.
PB0 TO PB7 FORM I/O PORT 2

play latch/decoder/drivers (MC14511), and seven-segment LED displays (Fig. 2). The a/d chips are powered by a 12-V supply, permitting a higher integrator-capacitor peak voltage than would a 5-V excitation. This improves the signal-to-noise ratio. The other parts on the display board are powered by a 5-V source.

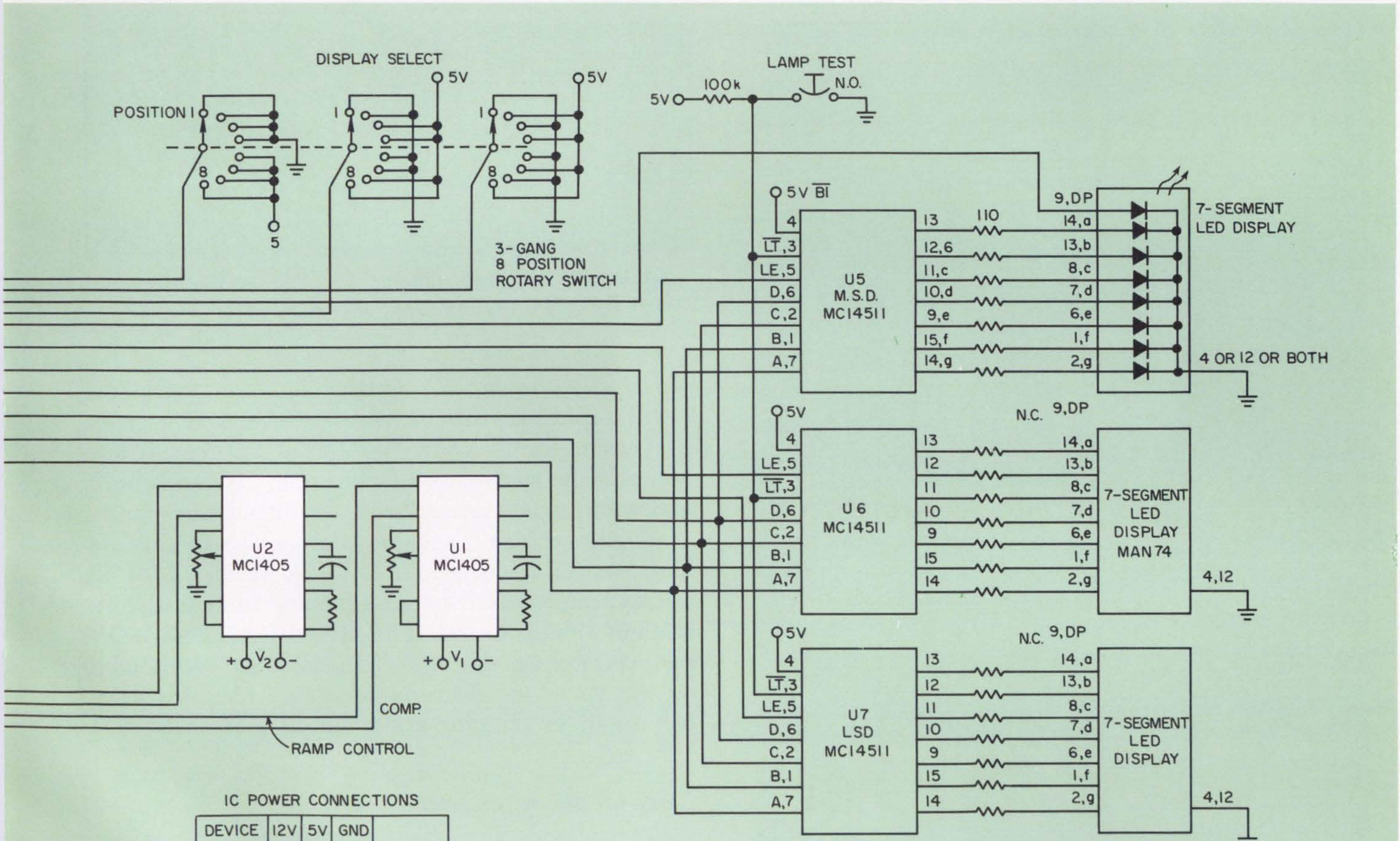
After it initializes the system, the control program reads the control switch, performs the necessary a/d conversions, does any required calculations and displays the result. Since the object is to represent an analog voltage digitally, the main segment of the program is the routine that controls the MC1405s and performs the analog-to-digital conversion (Fig. 3). The assembly-language coding for the conversion is listed in Fig. 4.

The a/d routine is entered with (1) the addresses of the appropriate limits in the X register; and (2) a bit set in the B accumulator corresponding to the PIA register line that carries the comparator input signal.

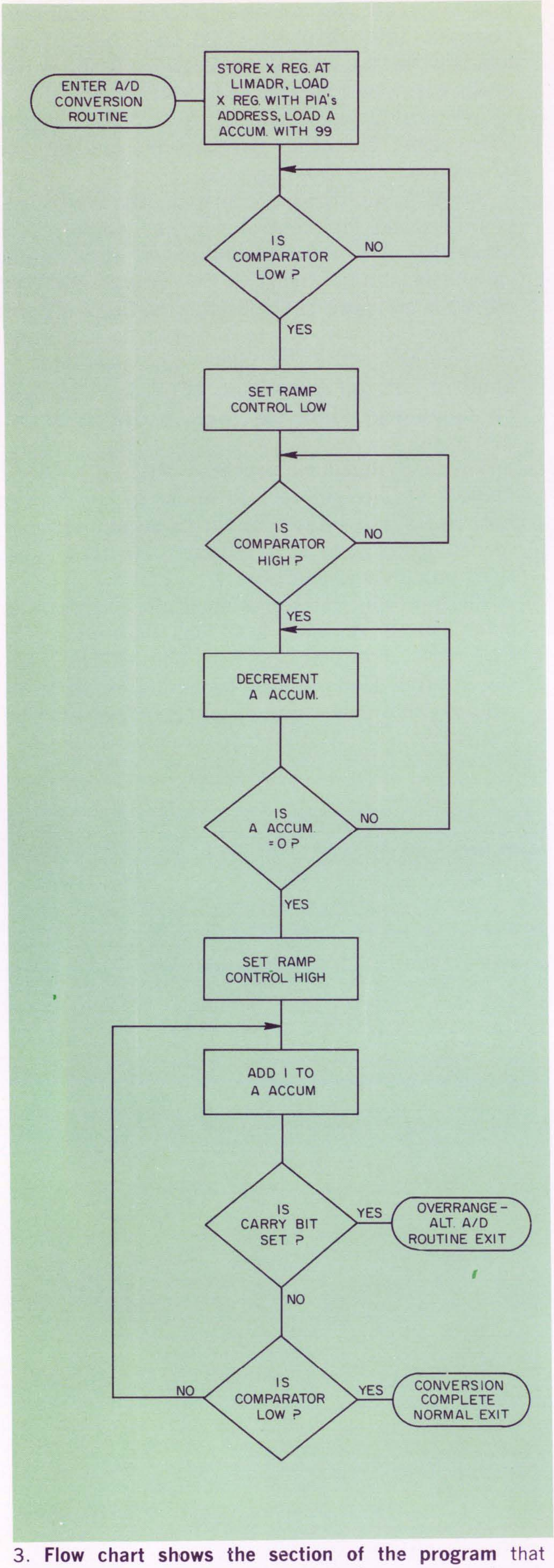
The routine first stores the limit addresses and loads the X register with the address of that PIA register interfacing with the MC1405. After the routine loads the A accumulator with 99—one less than the value of 100 required as a base count for a 2-1/2-digit conversion—it checks to

Table. Display-select switch settings

Position	Display
1	V_1
2	V_2
3	V_3
4	V_4
5	V_1^2
6	$V_1 + V_2$
7	$\|V_1 - V_2\|$
8	$V_1 \cdot V_2$



2. **The a/d-converter subsystem** and all hardware external to the μP mount on one board. Included are the display and its drivers, plus the required switching.



3. **Flow chart shows the section of the program** that controls the converter chips and performs the analog-to-digital conversion routine.

A2DRTN	STX	LIMADR	Save address of limits
	LDX	#PIAADR	Get PIA address
	LDA A	#99	
LOWC	BIT B	O,X	Is the comparator low?
	BNE	LOWC	No—Check it again
	CLR	O,X	Yes—Set ramp control low
HIGHC	BIT B	O,X	Is the comparator high?
	BEQ	HIGHC	No—Check it again
CNTDWN	BIT B	O,X	Yes—Countdown 100
	NOP		
	NOP		
	DEC A		A = 0?
	BNE	CNTDWN	No—Decrement A again
RCHIGH	NOP		Yes—Set ramp control high
	NOP		
	NOP		
	CLR A		
	COM	O,X	
CNTLP	ADD A	#1	Then do conversion count
	BCS	OVRRNG	Exit if count = 256
	BIT B	O,X	Is the comparator low?
	BNE	CNTLP	No—Continue counting
	SUB A	#10	Yes—Adjust count

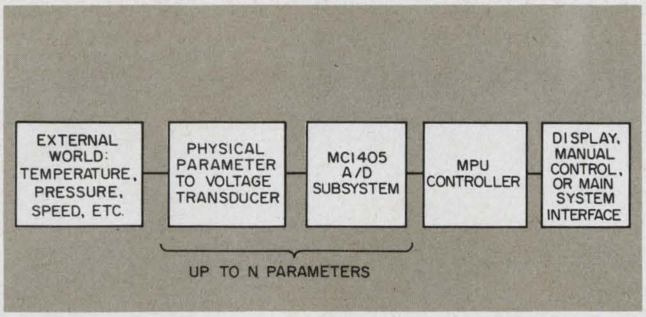
4. **Assembly-language coding** for the analog-to-digital conversion. The routine takes about 4.6 ms.

see if the comparator output is low. If it isn't low the routine waits until it is. Otherwise, a false conversion value would be obtained. When a low occurs, the routine sets the ramp control high and waits until the comparator output goes high.

When the high appears, the routine begins its base count: It decrements the A accumulator in a loop from 99 to 0 to produce the basic a/d-conversion time interval. The BIT B O,X and NOP instructions act as "filler" in the base-count loop so the time per decrement equals the time per increment in the conversion-count loop.

Carry bit serves as overrange

The hundredth count time required for the 2-1/2-digit conversion is provided by the COM O,X instruction, which sets the ramp control high



5. **In a typical application,** the μP controlled system monitors physical parameters, such as pressure, and provides a digital readout of a desired value.

and the CLR A and NOP instructions immediately preceding. In this way, the ramp control goes high at the end of the base count and the conversion count immediately begins.

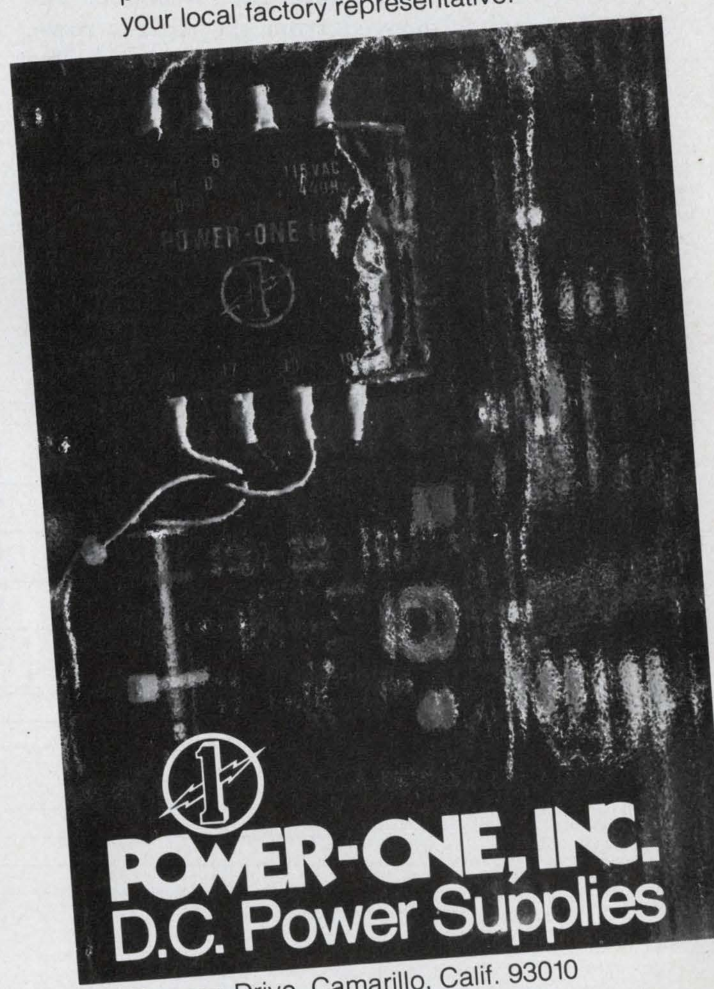
To perform the conversion count, 1 is added to the A accumulator. The carry bit acts as an overrange detector for the BCS OVRRNG instruction since the bit is set if the count reaches 256. When this happens, the program exits from the conversion-count loop and goes to the voltage-overrange display routine.

Continuing in the conversion count loop, the program next checks the comparator output. To do this, the routine loops back up and adds 1 to the A accumulator if the comparator output is still high. When the output goes low, the program exits from the conversion-count loop and corrects the conversion value by subtraction of 10 as the MC1405 requires.

The value now in the A accumulator is the digital representation of the analog input voltage. Since the conversion-count loop requires 15 CPU clock cycles per count, at a CPU clock frequency of 1 MHz for a full scale conversion, the a/d routine requires 15 μs count $\times$ (100 + 199 + 10) counts $=$ 4.64 ms plus the comparator check time.

For use in a parameter sensing system, the outlined routine can be easily converted to a subroutine independent of the PIA address. Just put the first two instructions before the subroutine call and begin the subroutine with the LDA A #99 instruction. No other modifications are required since the routine is already independent of the PIA data register line on which the comparator signal appears.

If you do convert to a subroutine you can retain the overrange-detect feature by setting a flag before returning from the subroutine and after the conversion has gone to overrange. A check of the conversion value against preprogrammed limits can also be included in the subroutine. In this way, you can apply the subroutine to a μP controlled, parameter-sensing system (Fig. 5). ■■



Keyboard circuit saves time, needs no microprocessor scanning software

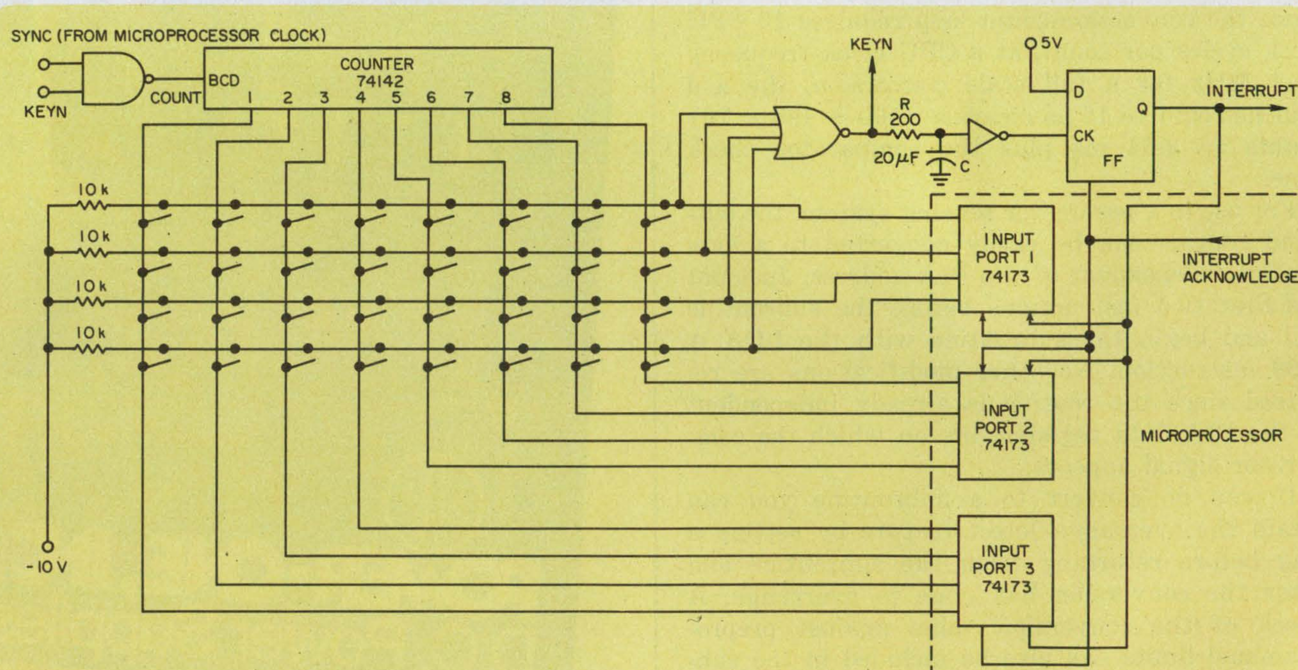
As much as 20 to 30 ms of valuable microprocessor time wasted in scanning keyboard inputs can be saved with a circuit that does not need any software and uses only a few TTL ICs.

Though the example in the figure is an 8 × 4 matrix, the circuit can easily be expanded to 8 × 8 or any other suitable configuration. Decimal-decoded outputs of a 74142 BCD counter drive the columns of the matrix. The counter's input signal is derived from the microprocessor's SYNC clock and the circuit's KEYN signal. The KEYN signal is derived from the matrix rows, via a NOR gate, whenever any key is closed. The KEYN signal also clocks a D flip-flop to provide an interrupt signal for the microprocessor.

Three-state output 74173 TTL latch ICs serve as the input port of the system. The interrupt signal, when it goes HIGH, clocks the data into the 74173s. An RC time constant of 2 to 3 ms on the KEYN signal, before it's used to clock the D flip-flop, takes care of switch bounce. An interrupt-acknowledge signal from the microprocessor then resets the 74173s and the D flip-flop, after the input ports are read.

A second interrupt signal will not be generated unless the first key is released. Thus the circuit automatically provides a two-key lockout. Further, the microprocessor should be programmed to provide an error signal if it detects more than one HIGH bit at any one time in the input port latches.

Ram N. Sahni, Project Engineer, NCR Corp., Ithaca, NY 14850. CIRCLE NO. 311



Closure of any switch in this keyboard matrix sets a flip-flop that provides an interrupt signal for a microprocessor. The matrix' configuration can be readily increased to 8 × 8 or larger.

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INFORMATION RETRIEVAL NUMBER 900

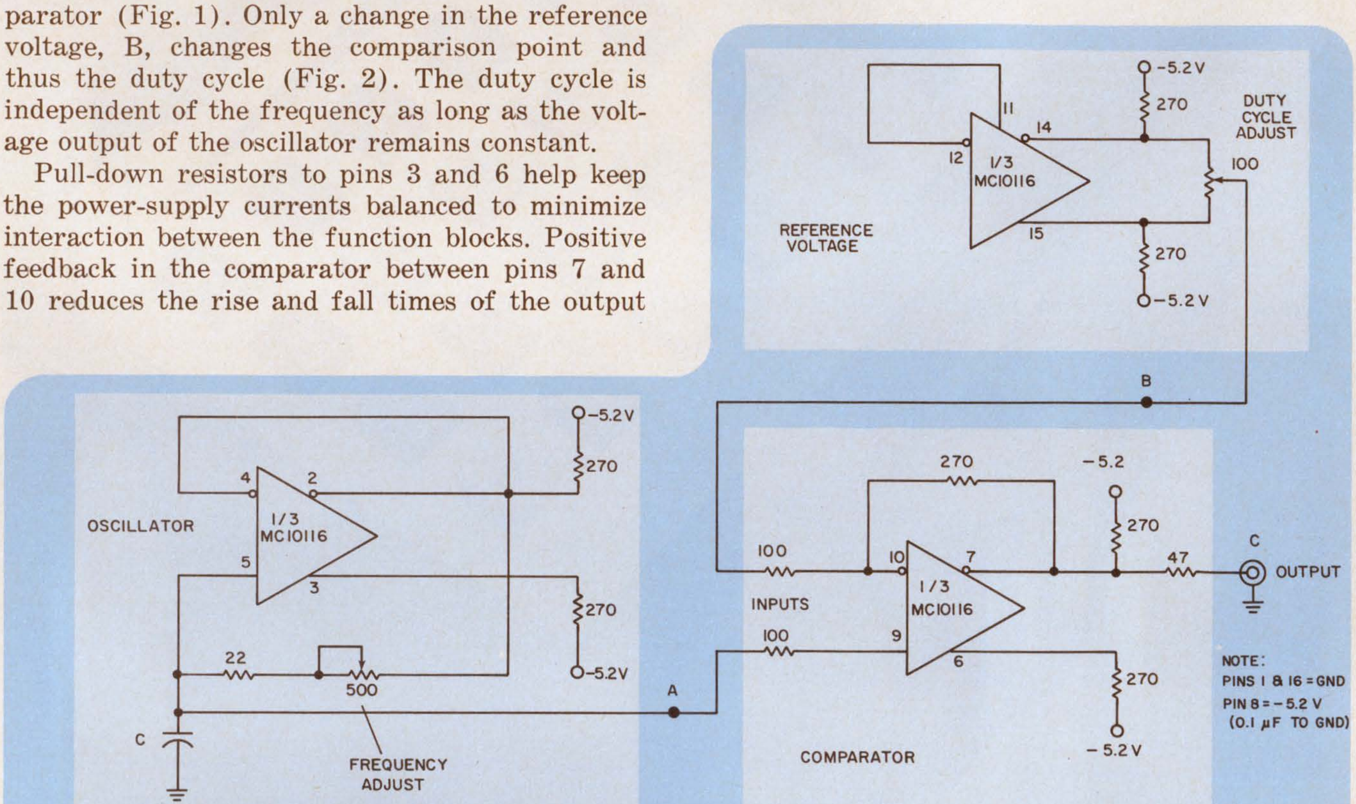
Single-chip pulse generator provides 50 MHz with adjustable duty cycle

One chip, the MC10116, can be used to construct a pulse generator with a variable duty cycle. And even with the generator operating at repetition rates above 50 MHz, the duty-cycle adjustment still remains fully effective. Interactions between the duty-cycle adjustment and oscillator frequency are nearly imperceptible.

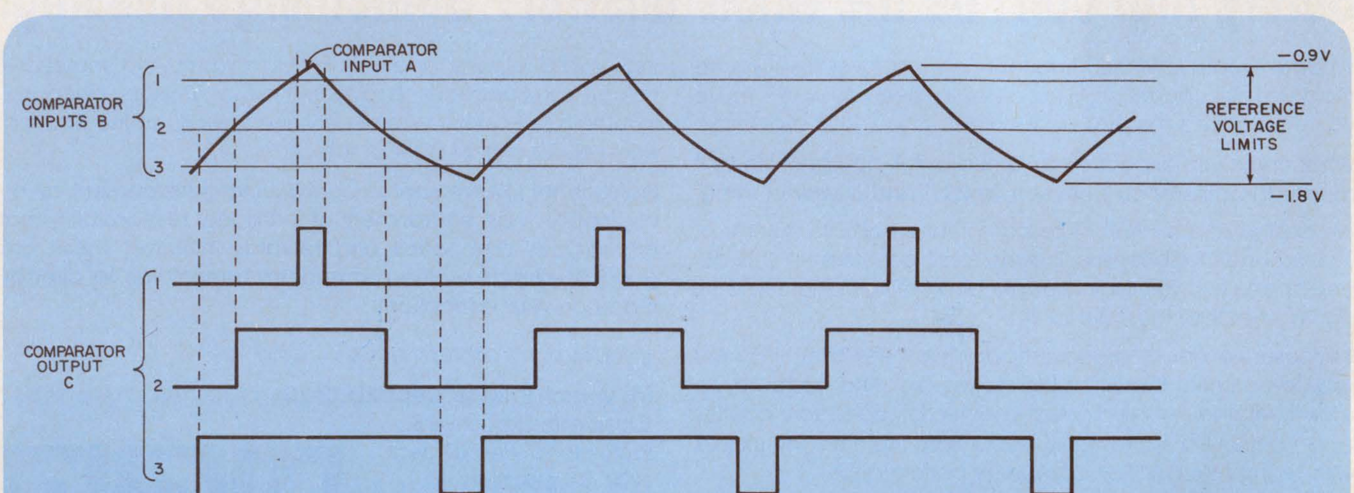
The circuit is divided into three main blocks—an oscillator, reference-voltage supply and comparator (Fig. 1). Only a change in the reference voltage, B, changes the comparison point and thus the duty cycle (Fig. 2). The duty cycle is independent of the frequency as long as the voltage output of the oscillator remains constant.

Pull-down resistors to pins 3 and 6 help keep the power-supply currents balanced to minimize interaction between the function blocks. Positive feedback in the comparator between pins 7 and 10 reduces the rise and fall times of the output pulses and also minimizes narrow-pulse jitter. The 47-Ω resistor, in series with the output terminal, ensures a 50-Ω output-impedance match to a coaxial cable.

William A. Palm, Principal Engineer, Control Data Corp., 7801 Computer Ave., Minneapolis, MN 55435. ·CIRCLE NO. 312



1. **Variable-duty-cycle pulse generator** is made from an IC chip that contains three ECL receiver sections.



2. **The duty cycle is controlled** by comparator input B from the reference-voltage source.

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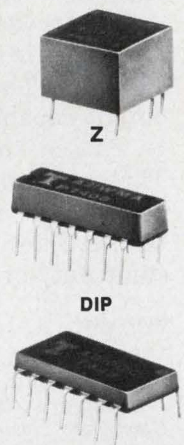

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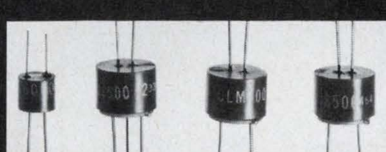

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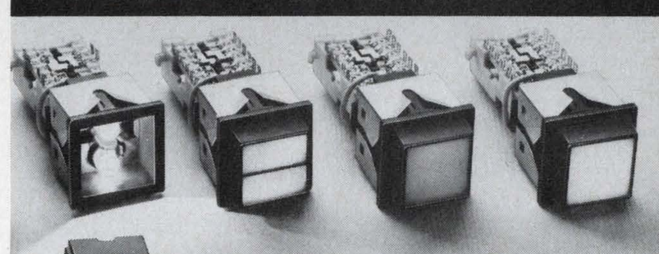

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INFORMATION RETRIEVAL NUMBER 42

Current sinks increase the range of IC function generators

When a current sink is substituted for the external control resistors[1] in IC function generators, the range of adjustment is greatly expanded. For example, the XR-2206, with the factory recommended resistor hookup shown in dashed lines, has a frequency range of 2000:1, but with a current sink, a tuning range of 8000:1 is attainable (Fig. 1).

The XR-2206 can also be used as a variable duty cycle pulse generator if a second current sink is arranged to track the first (Fig. 2). However performance of the factory-recommended hookup with two fixed resistors is limited to a single frequency and duty cycle. The current-sink circuit gives just over a 100:1 duty-cycle range controlled by variable-resistor R. The output frequency can still be controlled over about the same range as with the circuit of Fig. 1, but the duty cycle varies at the extremes of the frequency range.

The major parameter that affects performance of the circuit is the threshold current of the tuning inputs. In particular, differences between the thresholds of terminals 7 and 8 limit the performance of the circuit in Fig. 2. Tuning becomes somewhat nonlinear as control currents approach the threshold levels.

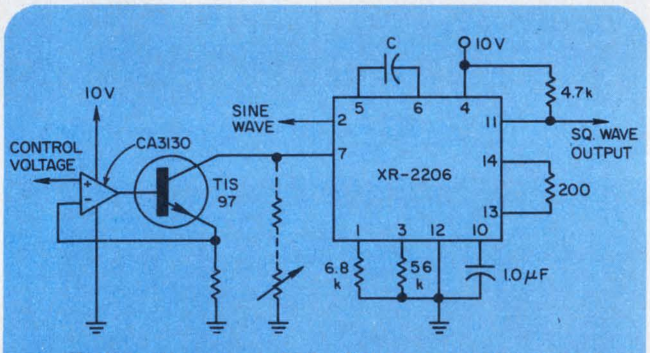
The frequency can be controlled if the input amplifier is driven by a current-output DAC (Fig. 3). The value of R_1 must match the DAC output capability, and the R_1/R_2 ratio must then be chosen to give the required current range. Threshold current limits allow the use of a 10-bit DAC in a Fig. 1 configuration, but only a 7-bit DAC for the Fig. 2 configuration with constant duty-cycle operation.[2]

Reference

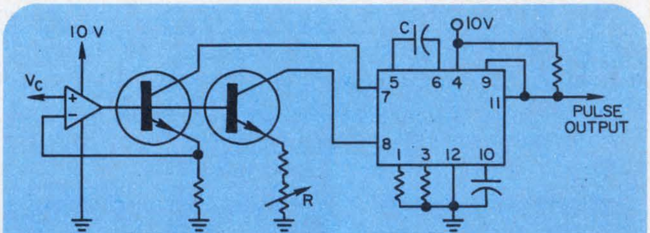
1. Grebne, A. B., "Generate Waveforms with a Single IC," *Electronic Design*, Sept. 13, 1974, p. 132.
2. Kaye, D. N., "Focus on A/D and D/A Converters," *Electronic Design*, Jan. 4, 1973, pp. 58-65.

Ralph Tenny, Senior Research Assistant, Texas Instruments, Inc., P.O. Box 5936, Dallas, TX 75222.

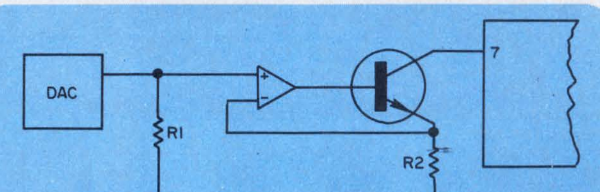
CIRCLE No. 313



1. **A function generator's frequency output range is increased** to 8000:1 by use of a current sink.



2. **Tracking sinks allow both frequency and duty cycle control.** Resistor R can set duty cycle over range of 100:1.



3. **Digital control of frequency** can be added to the current-sink circuit with a digital-to-analog converter.

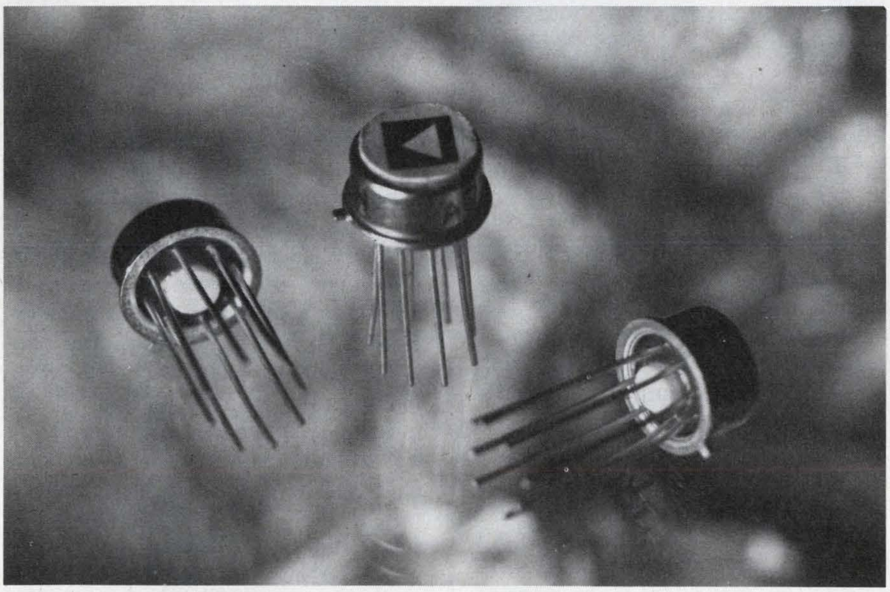
IFD Winner for August 16, 1975

G. R. Lewis, Engineer, Cerwin-Vega, Inc., 6945 Tujunga Ave., North Hollywood, CA 91605. His idea "Low-Cost Temperature Controller Built with Timer Circuit" has been voted the most valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number of your selection on the Information Retrieval Card at the back of this issue.

SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of $1050 (cash)! Here's how. Submit your IFD describing a new or important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive $20 for each published idea, $30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of $1000.

FET-input hybrid op amps match modules for performance at low cost



Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. P & A: See text.

By combining a matched FET pair with a wideband amplifier, Analog Devices has come up with a hybrid op amp that rivals the high performance of modules and the low cost of ICs. The 515 series of electrometer op amps has input bias currents as low as 75 fA, maximum, and small-signal bandwidths of over 350 kHz. And they cost about half as much as competing modules and about 20% less than competing monolithic ICs.

The Model 515 amplifiers use a separate matched FET chip and laser trimming to minimize input offset to 1 mV, maximum, and drift to only 15 μV/°C. Noise has also been kept low—only 4 μV, pk-pk, over a 0.1-to-10-Hz bandwidth. The op amp has internal compensation, is free of latch-up and is short-circuit-protected on the output. A case guard connection in the hermetic TO-99 metal package minimizes stray leakage to the case and shields the input circuitry from external noise and transients.

Quiescent current drawn by the op amp is claimed to be around the lowest available—only 1.5 mA, max, for ±15-V supplies. With ±5-V supplies, the quiescent drain drops to 0.5 mA. The op amp has a 0-to-70-C operating temperature range and comes in three performance versions.

The 515J, K and L have maximum input-bias currents of 300, 150 and 75 fA, respectively, when measured after warmup on ±15-V supplies. Maximum input offset voltages are 3, 1 and 1 mV, respectively, and offset voltage drifts are 50, 15 and 25 μV/°C, respectively. All amplifiers have a differential input of 10^{13} Ω and a common-mode input impedance of 10^{15} Ω.

Prices for the Analog Devices 515 series amplifiers are $16, $21 and $27 for the J, K and L models, respectively, in 1 to 24 pieces. In 100 unit lots the prices drop to $9.90, $14 and $18, respectively. Delivery of all three versions is from stock.

Competitive modules, such as the 102901 from Teledyne-Philbrick (Dedham, MA) or the A-127 from Intech (Santa Clara, CA), are about double the cost of the 515. They are also many times the size, with both the 102901 and the A-127 modules at least 1.5 × 1.5 in.

There are, though, some IC op amps that can meet some of the 515's specs—such as the 3523 series from Burr-Brown (Tucson, AZ) or the 142902 from Teledyne-Philbrick—but they tend to cost more.

Analog Devices	**CIRCLE NO. 302**
Burr-Brown	**CIRCLE NO. 303**
Intech	**CIRCLE NO. 304**
Teledyne-Philbrick	**CIRCLE NO. 305**

130-bit CCD register delays up to 25 ns

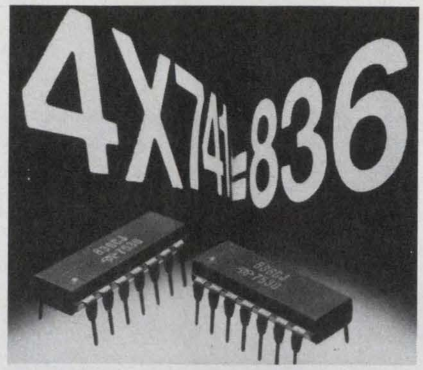
Fairchild, 464 Ellis St., Mountain View, CA 94042. (415) 962-3816. $49 (100-999); factory stock.

A charge-coupled analog shift register, the CCD311, functions as a wide-range analog delay line. The device can be operated either as a single 130-bit device, or a 260-bit device using multiplexing techniques. It can operate over frequencies extending from 10 kHz to video rates up to 15 MHz. A range of delay times from 20 μs to 25 ms can be obtained simply by varying the rate of an external clock signal. The device comes in an 18-pin DIP, and features a signal-to-noise ratio of more than 50 dB and an input bandwidth of greater than 4 MHz.

CIRCLE NO. 308

INTEGRATED CIRCUITS

Quad amp boosts specs for 741-type units



Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, CA 94041. (415) 968-9241. $3.40 to $11.50 (100-999).

The 836 quad op amp—an improved 741-type amplifier—has a typical slew rate of 1.2 V/μs, small signal bandwidth (unit-gain frequency) of 1.5 MHz and power bandwidth to 20 kHz. The internally compensated amplifier permits class AB output operation. At maximum output voltage, an 836 output remains symmetrical about ground and typically swings within 1 V of either supply. Input common-mode voltage range is −15 to 13.5 V. Typical supply current at ±15 V is only 700 μA per amplifier resulting in a total dissipation per package of 84 mW, or only 21 mW per amplifier.

CIRCLE NO. 320

1-k bipolar PROMs start at $5.95

Monolithic Memories, 1165 E. Arques, Ave., Sunnyvale, CA 94086. (408) 739-3535.

A series of low-cost 1024-bit bipolar PROMs, with 256 × 4-bit organizations, are offered in both commercial and MIL temperature versions. The 6300-1 (open collector) and 6301- (three-state) commercial parts are priced at $5.95 in quantities of a hundred. The 5300-1 (open collector) and 5301-1 (three-state) military parts are priced at $11.95 (100-999). All units are said to have the lowest power dissipation available. At least 95% of all units will program to completion in two seconds or less.

CIRCLE NO. 321

CMOS family simplifies counting and timing

Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $1.50 to $17.00 (1000).

Seven CMOS devices complete the company's line of timing microcircuits for industrial control and instrumentation applications. The new devices consist of the 7045 and 7205 low-power counter-timers; the 7208 counter; and the 7038A, 7207, 7209 and 7213 crystal frequency generators. The 7045, which times intervals from 0.01 s to 24 h, typically dissipates 0.9 mW. The 7205 times from 0.01 s to 1 h and dissipates 2.5 mW typical. The 7208 is a 7-digit unit counter, requiring a LED display, two resistors, a capacitor and control switches for operation.

The 7038A is a CMOS oscillator, frequency divider and driver. It accepts crystals with frequencies from 200 kHz to 15 MHz, and provides outputs at the crystal frequency and at $\div 2^{13}$ and $\div 2^{15}$ frequency-divider stages. The 7207 is a complete frequency counter time base that dissipates less than 5 mW at 5 V. The 7207 accepts crystals from 1 to 10 MHz, and it provides outputs at the crystal frequency, and at $\div 2^{13}$, $\div 2^{17}$ and $\div 10(2^{17})$ divider stages. The 7209, a high-frequency clock generator for 5-V systems, accommodates crystals from 10 kHz to 10 MHz and provides outputs at crystal frequency and $\div 2^{3}$ divider stage. The 7213 is an oscillator, divider and waveshaping circuit using crystals from 1 to 6 MHz. Outputs are at crystal frequency, $\div 2^{22}$ frequency, and one-second and one-minute pulses.

CIRCLE NO. 322

$10 circuit provides 10-V reference

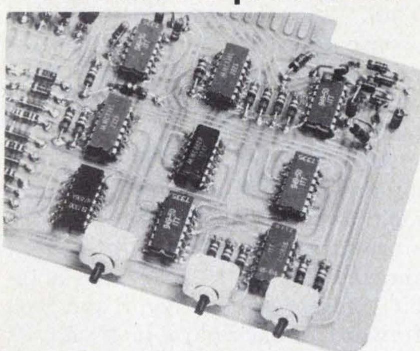
Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700.

The AD2700/L, a 10.000 ±0.001-V reference, costs just $10 in hundred quantities. The thin-film circuit has ±0.03% maximum output error at 70 C and 50-ppm/year long-term stability. The unit comes in a 14-pin DIP, and it is available from stock.

CIRCLE NO. 323

COMPONENTS

Pushbutton switches withstand PC processes



Grayhill Inc., 561 Hillgrove Ave., La Grange, IL 60525. (312) 354-1040. $0.98 (100 up); stock to 7 wks.

New PC-board mounted pushbutton switches, Series 39-251, withstand wave soldering and related cleaning processes. The switches have the terminals ultrasonically welded to the switch body, and the top and bottom halves of the cases are molded from high-temperature polyester, also ultrasonically welded. An optional semirigid boot is available to fit over the plunger. The switch can provide SPDT, SPST-NO or SPST-NC contact action. Gold-plated contacts can handle logic-level loads to 1/4 A for a minimum of 250,000 operations.

CIRCLE NO. 324

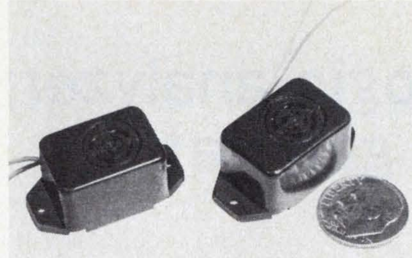
Toggle switches added to line

Oak Industries Inc., Crystal Lake, IL 60014. (800) 435-6106. Stock.

Oak's lines of switches now include miniature toggles with either SPDT, DPDT, 3PDT or 4PDT switching action. The new lines are Series 31, with standard toggles, Series 32, with long toggles and Series 33, with decorative flat plastic caps. Each consists of 20 basic switch models, with either solder or PC terminals. Several momentary-action types are also available. Contacts are rated at 6 A, 125 V ac. Mechanical life is 100,000 cycles and electrical life is 25,000 to 50,000 cycles.

CIRCLE NO. 325

Electronic buzzer generates no rf

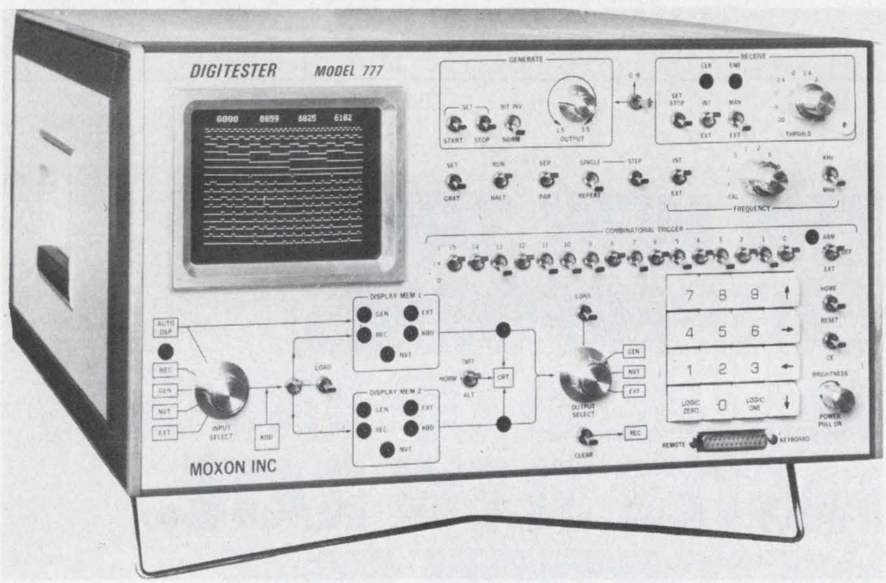


Kolin Industries Inc., 59 W. Pondfield Rd., Bronxville, NY 10708. (914) 961-5065. $1.99 list.

New Li'l Earsplitter miniature solid-state electronic buzzers, less than 1-in. long, 5/8-in. wide and 5/16-in. high, give off a big, rich sound. There are no mechanical points to arc and require maintenance, and no rf noise is generated. They are available with 3, 6, 9, 12 and 24-V ratings.

CIRCLE NO. 326

It looks like a logic analyzer; it's also a word generator



Moxon Inc., SRC Div., 2222 Michelson Dr., Irvine, CA 92664. (714) 833-2000. See text.

One quick glance at the timing-diagram display on Moxon's Model 777 Digitester, and you get the feeling that you're looking at yet another logic analyzer. But peer closer. Panel legends such as "generate" and "receive," along with a calculator-like numerical keyboard, tell you that there's more here than meets the eye. The 777 not only receives data; it generates words. And that, no other logic analyzer can do.

Thus with the 777 you can "tickle," say, a microprocessor with any desired bit pattern, and use the same piece of equipment to watch the μP respond. The pattern can consist of up to 1024 bits of serial data at rates up to 20 MHz. Or if parallel bits are what you need, you've got them: up to 64 sixteen-bit words. What the 777 dishes out, it can take right back—in either serial or parallel modes.

It costs $11,950, to be sure. But you can spend more than that for a logic analyzer alone.

Five internal memories in the Moxon unit let you do all kinds of good things. You can generate only, receive only or do both simultaneously. With one memory used as a scratch pad, you can direct the integral CRT to display the program as you formulate it. When you're satisfied with the pattern, you can then load it into a transmit memory for delivery to the circuit under test.

How fast do the data come out? As fast as you'd like, up to the maximum 20 MHz. Just dial in the crystal-controlled bit rate or let your system clock replace the internal oscillator for synchronous operation. And data can be delivered continuously or in bursts. Another parameter you can dial in is the logic ONE output level—it can be set to anywhere from 1.5 to 3.5 V.

With the 12-key numeric pad, entry of individual bits or strings of ONEs and ZEROs couldn't be simpler. Hit a number and then the LOGIC ONE or LOGIC ZERO button. For instance, the sequence, 1, 5, 6, LOGIC ONE, programs 156 consecutive ONEs.

In the serial mode, the bits appear horizontally along each line, from left to right, on the CRT. In parallel, the bits appear vertically for each word, from top to bottom, on the CRT. With the aid of a displayed cursor and a toggle switch, you can invert any bit without reprogramming or reloading memory. Thus you can examine the response to parity errors or the effects of single-bit changes. Other alphanumeric displays help even more.

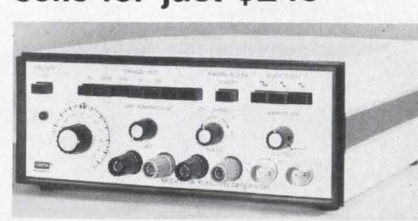
As a receiver, the 777 gives you all the features you'd expect in a logic analyzer and more: You can store results, adjust the input threshold (−10 to 10 V), set a 16-bit combinatorial trigger and look forward or backward in time.

You can juggle and transfer data between memories, take a snapshot and display just a portion of a data stream, or compare the contents of various memories. One memory can be the response, the other the preloaded, expected response or the transmitted data. If the contents of the two memories disagree, you'll know it right off by the flashing bits on the CRT.

These aren't all the tricks in the Moxon 777 repertoire. There are lots more. If you can wait 90 days to get one, you can check the unit out in your own lab.

CIRCLE NO. 301

Function generator sells for just $245

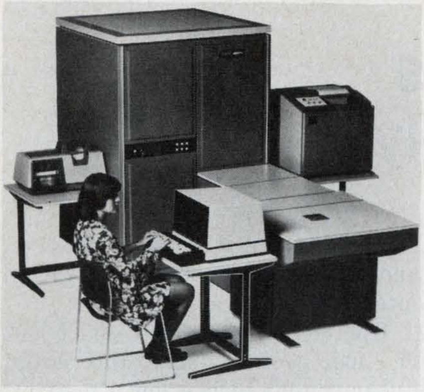


Exact Electronics, 455 S.E. 2nd Ave., Hillsboro, OR 97123. (503) 648-6661. $245.

Model 119 vcf function generator offers a dynamic frequency range from 0.02 Hz to 2.2 MHz with sine, square, triangle and variable time symmetry of all waveforms for ramp and pulse operation. A vcf input allows the generator frequency to be varied either up or down over a range of 1000:1. The HI output delivers 20 V pk-pk open circuit, 10 V pk-pk into 50 Ω. The LO output delivers 632 mV pk-pk open circuit, 316 mV pk-pk into 50 Ω.

CIRCLE NO. 327

Test system handles μPs and other LSI



Fairchild Systems Technology, 1725 Technology Dr., San Jose, CA 95110. (415) 962-3047. $250,000 to $350,000; 90 days.

Sentry II is a computer-controlled semiconductor test system that uses multiprocessor techniques. The system is said to accommodate the most intricate semiconductor circuitry used or produced today, including microprocessors and equivalent memory components in which cells must be individually verified. It can test each device at its individual operational speed. Key feature of the Sentry II is its use of two special purpose processors, a Sequence Processor and a Pattern Processor.

CIRCLE NO. 328

Probe converts rms to dc output signal

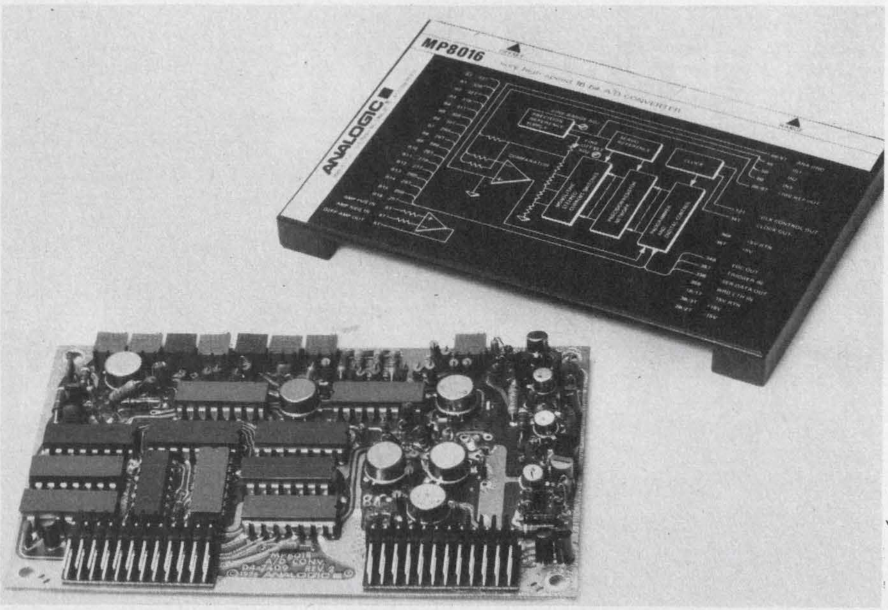
Non Linear Systems, P.O. Box N, Del Mar, CA 92014. (714) 755-1134. $149; stock.

Model RMS-10 is a portable, battery powered probe for measurement of true rms. The unit has three ranges—2, 20 or 200 V fs. A dc output signal of 0 to 2 V represents the rms value of the input, whether dc, ac or a combination of both. Accuracy of the conversion is ±1%. Input impedance is 1 MΩ and response is −3 dB at 10 kHz. NiCd batteries and a charger unit are included. Size is only 1.4-in. dia. and 7-in. long.

CIRCLE NO. 329

INFORMATION RETRIEVAL NUMBER 51

A/d converters with accuracies to 0.0015% drop prices sharply



Analogic, Audubon Rd., Wakefield, MA 01880. (617) 246-0300. See text.

High-precision analog-to-digital converters have been available, but at prices not all users could afford. Analogic, with its 8000 series of 14-bit through 16-bit converters, does the job without putting the customer into hock—prices start at $480. Heretofore the going price for this precision was about $1000.

There are three units in the series: the 8014, a 14-bit; the 8015, a 15-bit; and the 8016, a 16-bit a/d converter. All converters can be short-cycled if shorter word lengths are needed. Accuracies, based on measurements traceable to NBS standards, are 0.006%, 0.003% and 0.0015%, FSR, for the 14, 15 and 16-bit converters, respectively.

Absolute accuracy is ±0.006% for the 14 and 15-bit models and 0.003% for the 16-bit model. Noise produced by the converters is less than 1 LSB—at 300 μV, pk-pk, for a 3 σ measurement. Power-supply sensitivity for all three models per 1% change in supply voltage is 0.0005%. Warmup time to full-rated accuracy is only 10 minutes, and the recommended recalibration interval is six months.

The converters won't drift out of spec either—the differential linearity tempco is a low 1 ppm/°C max, the gain tempco less than 2 ppm/°C and the offset tempco less than 1.5 ppm/°C.

All converters have a built-in buffer amplifier that provides an input impedance of 1000 MΩ. The converters can handle input voltages of 0 to 10 V or −10 to 10 V, and they deliver either offset binary, ONEs complement or TWOs complement binary outputs.

All units have a conversion speed that is externally adjustable from fixed times of 1.5, 2 and 2.5 μs per bit to a minimum of 0.6 μs per bit. And the internal clock has a stability of 0.1%/°C.

Competitive converters are few. Analog Devices (Norwood, MA) has several models that provide 14 or 16-bit outputs, but they tend to be slower or much more expensive. For instance, that company's ADC-141 and 171, which are 14 and 16-bit converters, have conversion times of 10 ms and cost $272—almost 100 times slower than the Analogic converter, but at half the cost. The ADC-16Q, on the other hand, converts in 400 μs but costs $1418—still slower but almost double the cost of an equivalent unit from Analogic.

Prices for the Analogic converters start at $480 for the 14-bit unit, $560 for the 15-bit unit and $640 for the 16-bit. All units are available from stock.

Analogic **CIRCLE NO. 306**

Analog Devices **CIRCLE NO. 307**

High accuracy modulator is linear to ±0.1%

Computer Conversions, 6 Dunton Ct., East Northport, NY 11731. (516) 261-3300. Under $100 (large qty.); stock to 4 wk.

The MOD 503 series of high-accuracy modulators with up to ±0.1% full-scale linearity converts dc-input signals to linearly proportional ac-output signals. The modulators accept ±10-V-dc or ±100-V-dc inputs and provide an ac output of 0 to 7 V rms. These modulators have an output impedance of only 1 Ω, maximum, and are insensitive to ±10% reference line changes. Any ac output voltage can be provided via internal or external transformers, and the output is short-circuit protected. Gain and zero adjustments are also standard. The units have a reference input of 26 V, 400 Hz ±5% (60-Hz units available); input impedances of 100 kΩ, minimum; operating temperature ranges of 0 to 70 C (MOD 503-1) or −55 to 70 C (MOD 503-2); and measure 2.6 × 3.1 × 0.625 in. The modulators require ±15 V at 50-mA supplies.

CIRCLE NO. 330

Solid-state flasher handles 10-A surges

SSAC Precision Products, P.O. Box 395, Liverpool, NY 13088. (315) 457-9610. From $1.95.

The Mini-Flasher, a solid-state on/off blinker, can handle 10-A surges. It will operate 120-W resistive, incandescent or inductive loads. The flasher has a 1-A, 115-V-ac steady-state rating; with a 50% duty cycle. The flash rate is 75 fpm and the unit operates over a 0-to-135-F range. A cylindrical case that measures 1.5 in. long and has a diameter of 15/16 in. houses the flasher.

CIRCLE NO. 331

Ultraviolet lamp has intensity of 72 mW/cm^2

American Ultraviolet, Commerce St., Chatham, NJ 07928. (201) 635-8355. $160, $20 (tripod); stock.

The Porta-Cure 1/100 ultraviolet irradiator has a typical intensity at 12 in. from light source of 72 mW/cm^2. This power is in the spectral range of 325 to 382 nm. The lamp requires 120 V ac at 2.1 A, measures 8 × 6.125 × 8.5 in. and has an optional tripod stand.

CIRCLE NO. 332

Reinforced nylon has high tensile strength

Fiberfil Div., Dart Industries, 1701 N. Heidelbach Ave., Evansville, IN 47711. (812) 424-3831. $1.28/lb (32,000 lb and up); stock.

Type 66 fiberglass reinforced nylon with silicone additive, Hilube Nylafil J-1/30/SI/3, has an increased service life under load bearing conditions. This is due to the silicone additive that reduces the coefficient of friction. Property test values include tensile strength of 22,000 psi, flexural strength of 30,000 psi, elongation of 2%, coefficient of linear thermal expansion of 2.1×10^{-5} and a deflection temperature under load at 264 psi of 485 F.

CIRCLE NO. 333

Conductive adhesive has R of only 0.0005 Ω-cm

Aremco Products, P.O. Box 429, Ossining, NY 10562. (914) 762-0685. From $21.50 (50 grams).

Aremco-Bond 556, a two-component silver filled epoxy, has a volume resisitivity as low as 0.0005 Ω-cm. Its shear strength after bonding to metals, ceramics, glass or epoxy ranges from 3000 to 4000 psi. The material has a pot life of 30 m and a shelf life (unmixed) of 6 mo. It can be cured at room temperature in 12 h, or there are several optional heat cure cycles such as 105 C for 3/4 h, or 65 C for 3 h. After curing the material has an operating temperature range of −60 to +200 C.

CIRCLE NO. 334

Switcher weighs 4 lb, yet delivers 50 W

Nippon Electronics Memory Industry Co., Ltd., Park Avenue Bldg., 1-20-1 Sendagaya Shibuya-ku, Tokyo, 151, Japan. Start at $87 (50-W unit).

HR series of switching power supplies delivers various voltages from 5 to 48 V at 50, 100 and 150 W. Size of the 50-W unit is 2.68 × 7.65 × 7.09 in., and weight is 4.19 lb. Efficiencies range from 70 to 80%. The MTBF is listed as 120,000 h. Features include remote control and sensing, overvoltage and overload protection.

CIRCLE NO. 338

Solid-state supply provides 60 kV

Spellman High-Voltage Electronics, 1930 Adee Ave., Bronx, NY 10463. (212) 671-0300. $550; 4-6 wks.

Model UHP60P5, zero-to-60-kV dc power supply operates from an input voltage of 115 V rms, 60 Hz. Output current is 75 μA at 60 kV and increases to 250 μA below 20 kV. The output is positive with respect to ground and the unit features ripple of less than 0.5% rms. A ±2% meter reads the output voltage directly through a high-voltage multiplier resistor.

CIRCLE NO. 339

Supply maintains power on RAMs when line fails

Scarpa Laboratories, Inc., 46 Liberty St., Brainy Boro Station, Metuchen, NJ 08840. (201) 549-4260. $150; 2-4 wks.

This 5-V, 6-A open-frame supply features an auxiliary battery back-up which can automatically keep permanent power on a 4-k by 8-bit RAM memory bank of 2102s. The stand-by battery pack is continuously trickle charged as long as line voltage is present. Power outages can range from between one week and one month without loss of data. The modules feature short-circuit-proof operation and overvoltage-crowbar protection.

CIRCLE NO. 340

DISCRETE SEMICONDUCTORS

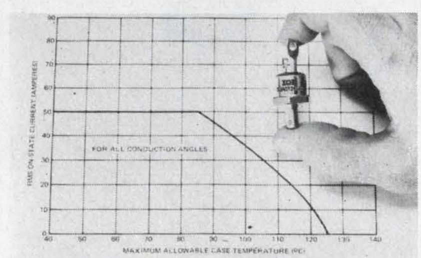
12 and 24-A rectifiers housed in TO-3 cases

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, FL 33404. (305) 848-4311. From $2.10 (100-up); stock.

Two series of fast switching silicon planar integrated power rectifiers are available in hermetic TO-3 cases. The SPDA 6205, 10, 20, 30 are 12-A devices (6 A per chip) and the SPDA 12205, 10, 20, 30 are 24-A units (12 A per chip). Each series is available with common-cathode, common-anode or doubler construction. Both the SPDA 6205 through 6230 and the SPDA 12205 through 12230 offer rated breakdown voltages from 50 to 300 V. The units have reverse recovery times of less than 200 ns and storage temperature ranges from −65 to +200 C. The TO-3 copper case dissipates 1.25 C/W.

CIRCLE NO. 341

High power triac comes in TO-65 package



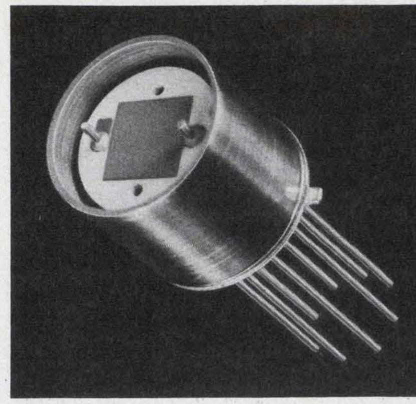
50 AMP. 1200 VOLT TRIAC (IR50AC)
RMS On-State Current Vs Case Temperature
(50 to 60 Hz)

International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, CA 90245. (213) 678-6281. From $15.40 (25-up); stock.

The 50 AC series of triacs is rated for operation at 50 A, with voltage ratings up to 1200 V. The company believes these units to be the first rated for such high power operation that are available in standard TO-65 packages. The line offers a choice of gate drive currents—a standard 500-mA gate and a sensitive 200-mA gate. Triacs in the series are available with blocking voltage ratings of 400, 600, 800, 1000 and 1200 V and a surge current of 1200 A, maximum. Commutation dV/dt is 10 V/μs at rated voltage and 125-C junction temperature.

CIRCLE NO. 342

Impedance converter also houses IR detector



Eltec Instruments Inc., Central Industrial Park, Daytona Beach, FL 32014. (904) 252-0411. $45 (10 up); 2 wks.

Model 320 impedance converter is designed for IR radiation detectors that need high-impedance, low-capacitance and low-noise coupling. This package allows selection of detector and window material, load resistor and mounting for the detector without interfering with the impedance converter performance. The converter circuit is hermetically sealed in a TO-99 housing and detectors up to 3-mm dia can be used. The circuit uses an n-channel JFET, a selection of three load resistors and one output resistor. The entire circuit floats. Voltage noise with $R_{in} = 5 \times 10^{11}$ Ω is 90 $\mu V/\sqrt{Hz}$. Input capacitance is 3 pF and gain is 0.6. The supply voltage can be between 5 and 15 V dc. Power consumption is 2.5 mW max.

CIRCLE NO. 343

LED displays use light pipes for 1-in. height

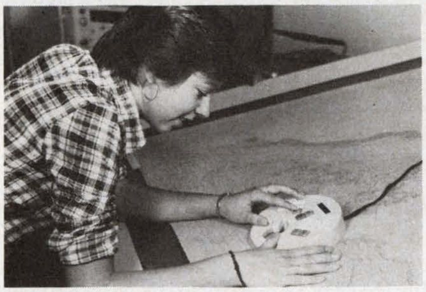
IEE, 7740 Lemona Ave., Van Nuys, CA 91405. (213) 787-0311. $4.35 (100-up); 60 day.

The single-digit "light-pipe" series 1720R/1723R are 1-in.-high LED numeric displays. They are available with either a common-anode (1720R) or common-cathode (1723R) and are housed in an electrically nonconductive, plastic-compound base that measures 1.3 × 0.886 × 0.334 in. Typical luminous intensity is 250 μcd at 20 mA and 3.3 V per segment. The maximum dissipation is 760 mW per digit.

CIRCLE NO. 344

DATA PROCESSING

Cursor enters data from maps and graphs

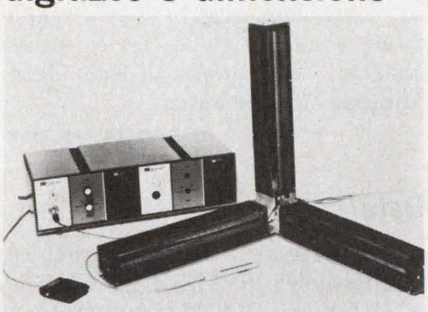


Instronics Inc., One Regency Dr., Bloomfield, CT 06002. (203) 242-2219.

A keyboard cursor facilitates the entering of numerical data while digitizing maps and charts. A keyboard is built right into the new cursor. A Gradicon digitizer then senses the cursor position and converts the coordinate data into digital form for computer processing.

CIRCLE NO. 347

Sound-sensor system digitizes 3 dimensions

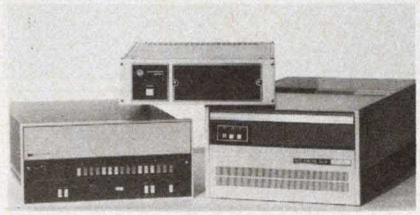


Science Accessories Corp., Kings Highway West, Southport, CT 06490. (203) 255-1526.

A new three-dimensional Graf/Pen sonic digitizer, Model GP-3/3-D, is used to convert descriptions of three-dimensional objects into digital form suitable as inputs to data-processing systems. Slant-range distances are converted to orthogonal coordinate sets by the software of the data system. The operator traces an object with a stylus that generates supersonic pulses. The time for the sound wave to reach three linear microphones is a measure of the distance. Outputs are in English or metric units. Resolution of English units is 0.01 in. and sensor lengths are up to 24 in. Standard size is the cube enclosed by 14-in. sensors.

CIRCLE NO. 348

Disc memory system handles to 4500 Mbytes



Microcomputer Systems Corp., 3068 Kenneth St., Santa Clara, CA 95051. (408) 985-1414. $17,500: 40 Mbyte: 30 days.

The MSM-10 disc systems for HP-2100 and 21MX computers consist of an Ampex, CDC or Century Data disc drive, Microcomputer System microprogrammed controller and host adapter. Expandable up to 15 drives and multiported up to eight computers, the system can provide 4500 Megabytes of disc storage with a single controller.

CIRCLE NO. 349

Application Notes

Curve tracer

A "Testing Opto-isolators" bulletin deals with using a standard curve tracer to check the most important opto-isolator device specifications. Tektronix, Beaverton, OR

CIRCLE NO. 350

Dc clocks

Simplified dc circuitry for driving the company's SP-151, SP-152 and SP-352 planar gas discharge displays is presented in a four-page bulletin. Beckman Instruments, Helipot Div., Fullerton, CA

CIRCLE NO. 351

Impatt diodes

Advantages of double-drift Impatt diodes for high-power cw microwave applications are given in a 12-page brochure. Information about circuits and operating characteristics are included. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 352

Impedance measurement

An application note is intended as an introduction to mechanical-impedance testing. Described are some of the terms used, problems encountered and techniques employed in mechanical-impedance testing. EMR Telemetry, Sarasota, FL

CIRCLE NO. 353

RFI suppression

Among the topics discussed in the illustrated eight-page "Radio Frequency Interference Suppression in Switched-Mode Power Supplies" applications note are interference specifications; effects of circuit design and construction on RFI; RFI produced by heat-sink current, interwinding capacitance and currents in the transformer core; wiring layout; RFI generated by diodes; and RFI at the output. Ferroxcube, Saugerties, CA

CIRCLE NO. 354

Design Aids

Microwave materials

Typical properties of 3M microwave materials are highlighted in a six-page foldout. 3M

CIRCLE NO. 355

Copper-clad laminates

An easy-to-read six-page foldout chart lists applications and specifications for copper-clad laminates for PC boards. Westinghouse Electric, Micarta Div.

CIRCLE NO. 356

Metric conversion

"Conversion Factors," a 24-page booklet, provides multiplication factors for literally hundreds of industrial and scientific measurement units. They run the gamut from A to Y (abamperes to years) and from common to esoteric terms (bushels to parsecs). Engelhard Minerals & Chemicals.

CIRCLE NO. 357

Data code conversion chart

A Universal Code Chart provides a cross-index of ALPHA-NUMERIC, HEX and OCTAL for fast, easy reference. Codes listed are ASCII-8, ASCII-7, EBCDIC, EBCD, FIELD DATA, 6-BIT TRANSCODE, SELECTRIC and BAUDOT. The Hex-to-Character Code Chart provides reference from Hex to character in the same codes as the aforementioned. Atlantic Research.

CIRCLE NO. 358

LED cross-reference

A four-page folder matches all widely used LEDs primarily on the basis of size, shape, input and output characteristics. Actual part numbers are listed on side-by-side charts to show which LEDs are interchangeable with the company's products, and an alphabetical code is used to indicate specific differences in cross-referenced pairs. Chicago Miniature Lamp.

CIRCLE NO. 359

New Literature

Freq control components

Forty types and series of quartz crystals, crystal oscillators, crystal filters and solid ultrasonic delay lines are covered in a 12-page catalog. Frequency ranges and tolerances, temperature ranges, drive levels and other application data are included. Bliley Electric, Erie, PA

CIRCLE NO. 360

Switches

Toggle, rocker and lever-handle miniature switches are illustrated in an eight-page catalog. Data include basic switching functions, contact ratings, terminations, handle types and hardware options. Airpax Electronics, Cambridge Div., Cambridge, MD

CIRCLE NO. 361

Power transistors

An updated and expanded 44-page edition of the power transistor directory lists power transistors and power hybrid circuits. Applications information, a list of transistors which may be used as complementary pairs and charts are included. RCA Solid State Div., Somerville, NJ

CIRCLE NO. 362

Bridges

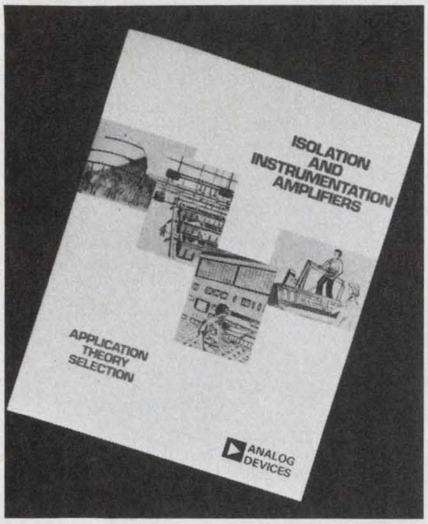
Impedance, capacitance, resistance, and inductance bridges are covered in four sections of a 40-page catalog. Specifications are included for 25 instruments, and each major section is introduced by a brief description of measurement techniques and theory related to that section. General Radio, Concord, MA

CIRCLE NO. 363

Thermistor thermometers

A four-page brochure features the DigiTec HT Series (High Technology) portable thermistor thermometers. United Systems, Dayton, OH

CIRCLE NO. 364



Amplifiers

The application, theory and selection of single and multichannel isolation amplifiers and instrumentation amplifiers are covered in a 16-page brochure. Specifications and definitions are included. Analog Devices, Norwood, MA

CIRCLE NO. 371

Switches

Photos, line drawings and specifications of switches are contained in a 16-page catalog. Molex, Lisle, IL

CIRCLE NO. 372

Terminal blocks

More than a dozen different types of modular rail mounted blocks are featured in a 36-page catalog. All are described with ratings, dimensions, AWG wire sizes, material specifications and tables of accessories. Technical and application data are included. Electrovert, Mount Vernon, NY

CIRCLE NO. 373

Microelectronic technologies

"Microelectronics Interconnections and Packaging," a 16-page booklet, is devoted to ceramic packaging and to microinterconnect systems and their primary application: beam tape technology. 3M, St. Paul, MN

CIRCLE NO. 374

Circuits, interconnections

Custom, high-reliability flexible circuits and interconnections are illustrated in a 16-page brochure. It includes several charts outlining properties of conductors and insulators, as well as round-to-flat conductor conversions and a cable-material selection guide. Hughes Connecting Devices Div., Irvine, CA

CIRCLE NO. 375

Conductive silvers

Applications of conductive silvers in semiconductor work, thick-film hybrid and thin-film microelectronic circuits, as well as capacitor terminations, are covered in a 10-page catalog. Transene, Rowley, MA

CIRCLE NO. 376

Crystal impedance meter

Features and specifications of a crystal impedance meter are covered in a four-page brochure. RFL Industries, Boonton, NJ

CIRCLE NO. 377

Power supplies

Power supplies for integrated-circuit logic and op amps are described in a four-page brochure. Acopian, Easton, PA

CIRCLE NO. 378

Relays

Dimensional drawings, specifications, ordering data and prices on hundreds of relays, stepping relays (steppers), solenoids and solid-state controls are included in a 16-page catalog. Guardian Electric, Chicago, IL

CIRCLE NO. 379

Process controller

A 60-page bulletin describes the operation and applications of the Bristol UCS 3000 process controller. Included are a sample flow diagram, a wiring drawing of the control and reporting system, module coding sheets used to enter the system configuration and system documentation automatically prepared by the Accol compiler. Acco, Bridgeport, CT

CIRCLE NO. 380

Pluggable gp relay

A general-purpose pluggable relay available in 6 to 230 V ac or 6 to 110 V dc operation is described in a four-page bulletin. Included are specifications, selection procedures, mounting dimensions and life charts. North American Philips Controls, Cheshire, CT

CIRCLE NO. 381

Microwave, rf components

A 96-page loose-leaf data booklet covers microwave and rf components. Complete specifications are given on all products, and curves, block diagrams and outline drawings are included. Trak Microwave, Tampa, FL

CIRCLE NO. 382

Accelerometers

Features and characteristics of semiconductor strain gauge accelerometers are described in a 28-page manual. Entran Devices, Little Falls, NJ

CIRCLE NO. 383

Wirewound trimmers

Three-quarter-inch rectangular wirewound trimming potentiometers are featured in a data sheet. Data on special options, a chart of standard resistance specifications and ordering information are included. Amphenol Connector Div., Broadview, IL

CIRCLE NO. 384

Modular microcomputers

A 16-page catalog describes modular microcomputers. The company's book on designing with microprocessors, "Microcomputer Design," is included in the catalog. Martin Research, Northbrook, IL

CIRCLE NO. 385

Audio ICs

The "Audio IC Selection Guide" indicates the operating supply voltage range and the package used for each audio IC manufactured by the company. SGS-ATES Semiconductor, Newtonville, MA

CIRCLE NO. 386

NEW LITERATURE

Electronic components

Electronic components, test equipment and production tools are covered in a 48-page catalog. Prices are included. Mouser Electronics, Lakeside, CA

CIRCLE NO. 366

Thermal printers

Specifications and application data on the Model DPP-7 miniature seven-column panel-mounting printer are covered in a 12-page catalog. Block and wiring diagrams are included. Datel Systems, Canton, MA

CIRCLE NO. 365

Rf inductors

A 16-page catalog highlights rf inductors. Special and nonstandard coil capabilities are shown in diagrams and photos. Airco Electronics, Nogales, AZ

CIRCLE NO. 367

Transducers

Subminiature pressure transducers for industrial and aerospace testing are featured in a six-page catalog. Sensotec, Columbus, OH

CIRCLE NO. 368

Gas discharge displays

Technical and application data for Plasma-Lux gas discharge display panels are contained in a literature kit. Included are individual sheets containing dimensional drawings and electrical specifications. Cherry Electrical Products, Waukegan, IL

CIRCLE NO. 369

Instrumentation

"News from Rohde & Schwarz" presents equipment shown by R&S at the 1975 Hanover Fair. Detailed articles cover the uhf-vhf receiving system ET 001, the motor-vehicle sound-level meter ELMOT and the tone-sequence generator SSN/SSN-Z. An article shows how to combine the automatic radio-telephone test assembly SMPU with Tektronix' desktop calculator TEK 31. Rohde & Schwarz, 8000 Munchen 80, Muhldorfstrasse 15, West Germany

CIRCLE NO. 370

Bulletin Board

Monolithic Memories is **second-sourcing National Semiconductor's** 18-pin Model MM5270 and 22-pin Model MM5280 **4096-bit RAMs.**

CIRCLE NO. 387

Signetics has introduced 19 more **74LS-TTL elements.** Twelve devices are MSI functions and seven are SSI.

CIRCLE NO. 388

Systems Engineering Laboratories has announced a **program translator** that converts SEL 800 series computer programs to SEL 32 series computer programs.

CIRCLE NO. 389

General Semiconductor Industries has completed qualification of its **2N3418/19/20/21 npn transistors** to MIL-S-19500/393 (USAF).

CIRCLE NO. 390

Facsimile, word-processing and time-sharing terminals can now file **Western Union's** Mailgrams.

CIRCLE NO. 391

Fairchild and Mostek have jointly announced that Mostek will second source Fairchild's **F8 microprocessor.**

CIRCLE NO. 392

Digital Equipment has introduced **Fortran/RT-11** extensions that add extensive software support for PDP-11 laboratory peripherals to the RT-11 disc operating system.

CIRCLE NO. 393

Exar Integrated Systems is offering **custom integrated injection logic** (I^2L) in volume quantities.

CIRCLE NO. 394

Significant steps in **a program to standardize and improve specifications and performance for COS/MOS ICs** have been announced by **RCA Solid State Div.**

CIRCLE NO. 395

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.

Weil-McLain. Heating and air conditioning, fluid systems and air handling systems.

CIRCLE NO. 396

Tracor. Components, instruments, and research and development.

CIRCLE NO. 397

AMP. Electrical connection, switching and programming devices and application machines and tools, and power units.

CIRCLE NO. 398

Superior Electric. Industrial products for voltage and motion control.

CIRCLE NO. 399

Philip Morris Industrial. Electrosensitive paper, packaging adhesives and materials, and coatings.

CIRCLE NO. 400

Reynolds Metals. Aluminum.

CIRCLE NO. 401

The International Nickel Co. of Canada. Metals and batteries.

CIRCLE NO. 402

Pfizer. Chemicals, materials-science products and pharmaceuticals.

CIRCLE NO. 403

Conrac. Communications, control products, information displays and automated assembly.

CIRCLE NO. 404

Electronic Design

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quick ads

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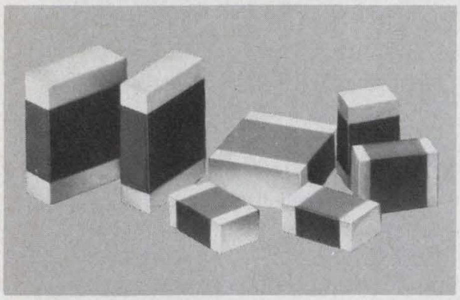

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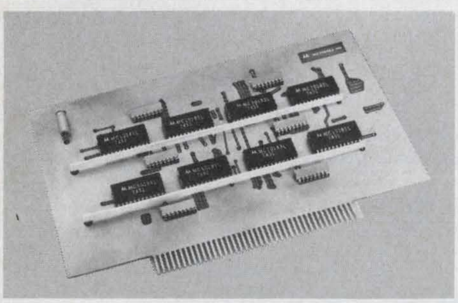
MULTILAYER CHIP CAPACITORS **601**



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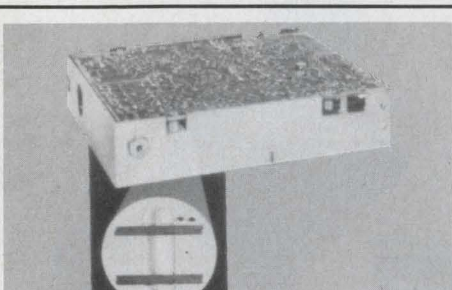
MINI/BUS **602**



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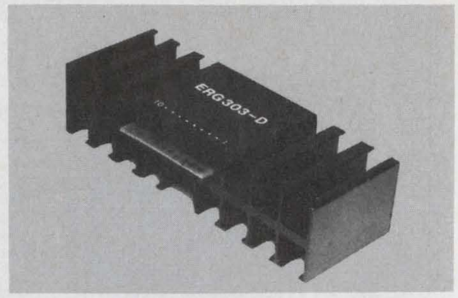
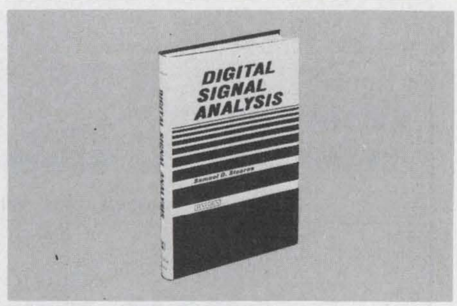
POLYAMIDE SPACER-BUSHING **603**



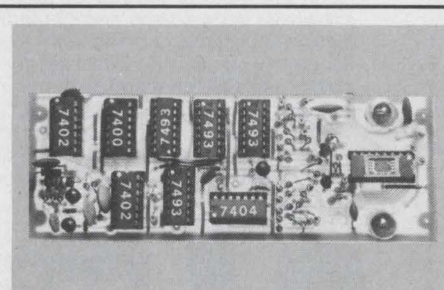
Transconductance Power Driver for $33.50. The ERG 303D drives high-power audio amplifiers; accurately controls servo motors. With ±50V. supply and output transistor pair, the ERG 303D produces 100-300+ Watts R.M.S., 0.02% T.H.D. Bandwidth 80kHz-200kHz. $29.95 in quantity. Electronics Research Group, Inc., 134 Mt. Auburn St., Cambridge, MA 02138 (617) 661-9383

ERG 303D **604**



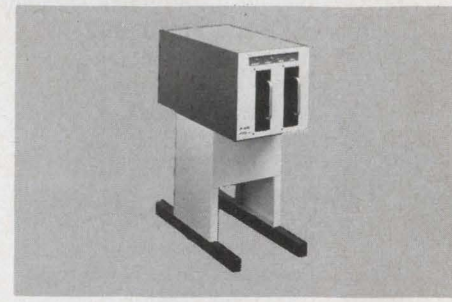
DIGITAL SIGNAL ANALYSIS, S. Stearns. Contains the most recent advances, brand-new design material, and a comparison between continuous and digital systems, making it an ideal master reference to today's signal processing techniques and systems. #5828-4, 288 pages, $18.95. Circle the Info Retrieval Number to order 15-day exam copy. When billed, remit or return book with no obligation. Hayden Book Co., 50 Essex Street, Rochelle Park, N.J. 07662.

DIGITAL SIGNAL ANALYSIS **605**



Low Cost Image Sensing Module contains a 1024 element (32-by-32) image sensor and all support circuitry on a single pc board. Digital video output may be displayed directly on an oscilloscope. Complete module (SE1024W) is $150. Kit (SE1024K) is $90. Cromemco, 26655 Laurel, Los Altos, CA 94022.

MODULE **606**



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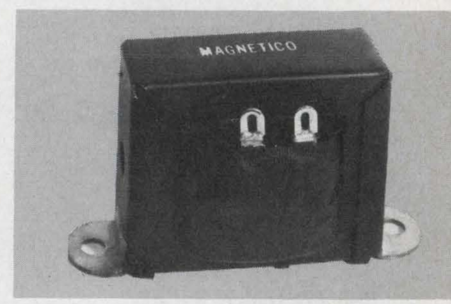
DISC SYSTEM **607**



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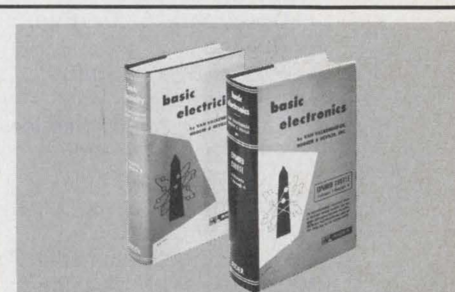
TRANSFORMER SERVICE **608**



Basic Electricity & Basic Electronics by Van Valkenburgh, Nooger & Neville, Inc. Derived from the COMMON-CORE Training Program initially developed for the U.S. Navy. Thorough, comprehensive coverage. Available in separate paperbacks or cloth volume. Write for FREE brochure. Hayden Book Co., Inc., 50 Essex St., Rochelle Pk, N.J. 07662 (201) 843-0550.

TRAINING TEXT **609**

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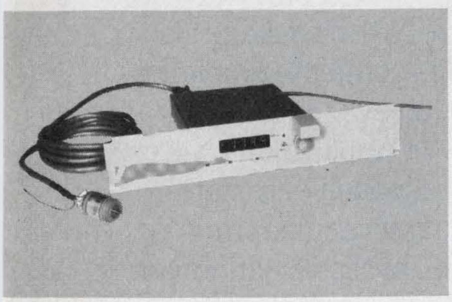
MODULAR DC/DC CONVERTERS 610

Model A-101 Ultrasonic Pulser/Receiver drives piezoelectric transducers. High energy negative spike output variable from −50 to −350 volts into 50 ohms. Pulse repetition rate adjustable from 100 Hz to over 10 kHz. Pulse risetime better than 15 nsec., output pulse monitor, adjustable damping. TTL-compatible external trigger, sync. Low noise receiver amplifier has selectable gain, 15 MHz bandwidth, switchable high-pass filter. MetroTek, Inc., P. O. Box 101, Richland, WA 99352, (509) 946-4778.

ULTRASONIC PULSER 613

Free New '75 catalog contains over 34,-500 quality power supplies from the world's largest manufacturer, Power/Mate Corp. Power Supplies for every application including submodulars, open frame, varirated, encapsulated, laboratory & system. All units UL approved and meet most military and commercial specs for industrial and computer uses. Power/Mate Corp., 514 S. River St., Hackensack, NJ 07601 (201) 343-6294

POWER SUPPLIES 616



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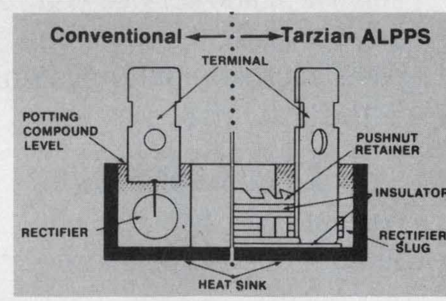
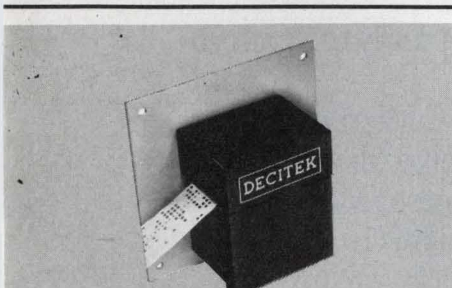
Solid State Digital Power Line Monitor is ideally suited for use with power generation equipment, computer systems, control panel installation labs where power sources must be monitored for assuring test equipment accuracies. Four models available. From $129 ea. Electro Industries, P.O. Box 3542, No. New Hyde Park, N.Y. 11040. (516) 621-6652

POWER LINE MONITOR 614



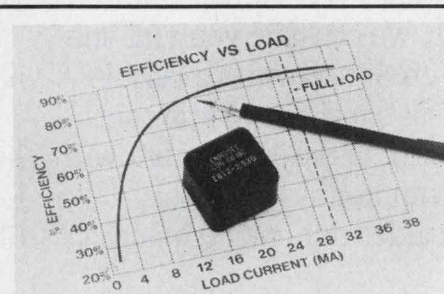
TARZIAN BRIDGE RECTIFIER ASSEMBLIES. Patented ALPPS design has faster, more consistent heat dissipation for high stability and conservative rating. 0.6" sq. 10A unit has 200A surge. 30A 1-1/4" round has 400A surge. ALPPS design available in custom units too. Sarkes Tarzian Inc., 415 N. College, Bloomington, IN 47401 (812) 332-1435.

BRIDGE RECTIFIERS 617



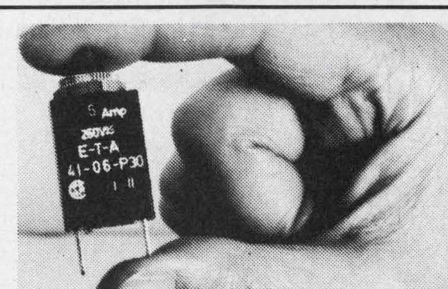
Low-cost tape reader is fast—up to 300 cps—and quality-built. Dual sprocket drive, a state-of-the-art fiber optic light source and photo transistor read head. Simplicity of design makes it easy to adapt to specific OEM requirements. Decitek, 250 Chandler Street, Worcester, MA 01602 (617) 798-8731

SAM® TAPE READER 612



Activate gas discharge readouts! DC-to-DC power supplies convert low DC line voltages of 5, 9, 12 or 15 volts to nominal 200 and 250 volt DC levels required to run gas discharge information displays. Ideal for battery powered applications! Free literature. Endicott Coil Co., Inc., 31 Charlotte Street, Binghamton, N.Y. 13905

POWER SUPPLY 615



Overcurrent Protector, manual reset eliminates fuse replacement. Convenient panel mounting. 19 fractional ratings from 0.1 to 5 amp. Other models up to 400 amp. Trip-free and fool-proof, UL and CSA approved. High quality, low cost $1.29 ea. in 1000 lots. E-T-A Products Co. of America, 7400 N. Croname Rd., Chicago, Ill. 60648. Tel: (312) 647-8303. Telex: 253780.

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INFORMATION RETRIEVAL NUMBER 70

Advertiser's Index

**Advertisers in non-U.S. edition*

Product Index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

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free wall chart!

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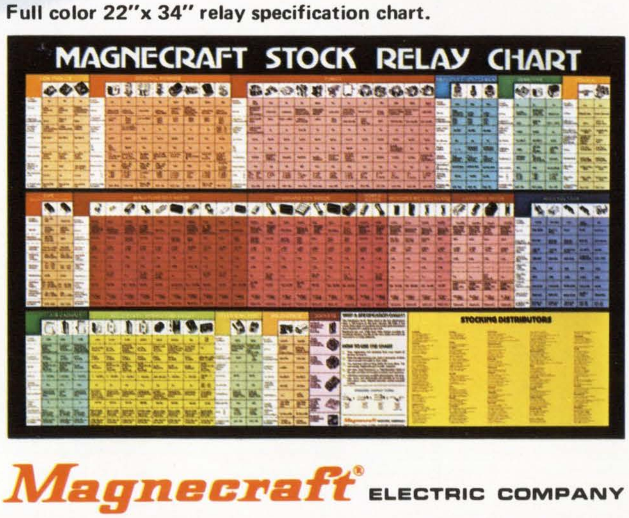
Full color 22"x 34" relay specification chart.



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