MARCH 16, 1978

THE DISTRIBUTOR'S QUANDARY: HOW TO FINANCE GROWTH/84

A second-generation microprocessor development system/113

Microprogramming for real-time signal processing/136

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Electronics

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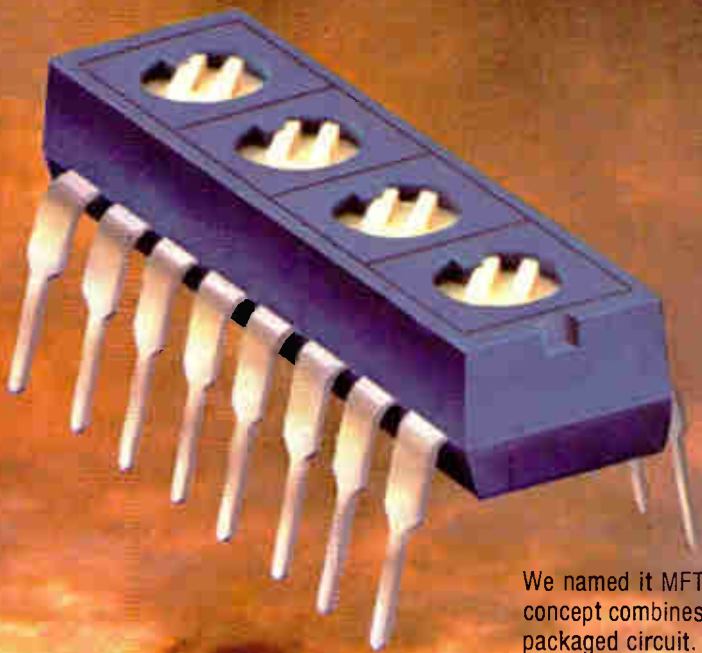

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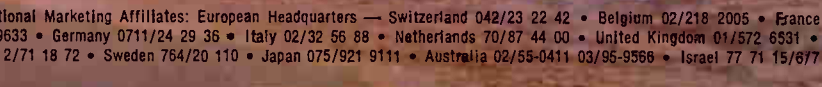

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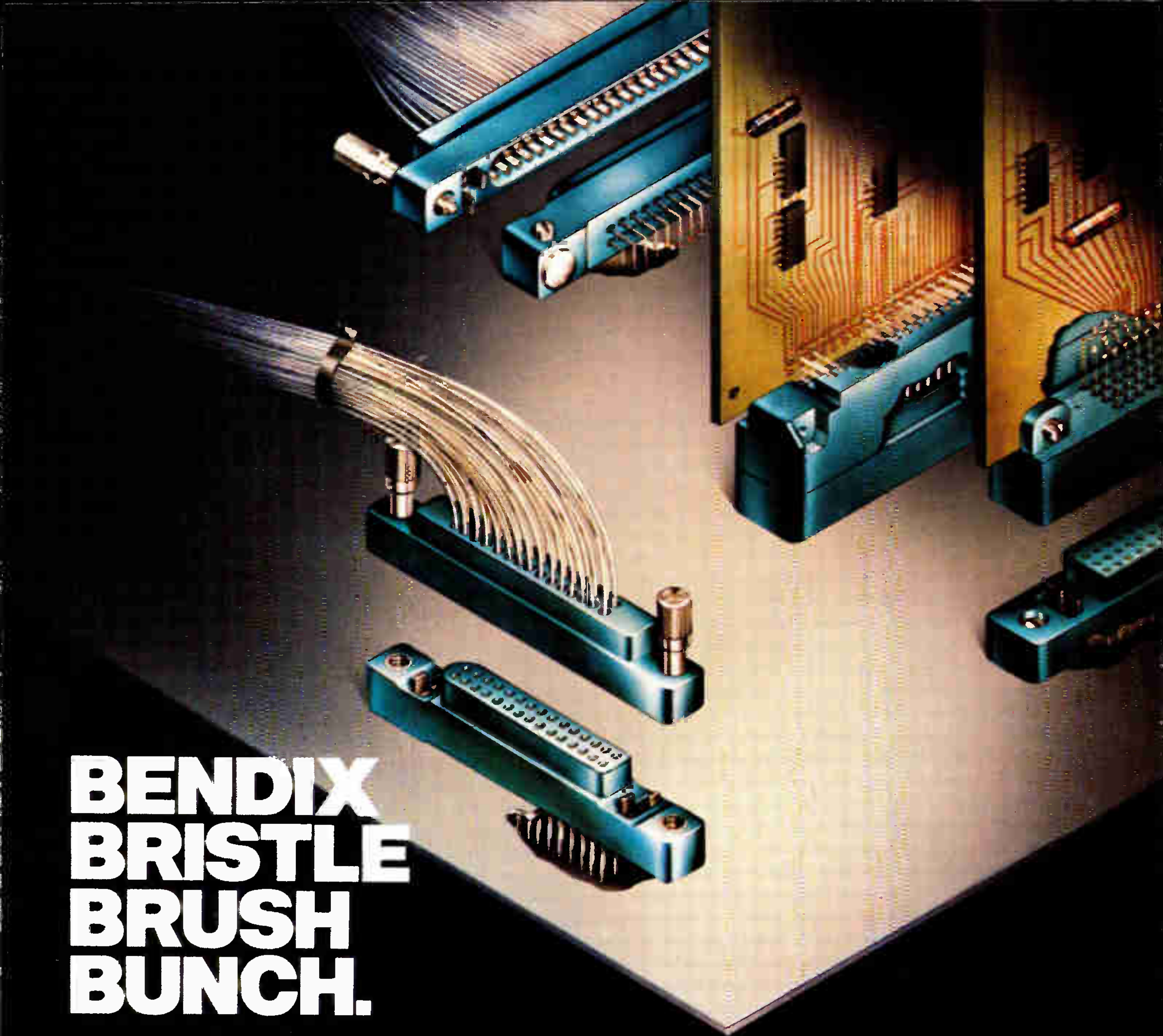

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Circle 2 on reader service card

Bendix

Electronics
The International Magazine of Electronics Technology
Vol. 51, No. 6 • March 16, 1978

Highlights

Cover: 3-in-1 unit cuts troubleshooting costs, 105
A new concept in general-purpose instruments, the digital testing oscilloscope, has the capabilities of a go/no-go comparison tester, a time-domain logic analyzer, and a storage scope. It also features a high degree of automated testing.
Cover by Ann Dalton.

U. S. electronics attracts foreign investors, 90
American electronics markets look golden to such European firms as Siemens AG. The man behind the company's investments in the U. S. tells why and talks about what the experience has been like.

Costs down, capabilities up in MDS, 113
The next generation of microprocessor development systems is here, with a $3,250 bottom price tag. Yet the new family offers flexible capabilities to match the expanding range of processor applications.

Minicomputers can process fast signals, 136
A microprogrammable minicomputer can process fast 10-kilohertz signals in real time. The trick is to store operating-system instructions, as well as the fast Fourier transform, in hardware.

And in the next issue . . .
Measuring time and frequency: part 1, counters . . . bigger and better ROMs are coming: a special report.

Electronics

Publisher's letter

It's been 10 years or so since William Shoemaker and David Wilson began working together. Most recently they developed the DTO-1 digital oscilloscope for Gould Inc.'s Biomation division and then co-authored this issue's cover article on the pace-setting instrument (p. 105). Further back, in 1971, the two had formed Sitek Corp., a benchtop-tester firm, which in 1976 was acquired by Biomation.

Developing the digital oscilloscope was something of a cliff-hanger for these senior product engineers. Wilson, who was responsible for the hardware design, and Shoemaker, who headed the software planning, were convinced that other companies were working on the concept.

"We very much wanted to be first," recalls Shoemaker. "Once or twice we saw a product announcement that bordered on what we were doing, and we held our breaths. But none was a direct hit."

"Fast development is normal at Biomation," Wilson points out. "Because we are a small company, we were able to compress our development schedule."

Will the Wilson-Shoemaker team ride again? Right now they're on separate projects, but the possibility is not out of the question should the right product materialize. "We're a good combination. I'd be happy to team up again," Wilson observes.

Periodically we take stock of what's going on among the electronics distributors, and with good reason. They're estimated to serve over 50,000 customers and should reach 100,000 accounts by the 1980s. In contrast, electronic-components manufacturers supply directly something like 500 to 1,000 major users.

But rapid growth has created problems, as the Probing the News story on page 84 points out. New York bureau manager Bruce LeBoss, who put together the story, reports that this expansion has strained distributors, which have always seemed to operate on the thin edge of profitability. Like many manufacturers, they are hard pressed for capital to finance larger operations. As a result, we may be seeing the beginning of some important changes in the way distributors do business, Bruce concludes.

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Readers' comments

Other ways to skin the cat

To the Editor: "LSI: the testing nightmare" [Dec. 8, p. 65] was quite thought-provoking. It's obvious that conventional testing methods have come just about to the end of the road with chips of the present complexity. When the next generation hits, the testing problem will be altogether intractable, unless something changes.

I can think of a couple of approaches to try. First, we could operate on the assumption that we will be using parts with hidden flaws and expect only that lots will be sample-tested with comprehensive patterns to catch reproducible bugs. That means memories will once again carry parity checks, maybe even error-correcting codes.

Central processing units, direct-memory-access controllers, and other large-scale integrated chips could be used in triple sets, with majority-voting logic at the outputs. Triple redundancy could well turn out to be cheaper than thorough testing. (Anybody planning to build a commercial data-processing computer around present-day microprocessor chips and memories would do well to consider redundancy and error checks, to judge by some of the stories I've been hearing.)

Another approach would be to design testability into the chips. As an extreme example, memory chips could be laid out as an array of subchips, with separate bonding pads and no interconnections except maybe buses and power. N^2 patterns could be run simultaneously on all subchips at the wafer-probe level to check out each one thoroughly.

Then, if film-carrier lead frames were used, it would be no trick to interconnect the subchips during gang-bonding. Only a simple final test would be needed to verify good bonds. N^2 patterns being what they are, that would take a lot less testing time than trying to do the whole memory in one indigestible chunk, and really searching patterns like galloping write recovery might become practical again.

CPUs might also be segmented and probed a section at a time, or extra gates might be included to give the pins access to part of the system at a time for test purposes. That would permit systematic checkout of the device gate by gate, much the way hardwired systems are checked out. The final step would then be propagation of 1s and 0s through the partitioning gates in their normal mode. A less drastic version of this approach would be to use a couple of pins to catch a number of internal connections in a shift register and then read them out.

John A. Carroll
Winchester, Mass.

The only way to skin this cat?

To the Editor: In your Nov. 10 editorial [p. 12], you wrote of the potential danger to emerging businesses and those yet to emerge posed by the proposed tax change that would treat capital gains as ordinary income and, as compensation, allow larger dividend exclusions.

You are right as far as you go, but all forms of taxes remove funds that might otherwise be available for risk capital. If national productivity, including new products, is to increase enough to meet environmental strictures, energy-shortage and -transition problems, Social Security and pension-fund obligations, etc., a fundamental tax reform is needed.

What is required is a limitation, constitutionally established, on the percentage of total personal income Government can take through taxes—including the tax known as inflation. New and growing electronics firms will then be able to get the venture capital they need.

James L. Blilie
Shoreview, Minn.

Correction

In the Jan. 5 Engineer's Notebook ["Digital thermometer circumvents drift," p. 176], the converter chip referred to should be the MC14433, as in the schematic, and the MC1413 is, of course, a hex inverter. Also, the first sentence of the last paragraph should read: "Using a standard diode sensor results in an error of the system of no less than 1.0°."

News update

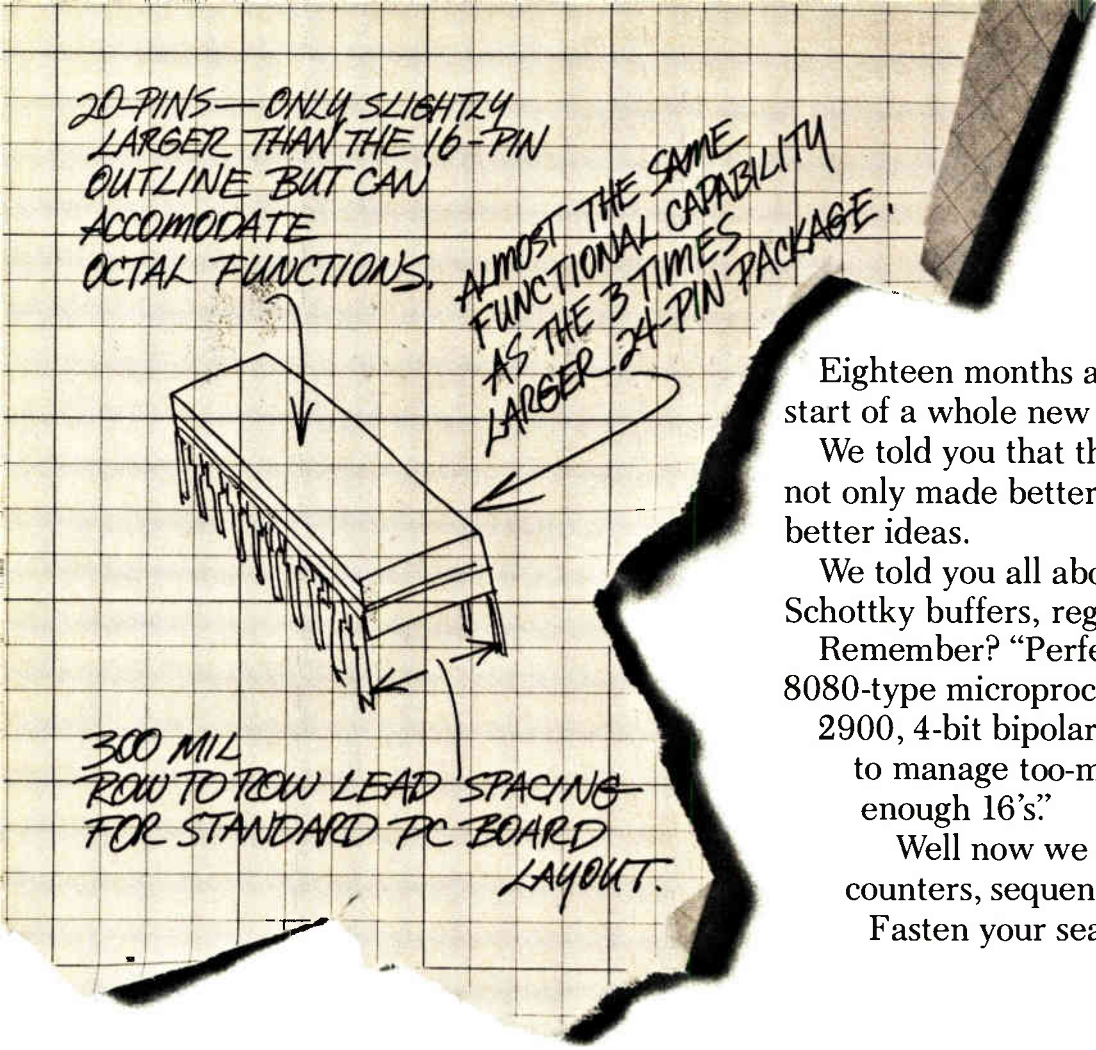
■ RCA Corp.'s Astro-Electronics division in Princeton, N. J., has begun flight acceptance and environmental tests on sophisticated new instruments and sensors recently installed on the Tiros-N spacecraft, which is the first of a new series of environmental satellites and is scheduled for a mid-1978 launch. The instruments will provide a greater amount of information about solar energy, air, surface sea ice, water, and weather conditions and do so more accurately and faster than those on board the present ITOS series of satellites [*Electronics*, July 7, 1977, p. 74].

A recent addition to the Tiros-N instrument payload, according to RCA's manager of satellite programs, Abraham Schnapf, is a magnetic-movement control device. Built by Ithaco Inc. of Ithaca, N. Y., the device senses the magnetic field and adjusts the magnetic movement of the spacecraft. What's more, Schnapf adds, the last three of the eight Tiros-N/NOAA spacecraft that RCA is building will carry aloft a major new payload designed for search and rescue.

An outgrowth of a joint $30 million development program, shared equally by the National Aeronautics and Space Administration and the Canadian government, ground-based and spaceborne hardware for this payload will enable the spacecraft to locate downed aircraft and boats in distress.

■ The first commercial international digital facsimile service, capable of transmitting high-resolution documents in 26 seconds, went into service this month. The facsimile machines feature the latest error-correcting technology plus a very high degree of data compression using relative-address-coding techniques developed by Kokusai Denshin Denwa Co. of Japan [*Electronics*, Feb. 17, 1977, p. 55 or 8E]. Called Q-Fax, the service operates at 9,600 bits per second on a full-duplex circuit, but also can run at 4,800 or 2,400 bits. The cost is $10 per 8½-by-11-inch page.

Bruce LeBoss



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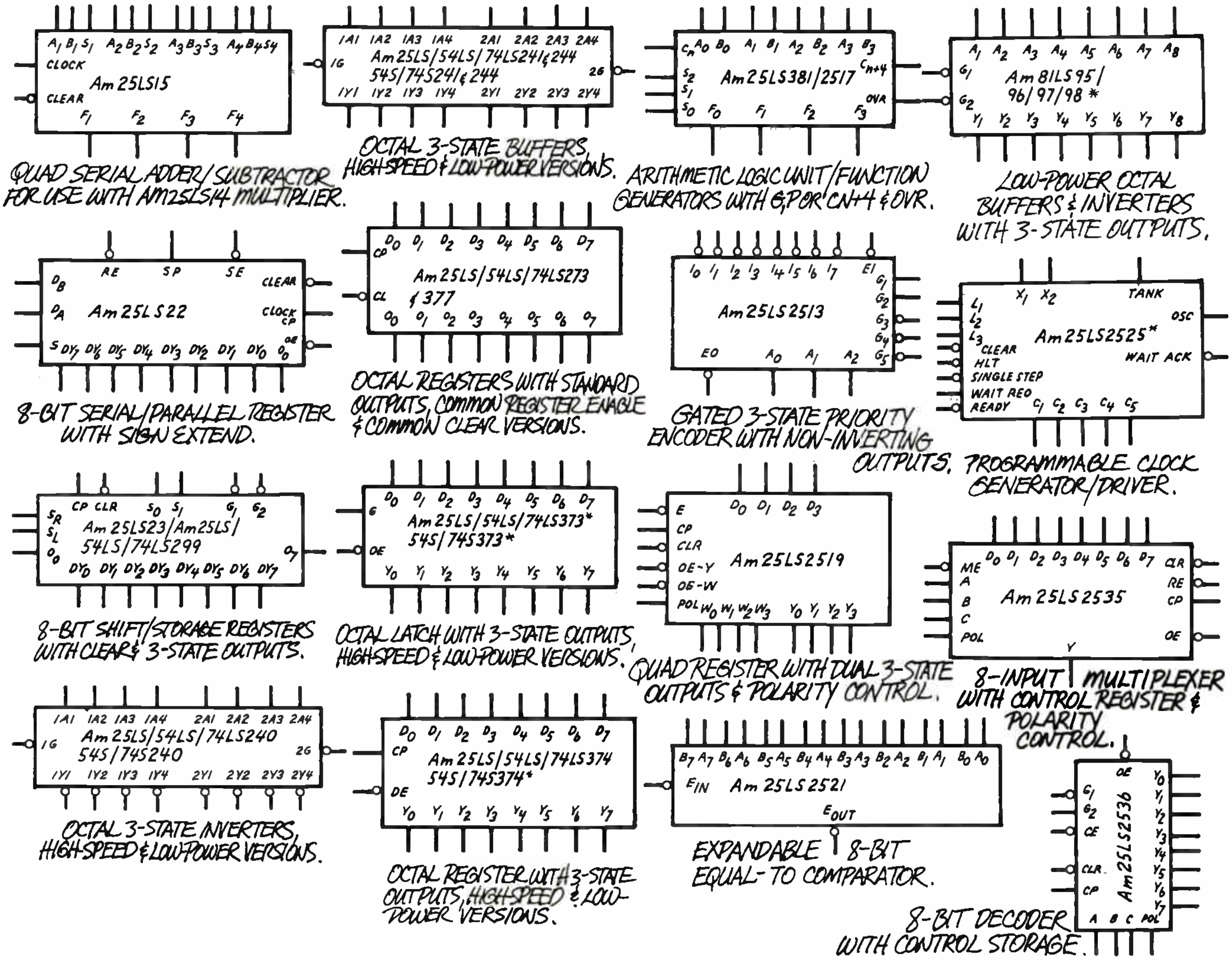
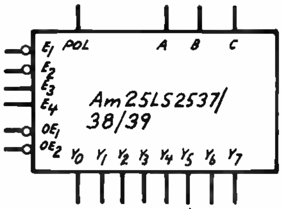
Circle 9 on reader service card

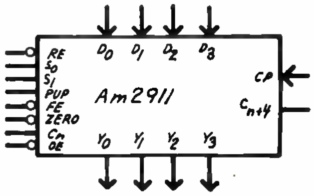


THIRTY-NINE TWENTIES.

AND A TWENTY-TWO, TOO.



DECODERS WITH 3-STATE OUTPUTS & POLARITY CONTROL.



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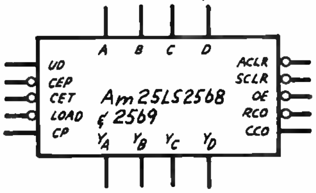

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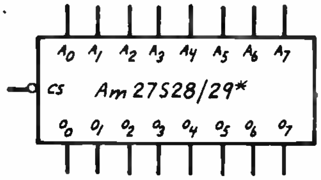

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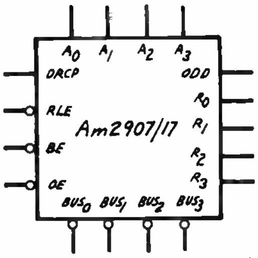

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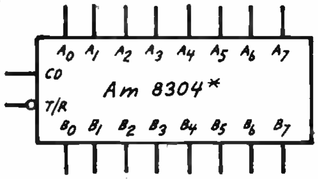

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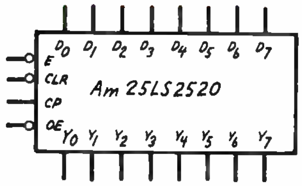

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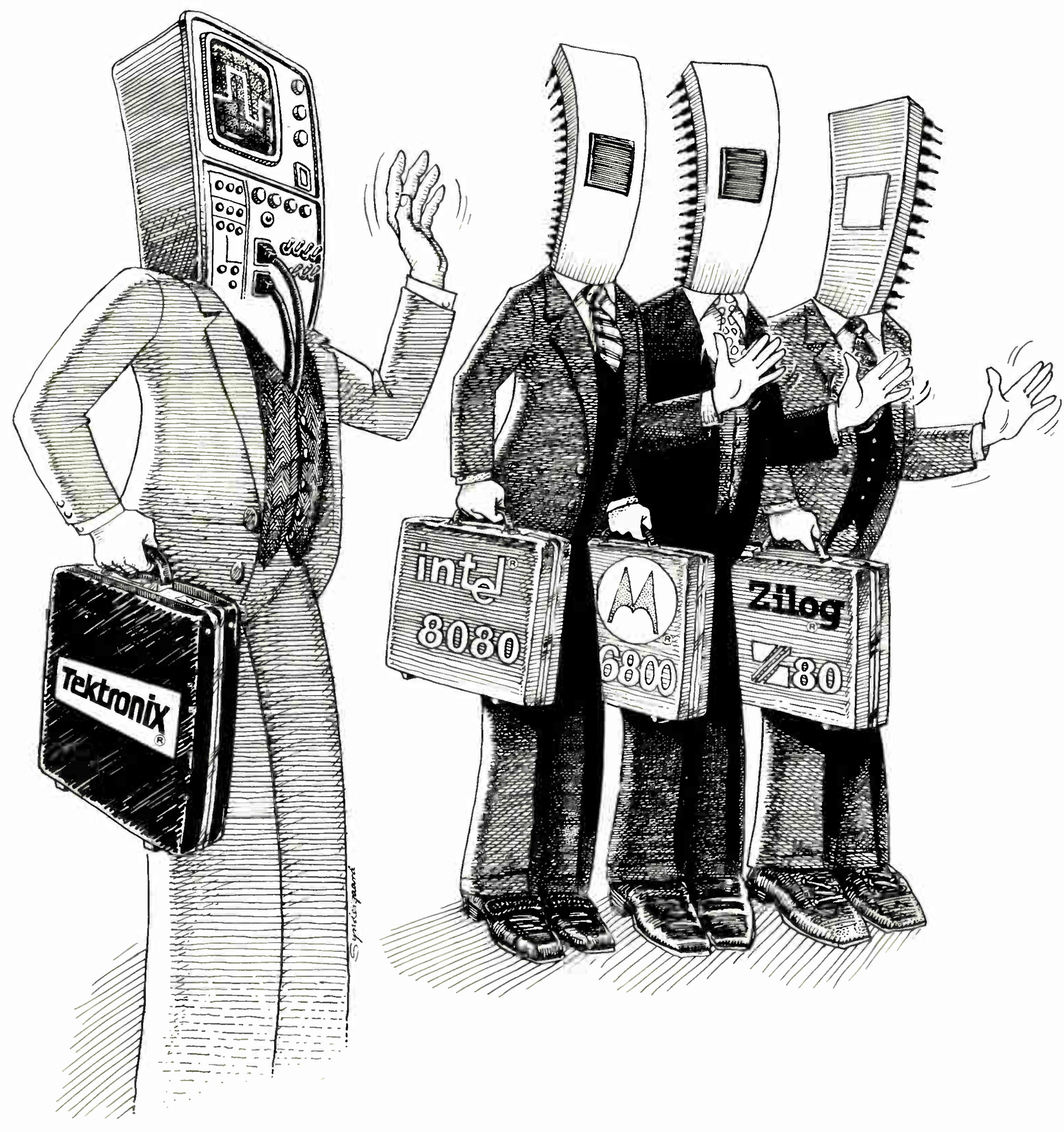

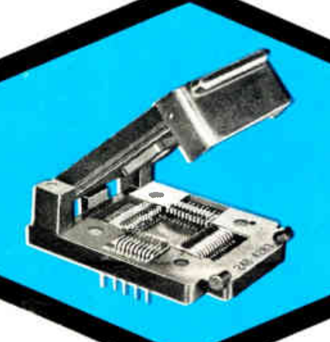

People

Data bases getting attention, says Tandem's Held

Data-base design is just now getting real attention from industry and the academic world, says Gerald Held of Tandem Computers Inc. Newly named manager of data-base and language development at the rapidly expanding Cupertino, Calif., company, Held grapples with the problems of on-line data-base management for the firm's high-reliability minicomputers.

"Distributed systems have brought to light many data-base problems, and lots of work is being done now that systems are up and running," he says. "In the 1960s, the subject was first compilers and then operating systems; now, it's data bases."

He is looking at new data-base models that will serve the burgeoning world of distributed processing more efficiently. Most data-base management systems today use either a hierarchical or a network approach, both of which can be thought of as tree structures. An example might be the record of an employee filed under a department name, which in turn is filed under a division name. But "life really isn't tree-structured," says the energetic 30-year-old software engineer. "It's more natural to file each record individually in more than one place, as in a department or in a division table. That eliminates the dependency of records on one another."

Relational data base. Held is describing what is called a relational data base. He gained recognition among his peers for the relational data-base management system he developed while working on his doctorate at the University of California at Berkeley before joining Tandem in 1976. Called Ingress, the system is being used in over 50 computing facilities worldwide.

He says that the proliferation of distributed processing systems will spur the work on relational data bases. "It's obviously much better for distributed systems, since all records are modular and can more easily be passed around a network. Distributed processing is helping make the concepts better understood, because now we have working hardware to study."

What is the future for data bases? "Since no one data-base structure is best suited for every application, I think we'll be seeing data bases that support several models—hierarchical, network, and relational—and that can even interchange structures as needed," Held says.

Boschert sees switchers moving into low power

Switching power supplies, long dominant in the aerospace industry because of their high power output in a relatively small size, will eventually take over all but a small portion of the power-supply market, including the low-power area, says Robert J. Boschert, president of Boschert Inc. The seven-year-old Sunnyvale, Calif., manufacturer recently introduced several off-the-shelf units, one producing as little as 25 watts [*Electronics*, March 2, p. 159], a sizable drop from the several-hundred-watt levels at which the switchers have made their mark.

"It's perfectly analogous to the transistor taking over from the vacuum tube," Boschert, 41, explains. "Initially, transistors had advantages in size and weight and heat, but had disadvantages from the standpoint of reliability and cost." However, as the industry "got further along the learning curve," these disadvantages disappeared, he says. "It's my belief that there will be only a small portion of the market where linears will remain untouched," he continues, perhaps only "the sensitive analog instrumentation area" that requires low-level analog signals at a wide bandwidth.

As cost and power come down, switching supplies, which operate at boosted frequencies without bulky transformers, will start taking over two areas, according to Boschert: first, where more expensive linear devices cannot compete in terms of

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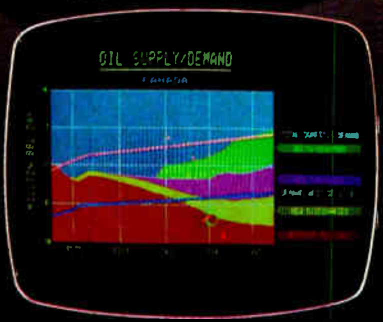

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Circle 15 on reader service card

People

The future. Learning-curve improvements are leading to more competitive switching power supplies, Boschert says.

size, weight, and heat dissipation, and, next, in the digital world of terminals and business computers.

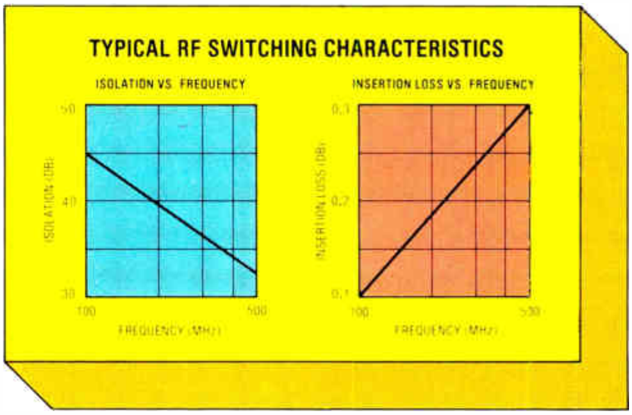
Although linear supplies beat switching supplies in terms of ripple and regulation, switching supplies compete because the digital computer world does not need quite as tight power-supply specifications. Boschert switchers already power floppy-disk drives, information terminals, cathode-ray-tube terminals, plasma displays, and microcomputer-based systems; and the company has even designed a low-power unit for an electronic watch.

Microcomputer impact. Boschert believes that switchers will make their biggest impact in the microcomputer segment of the power-supply market, which is growing at 22% a year in noncaptive systems. Switchers are taking 30% of new business there, but the company sees this figure climbing to between 60% and 80% in the next few years.

By 1982, he predicts the 80/20 ratio between captive and bought will shift to 70/30. That is a tremendous amount of new business in a total market estimated to be about $3.5 billion worldwide this year. Boosting the trend toward outside purchase is the fact that switching supplies require a greater investment in technology, Boschert points out. Companies now comfortable making their own linear supplies will go outside for volume, he says.

TO-5 RELAY UPDATE

The world's smallest RF relay



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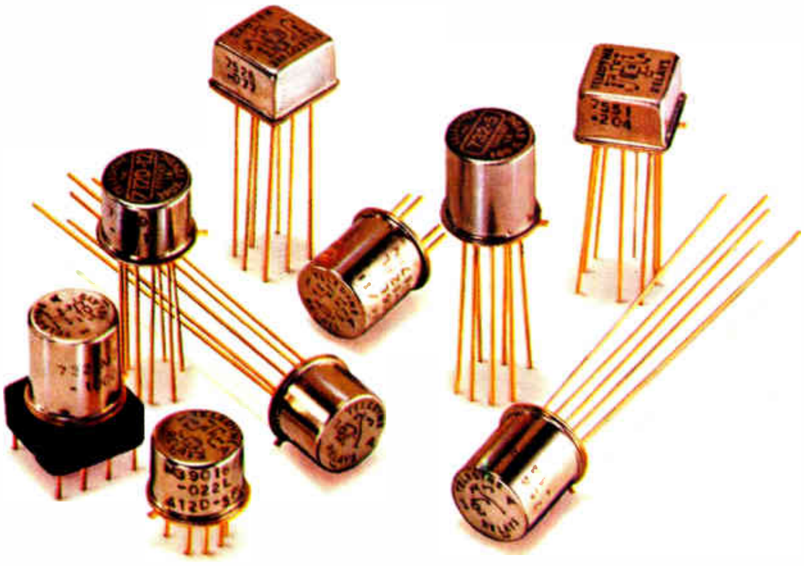
Our complete line of TO-5 relays includes military and commercial/industrial types, with virtually all military versions qualified to established reliability MIL specs. For complete data, contact Teledyne Relays — the people who pioneered the TO-5 relay.



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- **Maglatch Series**
  SPDT, DPDT, and 4PST magnetic latching types. Military and commercial/industrial versions.
- **Centigrid® Series**
  World's smallest relay—only .225" (5.72mm) high x .370" (9.40mm) square. DPDT, with optional internal suppression and steering diodes.
- **Hi-Rel Series**
  Screened versions for space flight applications (NASA qualified)
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Intel delivers the micro components designers

There's no more efficient way to solve your interface and control requirements for microcomputer-based systems than our peripheral components.

They're single-chip solutions to even the most complicated operations, integrating up to 22,000 transistors per chip to replace circuit boards full of discrete logic with a single component. Result: you cut parts cost, reduce package count and board space, and simplify both development and operating software.

"I can accomplish almost any I/O function with one chip using Intel's versatile peripheral interfaces and dedicated device controllers."

We've designed each of these peripheral chips to be an intelligent, programmable component in your system and to perform most functions with minimal cpu supervision. The resulting decrease in cpu overhead provides your system with higher performance and increased throughput.

The dedicated function components below are available now, with more on the way. Here's a brief description of their versatility.

8271 Programmable Floppy Disk Controller. Provides full control of up to four standard or minifloppy drives. (Available early 1978.)

8273 SDLC/HDLC Protocol Controller. For SDLC and HDLC communications.

8275 Programmable CRT Controller. Provides fully buffered interface and control of almost any raster scan CRT display.

8278/8279 Programmable Keyboard/Display Interfaces. Keyboard/sensor array input scan, and output scan for LED, incandescent and other displays. 128-key or 64-key input.

8251A Programmable Communications Interface. Industry standard USART for synchronous or asynchronous serial data transmission, including bisync.

8253 Programmable Interval Timer. Contains three independent 16-bit counters, programmable modes from dc to 2MHz.

8255A Programmable Peripheral Interface. General purpose I/O interface with 24 individually programmable I/O pins.

8257 Programmable DMA Controller. Provides four-channel, high speed direct memory access independent of CPU.

8259 Programmable Interrupt Controller. Handles eight levels of vectored priority interrupt. Expandable to 64 levels.

computer peripheral are talking about.

UPI-41™ is Intel's Universal Peripheral Interface, bringing distributed intelligence to microcomputer systems for the first time.

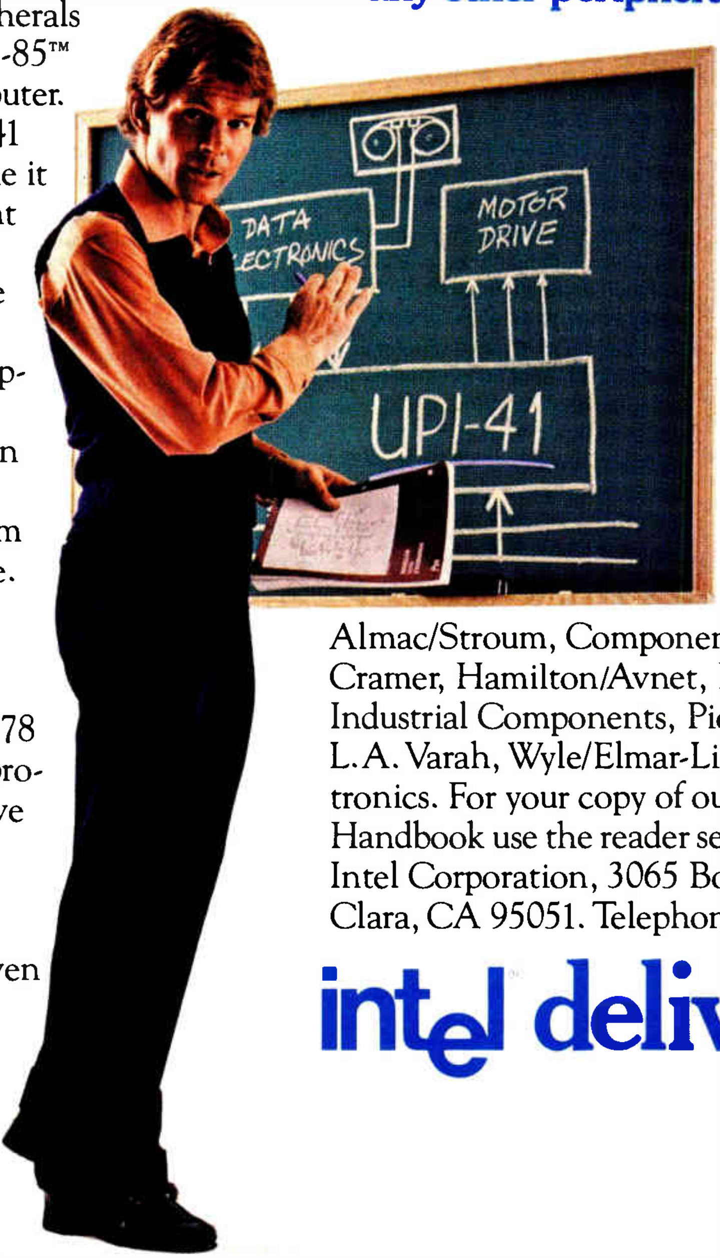
Actually a highly integrated, user-programmable microcomputer, UPI-41 is a new solution that obsoletes custom LSI and specialized discrete designs for interfacing most low and medium speed peripherals with an MCS-80,™ MCS-85™ or MCS-48™ microcomputer.

Intel delivers UPI-41 in two versions that make it easy for you to implement your own designs. The 8741 includes an erasable and reprogrammable 1K-byte EPROM, for development, testing and low volume production. Then the 8041, with masked ROM, provides maximum economy in high volume.

We've taken the UPI-41 concept a step further with the 8278, described at left. The 8278 is the first of several preprogrammed 8041's that we've adapted to specialized applications.

Because UPI-41 is a microcomputer, we've given it the same high level of support we give all our microcomputers. UPI-41 is supported by our Prompt™ 48 Design Aid, the Intellec® microcomputer development system with resident UPI-41/MCS-48 Macro Assembler. Plus applications assistance worldwide, full documentation, training classes, design seminars and a rapidly expanding users' software library.

"And, for my special I/O requirements, Intel's UPI-41 Universal Peripheral Interface is user programmable to control nearly any other peripheral device."



Intel's peripheral components, and the MCS-80, -85 and -48 microcomputers they support, are available through: Almac/Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey Electronics, Industrial Components, Pioneer, Sheridan, L.A. Varah, Wyle/Elmar-Liberty and Zentronics. For your copy of our Peripheral Data Handbook use the reader service card or write: Intel Corporation, 3065 Bowers Ave., Santa Clara, CA 95051. Telephone: (408) 987-8080.

intel delivers.

"There is a tide taken at the

4K CMOS EPROM's.

Intersil's 4K proprietary CMOS EPROM, the IM6603/04, offers the low power benefit typical of CMOS: An up to 10,000:1 power savings over competitive EPROM's. At the same time, it may operate on either TTL or MOS power supplies. Static and synchronous operation results in very fast access time. Three state outputs and chip select offer easy system expansion. And, they're both UV erasable and electrically programmable. Either 1024 x 4 or 512 x 8.

"Today, that tide is 4K memory."

Intersil

CMOS or NMOS, you'll find that Intersil is a leader in the memory market. For instance, Intersil has delivered a total of over 20 million RAM's to date. Not counting our complete add-on and add-in memory systems.

THE COMPETITIVE EDGE.

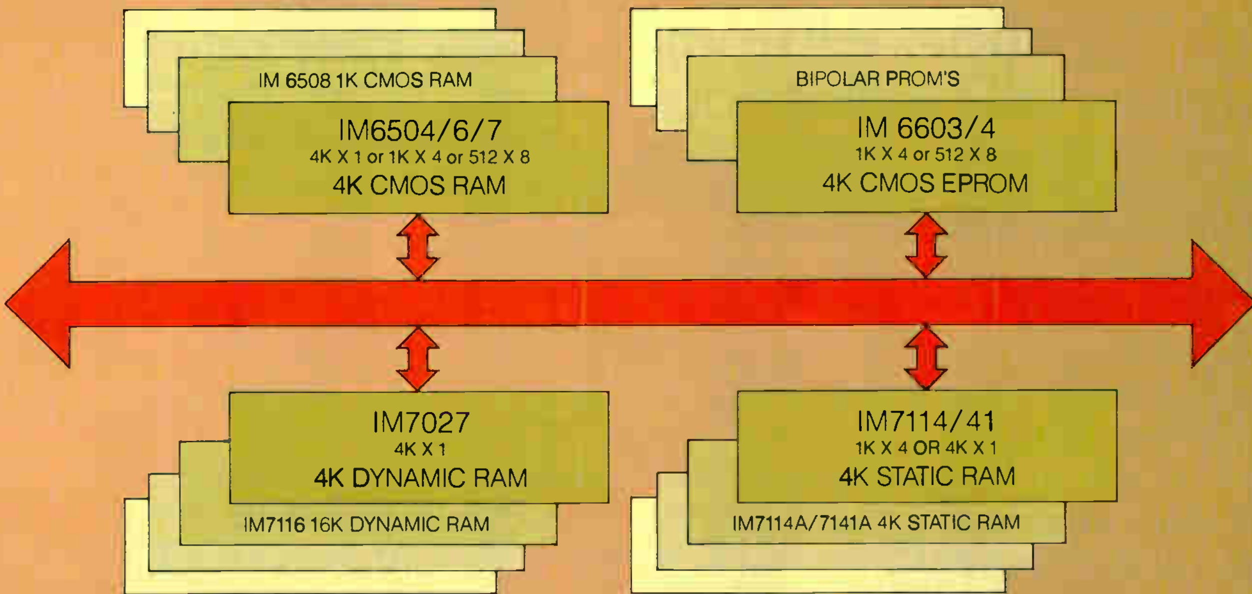
As a leader in 4K memory, we offer you a choice of low power CMOS or advanced NMOS memory products. In CMOS, 4K RAM's and 4K EPROM's. In NMOS, 4K static and dynamic RAM's. All, in standard DIP's. All, from a single source: Intersil.

4K NMOS STATIC RAM'S.

The IM7114/2114, and IM7141's are high performance static RAM's that offer you definite design advantages: Simple interface with a wide variety of microprocessor components; no need to refresh; a low power requirement that can effect an up to 30 percent power saving over the nearest competitor. Lower power means lower operating costs, lower cooling costs, lower PC board costs, and greater reliability. With pin compatibility to the RAM's you're using now. In either 1K x 4 or 4K x 1 configuration.

in the affairs of men which, flood, leads on to fortune."

William Shakespeare, 1564-1616



4K CMOS STATIC RAM's.

Over the years, Intersil has shipped more CMOS RAM's than any other manufacturer. By mid-year, we'll be adding a new dimension to our line of 1K RAM's with a series of new 4096 bit static RAM's, including the IM6504 (4096 x 1), the IM6506 (1024 x 4), and the IM6507 (512 x 8). Offering power benefits typical of CMOS, plus TTL compatibility, the new IM6504 will be ideally suited to memory systems requiring low power, non-volatility and high performance.

4K DYNAMIC RAM's.

The IM7027/MK4027 dynamic RAM is a second generation dynamic RAM that offers you substantial improvement in page mode, read/write timing and speeds up to 120ns access and 250ns cycle time. It's specifically designed for EDP, computer mainframe memory, microprocessor and microcomputer applications. Speed and power, coupled to a lower power dissipation, mean lower overall costs. Pin compatible with the slower speed, higher power RAM's you've been using.

THE TIDE IS WITH US. AND WE'RE WITH YOU.

At Intersil, we're working at the state of the art in memory components and subsystems. That means you can depend on Intersil to supply a full range of memory components in both low power CMOS and second generation NMOS technologies. And 4K memory is just one of the fields in which we excel. Our aim is not just to reach the crest of the wave; but to remain there. If that's the way you're thinking, join us. Today, the tide is running with 4K memory. And the flood is just beginning.

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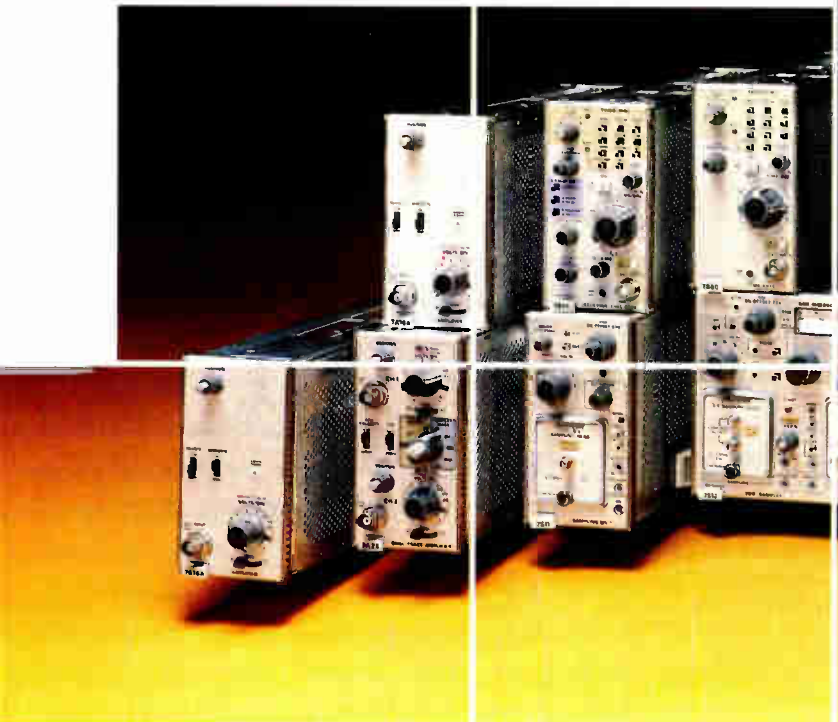


The Digital Alternative

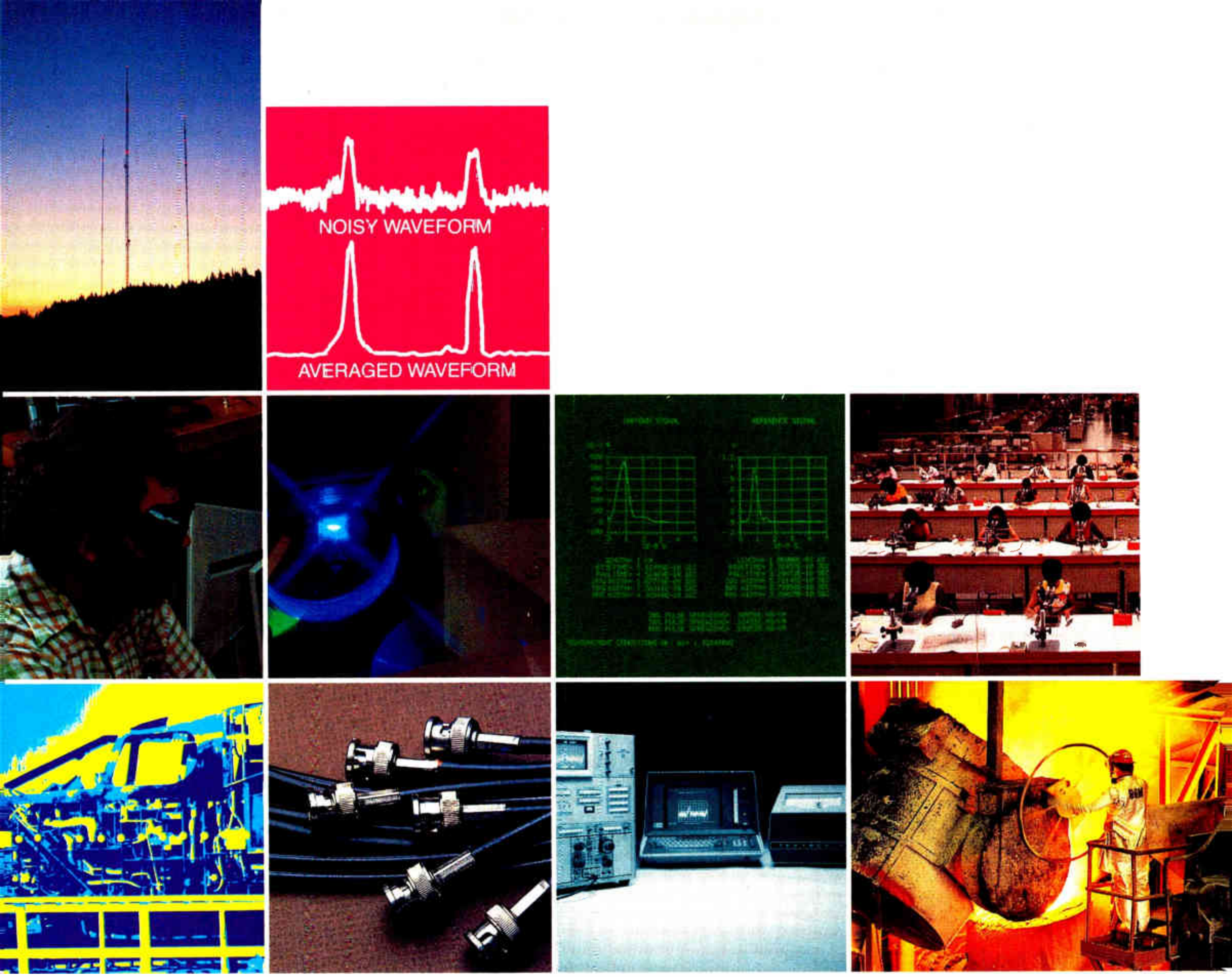
Our Digitizing Oscilloscope is a versatile data acquisition instrument based on the familiar TEKTRONIX 7704A Oscilloscope with a P7001 Processor added for interface to the digital world.

Signal Acquisition Flexibility. The Tektronix Digitizing Oscilloscope acquires data through a wide selection of standard 7000 Series Plug-Ins such as amplifiers, time bases, spectrum analyzers, sampling heads to 14 GHz, time domain reflectometers, curve tracers, digital counters or multimeters and more.

A/D Conversion with Four Waveform Memories. Almost any waveform that can be displayed on an oscilloscope, can be digitized to 10 bit by 512 horizontal point resolution and stored in any of four memories in the P7001 Processor. In addition to waveform data, all crt scale factor readouts are stored as well. Any of four stored waveforms may be recalled for display on the crt.

New GPIB Interface. A/D conversion memory selection and data transfer can now be controlled externally via the the GPIB bus. Digitized waveforms in any of the four memories may be transferred to a GPIB controller for analysis and automated processing. Complex waveform calculations are now possible with the convenience of oscilloscope acquisition.

And a New Optional Hardware Signal Averager. It permits rapid averaging of repetitive waveforms for dramatic signal to noise improvement.



With that kind of flexibility, practical applications for the Digitizing Oscilloscope are numerous!

In the field of...

Research–a Digitizing Oscilloscope can be used to analyze fiber optic circuits, or for their research and design. This unit is also an effective tool in chemistry and chemical research for electrochemical and perturbation kinetic studies.

Development–a Digitizing Oscilloscope can be used in microwave system development by extracting pertinent spectrum analysis data for study through a frequency range up to 60 GHz.

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Editorial

Maintaining the technological lead

One factor underscored by the recent International Solid State Circuits Conference is the growing international character of semiconductor technology. At least a third of the papers were from overseas sources, and perhaps a third of the attendees were foreign visitors.

The message is clear: no longer can the United States assume that it can dominate technology. Indeed, the keynote speaker at the ISSCC, Ian Macintosh, a widely respected technology consultant from Britain, pointed out that the technical lead of the U. S. semiconductor industry has perceptibly narrowed.

He contended that the lead the American producers enjoyed in the 1960s and early 1970s was not necessarily the result of uniquely gifted management within the semiconductor firms. Nor did he feel that the Government support many semiconductor producers received was the primary stimulant. Instead, according to Macintosh, the advantage came principally from the booming electronics markets right in their own backyard and, just as vital, the availability of venture capital to fuel the rise of the semiconductor industry.

There is a lot to be said for this argument. For example, lending substance to the proposition that U. S. management superiority is a myth is the fact that there have been as many failures as successes among semiconductor companies over the years. Also, it must be noted that RCA Corp. is the only one of the major electrical/electronics firms from before the semiconductor era to have made the transition and survived into the 1970s as an important factor in the commercial integrated-circuit market.

Yet, there is no reason why the United States cannot continue to lead in semiconductor technology, despite the acknowledged gains made, especially by Japanese competitors. Some facts of life need to be appreciated, however. For one, the cost of membership in the club comes high these days. It is now clear that small, leading-edge semiconductor companies, no matter how innovative, may have to join forces with larger systems-oriented equipment manufacturers to gain the capital and leverage needed for serving the giant data-processing and communications markets, both here and abroad. Witness the joint ventures of AMD/Siemens, AMI/Bosch, Signetics/Philips, and others.

Likewise, successful semiconductor producers will continue to be drawn toward participation in end-product equipment by forming systems divisions of their own. These organizations will not only keep the semiconductor firms close to the expanding markets they serve but, if well planned, will provide profits to reinvest in product development.

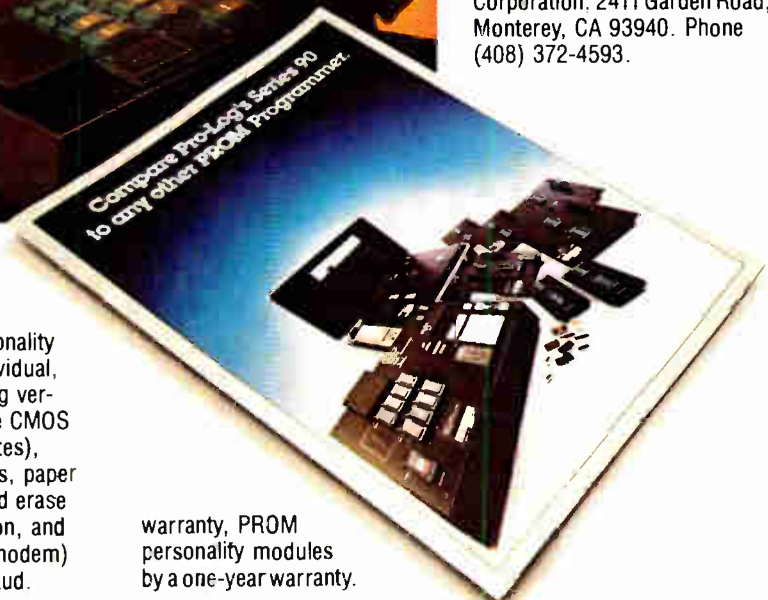
That leaves just one continuing obstacle to American technological growth: the lack of private venture capital and tax incentives for research and development. All across the country, from large and small companies, the same complaint can be heard. There is not enough capital available to finance new technology—technology that is becoming increasingly expensive to develop.

The major responsibility lies with the Federal government, which has failed to stimulate investment through tax credits or other incentives in advanced electronics technology. The sooner the Federal government is made to realize this fact, the better the long-range chance for continued U. S. leadership in technology.

The right PROM Programmer makes the job simple.

Pro-Log's Series 90 means simple PROM programming.
Microprocessor control reduces operating steps and guides operators through the few steps that remain. The Series 90 verifies PROMs as they're being programmed and automatically weeds out bad or marginal parts. Separate sockets for master PROM and copy PROM protect your master PROMs from accidental programming. Users never need to calibrate a Series 90.

This comparison guide makes selecting a programmer simple.
We've got a free full-color comparison guide to help you evaluate the leading PROM programmers side-by-side. Call or write for your copy. Pro-Log Corporation, 2411 Garden Road, Monterey, CA 93940. Phone (408) 372-4593.



Simple means flexible, reliable and safe.
A Series 90 is a complete yet versatile programmer. It consists of a single master control unit, a plug-in PROM personality module and options.

The master control unit handles any of our personality modules. There are modules for all major MOS and bipolar PROMs and for some one-chip microprocessors. The personality modules come in individual, generic family, or gang versions. Options include CMOS RAM buffer (to 4K bytes), TTY, parallel interfaces, paper tape reader, U.L. listed erase light, check-sum option, and RS-232 (terminal or modem) interface with Auto-baud.

Master control units are backed by a two-year parts and labor warranty, PROM personality modules by a one-year warranty.

Pro-Log's programmers are U.L. listed for your safety.

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Microprocessors at your fingertips.

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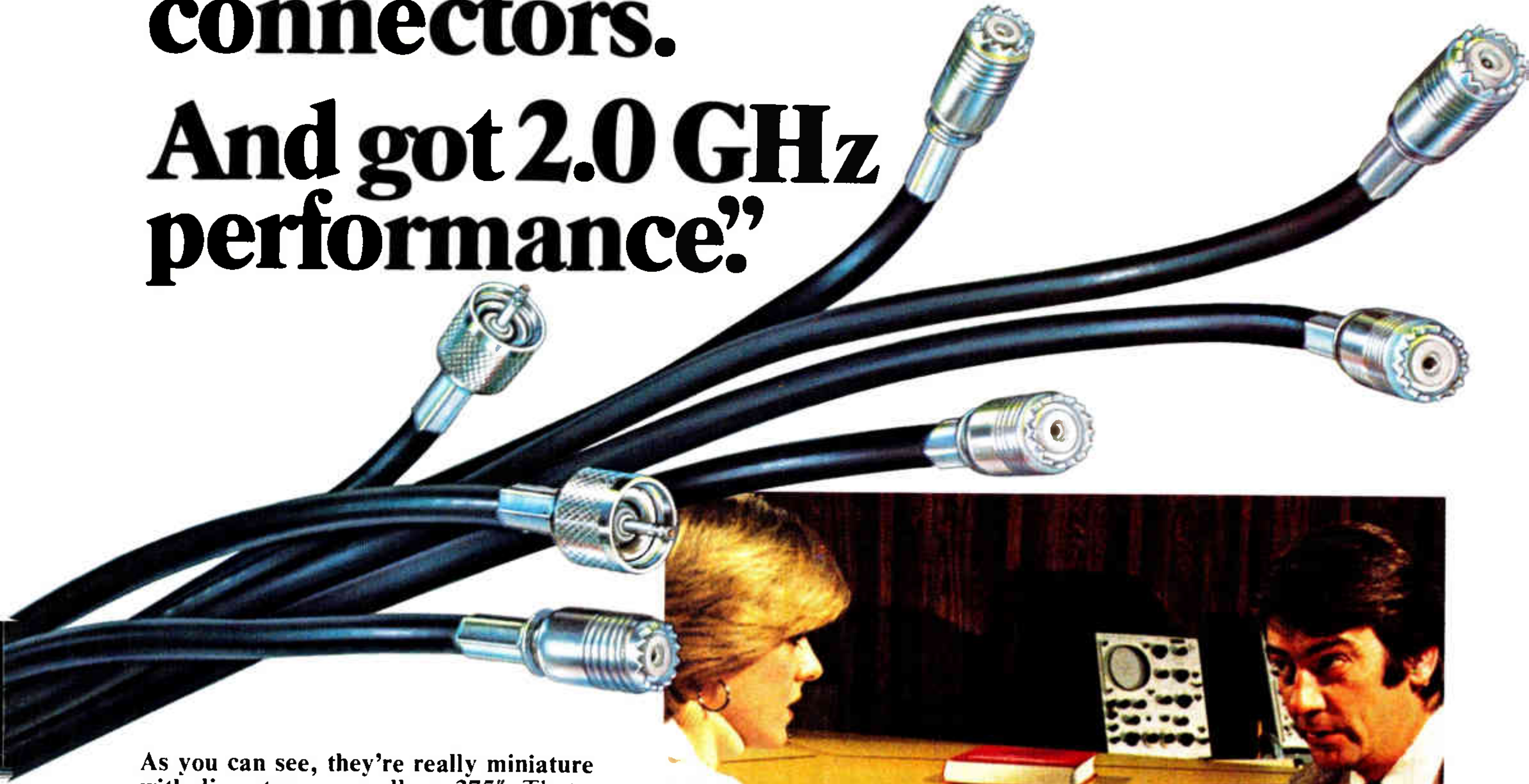

As you can see, they're really miniature with diameters as small as .375″. That not only saves space and weight but because their initial and applied cost is low, they literally save money from beginning to end.

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Meetings

AAMI **Annual Meeting & Exhibit Program,** Association for the Advancement of Medical Instrumentation (Arlington, Va.), Washington Hilton Hotel, Washington, D. C., March 29–April 1.

Metric Planning Forum, American National Metric Council (Washington, D. C.), Atlanta Hyatt Regency Hotel, Atlanta, April 2–5.

Symposium on Automatic Imagery Pattern Recognition, National Bureau of Standards and EIA, NBS, Gaithersburg, Md., April 3–4.

Industry/Joint Services Automatic Test Equipment Conference and Workshop, EIA, American Electronics Association (formerly WEMA), *et al.*, Town and Country Hotel, San Diego, Calif., April 3–7.

21ème Salon International des Composants Electroniques, Société pour la Diffusion des Sciences et des Arts (Paris, France), Paris, April 3–8.

Communications '78 International Exposition, IEEE *et al.*, National Exhibition Centre, Birmingham, England, April 4–7.

NAB **Convention and International Exhibition,** National Association of Broadcasters (Washington, D. C.), Las Vegas Convention Center, Las Vegas, Nev., April 9–12.

Seminar on New Components for Optical Communications, IEEE, Stevens Institute of Technology, Hoboken, N. J., April 10.

Acoustics, Speech and Signal Processing Symposium, IEEE, Camelot Inn, Tulsa, Okla., April 10–12.

Testing in Electronics Manufacturing, Industrial & Scientific Conference Management Inc. (Chicago), San Jose Convention Center, San Jose, Calif., April 12–13.

Pattern Recognition and Artificial Intelligence Conference, IEEE, Nassau Inn, Princeton, N. J., April 12–14.

Energy '78 Conference, IEEE, Camelot Inn, Tulsa, Okla., April 16–18.

Design Engineering Conference, ASME, McCormick Place, Chicago, April 17–20.

Scanning Electron Microscopy Meeting, Scanning Electron Microscopy, Inc. (c/o Om Johari, P. O. Box 66507, AMF O'Hare, Ill. 60666), Bonaventure Hotel, Los Angeles, Calif., April 17–21.

International Reliability Physics Symposium, IEEE, Town and Country Hotel, San Diego, April 18–20.

SID **International Symposium,** Society for Information Display (Los Angeles), Hyatt Regency Hotel, San Francisco, April 18–20.

International Symposium on Remote Sensing of Environment, Research Institute of Michigan (Ann Arbor), Philippine International Convention Center, Manila, Philippines, April 20–26

Communications Satellite Systems Conference, American Institute of Aeronautics and Astronautics, Town and Country Hotel, San Diego, April 23–27.

Electronic Components Conference, IEEE, Disneyland Hotel, Anaheim, Calif., April 24–26.

National Relay Conference, National Association of Relay Manufacturers and Oklahoma State University, Stillwater, Okla., April 25–26.

Microwave Power Tube Conference, IEEE, Naval Postgraduate School, Monterey, Calif., May 1–3.

Symposium on Offshore Technology, IEEE, Astrohall, Houston, May 8–11.

Intermag Conference, IEEE, Palazzo dei Congresso, Florence, Italy, May 9–12.

Conference on Software Engineering, IEEE, Atlanta Hyatt Regency Hotel, Atlanta, May 10–12.

"Talk about OPEN

Meet the new leader

Power-One's 83 different models easily represent the broadest selection of open frame power supplies in the industry. And these are "off-the-shelf" standards — ready for delivery. Ready when you need them.

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Amazingly, Power-One open frames were price competitive in '73. Think what they are today.

Talk about shipments...
Over 250,000 to date

Power-One shipped its first open frame power supply in May, 1973. We've now crossed the quarter-million mark. Over 100,000 units were delivered last year alone. That makes Power-One the largest producer of open frame power supplies in the world.

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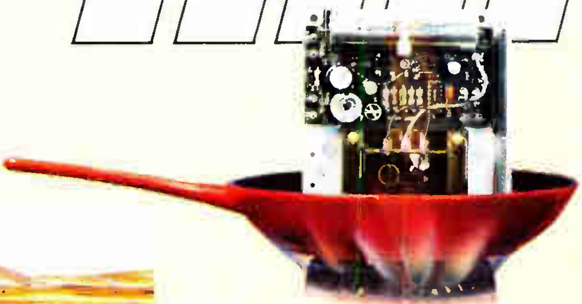
Power-One 83

We've not only outdistanced our competitors, we've even dethroned Heinz as the king of variety.

Frames



Talk about facilities . . . 60,000 square feet of open frames

Our recent move to the largest complex dedicated solely to the manufacture of open frames has been geared to a single objective — that of making the best product of its kind even better.

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So next time you're in the area, stop by. See for yourself who we are, what we are, and most important, why we're the world's largest manufacturer of open frame power supplies.

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Every single unit that bears the Power-One label undergoes a full functional test, followed by a minimum 2-hour burn-in plus a final full functional test. We repeat . . . **every single unit!**

We consider this tough burn-in testing one of the key factors in our company's growth. We know of no other company that conducts more than a single operational test on their standard production-line units. Consequently, we know of no other open frames that match up to Power-One's for long life and overall reliability.

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What engineering about using micro

Microcomputers are changing the competitive picture in hundreds of industries, in thousands of applications.

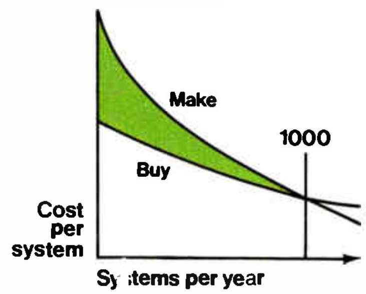
Designers are using microcomputers to create new products, even new markets. Microcomputers are breathing new life into existing products and providing competitive advantages in both price and performance.

For management, there's an added challenge. What's the most *profitable* way to take advantage of the microcomputer revolution? Should you start from scratch, dedicating time and resources to component-level design? Or should you take advantage of fully assembled and tested "computers-on-a-board"?

You didn't have a choice until just two years ago. That's when we introduced the first single board computer. Like "super components," single board computers have made it easy to add intelligence to any system.

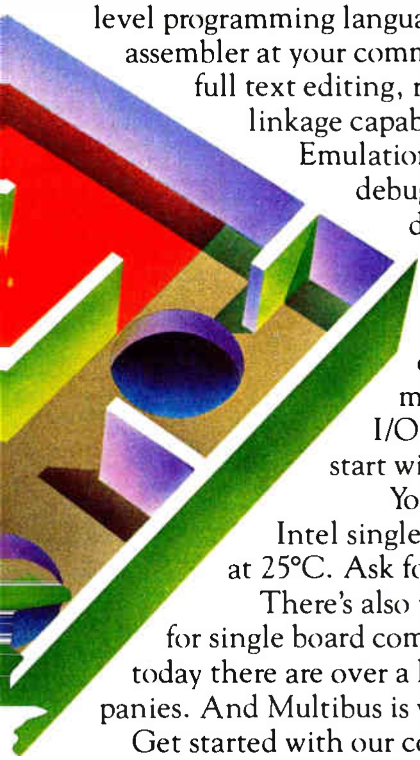
Sheer economics is one reason why. Up to 1,000 systems a year, you're money ahead with single board computers. That's based on a tradeoff formula that carefully considers amortized development and testing expenses, as well as direct material and labor costs.

Then, when production volume makes it more economical for you to switch to components, we'll provide all you need to do the job yourself—manufacturing drawings, pc artwork and a volume source for all the essential LSI components.



Time saved is another important reason single board computers make sense. You're into production sooner, without time spent developing the computer sub-system. Your engineers can go directly to the design of application-dependent hardware.

managers should know computers profitably.



RMX-80™ Real-time Multitasking Executive gives you a head start in software development, without the need to reinvent system software for every application. Intellec,® our microcomputer development system, speeds application software development. It puts PL/M and FORTRAN-80 (ANS FORTRAN 77) high-level programming languages and a macro-assembler at your command. And supports full text editing, relocation and linkage capability. In-Circuit Emulation, with symbolic debugging, provides a diagnostic window into your prototype to speed and simplify system development.

Our growing selection of iSBC™ products gives you the flexibility to tailor a system to your specific application, without compromise. Choose one of our five single board computers, starting at $99.* There's a full selection of memory expansion boards, communication interface boards, digital and analog I/O boards, mass storage systems and a high speed math processor. Or you can start with one of our packaged System 80's.

You're assured of the highest reliability when you build your system around an Intel single board computer. For example, MTBF for our iSBC 80/10 is 91,739 hours at 25°C. Ask for your copy of our iSBC Reliability Report.

There's also the security of Multibus,™ the multi-processing bus architecture we developed for single board computers. Multibus has become such a widely accepted industry standard that today there are over a hundred Multibus-compatible products available from 42 independent companies. And Multibus is your guarantee of compatibility with future Intel iSBC products.

Get started with our comprehensive iSBC System Configuration Kit. It's a catalog of Intel single board computer products, with detailed configuration instructions and worksheets to help you define the optimum iSBC solution for your needs.

For your kit, or for on-site assistance in configuring and pricing your iSBC system, contact your Intel representative or distributor. Or write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051. Telephone: (408) 987-8080. In Europe contact: Intel International, Rue du Moulin a Pàpier, 51-Boite 1, B-1160, Brussels, Belgium. Telex 24814. In Japan contact: Intel Japan, K.K., Flower Hill-Shinmachi East Bldg. 1-23-9, Shinmachi, Setagaya-ku, Tokyo 154. Telex 781-28426.

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Formatter coming for double-sided floppy drives

Look for Western Digital Corp. in Newport Beach, Calif., to be first on the market with a large-scale MOS formatter controller for dual-density, double-sided floppy-disk drives. **Thought to be unique in the microperipherals field,** the new FD1791 has all the control and bit-manipulation features that the firm's earlier 1771 and 1781 chips provide for single-sided floppy-disk drives, plus the capabilities needed to read, write, and format double-density diskettes.

Analog lists fast synchro-to-digital converter family

Analog Devices Inc. of Norwood, Mass., will soon announce a family of 3⅝-digit synchro-to-digital converter modules that boast **an extremely fast tracking rate of up to 75 revolutions per second.** The modules also will offer other such notable features as transformer isolation, programmable signal or reference input modes, a wide input frequency range (either dc to 400 Hz or 400 to 2,600 Hz), operation from a synchro or resolver input, and a choice of binary-coded-decimal output ranges (either 0° to 359.9° or −180° to +180°).

Peripherals due for I²L version of TI's 9900

Texas Instruments is about to introduce peripherals for the integrated-injection-logic version of its 16-bit 9900 processor. In the next few months, the 9900 will gain an I²L 16,384-bit read-only memory, priority-interrupt controller and interval timer, plus a serial input/output expander. **But even more important are several programmable peripherals,** including another I/O expander and an interface adapter, that are software-alterable.

Canadian firm has C-MOS version of Motorola 6802

Most Canadian semiconductor firms have been unsuccessful in attacking a broad spectrum of the LSI market, so Mitel Semiconductor of Bromont, Quebec, is aiming at the telecommunications and instruments industries **with two new high-performance LSI chips** in development and expected out by year's end.

One new device will be a C-MOS version of Motorola's 6802 bipolar microprocessor with 2 kilobytes of random-access memory, clock, and drivers on the chip. Designated the 46802, the 8-bit microprocessor is fabricated with an oxide-isolated silicon-gate process Mitel calls ISO-CMOS. In addition to being a zero-power device, the microprocessor is said to be faster that its counterpart from Motorola, which is understood to be talking with the Canadian firm about second-sourcing.

32-bit micros called key to market in data communications

The controversy among data communications professionals over the use of LSI circuits—some are gearing up for 8- and 16-bit microprocessors while others are unwilling to commit themselves—will remain unresolved until the 32-bit microprocessor becomes dominant. That's the opinion of Dennis Fairclough, chief computer scientist at the Eyring Research Institute of Provo, Utah. Fairclough, speaking at Interface '78, the data communications show held in Las Vegas, March 6–9, said that **the 32-bit machines will catch on because they will have the processing power of today's mainframes.** He predicted that the processors will take over such jobs as editing, code conversion, error correction and control, message buffering, and message switching.

Electronics newsletter

Willis leaves Solar Power, starts Solenergy

There's a new firm—Solenergy Corp.—in the solar photovoltaics business, but it is led by a familiar name. Robert W. Willis, who resigned last month as president of Solar Power Corp., North Billerica, Mass., put together private backing to start Solenergy in nearby Wakefield on March 1. Willis says Solenergy will sell silicon cells fabricated from purchased wafers, plus modules and consulting services, all for terrestrial applications.

He is convinced there is room in the Department of Energy's national photovoltaic program for small business enterprises **if they team up with much larger systems houses** and provide them with the expertise that will be needed to win DOE contracts for photovoltaics systems.

Chips cut cost of optical modules

Though optical data transmission is starting to catch on in some industrial and process-control environments, as well as for short computer-to-peripheral runs, the $500 to $1,500 price tag on transmitter and receiver modules is holding back widespread use of fiber optics. But Honeywell Inc. and Spectronics Inc. hope to change that: they have jointly developed **a pair of transmitter-receiver chips that will do most of either module's job.** The price for either should be less than $25 in large volumes, and about $100 for single units. Honeywell will make the chips; Spectronics will market them, with samples available later this month.

Grumman plans to soup up Mohawk radar

To provide field commanders with more timely intelligence information, Grumman Aerospace Corp. in Bethpage, N. Y., is proposing a modification to the APS-94 Side Looking Airborne Radar operating on its OV-1 Mohawk aircraft built for the Army. Specifically, Grumman has determined that **by using an electronically scanned antenna in place of its present fixed-beam unit,** the Mohawk's radar system can provide a real-time 90° field of view and give target speed and direction, two features not easily determined with the present system.

Addenda

Having lagged in the 4-k random-access-memory race, Motorola does not intend to be a 16-k also-ran; **it is now apparently shipping more than 100,000 parts each month.** That is not quite the level that Mostek, Intel, and NEC have reached, but it is enough to make some observers predict more parts than orders by June. . . . **Chrysler has chosen Mostek's 3870 microcomputer for the optional trip computer** it will hang from the ceiling of about 100,000 1979-model trucks. . . . . **TI will start shipping samples of its 9940E, a 16-bit microcomputer with on-chip erasable PROM,** next month. But the firm has managed to squeeze in the full 9900 instruction set, as well as decimal correction instructions, not just the subset it planned earlier. . . . **High-level languages promise to gain firm footholds in the microprocessor world.** By summer, Intel's development system will handle a beefed-up version of the ANSI-77 standard Fortran; Zilog's disk-based microcomputers will get a big (24-kilobyte) Basic compiler; and Microsoft is preparing its APL, which will open the door to all the IBM software in the public domain. . . . **TI has assigned functions to pins on its 64-k erasable PROM and plans to make samples available this summer**—about the same time that Intel plans to ship its 32-k version.

Keep those cards

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Single-chip level detector sells for 65¢

Bipolar device from TI combines many different components usually offered in separate packages

Moving to strengthen its position in the industrial linear marketplace, Texas Instruments Inc. is leading with a totally new device—a five-step analog level detector that promises to find many industrial, consumer, and automotive applications. It was unveiled at the same time the Dallas semiconductor maker released about a dozen new versions of traditional linear integrated circuits, including line drivers, data converters, and controllers for switching-regulated power supplies.

The detector, the TL489, is unique for two reasons: it combines a startling number of components on a single chip, and it sells (in quantities of 100) for just 65 cents. For this price, TI supplies five comparators, five output driver transistors, a high impedance input buffer, voltage regulator, and five scaling resistors.

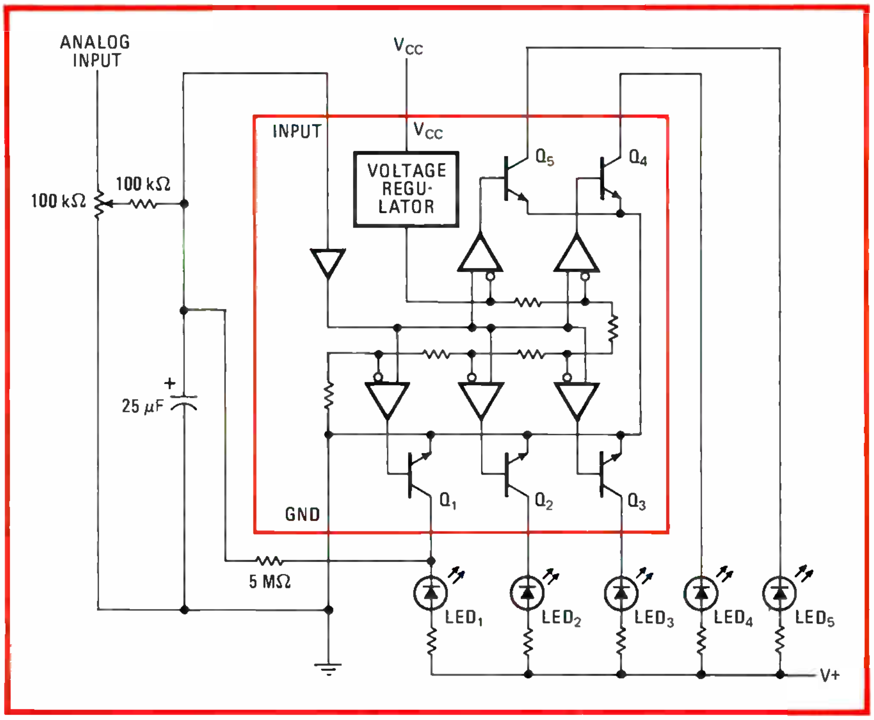
To make an equivalent level detector has till now taken an entire circuit card of components costing many times more. TI foresees the chip's use in such equipment as low-precision meters, warning-signal indicators, analog-to-digital converters, feedback regulators, pulse shapers, delay elements, and automatic range switchers.

Meet the chip. Each comparator on the bipolar chip, shown in schematic, has an open-collector output capable of sinking currents up to 80 milliamperes and withstanding voltages up to 18 volts. This means that the device can directly drive display elements such as light-emitting diodes or even filament lamps, as well as high-level digital logic like transistor-transistor and complementary-MOS logic. Moreover, the part offers a high input impedance of 100 kilohms typically.

At a nominal input voltage of 200 millivolts, the device's Q_1 output switches to a low logic level. Each 200-mv step at the input thereafter causes the other outputs, Q_2 through Q_5, to switch consecutively to a low logic level, so that all the outputs are low when the input voltage is approximately 1,000 mv.

The schematic shows the TL489 wired as a level indicator with a flashing alert. In this application, the device lights up the LEDs in sequence, turning on LED_1 first and LED_5 last as the input voltage increases in nominal 200-mv steps. When the voltage at the wiper of the input potentiometer falls below the device's 200-mv threshold, LED_1 flashes on and off periodically.

All five trigger points provide a switching hysteresis of about 10 mv, permitting the device to be operated with slow input signals yet be free of the danger of oscillation at the outputs. To prevent noise pickup, TI recommends connecting a capacitor between the unit's high-impedance input and ground, especially when



Five levels. Analog level detector packs five comparators and drivers, a voltage regulator, and input buffer onto one chip. Comparators switch for every 200-mV step in input.

the part is driven from a high-impedance source.

The TL489 operates from a supply voltage of 10 to 18 v. It comes in an eight-pin plastic dual in-line package for operation over the commercial temperature range of 0°C to 70°C. □

Commercial

Electronic lock stores its code in nonvolatile semiconductor memory

To thwart thieves with duplicate or master keys, hotelkeepers favor electronic locks for their rooms because the lock "combinations" are easy to change for each new guest. But there is a drawback: each lock must be linked to a central combination-storing station by a costly two-wire circuit or the hotel's television or telephone wiring.

Enter Arthur D. Little Inc., the Cambridge, Mass., consulting and market research firm. It has built a prototype of a new type of electronic lock that stands alone as the guardian of the guest room door. The combination is stored for record-keeping in the central station and also inside the lock itself—in a nonvolatile semiconductor memory.

Change. Moreover, the guest is the unwitting bearer of the lock's new code. It is stored on a plastic "key" resembling a credit card that the hotel provides upon check-in.

"The stand-alone and the intrinsically secure features are what makes this system different from other electronic systems," says Samuel W. Tishler, manager of the invention management program at ADL. By "intrinsically secure" Tishler means there are no signals representing the lock's combination running along the hotel wiring, which a sophisticated thief theoretically might be able to intercept.

The system also employs a random coding scheme that adds to its security. In effect, there are no secrets that can be learned and compromised, points out Daniel Sabsay, a 34-year-old inventor who received a patent for his Metaphase security system some four years ago. He tried unsuccessfully to interest at least 10 firms in developing it until he began working with ADL last July (see "Managing inventions at ADL"). Sabsay is employed as a programmer at another firm in Cambridge, while ADL brings his idea along. Right now, Tishler is ready to license an electronics firm to finish the hardware and another firm to market it. He says it is two years from completion.

It will be an unusual piece of equipment, driven by room current or a standby battery. It will have a metal-nitride-oxide-semiconductor memory to store the lock's code, light-emitting diodes to scan across the coded key, and a fiber-optic light pipe to bring the reflected light to a phototransistor. Directing it all will be a 4-bit microprocessor to compare the code on the key with the code in the lock and, when the codes match, trigger an optically isolated relay to open the door latch.

The prototype key uses punched-hole coding, but Tishler wants a printed bar code resembling the product code used in supermarkets. Each key would contain a 90-bit code. Two 28-bit portions would be devoted to activating the lock, the rest to such things as identifying the key's user.

One set of 28 bits is the lock code, its counterpart stored in the MNOS memory. The key is inserted in a slot by the door, and when the door and key codes match, the door unlatches. The harder part is when a guest checks in and is given a new key. The key not only contains a new code for the room but in the second 28-bit, or reset, space is printed what is now the old 28-bit lock code for the room—the code to be changed.

Double scan. The lock electronics scans the key and, if the lock codes do not match, checks the reset code. When this matches, the microprocessor then controls the writing of the new bar code into the lock's memory and the door is unlatched. Otherwise, the door will not open.

The lock codes will be generated randomly down at the front desk in a so-called Keymint and will be a function of the unit's internal clock, says Sabsay. The clock could run through the 2^{28} numbers, or more than 268.4 million possibilities, in minutes, with the chance of issuing the same combination for any two keys virtually nonexistent, he points out. The Keymint prints the new bar code on the key and stores it with the room number in memory. It also

Managing inventions at ADL

The Metaphase security system is only the latest in a series of inventions developed by Arthur D. Little's invention management program. Established in 1957, the program has seen many successful products licensed, such as penicillin synthesis to Bristol Myers and a facsimile transceiver to Graphic Sciences. Other products have included a text-editing system, ink-jet printing, a hand-held data entry device, silk-screen printing technology, and a two-way data-communication system using power lines.

The program evaluates inventions for their potential marketability and develops and licenses the most promising by supplying money and technical expertise. Most of the inventions come from outside ADL, although the program does sponsor in-house designs. Says Samuel W. Tishler, manager of the eight-person group, "We try to evaluate inventions from the point of view of practical application." And he adds wryly, "You should see some of the perpetual-motion machine ideas that wander in here."

Criteria the inventions must meet include a market potential of more than \$5 million annually; coverage by patents or patent applications; and a cost of production or use lower than that of similar products already on the market.

prints in the reset position the old 28-bit lock code for that same room.

The MNOS memory used in the prototype is General Instrument Corp.'s ER1400 electrically alterable read-only memory, organized into 100 14-bit words. The microprocessor is at present implemented with conventional transistor-transistor logic. Tishler estimates the lock electronics, which should fit on a 3-by-5-inch circuit board, could sell for about $30 and the Keymint, built around a microcomputer, in the $2,000 to $3,000 range. The wiring required with present electronic locks can boost their price up to $500 per room, he says. □

Batteries

Ni-Cad unit comes in dual in-line package

Now a rechargeable battery has been squeezed into the workhorse of the semiconductor industry—the dual in-line package—allowing it to be plugged directly into printed-circuit boards. The feat has been accomplished by General Electric Co.'s battery business department in Gainesville, Fla. It provides digital systems designers with small, plug-in standby supplies for protecting their normally volatile solid-state random-access memories. And with simple trickle-charge circuitry, the batteries will remain charged.

A General Electric spokesman expects the primary customers for the new Data Sentry batteries will be original-equipment designers and microprocessor users. Potential applications include microprocessor-based systems for computers, industrial controls, and appliance controls, as well as single-chip microcomputers, add-on memory boards, and point-of-sale terminals.

Plug-in. Rechargeable nickel-cadmium battery from General Electric can be plugged into or soldered to a circuit board.

Right on board. Heretofore, engineers had to mount standard cylindrical cells, of the AA, C, or D type, in special battery clips on the pc boards. Alternatively, they used larger rechargeable batteries mounted off the board. The new batteries, offered in 2.4- and 3.6-volt sizes, can be plugged into DIP sockets or soldered directly to the board.

The battery is built around a tiny, sealed cylindrical nickel-cadmium cell, the μP 80, which is just under 0.6 inch long and under half an inch in diameter. The batteries are rated at 70 milliampere-hours at 15 mA.

Typically, one of the units could power up a metal-oxide-semiconductor RAM drawing 10 microamperes for almost four months or a larger memory drawing half an amp for more than five minutes. Both batteries are rectangular, measuring 1.67 inches long and 0.6 inch high. However the 2.4-V unit is 0.67 inch wide, the higher-voltage unit 0.82 in. wide. For comparison, a standard plastic 14-pin DIP is smaller, measuring 0.76 in. long by 0.26 in. wide and 0.24 in. high. Both batteries come in a black plastic case with four dual in-line pins. In 100-plus quantities, the 2.4-V unit costs $2.76, the larger unit, $4.14. □

Charge-coupled devices

Chip helps detect targets automatically

To get the most out of new imaging systems planned by military users for spotting tactical targets, their operators could do with help in perceiving such targets as camouflaged tanks and guns, which are notoriously hard to see on a flickering display screen. Edge-detection computer routines fortunately can process the sensor data so as to enhance straight lines and thus outline man-made objects boldly. Unfortunately, even the simplest algorithms take up to 10 seconds to detect edges in each image frame.

To overcome this lag, Hughes Research Laboratories has used fast, charge-coupled-device integrated-

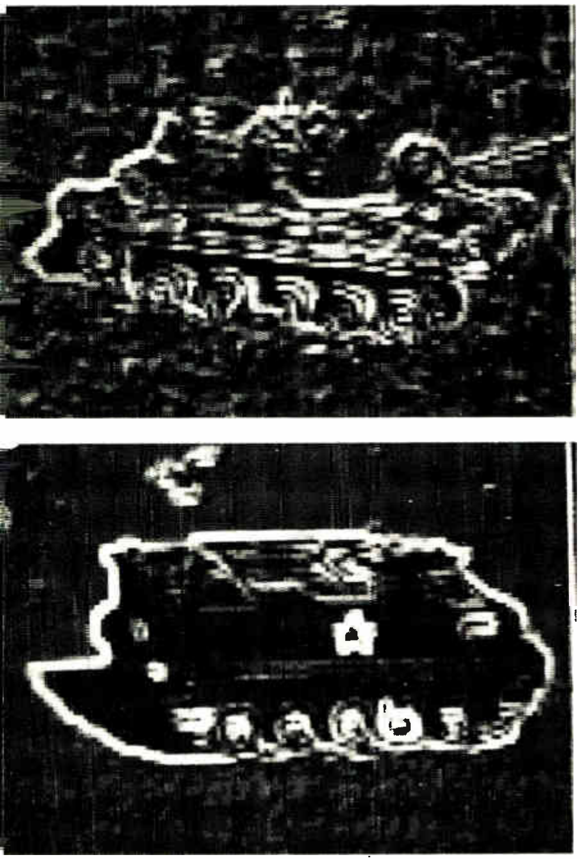
Bell develops lithium battery

While General Electric Co. has been repackaging nickel-cadmium batteries into a standby power source for integrated circuitry, scientists at Bell Telephone Laboratories in Murray Hill, N. J., have been busy developing a rechargeable lithium battery cell that could be used in larger standby power sources for telephones and central office equipment.

Key to the advance was the synthesis of a new material, vanadium disulphide, a layered compound similar to mica and graphite with the special ability to function as a battery material without permanently changing, either physically or chemically, during the charge-discharge cycle.

In Bell's one-celled battery, vanadium disulphide is the positive and metallic lithium the negative electrode. The lightweight cell puts out 2.5 volts, or about double the voltage of nickel-cadmium cells commonly used to power electronic devices. By comparison, nickel-cadmium cells are heavier and put out 1.3 V each while lead-acid systems are heavier still, but put out about 2 V.

According to Bell, most Ni-Cad or lead-acid batteries operate far below their expected capacity because considerable fractions of their active materials are used for mechanical support. Layered compounds would not have this drawback, but large, practical batteries have yet to be made. However, Bell continues, a practical lithium-vanadium-disulphide battery "might offer five to eight times the energy density of a lead-acid battery."



Clearer view. Edge-detection computer routines applied with Hughes' CCD chip help an operator at a cathode-ray-tube display to see targets better by outlining them, as for this personnel carrier and camouflaged tank.

circuit technology to build a chip that helps detect edges almost in real time. "The system works anywhere from 300 to 1,000 times faster than a general-purpose computer," says Graham R. Nudd, head of signal processing at the Hughes Aircraft Co. unit in Malibu, Calif.

A new technique. But two-dimensional image processing with CCDs had never been done anywhere, says Nudd. To build a device that would simultaneously locate edges in both X and Y planes, they devised a technique called bipolar charge weighting, for which the firm is applying for a patent.

The chip contains three parallel shift registers that receive image data from the primary tube or solid-state sensor. Each takes one line at a time, so the registers always hold three contiguous lines of the image. The 2-d operation is achieved by some 20 edge-detection algorithms fabricated in register architecture treating the three lines as a three-by-three array of nine separate picture elements. Straight-edge components are located simultaneously in horizontal and vertical planes by continuously calculating differences in weighting charge levels between the picture elements.

This key charge-weighting technique developed by Hughes is done by the register's gate structures, which sense analog charge levels proportional to image intensities. Lengths of these gates are varied to produce equivalent weighted charges in what Nudd is calling two-dimensional filtering. The CCD circuits detect edges and control gain and brightness. They also reject impulse noise and allow resolution in shadows and bright areas.

A 2-MHz clock rate. At present, the Hughes CCD circuit takes up only a 40-square-mil area on a standard 200-mil^2 chip, holding potential of adding more parallel processing, if it is desired. In tests, Hughes is operating the prototype at a 2-megahertz clock rate, edge-detecting still photographs and then displaying the results on a video monitor.

Nudd sees no great obstacles in the way to Hughes's goal of using the chip to edge-detect at the full 5-MHz rate of an ordinary television video system. Thus, he thinks the chip-based design could be ideal for military smart-sensor projects, which seek to integrate processing elements with detectors in order to simplify system design and operation. In fact, the two-year Hughes program is partly sponsored by the Advanced Research Projects Agency of the Defense Department.

The use of CCD technology has other benefits, in addition to the speed, he says. For one, the edge detector is compatible with the CCD detectors planned for sensing arrays, and the low power/product requirement (about 0.01 picojoule) allows circuit complexity to support even higher performance.

Further improvements are already under way, he says, and Hughes is now testing an adaptive CCD chip, which takes the edge-detected image and sharpens it further with five additional steps. Some algorithms for the program were developed by the University of Southern California's Image Processing Institute. □

Business

CCIA grows in influence, members

Few trade associations or professional societies can boast a sevenfold increase in their membership in only six years of existence. But that is what the Computer and Communications Industry Association has done since its founding in 1972 as the Computer Industry Association. Now with 47 members—and nine membership applications pending—CCIA is still not large, yet the impact of its operations, especially in Washington, is attracting more attention in Congress and the Federal bureaucracy than some of its much larger counterparts.

Much of the credit for CCIA's growth goes to its president, A. G. W. (Jack) Biddle, according to members attending its Fifth Washington Caucus last month. Unlike the larger Computer and Business Equipment Manufacturers Association, made up largely of the big makers of turnkey systems, much of CCIA's membership consists of independent producers of subsystems, terminals, memories, and software.

Biddle, a 46-year-old West Point graduate, recognizes that a large part of the success of CCIA, which began life as a vehement critic of what it regarded as anticompetitive practices by IBM [*Electronics*, June 7, 1973, p. 14], stems from the fact that before its creation "there was no strong representation in Washington for the medium-sized company" in computers and communications.

CCIA differs from CBEMA and most other trade groups in its one-man–one-vote structure and maximum annual dues of $42,000 regardless of a member company's size, continues Biddle. Trade associations

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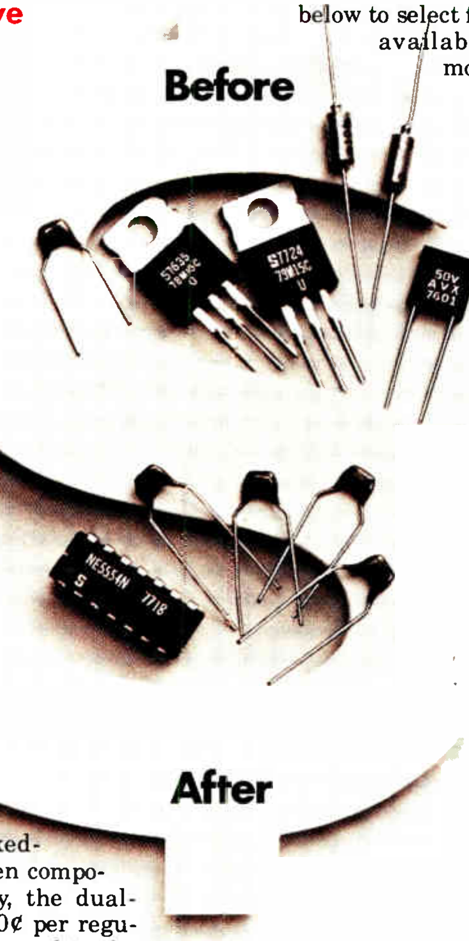

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Circle 43 on reader service card

Influencer. Working on it drop by drop, Jack Biddle hopes to have an impact on legislation that will increase competition.

usually assess dues on a company's annual sales, with the biggest contributors wielding the greatest clout.

Within the community of associations lobbying the Federal government, the group's clout is increasing. This was evident at its Washington meeting, which drew such speakers as Sen. Edward Kennedy (D., Mass.), chairman of the antitrust and monopoly subcommittee; Sen. Ernest Hollings (D., S. C.), chairman of the communications subcommittee; John Shenefield, assistant attorney general for antitrust affairs; and a handful of other stars in the Federal government establishment concerned with computer and communications issues.

Antitrust stance. Though Biddle acknowledges that CCIA is trying to shake its anti-IBM and, more recently, anti-AT&T images, the association's strong position in favor of antitrust reforms accounts for a large part of its acceptance within the bureaucracy. Sen. Kennedy's CCIA keynote address declared, for example, that "this is clearly a unique gathering of businessmen" in view of its support for increased competition in communications and for antitrust reforms. Then the Justice Department's Shenefield paid tribute to the members' solid support of his efforts "to promote competition and preserve the vitality of the free-enterprise system" in a world "where we have surprisingly few allies from business."

Many of CCIA's positions are uncommon. Biddle contends this is because its members' chief executive officers are almost all "first-generation creators of companies, most of whom didn't exist in 1960, and many of whom have come close to Chapter XI bankruptcies and came out of it." What troubles many of them, he points out, is that "Federal policy is often made by lack of policy," leaving development of competition and things like industry standards to be set, *de facto*, by the giant multinational firms.

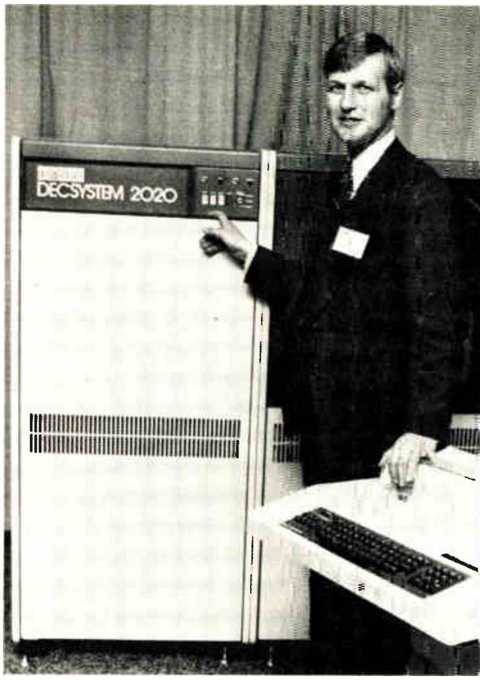
Can CCIA change that? Biddle believes it can make a major contribution but concedes that bringing about change in the capital is painfully slow—"like Chinese water torture, drop by drop, until you finally get a piece of legislation." □

Computers

DEC mainframe has 16-k RAMs, bit slices

Advanced semiconductor technology is the key to what officials at Digital Equipment Corp. say is the lowest-priced mainframe introduced to date. The minimum configuration of the Decsystem-2020 will sell for $150,000, a price that makes it competitive with some recently introduced minicomputers.

The 2020, as well as the much larger 2060 mainframe also introduced late last month, are new entries in the Decsystem-20 family. DEC officials believe the 2020 will be the first mainframe to make volume use of the 16,384-bit metal-oxide-semiconductor random-access memory in its main memory and could be the first with a bit-slice microprocessor in its central processing unit. Because of its low power consumption and compact size, the mainframe does not need airconditioned coddling in a special computer room, which could cut installation costs.



Powerful frame. Product manager Per Hjerppe stands before mainframe of Decsystem 2020, which dissipates just 1,400 watts.

Volume in July. Both the Decsystem-2020 and -2060 will begin volume shipments in July from the company's Large Computer Group in Marlboro, Mass. The 2060, like the other members of the family (the 2040 and the 2050), has a CPU implemented in emitter-coupled logic, a superfast but power-hungry logic family.

In contrast, the 2020's central processor is designed around low-power Schottky transistor-transistor logic. Its power consumption of approximately 1,400 watts is the amount needed by such consumer products as a hand-held hair dryer, and it operates from standard 110-volt lines. However, the big contributors to the 2020's low price and compact 5-foot-height are the 16-k RAMs and the 2901 4-bit bit-slice microprocessor family on the processor's data-path execution board. It is in that board that the actual instruction execution takes place, with the 2901s decoding the bit pattern coming from memory to determine

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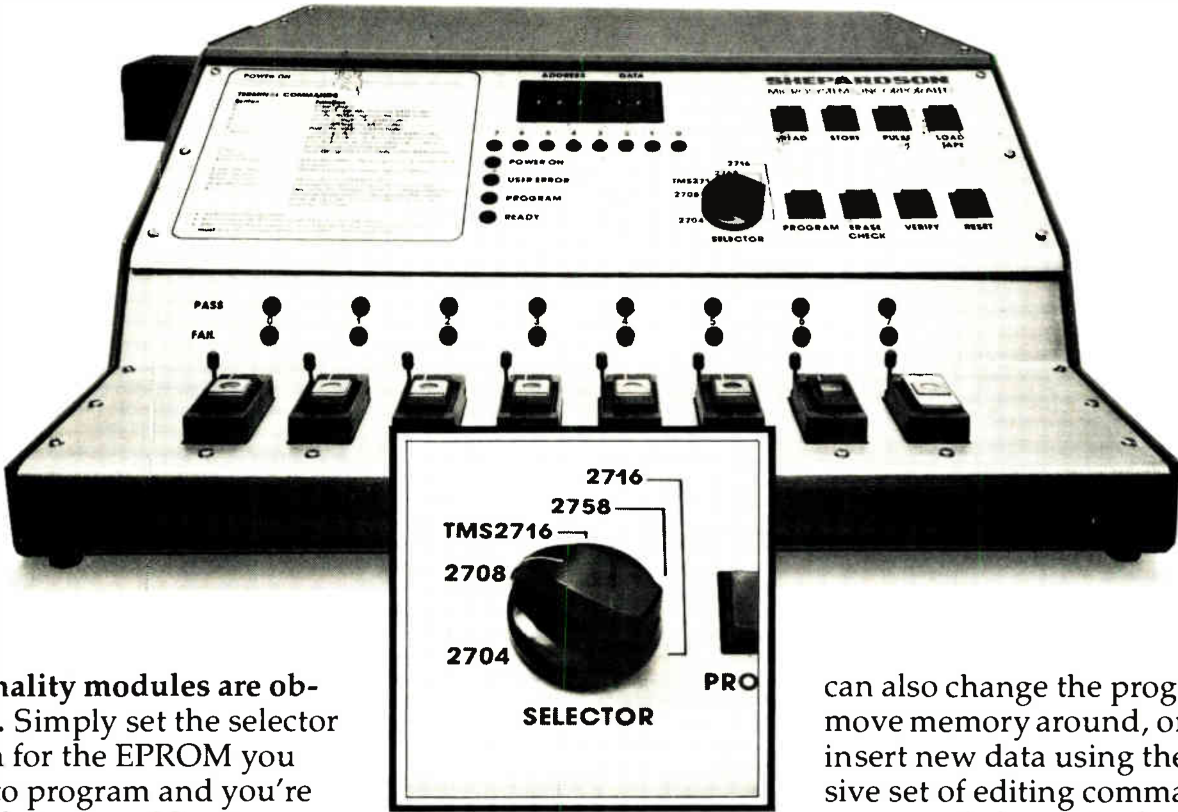

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Shepardson

IBM, HP price cuts—more than a reaction

Suddenly the small- and medium-scale mainframe computer market saw action the last week in February as the announcement of Digital Equipment Corp.'s 2020 and 2060 computers was followed by price reductions of up to 20% both in Hewlett-Packard Co.'s HP 3000 series and in IBM Corp.'s 370/138 and 370/148 computers. The timing of the reductions is more than coincidental—the comparable HP 3000, now $11,000 less at $129,000, but with a smaller 320-kilobyte memory, was described by DEC as directly competitive with the 2020, and the company's high-end 2060 is aimed at the IBM 370/138 and 370/148 markets. A comparable 148 is now $658,450, down from $799,000.

While decreasing hardware costs may have prompted HP's price reductions, IBM's announcement was predictable ever since it brought out its latest processors, the 3031 and 3032, in November. The 3032 offered better than twice the performance for the same price as the 148.

Although competitive position is one cause, price reductions are to be expected as a result of large-scale integration 's entry into mainframe designs and the exploitation of its price-performance benefits. "We're seeing declining prices in computers across the board because of the increased use of LSI," comments Computer and Communications Industry Association president Jack Biddle (see p. 42). He adds that the mainframe activity is also a result of other factors: "There is increasing pressure from the minicomputer area and in the growing number of sophisticated users who are less afraid to go to multiple vendors and build their own systems."

what instruction should be executed. There are just four circuit boards in the new processor, compared to 52 in the CPU for others in the Decsystem-20 family.

The impact of the 16-k RAMs on the 2020's size and price cannot be underestimated, says product manager Per Hjerppe. "We can fit 256 kilobytes of main memory on one board," he points out, "so we can get 2 megabytes on eight boards. That compares with just a half million bytes with 4,096-bit RAMs on eight boards of the same size."

Ronald Bingham, engineering project leader for the 2020, adds that each of the 10 2901 chips in the system is equivalent to about 400 logic gates and "effectively, we've taken some of the boards in the processor used in the rest of the Decsystem-20 family and put them on a single chip." The 2901 family is also built with low-power Schottky, which further reduces power consumption. The 2020's CPU has a switching power supply about a quarter the size of the unit required for the ECL-based machines.

The $150,000 2020 with 512 kilobytes of main memory is expected to compete with mainframes that include the IBM 370/115 and the HP 3000. A typical 2020 will serve 8 to 20 on-line users, with the largest configurations accommodating up to 32. A typical 2060 can handle 30 to 80 users and will sell for between $600,000 and $700,000. Both new systems are fully software-compatible with other Decsystem-20 computers and run the Digital Equipment's TOPS-20 operating system.

TOPS is key. Frederic "Ted" Withington, senior staff member and computer industry authority at Arthur D. Little Inc., is impressed with the 2020's cost. "This represents a really remarkable demonstration of price reduction in a mid-range computer," he observes. He puts his finger on the TOPS-20 as the key to the 2020's importance. "That's a more general-purpose data-processing operating system," rather than a scientific time-sharing system, "and means that DEC will be out there competing with the biggies" in business data processing. He says DEC's 32-bit minicomputer, VAX-11/780, may sell more units than the 2020, "but the 2020 could be more important to DEC in terms of new customer capture." ☐

Communications

AMI charts broad attack

Everyone agrees the market for large-scale integrated circuits in telecommunications will be enormous. Already there is a shift away from custom designs to dedicated products aimed at satisfying a range of customers, with large chunks of communications subsystems on programmable chips. Major efforts are under way at such newcomers to telecommunications as Intel, National Semiconductor, and Signetics.

But the effort is perhaps nowhere greater than at American Microsystems Inc., the largest single U.S. supplier of custom metal oxide semiconductors to the communications industry. The Santa Clara, Calif., firm is dipping into its arsenal of low-power complementary-MOS and speedy, dense vertical-groove MOS devices to mount an attack that relies on both dedicated and semicustom devices. AMI is going after three areas: subscriber telephone sets, private automated branch exchanges and central-office switching, and data communications.

AMI already has introduced a telephone-set part—the S2559 digital tone generator that produces low-distortion (less than 2%) signaling tones. A few months away are the S2560 key pulser for push-button sets and S2562 repertory dialer.

Turning to switching and data communications, AMI is developing two dedicated LSI chips that can serve different applications when operating with the 6800 microprocessor. These are the S2811 signal-processing peripheral and the S2815 programmable communications controller, both fabricated in V-MOS. For these, AMI uses a mobile array technique in which, as in gate arrays or uncommitted logic arrays, "you slap on the final metal to program the circuit," explains Richard R. Blasco, senior engineer for communications products. Once the chip's development cost is amortized over many

products, he believes AMI could supply even low-volume users with this semicustom approach.

The S2811 signal-processing peripheral, to be available in samples late this year, is AMI's first V-MOS venture outside memories. It is a special-purpose arithmetic processor with on-chip memories, multiplier, adder-subtractor, and accumulator in a pipeline structure for maximum throughput. It performs a 12-bit multiply in 300 nanoseconds.

The S2815 programmable communications controller may be used as either a master or a slave processor. The 40-pin package, which, like the processing peripheral, runs on a +5-volt supply, contains such communications-oriented features as a counter-timer, feedback shift register, variable word addressing, bit-wide logic operations, and serial word manipulation.

PCM family. AMI's third set of products involves a pulse-code modulation family of general-purpose LSI parts. They provide microprocessor-controlled voice-band signal-switching and -processing capability for central-office equipment, PABX gear, and key telephone systems. First out will be the S2563 PCM coder-decoder late this year. Based on n-channel silicon-gate technology, the codec fits on a single chip and has a conversion time of 24 microseconds for encoding and 3 μs for decoding. A power-down mode holds average power to less than 50 milliwatts.

Other parts will include the S2813 PCM aliasing filter for PCM-encoded voice-band signals, the S2819 PCM switch, analog and digital line-interface devices, and a frame assembler for the programmable communications controller. □

News briefs

Comsat, IBM seek to expand satellite data tests

Having demonstrated that a satellite can handle high-speed data communications between one computer in the U. S. and another in France, Communications Satellite Corp. and IBM Corp. have asked the Federal Communications Commission for permission to expand the tests to two more sites—one in the U. S. and another in Germany. The tests, completed late last year, achieved two telecommunications firsts. It was the first time that two large computers (IBM 370/158s) were connected via a 1.544-megabit-per-second channel, and it was the first full implementation of the high-level data-link protocol, the new international computer communications standard.

Modcomp adds minicomputer family

Modular Computer Systems Inc., Fort Lauderdale, Fla., has introduced a Classic series of minicomputers for industrial and scientific applications. Instructions have a word length variable from 16 to 64 bits, memory may be any mix of core or semiconductor up to a half megabyte, and special software has been developed for controlling continuous and batch processes.

Optical analyzer award coming

The Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio, expects to pick contractors next month for its optical spectrum analyzer. Used in electronic warfare, the analyzer will identify signals in dense electromagnetic environments [*Electronics*, Dec. 22, p. 29]. Goals are a 400-megahertz bandwidth, 4-MHz resolution, and 30-decibel dynamic range. Components including lenses and waveguides will be built as thin films.

Wescon/78 rescheduled, pared to three days

The 27th annual Western Electronic Show and Convention in Los Angeles has been moved up to Sept. 12–14. Originally, Wescon/78 was planned as a four-day convention from Sept. 19–22, but was rescheduled at the request of the Los Angeles Convention Center management to resolve a conflict with another convention, says the show's general manager, William C. Weber Jr. The reduction to three days, the same format used last year to avoid conflict with a religious holiday, will be the Wescon format from now on.

AIL cuts workforce by 10%, cites B-1 decision

Cutler-Hammer Inc.'s AIL division in Deer Park, N. Y., has begun laying off approximately 10% of its 2,800-employee workforce, citing the Carter Administration's curtailment of B-1 bomber production as the reason. The division was to have produced the sophisticated electronic countermeasures systems for the Air Force bomber.

TI unveils new intelligent terminal

Texas Instruments Inc. of Dallas has taken the wraps off an intelligent terminal designed for a distributed-processing environment. Introduced at Interface/78, the data communications conference and exposition in Las Vegas, the new 774/1 uses PPL 700 programming language, has two floppy-disk drives, and accommodates up to four of TI's 911 video displays.

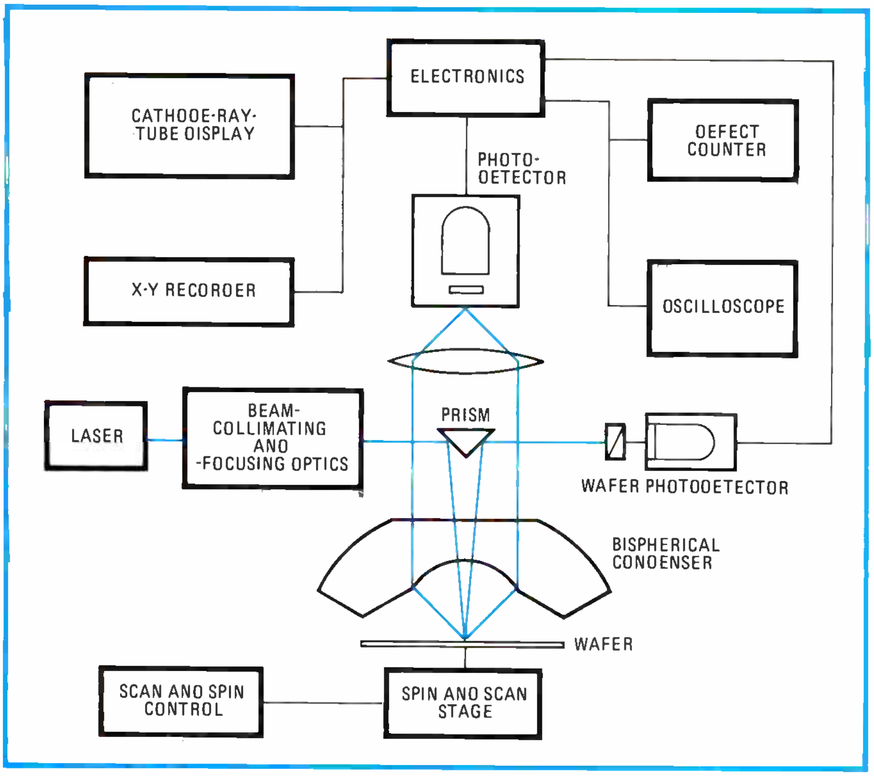
Packaging & production

Scanning laser senses wafer defects

A laser system is not only faster than a person using an optical microscope to inspect a silicon wafer for flaws—it can also make calculations that indicate the wafer's quality, report engineers at Texas Instruments Inc. Their laser surface analyzer takes just a few seconds to scan a 3-inch wafer for surface defects that scatter its light. In contrast, an inspector peering through a microscope can take as long as a minute.

The instrument was described last month at the Conference on Laser and Electro-Optical Systems in San Diego. It was developed under a contract from the Air Force Avionics Laboratory at Wright-Patterson Air Force Base, near Dayton, Ohio, as part of a program devoted to studying automated wafer-inspection methods.

The firm is not saying whether it plans to apply the analyzer to its own



Analyzer. Semiconductor wafer is spun about so that laser beam scans across its surface. Scattered light, picked up by photodetector, is used to determine defects.

production lines. But "we feel it has demonstrated itself to be a viable production inspection method," says Lloyd Crosthwait, manager of process analysis for semiconductor research and engineering at TI's Semiconductor Research and Engineering Laboratories in Dallas. He is co-author of the San Diego paper with TI's Pradeep Shah.

Feasible. The instrument was made only to demonstrate the feasibility of the principle, Crosthwait says. The inspection process, which detects defects as small as 0.8 micrometer, has been automated for both metal-oxide-semiconductor and bipolar wafers containing large-scale integrated circuits, he adds. TI is now using its own funds to simplify the analyzer, which fits atop a laboratory bench.

The analyzer is built around a commercially available 15-milliwatt, helium-neon laser. Its collimated beam is reflected from a prism and aimed through a bispherical condenser lens at the wafer's surface, as illustrated in the drawing. The presence of a wafer, placed in position by an operator, is sensed by the wafer detector, which generates a start pulse that initiates the inspection. The laser spot rapidly scans the wafer surface along a tightly wound helical path created by simultaneously shifting and spinning the wafer. Light scattered from the surface is collected by the lens and detected by a photomultiplier. Surface defects such as roughness, scratches, pits, films, and just plain dirt all scatter light.

Derived data. The electronics following the photodetector tube make the calculations that measure the quality of the wafer. Thus, not only are the absolute number of defects counted, but the analyzer also calculates their distribution and their variation from one wafer to the next. A gross surface defect like roughness can be evaluated, for example, by integrating the local scattered light and comparing the result with a predetermined value.

Defects may also be displayed on a map of the wafer on a cathode-ray tube, and derived defect data may be plotted on an X-Y recorder. □

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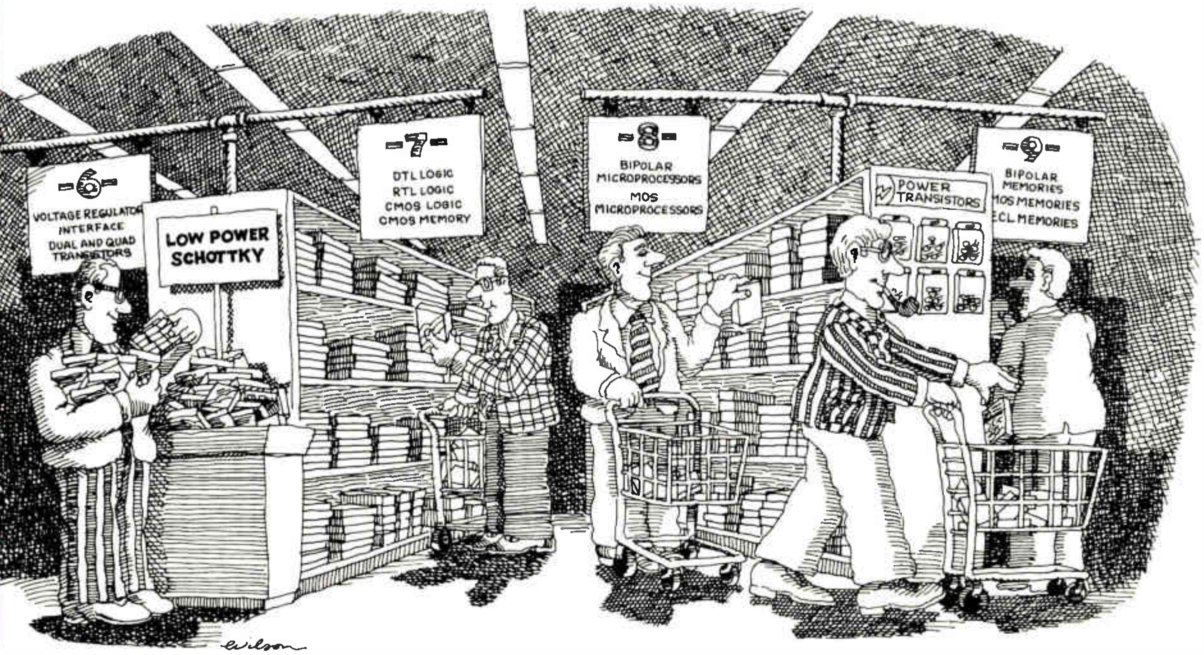

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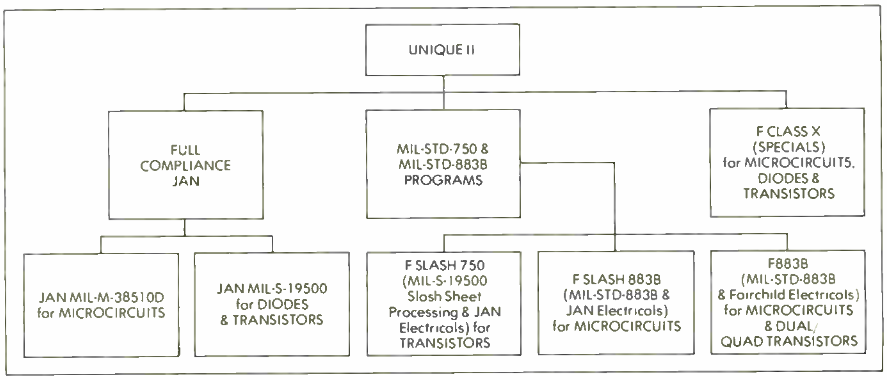

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IH5047	4PST	75Ω
IH5048	Dual SPST*	35Ω
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T_{on}	500nS	250nS	1000nS	300nS	N/S*	N/S*
T_{off}	250nS	150nS	500nS	250nS	N/S*	N/S*
Isolation	54dB @ 1 MHz	54dB @ 1 MHz	75db @ 100 KHz	N/S*	N/S*	N/S*
Charge Injection	15m Vp-p	10m Vp-p	20m Vp-p	N/S*	N/S*	N/S*
$R_{DS\,(ON)}$	75Ω	35Ω	75/35Ω	50Ω	200Ω	75Ω
$I_{D\,(OFF)}$ or $I_{D\,(ON)}$	1nA	1nA	N/S*	1nA	5nA	1nA
$I_{D\,(ON)}$ + $I_{S\,(ON)}$	2nA	2nA	N/S*	2nA	5nA	2nA
TTL Compatibility	YES	YES	NO	NO	YES	YES
Break Before Make	YES	YES	YES	YES	YES	NO
Second Sourced	YES	YES	YES	NO	NO	NO
Power Supplies Required	±15V, +5V	±15V, +5V	±15V, +5V	±15V	±15V	±15V

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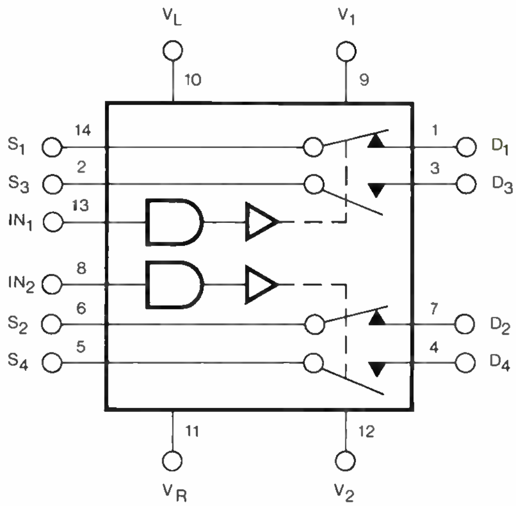

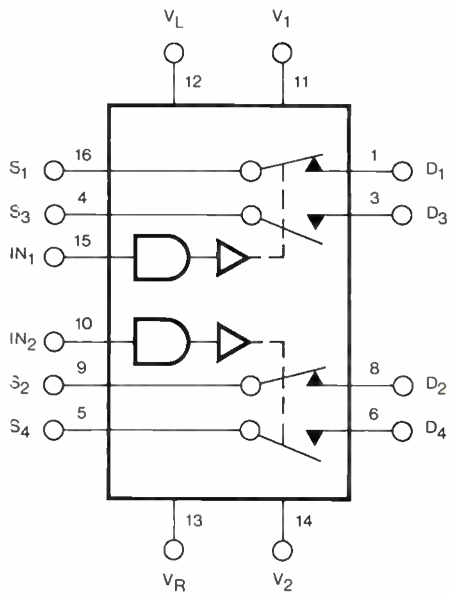

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Washington newsletter

Navy's costs double on Lamps antisub chopper

Navy cost estimates for its new shipborne antisubmarine helicopter, the Lamps Mark III, **have soared to an estimated unit price of nearly $20 million,** say congressional sources. The figure is more than double initial estimates and was disclosed after Defense Secretary Harold Brown told Congress that Lamps program costs were up, though he did not mention by how much.

United Technologies Corp.'s Sikorsky division is the prime contractor. It received $10.8 million in preproduction funds early this month, an increment on a $109.3 million contract for five prototypes. IBM Corp. is system integrator for Lamps, as well as subcontractor for on-board displays, while Raytheon Co. provides the electronic warfare system. Control Data Corp. supplies the AYK-14 computer, and other avionics suppliers include Fairchild Industries, Interstate Electronics, and Texas Instruments. The Navy wants $124.5 million for Lamps RDT&E in fiscal 1979, up 16% from this year.

Pitting AT&T against IBM called harmful to industry

Free-wheeling telecommunications competition between AT&T and IBM could damage industry development by bringing unendurable economic pressures to bear on other companies "caught commercially in this 'free-fire zone' without very deep pockets." That is the view of John Shenefield, assistant U. S. attorney general for antitrust. "Compounding the problem," Shenefield told the March meeting of the Computer and Communications Industry Association in Washington, "is that **neither of these giants has a particularly laudable record in terms of the tactics used to meet competition."**

TI TV tuner spurs FCC look at better use of spectrum

The Federal Communications Commission is preparing an April inquiry into ways to use the uhf spectrum more efficiently. It follows an FCC Laboratory assessment of a prototype TV tuner from Texas Instruments that rejects uhf interference so well that **it would make closer channel spacing possible and double the number of uhf channels.** The inquiry is being put together by FCC chief engineer Raymond Spence.

TI developed the tuner at its surface-wave technology laboratory using surface-acoustic-wave filters and metal-semiconductor field-effect-transistor components. Clinton S. Hartmann, manager of the lab, a branch of the TI Central Research Laboratories, delivered a detailed report on the tuner with the prototypes to the FCC, which had its laboratory test them and report back. Copies of both reports are available at Spence's office. While the prototypes indicate a tuner cost increase of about 40% to nearly $32 from existing uhf tuners, Hartmann told the FCC that these costs could be cut by the production learning curve.

NTIA to begin operations April 1

The National Telecommunications and Information Administration expects to be operating in the Commerce Department about April 1, according to Henry Geller, the new assistant secretary nominated to head it. Geller, appearing before a House Appropriations subcommittee on the NTIA budget request of $11.9 million, says the new policy-making group is to be created by merging the department's Office of Telecommunications with the former White House Office of Telecommunications Policy. **NTIA's first priority, Geller says, will be the common carrier industry,** which "has been in constant turmoil for the last decade."

Washington commentary

Can NTIA make telecommunications policy?

Even though the National Telecommunications and Information Administration is not yet officially in place in the Department of Commerce, it is already coming under fire. The fundamental issue on which critics in Congress and industry agree is that the new agency will be a poor substitute for the defunct Office of Telecommunications Policy in the White House, being too far removed from the President. Nevertheless, that is Carter's choice, and it seems certain to slip through Congress without much fuss.

The NTIA merges what was left of OTP with the Commerce Department's Office of Telecommunications and will be headed by Henry Geller with the title of assistant secretary. The Carter budget for fiscal 1979 proposes giving it a bankroll of just under $12 million, some 60% more than it got this year. The increase adds 35 people to the agency staff, bringing it to a total of 310, and hikes its spending level by 22% to approximately $9 million. Of that figure, an extra $1.8 million or so will go for policy studies, mostly in the area of common carrier regulation, while $200,000 more will be laid out for things like studies of "the economic, technical, and legal perspectives of radio spectrum scarcity" to enhance applications of telecommunications technology. Those numbers seem laughable to the Washington telecommunications community, which talks only in terms of several millions.

Weakened charter

Concern is also being expressed about NTIA's new charter, already weakened by successful jurisdictional grabs by the Departments of Defense and State, the Office of Management and Budget, and the General Services Administration. Yet Sen. Ernest Hollings (D., S. C.), chairman of the communications subcommittee, believes the draft Executive Order establishing the new agency gives it "a respectable mandate" despite these scars. "With aggressive leadership from the Secretary of Commerce and the White House, it has a chance to succeed," Hollings says. John Shenefield, assistant attorney general for antitrust, is somewhat more optimistic about NTIA's future, particularly in the area of telecommunications policy making, if only because he believes Henry Geller is "the very able and very aggressive sort of fellow" needed to make the new agency work.

Hollings is taking soundings on the possibility of supplementing NTIA with the formation of a White House communications policy council of some kind, or an information policy council to provide the domestic telecommunications policies that are so badly needed. Such a council appeals to many telecommunications industry leaders provided they are represented on it. Hollings' and others' support for NTIA, as they make clear, stems largely from the fact that "it is better than nothing at all," to quote one of them. Hollings is concerned that "at present there is no policy—there is no one in control, no person minding the store that you can go to for a decision. There is no coordinated telecommunications planning. As a result, technology that should be providing only the force for change is itself providing the direction of change and, in a sense, is actually determining policy."

The senator's views sat well with the members of the Computer and Communications Industry Association when he addressed their Washington meeting early this month. Made up largely of relatively small producers of telecommunications and computer equipment, CCIA warms quickly to signs of Government support for its efforts to open telecommunications markets to greater competition.

Congressional action

The creation of NTIA goes a step toward filling the vacuum in Federal telecommunications policy making. But it is no more than a first step. If the Carter Administration insists on leaving the development of national telecommunications policy in one small corner of the Department of Commerce, then the President is giving a clear signal to the Congress that he either does not recognize or is unable to cope with the dimensions of the issues involved. Sen. Hollings, for one, has come to recognize the problems facing telecommunications. "The market is growing continually and spinning off new markets," he says, conceding that trying to grapple with all of them effectively produces a sense of frustration akin to that "of a monkey trying to make love to a football."

On the House side, the Commerce Department's subcommittee on telecommunications is clearly farther along in dealing with the issues [*Electronics*, March 2, p. 55]. Under Rep. Lionel van Deerlin (D., Calif.), the members plan to complete their rewrite of the 1934 Communications Act so it can be put to a vote before the year is out. By that time, they expect to be ready to address the issues, too. Then Jimmy Carter should have a piece of legislation telling him that NTIA, however effective, is not enough.

Ray Connolly

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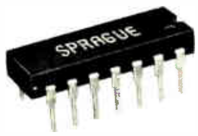
- Type UDN-2956A and UDN-2957A 14-lead DIP designs are customarily used for switching the ground side of telecommunications relays (usually −48V). Positive input and "enable" levels activate the output load.
- Series UDN-2980A 18-lead DIP devices are 8-channel source ICs for general applications, including MUXed LEDs (segment-driver/common-cathode; digit-driver/common-anode), lamps, relays, solenoids, motors, triacs, etc. An appropriate logic "1" on the input switches the output "on"; an input inverter buffers the high supply voltage from the logic circuitry. A prime application is the replacement of current-sinking ICs which may experience logic malfunctions associated with high ground currents (IR buildup) or ground noise.
- Type UDN-6118A and UDN-6128A 18-lead DIP devices are intended for vacuum fluorescent display interface. A positive input signal causes the driver outputs to switch high. Internal pull-down resistors minimize component count as well as reduce circuit cost.



Application	Telecommunications Relays, PIN Diodes, & General-Purpose Power		LEDs, Relays, Motors, Lamps, Triacs, Solenoids, & General-Purpose Power		Vacuum Fluorescent Display Segment and Digit Driver	
Type Number	UDN-2956A	UDN-2957A	UDN-2981A/83A	UDN-2982A/84A	UDN-6118A	UDN-6128A
Sustaining Voltage	80V	80V	50V (UDN-2981A) 80V (UDN-2983A)	50V (UDN-2982A) 80V (UDN-2984A)	85V	85V
Source Current	500mA	500mA	500mA	500mA	40mA	40mA
No. of Drivers	5	5	8	8	8	8
Input	6-15V	5V	5V	6-15V	5V	6-15V
Engineering Bulletin	29309		29310		29313	

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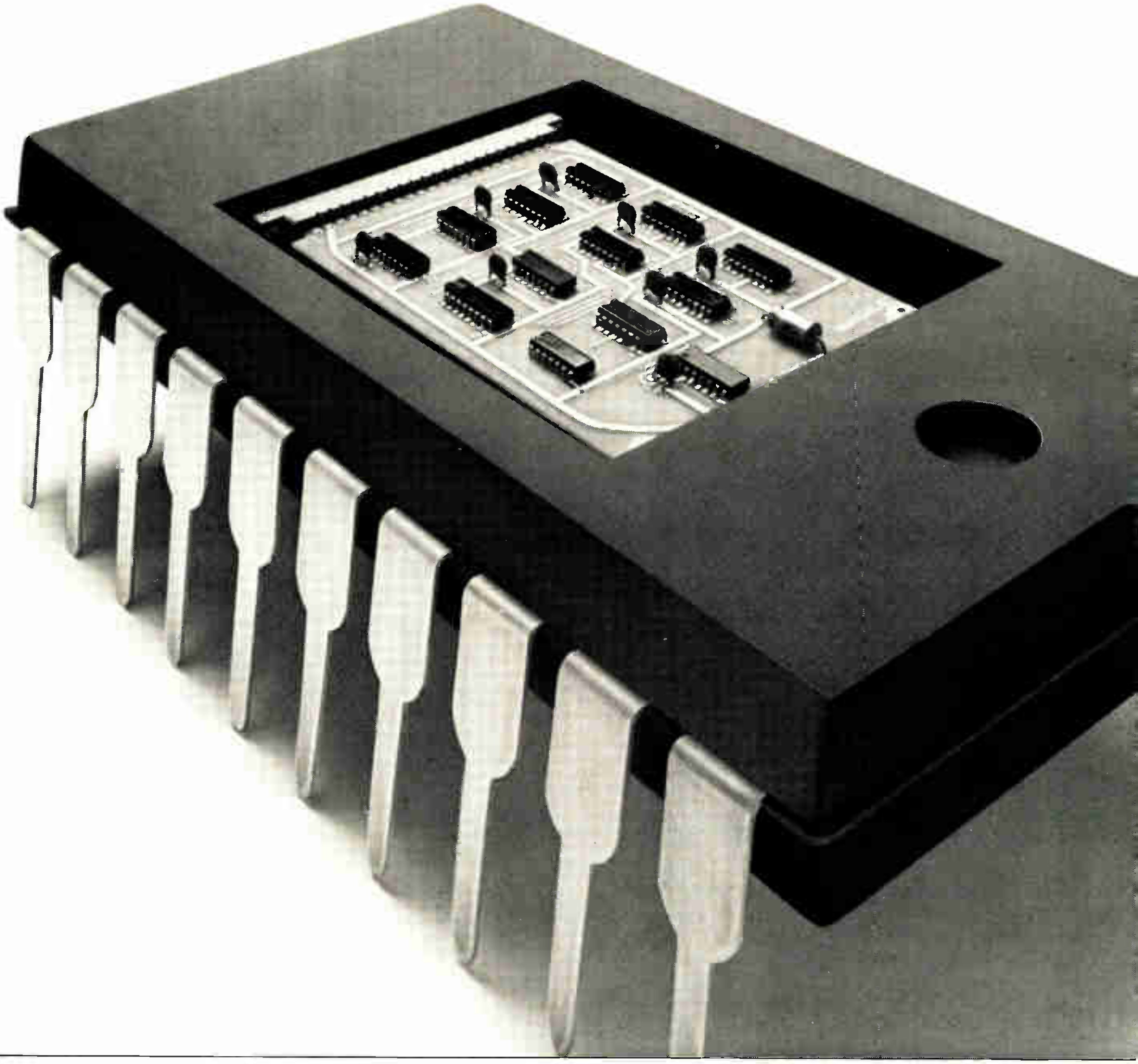

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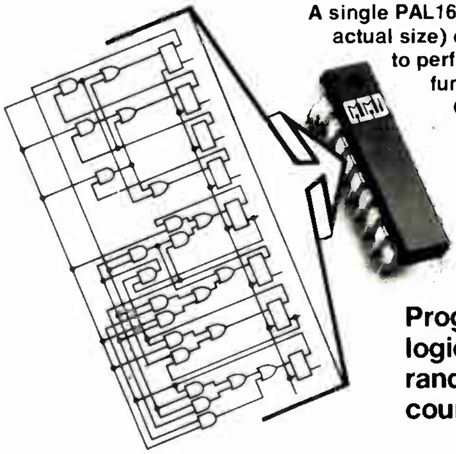
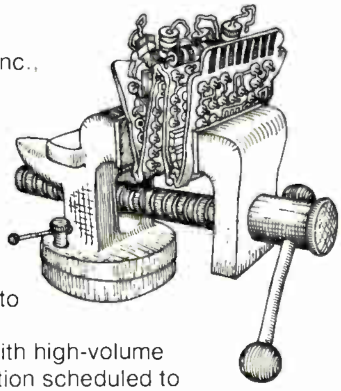


A single PAL16R8 (package shown actual size) can be programmed to perform all the logic functions shown here. Other devices in the PAL family offer comparable efficiencies.

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



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

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

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

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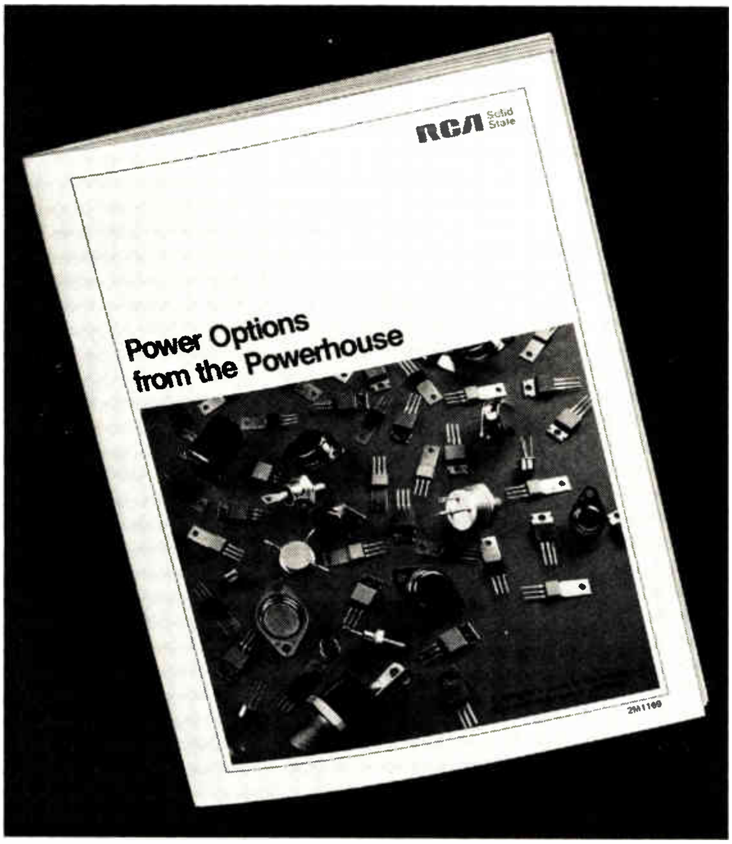
A new source for the C106. This popular 4A general purpose SCR and corresponding sensitive-gate triac are now available from RCA. In the economical, easily mounted 3-lead Versatab package.



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G4000	50-400	15	3	Gate Turn-off SCR	TO-220
S860	50-600	100	200	Gen. purpose SCR	½" stud
S5800	100-600	5	50	Fast switching SCR	TO-220
C106	15-600	4.0	0.200	4-amp gen. purp. SCR	TO-202
T2320	50-400	2.5	3-40	Sensitive-gate triac	TO-202
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Circle 62 on reader service card

International newsletter

Eastern Bloc starts new series of small computers

The Soviet-led Comecon Bloc is embarking on a multination development program of a series of small computers. East European sources say what is involved is a family consisting of the SM-1, -2, -3, and -4. **Details are sketchy, but the latter pair is known to be coming from the Moscow-based Institute for Electronic Control systems.** To enter production shortly in Moscow and Kiev, the SM-3 is said to handle 250,000 operations per second. The SM-4, still in development, is reported to have twice that capability. The new effort parallels the Comecon program for the ES (Ryad) family of medium-sized and large data-processing systems [*Electronics*, May 24, 1973, p. 76].

ESA moves closer to launching its own satellites

Europe's satellite-telecommunications program is a step closer to reality after several decisions by the European Space Agency early this month. Delegates gave the go-ahead to the European communications satellites ECS-1 and -2 (Germany reserved its acceptance until later this month because of a ministry changeover). They also approved a second marine communications satellite to join the Marots launched by an American rocket. **Yet another decision is to study ways of turning the heavy direct-broadcasting satellite experiment into an operational program,** despite the lack of a decision on building and launching the test H-SAT. Coming up next week: a decision on whether to support the production phase of the French rocket Ariane, which would carry the satellites. If all goes well, launchings could begin in 1981.

ICL readies 1-ns, 400-gate standard logic array

Britain's International Computers Ltd. will be using standard logic arrays, customized by a double-layer metalization, alongside fully custom circuits in its next generation of computers, scheduled for the 1980s. Now being readied is **a 400-gate emitter-coupled-logic standard array accommodated on a 30,000-mil^2 chip with gate-to-gate speeds of 1 ns.** Plessey Semiconductors provided process know-how based on its speedy process 3, in return for which ICL made available its extensive computer-aided-design software capability. Circuits developed in West Gorton will be manufactured by Philips, Plessey Semiconductors, and Motorola.

Algeria ready to produce TVs, radios, recorders

Algeria will start to manufacture TV sets, radios, and tape recorders this summer, with production of components already under way at a new plant at Sidi Bel Abbes, about 30 miles south of Oran. The first finished goods—black-and-white TV sets—are expected to hit the market by midyear. **Eventually the factory will have 5,000 workers who will turn out 250,000 TV sets, 500,000 radios, and 50,000 tape recorders a year,** says A. S. Nazerali, international director for General Telephone and Electronics. GTE built the plant under a $250 million contract that includes running it for three years and training Algerians to operate it on their own.

Bubble memory to act as page composer

An optical flight-data recorder being developed by researchers at Plessey's Allen Clark Research Centre, Caswell, Northants., under a Ministry of Defence contract, uses a magnetic-bubble page composer to image data at high speed onto film for subsequent analysis on ground. It employs holographic techniques, which Plessey says offers far higher densities and recording rates than conventional magnetic techniques and leads to a major reduction in the size of the airborne recorder. The instrument's bubble memory images data onto film at a rate of 1 million bits per second by exploiting the Faraday effect: **the presence of a magnetic bubble rotates the plane of polarization of an illuminating laser source until it is coplanar with the analyzer plate.** Each magnetic bubble thus acts like a light valve. The serial-shift-register organization of the page composer means that a complete page of data can be read serially into the bubble memory and recorded in one short exposure.

Packet-switching net to use 8080 processors?

Under development by the British Post Office is an experimental multi-microprocessor packet-switching exchange using Intel 8080s. It is intended for possible use in the 1980s on the public packet-switching network, **which is to follow the year-old experimental packet-switched service** (EPSS) **in a year or so.** The present EPSS system is based on a network of 10 Ferranti 700E minicomputers, and the public network will go into service with minicomputers.

Color TV camera from Sony uses CCD chips

Sony Corp. has an experimental color TV camera using three charge-coupled-device chips, one for each primary color. The company expects to be able to start sales of a consumer version during the autumn of 1979 at a price in the neighborhood of $1,000. **It will probably be somewhat lighter than the experimental unit's approximately 2-kg,** including built-in camera control circuits, zoom lens, and electronic viewfinder. Each CCD chip contains an array of 226 by 492 sensing elements on a 10.3-by-9.1-mm silicon substrate.

STC to test telephone lines with microprocessors

Second in Standard Telephone and Cables Ltd.'s a range of microprocessor-based telecommunications products is a remote line-testing unit built around General Instrument Microelectronics' LP 8000 microprocessor. By siting the remote units close to the line under test, the characteristics of the intervening network are eliminated from measurements of subscribers' line leakage, capacitance, voltage and other line parameters. The company has launched OPAS, for operator-position assistance systems, with 13 Intel 8080s [*Electronics*, Dec. 8, 1977, p. 3E or 55].

Addenda

In a bid to stunt Far Eastern imports, Philips is producing color-TV tubes **having 90° deflection angles, with first deliveries in the autumn.** The Dutch firm will continue to sell its 110° tubes, the type that predominate in Western Europe. . . . Anticipating a big market in industrial applications for one-chip microcomputers, **Siemens AG will start volume production later this year of the 8048 family.** As part of the second-source agreement with Intel, the West German firm will also turn out the 8085 microprocessor family. . . . Toshiba is transferring sales for its ACOS medium-sized and large computers to a joint-venture company with its partner, NEC, which makes and sells about 80% of the ACOS machines. **Toshiba says it will continue development and manufacturing** of the line and of other computers. . . . Hitachi's fast 4-k static complementary-MOS RAM [Electronics, March 2, p. 41] **will be available in samples this summer.** When production starts rolling, the per-chip price in lots of 10,000 will be only $8.33, the company says.

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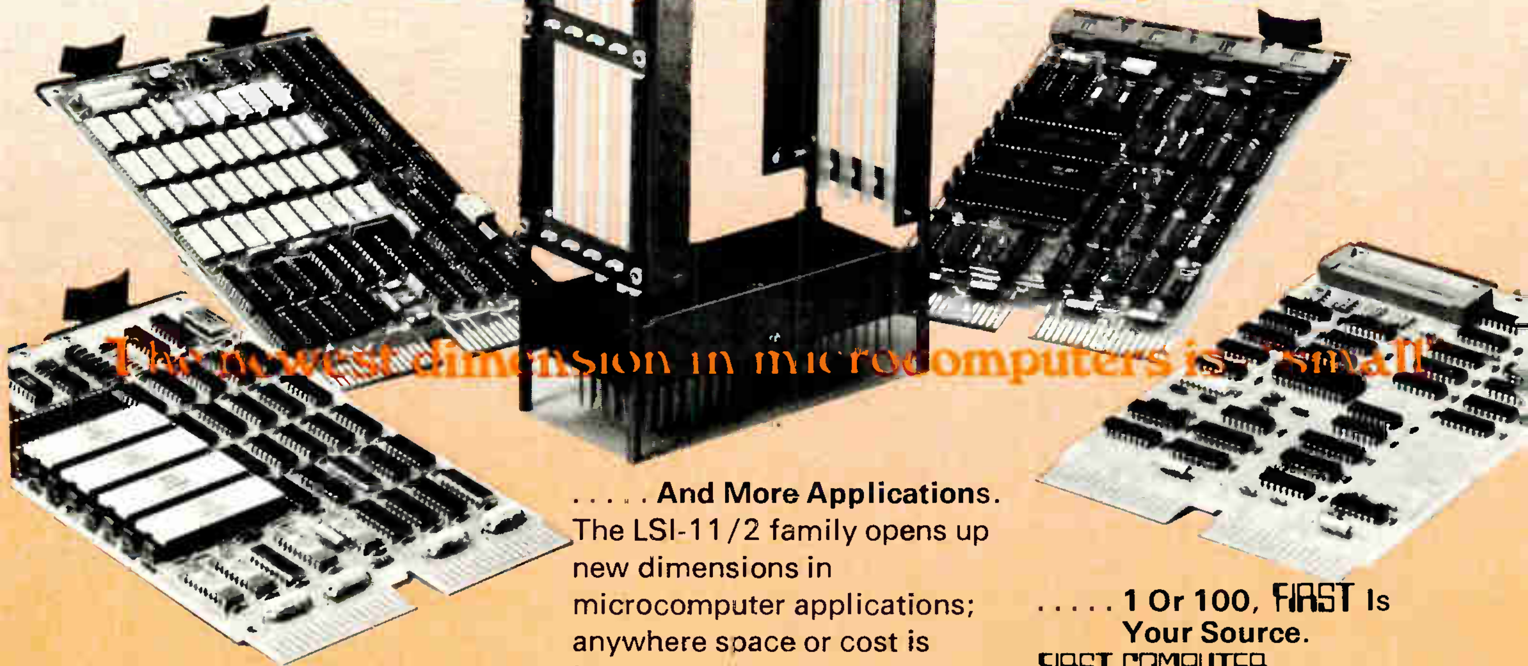
Announcing The Latest From DEC, The LSI-11/2.



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Facsimile system ready for crucial coding choice

When world standard is set in 1980, Matsushita machines will be easy to retrofit, if necessary

The makers of high-speed facsimile systems are facing a crucial deadline: in 1980, the international telecommunications consultative committee, CCITT, will choose among the firms' various coding formats for an international standard service that delivers a 210-by-297-millimeter page in less than a minute. Thus they are designing their new machines for any necessary retrofitting to the standard while keeping the capability of communicating with machines that continue to use the present coding.

At the forefront of the latest developments in high-speed fax systems is Matsushita Graphic Communication Systems Inc.'s versatile new UF-2200 [*Electronics*, International Newsletter, Feb. 16]. It uses the industry-government jointly developed Admix redundancy-reduction coding scheme to provide a very competitive transmission time. It also offers many microprocessor-controlled auxiliary functions (see "From one scan, many copies").

Already the Japanese government is using the Admix digital-coding algorithm in its internal communications system. The ministry of posts and telecommunications developed it jointly with Matsushita, Fujitsu, Nippon Electric Co., Toshiba, the phone company, the public broadcast network NHK, Japan National Railways, and several universities. This scheme is also found in Fujitsu commercial faxes, which Matsushita manufactures, while Nippon Electric machines use a similar scheme with a slightly different algorithm.

Faster. Redundancy reduction schemes cut transmission times because they reduce the amount of data needed to send patterns of white or black that they pick up from scanning across the document. In the UF-2200, microprogrammed logic and 200 bytes of memory perform the redundancy reduction, while a two-chip version of the F8 microprocessor performs protocol at the beginning and end of the message, error correction, multiple-copy control, and other support functions. The change to microprogram-

From one scan, many copies

The new Matsushita UF-2200 facsimile machine is not only fast, it also boasts a number of auxiliary functions made possible by its incorporation of a Fairchild 8-bit F8 microprocessor.

Perhaps most striking is its ability to send the same series of documents sequentially to as many as 28 selected locations, with a timer starting operation after rates are reduced at night. Such sequential transmission is superior to simultaneous transmission because its speed can be optimized for the transmission line in use, and error correction may be performed as necessary. Also, the Nippon Telegraph and Telephone Public Corp. permits simultaneous automatic dialing of only two numbers at once, and one or more receiving stations may be busy.

The digital memory that stores the facsimile signal after redundancy reduction makes it possible to send the document to many locations, even though the document has been scanned and dropped into an out basket. The memory contains 72 16,384-bit MB8116 dynamic random-access memories. The chips usually can store the data from two or more documents, and they have enough capacity for at least one document of almost any conceivable type. An optional 576 chips increase capacity by 16 more pages if a large quantity of documents must be sent.

On the receiving end, the memory makes it possible to turn out an extra two copies of the incoming message during the 10 seconds it takes for the protocol before receiving the next message. Such a copy feature has not been available on facsimile receivers.

Facsimile pickup is by a linear array of 2,048 metal-oxide-semiconductor sensors for a 256-millimeter width. The array is not as wide as that, so a lens system projects the document onto the array. During transmission, an automatic density-level control adjusts line pitch to match the document, or portion of the document, and gives the best compromise between send time and ease of reading. Circuits in the transmitter automatically sense a high correlation between successive lines when sending large type or handwritten documents and switch to a 3.85-line/mm mode. Since this would give low-density printout, each received line is printed twice at the minimum 7.7-line/mm pitch. Slanted lines become steps, but density and legibility are greatly improved.

TRANSMISSION TIMES FOR FACSIMILE CODING SCHEMES					
	Modified Huffman	Admix	EDIC	RAC	DEX
Density of 8 dots/mm by 4 lines/mm	57.3s	48.1s	48.9s	51.2s	51.2s
Density of 8 dots/mm by 8 lines/mm	114.5s	89.6s	89.5s	93.8s	96.7s

med logic makes for much less hardware than with the random logic used in earlier machines.

For the CCITT standard, the U. S. and some European countries are promoting one-dimensional digital coding with a modified Huffman code, which is the algorithm for sending the data gleaned from scanning one line with a typical line-to-line pitch of 3.85 millimeters.

However, the Japanese favor two-dimensional schemes because they provide faster transmission at the high line densities needed for the Japanese characters. Such systems either process two lines simultaneously and transmit them together, or they compare the line just sent with the next one, sending data only for those segments of the second line that differ from those immediately above. Both types are called two-dimensional because they compare information in two directions.

The chief engineer at the Tokyo subsidiary of Matsushita Electric Industrial Co. says a modified Huffman scheme also requires more read only memory for look-up tables and so is slightly more expensive. Thus it has no special advantage from a system standpoint.

Comparison. The average transmission times for eight standard CCITT documents, sent at 4,800 bits per second, are given in the accompanying table, which includes two more Japanese codes and that used by Burroughs subsidiary Graphic Science Inc. for its high-speed decision expediter (DEX) system.

EDIC (for edge difference coding) is a two-dimensional scheme developed by the Nippon Telephone and Telegraph Public Corp., while RAC is the relative address coding scheme developed by the Kokusai Denshi Denwa Co. for use on international lines [*Electronics International*, Feb. 17, 1977]. Both EDIC and RAC are relative schemes that can use a given line as reference for more than one immediately succeeding line. They operate slightly faster when processing four lines sequentially, but as this requires more repetition of information during automatic error correction, two-line processing may be optimum for phone lines.

There is a good chance the Japanese government will propose either EDIC or RAC, which were developed after Admix, to the CCITT, but Matsushita professes not to be worried. A spokesman says that Admix is more efficient for use on the standard switched telephone net.

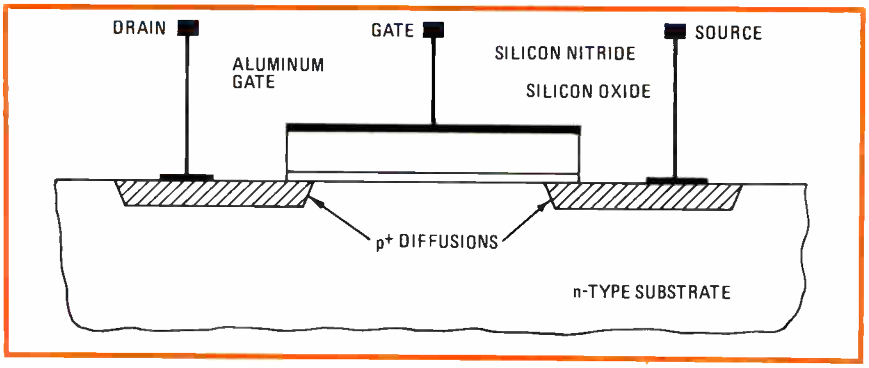
However, the company is not putting all its eggs in one basket. In its fax machines, the digital signal is expanded during readout from the memory (just as it is at the receiver) and reencoded before transmission. Should the CCITT settle on another coding scheme, Matsushita systems could be modified by the addition of printed-circuit boards carrying the hardware for the new algorithm. Then Admix would be used for storage and the international scheme would be used for transmission. The modified machines could still transmit to older Admix units that could not be updated economically. ☐

Great Britain

Plessey logic family combines MNOS and MOS for long data retention

As semiconductor devices acquire a wealth of new applications, the need for long-term nonvolatile data retention is growing ever more critical. A good bet for such storage, thinks Plessey Semiconductor, is its mix on the same chip of metal-nitride-oxide devices for electrically alterable data storage and metal-oxide semiconductors for logic functions.

Thus the British firm is plunging into this still uncharted market with the first three products in its Novol range [*Electronics*, March 2, p. 63]. They are a quad latch, a four-decade counter, and a 64-by-4-bit memory, all of which operate from standard 12- and 5-volt supplies. They are



No-power storage. With an MNOS transistor such as this one, data may be stored for long periods without power. Plessey combines these devices with conventional MOS logic.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intended for a variety of military and civilian applications.

Plessey's process is essentially a conventional p-channel metal-gate process, with an important addition: variable-threshold MNOS memory transistors may be fabricated alongside conventional fixed-threshold MOS transistors by one more masking operation that lays down a thin nitride layer. The MNOS transistor thus has a gate dielectric consisting of a layer of silicon oxide and a thicker layer of silicon nitride on top (colored in the illustration).

Injecting charge. By applying suitable voltages to the terminals, it is possible to inject charge through the thin oxide layer. The charge subsequently becomes trapped at the oxide-nitride interface and modifies the threshold voltage of the transistor. Since the injected charge is not affected by surface leakage, it can be detected as a threshold difference over a very long period. This difference can be used to represent high and low logic states.

However, write and erase operations with MNOS devices require a nonstandard voltage between 30 and 40 V in order to push the charge through the oxide layer. So Plessey engineers first juggled the device parameters to achieve an operating voltage that will not damage the on-chip p-MOS devices. Then they incorporated an internal free-running oscillator, which generates a −35-V supply from the −12-V V_{GG} supply while requiring only a single external reservoir capacitor.

The result is a logic chip running from standard supplies and having inputs and outputs compatible with transistor-transistor-logic and complementary-MOS requirements. In the absence of applied power, a data retention time of at least one year is guaranteed over the temperature range of 0°C to 70°C. Also guaranteed is a minimum 10^6 write cycles.

Products. The first Novol product to reach the market will be a nonvolatile 4-bit data latch, the MN9102, which uses MNOS transistors as memory elements. Data applied to the four inputs is written into the memory when the save control is taken to logic 0. The stored data is automatically applied to the output whenever power is applied.

Next will be the MN9105 four-decade counter implemented in standard p-channel MOS technology with a nonvolatile MNOS output that ticks over at 0.5 megahertz. If a count number is to be retained, operation of the save control will load the 4-digit count into the MNOS latch in 10 milliseconds. This count number can be subsequently read in 2 to 3 microseconds.

The Swindon, Wiltshire, company has already applied its process in the military market where loss of data due to power failure could be catastrophic, says Kenneth Bradshaw, sales and marketing manager for the United Kingdom. Now he foresees a large number of commercial applications, for equipment that is powered intermittently and that requires storing of only small amounts of variable data or input/output latch states from day to day.

Examples cited for the quad latch include its use as a replacement for latching relays, as a nonvolatile add-on to counters in coin mechanisms and other systems, as security code storage, and as a last-channel memory for digital tuning. While dielectric fatigue from the write operations ultimately limits the lifetime of MNOS devices, the applications that Plessey has in mind are highly unlikely to approach that number of write cycles.

The 64-by-4-bit memory, the MN9410, has full decode driving and control circuitry on chip. Moreover, such standard MNOS/MOS products are not all that Plessey has in mind. Where there is a potential for large volumes of custom circuits, the firm will be in there pitching. Such work accounts for over half of its turnover. □

West Germany

Solid-state digital television frame store provides moving scenes, mirror-image effects

Yet another stepping stone on the way to the all-digital television studio is the digital frame store for producing special video effects. One of the latest solid-state single-frame stores to come on the market comes from West Germany's Bosch-Fernsehanlagen, a division of Robert Bosch GmbH. As part of a studio's mixing console, the single-frame store can be addressed to provide a number of video tricks. Moreover, the digitizing technique represents a new departure in TV applications.

Designed around a random-access memory, such a video store provides what is called the quad split, which compresses the image to a quarter its usual size and displays it in each of the four quadrants of the broadcast picture. Any or all of these quadrants may be frozen to provide a still picture. Moreover, the first quad-split picture may be compressed again to appear in one or more quadrants.

A number of mirror-image effects can also be achieved. With these, explains Hans Peter Maly, an engineer at the Darmstadt-based division, a picture can be reversed horizontally and inverted vertically. Thus the observer sees two mirror images, one reversed from side to side and the other inverted from top to bottom.

The video effects are realized by the random access to the individual storage cells. The store uses two address generators, one to generate the write-in address in accordance with the TV raster and the other a controllable generator for the desired sequence of the read-out addresses. For example, to obtain the horizontal mirror effect, the sequence of addresses in each line of the picture is reversed by inverting the individual addresses.

To digitize the color video signal before loading it into the store, the Bosch designers are using a pulse-

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code-modulation technique called component PCM encoding. The video signal is separated into its luminance and chrominance components for individual encoding. Compared with composite PCM encoding, a technique that encodes the complete video signal and that is used in other digital frame stores, component encoding makes possible more digital video effects, Maly says.

In the Bosch scheme, the luminance signal is separated from the video signal by low-pass filtering. The chrominance component is obtained by comb filtering and subsequent demodulation. After separation, each component is sampled and quantized, and the resulting digital information is fed into the store, an array of TMS 4,096-bit RAM chips.

One field. Since the memory will frequently store still scenes—that is, freeze individual phases in a sequence of movements—its designers considered it practical to store the information of only one of the video frame's two fields. Storing both fields' information would result in flicker of the still picture, because two consecutive fields of a complete frame generally contain different phases of a movement, Maly says.

In the memory read-out process, the missing information of the second field comes from repeating the first field's stored information, producing the complete frame. The resulting interlace jitter at the vertical-signal transitions is eliminated by averaging adjacent lines of the stored field to obtain the lines for the missing field. This operation is simpler with component encoding than with composite encoding, Maly explains. It is impractical to add two adjacent lines with different subcarrier phases.

So far Bosch has readied special-effects stores for both the European PAL and the North American and Japanese NTSC color-TV standards. To cost less than $24,000, the first units will be delivered around mid-year. There is a version in development for the Secam color-TV standard used in France, most of Eastern Europe, and those parts of Africa not on the PAL standard. □

Japan

Portable TV vidicon has single pickup

The latest launch in portable TV cameras for use with a video cassette recorder is coming from Hitachi Ltd., which is introducing a lightweight unit with a new version of its trielectrode single-pickup tube.

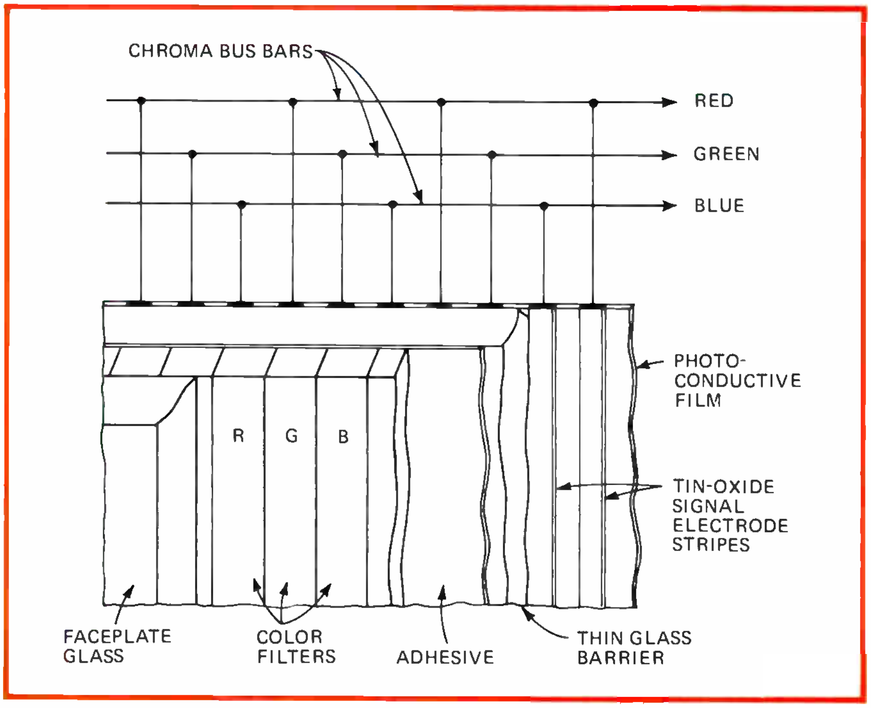
Simultaneous direct generation of the three primary colors greatly simplifies television camera design, a Hitachi spokesman says, as well as eliminating a variety of problems in such areas as registration and shading, which plague both multitube versions and other single-tube types. It is the only trielectrode vidicon on the market, although RCA Corp. did work on the concept 20 years ago.

The tube design is essentially unchanged from the prototype developed at the firm's central research laboratory [*Electronics*, Jan. 10, 1974, p. 6E]. An earlier version is used in a $3,700 broadcast camera that went on the market in October 1975, but improvements in the photoconductor target have increased sensitivity while cutting the image's decay-time constant.

2,000 a month. Most important of all, subsidiary Hitachi Denshi Ltd. has geared up to produce 2,000 1-inch-diameter consumer camera tubes a month initially by installing new equipment, much of it automatic. Also helping to reduce costs are picture-quality standards realistic for consumer use though perhaps too low for broadcast applications. While the tube will be available to other camera makers, prices are not set yet.

The single-pickup tube (see diagram) that directly generates the three primary colors simplifies camera circuits and eliminates some heavy and bulky components, such as a glass horizontal delay line. Circuit design techniques have improved since the development of the broadcast camera, so the number of electronic components is down from 750 to 550.

The Hitachi camera will go on sale in Japan at the end of the month for $1,008. The electronic viewfinder is optional, at $208, and a 6× zoom lens costs another $212. Export plans are not set—Hitachi has yet to export even the basic VCR. □



Three in one. Hitachi color TV camera for VCR uses a single-pickup trielectrode tube.

Seven points to consider before you buy your small computer.

In this magazine, alone, there are probably a dozen ads for small computers. New companies are breaking ground like spring flowers.

How, then, do you determine which computer offers the features you need most...at the price you can afford?

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Many buyers of small computers are in for a rude awakening when they have to spend additional money for interfaces.

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Where are they located?

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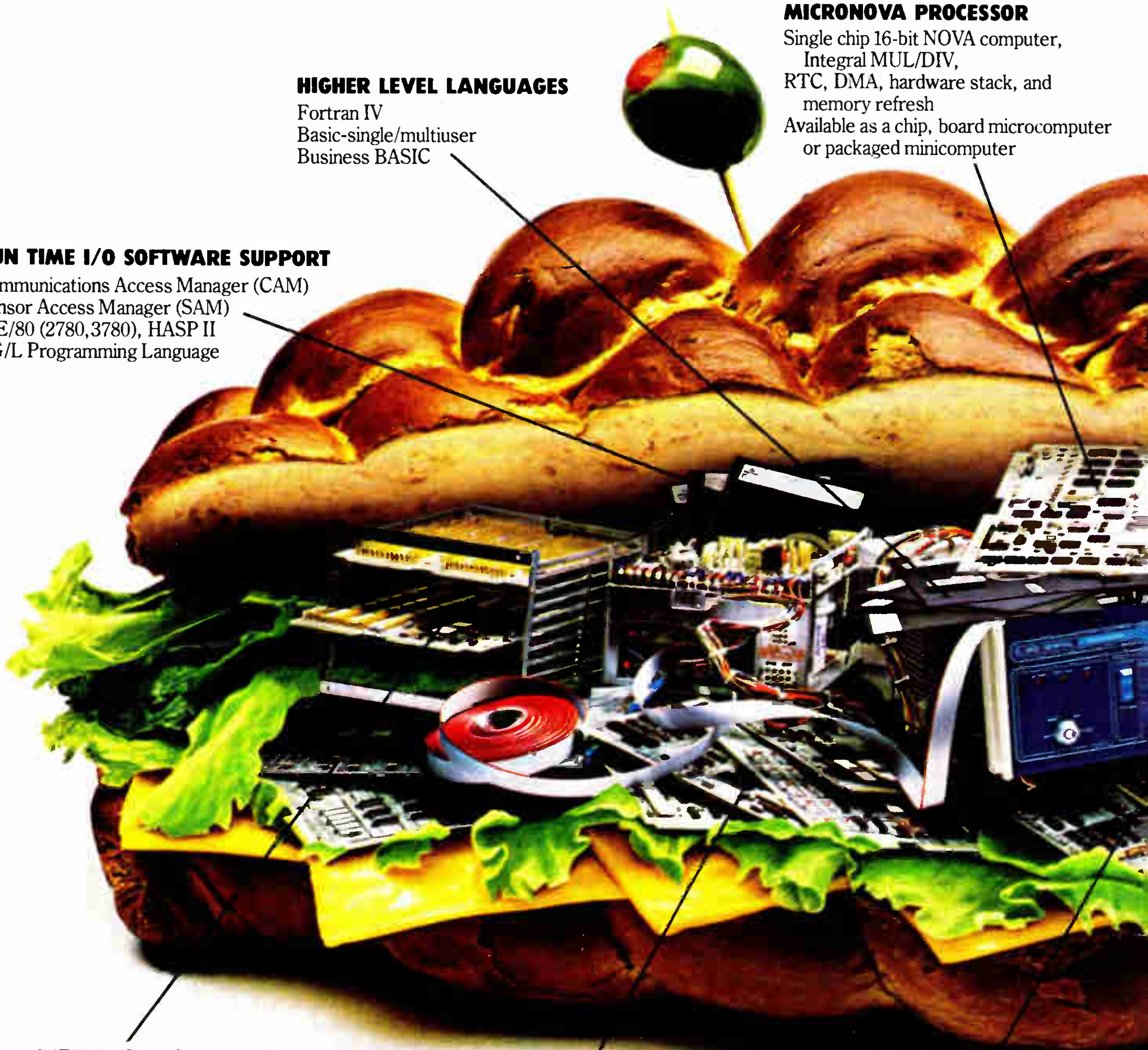

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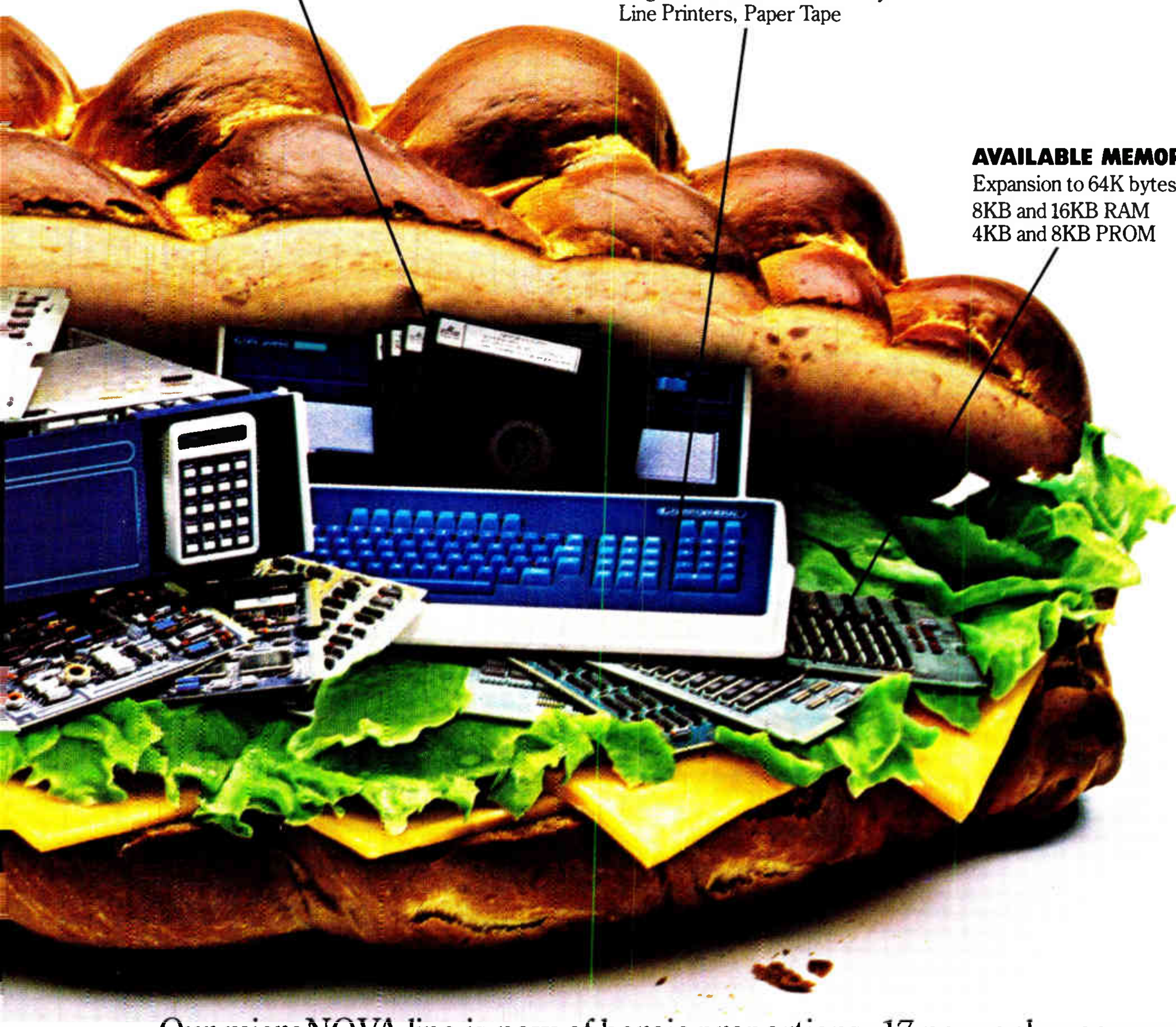

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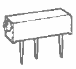

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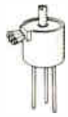

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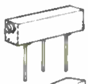

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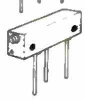

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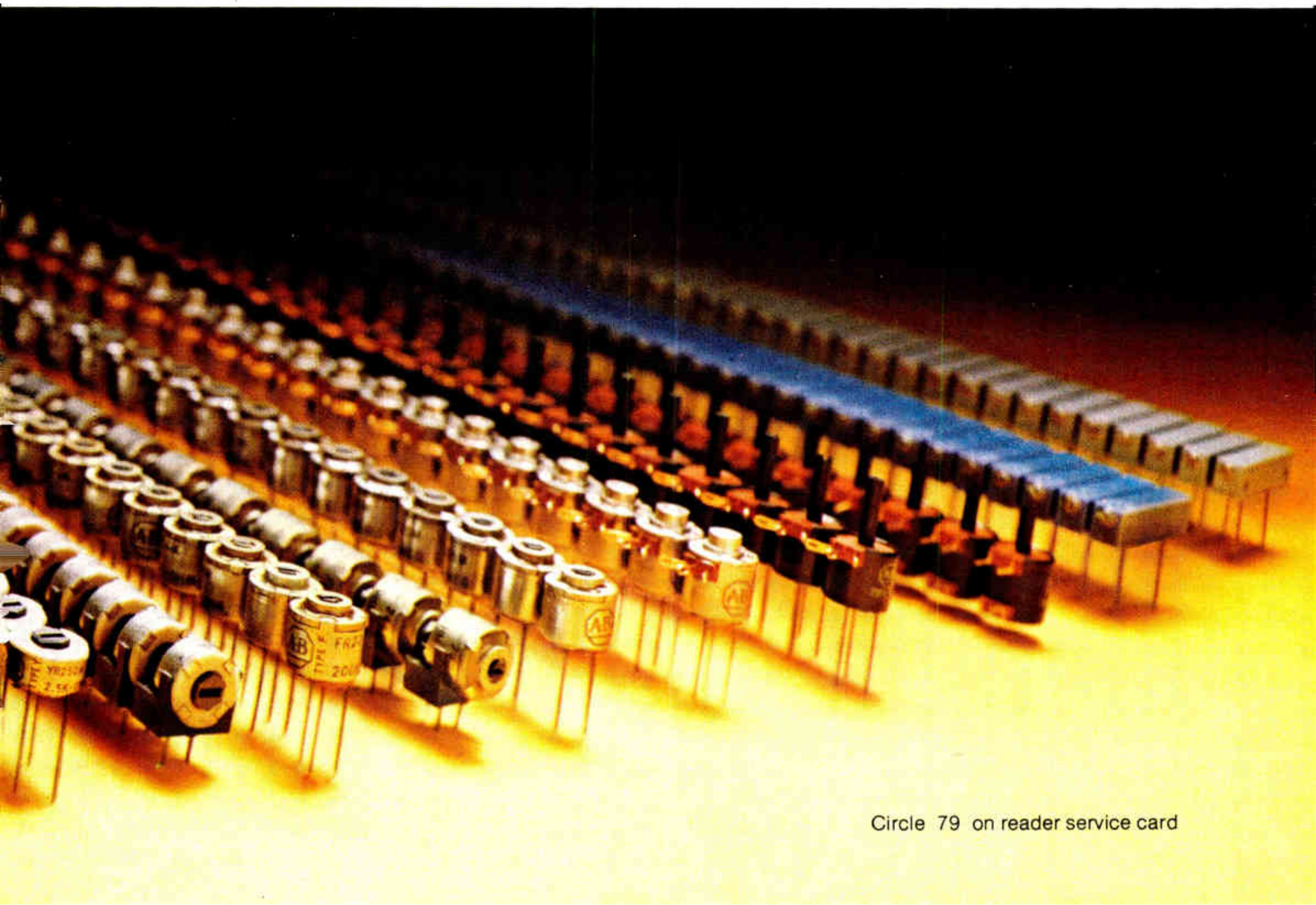

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Automatic test generation

No Longer the Impossible Dream.

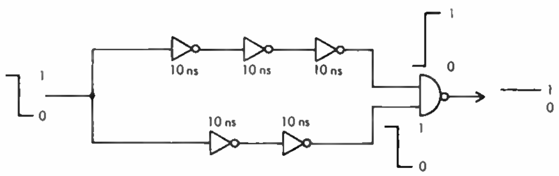
Automatic test generation, long the dream of manufacturers hard-pressed to keep up with the volume and complexity of circuit boards, became a commercial reality with the introduction of Teradyne's P400 Software Package. An offspring of the D-LASAR program originally developed for military and scientific use, the P400 has now been field-proven at a number of electronics manufacturing plants. The P400's success has surprised many in the industry who were convinced that total "ATG" could never succeed commercially.

The skepticism was understandable. Designing an ATG program to serve a wide variety of customers and circuits means doing battle with some ferocious testability problems.

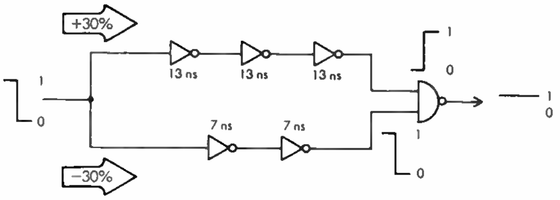
But a barrier is a barrier only until you identify it, characterize it, and design a strategy to deal with it. So it is with testability problems. Once you find out what they are and where they are, they become a lot less frightening.

To do the finding out, the P400 employs a "preprocessing run" designed to flag all asynchronisms, race conditions, uninitializable circuits, and other problem areas before the work of generating test patterns begins. Then, with the hazards all out in the open, the P400 neutralizes some of them, maneuvers around others.

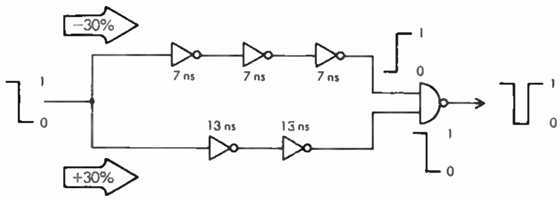
By way of illustration, suppose that the P400, during its "preprocessing run," comes across a circuit like this:



Here lurks the possibility of a race condition if the gate delays are much more or less than the nominal 10 nanoseconds. To investigate, the P400 inserts delays corresponding to worst-case combinations of component tolerances. Assuming that the user-selected tolerance is ±30%, the P400 first sizes up the circuit with +30% tolerances in one branch and −30% in the other, thus:



Here the transition traveling the bottom path arrives at the nand gate first, as in the nominal case. No problem. Then the P400 reverses the + and − tolerances to create the other worst-case condition:



Here's trouble: The signal traveling the top path arrives first at the nand gate, where it could produce an unwanted pulse. The P400 has uncovered a race condition, which can now be easily addressed in the generation of the test program.

To protect test results against the effects of race conditions, the P400 automatically staggers inputs where the race is caused by two inputs and generates "unknowns" where it is caused by a single input, as in the above case. (Lest there be a mindless proliferation of unknowns, the P400 considers only those races involving sequential logic.) Labeling any gate outputs as unknown does lessen fault coverage, but it also keeps bad data out of test results. And the fault coverage can be restored either by test points or straightforward programmer intervention, with P400 messages pointing the way.

What the system does for races, it also does for latches that can't be initialized and for a number of other testability problems.

The proof of the pudding is in the eating, and the P400 has now been thoroughly digested on boards containing ECL, CMOS, TTL, and just about every other popular device family. The results show substantial savings in programming time, plus better fault coverage. Most important of all to many P400 users is the quick availability of programs needed to bring new products to market. Test programmers are precious these days, and the company that depends on help-wanted ads to solve that problem will likely be outrun by competitors who generate their programs automatically.

TERADYNE

View from Paris show is multihued

European components picture reflects changing coloration of varying politics and growth rates on the Continent

by the European editors of Electronics

Like a kaleidoscope with warped mirrors, the $7.3 billion Western European components markets are showing strange patterns as manufacturers prepare for next month's Paris components show.

As always, technological evolution is changing the basic mix of bits and pieces of the hardware that goes into these markets. But this basic pattern gets distorted when mirrored by a country's economy, and the economic outlook for the year ahead varies greatly among Western Europe countries—from a little better than 3% growth for West Germany down to no growth at all in Sweden. What's more, political upheaval in two major markets—France and Italy—could sour prospects there (see p. 86).

So the thousands of components suppliers and their equipment-making customers that will head to Paris for the annual Salon International des Composants Electroniques (April 3–8) will come as much for a reading on market prospects as for a look at what's on the stands of some 1,200 companies from 30 countries.

Not surprisingly, they will almost certainly return home convinced the microprocessor market is set for a solid year. Other semiconductor markets should also hold up well, although it does not look as if they will grow as much as they did in 1977. "The key question is whether to expect a shrinking market in 1979," thinks Piero Martinotti, European marketing director for the Motorola Semiconductor Group.

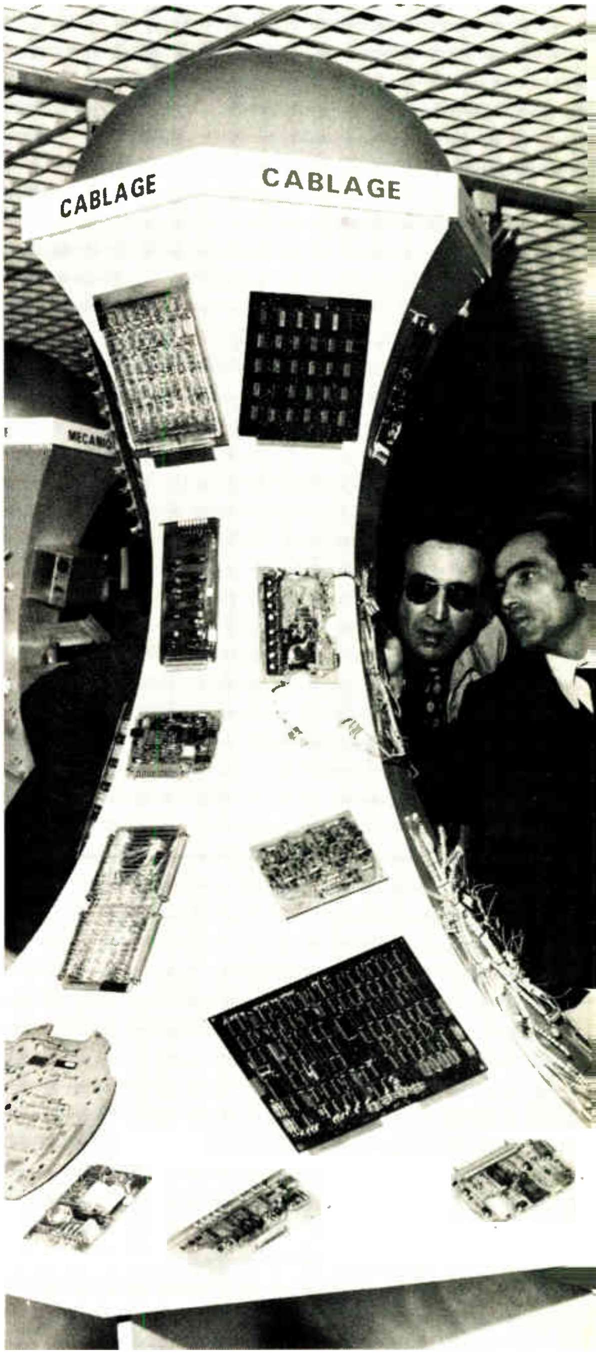
France. Anyone involved in the French components markets surely will still be trying to figure out at show time what the impact of the mid-March legislative elections will be. Pollsters give the Left coalition a slight edge, but the grouping that backs President Giscard d'Estaing could well come back. As a result, there are all sorts of scenarios.

One, based on the Left winning and carrying out its promise to nationalize the major professional-electronics producers and their subsidiaries, foresees a slowdown there but a burst for consumer electronics because of higher wages for workers. Another, assuming the Center-Right gets back in, postulates an upswing in investment by business, continued heavy spending for telecommunications, and a strong but not booming consumer-electronics market.

Uncertainty. As Pierre Mestre told a late-February press conference announcing the components industries' results for 1977, "there is a wide band of uncertainty for 1978." Mestre is head of the components operations of Thomson-CSF and also is president of the French trade association for tube and semiconductor producers.

Last year, he pointed out, French components makers had a fairly satisfactory year, turning out some $1.445 billion worth of hardware. (French market figures are calculated at the rate of 4.7 francs to the dollar.) That works out to a gain of 9% over 1976. Barring cataclysmic changes, Mestre figures the year ahead will see components output in France move about the same, or nearly so.

One key is color television, and the



Board meeting. April in Paris means the components show. These attendees inspect circuit boards at last year's show.

market looks solid. At the end of 1977 only 5 households out of 18 had color sets. As a result, color TV sales to dealers this year are expected to rise to 1,420,000 sets, compared with 1,335,000 last year.

Good performers. There are other pluses. "The computer sector is doing remarkably well," says Roger Sallebert, director general of the Fédération des Industries Electriques et Electroniques. Output of professional electronics, such as radar, broadcast equipment, and avionics, should stay high through this year and next because of big order backlogs. But, Jean Pierre Bouyssonnie, president of Thomson-CSF and a vice president of FIEE, warned last month as the trade group announced its 1977 results, "there has been a slowdown in orders for professional electronics from the conservative Arab countries."

Needless to say, the overall outlook is a mix of results of leaders and laggers. Output of integrated circuits bounded up by a third last year, for example, making it the French market leader. At the low end came passives, with a gain of only 7%. "It could be better in 1978," says Alex Clément, president of hardware-producer SECRE and of the trade association for passive components as well.

Germany. For the semiconductor people, anyway, confidence will be the prevailing attitude among the 145 or so German companies that will be pitching their products in Paris. Business through the end of this year will stand up well.

"There is hardly a sector that is not performing positively," observes Dirk G. Vogler, manager of marketing administration at Texas Instruments GmbH. What with "some new sectors expected to go all out for electronic devices in 1979 and beyond, the medium-term outlook is not bad either," says Günther Katholing, product manager for consumer ICs at Siemens AG. Vogler pegs semiconductor market growth in West Germany this year at less than 10%, a far cry from what it was a few years ago.

Producers of computer mainframes and small electronic data-processing systems will also keep semiconductor merchants busy, as will manufacturers of other professional electronics gear, marketing people say. And at long last, they add, the telecommunications sector is turning into a strong components buyer because the post office is loosening its purse strings after years of keeping the lid on spending for electronics.

All told, except for price declines and some competition from Japanese producers—in memories, for example—German semiconductor makers have little to worry about through the end of this year. However, "5% growth in 1978 won't materialize," says a marketing man at the Roederstein group, a big manufacturer of capacitors and resistors. "It now looks like 1978 will be a zero-growth production year." This stagnation is partly a result of declining exports, he says.

But the Roederstein man is hopeful for 1979, and definitely so are semiconductor market people. "The long-dormant automobile sector will open wide next year," predicts Siemens' Katholing. He sees a breakthrough for electronic ignition systems coming in Europe in 1979 and a big spurt in demand for engine-function monitoring devices. Together with the advent of other automotive equipment, that will finally turn the car sector from a piecemeal customer to a high-volume buyer.

Britain. It is not quite the same story in Britain. There, most sectors are performing as observers expected, particularly the color TV market. It has been stagnant, and

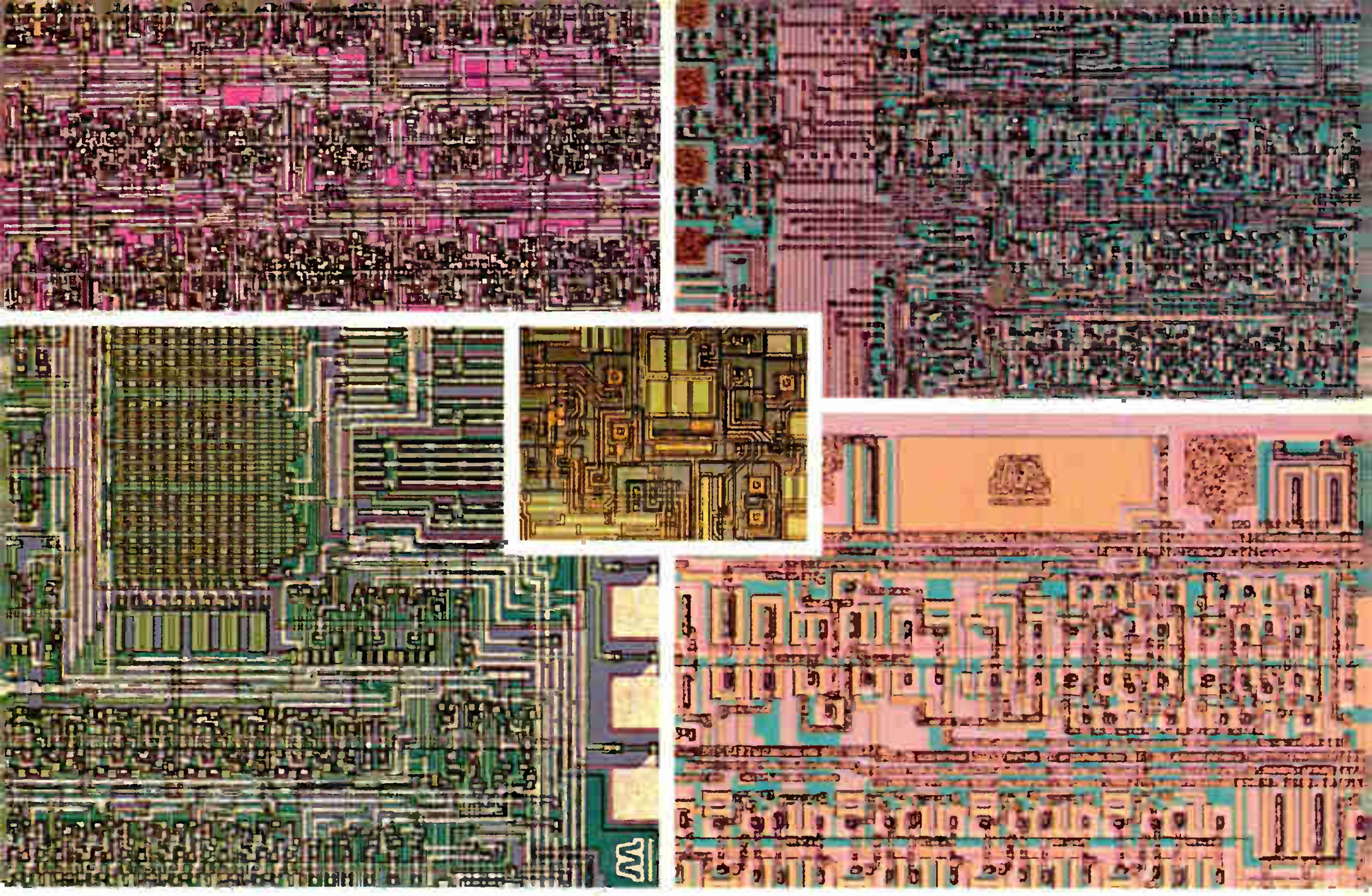
Floor show. Here is a small part of the exhibition at the Paris components show last year. This year it will run April 3–8.

set-makers' orders to their components suppliers show it. The improvement over last year has been only marginal, reports John Gregory, marketing manager for consumer-electronics components for Mullard Ltd. of the Philips group.

More optimistic, Gerry Thomas, general manager for ITT Semiconductors, points out that some comfort is coming from higher semiconductor content in TV receivers as English set makers add frills like remote controls to their wares. Barry Charles, marketing manager for RCA, sees some offset in buoyant sales by distributors, reflecting an upturn in business for industrial electronics, while Mike Alderson, marketing manager for Motorola Semiconductor UK, says the final figures for the year for consumer electronics might look better if the April budget pumps some money into the economy.

Officials at ITT Component Services, one of the country's top distributors, believe there will have to be an upturn soon for the market to grow the 20% that some forecasters had in mind earlier. But, notes one, "firms are placing longer-term orders than before and that points to increasing confidence."

As for instruments, Fred Hutchinson, a product marketing manager for Gould-Advance, sees only a slight improvement over 1977, admittedly much better than the two dismal years before that. Working in this slack market, then, Gould needs to up its market share to reach its growth target of over 20%. □



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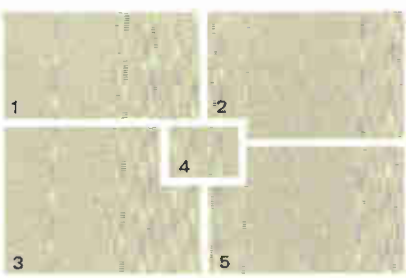

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Distribution

Growth creates financing problems

Most distributors feel firms will have to pay more attention to profits and less to sales volume as industry faces changes

by Bruce LeBoss, New York bureau manager

Distributors are caught up in a race that seems unending. They serve a rapidly growing market for microprocessors, support chips, and other semiconductors, as well as for microcomputer development systems, minicomputers, and peripherals. But many leading firms among them have extended themselves financially to handle the past two years' growth and may be hard-pressed to maintain the pace.

"There's no question but that distribution is handling more electronic component business. But with the exception of a few distributors, most can't afford to keep growing," states Sidney L. Spiegel, group vice president of the Wyle Distribution group in El Segundo, Calif. Spiegel estimates that of the top 10 distributors in sales, only about three—Hamilton/Avnet, Pioneer-Standard, and his own Wyle—are solidly profitable, with the rest ranging from marginal down to serious trouble.

Management. The inability of most distributors to generate the earnings needed to grow, Spiegel says, is due largely to "bad management, which has been totally interested in producing sales numbers rather than profit margins." What's more, "the situation has gotten past how much they can borrow." In fact, he continues, borrowing to finance the expansion of facilities and inventories to support the 40% sales growth of 1976 and 1977 has boosted expenses to the point where most distributors actually are losing money on new business.

According to Spiegel, what is really needed is a radical departure from standard practice: distributors must "cut off losing lines." Most of the top 10 distributors are feeling financial strains because of what the Wyle official calls "distributor mentality," that is, "they generate sales instead of net primarily because suppliers measure a distributor's performance by his volume." Thus, "a distributor's greatest security is the sales dollars he generates" to keep his suppliers content.

However, Seymour Schweber, president of Schweber Electronics in Westbury, N. Y., disagrees. He believes the syndrome "ended in the 1974–1975 crisis when many distributors were caught expanding for volume" just before the business turned soft. "They were caught holding the bag with large amounts of finished goods inventory and expenses." Today, he adds, distributors realize "it's profits that are important, and that they don't make deposits in the bank or pay their income tax with volume."

Overall, Schweber describes the distribution business as moderately profitable, and says that the income curve is rising largely because "suppliers now are concerned that their distributors do make a profit. Unless distributors are profitable, the suppliers don't have a good business." However, he concedes that business failures among his compatriots are on the horizon. In fact, he says, "a couple are imminent."

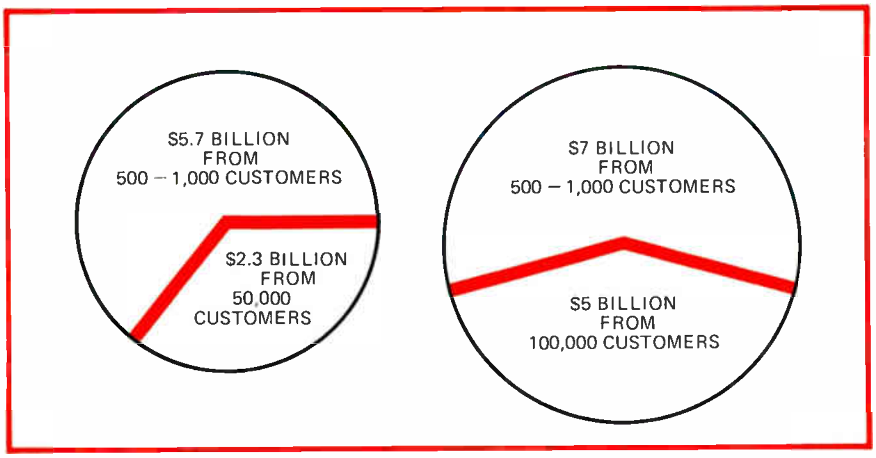
Schweber declines to identify which distributors he believes are in trouble. Also, figures are closely guarded in an industry in which half the top 10 firms are privately owned or are divisions of larger corporations that do not break out sales or profit figures by division. Still, some measure of the problem can be gained by the view of one distributor that, in the $2.5 billion industry, "four firms do a sixth of the business, and collectively they've made no money over the last few years."

Agreeing with Spiegel that all is not well in the distribution business is Anthony R. Hamilton, president of the industry's leader, Hamilton/Avnet Electronics in Culver City, Calif. "One thing," he says, "they know how to get volume, but not profits."

Hamilton won't name names, but he concedes the lineup of the top 10 could change greatly in the next few years. "You might see contraction of the national distributors with some aggressive, small regional expanding" and failure for some weaker firms.

The prospect of distributors dropping less profitable lines is a ticklish subject, Hamilton observes, since profit margins are a subject of continuous mutual pressure between often warring distributor-manufacturer camps. What's more, he doubts the consistently troubled distributor even knows which lines are losing most. The managements of most distributors cannot tell which lines are least profitable, he says, "because they don't have control over their expense ratios and their financial reporting isn't up to date."

Optimist. Despite his competitors' lack of profits, Preston B. Heller, president of Pioneer-Standard Electronics Inc. of Cleveland, foresees no business failures. "Companies can go on indefinitely making no money," he says. "Distributors don't have high fixed costs, and the business tends to be self-correcting. Every time a distributor gets overextended,



Reslicing the pie. Market base should grow between now and 1982. Manufacturers will serve the same 500–1,000 customers; distributors will handle the rest.

a vendor will cut him off and that gives the distributor new money, because the vendor buys back his inventory."

Nonetheless, profitability is achievable, and "companies like Hamilton/Avnet, Wyle, Newark [Newark Electronics Corp. of Chicago] and Pioneer have demonstrated that it's possible," Heller says. His firm's success stems partly from its "emphasis on profitability instead of volume" and, he says, "that includes associating primarily with suppliers that allow reasonable margins."

However, suppliers are not always so benevolent, notes Wyle's Spiegel. "We are being strongly encouraged to provide technical support by manufacturers of instruments and microprocessor development systems, who have no intention of paying for it," he says. For example, "instrument manufacturers, who sell on price, say they can't afford the 25% margin distribution requires." While one microprocessor maker gives an additional margin for providing technical support, Spiegel notes, "they first threatened to reduce margins if we didn't provide such support. Thus, it gains us nothing in reality, except an expense of about $500,000 for what is less than $10 million in business."

In the face of these pressures, there is more than a ray of hope. The market for electronic components and systems is rapidly expanding, notes Larry Pond, vice president and general manager of Wyle's Elmar Electronics unit in Mountain View, Calif. He sees the domestic customer base for electronic components growing from an estimated 40,000 in 1975 to 50,000 this year and 100,000 in 1980. "During the same period," he notes, "manufacturers can be expected to service the same number of customers directly, about 300 to 500 typically, but perhaps 1,000 for some." Thus, the expansion of that customer base, Pond says, "has left a vacuum that distribution is filling, and distribution's share of the market will grow from about 25% to 40% to 50%" over the same period.

How will distributors position themselves to meet that growth? Pioneer, for one, will continue to finance growth from its retained earnings and, says Heller, "borrowing in proportion to those earnings." Similarly, Schweber looks to retained earnings and lines of credit with three top banks.

Credit. An official at Cramer says his firm had a large revolving line of credit with a consortium of banks headed by Citibank, and that the loan has not been used up yet. "I see inventory turning around more quickly and financing being able to come, in part, from this," he says. What's more, he expects to finance growth out of profits, but with "better management, better control, and higher productivity helping."

The Cramer spokesman sees larger systems supporting growth, too. "With high-technology systems come dramatically higher prices than with devices." Although the costs of handling, field applications, and demonstration are greater, "there should be the same or slightly better returns from these high technology systems," he says. □

Electronics abroad

Italian politics casts shadows

Chaotic conditions, inflation, unemployment stunt growth and keep electronics firms guessing

by Arthur Erikson, Managing Editor, International

Forging a link. Italian workers unroll fiber-optic cable. Phone network has cut back on spending, so manufacturers look to exports.

In the bewildering Italian scheme of things, nothing in politics succeeds like failure. And so having failed to get the country going after a 16-month stint, Giulio Andreotti's Christian Democrat minority government and its Communist Party "silent" partner were tapped to try again. In mid-February, outgoing and probably also incoming Prime Minister Andreotti and his cohorts were trying to put together an "emergency" economic program and a new government that the six major parties could back and that could end the current crisis.

Even if it had not started with the fall of the government and the accompanying political chaos, 1978 would have been a tough year for Italy. Italian economists now figure that the country's economy grew by approximately 2% last year and that it will do about the same this year. However, economy watchers at the 24-nation Organization for Economic Cooperation and Development predict that growth will be only 1%, all of it in exports.

At either rate, there will not be enough natural expansion and new jobs to meaningfully reduce the rolls of the unemployed, a prime problem for the country. And because inflation is just barely under control—the yearly rise for the retail index dropped to 15% at the end of 1977 from 22% a year earlier—a burst of deflation financed by a budget deficit might be a cure more dangerous than the disease. This is the dilemma that Andreotti must resolve.

Tentative. It will be the end of March, at the earliest, before the new government presents a detailed budget for the year ahead to the parliament, so any forecasts now about how Italian electronics markets will fare in 1978 have to be hedged accordingly. After its annual survey last fall, *Electronics* came up with a consensus forecast of $2.474 billion for assembled equipment. Nominally, that is a 15% rise over the estimated $2.149 billion for 1977. Actually, though, it represents little real growth: the markets are valued in current money, so that much of the apparent gain is nothing other than inflationary price rises.

Consumer electronics is expected to move out the most, followed by computers. Despite the worrisome political situation, spending for military electronics should hold up well. And because color TV set production should stay high, components suppliers, too, should do reasonably well. The survey points to a rise to $533 million for components markets, up just under 12% from an estimated $476 million for 1977.

PAL arrives. Color TV—the PAL system used in western Europe except France—came officially to Italy in 1977 after several years of casual colorcasting, some of it experiments by the state-run radio-television network, but most of it pirate programming from Switzerland, France, and Yugoslavia. Italian consumers bought color sets heavily last year—some $312.5 million worth, according to the survey, with a further rise to just under $400 million likely this year. Meanwhile, the monochrome market should dwindle from 1977's estimated $108 million to about $102 million.

Most of the color sets will be Italian. The country's set makers turned out 850,000 color receivers last year and roughly 60% of them went into the domestic market. This year, they plan to boost their output to something like 970,000 and hold the same domestic-market/export ratio. It must be pointed out, though, that, recently, early-year forecasts by set makers have been cut.

Computers bullish. Despite the general sluggishness, computer makers figure to have another good year in 1978. "Computer demand seems to evolve independently of GNP and inflation, because the market in Italy is so young. It should stay that way through the mid-'80s," says Mario Speranza, head of market research and analysis for Honeywell Information Services Italia SpA.

Spending for computers and related hardware adds up to only 1.5% of the Gross National Product in Italy, compared with 2.5% or better in countries like West Germany, France, and Britain. Thus, there is plenty of growth potential as Italy catches up relatively in computers. *Electronics* forecasts a market for

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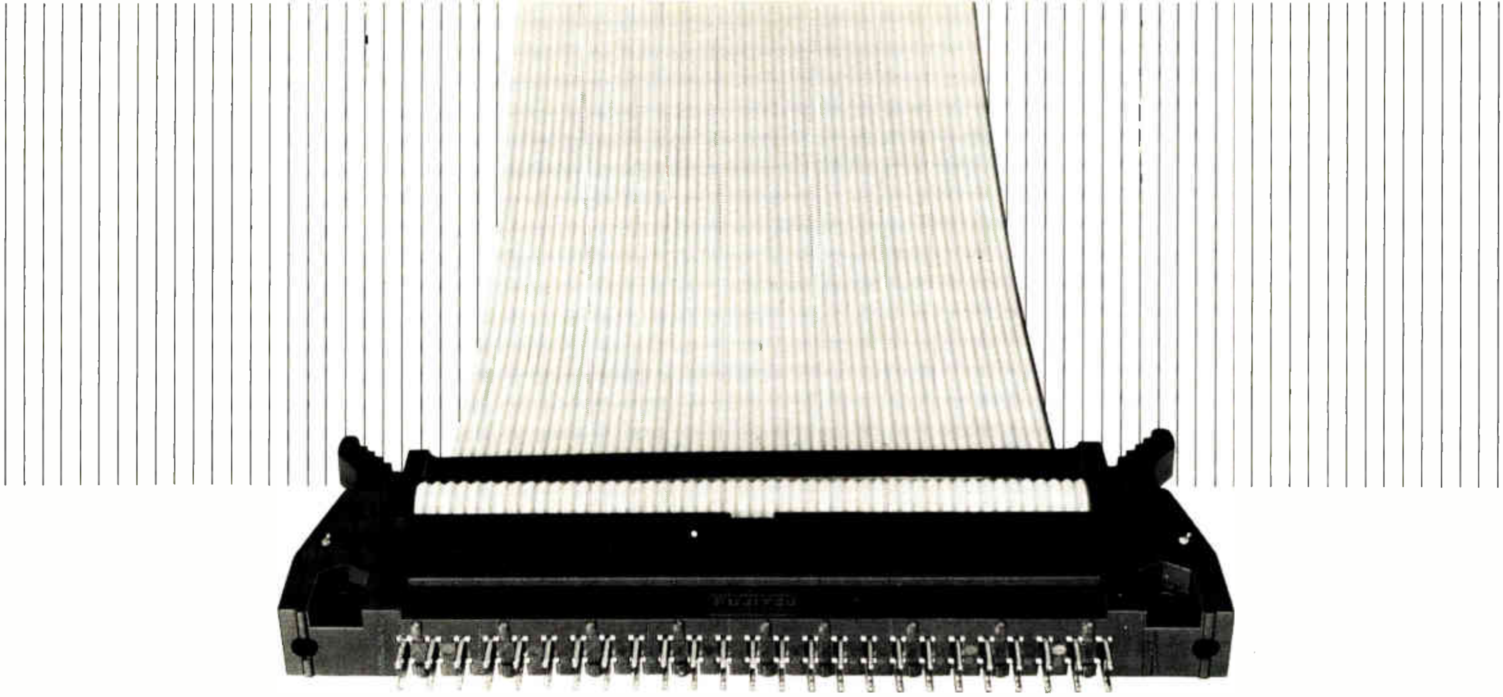

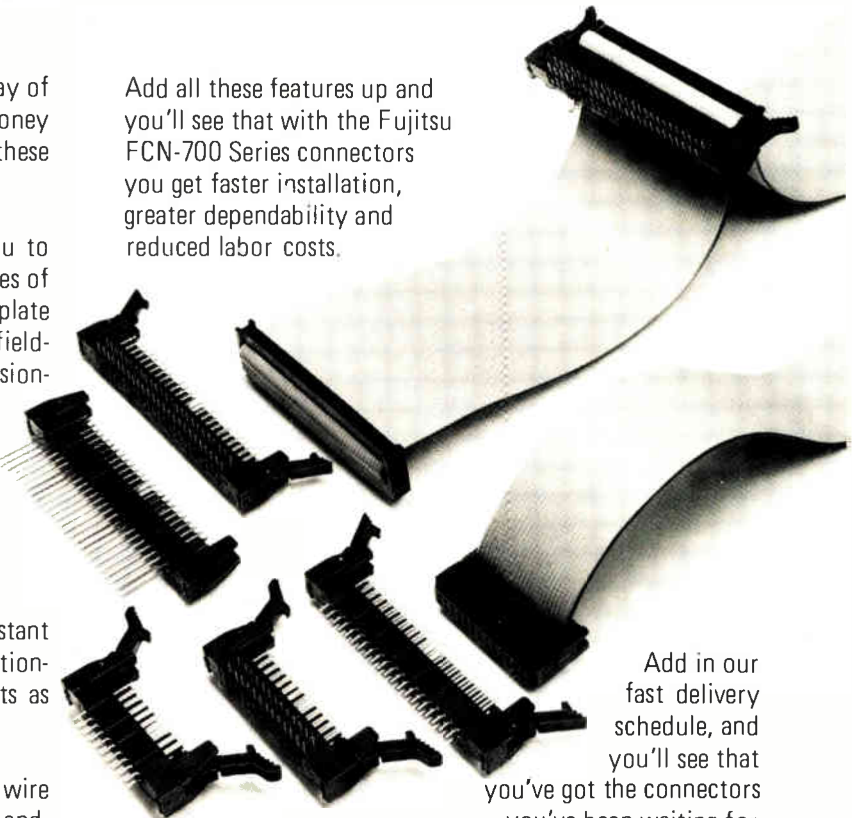

1978 of $792 million, up slightly more than 15% from an estimated $687 million last year.

In contrast, Italian communications equipment makers, the survey shows, cannot count on much growth at home. Largely because the state-owned telephone network has cut way back on its spending, the rise in sight this year is under 9% to $448 million. Fortunately, Italian manufacturers of telecommunications equipment have been scoring reasonably well in export markets. The major exception is the dominant telecommunications producer, SIT-Siemens SpA, which is part of the government telecommunications group STET, itself a unit of the government's holding company, IRI.

Military. Although they are pushing hard for exports and have considerable business to show for it, Italian producers of military electronics gear have a reasonably strong home market going for them this year as well. What's more, the medium-term prospects are reassuring. The air force, for example, has started to upgrade the Italian section of Nadge, the NATO air defense ground environment system, with Selenia SpA, also in the STET group, figuring to get most of the business for the necessary radars and control consoles. Also, production orders should start coming during 1979 and 1980 for the avionics gear that will fly aboard the Tornado multirole combat aircraft.

Exactly where the extra money for defense hardware will go and when the spending will start will have to be worked out by the new government. The same is true for a $340 million package adopted in rough outline by parliament last September to bolster research and development and to restructure key electronics sectors over the next three years. Component makers, particularly the STET group's semiconductor house, SGS-ATES, will get priority under the package.

The VLSI program is part of an overall proposal put together by FAST (the federation of technical and scientific associations) at the government's behest. Details still have not been released, but presumably there will be tie-ups with the computer and telecommunications sectors as well. The government has indicated it wants Ing. C. Olivetti & C., the country's leading native office-machine and terminal maker, to work with STET in computer-related fields, and there is talk of pairing up SIT-Siemens and Telettra SpA, a company in the Fiat group that is particularly strong in microwave links and advanced telephone-telegraph carrier equipment. □

Last in a series examining European markets.

ITALIAN ELECTRONICS MARKETS FORECAST
(IN MILLIONS OF DOLLARS)

	1976	1977	1978
Total assembled equipment	1,879	2,149	2,474
Consumer electronics	557	640	752
Communications equipment	372	411	448
Computers and related hardware	597	687	792
Industrial electronics	217	258	304
Medical electronics	68	75	89
Test and measurement equipment	43	49	55
Power supplies	25	28	32
Total components	419	476	533
Passives	192	218	248
Semiconductors	120	138	155
Tubes	106	119	129

(Exchange rate: $1 = 878 lire)

Note: Estimates in this chart are consensus estimates of consumption of electronic equipment obtained from a survey made by *Electronics* in September and October 1977. Domestic hardware is valued at factory sales prices and imports at landed costs.

Companies

To Siemens, U. S. is vital component

Friedrich Baur's parts group did $30 million in sales in America last year and expects still more expansion

Looking west. Siemens' Friedrich Baur expects his components group to add to its list of investments in the U. S.

There is no denying that European companies are investing heavily in the U. S. electronics industry. During the past seven years, some sources say, they have spent about $300 million on company acquisitions on the American side of the Atlantic Ocean.

One of the early heavy investors is Siemens AG. Overall, the West German company, with total sales of about $11.8 billion last year, has spent nearly $125 million in the electrical and electronics fields in the U. S. during the past 25 years, mostly recently. In fiscal 1977–78, the Munich firm expects to invest another $80 million in America. The expenditures are starting to pay off handsomely: the company's 1976–77 U. S. sales came to some $300 million, roughly 30% above the 1975–76 level.

Of Siemens' seven divisions, particularly active in the U. S. of late has been the $700 million Electronic Components Group. It has invested about $40 million during the past three years. Landmark deals are the takeover of Dickson Electronics in Scottsdale, Ariz.; the cooperative deal in microprocessors with Intel Corp. of Santa Clara, Calif.; the 80% acquisition of Litronix Inc. in Cupertino, Calif.; the 20% participation in Advanced Micro Devices Inc. in Sunnyvale, Calif.; and the founding of Advanced Micro Computers, which is a joint venture of Siemens (60%) and AMD (40%) and is also situated in Sunnyvale.

The chief architect of these deals is Friedrich Baur, 50, a member of the Siemens board of management and president of the components group. Seated near the video-telephone that connects him to West Germany's post office research laboratory in Darmstadt and to the ministry of posts, telephone and telegraph in Bonn, Baur expressed his thoughts on various aspects of his group's activities in the U. S. in an interview with *Electronics*. Here are the highlights of that interview:

Q. Why are you becoming so active in the U. S.?

A. Very simple. Components are in demand primarily in industrialized countries with a strong electronics base. So, if you want to sell components, you must go to a highly developed country. And what place is more developed than America? Another important factor is the large size of the relatively homogeneous U. S. market.

Q. Does the desire to be in a high-technology market also play a role?

A. Sure. The U. S. market spawns many things that come out in Europe with a three-to-five-year delay. Essentially, these are digital products—computers, terminals, and the like. In the U. S. they appear on the market at a time when Europe still ponders what to do. Such an innovative environment benefits us as a components maker.

Q. Is the political and economic stability another factor?

A. Yes, that's another point. We probably have more freedom of disposition and movement there than anywhere else abroad. All in all, to us as a company with long-range planning, America presents itself as a pilot market in several respects—in innovation, volume, and early-stage product introduction. .

Q. How successful have you been?

A. Our components business last

year came to about $30 million. But there are other sides to success. We understand the American market much better than we did only a few years ago. We know more about operations there, about intercompany relations, distribution channels. By contrast, a few years ago we used to be surprised to find that certain things were handled differently in the U. S.

Q. Does your experience in America help you elsewhere?

A. If you can operate in the American market, you can surely operate in others as well.

Q. Do you consider any particular American sectors—communications, for example—inaccessible or at least difficult to sell to?

A. Markets are difficult only insofar as there are some decades-long and well-established contract and business relationships between, say, customers for communications equipment and suppliers like AT&T. And if you want to enter such sectors, you must face these strong and time-proven relationships. In that sense, U. S. markets may be difficult. But they aren't any more difficult than in other countries—in England, Germany, France, or elsewhere.

Q. It's being said that what's left for foreign companies in America are firms in financial trouble, firms that an American company would not want. Is there any truth to that?

A. Not really. It's basically a question of "what must I do to reach my business goals in America?" Of course, it is relatively easy to buy firms that are going bankrupt. In this case you must put up enough capital to effect a turnaround for the firm and to steer it into a new direction, one that furthers your aims. But you can also buy into financially sound firms, especially if, besides money, you bring along technology and sales experience in other markets. We have become involved in both kinds of companies. Litronix is one that has gone through bankruptcy, and AMD is a fantastically prosperous enterprise.

Q. Have you been readily accepted as a foreign company?

A. We have encountered no difficulties as a result of being a foreign company. In one form or another, we have been active in the U. S. for decades and we will expand our activities there step by step. As I see it, markets are becoming increasingly world markets. This is true particularly for components because it is easy to ship a component made in, say, Singapore to the U. S. or Germany. Or one made in California or Germany can be air-freighted in one day to anywhere in the world. So what we have today is a world-market situation, one in which a component's country of origin is not as important as is its design, performance, or price.

Q. Do you have plans for more U. S. joint ventures or acquisitions?

A. While we cannot reveal every detail about what we are contemplating, one thing is clear: given the significance of the American market, we will try to serve that market as well as our strength permits. A whole arsenal of business possibilities is at our disposal, and we are going to use that arsenal.

Q. A top Siemens executive recently said that annual growth rates of 10% to 20% in the U. S. should be possible for the company as a whole. What are the prospects for your group?

A. You have to look at each sector individually. I think a 10% growth rate would be rather modest for integrated circuits, but a lofty target for passives, for example.

Q. Will you be pushing any specific component categories in the U. S.?

A. We will introduce in America what we think are excellent devices for entertainment electronic products. Further, together with AMD, we will build up our microcomputer activities there. We will also cultivate fields in which we think we are particularly strong—ferrites and surge-voltage protectors, for example. In short, we will go to market with all our products, from tubes to electrolytic capacitors, if the market is interested in them.

Q. What's your sales strategy?

A. Broadly speaking, we want to serve the U.S. market with both standard and selected products, the former covering devices that every electronics equipment maker needs, and the latter intended for special customers. An example of a specialized product is the traveling-wave tube built for the U. S. Navy [*Electronics*, Jan. 20, 1977, p. 36]. □

Companies

Testing for others means business

Macrodata has been doing $1 million worth a year after establishing a lab and programs for LSI devices

by Larry Waller, Los Angeles bureau manager

In recession-battered 1975, Macrodata Corp. had its full share of slowdown worries. Its testers for large-scale integrated devices often sat idle for weeks waiting for shipment, and so did the applications engineers who install them. "Then we wondered," recall two engineers, "why not use them to make some money?" That question triggered a thriving new business for the subsidiary of Cutler-Hammer Inc.: selling a service package of LSI testers, engineers, and software to perform complex device testing at the Woodland Hills, Calif., headquarters.

Those two engineers are Richard

Turned on. Macrodata test technician Daniel Kennelly characterizes a microprocessor at the Woodland Hills, Calif., facility.

C. McCaskill and Wayne Sohl. McCaskill, as manager of applications services, ran the testing operation with the aid of Sohl. McCaskill has left Macrodata, but still serves it as a consultant. He was succeeded as testing chief by Sohl.

What supports LSI testing as a separate business is a two-edged trend in application services that McCaskill and Sohl spotted early on. On one hand, says Sohl, "the engineer wants to know what a part looks like before designing it in." Since semiconductor manufacturers do not supply enough "characterizations" for the functional operation of increasingly complex LSI processors and memory, users have to generate such test data on their own.

But the economics of LSI testing bar all but the largest users from having an in-house capability. "Buying and operating your own test lab can cost $500,000 to $600,000 in the first year, bare bones, just getting started," he explains. Macrodata's biggest tester, the 10-megahertz MD-501 with 64 test channels, costs up to $400,000, and the annual tab on one engineer can be $60,000 in salary and upkeep.

To get business in 1975, McCaskill and Sohl hit the road. The first major customer was the Air Force's Rome, N. Y., Air Development Center, which needed characterization data on commercial static random-access memories in order to write initial military specifications on what were then new devices.

All alone. From this part-time start, testing operations grew to a full-fledged business during 1976. Boosting Macrodata prospects is a lack of competition. As McCaskill points out, "Commercial IC testing houses largely do burn-in," a high-temperature procedure more concerned with quality control than characterization.

Macrodata's plan, along with building business, was to compile a library of test programs during 1977 for all state-of-the-art LSI processors, memories, and peripheral chips, then use the programs to go after high-volume customers in 1978. To a base of test programs for all 4,096- and 16,384-bit random-access-memory chips and basic processor families (including 8008, 6800, 2901, and 1802 devices), Macrodata keeps adding programs for such new chips as Texas Instruments' 74S481, a 15-megahertz bit-slice, and the C-MOS 6100, made by several firms.

An order to characterize functions of 5 to 10 LSI parts, which Sohl terms typical, takes 80 or 90 testing hours. Prices vary with how much testing a customer wants and whether software already exists. Costs for processors are higher than for memories: developing a test program for a memory runs about $3,000, and characterization averages $45 to $125 per 16-k device, whereas processor programs go from $5,000 to an extreme of $22,000, while putting one through its paces falls in the range of $50 to $150 per device. Straight go/no-go testing costs $1 a part in volume. All devices are tested at three temperatures in the standard −55°-to-+125° C range.

With two years experience under

its belt and a growing program library, Macrodata feels poised to move out of what amounts to small-scale custom testing into the really big volumes. "These amount to 1,000 to 10,000 devices per month per customer," Sohl says. Currently, there are three testers at work, employing four applications engineers on two full-time shifts, sometimes adding a third. "We're booked pretty heavily now," he says.

As for the contribution to company revenues, the firm will not talk, but sources say it could approach $1 million on an annual basis. Although Cutler-Hammer does not report Macrodata results separately, the tester maker had revenues of $11 million to $12 million a year when it was acquired.

Serendipity. Beyond being a good business, testing is paying off in another way. "As probably the heaviest user of its own equipment, Macrodata gets the biggest insight into how it works, where it is deficient, and where improvements are needed," McCaskill says. The first result is a new family in which "not one piece is the same as before—we took a new sheet of paper and started over again." This approach is required by the size of the next generation of RAMs, with both 131,072- and 262,144-bit devices in sight, and processor speeds in excess of 10 megahertz. Prototype testers are scheduled for completion this month.

Macrodata's testing customers come from most parts of the industry, mainly computer manufacturers, the military, and systems houses, as might be expected. Surprisingly, semiconductor houses make up a growing part of the business, but McCaskill and Sohl will not identify them. "They use us as an uninvolved third party with no ax to grind," Sohl explains. These manufacturers do not seek routine service, "but come only with big problems."

Another user of Macrodata programs, which turn up many unexpected device failures, particularly in supposedly identical devices from a different vendor, is a manufacturer altering his production processes.

For the user, the Macrodata testing service saves money and time, according to Kenneth Houghton, senior components engineer at Sperry Univac's minicomputer operation in Irvine, Calif. "It's difficult to justify a microprocessor tester for small volumes," he says, "so it's beneficial to send parts out to test." Although the division has a memory tester, it cannot handle all of the 30,000 dynamic RAMs that come in the door each month.

Another customer at a government agency that has been giving characterization tasks to Macrodata since 1976 observes, "I suspect they have a leg up on this business," since other independent testing houses do not have equivalent equipment or software.

Macrodata's growth in a new business niche "underscores the entire testability issue," in the opinion of the two engineers. And interest in LSI testing is creating a seller's market for experienced engineers who can run programs. Since there are not enough yet to go around, firms like Macrodata that have a trainee pool must fend off raids. □

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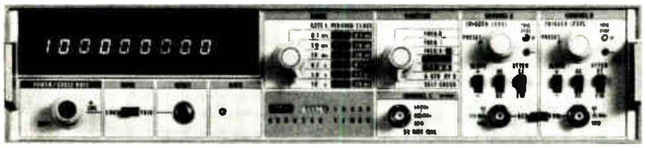

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Number of Digits	6	7	7	7	9	9	7/8	9
Frequency (MHz) *Basic Unit* *Options*	80	125	250	520	520 1250	125 520	80	125 1250
Period	•	•	•	•		•	•	•
Totalize	•	•	•	•		•	•	•
Time Interval							•	•
Ratio		•*	•*	•*	•*	•*	•	•
A gtd by B							•	•
Sensitivity (mV)	25	15	15	15	15	15	50	30
Trigger Level Control		•	•	•		•	•	•
External Timebase Input		•	•	•	•	•	•	•
Battery Option	•	•	•	•	•			
TCXO Option		•	•	•	•	•	•	•
Ovenized Timebase Option						•		•
DOU Option	•	•	•	•	•	Std		•
Autoreset	•	•	•	•	•	•		
Autorange	•	•	•	•		•		
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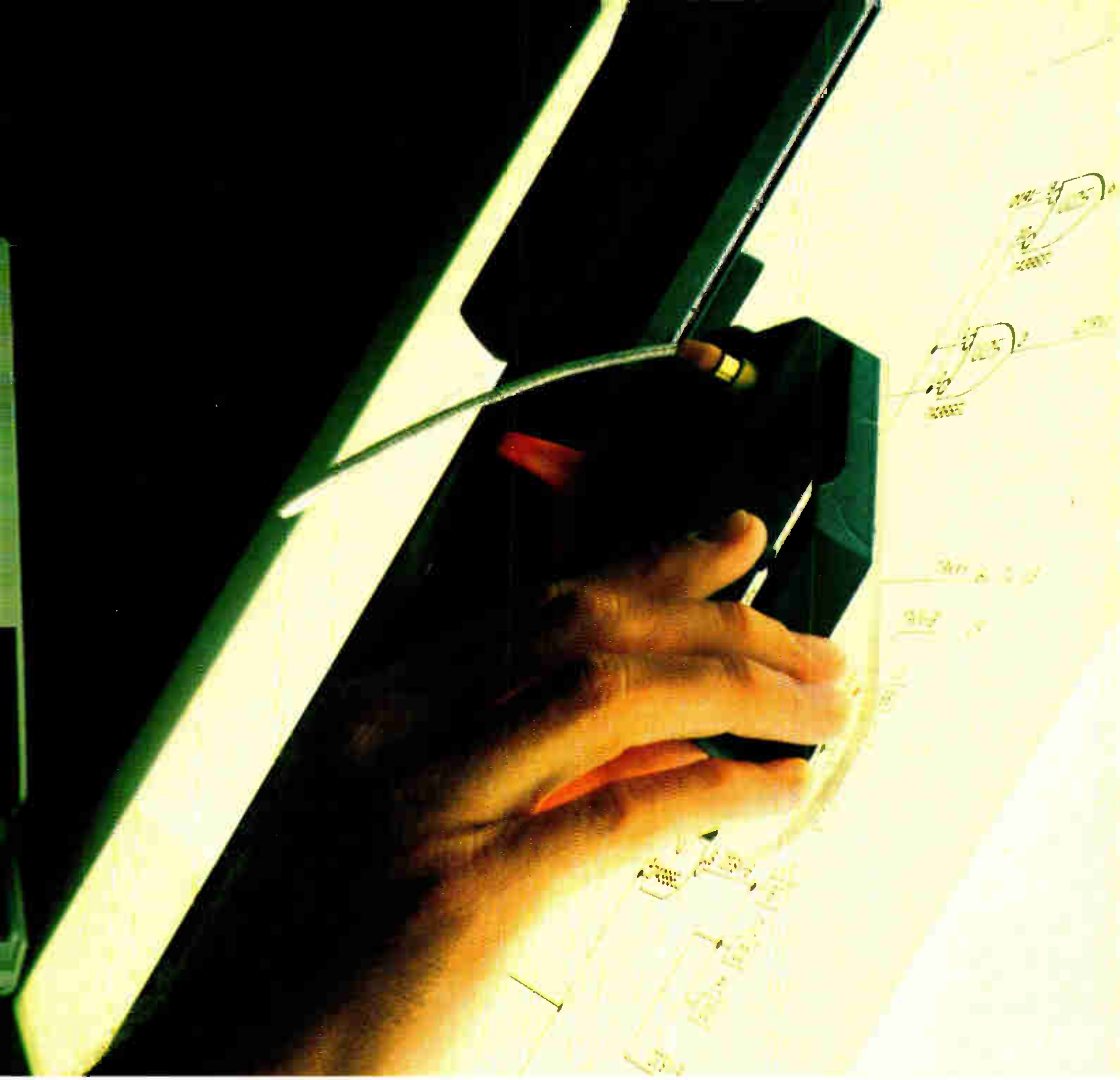

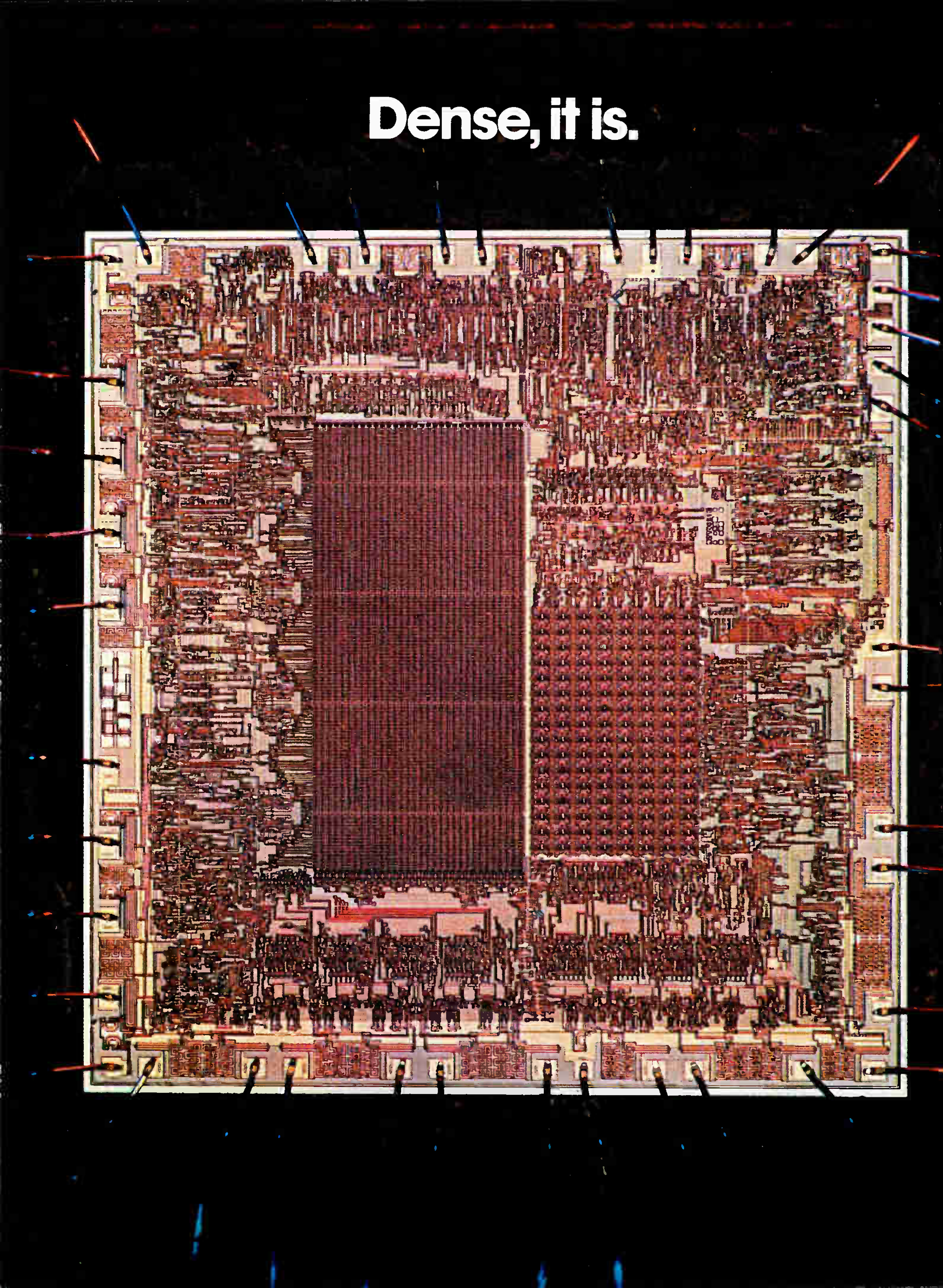
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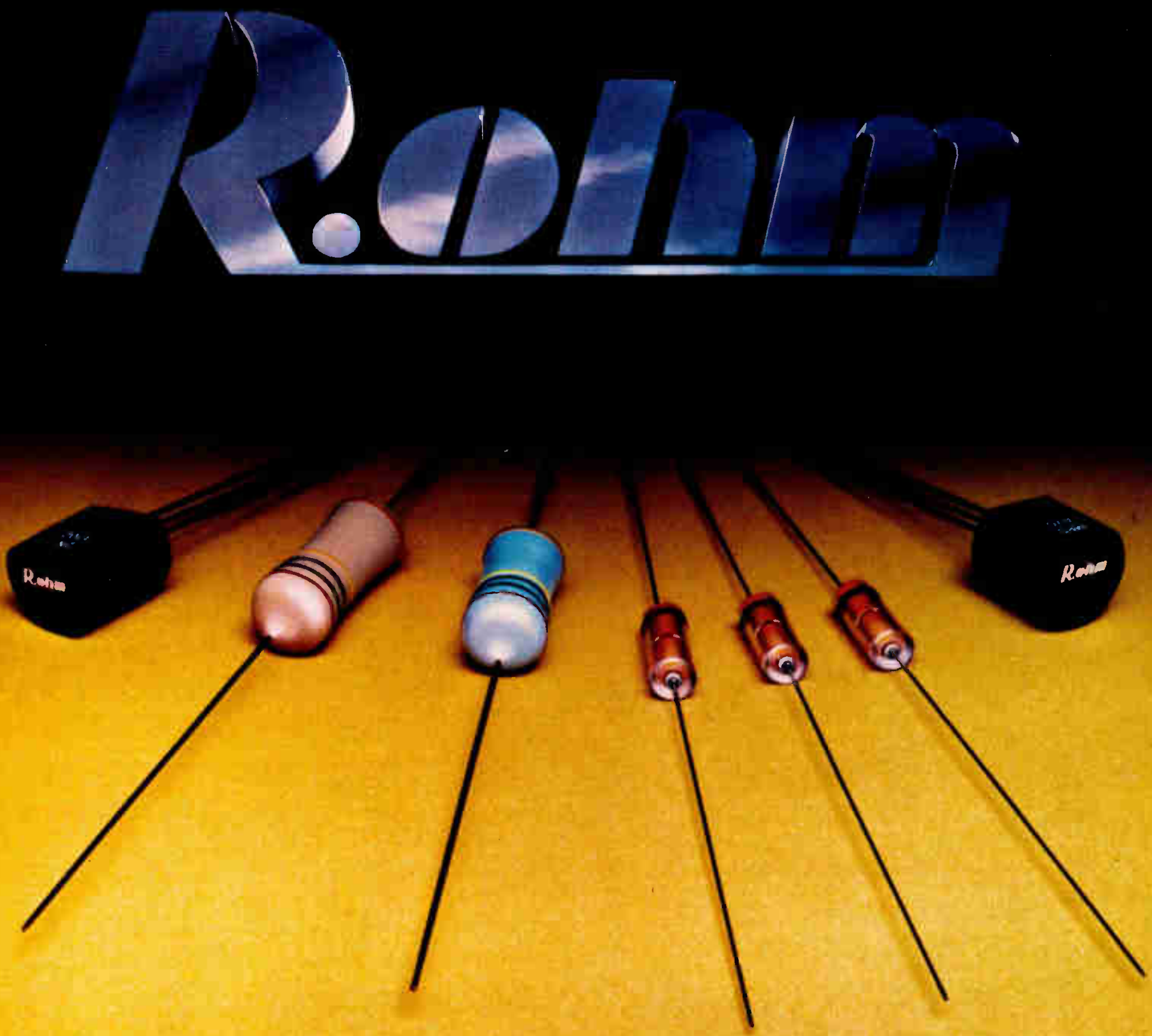
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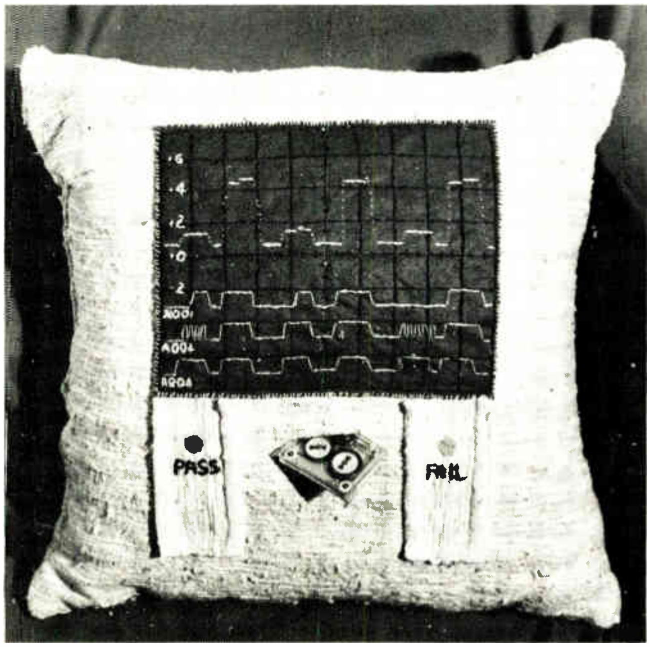
Digital testing oscilloscope cushions against mounting costs of troubleshooting



by William E. Shoemaker and David W. Wilson, *Gould Inc., Biomation Division, Santa Clara, Calif.*

☐ Troubleshooting today's digital products is a major expense. Even with the use of automated testers, many manufacturers are being forced to spend more on testing and fault diagnosis than on assembly. The problem is that fault isolation, whether done in the factory or in the field, generally defies automation. But that is not all: the unpredictability of troubleshooting time, a shortage of field engineers, and rising training expenses and wages for technicians are problems as well.

To help bring these costs under control, the Biomation division of Gould Inc. has developed a new concept in general-purpose instruments—the digital testing oscilloscope. This instrument simplifies troubleshooting at the end of the production line, in the repair depot, and in the field. It is also a powerful new engineering tool for design, documentation, and field changes.

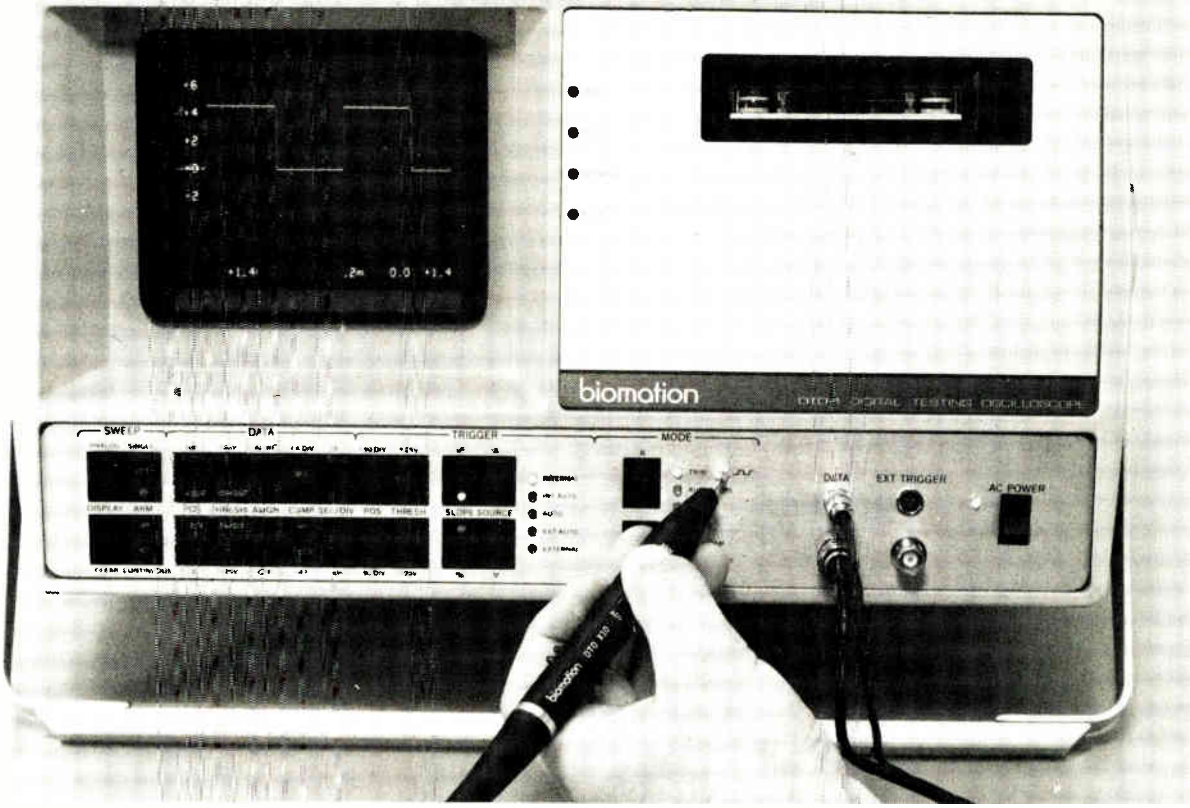
The DTO-1 is the first oscilloscope-like instrument designed to test and troubleshoot digital systems. It performs automatic tests, as well as manual troubleshooting procedures, not only on digital but also on related analog circuitry. (An analog troubleshooting capability is important in digital testing, since many faults have analog origins. Replacing a microprocessor that drops bits, for example, is no solution if the problem is a short between adjacent printed-circuit traces.)

The DTO-1 is used with a single probe, much as an oscilloscope is, and has oscilloscope-like controls (Fig. 1). It combines the capabilities of three instruments: a go/no-go comparison tester, a time-domain logic analyzer, and a storage oscilloscope.

As a go/no-go comparison tester, it automatically compares logic waveforms from a known good system with waveforms acquired from a system or board being tested. The reference waveforms and other test data are stored on miniature tape cartridges during test programming by an integral tape unit, for playback during test operation. A microprocessor compares the waveforms, displays both logic traces on the cathode-ray tube, and lights up pass or fail light-emitting diodes on the probe.

As a logic analyzer, it can display up to eight traces simultaneously in the familiar timing-diagram format. Logic-analyzer capabilities include pretrigger recording, post-triggering, combinational and internal triggering, and detection of glitches, such as high-frequency noise spikes. The traces are acquired one at a time and stored in memory for later display.

As a storage oscilloscope, it can display digitized analog waveforms on the same time base used to display



1. Three instruments in one. The DTO-1 digital testing oscilloscope can operate as a go/no-go comparison tester, logic analyzer, and storage oscilloscope. It provides its own calibration signal for checking and adjusting the probes. When a probe is touched to a front-panel test point, the test signal is displayed to serve as a visual aid while the operator trims up the probe circuitry.

logic traces. Any number of analog waveforms can be stored in memory and superimposed on the upper part of the CRT display at the same time that up to three logic traces are displayed on the lower part. The combined displays help the troubleshooter determine whether a fault is caused by an analog or a digital malfunction and provide information needed to correct either type.

The DTO-1 is virtually self-programming and uses no software language to program tests. Instead it records on tape the reference logic traces and control settings acquired from a known good board or system. When the operator plays back the tape, the instrument automatically sets itself up to perform a go/no-go test.

As a design instrument, the DTO-1 is more versatile than conventional logic analyzers and oscilloscopes. It is an ideal before-and-after tool, since it can record reference patterns before a design change and play them back later to display the effects of the change. Its performance is high enough even for some emitter-coupled-logic designs—its maximum sampling rate of 100 megahertz allows it in practice to handle input signals with frequencies up to about 20 MHz.

Selective automation

To expedite troubleshooting and reduce training costs, the digital testing oscilloscope selectively automates test routines. Since an operator's skills are not required to troubleshoot a system's good functions, the DTO-1 automates those tests that determine which parts of a system operate properly. When a bad function is located, the DTO-1 acts as a general-purpose instrument that can isolate the causes of either digital or analog faults.

At the beginning of a test sequence, a microprocessor within the instrument determines, from a single test, the frequency difference between the system under test and the reference traces and automatically allows for it throughout the sequence. Then the operator simply uses the smart data probe to check the specified points in the system. As he does so, the microprocessor sets up the instrument for each test and makes go/no-go decisions.

The probe has pass/fail lights and two push buttons for automated testing, freeing the operator from having to look at the display or reach to the control panel. He merely looks to see whether the lights are green (pass) or red (fail), and if the pass LEDs light up, goes to the next test point. When the fail LEDs light up, the operator looks at the CRT display for clues to the cause of the problem. The display shows a system-under-test and reference logic-trace pair and up to six previous traces that had passed the tests. The main clue is an underlining of the system-under-test trace where it disagrees with the reference trace.

The operator then either goes to a manual mode for combined digital and analog troubleshooting or runs a previously programmed fault-isolation sequence. In the manual modes, the DTO-1 operates as a single-probe logic analyzer with oscilloscope-like controls, as a storage oscilloscope, or as a combination of the two. For instance, the faulty trace, still underlined, can be visually compared with a variety of traces and waveforms, such as the actual analog waveform of the trace, associated timing signals, power-supply levels, and comparator outputs. Acquired with the same probe, these are shown above the system and reference trace pair on the same time base.

Such combination displays usually lead to the cause of the fault. If an analog signal is bad, the technician spends no further time checking digital functions. If the fault is digital, he can check out basic digital devices as he would with an oscilloscope (or with an analyzer) or go to a recorded fault-isolation subroutine to check out complex devices and obtain more clues.

Inside the DTO-1

The ditigal testing oscilloscope is basically a single-channel logic recorder controlled by a 6800 microprocessor (Fig. 2) whose operating software is stored in 16 kilobytes of read-only memory. Its random-access memory stores traces and control settings and transfers them to the tape and to the display via a direct-memory-access channel. Maximum RAM size is 16 kilobytes, for transcribing up to 100 records per tape cartridge (standard miniature data cartridges, 3M type DC 100A). Each cartridge can actually store 200 test records, but all records are written twice so that the microprocessor can use backup data when an incorrect record is detected. Each record contains 1,000 samples of a logic-trace pattern, 120 bits for control settings, and 8 bits for cyclic redundancy checking.

The names of the DTO-1's controls have been kept as close as possible to those of the oscilloscope. For example, analyzer sampling rates are automatically derived from a seconds-per-division setting. Even pretrigger recording, a function not available on real-time oscilloscopes, is expressed in terms of CRT divisions. Push buttons, used in place of rotary switches to select ranges and other variables, increment or decrement values displayed on the CRT screen.

The input circuitry is essentially a pair of high-speed comparators that are calibrated and set up by the microprocessor. In fact, the instrument contains very little analog circuitry, since input signals are immediately digitized upon capture and then processed digitally.

The data-probe signal input is compared with the logic threshold at sampling intervals down to 10 nanoseconds (at the 100-MHz rate). The resulting bit stream is applied to a high-speed transistor-transistor-logic memory with an emitter-coupled-logic front end, which stores the most recent 1,024 bits. After the trigger event occurs and the trigger countdown is completed, the memory's contents are transferred to the main RAM for processing into display bits (and, if desired, for recording).

For display purposes, the 1,000 bits are compressed to 200 bits by an algorithm (Fig. 3) that preserves significant pulse-train details. For example, a string of several 1 bits can be compressed to just a few bits, whereas a 1 bit in a string of 0 bits is retained, since it might be a noise spike. A complete 200-bit display trace may actually be generated with as few as 40 bits, even at the maximum-expansion setting of the trace.

Analog-signal processing

If eight traces are acquired sequentially without changing the time base or triggering conditions, the display shows a timing diagram like that displayed by an eight-channel logic analyzer, as noted earlier.

Analog waveforms are acquired at sampling rates up to 100 MHz. Up to 200 hertz, successive approximation is used to perform analog-to-digital conversion (1 part in 39). At higher frequencies, the microprocessor functions as a decision-making controller to provide a resolution of 1 part in 39 with the two comparators. (The 39 steps were chosen to allow 10 increments within each of four divisions on the CRT.)

The microprocessor divides the analog display area into 39 voltage increments, or windows, each bounded by a pair of thresholds. If the range is set at 0 to 4.0 v, for example, the highest pair is 3.95 and 3.85 v, the second is 3.85 and 3.75 v, and so on. The microprocessor steps through the 39 windows, and at each sampling time-interval, analog signal levels within that window all the way across the screen are digitized and stored as 1s in the high-speed memory.

After each analog signal sweep across one window, the contents of the high-speed memory are transferred to RAM and the bits are processed to produce 200 display bits, as in trace acquisition. Here, too, an algorithm (similar to the one in Fig. 3) is used that preserves significant features of the waveform, such as overshoots and undershoots.

The display bits are stored in one row of a 39-by-200-bit RAM matrix. As the matrix is filled row by row, the 39 waveform strips are "painted" on the screen until the waveform display is fully developed.

Low-frequency signals are digitized in a single pass and similarly processed and stored.

The practical limit to the number of signals that can be superimposed on the analog waveform display is reached when the operator can no longer distinguish one waveform from another. Timing-control changes clear the analog display so that waveforms can be acquired on the new time base.

Self-testing

The microprocessor also performs many self-tests on the instrument. It runs memory diagnostic routines and input calibration tests and also checks the tape records using cyclic redundancy checks.

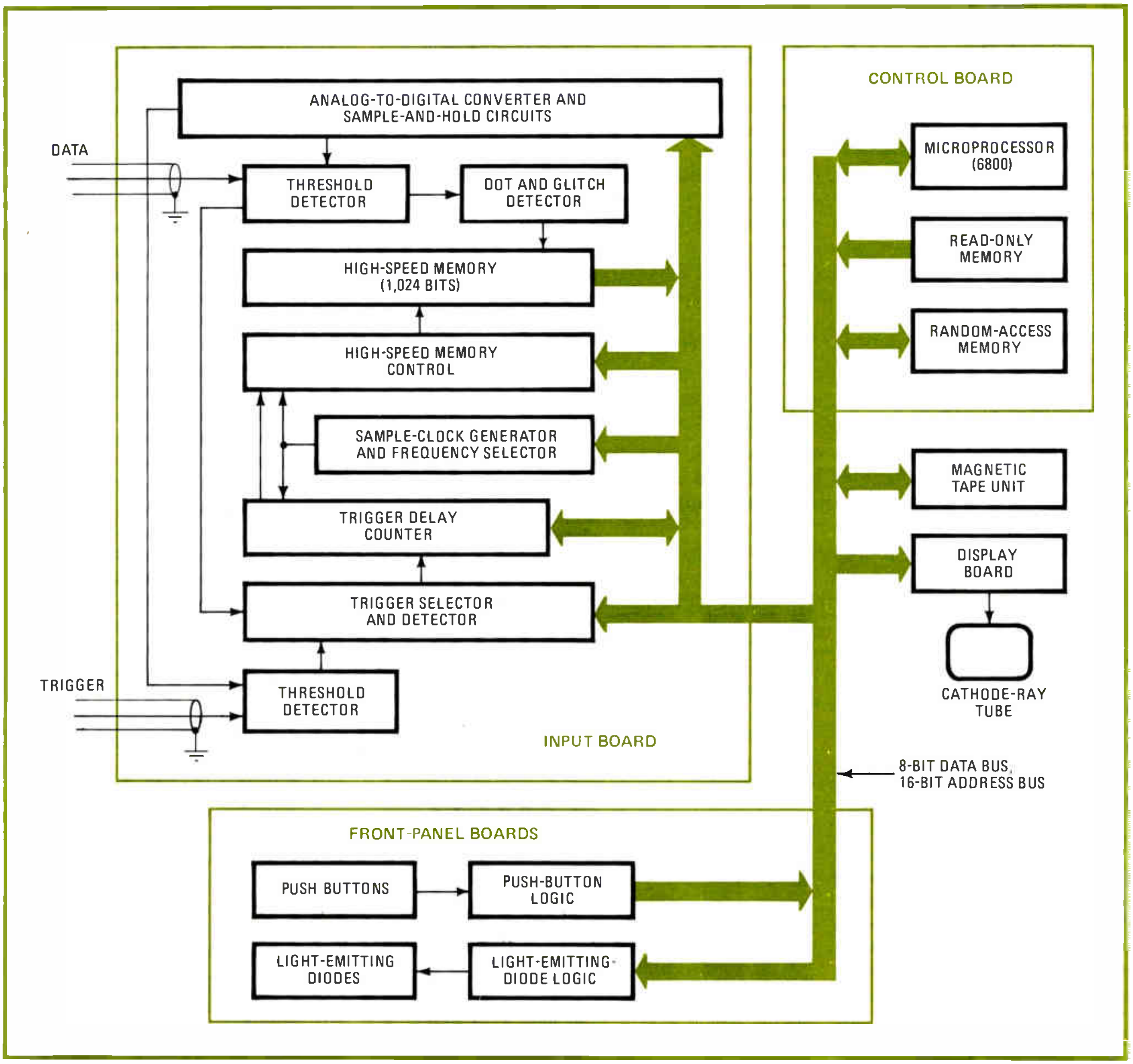
Whenever the tape is read, the CRC byte is used to check the test record. The Hamming code used in the CRC ensures 100% detection of 1-, 2-, or 3-bit errors anywhere in the stream and groups of errors spanning 8 bits or less, and better than 99% detection when more than 3 bits are in error or the span exceeds 8 bits.

If the first of the two test-record copies fails the CRC, the second is read and checked. If both fail, these redundant checks are made up to three more times by rewinding and rereading the two records.

If all eight CRCs fail, the microprocessor displays the message READ ERROR AT XXX (the position number). Pressing the clear button results in the trace being displayed with an E instead of its normal R prefix. Most probably, the cause of such a failure is a dirty tape read/write head, but it might be a scratched tape or a component failure.

The DTO-1 operates in six modes, but test operators will generally use only four: trim, autoscope, mixed, and scope. The other two, program and transcribe, are used to set up test procedures.

The trim mode is initially used with a probe-calibration waveform accessible at a test point on the DTO-1's front panel (see Fig. 1). This signal passes through the



2. Microprocessor-based. A 6800 microprocessor supervises operation of the DTO-1 in all modes and handles all data processing related to test and programming operations. In addition, it isolates faults in its ROM and RAM, calibrates the input circuitry, checks the accuracy of records while they are read, and alerts the operator by setting panel lights, preventing trace acquisition, and displaying error messages.

data or trigger probe and generates a square-wave display. If the wave is not squared up correctly, it is corrected with a trim adjuster on the probe. The input circuitry within the instrument is calibrated automatically by the microprocessor before each trace or waveform acquisition.

The autoscope mode is for automated comparison testing. The CRT displays up to eight logic traces (the reference and system-under-test traces that are being compared and as many as six previous traces). To obtain the traces, the operator presses the advance and arm buttons on the data probe. He then sees the test results on the probe's pass/fail LEDs.

The mixed and scope modes are for manual operations. In either mode, up to eight logic traces or up to three logic traces plus analog waveforms can be displayed. In the mixed mode, the two bottommost traces, if any, are holdovers from a previous mode. Typically, they are a reference and system trace pair held over from the autoscope mode, with system disagreements underlined.

Programming modes

In the program mode, the DTO-1 can also display up to eight logic traces. The engineer will usually list record numbers and test points on a test procedure. As the traces are acquired, he can assign record numbers, manipulate the control settings, and reacquire the traces for recording with the desired settings. For instance, he can use the trigger-position control to shift a critical logic transition to the first division of the screen, then use the seconds-per-division control to expand the trace;

or he can compress it to show a series of transitions.

In the transcribe mode, the microprocessor transfers test records between RAM and the tape unit. Records can be written back onto the same tape or onto different tapes. This allows newly and previously recorded test records to be combined for various applications.

The tape records may be organized into different routines and subroutines to perform tests at the system, board, and component levels. For example, one cartridge may contain high-level tests and a second cartridge the component fault-isolation routines; or a cartridge may contain the high-level tests for a small system at the tape's front end and the fault-isolation routines on the remainder of the tape. Subroutines need not be programmed for well-known devices. If input/output lines begin failing, for example, the procedure can simply tell the operator to check, in a manual mode, the power-supply levels and the input/output traces of the unit's line drivers.

Using the test records

When the DTO-1 is used in the autoscope mode, data alignment and data comparison work together to reduce most troubleshooting decisions to a simple pass/fail reading. These functions also allow logic operations to be tested when there are timing differences between the system and reference waveforms.

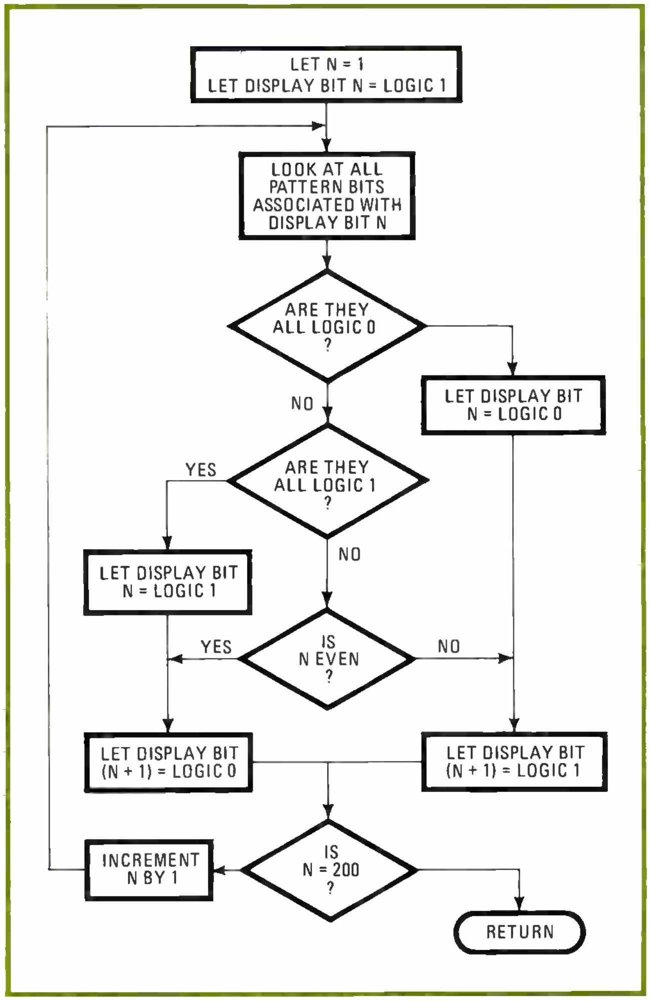
When the first record is called from tape, the logic trace appears in the eighth (bottom) position on the display and is labeled R001 (Fig. 4a). When the corresponding system trace is acquired, it appears in the seventh position and is labeled A001 (Fig. 4b).

The first test point in a probing sequence is usually a node providing a system clock signal or an associated rectangular wave. If, say, the system clock frequency is 7.7% less than the reference frequency, the actual trace appears slightly stretched out with respect to the recorded trace. Pressing the data-align-AF/RF (actual frequency/reference frequency) button causes the value of the frequency ratio to appear on the screen (0.923 in Fig. 4c) and the R001 trace to stretch to align with the A001 trace.

The ratio remains on display and all subsequent R traces stretch automatically to align them with the corresponding A traces, unless the operator again presses the alignment button. He may do that to check a system clock adjustment or to troubleshoot a timing problem if the ratio exceeds a specified limit.

To perform frequency alignment, the microprocessor determines the number of transitions and their positions in the actual and recorded logic patterns. From this, it calculates the frequency ratio. Then it compares the patterns bit by bit, taking into account the frequency ratio used to adjust the trace display generated by processing the reference pattern. On subsequent comparison tests, the microprocessor automatically allows for the frequency ratio so that logic functioning is tested despite frequency differences. Frequency alignment continues through mode changes (Figs. 4d and 4e) if the alignment buttons are not pressed again.

When the A001 trace first appears, the microprocessor draws a line (data-comparison trace) between the A001 and R001 traces where the A trace disagrees with the R trace. If the two traces match after alignment, the underlines disappear. The pass/fail LEDs are set depending on the amount of disagreement.



3. Display processing. This algorithm is used by the microprocessor to compress 1,000 input sample bits into 200 bits used to generate the logic trace on the CRT screen. The algorithm preserves transients and other details. A similar algorithm is used to process stored information for analog waveform displays.

The tester will indicate a failure if any underline exceeds the programmed data-comparison value or if the total length of all underlines exceeds 30% of the trace width. The latter is a built-in safeguard against system conditions that may not cause the comparison value to be exceeded at any particular trace segment but should be checked by the operator to ensure that they do not cause operating problems.

The next reference record is called by means of the probe's advance button. R002 replaces R001 in the eighth position, A001 moves up one position, A002 appears after acquisition, and the microprocessor again aligns, compares, and underlines. When there are six previous A traces above the newest A and R trace pair, the next test causes the oldest A trace to roll up off the top of the display.

When faults are detected, the operator may go to a programmed subroutine, if available, or to a manual mode to troubleshoot and adjust or repair. Or he may simply note the steps at which the fail LEDs lit and continue automatic testing. The latter procedure may be used if the operator is not skilled and will refer the fault locations to a troubleshooter, or if it is more efficient to continue high-level tests and look for fault groupings before going on to manual troubleshooting.

Training advantages

Training requirements, and thus expenses, are sharply reduced because the automated routines allow an operator untrained on a particular system to check it out almost as rapidly as one who has been so trained. The routines can bring him right down to a fault-isolation level at which he needs to understand only how to check such basic functions as flip-flops and power-supply levels. In effect, the operator trains himself by learning the test routines and the operation of the system under test through working on it.

Also, pretrigger recording, delayed triggering, combinational triggering (using an optional trigger pod), and other analyzer functions helpful in testing such complex devices as microprocessors can be used in the tests without specially training the operator. The fact that pretrigger recording, for example, is not a conventional oscilloscope function is of no concern to the novice user; when he probes the system, he sees what appears to be a real-time display, even though the display shows instructions, input/output states, and other conditions that occurred before the trigger event. (The pretrigger conditions are programmed into the test record.)

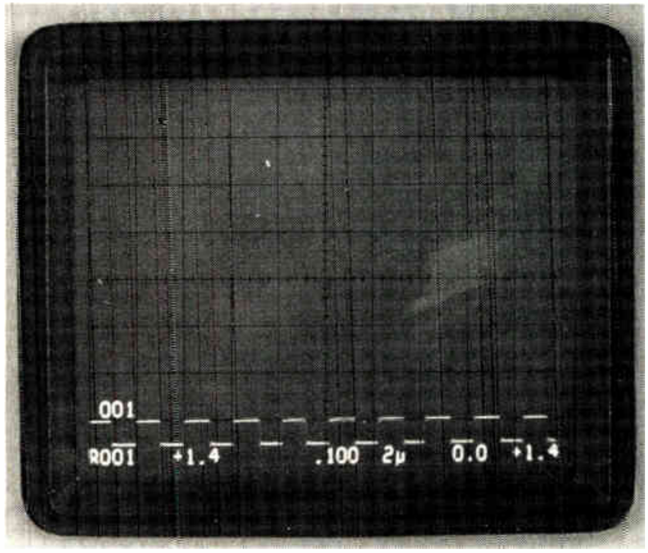
Furthermore, conventional logic analyzers have seldom been used for testing and troubleshooting (as opposed to designing and debugging) because they require familiarity with a design, a long setup time for each test resulting from the use of multiple data probes, and time-consuming analysis in interpreting the display. The DTO-1's intelligence, single data probe, oscilloscope-related controls, and recorded logic traces eliminate these obstacles.

The DTO-1 thus meets the needs of many applications where technicians work on a large variety of systems, as in repair depots and calibration labs and in field service. In such situations, a technician may work on a particular system only occasionally, making it difficult to isolate faults and requiring a sizable stack of manuals. A set of test tapes can replace most of the written material and illustrations usually needed. Also, since the DTO-1 can duplicate tapes, the equipment manufacturer can send copies to service organizations and users as economically as extra service manuals. Or, since the programming methods are simple, users can prepare tapes in the field from a known good system.

Production testing

The digital testing oscilloscope also meets all major factory testing requirements, including engineering control, stand-alone testing, and use with other automated testers. It can be employed in pilot production, routine production, burn-in and other environmental testing, and quality-assurance testing.

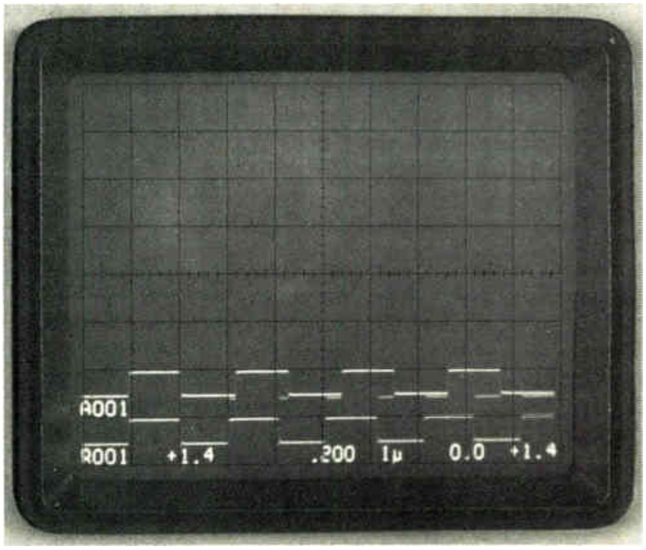
Use of the DTO-1 where design details change so fast that conventional control is effectively lost, as happens during initial production runs, solves an otherwise serious problem for engineering personnel responsible for documentation and test procedures. With it, the engineering department can maintain a reference-trace catalog on tape, update it to reflect each approved design change, and reference the resulting test records to models by serial number. The records provide the basis for production tests and may be kept permanently on tape. They can be used to facilitate field service, to update manuals, and if problems occur in the future, to provide a basis for engineering analysis.



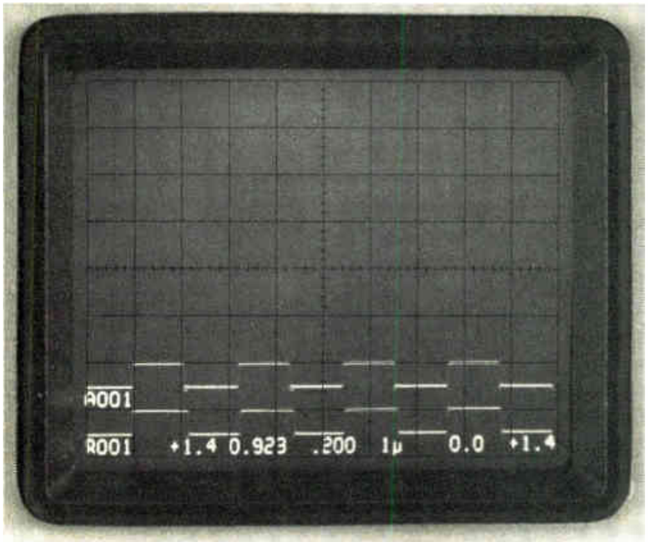
4a. Test programming. The programmer is in the process of programming a test tape. To record the first record, he has selected a data position number (001), selected other settings, and acquired the reference logic pattern with the smart probe. When the instrument writes the record on tape, it will display R001.

As a test system, the digital testing oscilloscope does not require either personnel and equipment for software development or major backup instruments such as oscilloscopes and frequency counters (it verifies the accuracy of clocks and other timing signals by comparison with the corresponding timing signals of the known good system). For stand-alone testing, the only basic requirement is that the system under test be powered. Indeed, a major attraction of the DTO-1 is its ability to test system resources such as clocks and power, since it does not use these resources when it is testing (see "The DTO-1 vs other testers," p. 112).

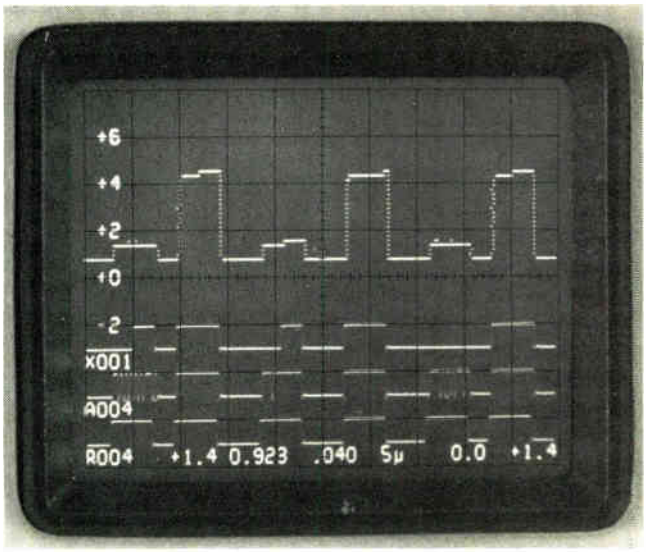
Troubleshooting boards in conjunction with other automatic testers is a natural application. Although properly programmed testers will separate good boards from bad ones, even guided-probe or bed-of-nails systems (large, multiprobe comparison testers) cannot isolate faults at the component level without extensive software programming. Particularly effective is the use of a stimulus tester with a DTO-1. Stimulus testers generate predictable patterns at system nodes; whereas the DTO-1 provides fast recording of good patterns and, on playback, comparison testing. The combination of predictable patterns, automatic comparison, and visual aids eliminates guesswork and helps get the trouble-



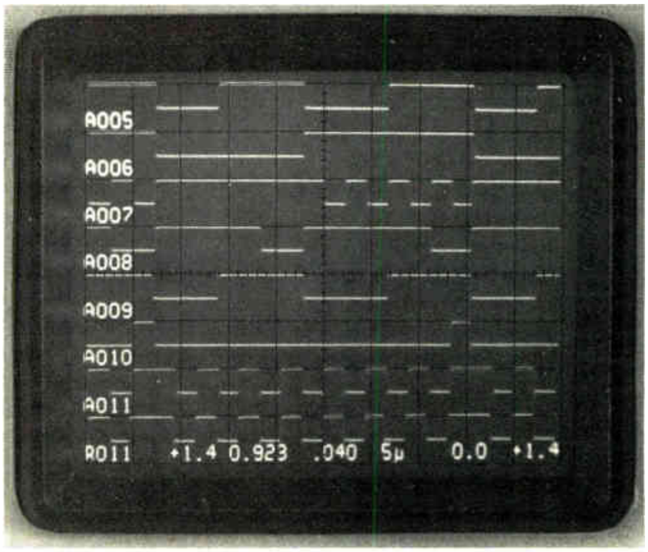
4b. First automatic test. The operator has selected test R001 and acquired the corresponding trace from the system under test (A001). The DTO-1 compares the two patterns and underlines the test trace where it disagrees with the recorded pattern. This first test is usually a system frequency check. The signal acquired from the system has a different frequency than the recorded signal.



4c. Frequency alignment. The operator has pressed an align button, causing the instrument to align the R trace with the A trace, display the frequency ratio (0.923), and remove A trace underlines due to frequency differences. Subsequent R traces will automatically align with A traces and be underlined if there are logic disagreement, and pass/fail LEDs will light up accordingly.



4d. Fault finding. On the fourth automatic test, the DTO-1 indicated that the system input that generated trace A004 was faulty. The operator switched to one of the manual troubleshooting modes (mixed mode) to retain the A004 and R004 traces and to acquire a related trace (X001) and the analog waveform of the faulty digital signal (top). He can also acquire supply voltage levels.



4e. Back to automatic. With the DTO-1 still frequency-aligning R and A traces, the operator has returned to the autoscope mode and run seven more automatic comparison tests which the inputs have passed. On the next test, R011 will be replaced by R012, all A traces will move up one division, A005 will roll up off the screen, and when A012 is acquired, it will be displayed above R012 and tested.

shooter to the cause of a circuit fault quickly.

Since traces and waveforms can be displayed, the instrument can be used in the lab not only to debug digital functions but also to solve related analog-circuit problems. High-speed transients, for example, can be seen on all types of displays. If a sampling interval longer than the minimum 10 ns is used for traces, a "glitch catcher" still detects 10-ns transients. Logic traces are acquired with the single data probe from anywhere in the system.

The taped-reference-catalog approach makes the DTO-1 an ideal before-and-after tester for evaluating the effects of design changes, component tolerance changes, second-source components, and the like. The before and after comparisons are automated, as in go/no-go testing, and result in display of disagreements between before and after traces for such purposes.

When updated to include records made after acceptable changes, the catalog becomes a basic document for developing manufacturing test procedures, post-installa-

The DTO-1 vs other testers

The goals in designing the DTO-1 not only were to make it as easy as possible to program and use for fault isolation, but also to overcome the limitations of previous techniques. One idea led to another—for example, the reference-trace catalog to providing digital clues automatically, the integral tape recorder, and the emulation of a logic analyzer and a storage oscilloscope for the investigation of both digital and analog clues.

Automated testers have used node-pattern comparisons for years. More recently, signature analyzers have been developed to detect faults in microcomputer systems. Both can point to faulty logic functions, but unless a digital device obviously caused the malfunction, an operator must still probe with a general-purpose instrument to isolate the fault.

Tables 1, 2, and 3 indicate the limitations of oscilloscopes and signature analyzers (Tables 2 and 3 update those in a report on signature analyzers in *Electronics*, Nov. 10, p. 107). In addition, signature analyzers require software development that the service organization might not be capable of.

While the chief drawback of oscilloscopes is that they are not very effective as digital fault isolators, the reverse is true of signature analyzers. Analyzers fall short in isolating analog faults—a serious limitation, since most digital faults are of an analog nature. Also, small software-based testers generally rely on system resources that they cannot test.

The DTO-1 can isolate both kinds of faults, does not require software support, and is essentially a stand-alone system operating independently of the resources of the system under test. It can check the functions needed to test the system and then the system itself. But it requires a clock signal, which can also be tested first.

TABLE 1: SYSTEM TEST CAPABILITY COMPARED

Testable system elements	Oscilloscope	Signature analyzer	In-circuit emulation with signature analysis	DTO-1
Power supplies	yes	no	no	yes
System clocks	yes	no	no	yes
Processor/control logic	no	no/yes	yes*	yes
Digital input/outputs	no	yes	yes*	yes
Analog I/O	yes	no	no	yes

*System must have a processor

TABLE 2: ADVANTAGES OF DTO-1 IN SYSTEM TEST APPLICATIONS

	Operates without built-in test source	System level diagnostics	Module fault isolation	Component fault isolation	Operates on nonmicroprocessor-based system
In-circuit emulation and signature analysis	yes	yes	yes	yes	no
In-circuit emulators	yes	yes	no	no	no
Signature analysis	maybe	no	no	yes	yes
DTO-1	yes	no	yes	yes	yes

TABLE 3: DTO-1 COMPARED WITH IN-CIRCUIT EMULATION AND BUILT-IN FUNCTIONAL TESTS

Resources of system under test	Resources required for system to be testable		
	Built-in functional test	In-circuit emulation functional test	DTO-1
CRT/keyboard or other operator interface	partly yes	no	no
Diagnostic read-only memory	partly yes	no	no
System random-access and read-only memory	no	no	no
Central processing unit	yes	no	no
System input/output	partly yes	no	no
Address and data bus	yes	no	no
Control bus	yes	no	no
System clock	yes	yes	no
System power	yes	yes	no

tion checkout tapes, and so forth. In fact, the digital testing oscilloscope evolved from the idea that such a catalog would be extremely useful for such purposes.

Furthermore, the DTO-1 can feed debugging and test-requirement information in readily usable form from the field to the factory. When field personnel run into unexpected problems, they can record the troublesome patterns, along with the instrument settings used to solve or to attempt to solve the problems. Mailed back with an explanatory note, the tape cartridge provides visual aids for further debugging or updating of test programs.

In addition, the DTO-1 is easy to program. To organize test sequences, the engineer can either acquire the traces (and test records) in the order they will be used or reorganize existing records with the DTO-1. Records from different tape cartridges may be assembled onto one tape, blocks or individual records may be moved, and records may be erased and changed—all without using software language.

Since the DTO-1 is virtually self-programming, test routines that might take days or weeks to write out or program with software can usually be prepared in hours or days. Many records not directly involved in test routines can be supplied to personnel such as field engineers to cover unanticipated problems, simply by transcribing them from a catalog of reference traces.

All these features and capabilities result in substantial reductions in the costs of documenting designs and preparing and printing test procedures, as well as instruction manuals. □

Next-generation development systems are costing less and doing more

To match the expanding range of microprocessor applications, a new family of development tools offers flexible capabilities with a $3,250 bottom price tag

by Paul Rosenfeld, *Intel Corp., Santa Clara, Calif.*

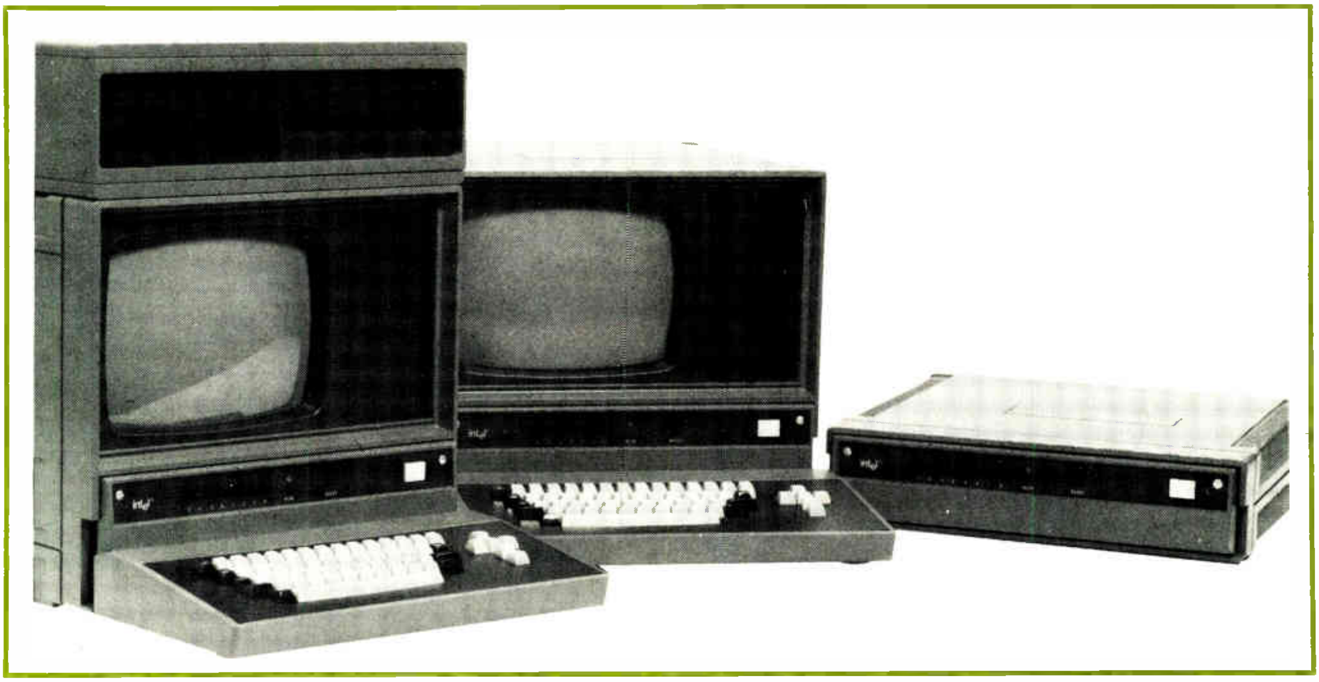
☐ Capitalizing on the latest advances in semiconductor technology, a new generation of development systems helps accomplish the widely varying, detailed design tasks that arise as microprocessors appear in more and more applications. The design process for such products calls for developmental tools that let the designer choose from a variety of solutions, including the appropriate software. As well as filling this need, the new generation of development systems is the next step in the design of basic hardware that can be upgraded quickly to support new, more powerful microprocessors.

During the early years of the microprocessor, development systems were almost unknown. Most users struggled to develop their own special hardware and software, or else they turned to a timesharing service for simulation of their application. The primitive development systems available were useful only for the simplest, least complicated tasks.

However, the technology of the development systems has advanced as rapidly as that of the microprocessor, so that today they provide the tools to solve a wide range of intricate design problems. This advance is due in part to the increased power of microprocessors that are incorporated into the system hardware. It also is due to Intel's development of ICE, the in-circuit emulator [*Electronics,* April 15, 1976, p. 116].

The ICE modules give designers full control over development of a microprocessor-based product, because it permits complete hardware and software debugging in a prototype at real-time speed. Thus it is no longer necessary to build special instruments or use timesharing simulators. Moreover, hardware and software can be debugged together rather than separately.

While the ICE module added significant debugging capability to development systems, new software tools were also needed. Even though most microcomputers are programmed in assembly language, more engineers are turning to high-level languages. The advance of resident compilers in development systems including both PL/M and now Fortran have further increased the need to use a



1. Flexible developer. The Series II microprocessor development system makes extensive use of new peripheral control chips for a compact unit with built-in CRT and floppy-disk drive on two models. There are three models in all, designed to cover a wide range of applications.

SERIES II VS MDS-800 FAMILY

Price	
Series II, Model 210	$ 3,250
MDS-800, plus 16 kilobytes additional RAM	$ 5,325
Series II, Model 220	$ 7,450
MDS-800, plus 16 kilobytes of RAM, a CRT display, and a single disk drive	$10,415
Series II, Model 230	$12,900
MDS-800, plus 48 kilobytes of RAM, a CRT, and a dual-density disk drive	$13,800
Series II, Model 230	$12,900
MDS-888	$15,000

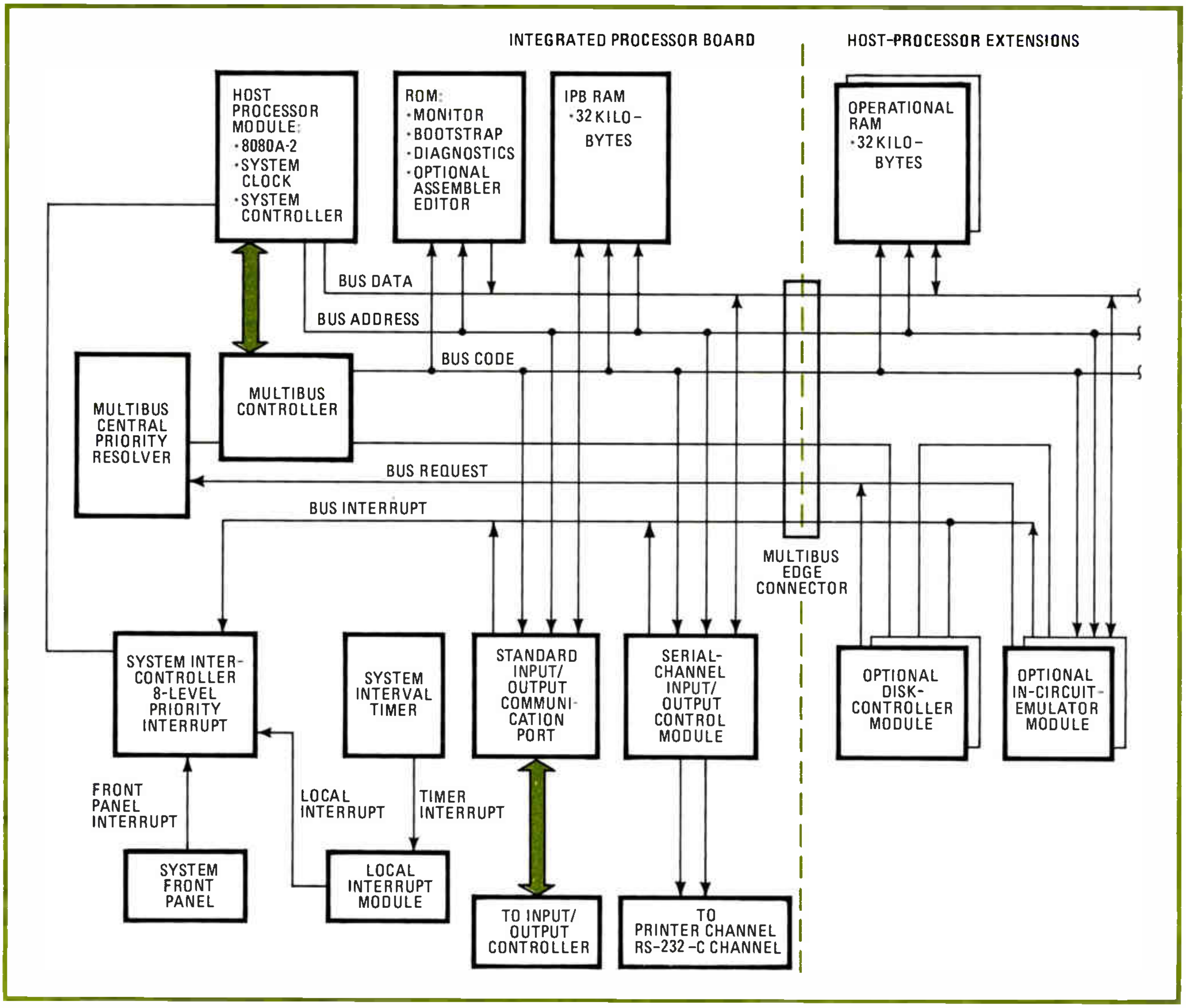
Hardware		
	Series II	MDS-800
Standard boards	integrated processor board input/output controller (outside card cage holding other boards)	CPU front-panel monitor MDS-016 and/or MDS-032
Optional boards for 220/230	32 kilobytes of RAM disk controller (2 boards)	32 kilobytes of RAM disk controller (2 boards)
Total slots used	1 (210/220) 4 (230)	
Slots available for expansion	3 (210/220) 2 (230) (with 4 more as an option)	

microcomputer development system as a design tool.

Now a new series of development systems, designed from the ground up to provide the capabilities needed by the designer, allows all this flexibility in a compact package (Fig. 1). This Intellec Series II family consists of three models with a range of capabilities that make it possible to match the development system to the particular developmental requirement, eliminating the need for a separate keyboard and display, a separate floppy-disk drive, and a controller. What's more, there are significant price reductions over roughly comparable models in the original Intellec series (see table).

Three models for many uses

The simplest Series II unit is the model 210, for the designer who wants to get a small job done fast. Its assembler and test editor, based in read-only memory, and 32,000 bytes of random-access memory provide assembly of source code directly from RAM for small and medium-sized programs. Its $3,250 price tag is a breakthrough in cost.



2. Host with the most. The integrated processor board in the Series II has a host processor module designed around the 8080A-2. It features a Multibus controller, which routes communications traffic between the master and slave modules throughout the system.

The second new entry, model 220, is geared toward those designers working on microprocessor-based systems that require more powerful development support capabilities. To the basic series design, it adds a full-sized floppy-disk drive, a cathode-ray-tube display, and a full ASCII keyboard, all in one chassis. It costs $7,450, almost $3,000 less than an earlier Intellec in the same configuration.

The third in the series, model 230, adds 32 kilobytes of RAM and has a million bytes of on-line disk storage with ISIS-II diskette-operating-system software. The price for all this capability is $12,900. To get an earlier Intellec to this level would cost over $13,000.

All three Series II models contain a card cage with an optional expansion module and can support a complete line of peripherals such as printers, paper-tape readers and punches, and programmable-ROM programmers. In addition, the 220 and 230 models can host in-circuit emulators for a variety of microprocessors.

Incorporated into the series are up-to-date microprocessor and memory chips, plus recently developed, highly integrated peripheral controller chips that perform logic functions as well as processing functions. Besides the 8080A-2 central processing unit used in all three models, the 220 and 230 take advantage of the new 8271 floppy-disk controller chip, the 8275 CRT controller chip, and other 8200-family multifunction input/output components. All three models use the UPI-41, a new universal peripheral-interface chip to perform general-purpose parallel peripheral-interface control functions, as well as to control the keyboard on the 220 and 230.

Like the original Intellec, each Series II model has a system monitor resident in ROM. In addition, a ROM-based 8080/8085 assembler and text editor is offered with the model 210. Combined with the capabilities of the monitor, it enables users to edit and assemble their assembly-language programs directly from RAM without the use of paper tape. A ROM editor/assembler from the MCS48 family is optional.

The other two models use the ISIS-II diskette operating system to supplement the system monitor. Through the file-manipulation capabilities of ISIS-II, designers have access to comprehensive disk-based program-development software such as assemblers for a variety of Intel microprocessors, compilers for both PL/M and Fortran, and a sophisticated relocation and linkage system.

Finally, to keep downtime to a minimum, all Series II models provide a ROM-resident diagnostic package. It enables designers to determine whether their Series II systems are working fully and then to locate trouble spots within easily replaced functional blocks.

Architecture promotes expansion

The various components that make up the Series II hardware are in two independent microcomputer subsystems. Each on its own printed-circuit board, these subsystems communicate with each other and maintain a master-slave relationship.

The master is called the integrated processor board (Fig. 2), and essentially it is a complete microcomputer system. In addition to the usual management and control functions of a master subsystem, it serves as the interface with the in-circuit emulator and other optional microcomputer-development modules that may reside in the card cage. The modules that make up the master system are interconnected through Intel's Multibus concept, which allows expansion in modular fashion. (See "A ride on the bus" p. 117.)

The host CPU is designed with the MCS-80 microcomputer family. The 8080A-2 microprocessor has the power for fast and efficient support of the operating system, several high-level languages, and other microcomputer-related software tasks, as well as interfacing with the bus. The interface between the central processor module and the Multibus is the 8218 Multibus master control chip.

The main memory module accommodates both ROM and RAM chips. The read-only memory is used for fixed system programs such as the system monitor, bootstrap, diagnostics, and in the case of model 210, the editor and assembler. The RAM is used for programs that need not remain in memory: system and user programs, including the ISIS-II, assemblers, and compilers.

The RAM and ROM address spaces partially overlap, which in effect extends the available main memory beyond the 64,000 bytes allowed by the 8080 microprocessor. This partial overlap is possible because the program in the overlapped section of ROM, the system bootstrap and diagnostics, is never executed concurrently with RAM programs in the same address space.

All on one board

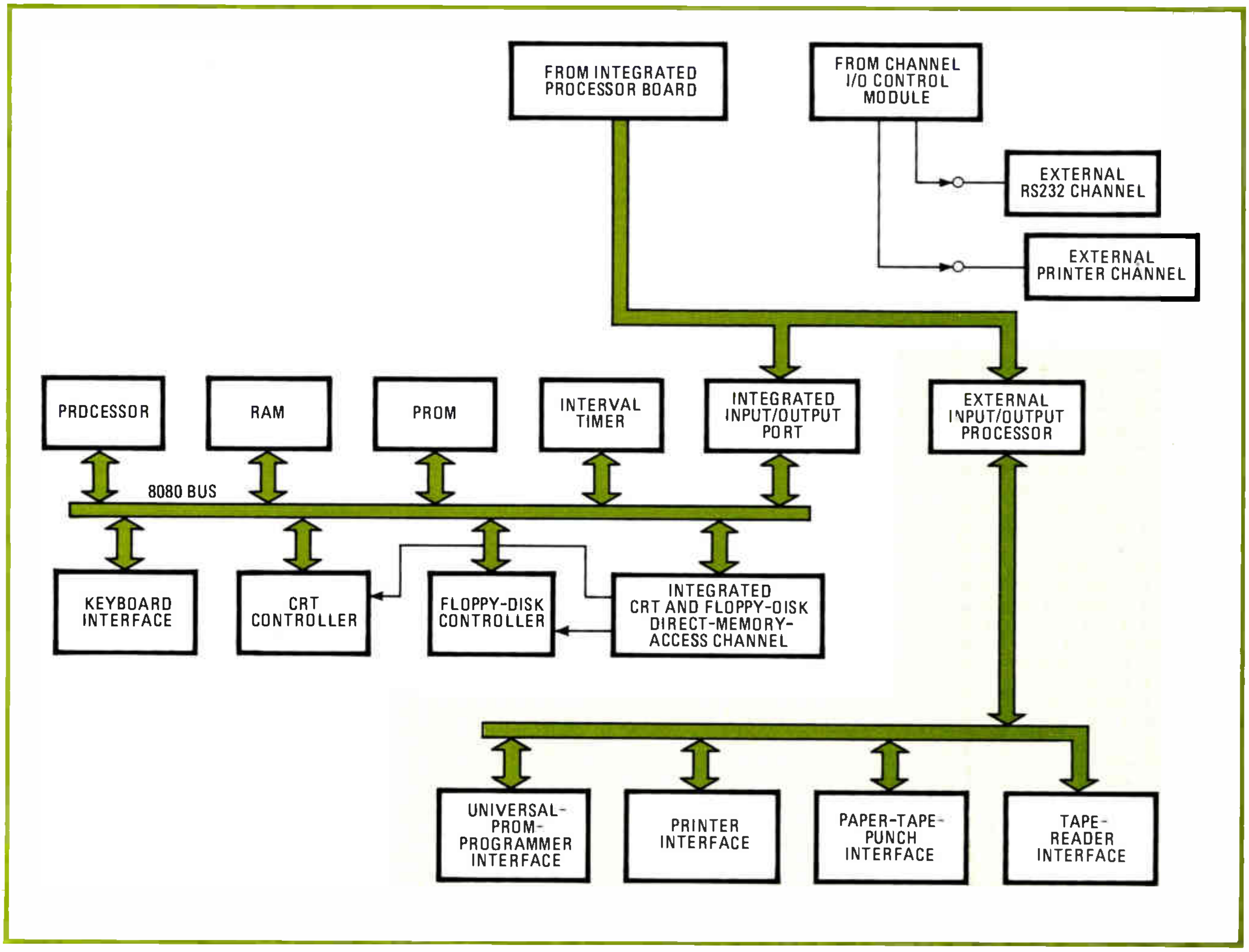
Using the connecting Multibus configuration, the integrated processor board brings the 8080A-2 CPU and the memory module together with two serial channels with both RS-232-C and current-loop provisions, the timer and interrupt modules, and the communication port to the slave I/O control processor. In addition, it has provisions for plugging in a small piggyback pc board that houses 20,000 more kilobytes of ROM. The original Intellec required five boards for the same configuration.

The resident RAM is implemented with 16,384-bit chips, and the resident ROM also uses 16-k chips. The two serial channels are provided via two 8251 universal synchronous/asynchronous receiver/transmitters. An 8253 interval timer generates the serial-channel baud-rate signal, as well as the logical real-time clock interrupt. System and front-panel interrupts are controlled via an 8259 interrupt processor. Interface to the slave I/O is with an 8255 programmable I/O controller.

To facilitate communications with various options that extend the host processor, the integrated processor board initiates and controls the bus by means of an edge connector. This arrangement extends the bus to the pc motherboard and to the rest of the system.

The slave processor is on the I/O controller board and comes in two versions. The one used with the 220 and 230 contains controllers both for the integrated CRT and the floppy-disk drive and for the interface to parallel peripherals. For the 210, a pared-down version contains only the interface controller for parallel peripherals. Both are shown in Fig. 3, where the pared-down version is within the color tint.

Appearing in both versions is the new UPI-41, the



3. To the outside world. The input/output controller board is the link between the integrated processor board and various I/O units. In the model 210, a UPI-41 I/O processor controls external units (shaded area). The 220 and 230 have control chips for the CRT and disk drive.

single-chip peripheral controller containing an on-chip 1,024-bit ROM, 64 bytes of RAM, and the necessary I/O ports to perform all control and data-transfer functions that are required between the peripherals and the host computer. The 220/230 version, on the other hand, adds its own 8080A-2 processor to set up and direct the concurrent operation of the floppy disk and the CRT display.

The keyboard has its own independent single-chip computer, another UPI-41. It performs all necessary keyboard tasks including creating key codes, controlling key rollover and multiple-key depression, and transmitting key codes to this board's 8080A-2 via an 8255 I/O port. The I/O controller board contains 8,000 bytes of built-in RAM, which functions both as the data-transfer buffer between the host processor and the peripherals that are part of the package and as temporary storage for the slave processor.

Data transfer between the CRT and the disk drive and the host processor takes place in two steps. First, there is transfer of data between the host memory and the slave RAM. This transfer takes place on a byte-at-a-time basis under the direct program control of the processors in both the host and the slave. Next comes data transfer between the slave memory and the target peripheral. This transfer takes place under direct-memory-access control, using an 8257 DMA controller.

The data-transfer operation to the external parallel peripherals, such as a printer or PROM programmer, takes place through the UPI-41 single-chip peripheral controller. For the packaged peripherals—the CRT, the floppy-disk controller, and the DMA controller—the programs reside in 8 kilobytes of ROM on the I/O controller board. They are responsible for setup, direction, and allocation of slave-processor resources, including the various controllers and the memory space. Also, they are responsible for controlling data transfer to and from the host processor. The host-slave transfers are initiated upon request from the host and take place over an 8-bit bidirectional data link between the host and the slave, using a standard protocol that was developed for communication between the 8080 and the UPI-41.

Packaging together the most commonly used elements in a microprocessor development system (the two boards, the floppy disk, and the CRT console) has saved the cost of separate power supplies and separate enclosures, thus reducing overall system cost. In addition, the unit takes up less space on the user's work bench.

Based on studies of the usual configurations of systems under development, six card slots are included in

A ride on the bus

The Multibus configuration is a clocked asynchronous bus allowing multiple independent and concurrently operating processor modules to communicate with each other and to share access to common system resources efficiently and economically. Modules connected with the Multibus scheme are distinguished as either masters or slaves, with the former being able to gain control of the bus and initiate data-transfer operations by requesting a bus cycle from the bus control logic, when one is required.

Bus requests are assigned priorities so that access is granted to the module with the highest priority when two or more simultaneously request access to the bus. The module granted the bus access will maintain control until its transfer cycle is complete.

For example, when the central-processor module obtains a bus access to fetch an instruction byte from memory, it maintains control of the bus through the transfer of address to the memory and receipt of the instructions back from the memory. Therefore, the bus-transfer cycle time and the bus throughput are a function of the type of transfer and the response time of the addressed module to the requested operation. In this case, the memory access time determines the length of the transfer cycle.

A significant gain in performance comes from the Multibus setup's ability to transfer control from one master to the next in parallel with the on-going data transfer operation. This feature eliminates costly overhead time. The bus is accessible to the various modules within the Series II system via a printed-circuit motherboard that has provisions for plugging in various standard as well as optional modules.

all models. The 210 and 220 use only one slot while the 230 uses four slots. The extra slots should satisfy the needs for most development systems; however, four extra card slots can be added to all models by attaching an expansion chassis. The I/O controller board does not take up a slot. It is mounted flush against the back panel to eliminate extra wiring in the chassis.

Matching software to needs

Microcomputer applications span the range from simple controller designs to large multiprocessor designs with hundreds of thousands of bytes of program code. Clearly, microprocessor development software must also span a range of capabilities to match these varied applications. In the case of the Intellec Series II, software is available on several levels consistent with the hardware capabilities of each model.

Two distinct, yet compatible, operating systems are available, as mentioned: a ROM-based system monitor and the ISIS-II diskette operating system. The system monitor provides basic supervisory functions for all Series II systems. These functions include the user interface for systems based on the 210, a rudimentary program debug and checkout facility for 8080 programs, and a generalized I/O system accessible to the designer's program. The 210 uses the monitor as its sole operating system. ISIS-II, which provides a set of file management services to augment the supervisory functions of the monitor, is on a floppy disk with the 220 and 230.

The ISIS-II command language is easy to use and does not force upon the design engineer the types of artificial abstractions present all too often in other command languages. Nonetheless, a simple-to-use command language does not imply a limited operating system. ISIS-II supports a wide selection of system configurations, from the simplest 220 to a 230 system with six floppy-disk drives for a total of 2.5 million bytes of on-line storage, plus a high-speed line printer and various kinds of input devices.

An important feature of the Series II is the availability of higher-level languages and macro-assemblers for coding program reliably. On the high end of the spectrum are both PL/M, invented by Intel in 1973, and a new resident Fortran compiler. The PL/M compiler, available for the 230, generates code for both the 8080 and the 8085 microprocessors.

Since many engineers have some familiarity with Fortran, a new compiler for the Intellec systems supports a language compatible with the 1977 ANSI Fortran specification. Therefore, it offers designers the ability to connect software from one hardware system to other computer systems. The introduction of Fortran 77 in a development system opens new avenues for creativity in product development. This compiler is designed to run on model 230 under the ISIS-II operating system.

The advantages of sophisticated programming languages become apparent when developing software by building up modules. It may be advantageous both for speed of the development process and for reliability and ease of maintenance of the final product to produce modular software. Yet, for many applications, it is not feasible or wise to use a single programming language when developing the software. A powerful feature of ISIS-II is the ability to link programs written in PL/M, Fortran, and assembly language easily without any direct user knowledge of the interface.

A sophisticated relocation and linkage package included with the ISIS-II operating system allows the software developer to write 8080 or 8085 programs in small modules, each module being in any Intel programming language, and then automatically link the modules together. The final module may then be located any place in system memory, taking into account the location of ROM and RAM. Also, a library management program in ISIS-II allows the user to store frequently used routines where they may be easily linked to any referencing program.

In short, the user can choose from a variety of software development tools to build the system that best suits specific needs, yet be assured that in the end software requirements will be met. Moreover, the elements are in place for continually upgrading of development system hardware and software to keep pace with advances in microprocessors. □

Scanned keyboard activates eight-tone generator

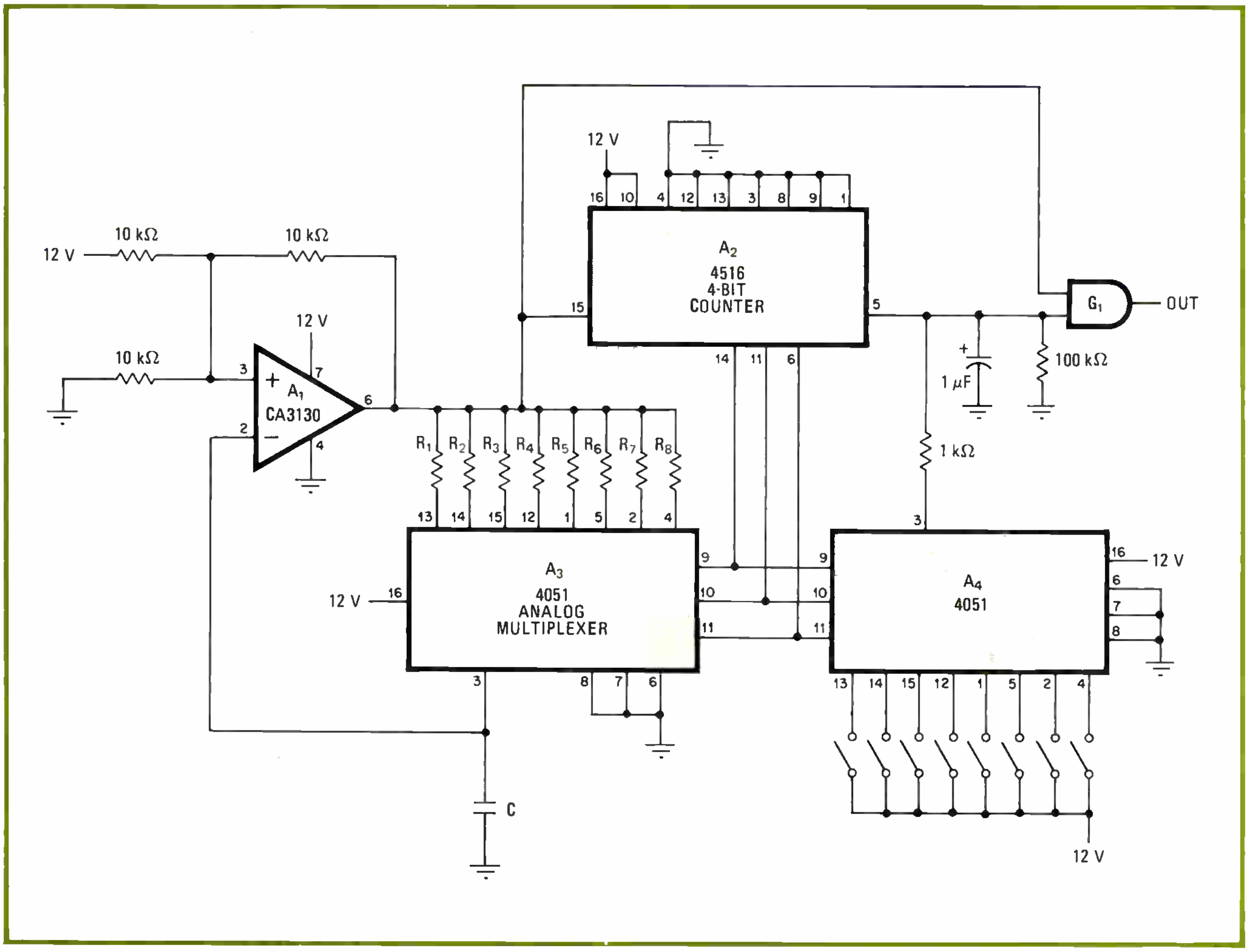
by Albert Helfrick
Aircraft Radio and Control Division of Cessna Aircraft Co., Boonton, N. J.

This keyboard-activated eight-tone generator owes its simplicity to a single oscillator, which makes possible the scanning of the keyboard and simultaneously functions as the tone generator. As a result, its device count is low and its cost is minimal.

Circuit operation is easily understood. The CA3130 operational amplifier, A_1, is configured as a relaxation oscillator, its frequency controlled by R_iC. R_i lies in the 100-to-500-kilohm range, and C is 0.01 microfarad or so for frequencies in the 1-to-10-kilohertz range. The oscillator has excellent frequency stability as a result of the operational amplifier's extremely high input impedance and the complementary-metal-oxide-semiconductor output circuit.

A_1 drives the 4516 4-bit counter, A_2. As the counter increments, it scans each input port of two analog multiplexers, A_3 and A_4. A_3 sequentially places all resistors, R_1 through R_8, in the oscillator circuit, enabling A_1 to generate exactly one cycle of each frequency determined by each R_iC combination. At no time is there any output from G_i, however.

Meanwhile, multiplexer A_4 is scanned to determine whether any keyboard switches are closed. If any switch should be depressed, a logic 1 will emanate from pin 3 of A_4, freezing the counter and enabling G_1. A_1 will then oscillate at the frequency determined by the particular value of R that is in the oscillator circuit when the counter halts. Since the counter cannot advance while the key switch is closed, and simultaneously closing any



Scanned tones. Self-gating oscillator, A_1, advances counter and with aid of multiplexer A_3 sequentially places R_1–R_8 in series with C so as to control frequency. Op amp's high-input impedance and C-MOS output ensures high oscillator stability. No signal appears at output until a keyboard switch is closed, when A_4 freezes counter and activates G_1, enabling generation of the single desired frequency.

other key will have no effect on the output frequency, the circuit has in effect a built-in lock-out feature.

The time required for the system to latch to any particular frequency is a function of both the number of frequencies that can be selected and the actual frequencies of oscillation. The maximum acquisition time works out to approximately:

$$t = \frac{1}{f_1} + \frac{1}{f_2} + \; . \; . \; . \; \frac{1}{f_i}$$

where each f_i is equal to $1/0.69\ R_iC$. For eight frequencies in the kilohertz range, t equals about 8 milliseconds, which is an acceptable period of time for manual keystroke applications. □

Frequency multiplier uses combinational logic

by R. J. Patel
Tata Institute of Fundamental Research, Bombay, India

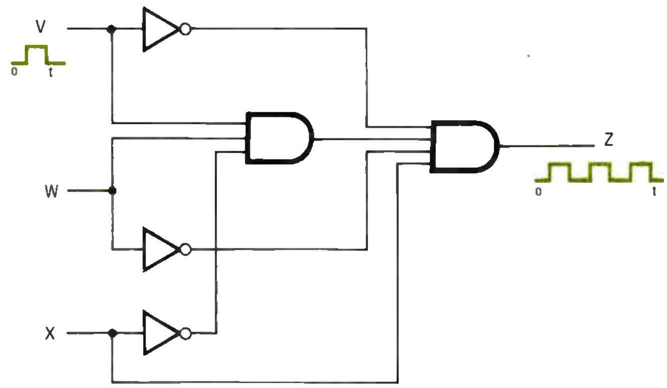
Relying on a technique that uses digital logic rather than high-speed system clocks or nonlinear generators to perform frequency multiplication, these circuits derive a square wave with an output frequency of up to four times that of the input signal. Extremely easy to understand and implement, the general method used in synthesizing these combinational-logic circuits is useful for achieving practical high-order frequency multiplication of up to eight times.

Since frequency-doubler circuits are relatively simple and well-known configurations exist, the logic technique is shown in Fig. 1 for a frequency tripler. For the logic circuit to perform tripling, the waveform at Z must traverse three full cycles, or six half-cycles (represented by states 101010), during the time of one input cycle (represented by 111000) at V. Thus the circuit must detect six different logic states, and so a minimum of three input variables, V, W, and X, is required.

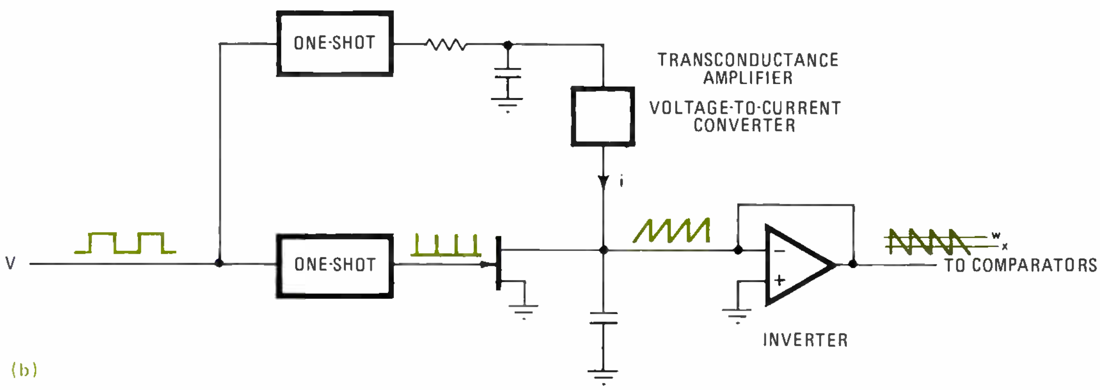
Note, however, that the input signal at port V is the

FREQUENCY TRIPLER

STATE	V	W	X	Z
1	1	1	1	1
2	1	0	1	0
3	1	0	0	1
4	0	1	1	0
5	0	0	1	1
6	0	0	0	0
OUT = $V(\overline{W+X}) + \overline{V}\overline{W}X$				



(a)



(b)

1. Multiply by 3. Digital frequency multiplier is an alternative to multipliers using high-speed clocks and nonlinear generators. States W and X are derived from V, although transformation cannot be done digitally (a). Ramp and comparators can generate the required digital voltages from V, however (b). Use of linear ramp allows easy determination of the threshold levels that must be detected to switch logic elements.

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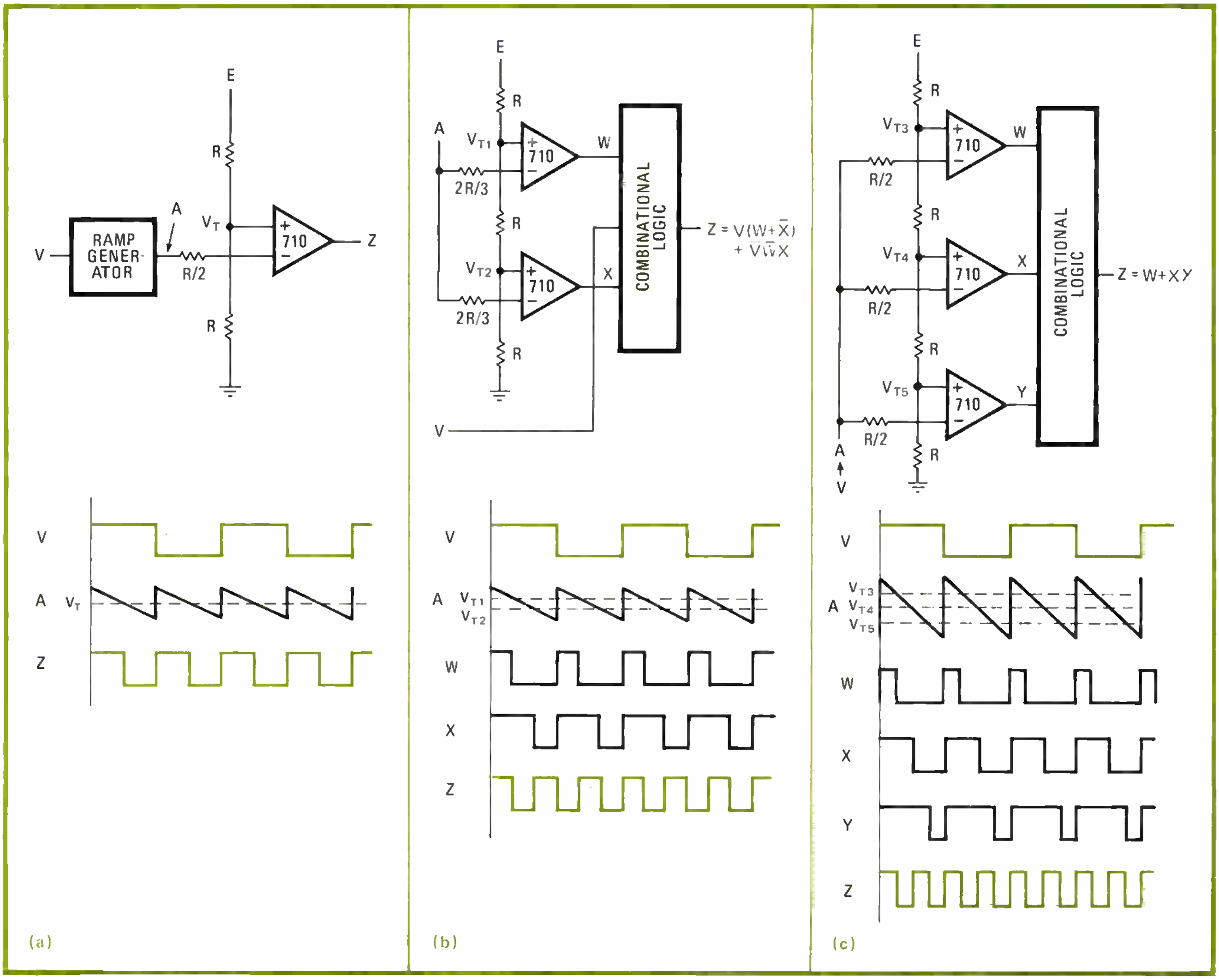


2. Two, three, four.... Frequency doubler (a), tripler (b), and quadrupler (c) are easily synthesized with combinational logic and comparators. Technique can be extended to multiply by up to eight circuits. Number of comparators in multiply-by-N counter is N – 1; threshold value V_T has value of ME/N if ramp is linear, where M is the comparator number and E is the supply voltage.

only waveform available, and therefore signals W and X, whose logic states for a particular V are not yet known, must be derived from V itself. The particular values of W and X may be assigned to the truth table once it is realized that the duty cycles of the three input variables are different and that the logic states of the dependent variables, W and X, must change at a faster rate than the independent variable, V. Once the logic states are assigned, the Boolean equation may be determined and the circuit synthesized with simple logic gates. Although several combinations of W and X may be assigned to a given V, the end result should be virtually the same in the Boolean expression. However, it is important to assign the logic 1 states to W and X before the 0 states are assigned to them, for reasons that will shortly become obvious.

Variables W and X not only change with the state of V, but also vary with time when V is constant, as shown. Therefore, W and X cannot be derived directly from V in the digital domain. However, a negative-going ramp voltage whose sweep rate is equal to twice the input frequency can, with the aid of operational-amplifier threshold detectors, synthesize the digital signals required at W and X for the doubler (a), tripler and quadrupler, as shown in Fig. 2. The timing diagram details the circuit operation, obviating the need for a description of each logic circuit.

There are several well-known ways to generate the negative ramp voltage required, many of them constructed with multivibrators and op amps. The block diagram of such a ramp generator is shown in the lower portion of Fig. 1. Use of a linear ramp of the type shown allows easy determination of the threshold levels that must be detected in order to switch the logic elements at the proper times.

Generally, the number of comparators in a circuit will be equal to N – 1, where N is the multiplication factor, whose maximum practical value is 8. The threshold voltages will be equally spaced if a linear ramp is used, each voltage being equal to ME/N, where M is the comparator number and E is the supply voltage. ☐

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

Communications chip interfaces with most microprocessors

ACE, a completely bidirectional asynchronous line-control element, also has a priority interrupt scheme and on-chip baud-rate generator

by Sam Travis, *National Semiconductor Corp., Santa Clara, Calif.*

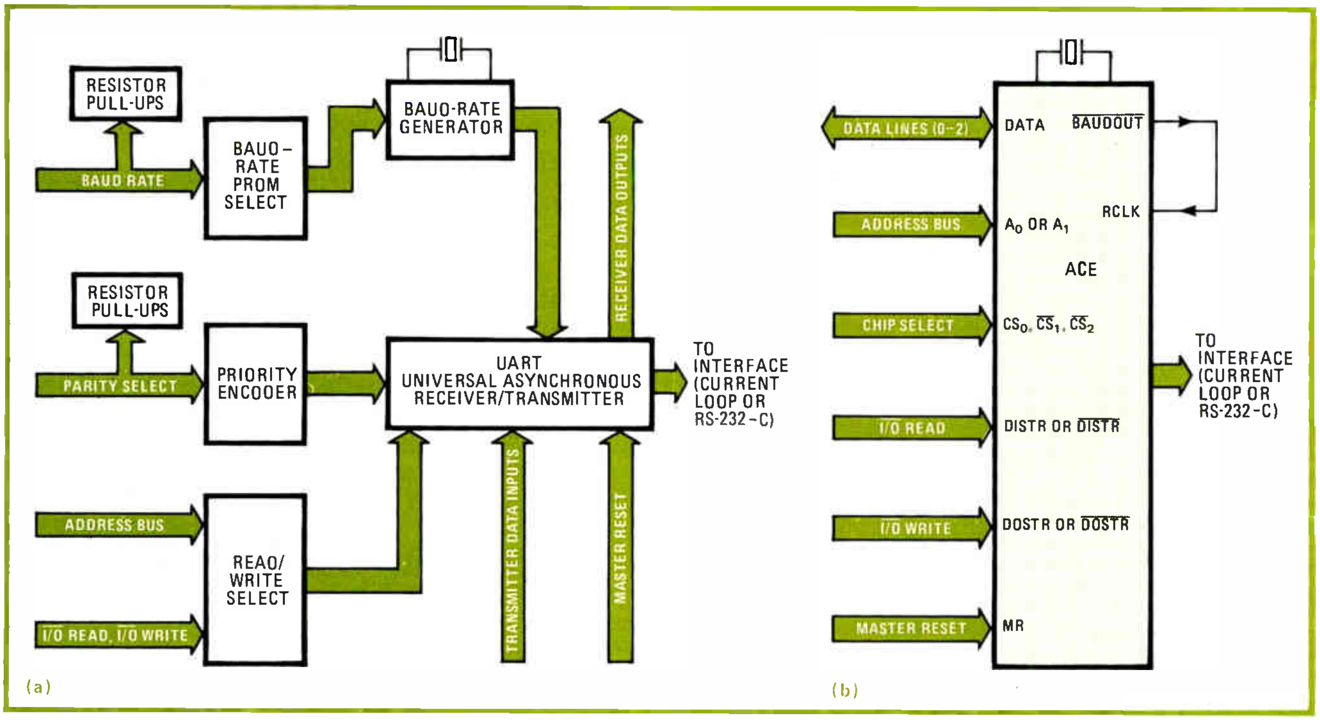
☐ Data communications owes some of its rapid growth to the microprocessor, which makes it relatively simple and inexpensive to build equipment like front-end processors, data multiplexers, and intelligent terminals. But the designer of these and similar systems still lacks a single, standard means of supplying the microprocessor with both an interface to the communications device and the equivalent of the line-control unit found in larger computer systems.

For line control, the engineer often must resort to a universal asynchronous receiver/transmitter, adding a board full of transistor-transistor-logic and other circuits for interface with the communications device (Fig. 1a). With luck, a large-scale integrated circuit that performs as an asynchronous communications interface may instead be available for the particular microprocessor being used.

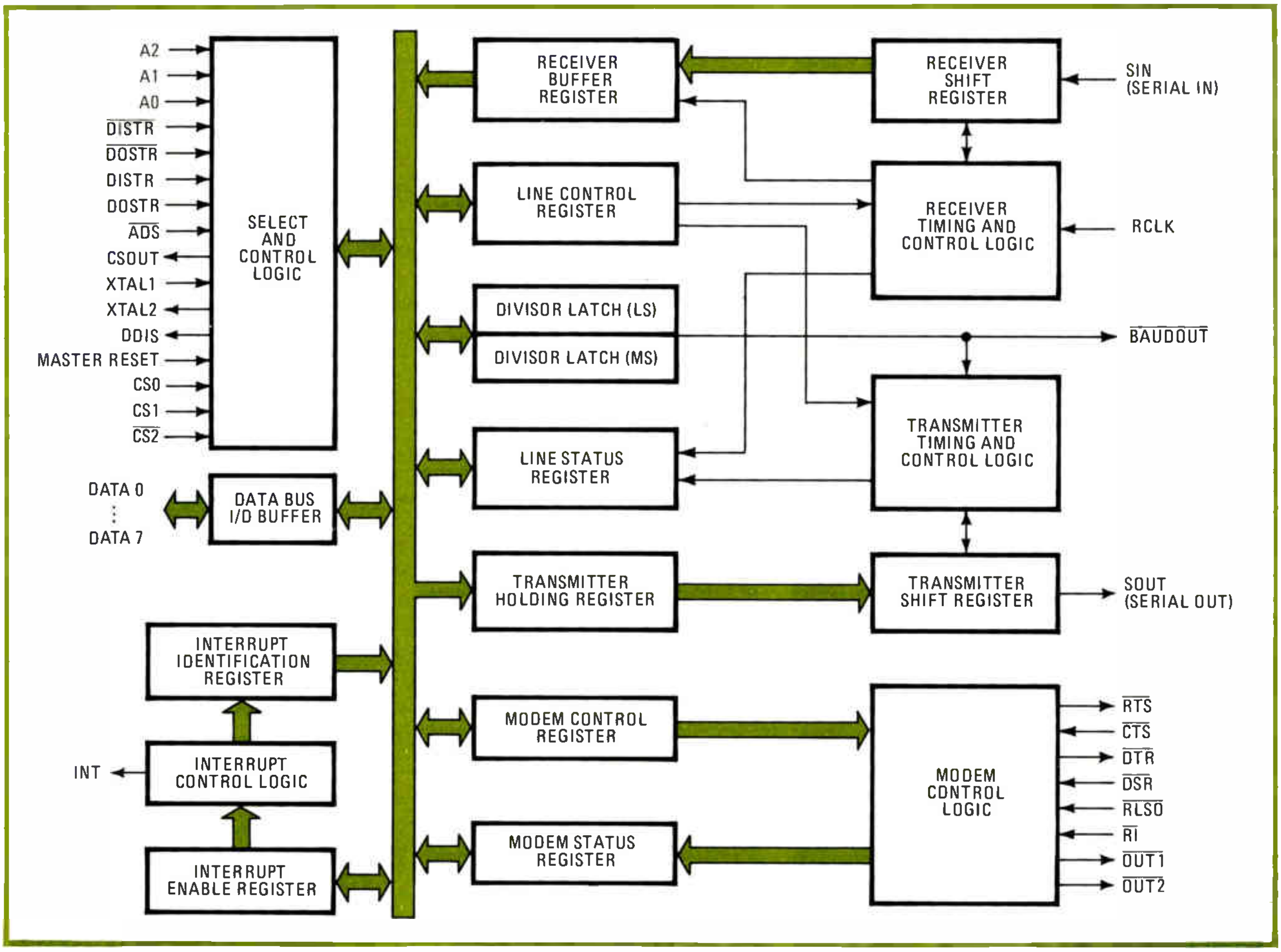
But what is needed is a standard interface chip, versatile enough to link most of the popular microprocessors to most modems and therefore capable of being produced in volume at relatively low cost. The asynchronous communications element (Fig. 1b) aims to be such a device for processors like the 8080, SC/MP, PACE, 6800, 2900, and Z80.

The ACE is an n-channel chip in a 40-pin dual in-line package. As a fully bidirectional communications device that handles all the timing and protocol requirements of asynchronous data communications, it further simplifies the design task by incorporating a user-programmable baud-rate generator on chip, and it enhances system performance with an efficient priority-interrupt scheme that also is user-programmable. Its chip-select logic and latch can be used very easily with multiplexed bus lines, and two of its modem control outputs are user-defined.

As added evidence of its flexibility, the ACE can interface to a modem via the RS-232-C connector or a 20-



1. Simpler interface. The single asynchronous communications element (ACE) shown in (b) performs all the functions that previously would have required the devices in the circuit in (a): a universal asynchronous receiver/transmitter plus baud-rate generator, baud-rate select, priority encoder, read/write select and pull-up resistor networks. Also, the ACE interfaces with any of today's popular microprocessors.



2. All in the chip. Block diagram of ACE details all the functions and interfacing that exists on-chip needed to perform the timing and control functions required for bidirectional data communications. The chip is housed in a 40-pin dual in-line package.

milliampere current loop, or it can bypass the modem completely and interface directly to a data terminal. Linked to just one microprocessor, an ACE can form a stand-alone peripheral. Alternatively, using interrupt polling, two or more ACE packages can be linked to the same microprocessor.

The link with the microprocessor

Each ACE communicates with its microprocessor through eight bidirectional data lines and up to 18 control lines and with the transmission line and modem through five input and up to five output lines, two for serial data and up to eight for modem control (Fig. 2). Internally, the data bus buffer and the timing and control logic that manipulate the microprocessor inputs and outputs communicate over an 8-bit bus with: the receiver and transmitter buffer registers; the line and modem status and control registers; the interrupt enable and identification registers; and the divisor latch that serves the baud-rate generator. As in a UART, received and transmitted data are double-buffered. But unlike in a UART, the timing input to their control logic comes wholly or in part through the on-chip baud-rate generator. The priority interrupt system is also an advance on the bit-scanning schemes preferred by some other communications interface chips.

The microprocessor controls the ACE, and through the microprocessor the system programmer can control any register on the ACE. To access the device, the microprocessor can use up to three chip-select inputs, CS_0, CS_1, and $\overline{CS_2}$. Then to access the internal registers in the ACE, it uses the three least significant bits of its address word tied to the ACE's A_0, A_1, and A_2 lines (see Table 1). The master reset, as usual, initializes the device by clearing all registers. Data and control information pass back and forth between the processor and ACE over the 8-bit bidirectional data bus.

Worth noting is the availability of both the true and complement versions of the data input strobe (DISTR) and data output strobe (DOSTR), both referenced to the microprocessor's input and output conventions. The option enables ACE to interface directly with more microprocessors. DISTR or $\overline{\text{DISTR}}$ is used to transfer data from the ACE to the microprocessor during the input cycle; it is the equivalent of the 8080's I/OR signal, SC/MP's WRDS, and PACE's IDS. Conversely, DOSTR or $\overline{\text{DOSTR}}$ helps transfer data from the microprocessor to the ACE during the write cycle.

For synchronizing its internal operation, the ACE offers the designer a choice of two clocks, either an on-chip clock controlled by an external crystal or an external clock generator. Either clock is used to refer-

The trend to communications controller chips

Many semiconductor firms are viewing the rapidly expanding field of data communications with increasing interest. Although a few dedicated chips have been available, they provided only limited functions, and several were needed in most data-communications and distributed-processing applications. The trend now is towards packing all the needed functions on a single large-scale integrated circuit. And these LSI chips actually contain more circuits and functions than the microprocessors that they are designed to work with.

Indicative of this trend is National Semiconductor's new asynchronous communications element (ACE), described in this article, and Signetics' 2651 programmable communications interface (PCI) and 2652 multiprotocol communications controller (MPCC), both of which National is second-sourcing. These parts are powerful communications chips, containing a baud-rate generator, self-test modes for local and remote loop-feedback tests, asynchronous and synchronous byte-oriented protocols in both receive and transmit modes, and special processing to support the IBM data-link control and other protocols.

In addition, Zilog offers its Z80-SIO serial interface chip, which is similar to the 2652 MPCC. It lacks an on-chip baud-rate generator, but has two channels in both the receive and transmit directions. Also, Western Digital, Standard Microsystems, Intel, and General Instrument have fairly complex, universally asynchronous and synchronous receiver/transmitter chips, while Motorola makes three programmable asynchronous data-communications adapters (ACIAs), which handle most of the commonly used serial asynchronous protocols.

All this is just the tip of the iceberg, more of which should become visible this year as makers add to the growing list of dedicated LSI chips. **Richard Gundlach**

ence the time base for the on-chip baud-rate generator, which users should remember will produce a signal ($\overline{\text{BAUDOUT}}$) that is 16 times the actual baud rate. To represent a 16-bit modulus of divisor for the baud-rate generator, two 8-bit bytes are loaded into its divisor latches. The formula for the divisor is:

Input frequency/(16 × baud rate)

An input frequency should be chosen such that the amount of error is minimal. Usually 1% is acceptable, and this is easily accomplished with an inexpensive 3.5795-megahertz crystal of the kind commonly used in U. S. color television sets. But a 1.8432-MHz crystal (the standard 8080 frequency divided by 10) results in superior accuracy over a wider range of frequencies. Note that a key advantage of the ACE baud-rate generator is that it can accept any input frequency from 960 kilohertz to 3.1 megahertz and reproduce any baud rate at or below 1,200 baud within a 1% error.

The transmitter clock is connected to $\overline{\text{BAUDOUT}}$ internally, and both it and the baud rate for the transmission of data will always be 1/16 the rate of $\overline{\text{BAUDOUT}}$. The receiver clock input (RCLK) can also be tied to $\overline{\text{BAUDOUT}}$ if the receiver and transmitter are to have the same baud rate; otherwise it must have a separate clock signal that is precisely 16 times the desired receiver baud rate.

On-chip line control

In time with the receiver clock, serial data from the peripheral enters the ACE through the serial input (SIN). There it is grouped by the receiver shift register into an 8-bit word for transfer to the receiver buffer register as directed by the line control register. At the time of the transfer, the line status register sets its data-ready status bit high, causing the interrupt enable register to send a data-received interrupt to the microprocessor. If the microprocessor fails to pick up the character before the next incoming character is completed, the line status register produces an overrun error flag, which again produces an interrupt.

After processing, the parallel data enters the transmitter holding register for transfer to the transmitter shift register, which shifts each character out of the ACE over the serial output (SOUT) at the pace set by the on-chip baud generator. The transfer of the data from the holding to the shift register takes place either immediately if the shift register is empty or else as soon as it becomes empty. At the time of the transfer, the line status register sets its transmitter-holding-register-empty signal high, which in turn prompts an interrupt to the processor. The processor then refrains from loading the holding register until the register-empty signal goes low.

TABLE 1: ADDRESSING THE REGISTERS

Divisor latch bit	Address lines A2	A1	A0	Register addressed
0	0	0	0	Receiver buffer (read), transmit buffer (write)
0	0	0	1	Interrupt enable
X	0	1	0	Interrupt identification (read only)
X	0	1	1	Line control
X	1	0	0	Modem control
X	1	0	1	Line status
X	1	1	0	Modem status
X	1	1	1	None
1	0	0	0	Divisor latch (least significant byte)
1	0	0	1	Divisor latch (most significant byte)

The serial input is a high-impedance, TTL-compatible line. It can receive data directly from an EIA RS-232-C terminal interface through TTL quad-line receivers such as the LM1489, which translate EIA voltage levels to TTL levels. Conversely, the serial output drives quad-line receivers such as the LM1488, which convert TTL signals to EIA levels.

The 8-bit line control register enables the designer to specify the format of the start/stop data exchange. The programmer may also retrieve this register to inspect its contents—a feature that simplifies programming and eliminates the need for separate storage of the line characters in memory.

Of the line control register's 8 bits, the first two specify the number of bits in each serial character; the

TABLE 2: INTERRUPT CONTROL FUNCTIONS						
Interrupt identification register			Priority level	Interrupt set and reset functions		
Data 0	Data 1	Data 2		Interrupt source	Interrupt flag	Interrupt reset control
1	0	0	–	none	none	–
0	1	1	highest	receiver line error	overrun, parity, framing, or break interrupt	read line status register
0	0	1	second	receiver data available	receiver data available	read receiver buffer
0	1	0	third	transmitter holding register empty	transmitter holding register empty	read interrupt identification register or write into transmitter holding register
0	0	0	fourth	modem status	clear to send, data set ready, ring indicator, or received line signal detect	read modem status register

word lengths may be 5, 6, 7 or 8 bits. The third bit specifies the number of stop bits to be sent (in the case of a 5-bit word, 1½ stop bits are sent by setting the bit high, as if for 2 stop bits).

The register's fourth, fifth, and sixth bits handle parity. The fourth bit when set inserts a parity bit between the last data bit in a transmitted character and the stop bit or bits; it also means that incoming, receiver words should have a similar parity bit. In conjunction with the fifth bit, the even parity select bit, it describes whether the data bits plus the parity bit in a given character add up to an odd or even number of 1s. In conjunction with the sixth bit, the stick parity bit, it enables the receiver to continuously transmit and receive a parity bit in the same logic state regardless of the data bits. In this mode, the parity and stick parity bits are set high and the even parity bit is held low.

The seventh bit in the line control register is the set break point control. When set high, it forces the serial output (SOUT) into the spacing state, so that only 0s are transmitted, regardless of other transmitter activity, until the set break control is set low again. This feature enables the microprocessor to bring the terminal it controls to the attention of the central computer in a communications system.

The line control register's eighth and most significant bit is the divisor latch bit. It must be set high to access the divisor latches of the baud-rate generator during a read or write operation. It must be set low to access the receiver buffer, the transmitter holding register, or the interrupt enable register.

Detecting errors

The line status register provides status information to the microprocessor to verify that data transfer is taking place. Error conditions that produce a receiver error interrupt are specified by the second through fifth bits of the register, after the word has been received.

The register's first bit is the data ready indicator. It is set high whenever a complete incoming word is received and transferred into the receiver buffer register. It may be cleared either by the processor reading the data in the buffer register or by the programmer writing a 0 into it.

An overrun error is specified by the line status register's second bit. It indicates that data in the receiver buffer was not picked up by the processor before the next character was transferred into the receiver buffer register, thus destroying the previous character. The overrun-error indicator is reset by reading the line status register.

The third bit specifies a parity error, indicating that the received data word does not have the correct even or odd parity as selected by the even parity select bit. It is set to a 1 upon detection of a parity error and is reset by reading the line status register.

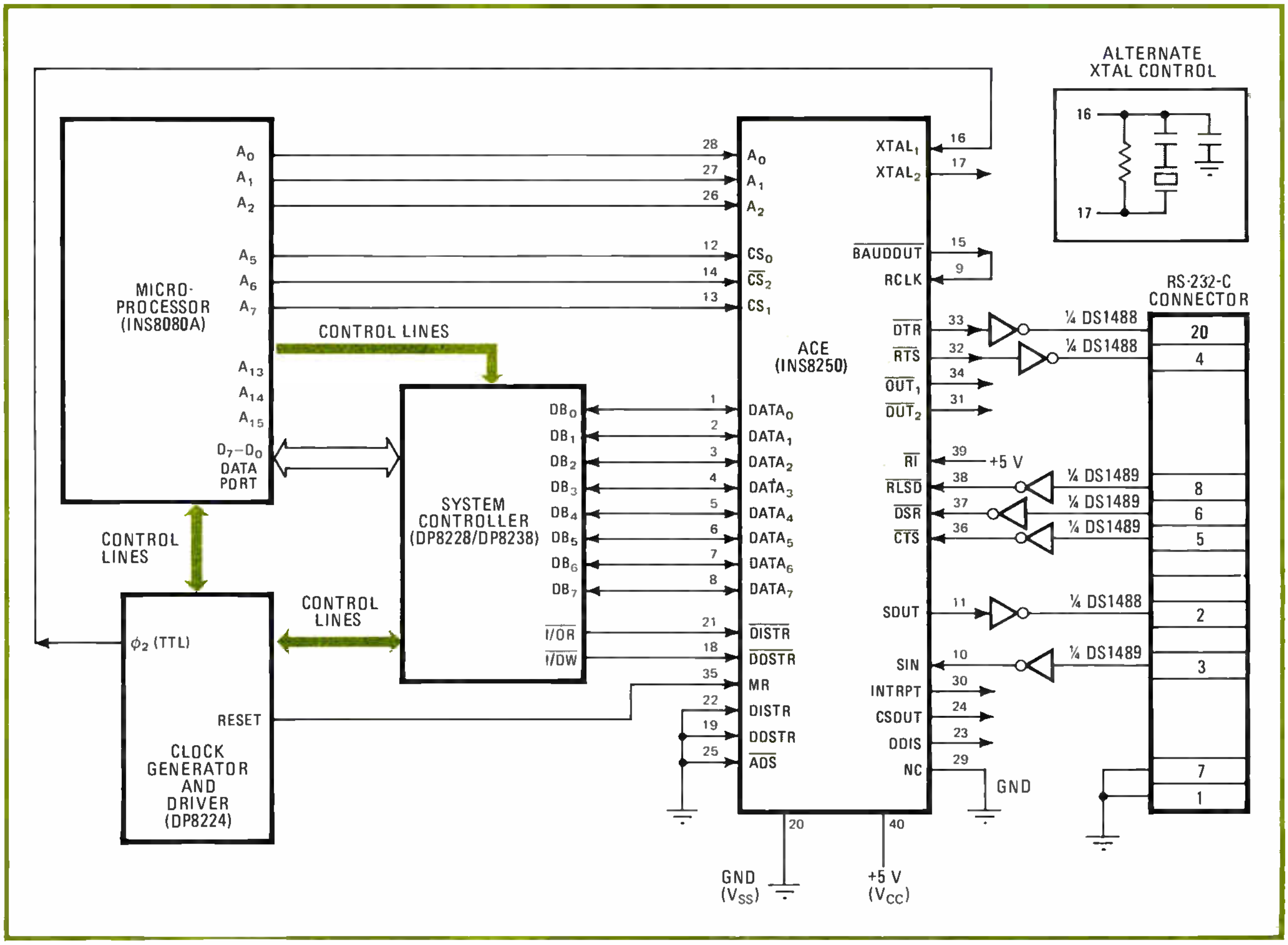
When the received character does not have a valid stop bit, the framing error indicator, the fourth bit, is set. Whenever the received data input is held in the spacing state, all 0s, for a period of time exceeding that required for a full word transmission (total time of start bit, data bits, and parity and stop bits), the fifth bit of the line status register is set, indicating that a break-interrupt condition exists.

Peripheral control

The operation of a modem (data set) or other peripheral device is controlled by the microprocessor operating through the ACE modem control register, while its modem status register reports the current state of the control lines from the modem to the microprocessor.

The ACE has eight built-in modem control functions. The four input control functions are clear to send ($\overline{CTS}$), data set ready ($\overline{DSR}$), ring indicator ($\overline{RI}$), and received-line signal indicator ($\overline{RLSD}$). The status of these lines is stored in the fifth through eighth bits, respectively, of the modem status register. The register's other four bits provide change information, being all set to 1 if a control input from the modem changes state and being reset to 0 whenever the register is read.

The four output control functions are data terminal ready ($\overline{DTR}$), request to send ($\overline{RTS}$), and two user-defined outputs ($\overline{OUT_1}$ and $\overline{OUT_2}$), which are under control of the first four bits of the modem control register. Each output is driven to a low TTL level when its bit is set and to a high TTL level when its bit is low. Also, for direct interface to RS-232-C communication, each can drive an EIA line driver, such as the LM1488 or the DS1488,



3. Bidirectional communicator. In this configuration ACE performs a parallel-to-serial conversion of the data received from the microprocessor system via the controller to the RS-232-C interface. A serial-to-parallel conversion occurs in the reverse direction.

which inverts the data from the ACE to produce a positive voltage output when any of the output lines is a TTL 0.

The extra outputs ($\overline{OUT_1}$ and $\overline{OUT_2}$) are used as special modem controls. They can function as loopback modes for link diagnostics, or provide additional control signals for modems that require them, or provide extra control lines when the ACE interfaces directly to data terminal equipment, thus bypassing the modems and telephone network. In the loop-back mode application, the four ACE modem control logic outputs are internally connected to the four input lines. These lines drive the lines of the data terminal equipment, and the ACE inputs are connected to the $\overline{DTR}$ and $\overline{RTS}$ outputs of the data terminal equipment.

The fifth bit of the modem control register provides the loopback feature for diagnostic testing of the communications link. It enables the processor to verify the transmitter- and receiver-data paths to the ACE, as well as the modem signal paths.

The interrupt system

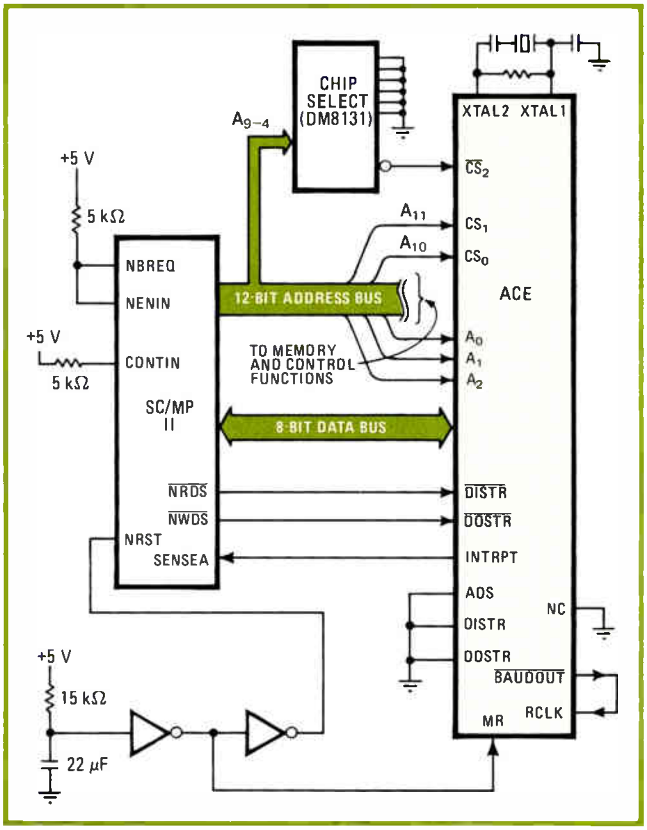
The interrupt system provided by the ACE allows for flexibility in interfacing to all popular microprocessors on the market today. Moreover, during data-character transfer the ACE grades interrupts into four levels of priority, so that the programmer need not include instructions to this effect or provide extra memory for storage of these instructions.

Information indicating that an interrupt of a given priority is pending and the identification of that interrupt is stored in the interrupt identification register. (Table 2 shows how the interrupts are set and how the reset functions work.) When addressed at chip select time, the IIR freezes the highest-priority interrupt pending. No others will be recognized until service of that interrupt is complete, with the exception of the transmitter-holding-register-empty interrupt, which is reset immediately upon the reading of the interrupt identification register.

The register's advantage is that its contents can be used as a pointer to the appropriate service routine. This results in a much more efficient interrupt response than is possible with the bit-scanning techniques that are used in many systems.

Enabling or disabling each of the four interrupt levels independently is accomplished via the 4 least significant bits of the interrupt enabling register. On-chip master-slave flip-flops store all interrupts, not only guaranteeing that signals are valid at the time that they are read, but in addition ensuring that interrupts occurring after the last recognized interrupt are remembered.

In applications where more than one ACE is used,



4. Single microprocessor setup. Here the ACE functions as a stand-alone peripheral. The microprocessor performs all the control functions with the aid of a chip-select integrated circuit; the ACE does the chores that normally require several peripheral chips.

interrupt polling can be applied effectively in either a polled or a hardware-priority environment. In a software polling system the microprocessor reads the interrupt identification register of each ACE in some predetermined sequence. If an interrupt is pending, the first bit is 0 and the contents can be used to gain direct entry to the appropriate interrupt routine. If, however, it is a 1, then no interrupt is pending.

This interrupt polling method is well suited for use by a number of microprocessors, including devices like SC/MP, 8080, PACE, and the 6800. On the other hand, microprocessors with hardware priority networks, such as PACE, may ignore the interrupt identification register's first bit and vector directly into the appropriate service routine, using the register's contents to modify a pointer to a list of addresses.

With the exception of the transmitter-holding-register-empty interrupt, all interrupts will be reset when they are serviced by the microprocessor. The highest-order interrupt will be serviced first, and then, if no other interrupt conditions are present, the original running mode can be restored.

Some applications

Figure 3 shows how to use the ACE in a system based on the 8080A microprocessor but typical for most microprocessors. When transferring information from the microprocessor to the RS-232-C interface, the ACE performs a parallel-to-serial conversion and conversely a serial-to-parallel conversion when transferring information from the connector to the microprocessor.

The ACE is controlled by the microprocessor. Its three address lines are tied to the 8080A's first three address lines and function as the ACE's address select. Its three chip-select lines are attached to the 8080A's address lines A_5, A_6, and A_7. The microprocessor's data lines are tied to the system controller (DP8228/DP8238), and the buffered outputs of the controller in turn drive the bidirectional data lines of the ACE. These lines provide the needed information for ACE to function according to the user's needs. The $\overline{I/OR}$ output of the controller is tied to the $\overline{DISTR}$ line of the ACE to provide a read signal. When the controller receives a read signal from the microprocessor, it generates a read signal to the ACE, which thereupon dumps the information from the specific registers that have been selected by the address select onto the data lines.

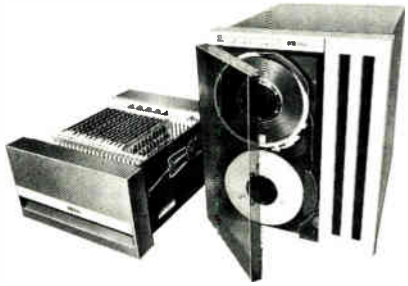
The converse happens when the microprocessor sends a write signal to the controller. Again, the ACE receives information from the controller on the data lines and loads it into the receiver registers. DISTR and DOSTR are then tied low, so that they are disabled, and the address strobe ($\overline{ADS}$) is tied low because A_0, A_1, and A_2 are stable during the address select time. A system clock signal at a TTL level is provided to the XTAL 1 input of the ACE via the clock generator and driver chip (DP8224). (An alternate clock signal may be provided by an alternate crystal control circuit.) The $\overline{BAUDOUT}$ is tied to the RCLK pin so that the receiver will run at 1/16 times the rate of $\overline{BAUDOUT}$, but the RCLK pin may be run at a different baud rate if the user so desires.

The master reset (MR) of the ACE is tied to the reset of the clock driver chip. When a 1 is received on this line, it clears all the registers except the receiver buffer, transmitter holding register, and division latches. The interrupt (INTRPT) pin is floating so that the user may access the interrupt flags. Also, the chip select out (CSOUT) is left floating so that the microprocessor may select the chip on CS_0, CS_1, and CS_2, while the driver disable (DDIS) is floating so that the microprocessor can access the internal transmitter of the ACE.

The communication outputs to the modem or data set are tied to a quad-line driver (DS1488), which ties to a RS-232-C connector. These outputs are $\overline{DTR}$, $\overline{RTS}$ and serial output SOUT.

The communication inputs of ACE are tied to the RS-232-C connector by means of a quad line receiver (DS1489). These inputs are $\overline{RLSD}$, $\overline{DSR}$, $\overline{CTS}$, and SIN. The ring indicator is not used in this application and is tied to +5 volts to prevent an interrupt from being generated. If a special function is required auxiliary outputs $\overline{OUT_1}$ and $\overline{OUT_1}$ are used.

Figure 4 shows ACE interfacing with a single microprocessor where it functions as a stand-alone peripheral. The SC/MP II does all the controlling itself along with a chip select, and the ACE performs all the functions that normally would be done by other peripheral chips. If, however, more than two ACEs are required, a high-capacity bus interface, such as a DM8833 or equivalent, is needed to prevent capacitive loading of the microprocessor in either transmit or receive directions. □



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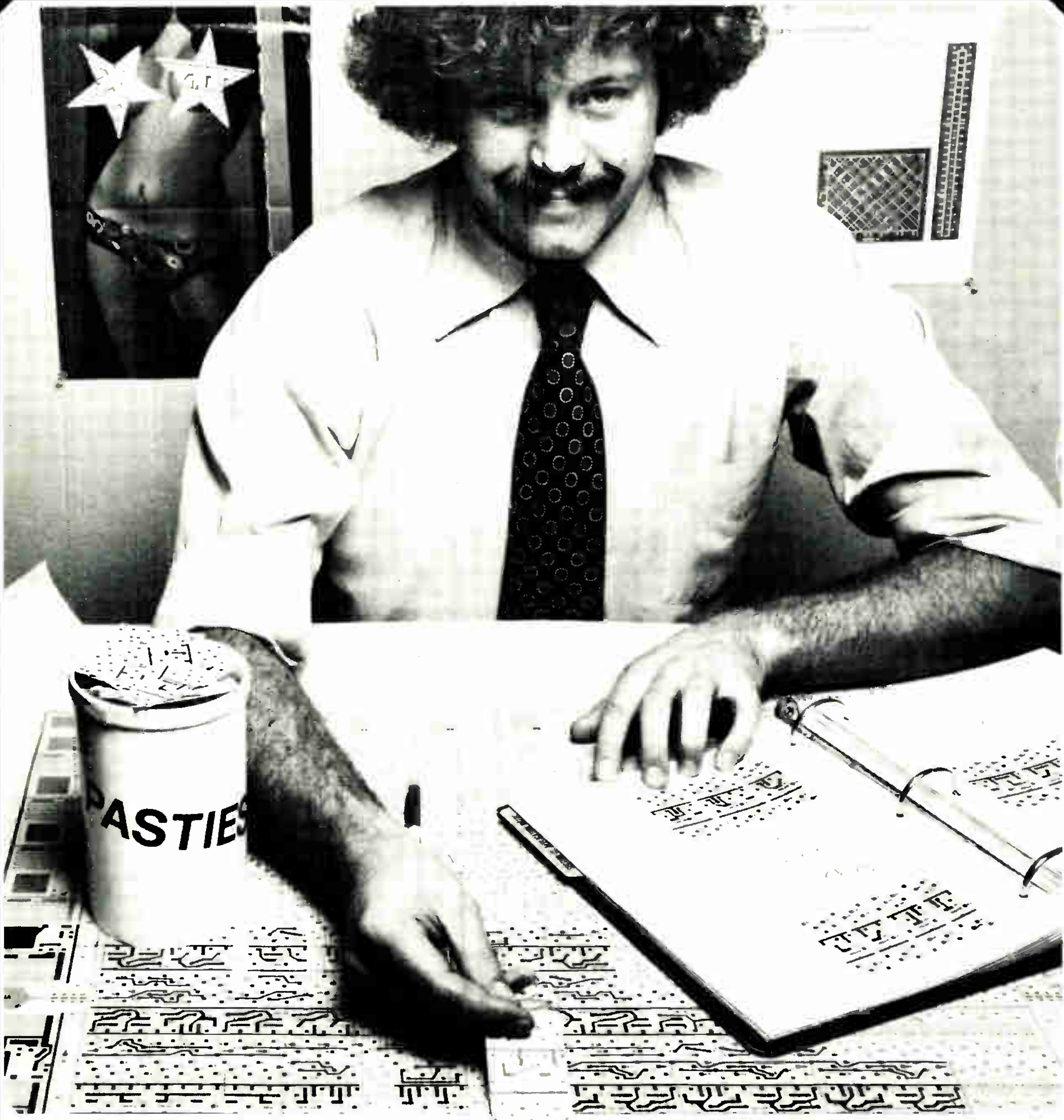

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What happens to semiconductors in a nuclear environment?

For designers who must select components to survive high-energy radiation, it's important to know how each type reacts

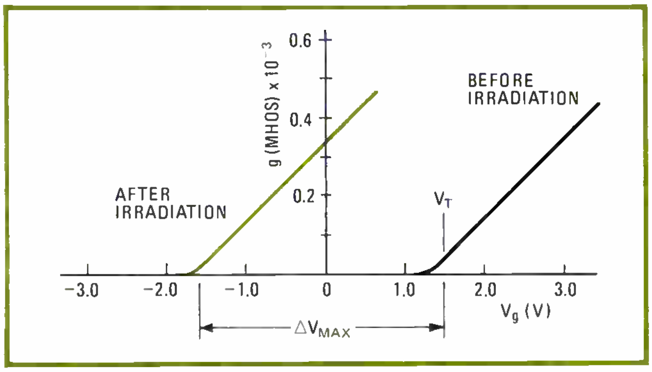
by David K. Myers, *Fairchild Camera and Instrument Corp., Mountain View, Calif.*

☐ Of all the many ambient conditions to which semiconductor devices are exposed, from a computer's air-conditioned room to under an automobile's hood, none is as demanding as the nuclear radiation encountered in certain military and space environments or in the nuclear industrial field. Unhardened digital electronic equipment can fail when exposed to ionizing radiation doses of as little as 10^3 rads (Si)—out in space, for example, in the Van Allen Belt—or to a neutron fluence of as little as 10^{11} neutrons per square centimeter—near a nuclear reactor, say. (Rads (Si) stands for roentgens absorbed dose in silicon, while a fluence is defined as the time integral of neutron flux.)

Anyone engaged in designing circuitry for use in such environments must be knowledgeable about their differing effects on different semiconductor technologies. Exposure to high-energy radiation introduces primary structural defects into semiconductor materials (and hence changes their electrical characteristics) in ways that depend partly on the duration and type of incident radiation and partly on that particular semiconductor material's resistivity, impurity types and concentrations, temperature, and carrier-injection levels.

The nuclear environments to be considered here are:

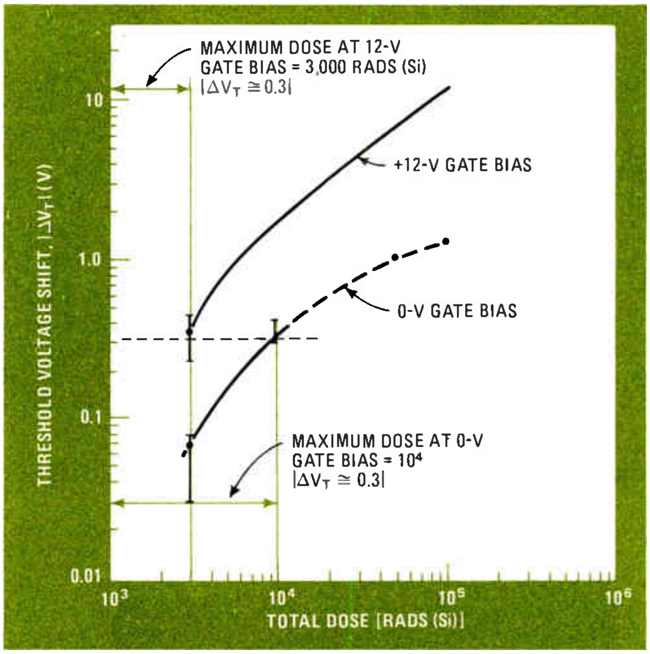
- Fast neutrons, which can permanently degrade gain in both bipolar and metal-oxide-semiconductor devices and increase the saturation voltage of bipolar transistors.
- Steady-state ionizing radiation (the total dose), which can increase leakage current in bipolar devices and alter threshold voltages in MOS and particularly complementary-MOS devices.
- The transient ionizing dose rate, which at a high enough level generates photocurrents in all reverse-biased pn junctions, causing changes of logic state in bipolar digital circuits and latch-up in C-MOS devices.



1. Radiation shift. In MOS and C-MOS devices, ionizing radiation alters gate turn-on voltage, changing the operating point radically. In the MOSFET curve shown, a threshold voltage change of almost 3 V is observed after exposure of the devices to ionizing irradiation.

Neutron effects

In general, it is only when neutron levels rise to 10^{10} to 10^{12} n/cm² (E = 10 kiloelectronvolts) that silicon devices start exhibiting changes in their electrical characteristics. The base transit time and the base width of a bipolar transistor are the main physical parameters affected by exposure to fast neutrons, as can be inferred from the degradation in current gain (h_{FE}). Modern semiconductor manufacturing methods measure neither of these parameters directly, but do control h_{FE} and the gain bandwidth product (f_t), from which base width can be deduced.



2. Radiated RAM. Threshold-voltage shifts are a function of radiation dosage and bias conditions for 4,096-bit n-MOS random-access memories. Units with gate bias fail at lower radiation levels than zero-biased units. A 0.2-to-0.3-V change in V_T induces failure.

TABLE 1: COMPARING THE RADIATION SUSCEPTIBILITY OF VARIOUS SEMICONDUCTORS

	Radiation environment / Semiconductor technology	Discrete bipolar transistors and J-FETs	Silicon controlled rectifiers	TTL	Low-power Schottky TTL	Analog integrated circuits	C-MOS	n-MOS	Light-emitting diodes	Isoplanar II ECL
	Neutrons (c/nm²)	$10^{10}-10^{12}$	$10^{10}-10^{12}$	10^{14}	10^{14}	10^{13}	10^{15}	10^{15}	10^{13}	$>10^{15}$
Ionizing radiation	Total dose (rads (Si))	$>10^4$	10^4	10^6	10^6	$5\times10^4-10^5$	10^3-10^4	10^3	$>10^5$	10^7
Ionizing radiation	Transient dose rate (rads (Si)/s) (upset or saturation)	–	10^3	10^7	5×10^7	10^6	10^7	10^5	–	$>10^8$
Ionizing radiation	Transient dose rate (rads (Si)/s) (survival)	10^{10}	10^{10}	$>10^{10}$	$>10^{10}$	$>10^{10}$	10^9	10^{10}	$>10^{10}$	10^{11}
Ionizing radiation	Dormant total dose (zero bias)	$>10^4$	10^4	10^6	10^6	10^5	10^6	10^4	$>10^5$	$>10^7$

Burnout by EMP

An electromagnetic pulse from a nuclear event can couple into a system's cables and antennas and create voltage/current spikes that may fuse the metalization on a semiconductor surface. Usually the interconnect system on a semiconductor device is a thin metal layer, only 10,000 angstroms or so thick, and will fuse at a current density of 10^6 amperes per square centimeter. Most integrated-circuit metalization stripe widths are designed to keep the current density below 10^5 A/cm² during normal operation, including worst-case testing.

EMP-induced burnout of semiconductor junctions is therefore a serious problem. But while it is a failure mode of semiconductor devices, it originates in the system design and not in semiconductor selection or reliability. The electromagnetic pulse must be shielded, filtered or shunted to ground.

Data available from Government laboratories and semiconductor manufacturers on semiconductors subjected to neutron irradiation indicates that double-diffused, epitaxially constructed integrated circuits, both digital and linear, will function within their original specification limits to neutron levels of 5×10^{13} n/cm² (E = 1 megaelectronvolt). This holds for diode- and transistor-transistor logic, as well as for low-power Schottky TTL. MOS circuits, whether n- or p-channel or C-MOS, are majority-carrier devices and not susceptible to neutron irradiation below 10^{15} n/cm².

The total ionizing dose

A steady state of ionization increases bipolar transistor leakage current most markedly in low-current, large-area devices. But even under worst-case conditions, these increased leakages are not enough to cause circuit failure at radiation levels below 10^5 rads (Si). Indeed, in many cases, bipolar integrated circuits have functioned well at levels in excess of 10^7 rads (Si). Tests run on DTL, TTL, and low-power Schottky TTL circuits reveal radiation-induced changes only above 10^6 rads (Si).

The effect of a total ionizing dose on MOS devices is more drastic. It permanently changes the crucial threshold voltage, V_T, which is applied to the gate of a MOS field-effect transistor to create the source-to-drain conduction path or channel. This change can be attributed to the buildup of a trapped positive charge in the gate-oxide insulator and to the creation of fast surface states at the interface of the silicon and silicon dioxide. The result is a marked shift in the operating point of a device (Fig. 1).

Recent radiation tests indicate that n-channel MOS dynamic random-access memories are very sensitive to ionizing radiation, having a nearly 100% failure rate at 3,500 rads (Si), regardless of manufacturer. For instance, the major failure mode of 4,096-bit dynamic n-MOS RAMs is the incidence of decoders stuck in the logic 1 state, which in turn is due to changes in threshold voltage that exceed the operating design tolerance.

Most current n-MOS test data is derived from these 4-k RAMs, but other large-scale integrated circuits like 16,384-bit RAMs, microprocessors, and similar complex n-MOS chips are also sensitive to continuous ionization, being manufactured according to similar design rules and processing. Failure threshold is 1,700 rads (Si) for 4,096-bit dynamic RAMs and 1,000 rads (Si) for n-MOS microprocessors.

Precise threshold voltage changes in n-MOS units are a function of dose and bias, as shown in Fig. 2. Under a normal +12-volt gate bias, shifts in V_T of 0.2 to 0.4 V have been observed at 3,000 rads (Si). Circuit analysis indicates that the n-MOS electrical designs will tolerate a change of 0.2 to 0.3 V in V_T without failing. Tests of MOS devices at zero gate bias (again, see Fig. 2) show they will fail only with the approximately 0.3-V shift in V_T caused by a dose of 10^4 rads (Si).

Radiation-induced shifts in threshold voltage similar to those described for n-MOS also occur with C-MOS semiconductors. The operating design tolerance $|\Delta V_T|$ is usually 1 V for commercial C-MOS products, indicating that a dose of 10^4 rads (Si) is required to cause failure. Actual cobalt-60 irradiations of Fairchild Isoplanar

TABLE 2: RADIATION SUSCEPTIBILITY OF EMITTER-COUPLED LOGIC			
Data source	Northrop	Sandia	Fairchild
Pulsed ionizing radiation			
Narrow-pulse transient failure level	3×10^8 rads (Si)/s	no tests performed	5–7×10^8 rads (Si)/s
Wide-pulse transient failure level	1.1–1.4×10^8 rads (Si)/s	"	no tests performed
Permanent-damage failure level	not determined – greater than 1.5×10^{11} rads (Si)/s	"	10^{11} rads (Si)/s maximum level (flash X-ray equipment*)
Neutron/gamma permanent damage			
Mean neutron failure level	2.2×10^{15} n/cm^2 (1-MeV equivalent)	1×10^{15} n/cm^2 (1 MeV equivalent)	1×10^{15} n/cm^2 * (1 MeV equivalent)
Total gamma dose	6.6×10^6 rads (Si)	2.5×10^7 rads (Si)	10^7 rads (Si)*
Observed neutron failure-level range	1.9–2.6×10^{15} n/cm^2 (1 MeV equivalent)	1×10^{15} n/cm^2 * (1 MeV equivalent)	1×10^{15} n/cm^2 * (1 MeV equivalent)
Device type tested	MC1678L 4-bit counter	custom IC fabricated by TRW	Isoplanar II, ECL F100101, F100117, F100102, F100141 and kit parts
Transistor gain-bandwidth product (f_T)	2.0–2.5 GHz	1.5 GHz	4.5–5.5 GHz

*Maximum radiation exposure level; no failures were observed at this level.

C-MOS and other available C-MOS devices cause device failures at above 5×10^4 rads (Si).

If the C-MOS design margin for V_T is reduced for electrical performance reasons, then the radiation tolerance would be sacrificed. This is the case for certain C-MOS circuits with a V_T of about 0.2 V, which all fail at approximately 2,000 rads (Si).

In general, improved tolerance of ionizing radiation could be realized by use of hardened oxide manufacturing techniques and circuit design modifications. However, though increasing the circuit V_T operating tolerance would raise the ionizing radiation failure threshold, it would also adversely affect the power, speed, component density, chip size, and yield.

Loss of memory and latch-up

A transient dose of ionizing radiation creates a photocurrent in any reverse-biased pn junction, such as the collector-base junctions of transistors and the pn junctions used for isolation in standard bipolar integrated circuits. These photocurrents can be large enough to cause digital circuits to change state, from a 1 to a 0. But though they may change the content of memories, they cause no permanent failure. For some programs, logic upset is acceptable, but survival at the specified transient radiation dose rate is required. Tests show that DTL, TTL, and low-power Schottky TTL devices will change logic state above a dose 5×10^6 rads (Si)/s and survive 10^{10} rads (Si)/s.

These transient photocurrents can induce another phenomenon, known as latch-up, in those types of IC that can be driven into silicon-controlled-rectifier action or second breakdown. In this situation, they force the device to latch into one state and remain there until the power is interrupted or the circuit destroys itself.

Such radiation-induced latch-up has not been observed in digital or linear bipolar ICs employing double-diffused epitaxial fabrication methods and operating within specifications. Fairchild has had over 140,000 low-power DTL devices tested by outside contractors to levels of approximately 10^{10} rads (Si)/s without a true latch-up failure. Nor has any been observed in TTL, Schottky TTL, or bipolar operational amplifier and comparator circuits.

Latch-up of triple-diffused ICs does occur. But this technology has not been used to manufacture commercially available circuits for over five years.

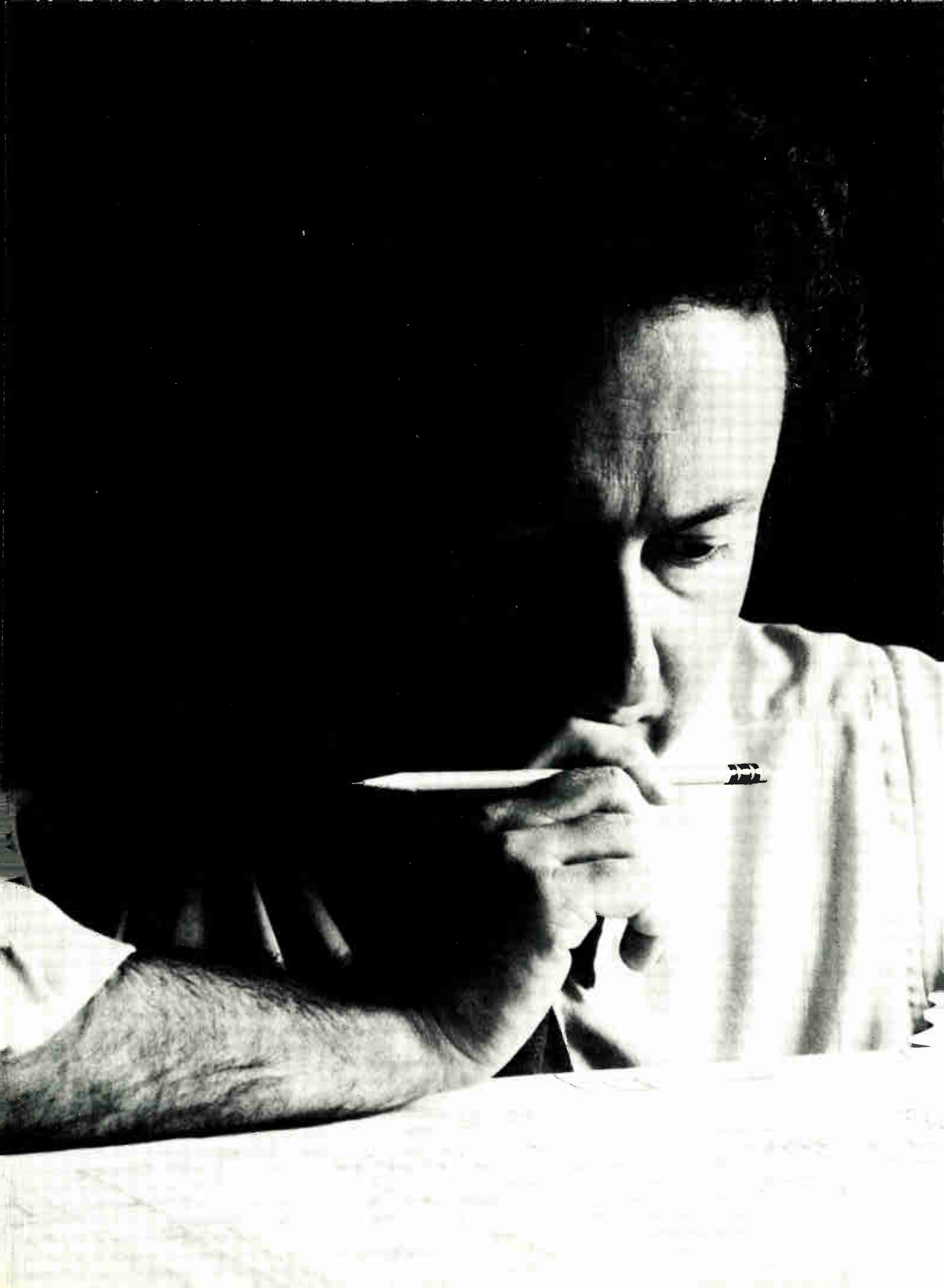
MOS resistance to latch-up, on the other hand, varies with the process used. The problem has not been found to afflict n-MOS devices, which lack the fourth junction necessary for SCR action. But junction-isolated C-MOS ICs, which have that fourth junction, have been observed to latch up at dose rates as low as 3×10^8 rads (Si)/s. When operated at 5 V in the latch-up state, C-MOS devices return to normal operation after the power has been interrupted. But when operated at 10 V, they fail catastrophically because of latch-up.

It is worth noting that the latch-up dose-rate level of C-MOS devices varies with the manufacturer, device function, and chip design: there is a very uniform susceptibility to latch-up for devices with the same function from the same manufacturer.

For bipolar devices, it is different. The radiation tolerance of a generic bipolar family can be determined by testing sample parts of the family, since circuit design rules and manufacturing processes are constant throughout. This theory has been tested and verified on low-power Schottky TTL ICs manufactured by Fairchild Semiconductor.

Low-power Schottky parts made by other IC firms have been tested using the same radiation criteria. These results, with the Fairchild data, add to the overall confidence that a specific bipolar part type has a specified radiation tolerance irrespective of its source.

Only limited testing has been reported on the radiation tolerance of high-speed emitter-coupled logic. A data summary of ECL failure threshold levels for various radiation environments is presented in Table 2. Nevertheless, a preliminary comparison of ECL with a number of other types of ICs and discrete semiconductor devices (Table 1) indicates that ECL easily excels them all in radiation tolerance. □



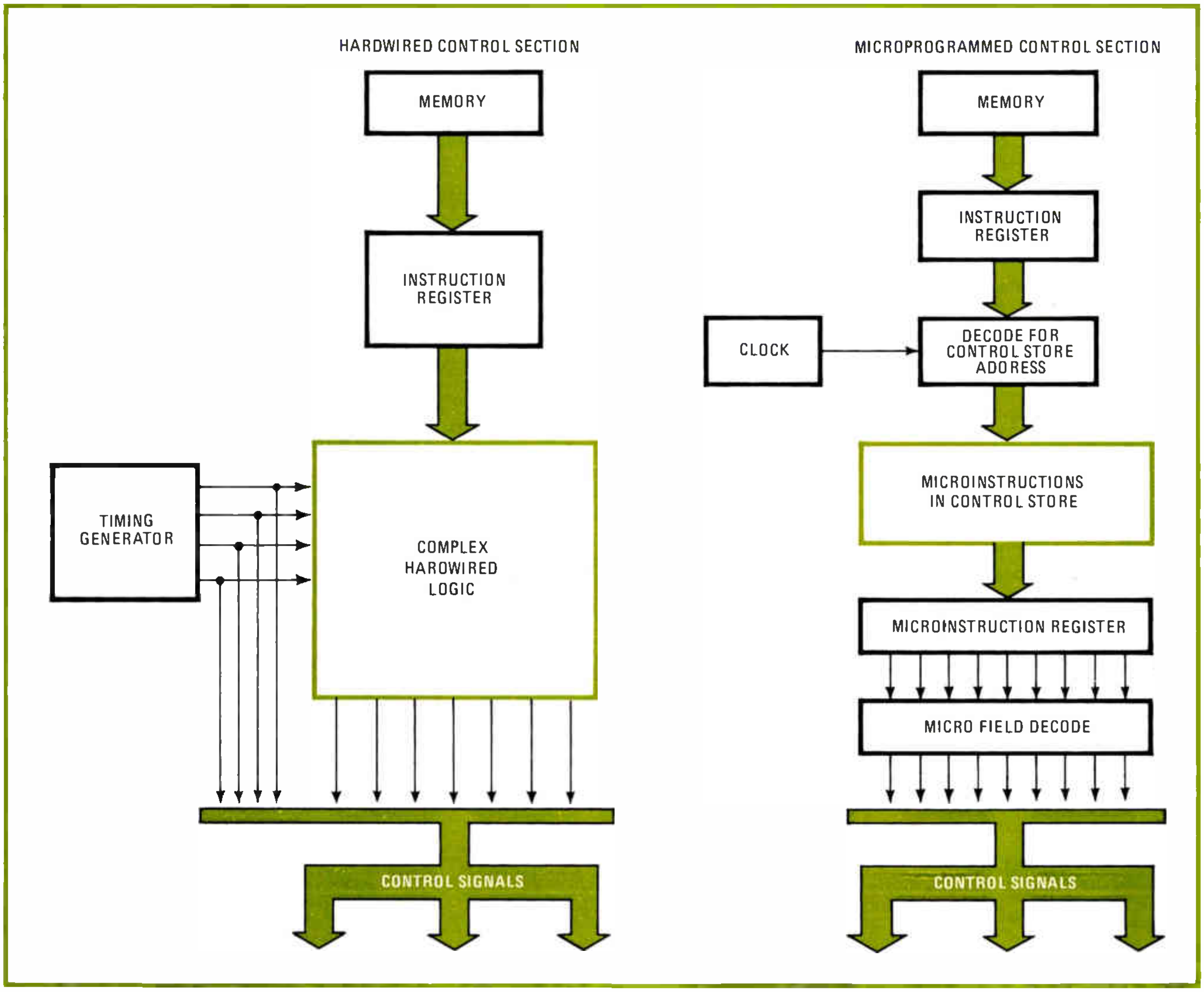
Microprogramming a minicomputer for fast signal processing

Storing operating-system instructions as well as the fast Fourier transform in a writable control memory boosts throughput by an order of magnitude

by Timothy Mulrooney, *Naval Underwater Systems Center, Newport, R. I.*

☐ Given a traditional division of functions between its hardware and software, a minicomputer cannot process signals of more than a few kilohertz in real time. As a general-purpose signal processor, it is simply not equipped to perform the complex computations fast enough. But it can reach a more than adequate speed if various of its software functions, including parts of its operating system, are incorporated in hardware.

Such a novel hardware-software synergy is most easily achieved with a microprogrammed architecture. At pres-



1. Streamlined control. The control section of a standard hardwired processor (shown at left) requires a multiphase clock and complex logic to decode the instruction register contents and generate control signals. In contrast, the microprogrammed control section (show at right) requires only a single-phase clock and generates control signals by decoding microinstructions stored in read-only memory.

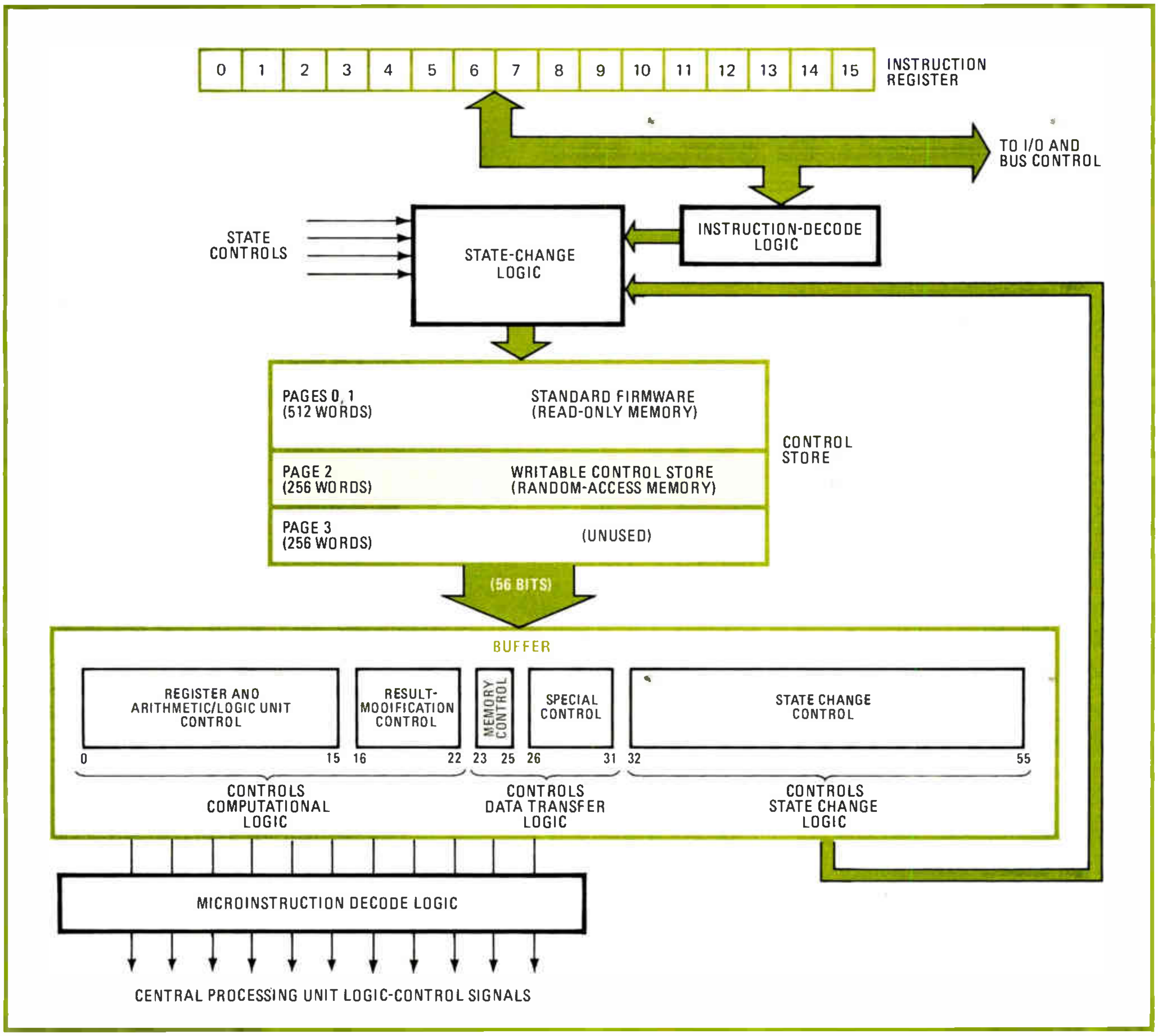
ent, special-purpose systems offer microprogrammed versions of the complicated fast Fourier transform essential to signal processing. But the real breakthrough comes when those elements of the operating system that handle the FFT are also made over to hardware. Then a general-purpose system becomes capable of handling signal bandwidths that otherwise require much more expensive hardware.

Using the Eclipse

A minicomputer like the Data General Eclipse S/230 has the writable control store and the multitasking software that are prerequisites for handling this kind of general-purpose signal processing. Such a system can schedule and maintain several programs in main memory at once, for execution either simultaneously or at different times, to serve a variety of real-time signal-processing applications. Multichannel spectrum analysis, beam forming for a nonuniformly spaced array of sensors, or linear predictive processing for speech or biomedical data are just a few examples.

A simple comparison between a hardwired and a microprogrammed computer control section is shown in Fig. 1. In general, computation that is complex or frequently used should be microprogrammed. This rule fits the fast Fourier transform, the key tool for signal processing (see "The ubiquitous FFT," p. 138), since the speed of execution of the algorithm is primarily governed by its great number of complex calculations. Special-purpose hardware could of course carry out the algorithm, but microcoding it into the computer's control memory is a more flexible solution.

Hardware implementation of the FFT is better than software implementation because in hardware many operations typically run in parallel, such as multiplications with memory accesses. Software on a general-



2. Microprogram control. The Data General Eclipse S/230 minicomputer has a 1,024-word control memory, a quarter of which is available to the user for microcoded storage of normally software functions. When such microprogramming includes operating-system instructions as well as algorithms for the fast Fourier transform, it speeds signal processing by an order of magnitude.

Microprogramming the Eclipse S/230

The control-program architecture of the Eclipse S/230 minicomputer is configured to be user-programmable with microinstructions, which are stored like other instructions in 16-bit instruction registers. Combinations of bits in the macroinstruction word are decoded to produce a 10-bit address for the location in control memory that contains the microroutine—or rather, the first of the series of microinstructions that make up the microroutine.

The control memory can store in all 1,024 microinstruction words of 56 bits each. Half of it is read-only memory, making up the minicomputer's standard firmware instruction set, and the rest is random-access memory. Half of the RAM is for custom applications and not normally used, and the other half—the writable control store—is for user-microprogramming.

As each microinstruction is executed, it generates the address of the next microinstruction. The microroutine can be any number of microinstructions long, and only when its execution is complete will the instruction register be loaded again. Clearly, the longer the microcoded routine (in terms of execution time and not necessarily the number of instructions), the less often will the instruction register have to be loaded and decoded—and the less time will the central processing unit waste on waiting for it.

This is the advantage of microprogramming a lengthy function instead of programming it in the traditional but cumbersome way. In a sense, the ideal in microprogramming would be to generate a starting address in control memory and thus cause one long, well-written microroutine to be executed forever.

Additional gains are realized when microroutines are very complicated. Such operations, which include complex arithmetic and extensive bit manipulations, traditionally take a very long time to execute. Microprogramming is generally more efficient at handling them because its long microinstruction words have access to many more general registers each and have direct control of hardware at the machine level.

For example, a simple register-to-register add instruction in a standard program takes three microinstructions: one to decode the instruction register and generate a control-memory address, another to do the actual addition, and a third to load the register with the next instruction. But a microprogrammed routine that added up a table of numbers could, if the table were very large, run almost three times faster than a comparable series of regular add instructions, since two thirds of the overhead—the loading of the register—would be eliminated.

purpose machine has no such opportunity for parallelism, for the central processing unit has to execute each part of the algorithm sequentially. The large microinstruction words in a computer's control memory, however, can carry out many operations at once.

The relative merits of software and hardware implementations of the FFT are best seen from an analysis of how they handle the operations involved in performing the algorithm. There are five such operations: the bit-reversal of the entire array of points; the complex multiplication of two 16-bit words; the complex addition and subtraction; the fetching of a complex exponential, which is needed at every stage of the computation; and the overhead operations. The last factor is actually external to the FFT algorithm, being just the time spent maintaining array pointers and counters and doing other such bookkeeping.

Three FFT versions compared

Thus partitioned, the FFT algorithm was programmed on the Eclipse S/230, the control section of which is shown in Fig. 2, in one software and two firmware versions. The first used assembly language (high-level languages were not even considered because of their prohibitively long execution times). The other two employed microprogramming by itself and microprogramming plus high-speed hardware to handle the complex multiplications.

The times each took to process the FFT are listed in Table 1. They can be interpreted in terms of the contribution each of the algorithm's five operations made to its overall execution time. (An interactive simulation program timed the five operations separately but assumed the use of interleaved elements, which has the speed advantage, since separate banks of memory are stored in consecutive locations and can be accessed simultaneously. The total overall execution times, though, are given for both interleaved and noninterleaved memory access. All times in the table are in milliseconds.)

On looking at an assembly-language implementation of the FFT for an array size of 1,024 points, for example, it is clear that the complex multiplication accounts for 46% of the total time, while the complex addition takes up 17%. The respective figures of 53% and 18% for the microcoded case are comparable. Evidently, the speed of arithmetic is not alone in affecting FFT execution time.

Microcoding speeds up arithmetic routines—complex multiplication, addition, and subtraction—by a factor of about 2.2, general overhead 2.6 times, and the exponential-fetching routine almost 3.5 times. But the greatest gain occurs with the bit-reversal operations, which microprogramming speeds up by a factor of 5.5. The improvement is due to the greater efficiency of the extra registers available to microcode and the direct hardware control of the many memory accesses needed. The total increase in execution speed is about 2.5 times, indicating that microcoding helps significantly in every area.

The last group of numbers corresponds to a microcoded implementation complemented by a hardware multiplication, so that only the data involving arithmetic operations changes. Note that although hardware multiplication improves arithmetic by nearly a factor of 10, the overall gain was just slightly better than 2.

The improvements garnered by the microcoded FFT algorithm can be reflected in real-time signal processing as a marked increase in sampling rate. Table 2 lists the maximum sampling frequencies possible for the three FFT implementations. With speeds about an order of magnitude better than those possible with traditional

TABLE 1: TIMES FOR DIFFERENT VERSIONS OF THE FAST FOURIER TRANSFORM OPERATIONS

Data points	Total execution time	Total execution time with interleaved memory access	Bit reversal	Complex multiply	Computations	Exponential fetching	Other
FFT time for assembler version							
8	3.261	(3)	0.220	1.476	0.564	0.288	0.713
16	8.606	(7)	0.554	3.936	1.504	0.768	1.844
32	21.280	(17)	1.186	9.84	3.76	1.92	4.574
64	50.924	(40)	2.690	23.616	9.024	4.608	10.986
128	118.350	(94)	5.780	55.104	21.056	10.752	25.73
256	270.122	(214)	12.389	125.952	48.128	24.576	59.077
512	606.579	(480)	26.104	283.39	108.288	55.296	133.501
1,024	1,346.588	(1,066)	55.493	629.76	240.64	122.88	297.815
FFT time for microcoded version							
8	1.343	(1)	0.037	0.672	0.228	0.084	0.322
16	3.501	(2)	0.102	1.792	0.608	0.224	0.775
32	8.640	(7)	0.217	4.48	1.52	0.56	1.863
64	20.623	(16)	0.501	10.752	3.648	1.344	4.378
128	47.924	(35)	1.055	25.088	8.512	3.136	10.133
256	109.313	(81)	2.297	57.344	19.456	7.168	23.048
512	245.439	(181)	4.800	129.024	43.776	16.128	51.711
1,024	544.857	(403)	10.176	286.72	97.28	35.84	114.841
Estimated FFT time for microcoded version with hardware multiply							
				5 µs	10 µs	5 µs	
8	0.6	(0.45)	0.037	0.06	0.12	0.06	0.322
16	1.517	(1.13)	0.102	0.16	0.32	0.16	0.775
32	4.0	(3)	0.217	0.48	0.96	0.48	1.863
64	8.728	(6.54)	0.501	0.96	1.92	0.96	4.378
128	20.148	(15.11)	1.055	2.24	4.48	2.24	10.133
256	45.825	(34.36)	2.297	5.12	10.24	5.12	23.048
512	102.59	(76.94)	4.800	11.52	23.04	11.52	51.711
1,024	227.417	(170.25)	10.176	25.6	51.2	25.6	114.841

All times are for noninterleaved memory access, except where noted.

TABLE 2: MAXIMUM SAMPLING FREQUENCIES

Data points	Assembler version		Microcoded version		Microcoded version with hardware multiply	
	Noninterleaved memory	Interleaved memory	Noninterleaved memory	Interleaved memory	Noninterleaved memory	Interleaved memory
8	2,453	2,666	5,957	8,000	13,333	17,778
16	1,859	2,286	4,570	8,000	10,547	14,159
32	1,503	1,882	3,703	4,571	8,000	10,667
64	1,257	1,600	3,103	4,000	7,337	9,786
128	1,081	1,392	2,671	3,657	6,353	8,471
256	948	1,196	2,342	3,160	5,586	7,450
512	844	1,067	2,086	2,829	4,991	6,654
1,024	760	961	1,879	2,541	4,502	6,015

All frequencies are in hertz; no scheduling and ideal double buffering are assumed.

processing, microcoding clearly makes real-time signal processing on a minicomputer practical for many applications. It pushes bandwidths into the kilohertz range for the smaller arrays of data points. Greater resolution of the FFT will require more points, of course, and will reduce sampling frequencies as well. The sampling-frequency limits for array sizes larger than 1,024 points can be extrapolated from the data in the table.

Ideal double buffering—where the instruction sequence requires no CPU waiting time—is assumed in the table. But actually, some wait time will always be required. If memory is slower than the system clock, interleaving memory elements can improve execution time. But a noninterleaved memory that keeps up with the system clock would produce even more dramatic results when used with the microprogrammed algorithm, since the FFT deals exclusively with taking elements from arrays, operating on them, and returning them to arrays—and this is best done sequentially.

Needed: real-time operating system

To take full advantage of the fast microcoded routines or the high-speed special-purpose hardware available for processing the FFT, a real-time operating system is

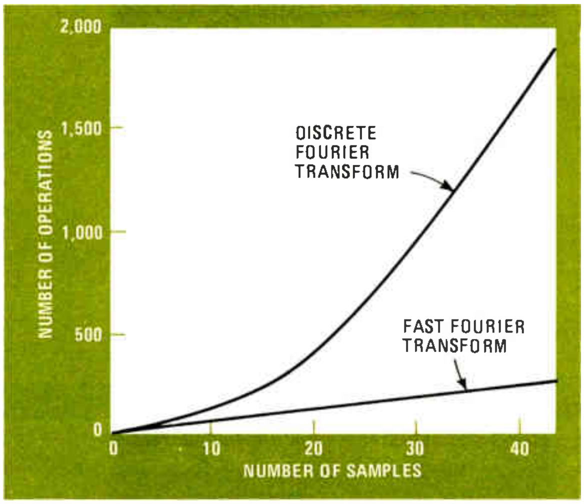
The ubiquitous FFT

Jean-Baptiste-Joseph Fourier laid the basis for the analysis of complicated waveforms more than 150 years ago, when he showed that any waveform is the sum of single-frequency, or sinusoidal, components. Scientists and engineers have learned that looking at the frequency spectrum of a signal's components provides great insight into the way signals behave with time. The analysis is possible only with a powerful Fourier transform, which maps a time-varying signal into the frequency domain and thus causes the spectral distribution of its sinusoidal components to become visible.

Since the Fourier transform requires evaluation of the integral of the input waveform, it can only be performed exactly on a waveshape with a known equation. But in real life, most waveforms are far too complex to be readily defined. The discrete Fourier transform, however, approximates the actual transform by sampling the waveform and operating on each point. It can therefore be computed digitally, but the number of operations it requires is so huge—the square of the number of samples—that even a reasonable approximation taxes the largest computers.

In 1942, a method was devised for reducing the number of operations from N^2 to NlnN, but as that was before the days of high-speed digital computers and few people cared to grind through the DFT by hand, the work of Danielson and Lanczos lay dormant for nearly twenty years.

Then in the early 1960s interest in the Fourier transform again picked up. J. W. Tukey worked with J. W. Cooley on the development of a transform algorithm suitable for the computer, and the result came to be known as the fast Fourier transform. Today, though many variations exist on the original Cooley-Tukey algorithm, any transform that requires NlnN operations is referred to as the FFT. As the graph shows, the difference in the number of operations required for the DFT and the FFT grows enormously for large numbers of samples. **Ray Capece**



needed—one that for the first time considers the timing constraints imposed on the computer's responses by real-time operations. The multitasking capabilities of many minicomputers allow their users to create, suspend, and change the priority of tasks in software if they are prepared to pay the price in execution time. However, microprogramming even a few frequently used system operations greatly enhances multitasking efficiency.

An advantage of the FFT algorithm, which may be used in either assembly language or microcode, is that its routine can be made reentrant: it need not store data within itself as an iterative routine does. Consequently, the program can easily be shared by many channels requiring independent signal-processing in a multitasking environment.

When used in a general-purpose signal-processing system, moreover, the FFT algorithm allows the multiprogramming techniques to be simpler than usual. Because of the nature of the FFT, all tasks can be assumed to have equal priority. Also, instead of jobs occurring and departing randomly, the FFT tasks are being completed and repeated continuously. In essence, only the question of real-time constraints, which are not nearly as stringent as in general multiprogramming, need be addressed.

That is why scheduling—removing the task being executed from the CPU and giving control of the CPU to the next task—turns out to be the most important duty of the real-time operating system in this signal-processing context. Since all tasks are independent of each other and have equal priority, a simple round-robin scheduling approach is used; each FFT task proceeds in increments until all have been completed. Just as in general multiprogrammed systems, round-robin scheduling is interrupt-driven; switching of tasks occurs at discrete intervals, which are usually determined by external interrupts.

The scheduler has four jobs: interrupt handling, getting the next task, searching for the end of the task queue, and scheduling the next task.

What the scheduler does

The interrupt rate, or amount of time allocated to each task, is critical in determining system overhead time. It is set by looking at the response times desired of the computer. At each interrupt interval, the entire state of the executing task must be remembered, and all the information for each task kept in task control blocks, which are chained together in sequence. Additional overhead is involved in determining which device caused the interrupt and how the interrupt should be handled.

Finding the next task to run consists of searching the chain of task-control blocks for the active block (the FFT being executed), removing it from the queue, and adding it onto the end in a round-robin fashion.

The length of the search for the end of the task queue directly depends on the number of tasks that are running. Each time it is necessary for the entire queue to be searched. Finally, the scheduler restores the next ready task to active status by using the information in the task-control blocks. Together, these four parts constitute the entire system overhead in scheduling.

TABLE 3: MAXIMUM NUMBER OF TASKS POSSIBLE IN REAL-TIME OPERATION							
Data points	Scheduling means	Type of FFT	Total time (ms)	System time (ms)	Remaining time (ms)	Number of tasks	Ideal number of tasks
512	A	A	2,560	307	2,253	4	5.3
	M	A	2,560	80	2,470	5	
	A	M	2,560	425	2,135	11	14.1
	M	M	2,560	124	2,436	13	
	A	MM	2,560	643	1,917	24	33.2
	M	MM	2,560	215	2,345	30	
1,024	A	A	5,120	614	4,506	4	4.8
	M	A	5,120	168	4,952	4	
	A	M	5,120	809	4,311	10	12.7
	M	M	5,120	242	4,878	12	
	A	MM	5,120	1,216	3,904	22	30.0
	M	MM	5,120	399	4,721	27	

A = assembler M = microcode MM = microcode with hardware multiply Sampling frequency = 200 Hz

TABLE 4: MAXIMUM SAMPLING FREQUENCY, SIMULTANEOUS EXECUTION OF 10 TASKS							
Data points	Scheduling means	Type of FFT	Total time (ms)	System time (ms)	FFT time (ms)	Maximum sampling frequency (Hz)	Ideal sampling frequency (Hz)
512	A	A	5,700.71	900.71	4,800	90	106.7
	M	A	5,020.90	220.9	4,800	102	
	A	M	2,149.64	339.64	1,810	238	282.9
	M	M	1,893.30	83.3	1,810	270	
	A	MM	913.77	144.37	769.4	560	665.4
	M	MM	804.81	35.41	769.4	636	
1,024	A	A	12,660.33	2,000.33	10,660	81	96.1
	M	A	11,150.62	490.62	10,660	92	
	A	M	4,786.22	756.22	4,020	213	254.1
	M	M	4,215.48	185.48	4,030	243	
	A	MM	2,021.97	319.47	1,702.5	506	601.5
	M	MM	1,780.85	78.35	1,702.5	561	

A = assembler M = microcode MM = microcode with hardware multiply Sampling frequency = 200 Hz

To examine the benefits of microprogramming the schedules, two versions were written, one in assembly language and the other in microcode. For a task-switching frequency of 1 kilohertz, measurements were made for up to 20 tasks sharing the CPU.

No pains were taken to optimize the microcoded scheduler, which merely duplicated the assembler version, yet it reduced the system overhead time by a factor of 3.5. In designing a general-purpose signal-processing system, therefore, system overhead is too important to be neglected. Over 20% of the 1-millisecond switching time is needed just for the assembly-language scheduling operation.

Real-life results

Two hypothetical problems can be set up to determine the actual advantages of a microcoded, general-purpose signal-processing system, first in terms of data-channel limits for a fixed sampling rate of 200 hertz, then in terms of maximum sampling rates for a fixed number of data channels. The first situation is typical of multichannel spectrum analysis, its solution yielding the number of spectra it is possible to determine concurrently by multitasking.

The results for interleaved memories and for resolutions of 512 and 1,024 data points are shown in Table 3. When the problem includes 1,024 data points, assembly-language scheduling ideally allows 4.8 tasks to be executed, as predicted in Table 1. Obviously, 0.8 of an FFT cannot be performed, and 4.8 translates to a limit of 4 FFTs at the 200-Hz sampling rate. Interestingly enough, even with microcoded scheduling (the next line down in Table 3), it is still only possible to perform 4 FFTs. The reason is that the assembly-language scheduler can use the time it cannot spend on the 0.8 task for system overhead. However, as more microprogramming is used, the time to perform each task gets smaller and smaller, and the ideal number of tasks increases dramatically. In those cases, the method of scheduling begins to make a significant difference. To sum up, microprogramming has nearly 10 times the computational power of assembler programming.

The second hypothetical problem fixes the number of data channels at 10, and its results determine the maximum allowable sampling rates. Assuming ideal buffering and no scheduling, they can be calculated from Table 4 by dividing the ideal frequencies by the number of tasks, 10. In the specific case of 10 FFTs on 1,024 points using interleaved memory, the ideal sampling frequency is 96.1 Hz. Assembly-language scheduling reduces the rate to 81 Hz, whereas microcoded scheduling boosts it to 92 Hz.

Overall, then, it is clear that microcoding, together with hardware multiplication, enhances processing speed by an order of magnitude. □

This article is based in part on work done at the University of Rhode Island.

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SY2102-1	1024x1, 500nsec, 70mA
* SY21L02-1	1024x1, 500nsec, 40mA
* SY21L02	1024x1, 1000nsec, 15mA
* SY21H01/-2	256x4, 175/200nsec, Separate I/O
SY2101-1	256x4, 500nsec, 70mA, Separate I/O
* SY2101A/-2/-4	256x4, 350/250/450nsec, 55mA, Separate I/O
* SY21H11/-2	256x4, 175/200nsec, Common I/O
SY2111-1	256x4, 500nsec, 70mA, Common I/O
* SY2111A/-2/-4	256x4, 350/250/450nsec, 55mA, Common I/O
* SY21H12/-2	256x4, 175/200nsec, Common I/O
SY2112-1	256x4, 500nsec, 70mA, Common I/O
* SY2112A/-2/-4	256x4, 350/250/450nsec, Common I/O
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* SY5102L-1	CMOS, 256x4, 450nsec, 10μA Standby, Power Down, 2102 Compatible
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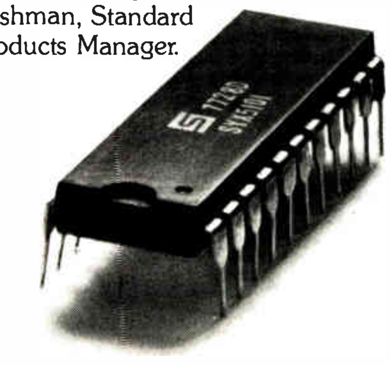

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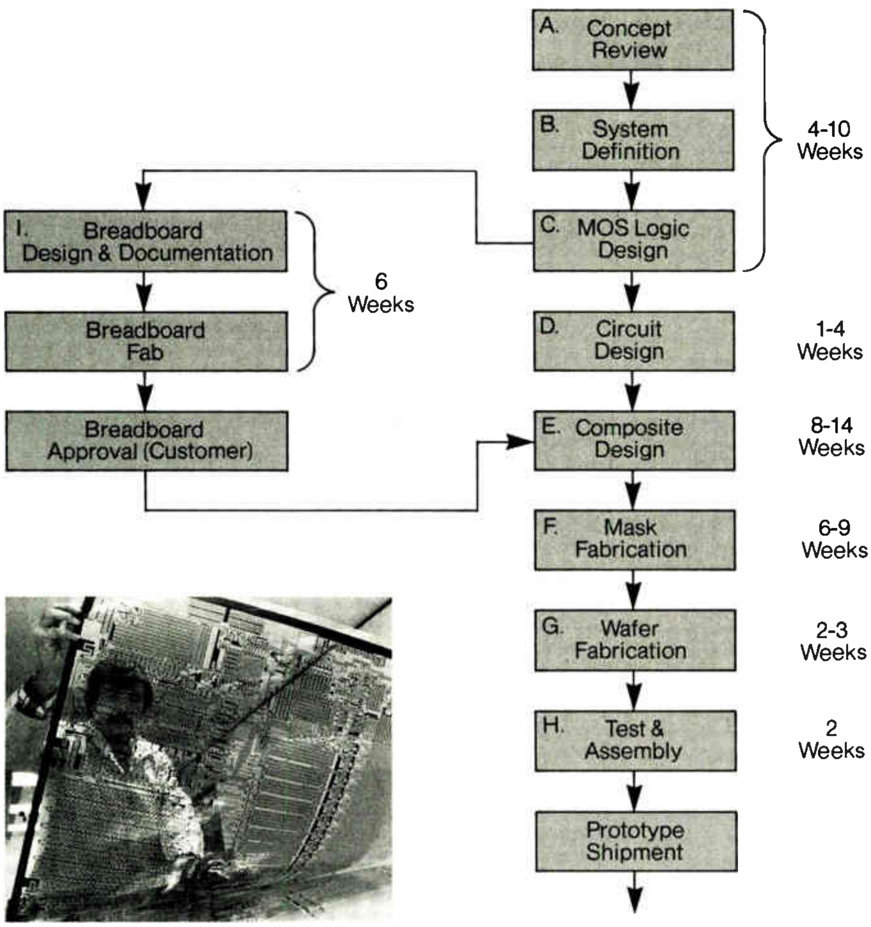

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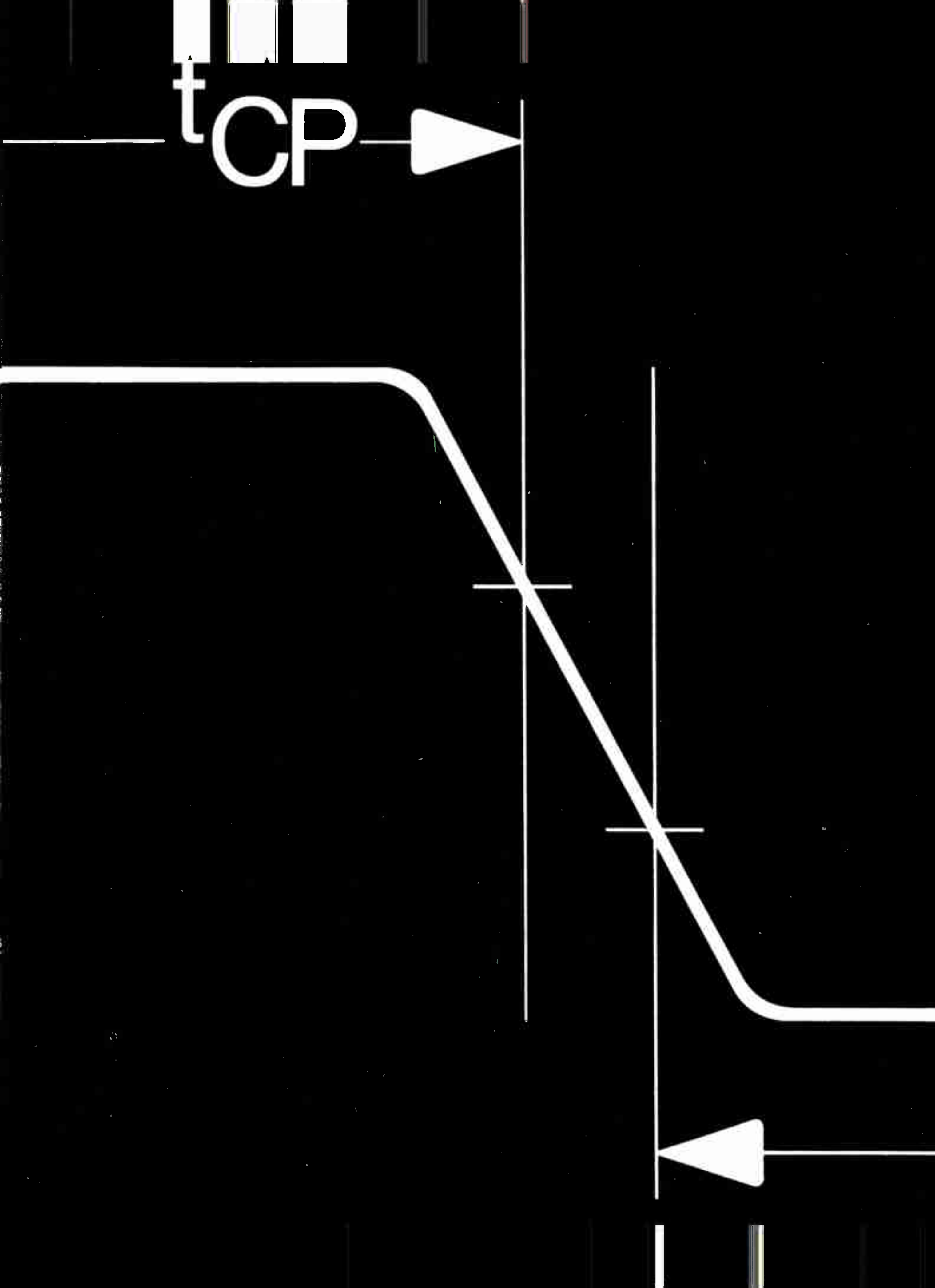
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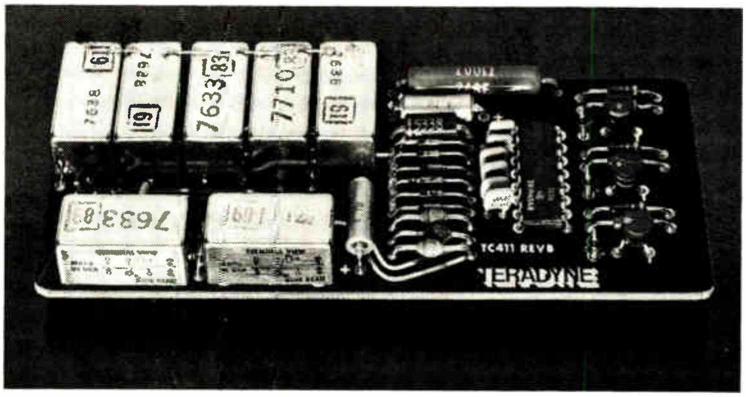

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Ultrasonic processor readies data for gray-tone display

by W. H. M. van Dreumel and Henk van der Hoek
Delft University of Technology, Delft, the Netherlands

If combined with a suitable ultrasonic receiver,[1] this circuit will convert ultrasound energy into 10 distinct gray tones for display on a cathode-ray tube. Thus defects and other imperfections in materials may be detected by this low-cost measuring system that provides a visual indication of the faults by means of trace-intensity modulation, where the intensity will be proportional to the amplitude of the input signal, or equivalently, the magnitude of the fault (the so-called C-scan method). The circuit can process signals having a pulse-repetition rate of up to 10 kilohertz and an individual pulse width of 70 microseconds or less.

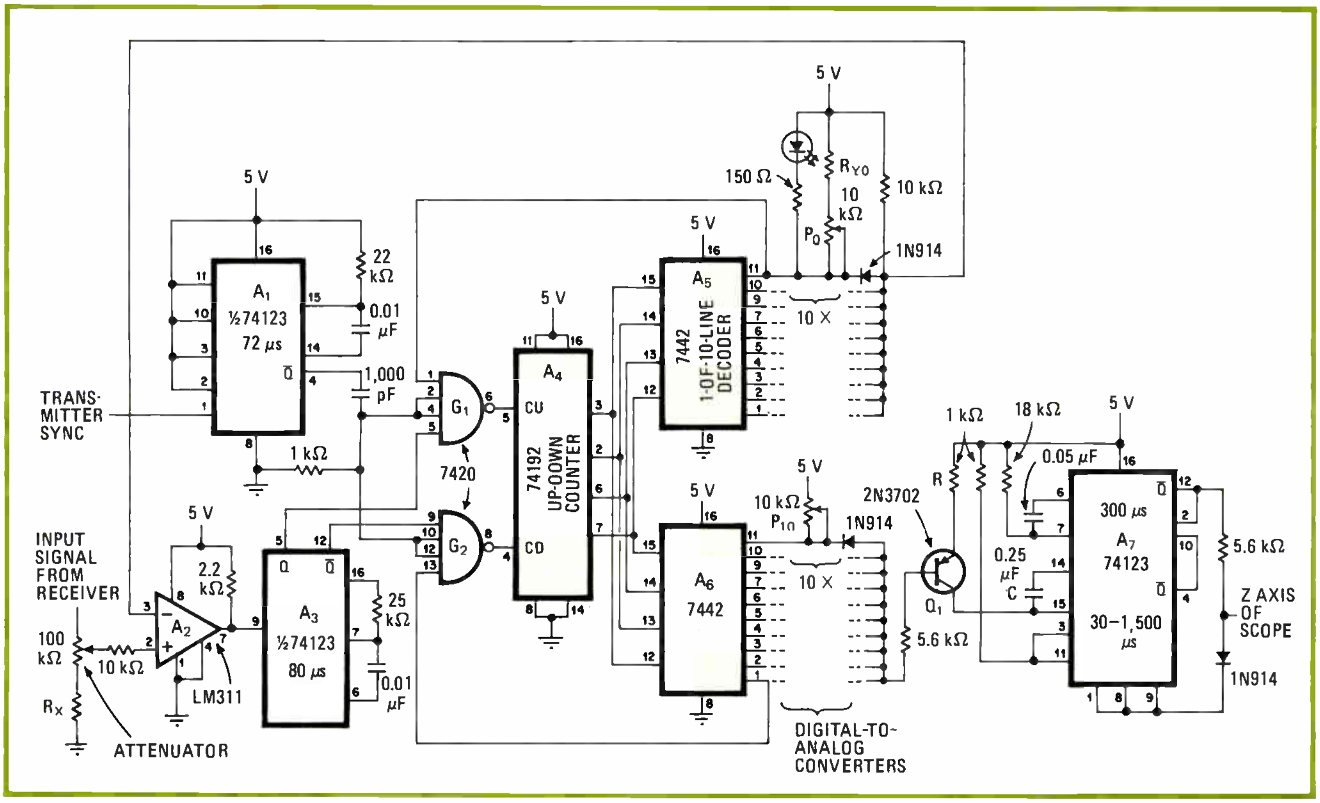
The system is synchronous, requiring a source- or transmitter-derived trigger to initialize the circuit, as shown in the figure. After the transmitter-sync signal fires monostable multivibrator A_1, the input signal at comparator A_2 is compared with the output of a digital-to-analog converter that is monitoring the contents of an up-down counter through a 1-of-10 line decoder.

If the amplitude of the receiver signal exceeds that of the d-a converter's output, the one-shot, A_3, is triggered. After 70 μs, A_1 times out, and the contents of A_3 are transferred through G_1 or G_2, incrementing the 74192 4-bit counter if A_3 has fired and decrementing it if A_3 has not fired. The output of the counter in turn drives two 7442 1-of-10 line decoders, sending one line on each device into the logic 0 state.

The d-a converter is essentially nothing more than a voltage-divider network, P_0–R_{y0} through P_9–R_{y9}, each connected to the 10 lines of A_5 and set to generate any 10 dc voltages corresponding to the range of input voltage expected. The magnitude of the voltage fed back to A_2 will depend on which line of the 7442 is active low, and therefore a dc signal is developed whose envelope closely follows the amplitude of the received pulses.

In a typical C-scan application, the dc output signal from A_6, which is wired in much the same way as A_5, is used to control the duty cycle of astable multivibrator A_7, through transistor Q_1. A_7's output is presented to the Z axis of the scope. A_7 is low for a period of 300 μs per scan (10 kHz); during that time, no trace appears on the CRT.

The trace will be observed during A_1's on time, t_{on}, however, and its intensity will be proportional to t_{on}, which can be varied from 30 to 1,500 μs by P_{10} through



C-scan. The amplitude of ultrasonic pulses having a duty cycle of less than 0.01% is converted to 1 of 10 dc voltages. Voltages are converted to gray tones by scope, enabling detection of material flaws. Seriousness of flaw is proportional to intensity of trace.

P_{19}. Q_1 is in the resistance-capacitance timing loop of A_7. Because the set voltages to the transistor base determine its conducting state, or equivalently, its emitter-to-collector resistance, Q_1 is thus used to modify the charge rate of the RC components by adding, in essence, additional resistance to the loop.

P_{10} through P_{19} should be adjusted such that the trace will generate a continuous-tone, or progressively deepening, gray scale in 10 equally spaced steps as the counter advances from 0 to 9. Although it would appear that only one 7442 is needed in the circuit, using both A, and A_6 protects the counter from reaching the underflow or overflow condition and also allows independent setting of the gray-scale voltages and the feedback voltages presented to A_2.

The light-emitting-diode array that monitors the contents of A_5 is useful for setting dc levels to conform to the range of input signals expected. It is also useful in determining signal-voltage trends; the relative brightness of each LED is discernible, even at a sampling rate as high as 10 kHz.

Resistors R_x and R_{y0} through R_{y9} are used for trimming purposes. Once the attenuator setting has been determined, all resistors must be set to minimize the voltage across the inputs to A_3 under no-signal conditions. This, of course, means that the 7442 counter, A_5, must be stepped sequentially. □

Reference

1. Gammell, Paul M., "Fast attack detector optimizes ultrasonic receiver response," *Electronics*, Aug. 4, 1977, p. 96.

Shunt comparator stabilizes high-speed digital servo

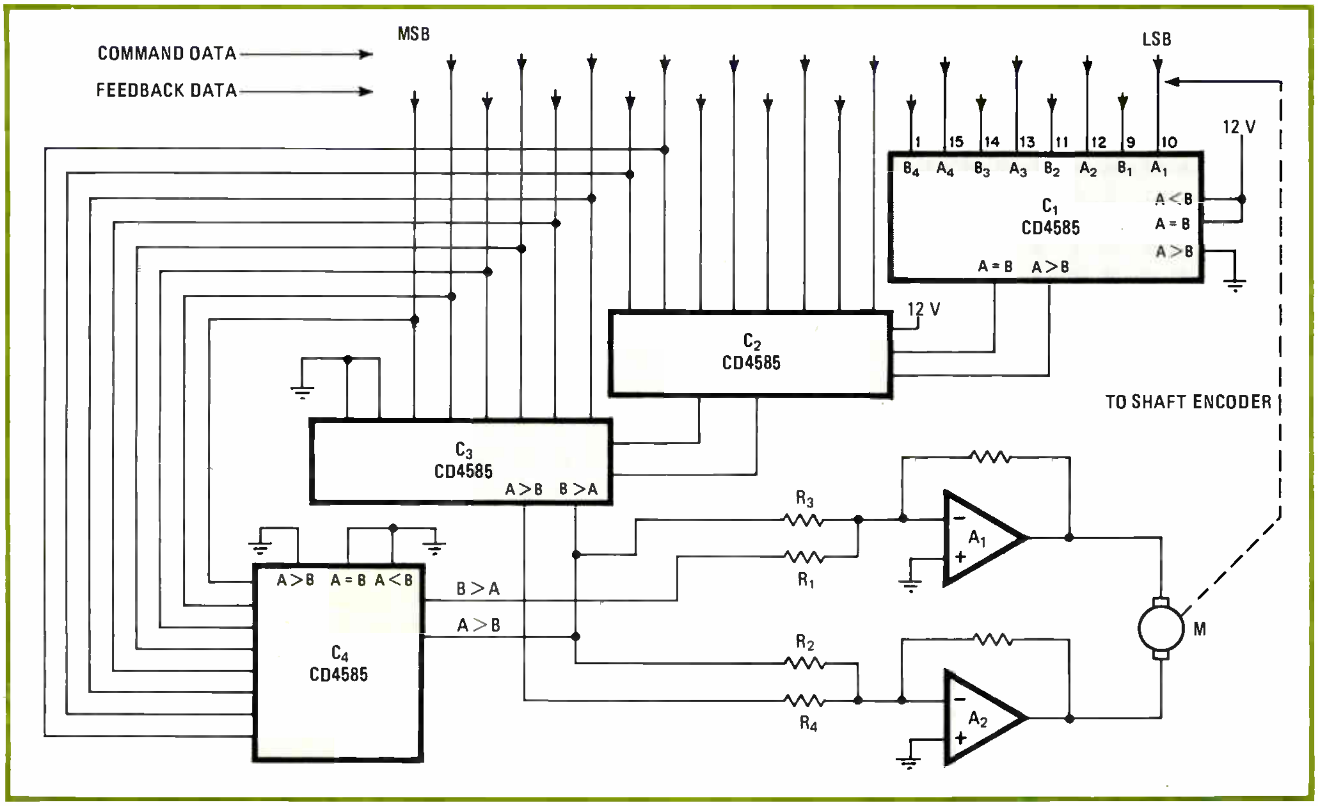
by B. Vojnovic

Gray Laboratory, Mount Vernon Hospital, Northwood, Middlesex, England

In high-speed applications requiring great positional accuracy, a digital servo system is usually preferred to an analog one because of its higher apparent accuracy. But its stability at high speeds is no greater. However, the digital servo system is easier to modify so that its overshoot and position-hunting problems are minimized.

The modifications are made to the kind of digital servo system shown in the figure—one in which the set and feedback values are compared digitally by three comparators, C_1, C_2, and C_3. They derive an error signal from the comparison of binary-command data with positional-feedback data generated by the motor, M, and an 11-bit digital encoder driven through a suitable gearbox. A balanced motor drive arrangement should be used to ensure low-noise pickup in cases where the controller is remote from the motor-drive circuit. It is also advantageous when good braking characteristics are desired.

Connecting comparator C_4 essentially in shunt with C_3 as shown reduces the likelihood of overshooting because



Stabilizing force. Addition of C_4 to circuit minimizes oscillations in high-speed digital servo. C_4 forces immediate coarse comparison of most significant bits (response time controlled by R_1-R_2), before fine comparison is made (response time controlled by R_3-R_4).

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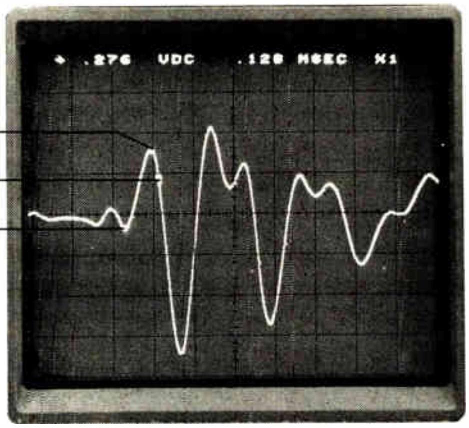

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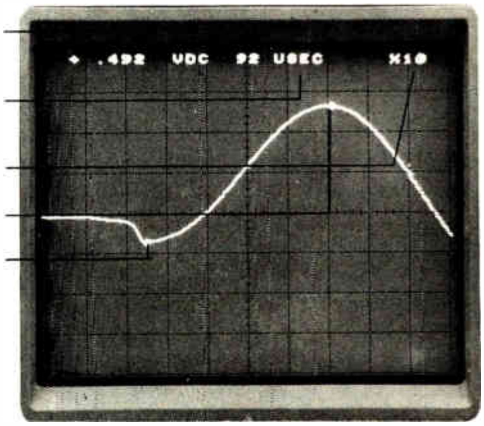
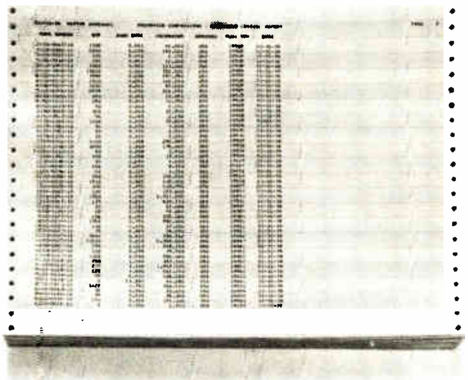


2 Expand the display for detail analysis.

When you need to analyze the event in detail, you can expand the display 2, 5, 10, 20 or 50x. Movable cursors let you pinpoint the portion of the waveform you want to study. And on-screen digital readout of time and voltage is automatic.



3 Perform computer data analysis.

Digital storage gives you maximum analysis flexibility. You can transfer the data, already digitized, to mag tape, disc or other permanent storage. Or you can read the data out directly to a programmable calculator or computer system.

The 820 is the latest product in our six-year history of using digital storage techniques to help you capture and analyze analog signals. Other Biomation products enable you to convert your scope to a "super scope" by adding digital storage. For more information, or to arrange a demonstration in your lab, call Don Dedinas, (408) 988-9600. Or write us: 4600 Old Ironsides Drive, Santa Clara, CA 95050.

GOULD biomation

a coarse (most-significant-bit) comparison is made first, forcing the full motor torque to be developed quickly. Motor speed is, of course, lowered when coarse equality is achieved, and then C_1–C_3 take over to perform a fine comparison. Therefore, overshooting will seldom occur, and a given positional accuracy will be achieved more quickly. The same accuracy might be achieved without overshooting if only C_1–C_3 were used, but the system speed would need to be reduced.

With this system, a single overshooting occurs very rarely, usually when multiple carries are generated—for example, when feedback data changes from 00001111111 to 00010000000. After such an overshooting, however, the return of the system to its desired position will be slow. System accuracy in all cases is within 1 bit of the desired position.

Another type of digital servo uses a digital-subtraction method and a digital-to-analog converter. It is, however, more complex, and furthermore it closely parallels the operation of the analog system. □

Divide-by-N counter generates square-wave output for odd N

by Steve Lieske
Hewlett Packard Co., Boise, Idaho

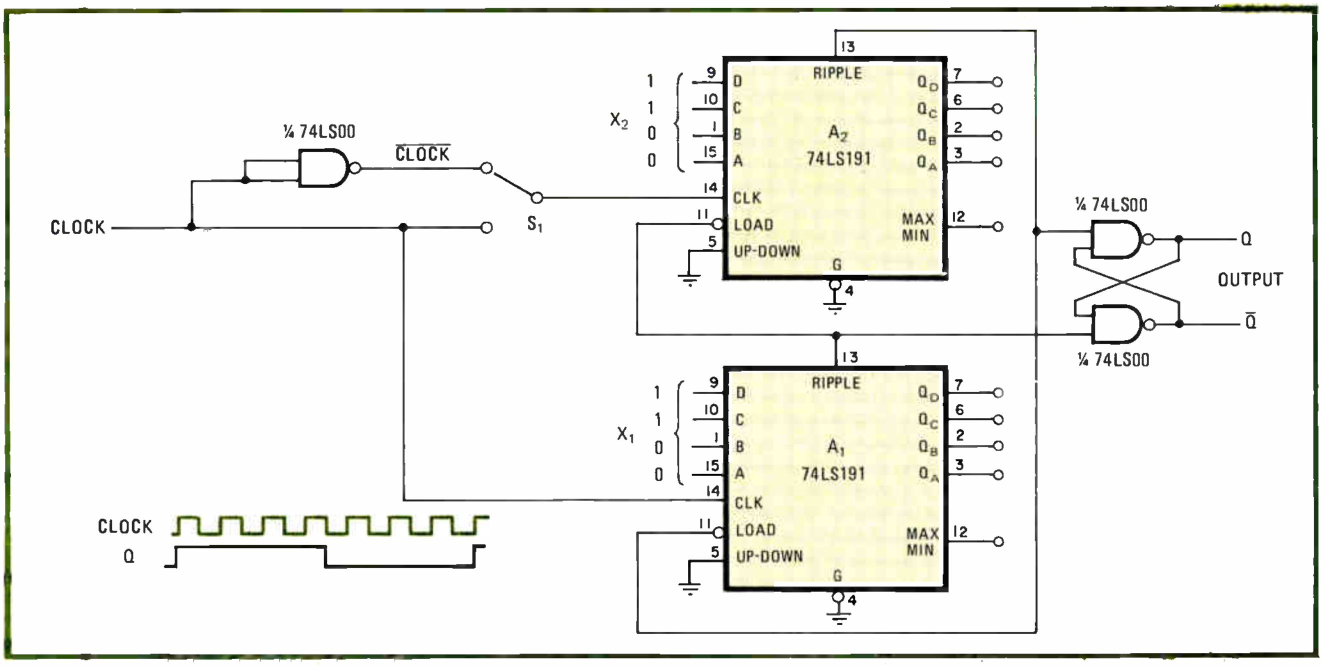
An extremely flexible digital frequency divider can be built using only two presettable synchronous counters and three NAND gates. The circuit allows the duty cycle of its output to be controlled to within one half-cycle of the input frequency. This capability is useful in many timing and control applications. For example, in dividing down a high-speed clock, the output duty cycle can be selected to optimize system timing considerations, such as propagation delay or data-setup time. It can also be used in control circuits to generate timing windows.

The 74LS191 counters A_1 and A_2, each programmed by the data at preset inputs X_1 and X_2, control the on and off time of the output cycle, respectively. When A_1 counts from its preset value to the counter's maximum value of 15, its ripple output goes low, setting the Q output of the two-gate, 74LS00 flip-flop to logic 0. A_2 is then asynchronously loaded with the X_2 data and counts from that point to 15. When A_2 overflows, its ripple output sets the flip-flop high, A_1 is loaded with X_1, and the cycle repeats.

If Q is to be asserted for an odd number of half cycles, A_1 and A_2 must be clocked on opposite edges (which produces a square-wave output when N is odd). If Q is asserted for an even number of cycles, the counters are clocked in phase. S_1 and the 74LS00 NAND gate at the input allow selection of either option.

The timing diagram at the bottom of the figure shows a square-wave output for a divide-by-seven counter. In this application, X_1 and X_2 are programmed so that the number 12 is loaded into their respective counters, as shown. Generally, the number that presets the counters will be equal to $15-N/2$, taken to the nearest integer.

N is limited to a minimum value of 1. In this circuit, it may assume a maxiumum value of 14. For greater frequency division, additional counters must be cascaded. □



Adjustable duty cycle. A_1 and A_2 in divide-by-N counter control on and off time of output cycle, respectively. X_1 and X_2 inputs determine N value, preset counters to $15-N/2$. Square-wave output for odd N is achieved by advancing counters on opposite edges of clock.

Microprocessor-based designs must be easy to service

If you're designing microprocessor-based equipment, chances are you'll soon have your field-service manager looking over your shoulder. He knows that **troubleshooting your system will take more than a portable scope and digital multimeter,** and he also knows that without an understanding of your design, he won't be able to choose among the growing variety of specialized field-test instruments becoming available. You can help him by becoming aware yourself of developments in such instruments, since **you will have to optimize your system design eventually** for the one that's picked. You'll also help yourself with management, which is becoming more bothered by the costly spare-board inventory needed to service complex systems.

There are already over half a dozen new schemes at which to look, among them: Intel's in-circuit emulation, Hewlett-Packard's signature analysis and programmed logic analysis, Biomation's stored-waveform comparisons, and Omnicomp's guided probing with portable board testers. Other companies, like Millenium and Paratronics, are offering various combinations of these techniques. Also, the more conventional approaches, such as those taken by Data Test and Tektronix, combining the measurement of voltage, frequency, and transition counts, should not be overlooked. And 1978 promises to bring many more schemes to the fore. A good starting point is the cover story on Biomation's approach (p. 105).

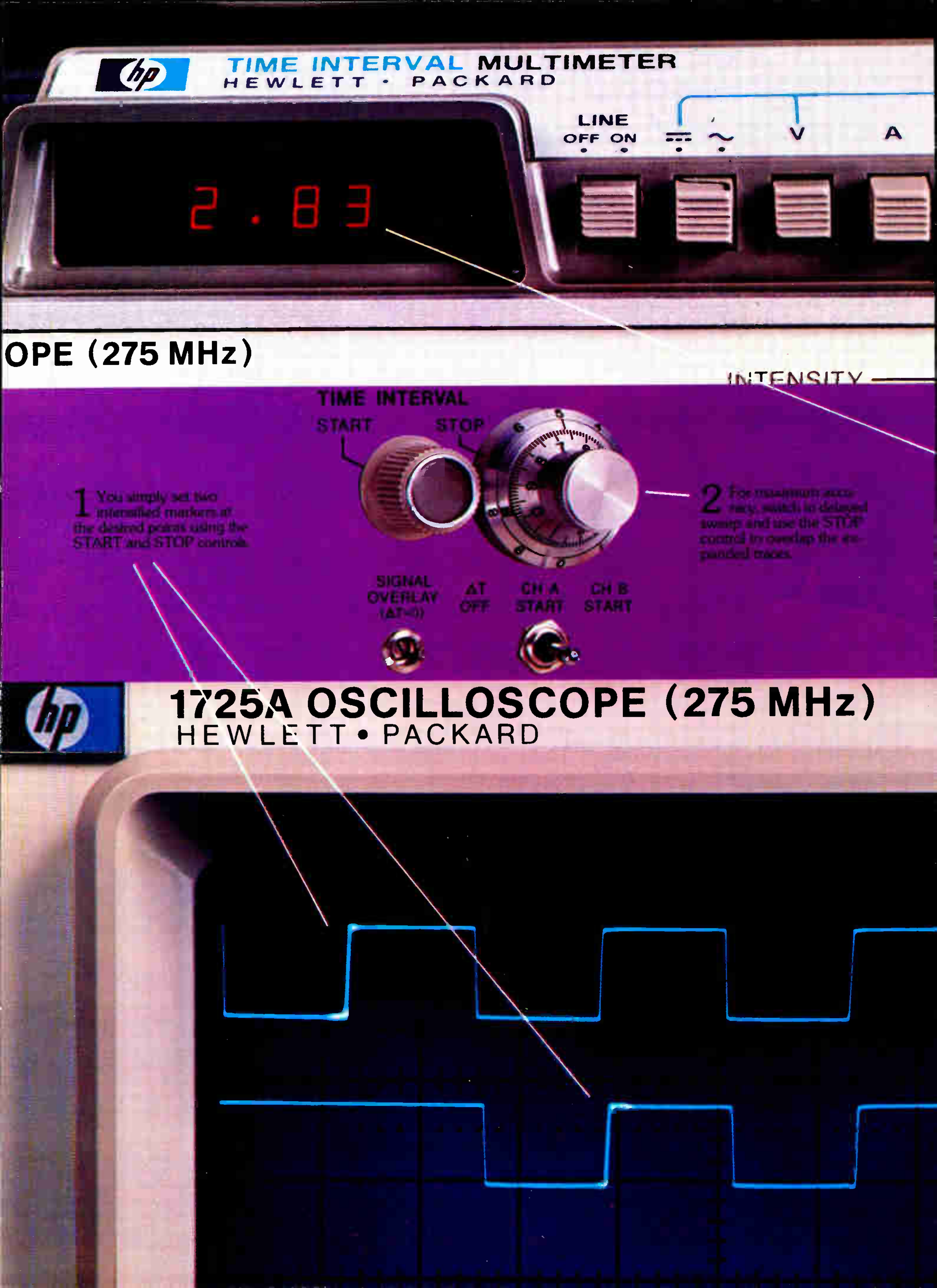
Two ways to prevent false triac firing

When triggered by a transformer, a triac may fire inadvertently, especially after prolonged operation at high temperatures. It's the **energy stored in the transformer that produces sneak gate currents that trigger the triac after it has switched off,** explains Terry Malarkey, who is with Motorola Semiconductor Products Inc. in Phoenix, Ariz. To prevent such retriggering, simply place a resistor in series with the triac's gate. This adds impedance to the sneak path and gives the inductive energy a place to dissipate. Resistance values from 5 to 22 ohms work best in most applications. **But if the gate drive is negative, a better method is to use a series diode with its cathode facing the transformer.** The diode's breakdown rating must be high enough to block the reverse inductive currents. To help dissipate the stored energy that the diode blocks, a resistor may be connected from the diode's cathode across the transformer.

How to double the program steps for the SR-52

Texas Instruments' SR-52 calculator, says Robert D. Cole, has nearly twice as many possible program steps as advertised—to be exact, **434 steps instead of the reported 224.** Each memory register can store eight program steps. So if you use memory registers 01–19 for program storage, you can recall the appropriate one and load it into one of the program registers (70–97) as needed. Theoretically, this should add up to 180 extra steps to the program. However, because of the way the SR-52 operates, moving the registers around alters the first instruction of the eight stored in register and it should be set to zero. This leaves seven that are usable, giving 133 steps. (Discounting the 35 or 40 steps required to make the program exchange leaves a net of about 100 extra steps.) Also, if you take care not to hit the CLR key, you can use memory registers 61–69 for program storage, gaining another 63 steps. Moreover, registers 98 and 99 may also be used for program storage. So, summing all these possibilities gives: the 224 known steps plus 133 plus 63 plus 14, for a grand total of 434 possible steps of program.

Lucinda Mattera



TIME INTERVAL MULTIMETER
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LINE
OFF ON
V
A
OPE (275 MHz)
INTENSITY
TIME INTERVAL
START
STOP
1 You simply set two intensified markers at the desired points using the START and STOP controls.
2 For maximum accuracy, switch to delayed sweep and use the STOP control to overlap the expanded traces.
SIGNAL OVERLAY (ΔT=0)
ΔT OFF
CH A START
CH B START
1725A OSCILLOSCOPE (275 MHz)
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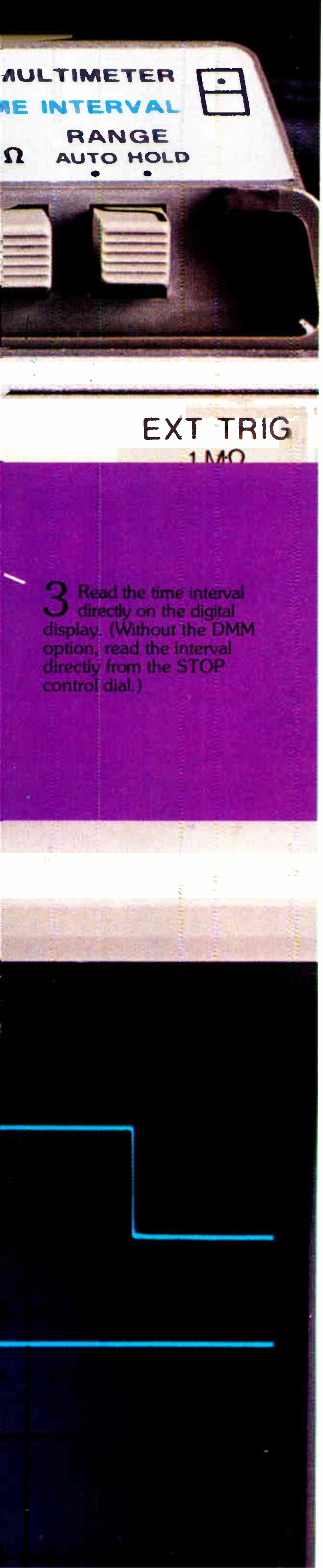


For improved Δ-time measurements, plus autoranging AC/DC volts, amps and ohms ...

HP's the Answer.

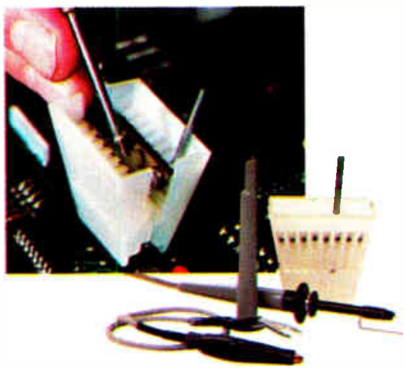
Now you can choose from two new scopes with improved Δ-time capability: The 200 MHz **1715A** priced at $3100* or the 275 MHz **1725A** for $3450*. Both offer an optional built-in DMM for direct Δ-time readout, plus autoranging AC/DC volts, amps, and ohms.

Δ-time measurements are now faster with the 1715A and 1725A. They're more accurate because scope and operator errors are significantly reduced. Plus you have switch selection of channel A or B as the starting point for Δ-time measurements, often eliminating the need to move probes and simplifying trace overlap for zeroing. But you can still select conventional delayed sweep with the flip of a switch, for brighter low-rep-rate traces and convenient trace expansion.

The optional autoranging 3½ digit DMM is priced at $325* factory installed. Or, for easy field installation, there's a kit priced at $375*. Another option, HP's "Gold Button" for $150*, gives you pushbutton selection of either time domain or data domain when the 1715A or 1725A is used with HP's 1607A Logic State Analyzer.

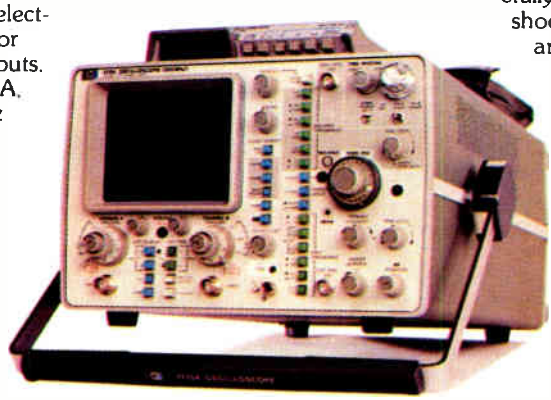
Like all new high-frequency HP scopes, the 1715A and 1725A have switch selectable 50 ohm or 1 Megohm inputs. And the 1725A, with 275 MHz bandwidth, is the fastest 1 Megohm-input scope available. That reduces the need for active probes when working with fast logic near maximum fan-out.

The story with both of these scopes is user convenience—from front-panel controls to the minimum of adjustments for servicing. Your local HP field engineer can give you all the details.



And here's something NEW for scopes. HP's **Easy-IC Probes.** A new idea for probing high-density IC circuits that eliminates shorting hazards, simplifies probe connection to DIPs and generally speeds IC troubleshooting. The probes are standard equipment with these two scopes.

*Domestic U.S.A. price only.



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087 8A

Circle 155 on reader service card

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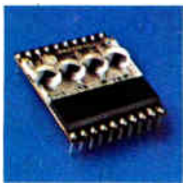
You will find advanced products not available anywhere else. As well as widely-used standard devices at highly competitive prices.

Some highlights:

ALPHANUMERIC LED DISPLAYS.



Character sizes from 0.16" to 0.50" in end-stackable arrays of 1 to 4 red characters — including an intelligent display that interfaces just like a RAM to μP buses.

DIGITAL LED DISPLAYS.

Green, yellow and red digits. Nine sizes from 0.1" to 1" high. In DIPs of 1 and 2 digits. On PCBs of 2 to 6 digits with edge connectors. Both light-pipe displays with very wide viewing angle and low-cost reflector displays. 70 different types.

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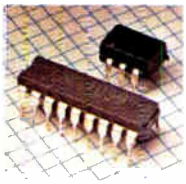
Red, orange, yellow and green lamps. T-1, T-1¾ and axial packages. Arrays of 2 to 10 lamps. With panel mounting clips. Lamps that flash on/off. Constant brightness lamps. Voltage-indicating lamps. 58 different types.

OPTO-ISOLATORS.



One, two and four-channel opto-isolators. Current transfer ratios up to 320%. Isolation voltages up to 5000v. Transmission rates as high as 4 megabits/sec. 15 JEDEC types. 25 different types in all.

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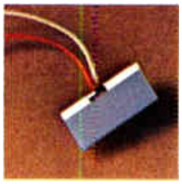

Silicon solar cells. Sensitivity from .04 microamperes to 2.8 microamperes. Twelve different types available.

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Contains 32 pages on all devices in the product categories above. Phone your local distributor or contact Litronix at 19000 Homestead Road, Cupertino, CA 95014. Phone (408) 257-7910.

Circle 157 on reader service card

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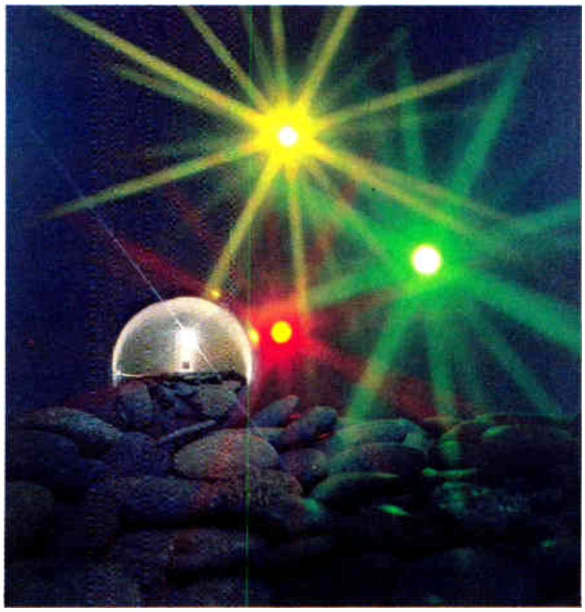
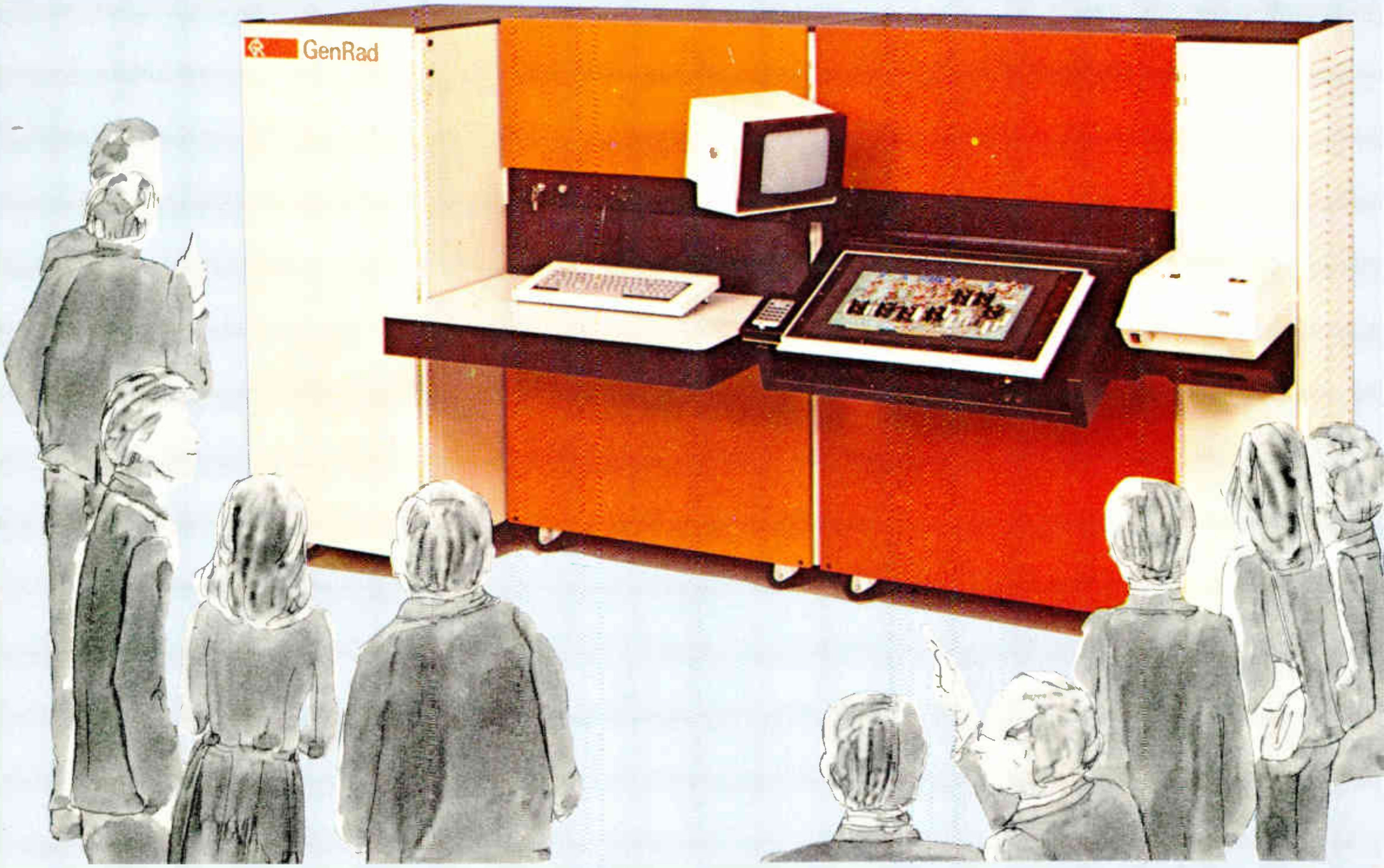
THE LIGHTS FANTASTIC



GenRad's new In-Circuit Tester will draw a crowd every place it's shown. Join the crowd.



In-circuit testing makes a lot of sense, so you are probably not surprised to learn that GenRad has a new in-circuit tester. What will surprise you is how much different it looks from other GenRad board testers and how many convenient features it is possible to build into an in-circuit tester.

A new system from the old pro

GenRad is in a unique position to offer an in-circuit tester since such a system is actually a cross between an impedance bridge and a functional test system. And GenRad is recognized worldwide as the company with the most expertise, experience, and sales volume in both areas.

In-circuit testing locates faults early

In PC-board manufacturing, the earlier you detect and locate faults such as solder shorts, opens, wrong parts, improperly seated parts, missing parts, etc, the lower your costs are going to be. This is particularly true for high-volume manufacturers, since failure to correct faults early can create severe bottlenecks later in the testing and fault-diagnosing stages.

What users will like about the 2270

GenRad's 2270 In-Circuit/Functional Test System has many features that are easily translated into user benefits. For instance:

Sophisticated Software. Test programs are generated automatically from simple circuit descriptions, minimizing programming time.

Optimum Man-Machine Interaction. The software provides optimum man-machine interaction, when required. Applies to on-line program editing, debugging, or for board setups and adjustments.

Expanded 4xn Scanner. With fully independent cross-point control, the scanner improves in-circuit testing accuracy and adds flexibility to functional testing.

Stable, Accurate GenRad Instrumentation. Provides long-term reliability, including synthesized sources, 14-bit D/A and A/D conversion, and quadrature reactance measurements.

Human-Engineered to Maximize Operator Efficiency. CRT display and bed-of-nails work surface are both adjustable for ease of reading and board loading.

Flexibility of Use. Can perform both in-circuit and/or functional testing on the same equipment.

And more. . . lots more.

Customer confidence — the extra bonus

For 10 years GenRad has installed computer-controlled test systems throughout the world. In fact, during 1978 we will install our 1000th system, a volume which we believe exceeds the total of all comparable systems installed by competitors. GenRad's expertise in system hardware and software remains second to none, and our after-sale support is reality and not empty promises. Only performance instills customer confidence, and we don't treat it lightly.

To learn more about the 2270, request a copy of our new brochure.

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Circle 158 on reader service card

Complete DMMs cost under $300

Two 4½-digit units read current as well as dc and ac voltage and resistance; one model responds to true rms, the other uses average-detecting circuitry

by Lawrence Curran, Boston bureau manager

The name of the game in 4½-digit digital multimeters these days is to have a price tag under $300. To get in on this portion of the bench instrumentation market, Data Precision Corp. has redesigned two earlier DMMs to come up with the models 2480 and 2480R.

Both instruments are priced below $300, which Data Precision president Harold Goldberg observes has become the magic number in the 4½-digit bench market. He underscores that these two entries are complete instruments, including current measuring, along with the usual dc and ac voltage and resistance measuring capabilities.

The only difference between the 2480 and 2480R is that the latter responds to true rms, whereas the 2480 uses average-detecting circuitry calibrated in rms for a sine wave. The 2480, including test leads and service manual, is priced at $279, and the 2480R at $299. A rechargeable nickel-cadmium battery pack available for an additional $19.50 makes either unit fully portable when necessary. The basic price of both also includes a line cord that can be removed when the multimeter is battery-operated, plus a one-year warranty and a certificate of conformance.

Goldberg observes that not all users want true rms readings, "so why make everyone pay for it? We're offering them a choice." He stresses that the rms feature is not an option but part of a completely separate instrument.

Goldberg does not claim that these DMMs were the first to break the $300 barrier, but points out that their chief competition doesn't offer current-measuring capability nor include test leads and a manual in its basic price. Further, the battery option is much more expensive in the competitive unit.

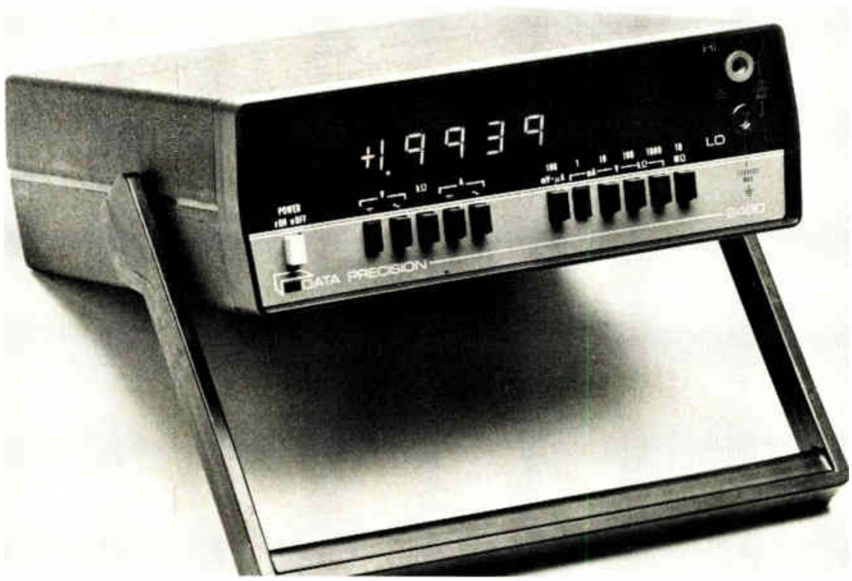
Both the 2480 and the 2480R measure dc and ac voltage and current in five ranges each, and resistance in five ranges. For dc and ac voltage, the ranges are from 100 mV to 1,000 V; for dc and ac current, from 100 µA to 1,000 mA; and for resistance, from 1 kΩ to 10 MΩ. Basic dc voltage accuracy is to within 0.03% of input ± one digit, with resolution of ± 10 µV, and every range has 100% overranging except for the highest voltage range.

All dc voltage ranges will withstand a maximum momentary voltage of ±1,200 V, or ±1,000 V continuously. Any ac voltage range will take 1,000 V rms up to 10 kHz, and any resistance range can safely handle 500 V without damage and loss of calibration.

Neither multimeter requires a front-panel zero adjustment, and the current circuits are protected by a 2-A fuse mounted on the rear panel of the case. That case measures 8½ inches wide, 2⅞ in. high, and 8⅞ in. deep. Both units have high-intensity light-emitting-diode displays that are 0.43 in. high.

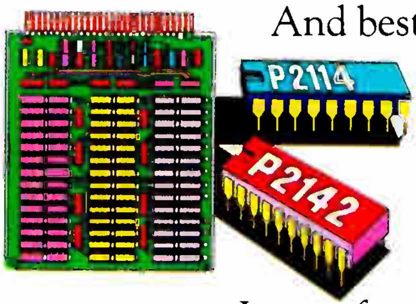
Input impedance on all dc and ac voltage ranges is a constant 10 MΩ in all ranges. Ac frequency response is specified to 50 kHz on all ranges except the most sensitive of the average-sensing 2480 and to 20 kHz on all ranges of the 2480R. Overvoltage is indicated by blanking of all digits except the decimal point and polarity sign, where applicable. Both models are available from stocking representatives.

Data Precision Corp., Audubon Rd., Wakefield, Mass. 01880. Phone Robert Scheinfein at (617) 246-1600 [338].



Intel delivers the Make the move now

Now's the time to replace those 2102 1K designs with Intel's higher density 2114, the most widely sourced 4K static RAM. The 2114 is already less expensive at the board level than the 2102. You'll save power without compromising speed.



And best of all, we're delivering the 2114 in volume. We can ship up to 10,000 parts within one week of receipt of order.

There's a full range of design solutions in the 2114 family. It starts with our 1Kx4 2114, for the highest possible density and modularity in an 18-pin 4K static RAM. Then there's the 2114L. Same pin-out. Just as fast. But 30% lower power.

For simplified designs in microcomputer-based systems, we're delivering the 20-pin 2142. It's the way to go when you want 2114 performance, but need an extra chip select and output enable. The output enable function cuts parts requirements in microcomputer systems by eliminating bus contention.

All our 4K static RAMs inherit the ease of use and low overhead of our industry-standard 1K 2102. You don't need a clock, refresh or set-up timing. You don't even need

2114 in volume. to 4K static RAMs.

pullup resistors or output gating. Our 4K static RAMs operate at TTL levels on a single +5V supply, and have buffered three-state outputs.

We guarantee identical access and cycle times on these parts, so you can surpass the performance of clocked static RAMs. For example, you can achieve a data rate of 20 megabits per second with the 200 nanosecond 2114-2 or 2142-2 parts. That's twice the data rate of clocked RAMs with a 200 ns access time. Intel specs guarantee that even at high throughput rates you'll need less than half the power of first generation static RAMs.

You can take advantage of 2114 and 2142 economy and Intel's production availability by ordering directly from: Almac Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey, Industrial Components, Pioneer, Sheridan, Wyle/Elmar, Wyle/Liberty, L.A. Varah or Zentronics.

Intel 1K x 4 MOS STATIC RAMs

	Access Time & Cycle Time (max) 0-70°C	Icc (max) @Vcc (max) 0-70°C
2114-2		100mA
2114L-2	**200ns**	70mA
2142-2		100mA
2142L-2		70mA
2114-3		100mA
2114L-3	**300ns**	70mA
2142-3		100mA
2142L-3		70mA
2114		100mA
2114L	**450ns**	70mA
2142		100mA
2142L		70mA

Or ask your Intel salesman how you can get an assembled and tested card, the Intel Memory System in-7000. It gives you up to 16K words on one card, up to 528K in one chassis.

Our entire selection of static RAMs are in the Intel 1977 Data Catalog. For individual data sheets on the 2114 or 2142 components or the in-7000 static RAM memory system write: Intel Literature Department, 3065 Bowers Ave., Santa Clara, CA 95051.

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Semiconductors

Optical coupler uses photo-SCR

Aimed at solid-state relays, photo-SCR isolator sustains 200 V across its output

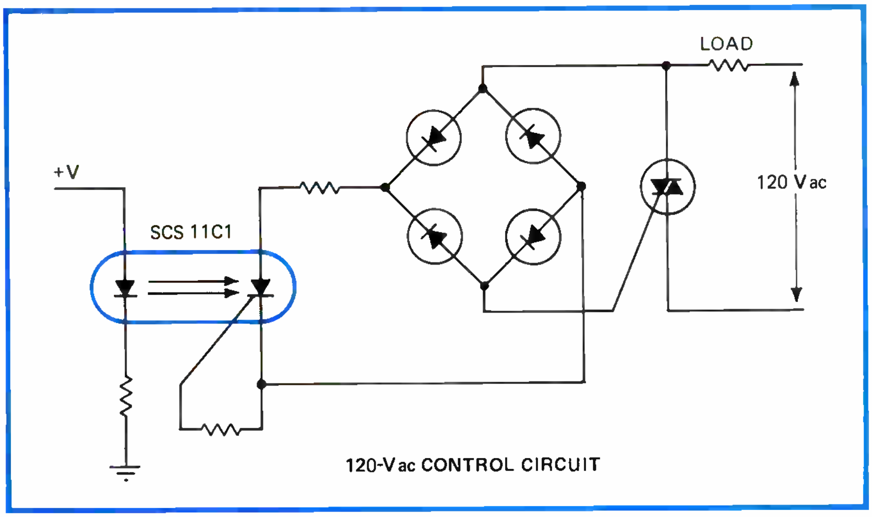
Light-sensitive silicon controlled rectifiers have been viewed for years as the next step in simplifying the solid-state relay, but until now sources for photo-SCR couplers have been limited. Now, however, a small Texas firm, Spectronics Inc., is going to second-source the photo-SCR coupler family made by General Electric Co. Multiple sourcing is the boost that these couplers need to win sockets away from earlier light-emitting-diode and phototransistor designs, the firm believes.

Optical couplers are fast following the lead of microprocessors in replacing electromechanical controls and switches in consumer and industrial equipment. The mating of an LED and photodetector provide the isolation necessary to protect electronic controls from the high transient voltages of electrical loads, particularly inductive loads such as mechanical relays and motors. The devices also isolate the equipment's ultimate user from touching a 110-V or 220-V system.

Most solid-state relays employ phototransistor couplers, whether supplied as a subassembly by a relay maker or built from components by the original-equipment manufacturer. In a relay the new photo-SCR coupler will replace the phototransistor coupler, as well as the SCR that the phototransistor drives, says James A. Oursler, program manager for the Richardson, Texas, firm.

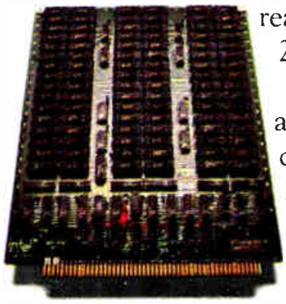
Like its GE counterpart, the Spectronics coupler will sustain 200 V across the SCR output, allowing the user to connect it to a 115-V line. Moreover, Spectronics will introduce a 400-V version in May designed to be used for 220-V equipment. Both devices will handle 300-mA forward current; with a current-limiting resistor, both will switch a larger, 30-A SCR or can be used with a diode bridge to trigger a triac (see figure). Applications are varied and include microwave ovens and other appliances, electronic heating and air-conditioning controls, vending machines, computer interfaces, and industrial and machine-control uses.

Versions are now available with LEDs that trigger at either 11 mA or 14 mA. All the Spectronics couplers use a patented, intermolded epoxy process to get input-to-output isolation of 3.5 kV ac, as defined by Underwriters Laboratories Inc. They are housed in standard six-pin plastic dual-in-line packages and will operate in −55°C to 100°C. Holding current of the devices is rated at 500 mA maximum, and dv/dt is 500 V/μs



Intel's new in-7000 static memory system with Word/Byte Control delivers speed, convenience and design flexibility. It's the easiest way to get our high-density 2114 4K static RAMs into your system.

The in-7000 is a complete static memory with interface and control logic contained on a single 10.8" x 8.175" printed circuit card. The system requires only a +5V power supply, is TTL compatible, and needs no refresh. You can choose from two versions, differing only in speed: the 7000, with a read and write cycle time of 250 ns; and the 7001 (350 ns).



The basic in-7000 card is available in four 16K configurations: 16K x 12, 16, 20 or 24 bits. Two chassis models are also available. The in-Minichassis can house six in-7000 circuit cards, and the in-Unichassis has a 32-card capacity.

A unique feature called Word/Byte Control gives you the design flexibility to standardize on the in-7000 for all your systems applications. Word/Byte Control allows the Byte Control inputs to be used either for reconfiguration or byte data control. In the Word mode, the Byte Control inputs select either or both halves of a word, effectively reconfiguring a 16K x 24 card to 32K x 12; a 16K x 16 card to 32K x 8; and so on. In the Byte mode, any combination of three bytes in a 24-bit word may be selected by the Byte Control inputs.

Get Intel 4K static RAMs into your system now with our in-7000. Phone your local Intel sales office or use the coupon below.

intel delivers.

Intel Memory Systems EL 3/16/78
1302 N. Mathilda Avenue, Sunnyvale, CA 94086
Phone (408) 734-8102

Send me more information on Intel's in-7000 static memory system.

Name____________________

Position____________________

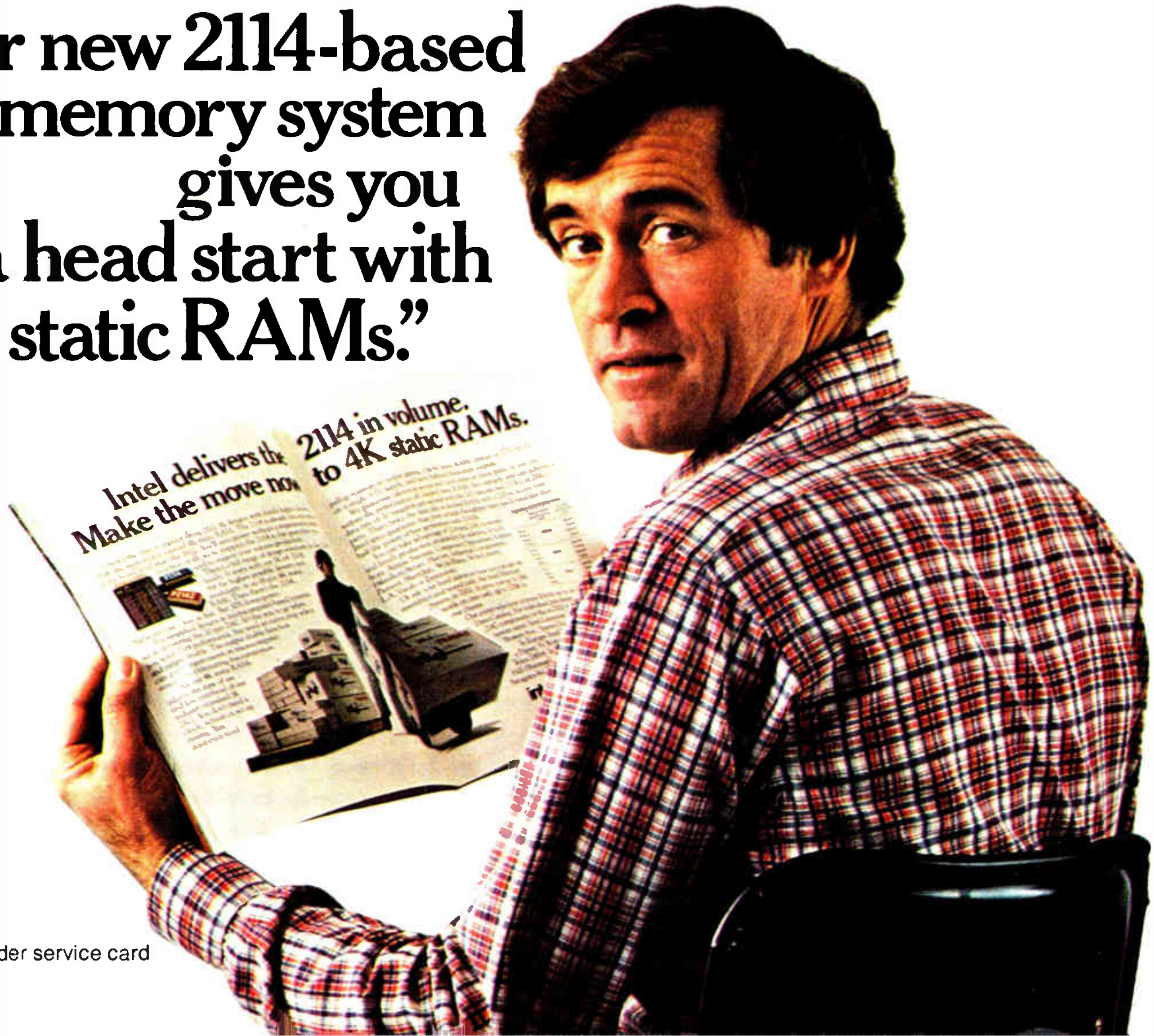
Company____________________

Address____________________

City, State, Zip____________________

Call me ______/____________________

"Our new 2114-based memory system gives you a head start with 4K static RAMs."



Circle 163 on reader service card

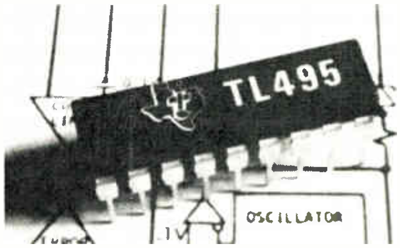
minimum, the company says.

Instead of delineating the SCR's junctions with a moat etch process and then passivating the devices with glass, Spectronics uses standard planar semiconductor processing. "That gives us a smaller chip, and a chip that's more easily assembled into packages," Oursler explains. While the firm plans eventually to sell the light-sensitive SCR chip as a product, it is initially offering a package with an LED in the SCS11C1 and SCS11C3 couplers. The SCS11C1 with an 11-mA trigger current sells for $1.10 in lots of 1,000 and as low as $0.55 in high volumes.

Spectronics Inc., 830 East Arapaho Rd., Richardson, Texas 75080. (214) 324-4271. [411]

Switching regulator IC includes high-voltage zener

A pulse-width-modulation control circuit, the TL495, is intended primarily for use in switching power supplies. Similar to the slightly older TL494, the new integrated circuit has an on-chip 39-V zener diode that allows the regulator to be used in high-voltage applications, in which the input voltage exceeds 40 V. It also has an output-steering control that overrides the internal control of the chip's on-board pulse-steering flip-flop.



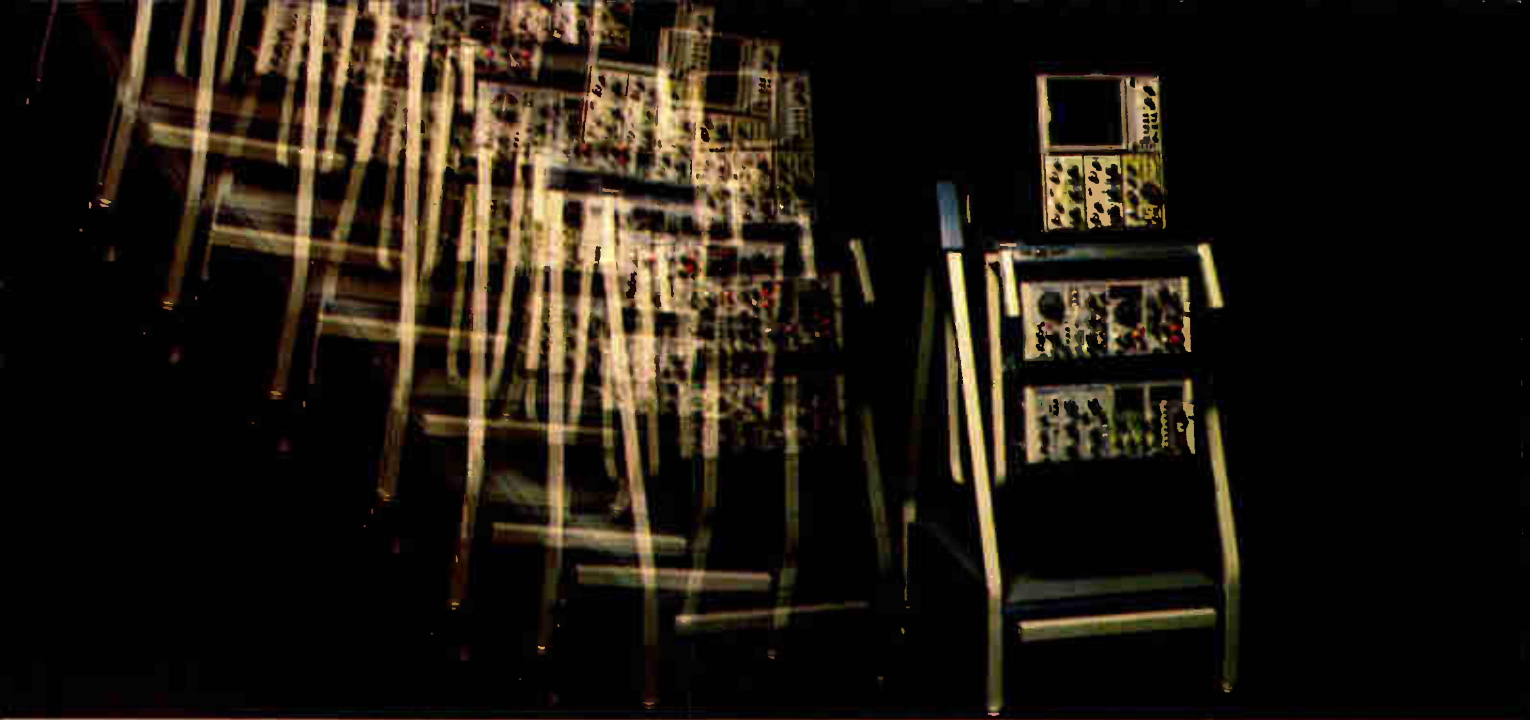
Otherwise the 495 provides the same functions as the 494. It contains a 5-V regulator, an error amplifier, a current-limit sense amplifier, a programmable oscillator, a dead-time control comparator, a pulse-steering flip-flop, and output control circuitry. Its uncommitted output transistors provide a choice of common-emitter or emitter-follower output capability. Push-pull or single-ended operation can be selected through the output control function.

The IC is housed in an 18-pin dual in-line package. For quantities of 100 or more it sells for $3.60 in plastic or $4.03 in ceramic. Availability is from stock.

Texas Instruments Inc., Inquiry Answering Service, P. O. Box 5012, M/S 308, Dallas, Texas 75222 [413]

Bi-FET op amps have low noise and low drift

Three series of FET-input monolithic operational amplifiers are designed for low-noise applications. Featuring matched junction field-effect tran-



Get Rolling.

If you need test and measurement instrumentation that really moves, get behind the wheels of cart-mounted instrumentation from Tektronix.

You can load the upper tier of a Tek Model 3 Lab Cart with your Tektronix Oscilloscope, put one or two TM 500 Mainframes on the lower decks and fill them with your own configuration of TM 500 modular plug-ins:

- DMMs
- Counters
- Generators
- Amplifiers
- Power Supplies
- Plug-in Scopes
- Logic Analyzers
- Word Recognizers
- Custom Plug-ins

There are over 30 TM 500 instruments to choose from, so you can assemble a configuration that handles several specialized applications or use each individual instrument for general purposes.

Your entire instrumentation system plugs into a power distribution unit requiring a single line cord.

Your probes, accessories, additional plug-ins and documentation tuck away neatly in the bottom drawer. Now you're all set to go places.

You can travel to immoveable machines and probe their inner workings . . . in one trip, not several. Or slip your mobile lab down a narrow laboratory aisle to give your bench more elbow room.

Or, zip across the production floor for a scope calibration. Tek instruments, Scopemobiles™ and Lab Carts have an internal common ground, an important feature if you get into sensitive digital circuitry.

And, if you need table top working space along with cart portability choose the TEK Rack Cart Model 7.

Like a moveable desk, the Rack Cart leaves a flat surface on top for charts, files and record keeping. And, 28" of depth inside allows room to rackmount Tektronix instrumentation to the front or rear of the cart. A special option lets you rackmount a TM 500 six wide mainframe at an upward angle for easier usage.

With a rollabout test and measurement laboratory of Tektronix instruments, you've got a lot going for you. Flexibility. Accuracy. Configurability.

So, get rolling.

Call your Tektronix Field Engineer and ask him about taking a test stroll with the TM 500 family of modular instruments. They really go together.

TM 500 Designed for Configurability

For configurable, accurate, reliable test and measurement instrumentation, contact: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077, (503) 644-0161, Ext. 5283. In Europe: Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

For Technical Data circle 165 on Reader Service Card
For Demonstration circle 141 on Reader Service Card

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COMMITTED TO EXCELLENCE

sistors, the amplifiers all have an input bias current of 30 pA, an input offset current of 3 pA, an input impedance of 10^{12} Ω, an input offset voltage of 1 mV, an input-offset-voltage temperature drift of 3 μV/°C, and an input noise current of 0.01 pA/Hz$^{1/2}$.

Specifications of the LF155 series include a 4-μs settling time, a 5-V/μs slew rate, a 2.5-MHz bandwidth, and an input noise voltage of 20 nV/Hz$^{1/2}$. The LF156 settles in only 1.5 μs, slews at 12 V/μs, has a 5-MHz bandwidth, and has an input noise voltage of 12 nV/Hz$^{1/2}$. The fastest amplifier in the series is the LF157, which is similar to the 156 except that it can slew at 50 V/μs and has a 20-MHz bandwidth.

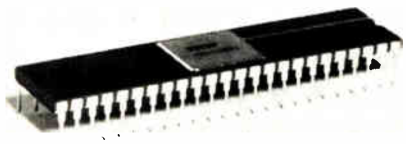
All three op amps can be operated from −55°C to +125°C and can work with supply voltages up to ±22 V. They can drive loads with capacitances up to 10,000 pF without stability problems. In quantities of 100 to 999, the amplifiers sell for $2.67. They are available from distributor stock.

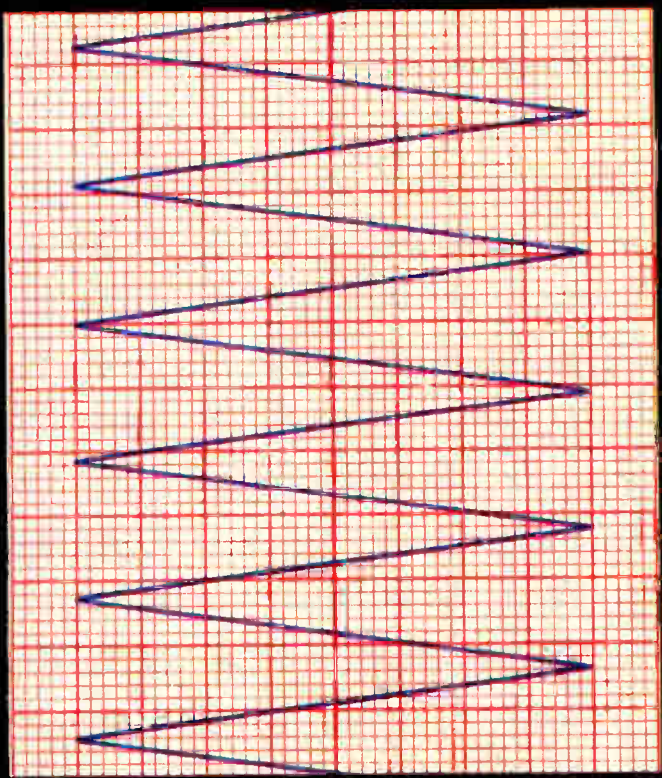
Signetics Corp., 811 East Arques Ave., P. O. Box 9052, Sunnyvale, Calif. 94086. Phone (408) 739-7700 [414]

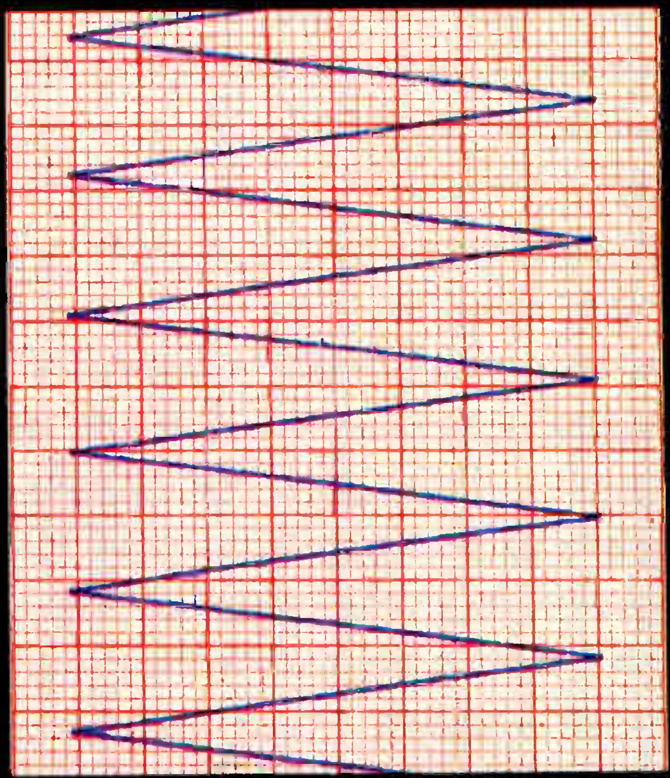
Monolithic unit does 8-by-8 multiplication in 70 ns

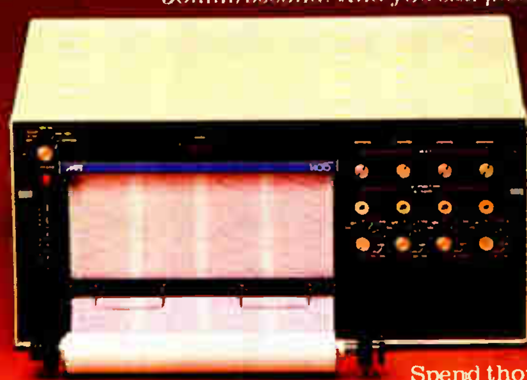
A monolithic, multifunction arithmetic device that can multiply two 8-bit binary numbers in only 70 ns can be used as either a multiplier or as a multiplier-accumulator. It can also perform 19-bit addition and subtraction in an accumulator-subtractor.

Designed as a central arithmetic block for use in digital filters (especially those used to implement fast Fourier transforms), the TDC1008J









contains input registers as well as its output accumulation registers. Both inputs and outputs are compatible with transistor-transistor logic levels. Three-state outputs are standard with this device.

Housed in a 48-pin dual in-line package, the TDC1008J is priced at $70. It consumes 1.2 W of power from a single 5-V supply. Delivery is from stock.

TRW LSI Products, P. O. Box 1125 Redondo Beach, Calif. 90278. Phone William Koral at (213) 535-1831 [415]

SCRs operate at junction temperature of 150°C

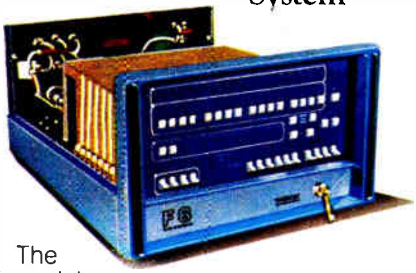
The 325PAH series of high-power SCRs consists of six units designed to function at junction temperatures as high as 150°C. The six units have a nominal root-mean-square current rating of 510 A, an average-current rating of 325 A, and peak-reverse-voltage ratings from 500 to 1,200 V. They are housed in compact hockey-puck packages with a diameter of 1.6 inches.

The 325PAH devices are suitable for phase-control applications such as dc motor drives, power supplies, and input rectifiers for uninterruptible power supplies. In quantities of 100, they cost from $44.85 to $87.65, depending upon voltage rating and other specifications. Delivery is from stock to approximately four weeks.

International Rectifier, Semiconductor Division, 233 Kansas St., El Segundo, Calif. 90245. Phone (213) 322-3331 [417]

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

The Formulator Development System

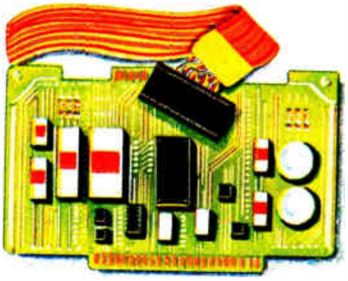


The Formulator family is designed to allow easy, efficient software development and real time hardware simulation of F8 or F3870 based systems. It is supported by a complete line of functional modules including memory, I/O and simulation cards that plug directly into the Formulator cardframe.

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

In-Circuit Emulation

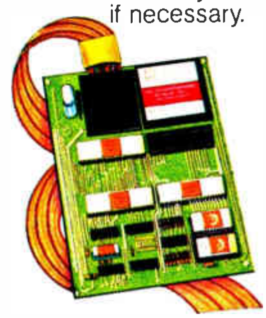
To develop, test and debug F8 and F3870 based products, Fairchild offers simulation options that extend the functional features of the micro-



processor from the Formulator to the 40-pin socket on your breadboard. This allows complete ROM firmware development, real-time symbolic debugging of your breadboard and freezing of ROM codes during the breadboard stage.

PROM Prototypes

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

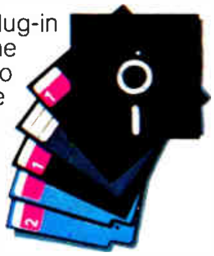


The F3870 Emulator plugs directly into the F3870 40-pin socket in the production prototype via a short cable.

Powerful and Complete Software

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

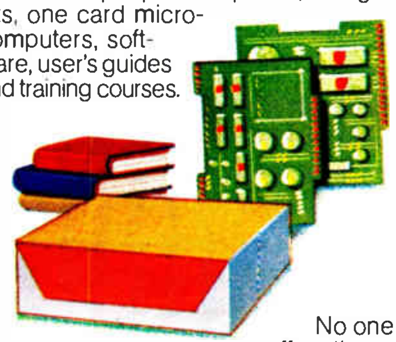
The Formulator-Floppy Disk Marriage



An inexpensive plug-in module interfaces the Formulator with up to four plug-compatible ICOM Floppy Disc Drives, providing over one megabyte of storage. If you prefer other Floppies an application note provides the information necessary to modify Drivers for your system.

And That Isn't All

There is a lot more to Fairchild's line of design aids: PCB modules, memory options, PROM programmer, application and peripheral options, design kits, one card microcomputers, software, user's guides and training courses.



No one offers the extensive F8 and F3870 support that you can get from Fairchild. Just ask us about it.

Fairchild Instrumentation and Controls, a division of Fairchild Camera and Instrument Corp., 1725 Technology Drive, San Jose, California 95110 (408) 998-0123, Ext. 220.

FAIRCHILD

Instruments

DMMs come with programs

Microprocessor-based multimeters offer range of capabilities

Two more digital multimeters that take advantage of microprocessors for a wide range of processing capabilities provide the user with more meaningful information than simply measurements. The instruments, the 5½-digit model 7055 and the 6½-digit 7065 measure dc and ac (mean reading displayed as rms) voltage with 1-μv sensitivity, as well as resistance, and display results on light-emitting-diode readouts. These instruments from Guildline Instruments join similar microprocessor-based DMMs in the high-end market.

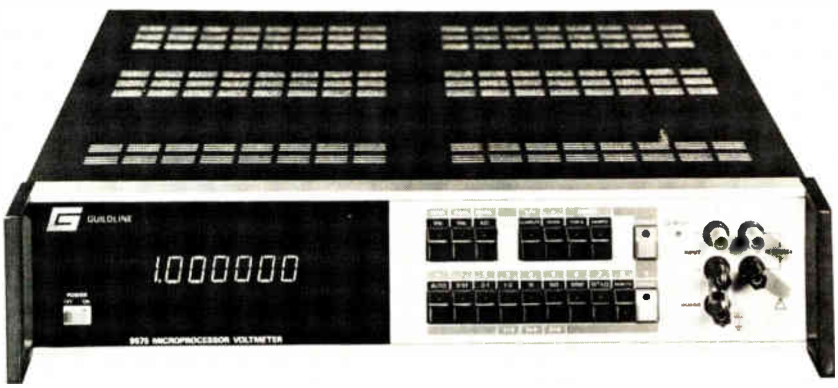
The 7055 and 7065 can call upon eight stored programs for manipulation of measured data. Programs can do the following:

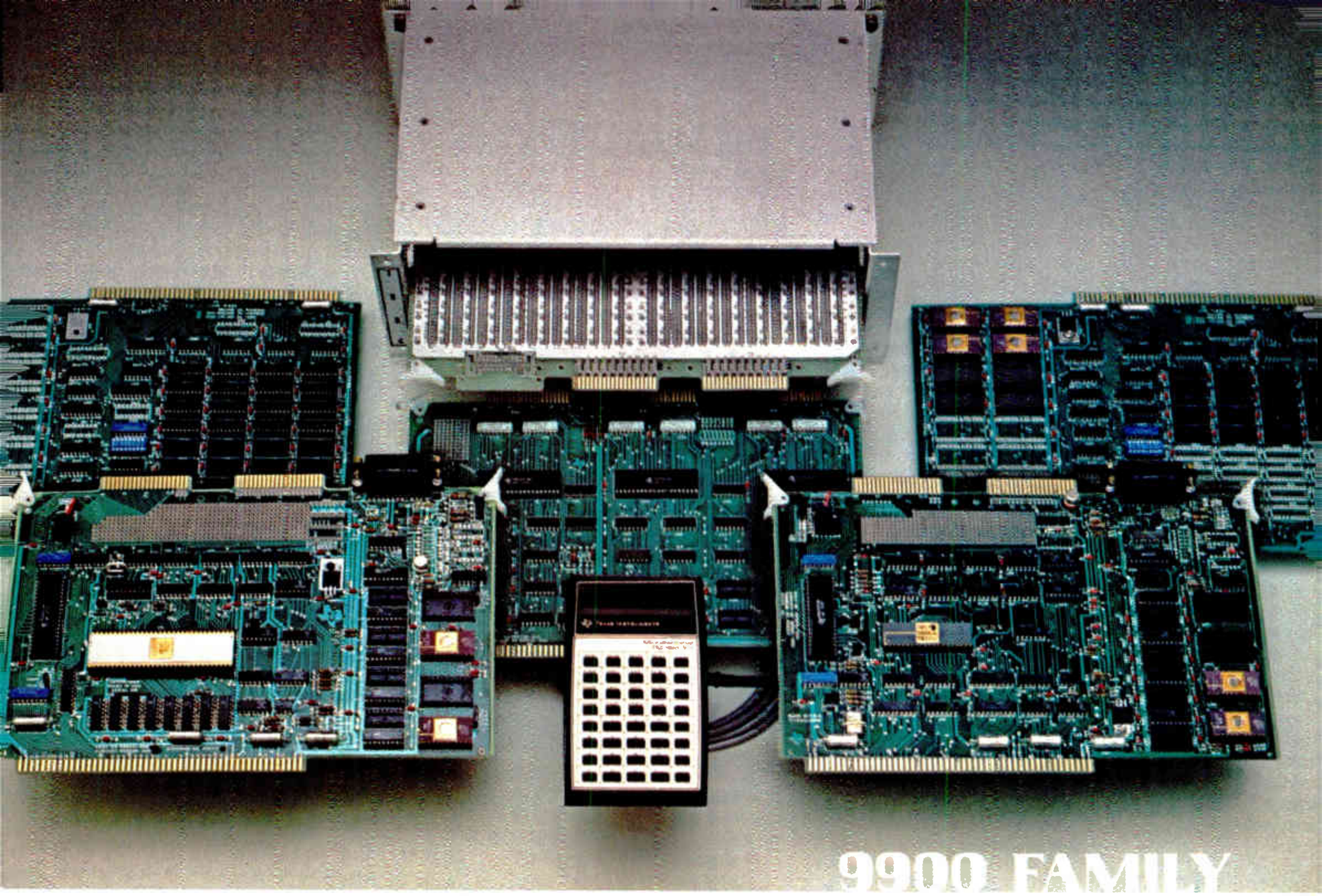
- Multiply each reading by a constant entered at the keyboard.
- Calculate percentage deviation from a keyboard-entered nominal value.
- Subtract a preset offset value from each reading.
- Calculate ratio with respect to a preset constant.
- Store maximum and minimum values of a series of readings.
- Compare readings with preset high and low limits.
- Calculate various statistical properties, such as average value, variance, standard deviation, and root mean square.
- Calculate correction factors for measurements using a thermocouple with known characteristics.

A ninth program uses the internal clock to allow automatic control of measurements, such as starting and stopping times and intervals between measurements. This feature is useful for unattended measurements that must be made over a long period—a weekend, for example.

The instruments also have three types of interfaces for systems use: binary or binary-coded decimal, RS-232-C, and IEEE-488 standard interface bus.

Full-scale ranges for dc voltages are 0.020000 to 1,000.00 v for the 7055 and 0.014000 to 1,100.000 v for the 7065. Accuracies for one year for the 7055 on the two lowest dc voltage ranges are to within 0.1% of reading ±4 digits and to within 0.01% of reading ±2 digits on the four upper ranges. For the 7065,





Now–more OEM μP modules from TI: 16-bit performance at 8-bit prices.

Compare TI's series of TM 990 microcomputer modules. Here's 16-bit performance at a cost less than 8 bits.

And 16-bit performance means increased throughput. Programming ease. Improved memory efficiency. All leading to greater system savings.

Use these new modules for μP evaluation. And as a production alternative. To speed your microprocessor-based design to market. To minimize design costs.

Leadership series

Included in the TM 990 Series are:

• TM 990/100M – TI's TMS 9900 μP, I/O circuits, and memory – all on a single board. $450.00*.

• TM 990/180M – 16-bit TMS 9980 μP offers 2 MHz operation with 8-bit data bus. $435.00*.

• TM 990/201 – Memory expansion board: 8K bytes of EPROM, 4K bytes of static RAM. Expandable to 32K bytes of EPROM and 16K bytes of RAM. $595.00*.

• TM 990/206 – Memory expansion board with 8K bytes of RAM. Expandable to 16K bytes. $585.00*.

• TM 990/301 – Microterminal for data entry and display. $125.00*.

• TM 990/310 – a 48-bit input/output expansion module. $295.00*.

• TM 990/401 – Interactive debug monitor (TIBUG™) preprogrammed into CPU EPROM. $100.00*.

• TM 990/402 – Line-by-line assembler preprogrammed into the EPROM. $100.00*.

• TM 990/510 – Four-slot OEM chassis on 1″ spacing. $190.00*.

• Cables, connectors, extender and prototyping boards are also available.

And even more modules will be available soon.

All are preassembled. Pretested. Ready to go. Supported by easy-to-use software.

9900 First Family compatibility.

The TM 990 modules are also supported by the advanced AMPL™ software development system. And all are instruction-set compatible with other members of TI's 9900 First Family.

For more details, call your authorized TI distributor. Or write Texas Instruments Incorporated, P. O. Box 1443, M/S 653, Houston, Texas 77001.

*One to nine quantity

TEXAS INSTRUMENTS
INCORPORATED

9333C

Circle 173 on reader service card

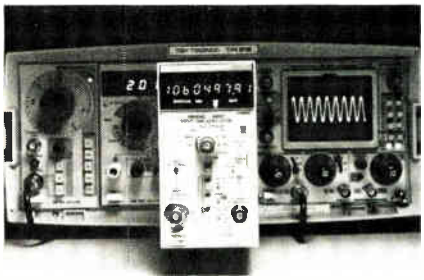
accuracy on the four lowest dc voltage ranges is to within 0.006% of reading ±4 digits and to within 0.006% of reading ±6 digits on the two highest ranges.

Price of the basic 7055 is $2,995; for the 7065, $3,995.

Guildline Instruments Inc., 2 Westchester Plaza, Elmsford, N. Y. 10523. Phone (914) 592-9101 [351]

1-GHz counter counts directly to 100 MHz

The latest addition to Tektronix' TM 500 series of modular instruments is a 1-GHz frequency counter with a direct input connection for frequencies from 10 Hz to 100 MHz and a prescaler input for frequencies from 75 to 1,000 MHz. The nine-digit instrument has a maximum sensitivity of 20 mv rms. Designated the DC 508, the counter has many features which suit it well for making measurements in communications systems, including the newly opened 806-to-947-MHz two-way band. Among them is a 100-times resolution multiplier that can make measurements on audio signals to a resolution of 10 millihertz in 1



second. Conventional counters require 100 seconds to reach the same resolution. The added measurement speed can be very important when measuring tone-squelch and frequency-shift-keying frequencies.

Other features include automatic gain control and wideband limiting on the prescaler input resulting in a dynamic range of 20 mv to 2 v rms. There are also an easily replaced input-protection fuse and a selection of time bases. The DC 508 sells for $1,100, not counting a TM 500 system mainframe. Delivery time is nine weeks.

Tektronix Inc., P. O. Box 500, Beaverton, Ore. 97077. Phone (503) 644-0161 [353]

Thermometer spans 255°C with maximum error of 3°C

Combine a measurement range of −55°C to 200°C with the capability to read in both °F and °C, add a maximum error of 3°C (including the ±1-digit uncertainty), pack the resulting thermometer into a compact logic-probe-type case, and you have an instrument that many people would value at more than its $215 price. The LTS 33T is a 3½-digit thermometer that operates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Coming through...
with a big lift for your new product designs
If it involves wire, involve Belden. Up front. We can give you comprehensive help in problem solving. Custom designs. Field engineering. And value analysis.
If you're involved in new product design, send for your "Big Lift" today. Belden Corporation, Electronic Division, P.O. Box 1327, Richmond, IN 47374; 317-966-6661.
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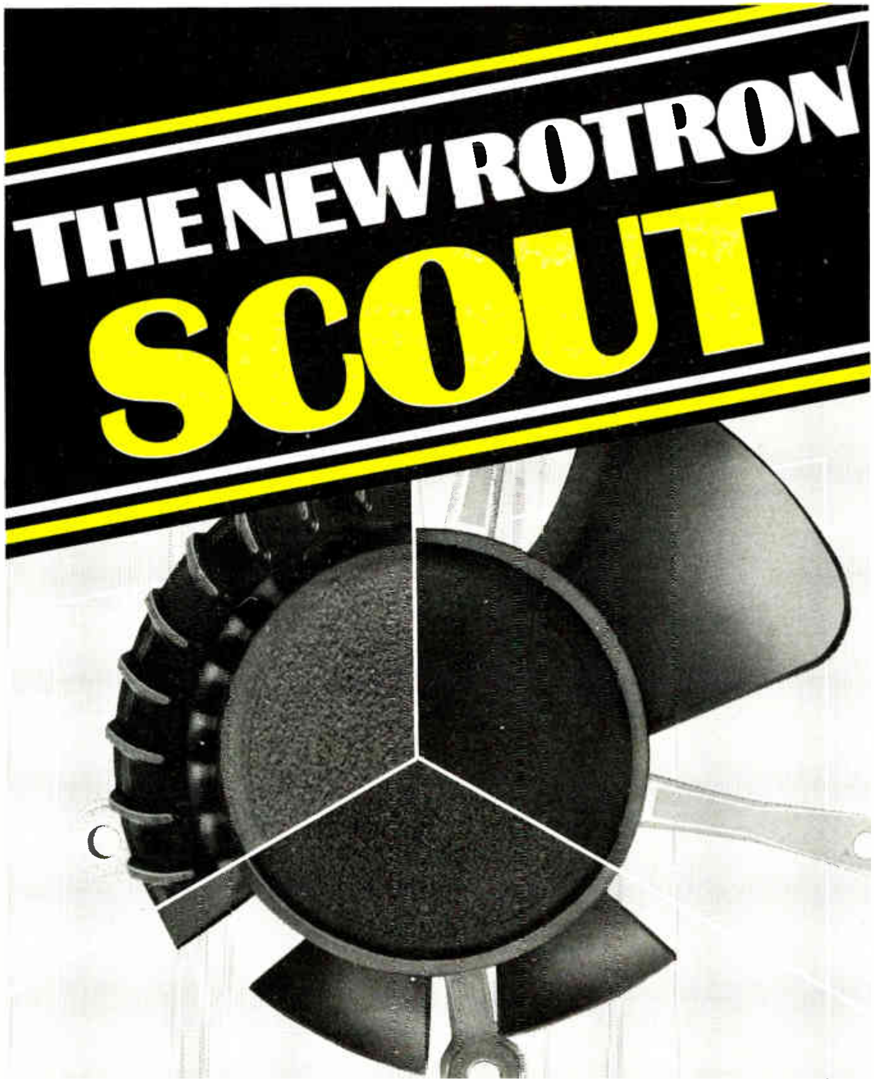


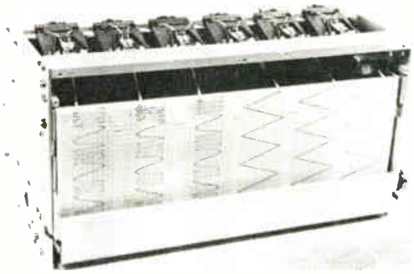
from rechargeable nickel-cadmium batteries and can also make use of the ac line while the batteries are recharging. Although it may be off by as much as 3°C over its full temperature range, the maximum error is reduced to 1°C for temperatures between 0°C and 100°C. (All accuracy specifications are for an instrument temperature of 23°C ±3°C.)

A variety of interchangeable plug-in sensor tips is available for the 33T. Among them are surface probes, immersion units, air-temperature detectors, corrosion-resistant units, and piercing probes. The 33T is warranted for one year.

Logical Technical Services Corp., 71 West 23rd St., New York, N.Y. 10010. Phone (212) 741-8340 [354]

Six-channel chart recorder loads instantly

Because its chart paper is preloaded into a cartridge, which is simply snapped in place, the model W602 XL chart recorder can be loaded with paper in essentially no time at all. Recommended for medical, aerial geophysical exploration, pollution

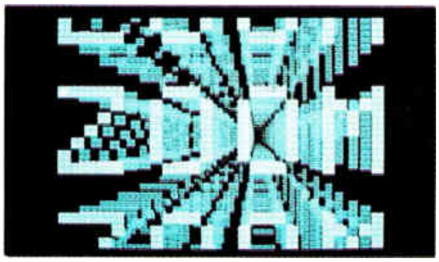


Most graphics terminals are too dumb for words.

Even expensive models get tongue-tied when it comes to alphanumerics. But now there's a bright new graphics terminal that has a lot to say for itself.

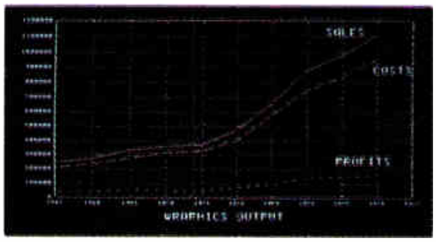
Alpha-graphics: the perfect combination.

It's the Hewlett-Packard 2648A alpha-graphics terminal. For just $5500* it will dazzle you with a



virtuoso display. You'll see zoom and pan, area shading, pattern definition, rubber band line, scientific plotting and graphics text composition. Having independent memories for graphics and alphanumerics, you can do auto-plots with or without words and figures on the screen.

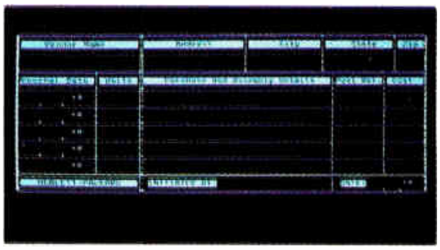
And when you need a smart alphanumeric terminal for on or off-line work, stay right where you are.



How smart is smart?

Ever seen a graphics terminal scroll 200 lines of interactive dialogue? And store up to 220K bytes of data (words and pictures) on twin cartridges? And cut out repetitive routines by storing up to 80 characters on each of eight "soft keys"?

The HP 2648A can also edit with the best of them. Communicate with a computer at rates up to 9600 baud. And accept a plug-in forms drawing mode to generate just about any form your company uses.

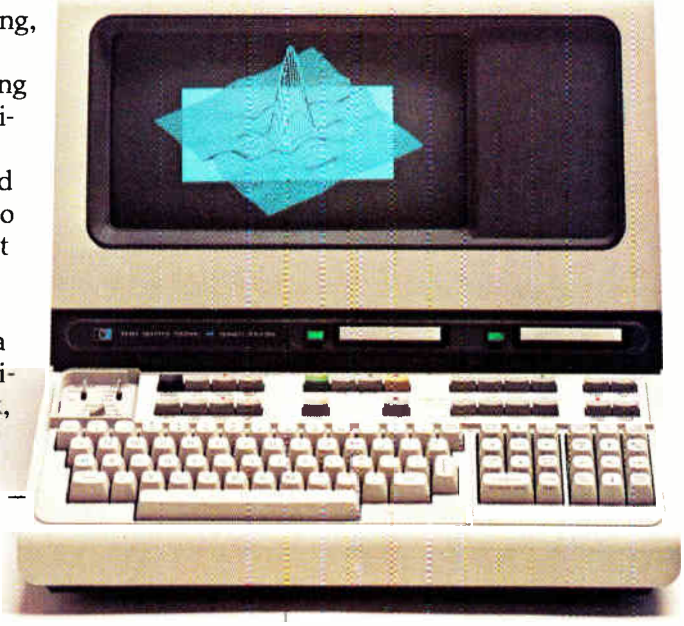


Strong as well as intelligent.

Like all our terminals, the HP 2648A has a clean, tough, modular design. Open it up like a suitcase, and you'll see the neat row of plug-in PC boards.

That makes it easy to add options or take care of maintenance. Not that downtime is a problem. Our terminals have such a good track record that we've lowered our maintenance price three times in the past two years. When you do need service, more than 1000 Systems and Customer Engineers worldwide are ready to take care of you.

So why settle for any dumb graphics terminal when ours can figure in your picture? See for yourself by calling the Hewlett-Packard office listed in the White Pages. Or send us the coupon and give our 2648A alpha-graphics terminal a screen test.



Yes, give me the good words (and pictures) on the HP 2648A terminal.

☐ I'd like a demonstration. ☐ Send me information.

Name ______ Title ______

Company ______

Address ______

City/State/Zip ______

Phone ______

Mail to: Ed Hayes, Marketing Manager, Hewlett-Packard Data Terminals Division, 19400 Homestead Road, Dept. 614, Cupertino CA 95014.

U.S. domestic price

HEWLETT hp PACKARD

42801HPT5

Circle 177 on reader service card

control, utility, aerospace, electronic laboratory, and industrial applications, the six-channel instrument uses heat-sensitive paper for inkless writing. Each of its channels is 50 mm wide and uses a position-feedback galvanometer for an overall error of no more than 0.5% of full scale and a frequency response that remains flat from dc to 100 Hz at a peak-to-peak amplitude of 10 mm. Sensitivity of the unit is 10 V/mm. The W602 XL sells for $2,650 and has a delivery time of 45 days, the company says.

Astro-Med, Atlan-Tol Industrial Park, West Warwick, R. I. 02893. Phone (401) 828-4000 [355]

Two-channel filter spans 0.01 Hz to 99.9 kHz

The model 3343 two-channel filter is digitally tuned over the frequency range from 0.01 Hz to 99.9 kHz. Each of its channels can operate in either a low-pass or a high-pass mode, and each has a slope of 48 dB per octave. When both channels are operated in the same mode and set to the same cutoff frequency, they can be cascaded to yield a slope of 96 dB per octave.

The 3343 consists essentially of two eighth-order Butterworth active filters. A front-panel switch allows the user to change them from maximally flat response to a response

optimized for filtering transients. Switch tuning permits cutoff-frequency calibration to within 2% accuracy and three-digit resolution. The filter sells for $2,000 and has a delivery time of 30 days.

Krohn-Hite Corp., Avon Industrial Park, Bodwell Street, Avon, Mass. 02322. Phone Ernie Lutfy at (617) 580-1660 [356]

Subassemblies

Track-and-hold does it fast

Self-contained hybrid unit has 100-ns acquisition time and only 5-μV/μs droop rate

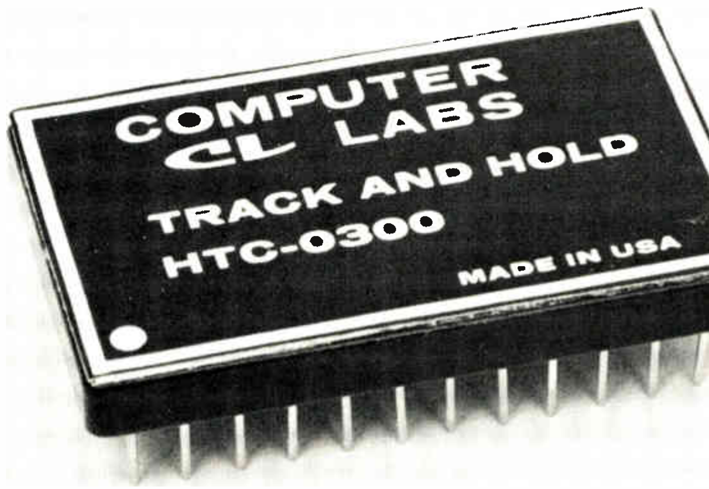
Offering both speed and accuracy in a miniature hybrid package, a track-and-hold amplifier from Computer Labs operates with an acquisition time of only 100 ns yet holds droop rate to a low 5 μV/μs. Designated the HTC-0300, the new hybrid is intended for a wide range of signal-processing applications, including waveform measurement, analog signal delay and storage, and signal sampling.

It may be operated in either the track-and-hold or sample-and-hold mode. In the former, it tracks the input signal until it receives a hold command. During the tracking period, the output follows the input, and the device functions as an operational amplifier having a gain of −1. In the latter mode, the HTC-0300 normally operates in the hold condition. To obtain a new sample at the output, the user simply applies a very short sample pulse, typically 100 to 300 ns, to the device's hold-command input.

The most common use for a track-and-hold amplifier is in front of an analog-to-digital converter to permit the digitization of signals having bandwidths larger than the converter alone can handle and also to reduce the aperture time of the system to that of the track-and-hold. Other uses are in peak holding functions and simultaneous sampling a-d converters (with appropriate analog multiplexing).

The HTC-0300 has an aperture time of only 100 ps, a wide input dynamic range of ±10 V, and a broad bandwidth of 10 MHz. It samples at a rate of 5 MHz and slews at a rate of 300 V/μs. Nonlinearity is held to only 0.005%, and output noise to 0.1 mV rms. At 500 kHz, harmonic distortion is down 75 dB, while feedthrough rejection is 75 dB from dc to 2.5 MHz. (During the hold period, high feedthrough rejection prevents input-to-output leakage from occurring.)

Completely self-contained, the unit even includes its own hold capacitor and does not require external trimming potentiometers and compensation devices. Active laser trimming at the factory reduces the unit's pedestal voltage (the offset during the hold period) to only 5 mV. Internal frequency-compensating elements provide stability and optimize the frequency response of the internal high-speed op amp.



Furthermore, with its output of ±50 mA at ±10 V and an output impedance of only 0.1 Ω at dc, the HTC-0300 delivers high drive capability. These specifications mean that the device can drive virtually all types of a-d converters directly.

Three supply voltages—±15 V at 18 mA and +5 V at 16 mA—are required but power consumption is just 620 mW. The unit comes in a glass or metal 24-pin dual in-line package. Its operating temperature range is 0°C to 70°C, although ruggedized versions having an extended operating temperature range are also available.

In quantities of one to nine, the HTC-0300 sells for $149 each. Delivery is from stock to four weeks.

Computer Labs Inc., 505 Edwardia Drive, Greensboro, N. C. 27409 Phone (919) 292-6427 [381]

150-watt power supply stands only 1.75 inch high

The DS151 switching power supply has a height of 1.75 inches yet can deliver 150 W of regulated dc. Three models are currently available: 5 V at 30 A, 12 V at 12 A, and 15 V at 10 A. All provide regulation to within 0.1%, operate with input voltages from 100 to 130 V ac, and have a typical efficiency of 75%. The supplies, which are 11.25 in. long and 5 in. wide, weigh only 3.5 lbs and occupy 90 cubic in.

Because they are aimed primarily

INTRODUCING THE BENDIX PORTABLE MODULE TESTER

Now automatic, on-the-spot module testing is on the way.

Here's a new way to test anything from a printed circuit board to a complex logic system. And you can do it on the job.

Our new portable unit weighs just 30 pounds and has no moving parts. Yet it does everything that stationary digital cabinet-type units can. It eliminates downtime while modules are tested away from the job site. Does away with trial-and-error testing and unwarranted returns, too.

You can take it on board planes or ships, to hospitals, to labs, to computers or communications equipment, and to sophisticated quality-control operations in mass production plants.

Highly trained operators are not needed. Programming procedures are so easy to pick up. And an interactive display system makes operation easier still. Test systems are stored on solid-state cards, providing reusable data memory.

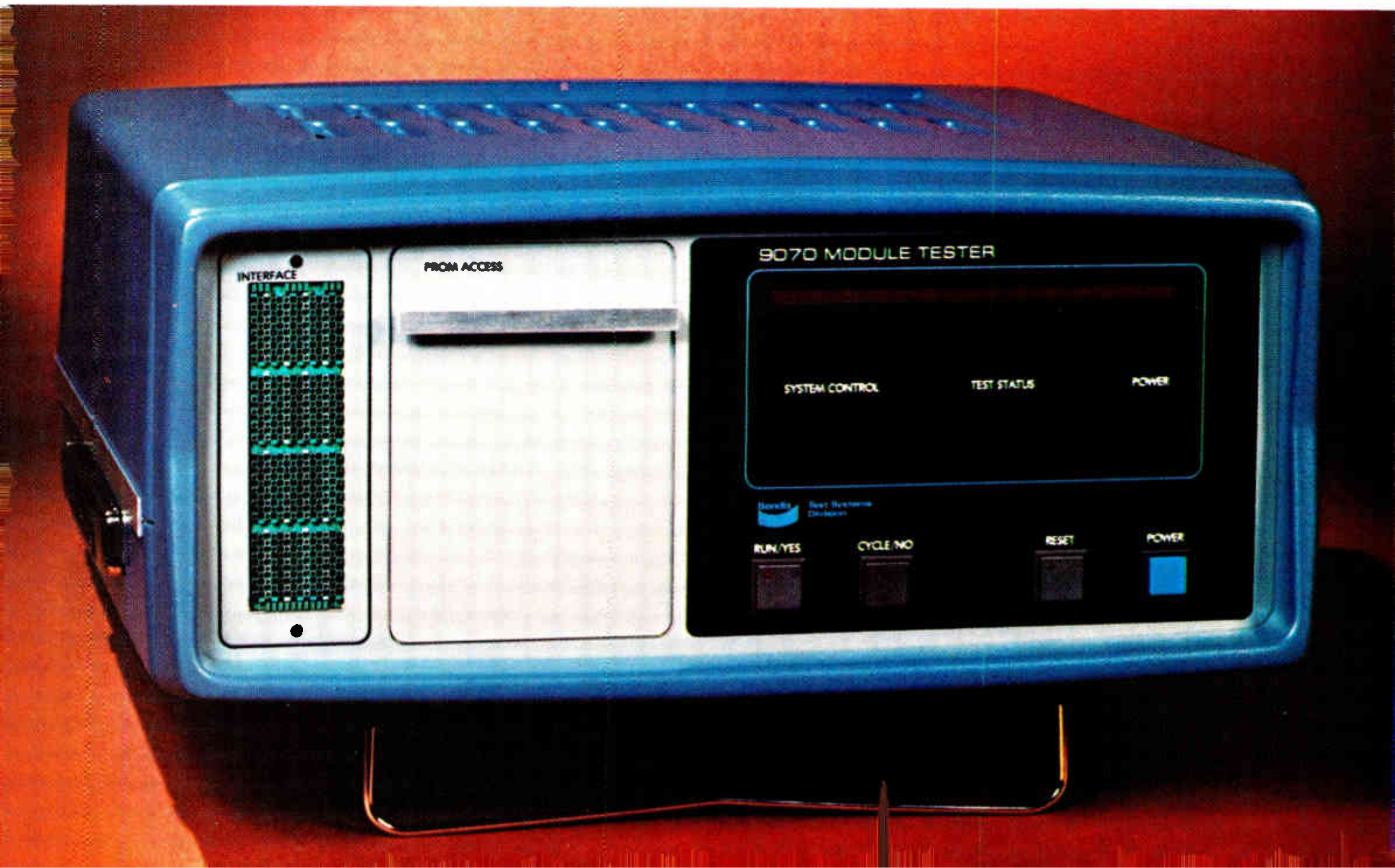
The Basic Bendix unit is capable of testing cards to 64 pins and has the capacity to expand to 256. Additional options are available including:

- Fault Isolation Testing
- Digital Voltmeter/Frequency Counter
- Teletype Interface and Advanced Software Aids.

For more information, contact: Bendix Corporation, Test Systems Division, Teterboro, N.J. 07608. Or call (201) 288-2000, extension 1789.

Bendix

Circle 181 on reader service card



at applications involving volatile and nonvolatile memories, the DS151 series units all include a power-fail signal as a standard feature. With this feature, should a power failure of a half cycle occur, a warning signal compatible with transistor-transistor-logic circuitry is produced. The system designer can set up his system to transfer data from volatile working memories to nonvolatile storage devices upon receipt of this power-fail warning. The power supply will continue to deliver energy to the system during the transfer period—usually just a few milliseconds long.

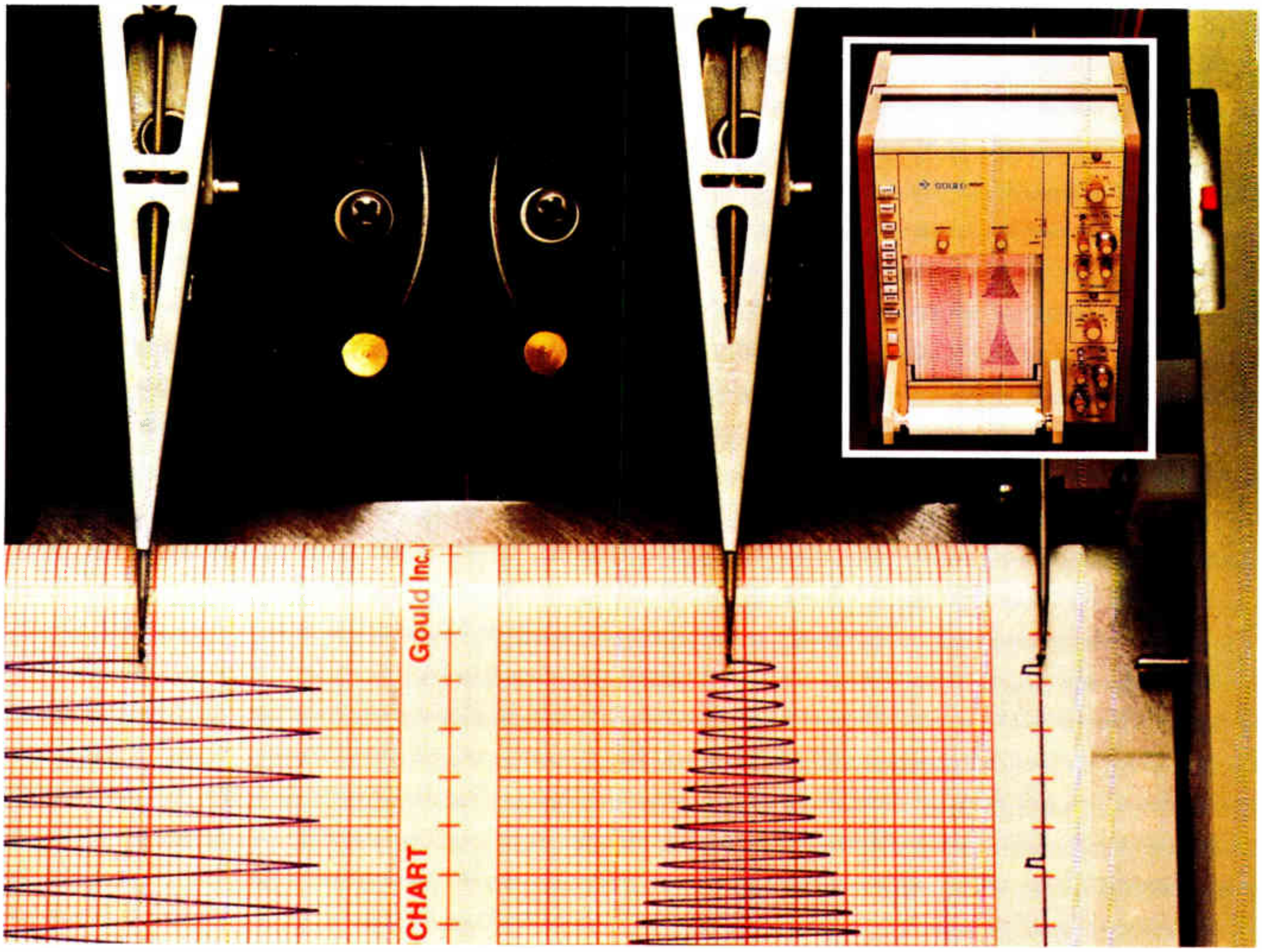
Prototype quantities of the DS151 units sell for $289 and have a delivery time of two to three weeks. In large quantities (1,000 or more), the price drops to $194. An export series, designated the DS153, is also available for operation from 220 to 230 v ac.

Digital Power Corp., 2060 The Alameda, San Jose, Calif. 95126. Phone Robert J. Fain at (408) 246-4337 [383]

D-a converters offer 16-bit resolution

Supplied complete with a reference source and an output operational amplifier, the DAC-HP series of digital-to-analog converters consists of hybrid units with 16-bit resolution. Housed in 24-pin ceramic dual in-line packages, the thin-film circuits has a maximum temperature coefficient of gain of 15 ppm/°C. Two basic models are available: the DAC-HP16B 16-bit binary unit and

Trace quality.
GOULD/Brush Recorders have it.



Regardless of pen velocity.

The exclusive GOULD pressurized fluid writing system assures you constant width traces regardless of pen velocity. The ink is injected into the paper and is wiped dry instantly by the high pen pressure seal. In combination with GOULD low cost chart paper, your traces are permanent. They won't fade or deteriorate as do other writing methods.

An event that may only occur once demands the highest trace quality you can buy . . . GOULD.

For more information write Gould Inc., Instrument Systems Division, 3631 Perkins Ave., Cleveland, Ohio 44114. Or Gould Allco S.A., 57 rue St. Sauveur, 91160 Ballainvilliers, France.

For brochure, call Gould toll-free at (800) 325-6400, Ext. 77.
In Missouri: (800) 342-6600

GOULD
The product development company

New products

the DAC-HP16D four-digit binary-coded-decimal version. The former has a maximum nonlinearity error of 0.003%; the latter can be off by as much as 0.005%. Over the range from 10°C to 40°C, the binary converter is monotonic only to 14 bits, whereas the BCD unit is monotonic to the full 16 bits.

In quantities of 1 to 24, units rated for operation from 0°C to 70°C sell for $119. Those rated from −25°C to +85°C go for $149, and the top-of-the-line devices, which cover −55°C to +125°C, command $199 each. High-reliability versions, screened to MIL-STD-883, level B, are also available.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone Eugene L. Murphy at (617) 828-8000 [384]

TOPICS

Subassemblies

Deltron Inc., North Wales, Pa., announces that its QPS series of open-frame power supplies has been granted UL 478 recognition. The low-profile supplies need no external heat sinking. . . .Also recently recognized under UL 478 are eight single- and multiple-output supplies from **LH Research Inc., Irvine, Calif.** The supplies, all of which are switchers, have power ratings from 375 to 750 W. . . .**TRW/IRC Resistors, Corpus Christi, Texas,** has qualified a 14-lead flat-pack precision resistor network to MIL-R-83401, style RZ030. Construction features include tantalum-nitride elements on alumina with gold-bonded terminations. Standard resistance values range from 150 Ω to 51 kΩ. . . .**Hewlett-Packard Co., Palo Alto, Calif.,** has developed a cathode-ray tube with a minimum brightness of 500 candelas per square meter (about 150 foot-lamberts). Available as an option in the company's model 1332A random-plotting CRT display, the tube offers about three times the brightness of earlier units. The high-brightness option adds $75 to the basic display price of $1,400.

DIGITAL, MARCH, 1978.

LSI-11/2 HELPS INSTRUMENT MAKER ENTER NEW MARKET.

A major east coast electronics manufacturer, never before in the in-circuit testing business, has designed an in-circuit/functional tester based upon Digital's LSI-11/2.

The tester will diagnose electrical component, interconnection, value and tolerance faults for printed circuit boards in consumer, automotive and telecommunication applications.

Why the LSI-11/2? Because it offers automatic ROM bootstrap loading, power up/down protection, and a 32K X 16 memory. Check the box.

PHOENIX ACHIEVES TERMINAL VELOCITY.

Just 24 months after groundbreaking, the 320,000 square foot Phoenix installation is pumping out terminals as fast as 1200 people can make them. The Phoenix plant is the first Digital facility to be dedicated entirely to the production of terminals. Phoenix output, combined with that of Digital's plant in Westfield, MA places current terminal production at a whopping 7,500 a month! And deliveries are now just 30 days from the placement of your order.

LIMITED TIME SALE SLASHES LSI-11 MEMORY PRICES 57%.

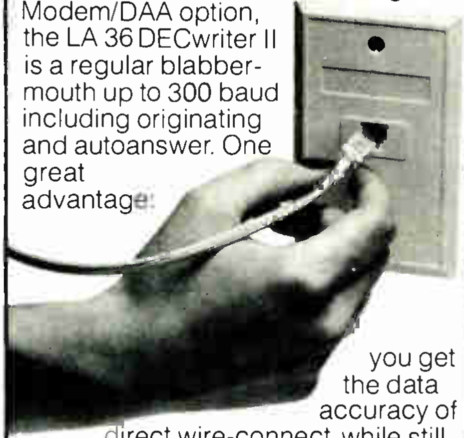
A special sale, aimed at the owners of the more than 20,000 LSI-11 microcomputers already sold, slashes the price of the MSV11-B 4K X 16 Dynamic MOS RAM from $625 to $270—a reduction of 57%!

The offer is first come, first served on existing inventories in Marlboro, Mass. and expires May 26, 1978. Sale prices are subject to LSI-11 Master Agreement discounts, and refer to U.S. only.

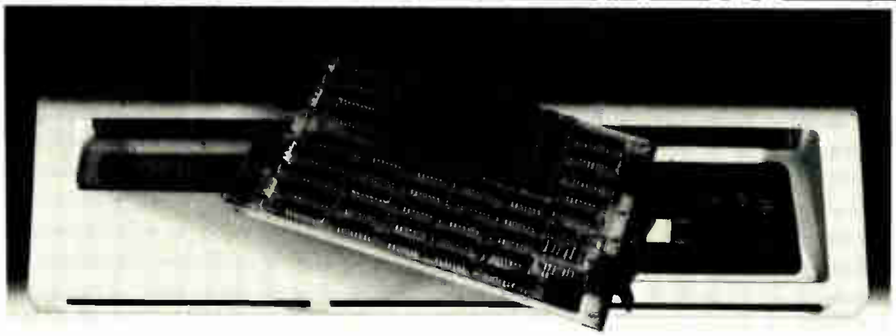
Many other memories have also been reduced, some dramatically. Contact your local Digital sales office or check the coupon. But hurry. There hasn't been a sale like this in recent memory.

INTEGRAL MODEM MAKES DECWRITER II A CHATTERBOX.

Once, a terminal needed a lot of complicated extra gear to talk with a remote computer, or to another terminal. No more. With the Integral Modem/DAA option, the LA 36 DECwriter II is a regular blabbermouth up to 300 baud including originating and autoanswer. One great advantage:



you get the data accuracy of direct wire-connect while still maintaining the use of your telephone as a telephone. Need communication terminals? Check the box.



LSI-11 SOLVES A PRODUCTION PROBLEM AND A MARKETING PROBLEM. AT ONCE.

Consider this major maker of electronic switching equipment, successfully selling a line of PDP-11/34 based products, when along comes the LSI-11 and the people inside begin to think small. What follows is the creation of an extended product line that reaches into low-end markets yet untapped. And it's all done with the greatest of ease in that the LSI-11 uses all the software of the 11/34s. With developmental and training costs minimized, the new products go to market propitiously positioned for profit.

DEVELOP LARGE PROGRAMS FOR YOUR LSI-11 ON THIS NEW HARD DISK SYSTEM.

You bought your LSI-11 because its speed and power meant you handle big programs at micro cost. Now there's an LSI-11 based system with big disk capacity to help you develop the programs. It's the new 11T03 with a 2.5 MB removable disk and a 5MB non-removable disk. Check the coupon and find out more.

Digital Equipment Corporation, Maynard, MA 01754. European headquarters:12, av. des Morgines, 1213 Petit-Lancy/Geneva. In Canada, Digital Equipment of Canada, Ltd.

digital

Tell me more about: ☐ The Memory Sale
☐ 11TO3 ☐ LSI-11/2 ☐ Integral Modem/DAA

Name ____________________ Title ____________

Address ______________________________

Company ______________________________

City ______________ State __________ Zip ________

Mail to: Digital Equipment Corporation, 129 Parker St. (PK 3-2/M18), Maynard, MA 01754.

The Analog Devices' AD534 Analog Multiplier. A new, monolithic, laser-trimmed, four-quadrant analog multiplier destined to smash the myth that analog multipliers are more complex than the computing function they solve.

The AD534 has a guaranteed maximum multiplication error of ±0.25% without external trims of any kind. This level of accuracy you'd normally expect to find only in expensive hybrids or bulky discrete modules. Excellent supply rejection, low temperature coefficients and long-term stability of the on-chip thin film resistors and buried zener reference preserve the AD534's accuracy even under the most adverse conditions.

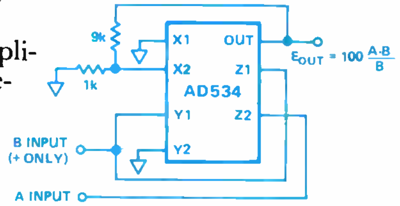
The AD534 is the first general purpose, high performance analog multiplier to offer fully differential high impedance operation on all inputs. And that's what gives the AD534 its amazing flexibility and ease of use.

The AD534 is a completely self-contained, self-sufficient multiplier which can generate complex transfer functions very close to theoretical. Our active laser trimming of thin film resistors on the chip to adjust scale factor, feedthrough and offset allow you to plug in the AD534 and run it virtually without adjustment.

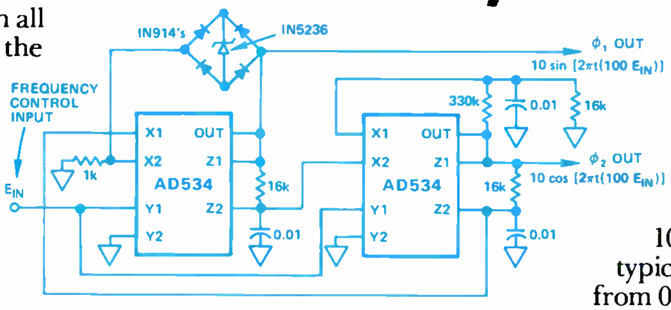
In addition to straightforward implementation of standard MDSSR functions (multiplication, division, squaring and square rooting), the AD534 simplifies analog computation (ratio determination, vector addition, RMS conversion); signal processing (amplitude modulation, frequency multiplication, voltage controlled filters); complex measurements (wattmeters, phasemeters, flowmeters) and function linearization (transducers, bridge outputs, etc.) You can set up the AD534 to perform complex calculations by using various feedback arrangements to manipulate the AD534 transfer function of $(X_1 - X_2)(Y_1 - Y_2) = 10\,(Z_1 - Z_2)$.

and use,

In Ratio Computing. The percentage deviation function is of practical value for many applications in measurement, testing and control. The AD534 is shown in a circuit that computes the percentage deviation between its two inputs. The scale factor in this arrangement is 1% per volt although other scale factors are obtainable by altering the resistor ratios.



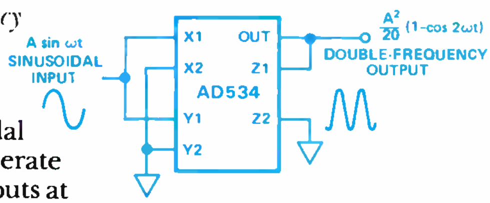
and use,



In Sine Wave Function Generation. The voltage controlled 2-phase oscillator uses two AD534's for integration with controllable time constants in a feedback loop. The frequency control input, E_{IN}, varies the integrator gains, with a sensitivity of 100Hz/V and frequency error typically less than 0.1% of full scale from 0.1V to 10V.

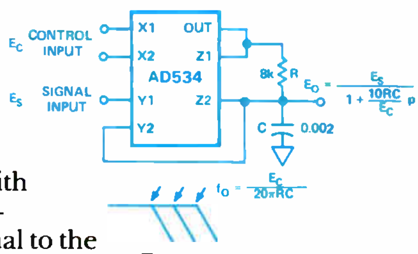
and use,

In Frequency Multiplication. Nonlinear circuits which accept sinusoidal inputs and generate sinusoidal outputs at two, three, four, five or more times the input frequency make use of trigonometric identities which can be implemented quite easily with the AD534 as shown. For this frequency doubling circuit the output should be AC-coupled to remove the DC offset resulting from the trigonometric manipulation.



and use.

In a Voltage Controlled Filter. The output voltage, which should be unloaded by a follower, responds as though E_S were applied directly to the RC filter but with the filter break frequency proportional to the input control voltage $\left(\text{i.e. } f_0 = \frac{E_C}{20\pi RC}\right)$. The frequency response has a break at f_0 and a 6dB/octave rolloff.



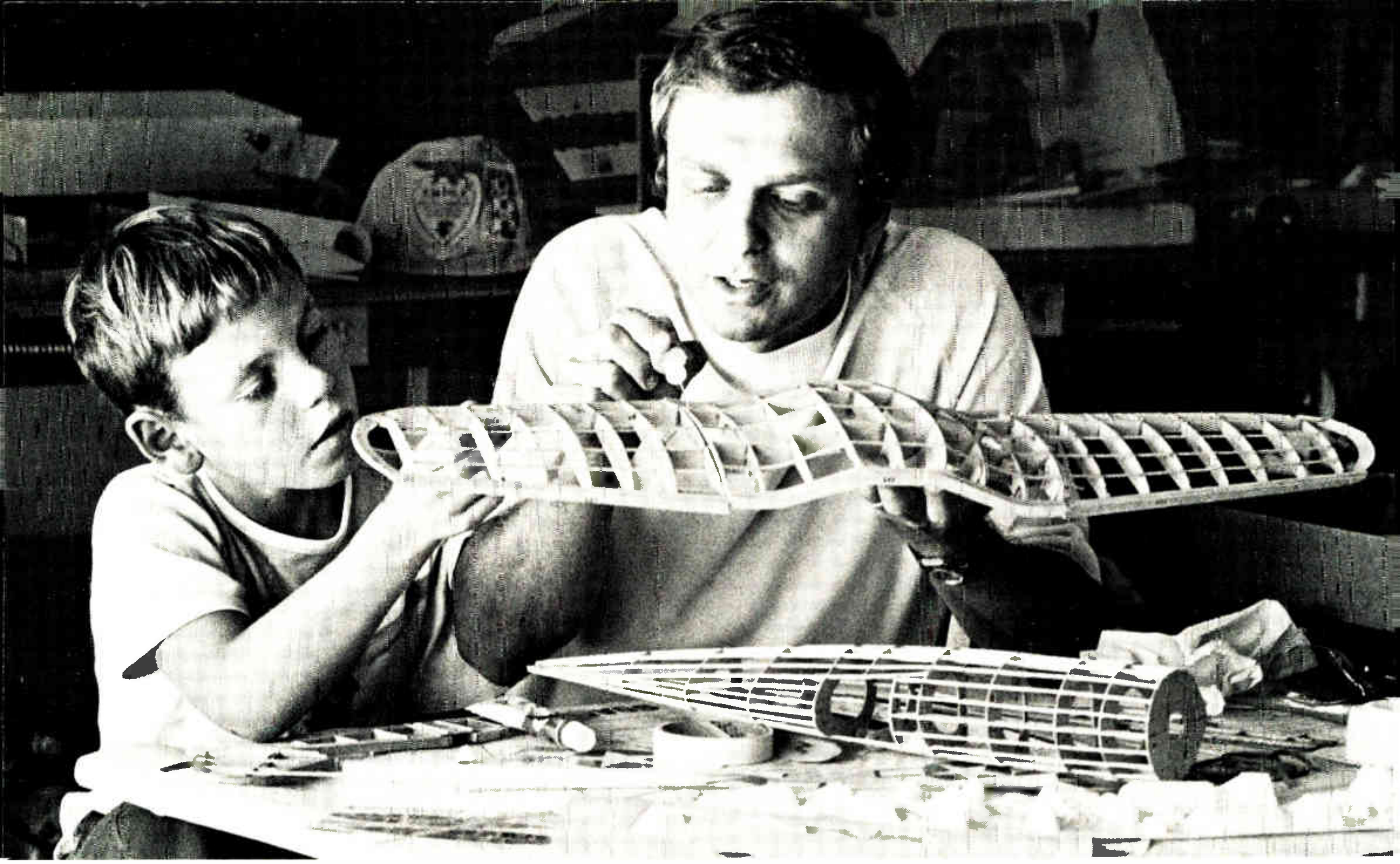
These uses of our new Single Chip Analog Computer, the AD534, are only the beginning. For the big picture call Doug Grant at (617) 935-5565. Or write for a copy of our new Multiplier Application Guide and the data sheet on the AD534.

ANALOG DEVICES

The real company in analog computation.

Circle 189 on reader service card

Analog Devices, Inc., Box 280, Norwood, MA 02062 East Coast: (617) 329-4700; Midwest: (312) 894-3300; West Coast: (213) 595-1783; Texas: (214) 231-5094; Belgium: 031/37 48 03; Denmark: (02) 845800; England: 01/94 10 46 6; France: 686-7760; Germany: 089/53 03 19; Japan: 03/26 36 82 6; Netherlands: 076/879 251; Switzerland: 022/319704; and representatives around the world.



Relax

It's amazing how an easy mind cements relationships.

We're the easy mind people. TRW Capacitors.

We can solve your problems connected with reliability in ultra-miniature capacitors. Our X463UW metallized polycarbonates are designed to do just that.

The X463UW gives you "Space Age" performance in circuits demanding the smallest possible size. Capacitances range from .001 to 10 mfd, at 50, 100, 200 and 400 vdc—with less than 1.5% capacitance change from −55°C through 125°C. IR is 60,000 megohm x mfd minimum at 25°C. DF is less than 0.3% at 25°C and 1 KHz. And stability? In humidity and shelf life tests the stability of the X463UW is actually two to three times better than polysulfone.

You get all that because we've applied the latest in component technology to combine the improved electrical performance of polycarbonate with dramatic size and weight reductions made possible by the use of our exceptionally reliable metallized dielectric.

We also put the same kind of effort into our engineering services and our field support. Try us. We can help reduce the tension. Give us a call, or write: TRW capacitors, An Electronic Components Division of TRW, Inc., 301 West "O" St., Ogallala, Nebraska 69153. Tel: (308) 284-3611.

actual size

TRW *CAPACITORS*

ANOTHER PRODUCT OF A COMPANY CALLED TRW

New products

Packaging & production

Image storage aids inspection

Still video pictures improve accuracy of viewing bonded IC chips

One of the more popular methods of inspecting the bonding and assembly of integrated circuits to either IC packages or hybrid substrates is to use a closed-circuit television camera coupled to a high-power microscope. It requires an inspector to watch, on the monitor of the CCTV/microscope combination, all the operations on the IC chip in continuous motion.

However, Unilux Inc., a N. J. manufacturer of video analysis systems, has developed an automatic video system called the Unilux 1050 ISIS (image-storage inspection system) that enables an inspector to see still, rather than continuous, pictures of each bonding during an assembly operation. The inspection system is composed of a TV monitor, TV camera, and a separate box with the control logic circuitry for picture-taking rate, blanking, and the order of blanking. Microscopes must be furnished by the customer, however.

In the Unilux equipment, the inspector sees still pictures, and each is made precisely at the completion of each of the critical steps in the bonding and assembly sequence. The inspector sees only these pictures and has 1 to 3 seconds to study each. This stop-action mode results in a greater accuracy in inspection than is possible with continuous observation, the company contends.

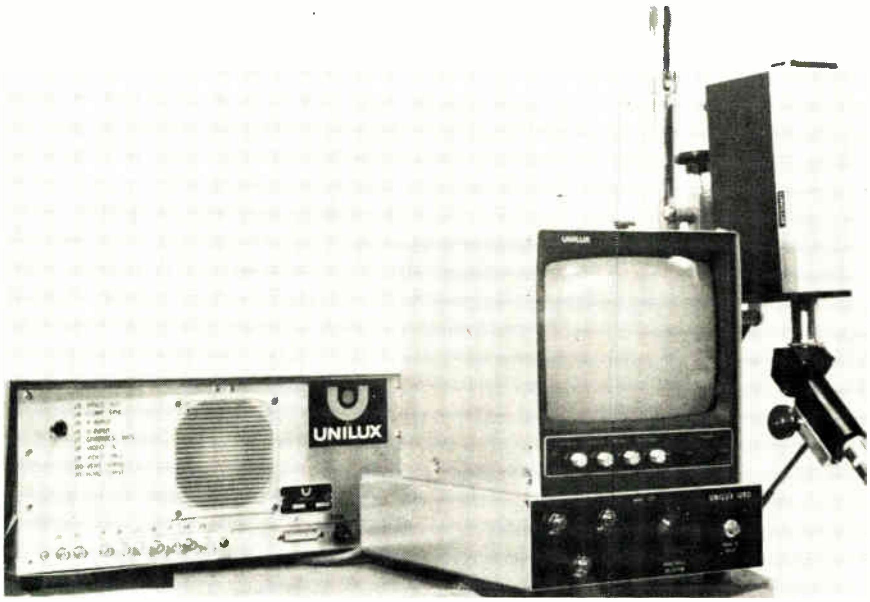
William Greenbaum, president of Unilux, notes that the first of these systems is already up and running at a Western Electric hybrid manufacturing facility. He expects that many other IC and hybrid manufacturers will give this new system serious consideration. Furthermore, he believes that the same type of discrete video imaging has other applications for other types of electronic assembly operations.

Prices of the ISIS vary from $15,600 to $19,800 depending on the complexity of the installation, that is, the number of assembly steps.

Unilux Inc., 290 Lodi St., Hackensack, N. J. 07601. Phone (201) 489-0800 [391]

Tester checks memory boards and systems

The MD-207 memory-board/system test system is a versatile piece of equipment that can test memories



fabricated in a variety of technologies: semiconductor, magnetic-core, plated-wire, and magnetic-bubble, to name a few. It performs dynamic tests at rates to 10 MHz and features a variety of user-oriented software packages for performing such engineering functions as automatic shmoo plotting, data logging, and statistical analysis. Production-oriented packages include automatic board diagnostics and error-mapping routines, management summaries, and a prompting menu for use by unskilled test-system operators.

Among the system's hardware features are a programmable split-cycle clock generator with up to 32 independently programmable edges to accommodate the increasingly complex timing requirements of synchronous and asynchronous semiconductor memory systems. The MD-207 is compatible with its predecessor, the MD-107, but offers greater testing capability. In particular, it offers Logic Link—a simple method for interfacing even complex boards and systems with the tester. Its basic price is $55,900 and its delivery time is currently being quoted as 90 days.

Macrodata Corp., P. O. Box 1900, Woodland Hills, Calif. 91365. Phone Alan Portnoy at (213) 887-5550 [393]

Dual-head rotary table maximizes insertion area

A dual-head rotary fixture, the model VCD-1192, has been designed to allow the maximum use of insertion area while providing a full 18-inch-diameter rotating area under each inserting head. Programmable to rotate to any axis, the unit requires no connections to be made

Knowhow. And where.

"Bussmann can help you choose the right fuse for the right place."

When you do something better than anyone else, people usually take for granted that it's all you *can* do.

Like Bussmann. You probably know us as the electronic industry's most complete source for fast-acting, dependable, state-of-the-art circuit protection. And you're right.

But only half right.

Because Bussmann can also be your most valuable source of expert technical help.

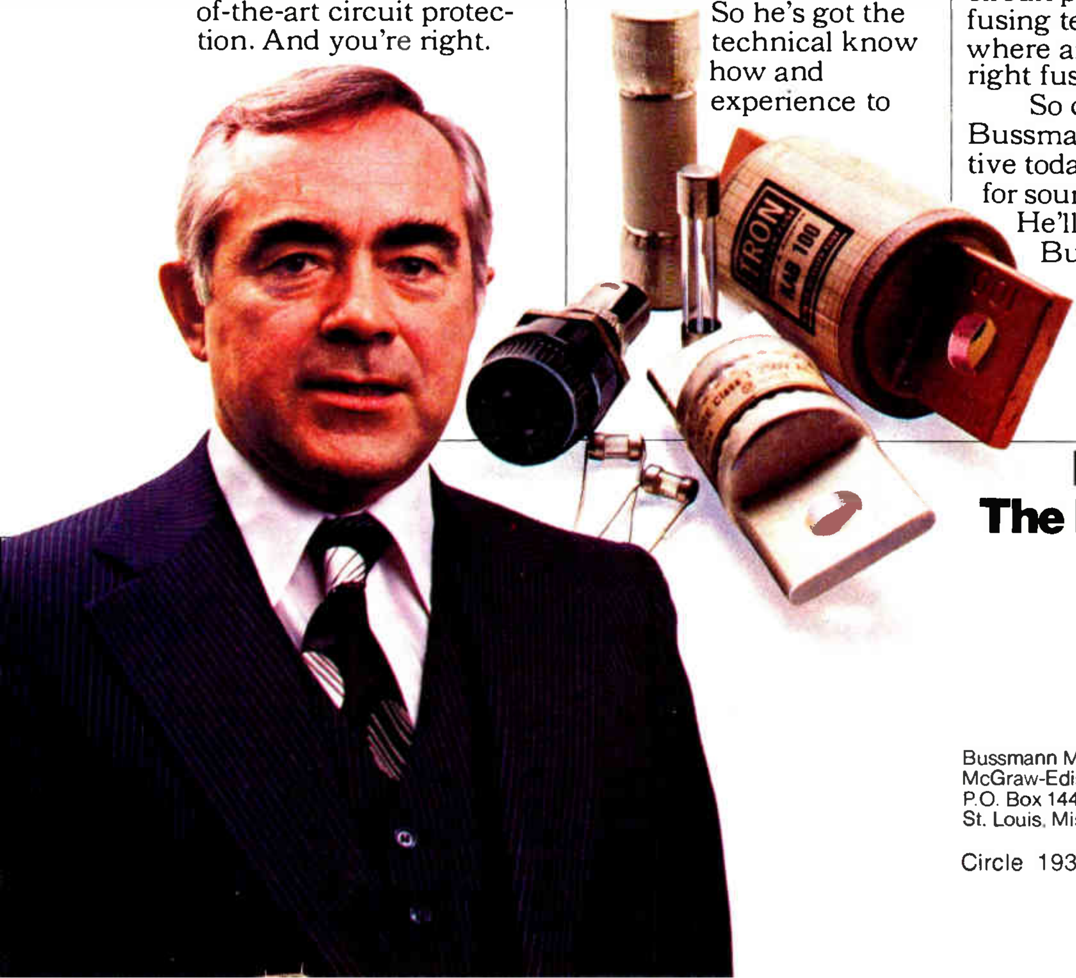
Take your Bussmann salesman, for example. He's more than just a salesman. He's an electrical protection expert.

So he's got the technical know how and experience to simplify and solve your most complicated circuit protection problems.

He can help you decide which fuse from our complete line fits the application you have in mind. Or he can put you in touch with one of our staff engineers for in-depth technical assistance.

Your Bussmann representative can also keep your staff up-to-date on the latest trends in circuit protection. New fusing technology. Or where and how to use the right fuse for the best results.

So call your Bussmann representative today. And trust him for sound technical advice. He'll show you why Bussmann means protection in more ways than one.

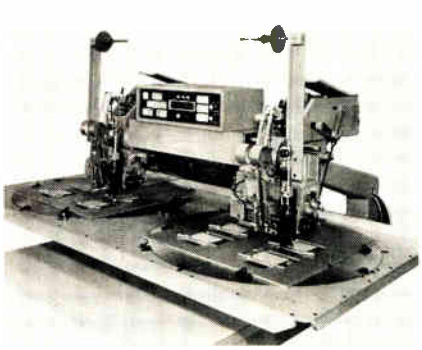


McGRAW-EDISON

Bussmann. The Protection Experts.

Bussmann Manufacturing Division
McGraw-Edison Company
P.O. Box 14460
St. Louis, Missouri 63178

Circle 193 on reader service card



to the rotating table—the insertion area is completely free of mechanical, electrical, and pneumatic connections.

The table may also be used as a conventional nonrotating fixture. In this mode, it can be configured to provide an insertion area that measures 18 by 26 in.—claimed by the manufacturer to be the largest available anywhere.

Dyna/Pert Division, USM Corp., Elliott Street, Beverly, Mass. 01915. Phone (617) 927-4200 [394]

Wrapped-wire jumpers make connections fast

A line of wrapped-wire jumper cables for connection to 0.025-inch-square terminal posts is offered as an alternative to conventional wrapped-wire and clip-lead connections during the development and testing of electronic equipment. The fully insulated jumpers, which can be installed in a matter of seconds, generally do not require that system power be turned off.

In contrast, the company claims, wire-wrapping usually takes more than a minute, what with measuring, stripping, and wrapping both ends of the wire, and generally requires that power be turned off. Furthermore, the company says, when temporary wire wraps are removed, they sometimes leave metal pieces behind—almost a guarantee of future service trouble.

The jumpers are available in lengths from 4 in. to 6 ft. There are five standard colors, but any color can be provided on request. The jumpers have gold-plated contact

One company can cut keyboard costs. Even when their keyboards cost more.

The most expensive mistake you'll ever make selecting a keyboard could be spending too little. In the long run, that adds up to cutting corners, not costs.

So to make sure you get the keyboard that really meets your needs, MICRO SWITCH uses Value Engineering.

Through Value Engineering, we look at your particular product needs to design a cost-effective solution to your problems. That means designing a keyboard that interfaces with your total system and meets your needs. Precisely.

It also means we can often lower your total system cost. For example, we might be able to incorporate into a keyboard several levels of codes that you had been paying for separately. And at a much higher cost.

Or maybe customize integrated circuits to provide you more logic for less money.

Besides giving you cost-efficiency, MICRO SWITCH keyboards out-feature practically every other in the industry.

You can choose LED or incandescent lighting. Tactile or linear feel. Sealed versions for military and industrial uses. Alternate or momentary action. Encoding techniques that'll meet any code requirement.

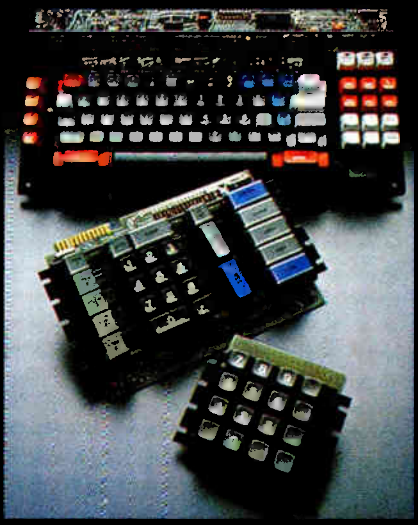
There are also wired-only assemblies or separate modules available. And you can pick from the industry's largest legend library.

Standard, solid state Hall-effect technology throughout the line delivers reliability no mechanical keyboard can offer. Plus, we back up every keyboard we make with a 1% Acceptable Quality Level and a two-year warranty.

It all adds up to quality you can put your fingers on every time.

For more information, call 815/235-6600.

With MICRO SWITCH, you'll be paying for keyboards instead of mistakes.



MICRO SWITCH

FREEPORT, ILLINOIS 61032

A DIVISION OF HONEYWELL

MICRO SWITCH products are available worldwide through Honeywell International.

Circle 195 For Data

surfaces and are rated to carry a continuous current of 3 A. They may be stacked up to three deep on a standard wrapped-wire pin.

American Data Cable Inc., 903 San Antonio Rd., Los Altos, Calif. 94022. Phone (415) 328-7176 [396]

Conductivity bridge measures water purity

The type RB conductivity bridge is a manually balanced, portable instrument intended primarily for water-purity determination. Available in a variety of calibrations for measuring solution conductivity, resistivity, and temperature, the unit is built around a stable ac Wheatstone bridge that provides accuracies to within 2% of reading. Models with manual and

automatic temperature compensation are available.

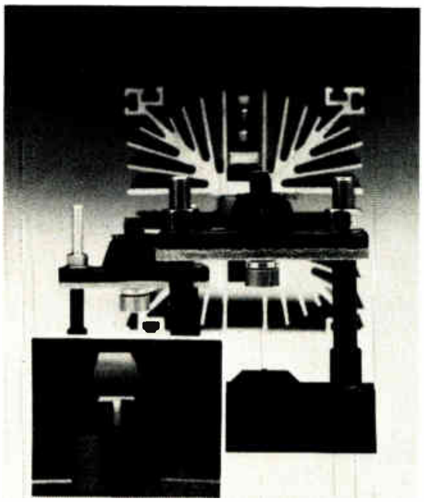
Beckman Instruments Inc., Cedar Grove Operations, 89 Commerce Rd., Cedar Grove, N. J. 07009 [395]

Heat-sink mounting clamps need no torque wrenches

Heat-sink mounting clamps in the 9644 series offer a pop-up compressive-force indicator that shows when the correct compressive load has been reached. The user simply tightens the nuts alternately and evenly with a wrench until the indicator pops up. Torque wrenches and guesswork are thus eliminated.

Intended mainly for mounting heat sinks on high-power rectifiers

New products



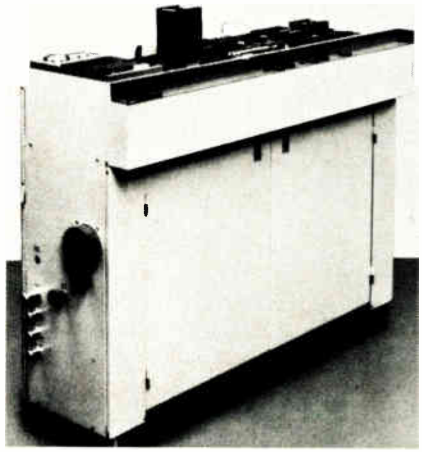
and silicon controlled rectifiers, the clamps feature a one-piece insulator cup molded from 40% glass-reinforced polyphenylene sulfide. It provides a minimum breakdown voltage of 24,000 v, is chemically resistant (no known solvents under 200°C), and will not cold flow under load. The clamp rods are electrically isolated with an irradiated polyolefin insulation with a minimum breakdown rating of 7 kv.

The 9644 series clamps are available in 1,000-, 2,000-, 4,000-, and 5,000-pound capacities. Various rod lengths are available to accept most device and heat-sink combinations. In lots of 1,000 or more pieces, the units sell for $4.76 each. Availability is immediate.

Thermalloy Inc., Dept M, 2021 W. Valley View Lane, Dallas, Texas 75234. Phone (214) 243-4321 [397]

High-pressure unit cleans silicon wafers

Offered as an alternative to brush scrubbers for silicon wafers, the HPC-2000 high-pressure cleaner provides a choice of solid and fan spray cleaning modes at pressures adjustable between 2,000 and 5,000 pounds per square inch. The cleaner is said to be particularly effective in removing contaminants from etched channels that cannot be reached by brush filaments. Furthermore, the



HPC-2000 does not leave scratches, marks, or brush residue.

Capable of cleaning up to 200 2-in. to 5-in. wafers per hour per track, the cleaner is completely automated. It may be operated on a cassette-to-cassette basis or interfaced directly with an oven or coater to reduce handling. The cleaning system is suitable for use before resist coating and diffusion or before and after epitaxial growth and chemical deposition. It can be supplied with from one to four tracks in a single cabinet. Macronetics Inc., 570 Maude Ct., Sunnyvale, Calif. 94086. Phone Tom McKee at (408) 733-3700 [398]

Pc-board drilling machine uses flexible-disk control

Unlike most other numerically controlled printed-circuit-board drilling machines, which are controlled by punched paper tape, the 78 MSD is controlled by a microcomputer that uses a floppy disk for program storage. The result, according to the company, is increased drilling speed and efficiency. Key operating specifications are hit rates up to 400 per minute, programmable spindle speeds of 30,000 to 80,000 revolutions per minute, 500-inch-per-minute feed and positioning speeds, and 1,000-inch-per-minute retraction. The 78 MSD sells for $69,950. Paul Dosier Associates Inc., 3050 Red Hill Ave., Costa Mesa, Calif. 92626. Phone (714) 556-7075 [399]

If the low profile relays you're now using can't survive these obstacles, you've got a problem.

You've got a problem!

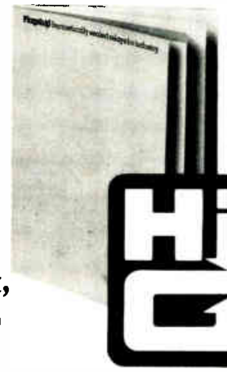
Every low profile relay has to face obstacles like these:

1. Excessive dwell time in flow solder bath
2. Repeated exposure to PC board cleaning solvents
3. End-product exposure to dirty, corrosive atmospheres
4. High impact shock conditions on the line and in the field

Throughout these ordeals, what happens to your contact system?

If it fails, if oxidation or corrosion makes operation erratic, you may be in for the worst obstacle of all: customer complaints.

Flagship™ low profile relays are the answer to your problem. All metal housing to withstand solvents. All welded hermetic seal for unexcelled contact life. And, best of all, a competitive price. If you can't afford Flagship relays, you certainly can't afford the alternatives.



For more information on Flagship 2 and 5 amp low profile relays, call or write for this new brochure.
Hi-G Incorporated, Relay Division, 580 Spring Street, Windsor Locks, CT 06096
(203) 623-2481.

Write also for new bulletins on field programmable time delay relays and BNC connectors.

Data handling

Interface board has 8 channels

Analog-output unit completes interface line for single-board computers

An analog-output interface board completes the line of interfaces that Data Translation Inc. has designed to mate with the Alpha, LSI 2, LSI 3, and LSI 4 single-board computers from Computer Automation Inc. Designated the DT1735, it produces eight analog voltage or (optionally) current channels from the computers' digital data. The other interface boards handle either analog inputs or both analog inputs and outputs.

The DT1735's output voltage range is ±10 v or 0 to 10 v, and the output current range is 4 to 20 mA, values that are especially attractive for industrial customers, according to Paul Severino, Data Translation's vice president for engineering. He says further that putting eight d-a channels on one board simplifies designs for customers "who use lots of d-a—they tend to use 32 channels, and that means they need only four of these boards." The only other d-a output interface unit for the Computer Automation family provides only two channels. Severino is especially interested in Computer Automation's LSI 4/10 Naked Mini, which he believes will enhance the minicomputer company's installed base among original-equipment manufacturers.

Measuring 7.5 by 16.9 inches, the DT1735 is compatible with the Computer Automation backplanes. Its d-a output specifications include a resolution of 12 bits, differential linearity of ±1/2 least significant bit, settling time of 3 μs to 0.01% of full-scale range, and a slew rate of 20 v/μs. All d-a ranges are selectable by means of a five-position switch in a dual in-line package associated with each d-a circuit. Coding for the d-a converters is also selectable, between offset binary and 2's complement.

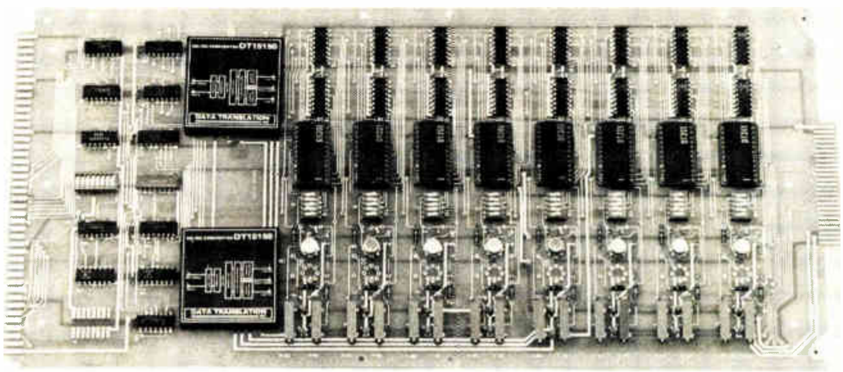
The price in single-unit quantities is $1,895. The 4-to-20-mA current option costs an additional $50 per channel. Delivery is from stock.

Data Translation Inc., 4 Strathmore Rd., Natick, Mass. 01760. Phone (617) 655-5300. [361]

Light pen aims for long distances

For use where long and different focal distances are a problem, as when a curved cathode-ray-tube screen is covered by a flat explosion shield, the LP-316 light pen has a finder beam, increased sensitivity, and an improved optical system.

Besides a push-tip-to-activate fea-



ture, the LP-316 comes with focal lengths ranging from 0.6 to 1.8 in. in 0.2-in. increments. All the electronics are built into the unit, which is 0.63 in. in diameter and 6.7 in. long and weighs 3.5 oz. Luminous sensitivity is adjustable down to 0.5 foot-lambert; response time is less than 300 ns. Spectral response is between 3,600 and 11,000 angstroms. Minimum vector speed is specified at 20 cm/ms with a minimum input separation of 10 μs.

The pen has a retractable cord, 14 in. retracted and 48 in. extended, which is supplied with connector. Power requirement is 5 v dc ±5% at 200 mA; −15 v dc ±5% at 25 mA.

Information Control Corp., 9610 Bellanca Ave., Los Angeles, Calif. 90045. Phone (213) 641-8520 [363]

Graphics system understands English

A computer graphics software system that can be programmed through a language processor in a limited but simple English vocabulary is now available for users with large computers or time-shared computers who want to produce graphic information in various formats.

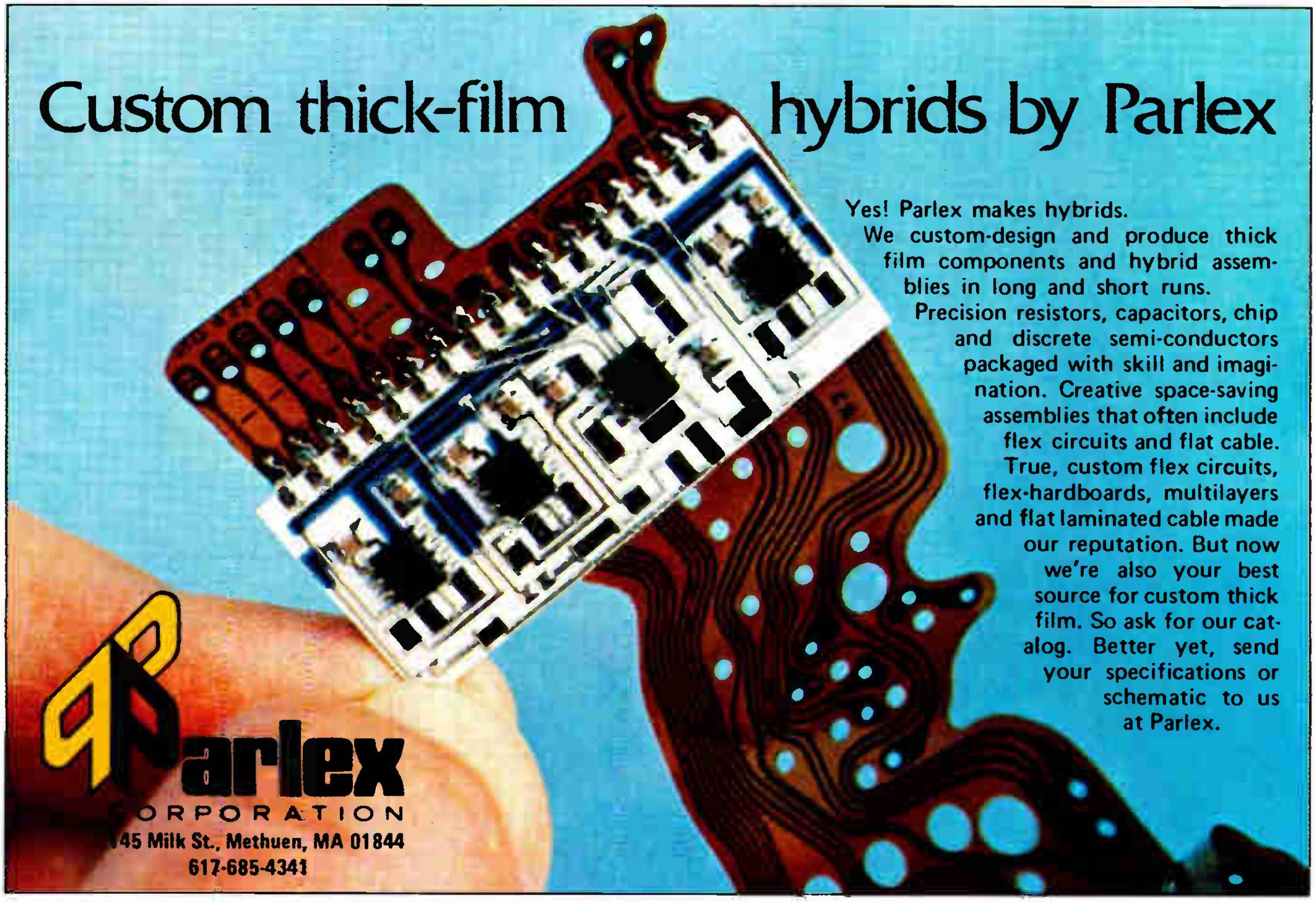
The Tell-A-Graf system takes data from the mainframe and produces pie charts, graphs, or bar charts depending on the requirement. Before selecting the format, the user can view the graphics on a cathode-ray-tube display, choosing the best configuration for printing on a plotter. After producing one type of display, the Tell-A-Graf may reformat it into another type. Also, the user can have the charts reproduced directly onto microfilm.

With the language processor, called Disspla, an unskilled programmer can make inputs and call up graphics at a keyboard using plain English commands. Price of the Tell-A-Graf system alone is \$19,500; it increases to \$39,000 when Disspla is added.

Integrated Software Systems Corp., 4186 Sorrento Valley Blvd., San Diego, Calif. 92121. Phone (714) 452-0170 [365]

Disk system stores communications data

Designed to store and manage 9,600-baud transmitted data for a wide range of communications applications, the Comm-Stor II is an intelli-



Circle 205 on reader service card

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gent floppy-disk system.

The system uses IBM 3740-compatible diskettes and interfaces with all RS-232-C communications devices. Variable-length files can be stored to get maximum use of the diskette. It is possible to merge and create new files composed of existing files, thus increasing editing capability. Also, a user can specify some files as unalterable, but still is free to create and alter other files in the disk store.

Delivery begins this month. A single-drive system is priced under $3,000 and a dual system under $4,000.

Sykes Datatronics Inc., 375 Orchard St., Rochester, N. Y. 14606. Phone Bruce Paton at (716) 458-8000 [364]

Unit interfaces computers with facsimile receivers

Facsimile receivers have many advantages over other graphics printers for use as computer terminals. Among them are low cost, convenience, and excellent gray-scale reproduction. Until now, they also have had a distinct disadvantage—incompatibility.

The problem has been solved by the model MS463 interface unit, which accepts digital signals from computers and translates them into the appropriate analog signals for facsimile receivers, including the insertion of all necessary command signals. A unit intended for use with facsimile transmitters is also avail-

 Circle 207 on reader service card

New products

able and provides a computer-compatible output.

Expected applications for the MS463 include meteorological satellite image transmission; police, fire, and utility data storage and retrieval; computer graphics manipulation; and cartographic processing.

Muirhead Inc., 1101 Bristol Rd., Mountainside, N. J. 07092. Phone Ian Smith at (201) 233-6010 [366]

CRT terminal executes remotely loaded programs

The ZMS-50 is an inexpensive (under $2,000) cathode-ray-tube terminal with a built-in microcomputer. Like more expensive terminals in the ZMS family, the model 50 features a list-driven structure, which allows it to display data on the screen in a contiguous fashion even if the data does not occupy contiguous positions in the unit's random-access memory. Its principal uses are expected to be as an intelligent terminal in data-entry and text-editing applications. But it can do more. One of its novel capabilities is a so-called down-loading feature with which user-supplied programs can be fed into the terminal's memory through a communications interface. For users who want to develop their own firmware for the ZMS-50, the manufacturer has available a development system built around the more-capable ZMS-70. The system includes diskette storage, a PROM programmer, and all necessary interfacing circuitry.

Zentec Corp., 2400 Walsh Ave., Santa Clara, Calif. 95050. Phone Dennis Daniels at (408) 246-7662 [367]

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At Centralab we are concerned with the same things you are – performance, reliability, on-time delivery. But any ceramic disc capacitor supplier can say that. We go that critical step further; we give you a choice of leads to help you cut your manufacturing costs.

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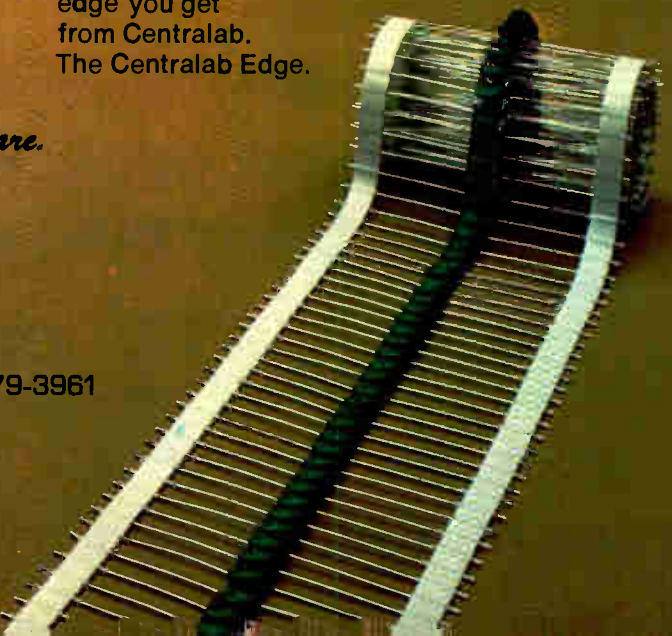

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Circle 209 on reader service card

Industrial

Control system includes software

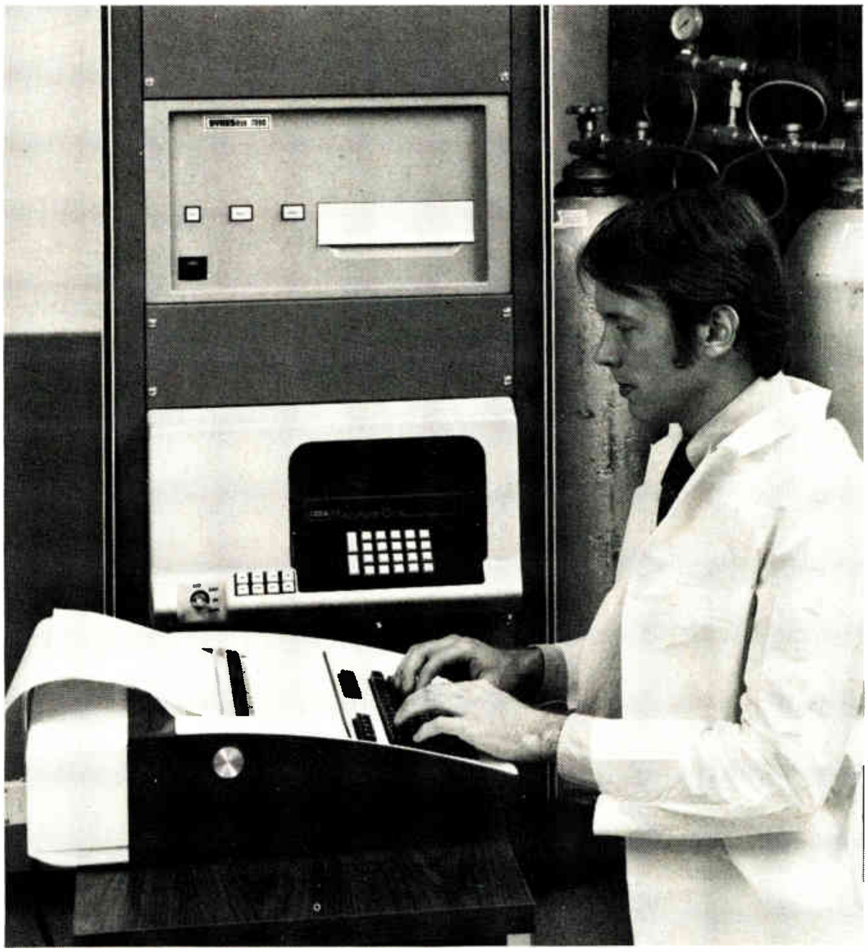
For lab and pilot plants, Macsym One comes ready to use, has 16-bit processor

In an intelligent measurement and control system, software development is undoubtedly one of the major difficulties and probably the most expensive to solve. A new measurement and control system from Analog Devices Inc., though, offers software that permits noncomputer people to write and run programs easily and quickly.

"Macsym One represents a logical vertical integration of the data-acquisition products we have developed over the past dozen years," says James Fishbeck, marketing manager for measurement and control products, which is part of the Norwood, Mass., firm's Instruments and Systems group.

Intended for laboratory-level automation and process industry applications, Macsym One may be used for data acquisition and storage, alarm monitoring, data reduction and analysis, and control functions. Data can be printed out in report or graphical form. Besides research and development, likely applications include quality control, use in production laboratories, and simulation or control of pilot plants in process industries.

"Macsym One is based on what is required to automate functions associated with real-world signals and not on what can be accommodated by the computer," says Fishbeck. The real key to the system, he emphasizes, is its ease of use. Real-



"A few words about imitation and flattery."

"The early days of in-circuit testing development were lonely. Those of us who believed in this new inspection testing technique for printed circuit board production found few converts. But we persevered. We built the hardware and the fixtures to interface with the PCBs to be tested. We developed control systems and software to make testing faster, more reliable and more versatile. Most important of all, we demonstrated unheard of improvement in yield of good boards and substantial reduction in costs for our customers.

We're not lonely anymore. We've made believers and customers of many of the major electronics manufacturers in the U.S. and abroad. And we've made believers and competitors of several test equipment manufacturers with convincing evidence that positive electrical access to the PCB solder nodes is the method of choice for verifying circuit integrity and performing non-destructive component tests on analog, digital and hybrid boards.

We're flattered by our imitators. And we welcome the competition. It's certain to benefit the industry as a whole and it will keep us on our toes in the effort to maintain our position of leadership.

When you want reliable, cost-effective production line test systems to increase your printed-circuit board yields, you have to consider in-circuit testing. And when you consider in-circuit testing, it makes sense to check with the people who led the way and lead today in technology, sales and service.

Let us show you how you can save money testing analog, digital and hybrid boards. Call or write to arrange a demonstration and we'll make you a believer."

M. E. Stanford, President

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(518) 783-7786

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Circle 211 on reader service card

world signals are interfaced via analog input/output cards that plug into the system's specially designed backplane.

Measuring 10.5 by 19 by 22 inches, Macsym One includes a 16-bit digital processor, up to 32,000 words of memory, a power supply, and the backplane, which has slots for up to 16 analog and digital input and output cards. A 31-character alphanumeric display and programmable operator keypad are available as options.

The system uses a single or dual floppy-disk drive for program and data storage, and a standard terminal as a console for writing and running programs. Other peripherals, such as line printers, modems, tape drives, and X-Y plotters, may also be connected.

Supplied with all necessary software, Macsym One employs an optimized language called Macbasic, which is an extension of the high-level Basic language. The system also comes with a file manager program and a series of diagnostics for verifying its operation. An assembler, editor, debugger, and linker-loader are available for users who wish to program in assembly language or write assembly-language subroutines that can be called from Macbasic.

A typical system—including 16 analog input channels, 8 analog output channels, 16 digital input and 16 digital output channels, 32 kilowords of memory, a teletypewriter, and a dual floppy-disk drive—is priced at under $20,000. Macsym One is available on purchase or lease. Delivery takes 30–60 days.

Analog Devices Inc., Route 1 Industrial Park, P. O. Box 280, Norwood, Mass. 02062. Phone (617) 329-4700 [371]

Pressure transducers measure up to 20,000 lb/in.^{2}

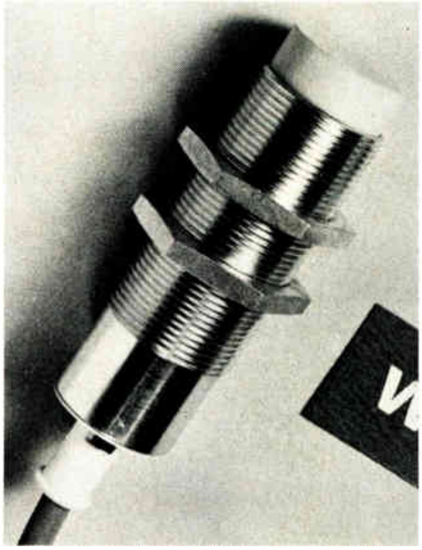
A series of diffused-diaphragm piezoresistive pressure transducers is available with full-scale gage-pressure ranges of 5,000, 10,000, and 20,000 pounds per square inch. The

three units in the 8511 series have full-scale outputs of 500 mv, and all of them include hybrid circuitry for temperature compensation over a span of 200°F. They are rugged units that maintain good linearity even when overloaded to three times their nominal full-scale range. Thus, if a dynamic analysis leads a user to expect a peak pressure of 9,000 lbs/in.², he can select the 10,000-lb/in.² transducer and be confident that it will work properly even if the actual pressure is 100% higher than the estimate.

Endevco DID., Rancho Viejo Road, San Juan Capistrano, Calif. 92675. Phone (714) 493-8181 [373]

Proximity sensor has sensitivity adjustment

A general-purpose, capacitive proximity detector, designated the CJ10-30GM, has a built-in potentiometer for adjusting its sensitivity; the



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Circle 215 on reader service card

potentiometer allows the user not only to set the sensing range, but also to set up the sensor to detect a wide range of materials—cartons, bottles, grain, chemicals, etc. The switch has a nominal range of 10 mm, but it will be different for different materials.

The self-contained solid-state device is threaded for easy installation on any support structure. It is also available with a mounting bracket. The standard detector is a 110-v ac, two-wire switch. Models with three-wire dc outputs and systems using separate control amplifiers are also available. The sensor has a length of 110 mm and a diameter of 30 mm. It operates from 32°F to 140°F.

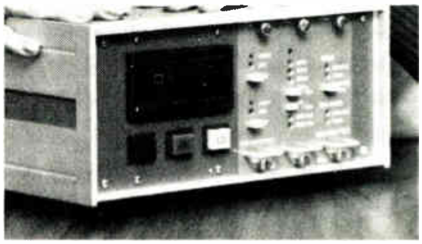
Gould Inc., Controls Division, 103 Broadway, Bedford, Ohio 44146. Phone R. B. Denison at (216) 232-8200 [374]

Process monitors include occlusion delay circuit

For use with load cells or pressure transducers, a line of process monitors keeps track of the force necessary to perform various operations. The monitors employ a new occlusion delay circuit to enhance their peak-signal detection.

The monitors operate by tracking the transducer signal until a peak is detected. This value is stored, displayed, and compared with preset limits. A relay and a front-panel lamp are energized if the signal exceeds the limits. The system can be reset automatically or by an external contact closure. Other modes of operation, such as track-and-hold and sample-and-hold, can also be provided.

Sensotec Inc., 1200 Chesapeake Ave., Columbus, Ohio 43212. Phone (614) 486-7723 [375]



 Circle 114 on reader service card

Circle 217 on reader service card →

VOLTAGE & CURRENT RATINGS LO SERIES

5V, ± 15 to ± 12 VOLTS * ADJ. — TRIPLE OUTPUT

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	VDC	MAX. CURRENT (AMPS) AT 40°C	50°C	60°C	PKG. SIZE	DIMENSIONS (INCHES)	PRICE QUANTITY 1	50	100
LOT-X-5152-A	0.15%	1.5mV	5	3.0	2.2	1.4	X	7 x 4-7/8 x 2-3/4	$ 88	$ 80	$ 72
			±15 to ±12	0.50	0.375	0.20					
LOT-W-5152-A	0.15%	1.5mV	5	6.0	4.5	3.0	W	9 x 4-7/8 x 2-3/4	110	100	90
			±15 to ±12	1.0	0.75	0.40					
LOT-V-5152-A	0.15%	1.5mV	5	9.0	7.3	5.2	V	4-7/8 x 13-3/4 x 4-7/8	154	140	126
			±15 to ±12	2.0	1.4	0.75					
LOT-R-5152-A	0.15%	1.5mV	5	12.0	9.5	7.0	R	4-7/8 x 16-3/4 x 4-7/8	181	165	149
			±15 to ±12	3.0	2.2	1.2					

± 15 to ± 12 VOLTS* ADJ. — DUAL OUTPUT

MODEL	REGULATION	RIPPLE	VDC	40°C	50°C	60°C	PKG. SIZE	DIMENSIONS	1	50	100
LOD-Z-152	0.15%	1.5mV		0.50	0.37	0.25	Z	4-7/8 x 4 x 1-5/8	47	43	35
LOD-Y-152	0.15%	1.5mV		1.0	0.75	0.50	Y	5-7/8 x 4-7/8 x 2-1/2	55	50	40
LOD-X-152	0.15%	1.5mV		2.0	1.4	0.80	X	7 x 4-7/8 x 2-3/4	82	75	61
LOD-W-152	0.15%	1.5mV		3.0	2.2	1.4	W	9 x 4-7/8 x 2-3/4	96	87	70

5 VOLTS ± 5% ADJ. — SINGLE OUTPUT

MODEL	REGULATION	RIPPLE	VDC	40°C	50°C	60°C	PKG. SIZE	DIMENSIONS	1	50	100
LOS-Z-5	0.15%	1.5mV		3.0	2.4	1.8	Z	4-7/8 x 4 x 1-5/8	37	33	27
LOS-Y-5	0.15%	1.5mV		6.0	4.9	3.8	Y	5-5/8 x 4-7/8 x 2-1/2	59	53	44
LOS-X-5	0.15%	1.5mV		9.0	7.6	6.2	X	7 x 4-7/8 x 2-3/4	74	66	54
LOS-W-5	0.15%	1.5mV		12.0	10.5	8.5	W	9 x 4-7/8 x 2-3/4	95	85	70
LOS-V-5	0.15%	1.5mV		17.0	14.5	11.5	V	4-7/8 x 13-3/4 x 4-7/8	113	101	91
LOS-R-5	0.15%	1.5mV		25.0	21.5	17.5	R	4-7/8 x 16-3/4 x 4-7/8	149	134	120

6 VOLTS ± 5% ADJ.

MODEL	REGULATION	RIPPLE	VDC	40°C	50°C	60°C	PKG. SIZE	DIMENSIONS	1	50	100
LOS-Z-6	0.15%	1.5mV		2.5	2.1	1.6	Z	4-7/8 x 4 x 1-5/8	37	33	27
LOS-Y-6	0.15%	1.5mV		5.0	4.3	3.5	Y	5-5/8 x 4-7/8 x 2-1/2	59	53	44
LOS-X-6	0.15%	1.5mV		8.5	7.1	5.7	X	7 x 4-7/8 x 2-3/4	74	66	54
LOS-W-6	0.15%	1.5mV		10.0	9.0	7.3	W	9 x 4-7/8 x 2-3/4	95	85	70
LOS-V-6	0.15%	1.5mV		15.5	13.0	10.3	V	4-7/8 x 13-3/4 x 4-7/8	113	101	91
LOS-R-6	0.15%	1.5mV		23.0	20.0	16.5	R	4-7/8 x 16-3/4 x 4-7/8	149	134	120

12 VOLTS ± 5% ADJ.

MODEL	REGULATION	RIPPLE	VDC	40°C	50°C	60°C	PKG. SIZE	DIMENSIONS	1	50	100
LOS-Z-12	0.15%	1.5mV		1.6	1.3	1.0	Z	4-7/8 x 4 x 1-5/8	37	33	27
LOS-Y-12	0.15%	1.5mV		3.3	2.8	2.3	Y	5-5/8 x 4-7/8 x 2-1/2	59	53	44
LOS-X-12	0.15%	1.5mV		5.7	4.8	3.9	X	7 x 4-7/8 x 2-3/4	74	66	54
LOS-W-12	0.15%	1.5mV		7.0	5.8	4.6	W	9 x 4-7/8 x 2-3/4	95	85	70
LOS-V-12	0.15%	1.5mV		10.8	9.0	6.7	V	4-7/8 x 13-3/4 x 4-7/8	113	101	91
LOS-R-12	0.15%	1.5mV		16.0	13.5	10.5	R	4-7/8 x 16-3/4 x 4-7/8	149	134	120

15 VOLTS ± 5% ADJ.

MODEL	REGULATION	RIPPLE	VDC	40°C	50°C	60°C	PKG. SIZE	DIMENSIONS	1	50	100
LOS-Z-15	0.15%	1.5mV		1.4	1.2	1.0	Z	4-7/8 x 4 x 1-5/8	37	33	27
LOS-Y-15	0.15%	1.5mV		2.8	2.5	2.1	Y	5-5/8 x 4-7/8 x 2-1/2	59	53	44
LOS-X-15	0.15%	1.5mV		4.8	4.0	3.2	X	7 x 4-7/8 x 2-3/4	74	66	54
LOS-W-15	0.15%	1.5mV		6.3	5.2	4.0	W	9 x 4-7/8 x 2-3/4	95	85	70
LOS-V-15	0.15%	1.5mV		9.5	7.6	5.6	V	4-7/8 x 13-3/4 x 4-7/8	113	101	91
LOS-R-15	0.15%	1.5mV		14.0	11.5	8.8	R	4-7/8 x 16-3/4 x 4-7/8	149	134	120

20 VOLTS ± 5% ADJ.

MODEL	REGULATION	RIPPLE	VDC	40°C	50°C	60°C	PKG. SIZE	DIMENSIONS	1	50	100
LOS-Z-20	0.15%	1.5mV		1.0	0.8	0.6	Z	4-7/8 x 4 x 1-5/8	37	33	27
LOS-Y-20	0.15%	1.5mV		2.4	2.1	1.8	Y	5-5/8 x 4-7/8 x 2-1/2	59	53	44
LOS-X-20	0.15%	1.5mV		3.8	3.2	2.5	X	7 x 4-7/8 x 2-3/4	74	66	54
LOS-W-20	0.15%	1.5mV		5.2	4.2	3.2	W	9 x 4-7/8 x 2-3/4	95	85	70
LOS-V-20	0.15%	1.5mV		7.7	6.0	4.3	V	4-7/8 x 13-3/4 x 4-7/8	113	101	91
LOS-R-20	0.15%	1.5mV		11.5	9.5	7.1	R	4-7/8 x 16-3/4 x 4-7/8	149	134	120

24 VOLTS ± 5% ADJ.

MODEL	REGULATION	RIPPLE	VDC	40°C	50°C	60°C	PKG. SIZE	DIMENSIONS	1	50	100
LOS-Z-24	0.15%	1.5mV		0.9	0.75	0.55	Z	4-7/8 x 4 x 1-5/8	37	33	27
LOS-Y-24	0.15%	1.5mV		2.2	1.9	1.6	Y	5-5/8 x 4 x 2-1/2	59	53	44
LOS-X-24	0.15%	1.5mV		3.3	2.8	2.2	X	7 x 4-7/8 x 2-3/4	74	66	54
LOS-W-24	0.15%	1.5mV		4.8	3.8	2.8	W	9 x 4-7/8 x 2-3/4	95	85	70
LOS-V-24	0.15%	1.5mV		6.6	5.2	3.8	V	4-7/8 x 13-3/4 x 4-7/8	113	101	91
LOS-R-24	0.15%	1.5mV		10.5	8.3	6.0	R	4-7/8 x 16-3/4 x 4-7/8	149	134	120

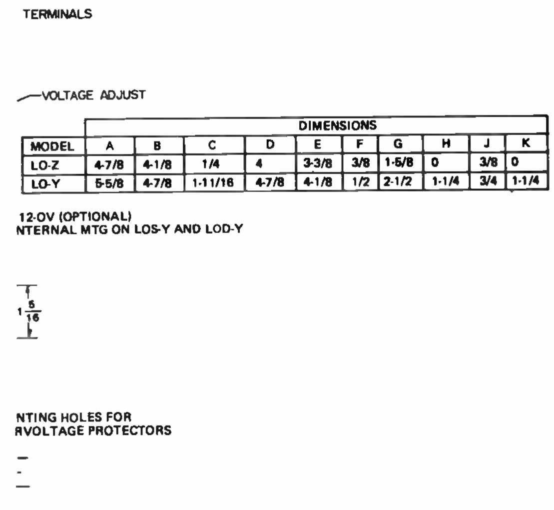
28 VOLTS ± 5% ADJ.

MODEL	REGULATION	RIPPLE	VDC	40°C	50°C	60°C	PKG. SIZE	DIMENSIONS	1	50	100
LOS-Z-28	0.15%	1.5mV		0.8	0.65	0.45	Z	4-7/8 x 4 x 1-5/8	37	33	27
LOS-Y-28	0.15%	1.5mV		2.0	1.7	1.4	Y	5-5/8 x 4-7/8 x 2-1/2	59	53	44
LOS-X-28	0.15%	1.5mV		3.1	2.5	1.9	X	7 x 4-7/8 x 2-3/4	74	66	54
LOS-W-28	0.15%	1.5mV		4.2	3.3	2.4	W	9 x 4-7/8 x 2-3/4	95	85	70
LOS-V-28	0.15%	1.5mV		5.9	4.6	3.3	V	4-7/8 x 13-3/4 x 4-7/8	113	101	91
LOS-R-28	0.15%	1.5mV		9.3	7.5	5.6	R	4-7/8 x 16-3/4 x 4-7/8	149	134	120

* ± 15 to ± 12 volts are each dual tracking outputs;

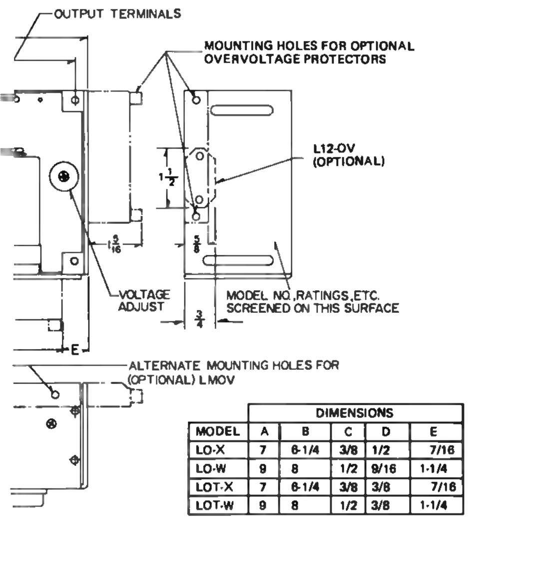
S LO SERIES SUPPLIES

Y series



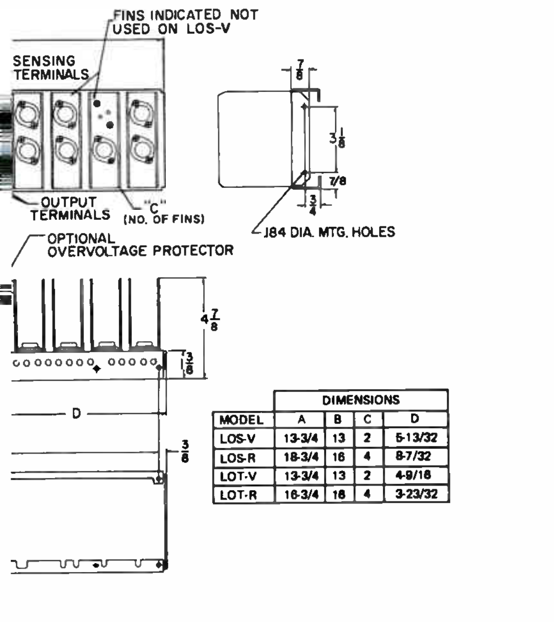
	DIMENSIONS									
MODEL	A	B	C	D	E	F	G	H	J	K
LO-Z	4-7/8	4-1/8	1/4	4	3-3/8	3/8	1-5/8	0	3/8	0
LO-Y	5-5/8	4-7/8	1-11/16	4-7/8	4-1/8	1/2	2-1/2	1-1/4	3/4	1-1/4

W series



	DIMENSIONS				
MODEL	A	B	C	D	E
LO-X	7	6-1/4	3/8	1/2	7/16
LO-W	9	8	1/2	9/16	1-1/4
LOT-X	7	6-1/4	3/8	3/8	7/16
LOT-W	9	8	1/2	3/8	1-1/4

R series



	DIMENSIONS			
MODEL	A	B	C	D
LOS-V	13-3/4	13	2	5-13/32
LOS-R	18-3/4	16	4	8-7/32
LOT-V	13-3/4	13	2	4-9/16
LOT-R	16-3/4	16	4	3-23/32

FEATURES

Convection cooled

no internal fans or blowers or external heat sinking required because of proven thermal design using heavy gauge aluminum chassis and ventilation holes

Regulation

regulation, load — no load to full load -0.15%.
regulation line — 0.15%.

Foldback current limiting

6 package sizes

up to 28 VDC, up to 25 A
available in single, dual and triple outputs

Ripple

1.5 mV RMS

Ambient operating temperature range

continuous duty from 0°C to +60°C

Temperature coefficient

0.03%/°C

AC input

105 to 125 VAC or
210 to 250 VAC, 47-440 Hz

3 mounting positions

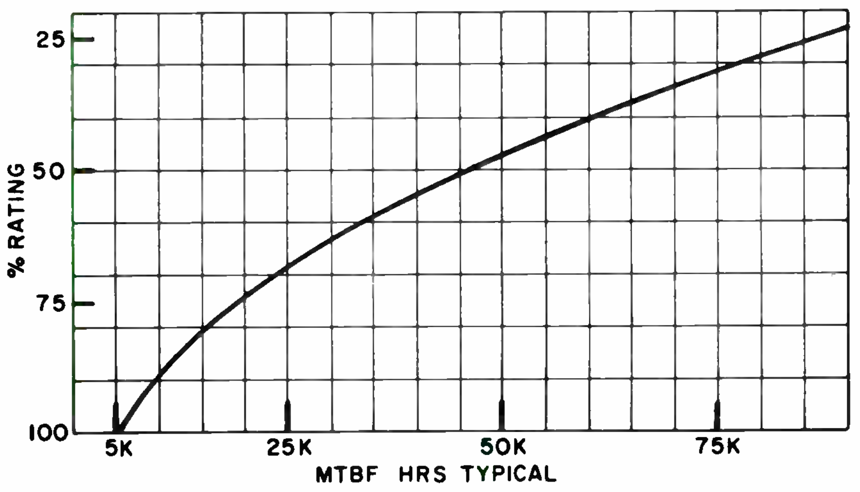
No overshoot or turn-on, turn-off, or power failure

Integrated circuit regulation

integrated circuit provides regulation system, except for input and output capacitors, rectifiers and series regulation transistors.

Job-rated calculated MTBF at worst-case condition (minimum voltage output, full load, 40°C, 125 VAC input) all models approximately 5000 hours for increased life at maximum conditions derate current as follows...

EXTENDED-LIFE CURVE



10% current derating .... 10,000 hours MTBF
20% current derating .... 15,000 hours MTBF
30% current derating .... 25,000 hours MTBF
40% current derating .... 33,000 hours MTBF
50% current derating .... 45,000 hours MTBF
(Equivalent to LAMBDA LX series)

Why has Lambda become the world's largest manufacturer of low-cost, open-frame power supplies in just two years?

QUALITY

Only the Lambda LO series gives you all these high quality features.

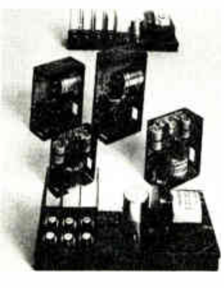
- All hermetically sealed semiconductors.
- Balanced thermal design with a known, defined level of quality.
- Sprague electrolytic capacitors.
- Quality controlled through Lambda manufacture of all its own sheet metal, transformers and P.C. boards.
- Purchased components rigidly specified by Lambda.
- Plated through hole printed circuit board.
- Flame retardant resistors.
- Teflon wiring in hi-temp location.

You'll get fewer failures with Lambda LO series power supplies. And the cost of failures is more important than the costs of repairing low-cost power supplies.

Costs to repair	Your Estimate	Lambda Estimate
Packing for shipment	–	$10
Cutting No Charge Purchase Order	–	25
Freight Charges (2 ways)	–	15
Receiving, incoming test and inspection	–	25
Total to implement guaranteed repair		75
To get cost of failure add:		
Field Service Call	–	200
Cost of down time (actual and product reputation)	–	?
		275+
3 failures will cost you		825+
15 failures will cost you		4125+

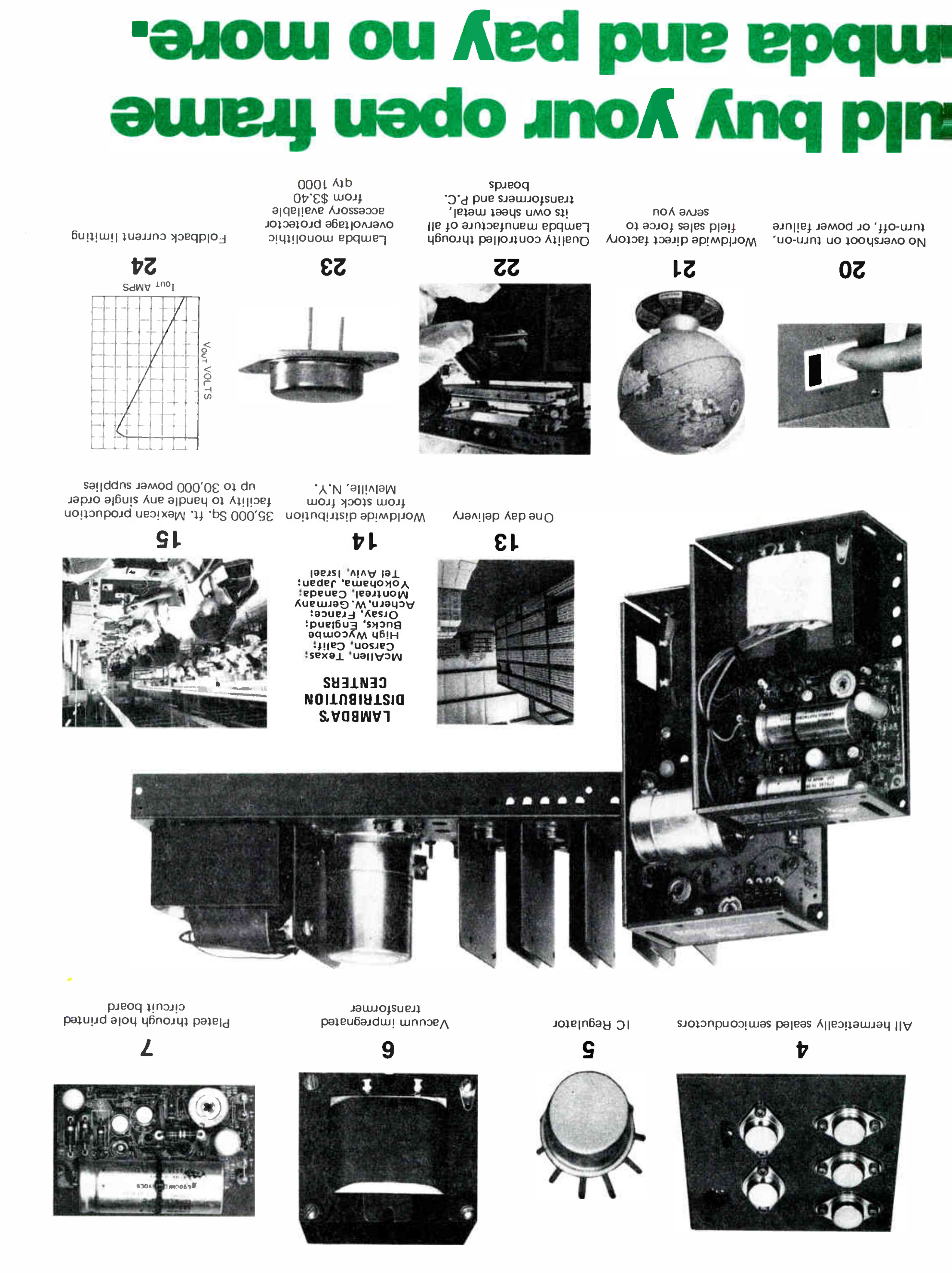
If you spend as much as $10 each for on-site repair of 15 failed low-cost power supplies, you will save $970 on the cost of implementing the guarantees.

The lowest cost power supplies are those with the fewest failures regardless of guarantees and initial price ..... Lambda quality means LO series power supplies have fewer failures than any other low-cost, open-frame power supplies



LAMBDA ELECTRONICS
515 BROAD HOLLOW ROAD, MELVILLE, L.I., NEW YORK 11746 (516) 694-4200

DIVISION of Veeco INSTRUMENTS INC



6 Amp Monolithic OV Protectors
$5.00 Qty 1 $3.40 Qty 1000

TO-3 PACKAGE, NO EXTERNAL COMPONENTS NEEDED

LAMBDA OVERVOLTAGE PROTECTORS
L-6-OV, L-12-OV, L-20-OV, L-35-OV Series

General Description

The Lambda overvoltage protector prevents damage to the load caused by excessive power supply output voltage due to improper adjustment, improper connection, or failure of the power supply. Load protection is accomplished automatically by effectively short circuiting the output terminals of the power supply when a preset limit voltage has been exceeded. The trip-point limit voltage cannot be adjusted. To reset overvoltage protector, remove AC input to power supply allow overvoltage protector to cool, and reapply power.

Overvoltage Protector Performance Specifications

PARAMETER	SYMBOL	L-6-OV SERIES		L-12-OV SERIES		L-20-OV SERIES		L-35-OV SERIES	
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
On State Current	I_{DC}	–	6A	–	12A	–	20A	–	35A
On State Voltage	V_{DC}	–	2.5V	–	1.3V	–	1.4V	–	1.6V
Non-Repetitive Peak Surge Current*	I_p	–	70A	–	200A	–	260A	–	350A
Standby Current	I_S	–	25mA	–	5mA	–	5mA	–	5mA
Operating Temperature (Blocking)**	T_{CB}	-40°C	+100°C	-40°C	+100°C	-40°C	+100°C	-40°C	+100°C
Operating Temperature (Conducting)***	T_{CC}	-40°C	+150°C	-40°C	+140°C	-40°C	+140°C	-40°C	+140°C
Storage Temperature	T_S	-40°C	+150°C	-40°C	+125°C	-40°C	+125°C	-40°C	+125°C
Power Dissipation @ 25°C Derate @ 1.5W/°C above 50°C	P_D		150 Watts						
Thermal Resistance	$R_{\theta JC}$		1.0°C/W						

*For sinusoidal current duration of 8.3 milliseconds max.

**Case temperature for overvoltage protector in non-conducting or "OFF" state.

***Case temperature for overvoltage protector in conducting or "ON" state. Power must be removed and case temperature allowed to drop to 100°C before application of output voltage.

The overvoltage protector must be mounted on external heat sink to maintain case temperature below rated limit. When the overvoltage protector is used with a Lambda power supply, the power supply chassis acts as the heat sink. The L-12-OV, L-20-OV, L-35-OV, overvoltage protector is supplied with mating connectors for pins on overvoltage protector (+V and –V engraved on unit).

OVERVOLTAGE PROTECTORS

NOM SUPPLY VOLTAGE (VOLTS)	TRIP POINT VOLTAGE^A (VOLTS)	6 AMP MODELS	PRICE QTY 1	QTY 100	QTY 250	QTY 1000	12 AMP MODELS	PRICE QTY 1	QTY 100	QTY 250	QTY 1000	20 AMP MODELS	PRICE QTY 1	QTY 100	QTY 250	QTY 1000	35 AMP MODELS	PRICE QTY 1	QTY 100	QTY 250	QTY 1000
5	6.6 ± .2	L-6-OV-5	$5	$4	$3.75	$3.40	L-12-OV-5	$11	$8	$7.50	$6.80	L-20-OV-5	$16	$11.20	$10.50	$9.50	L-35-OV-5	$20	$14.40	$13.60	$12.30
6	7.3 ± .2	L-6-OV-6	5	4	3.75	3.40	L-12-OV-6	11	8	7.50	6.80	L-20-OV-6	16	11.20	10.50	9.50	L-35-OV-6	20	14.40	13.60	12.30
9	10.5 ± .4	L-6-OV-9	5	4	3.75	3.40	L-12 OV-9	11	8	7.50	6.80										
10	11.0±.5	L 6 OV-10	5	4	3.75	3.40															
12	13.7 ± .4	L-6-OV-12	5	4	3.75	3.40	L-12-OV-12	11	8	7.50	6.80	L-20-OV-12	16	11.20	10.50	9.50	L-35-OV-12	20	14.40	13.60	12.30
15	17.0 ± .5	L-6-OV-15	5	4	3.75	3.40	L-12-OV-15	11	8	7.50	6.80	L-20-OV-15	16	11.20	10.50	9.50					
18	20.5±1.0	L-6 OV 18	5	4	3.75	3.40															
20	22.8 ± .7	L-6-OV-20	5	4	3.75	3.40	L-12-OV-20	11	8	7.50	6.80	L-20-OV-20	16	11.20	10.50	9.50					
24	27.3 ± .8	L-6-OV-24	5	4	3.75	3.40	L-12-OV-24	11.	8	7.50	6.80	L-20-OV-24	16	11.20	10.50	9.50					
28	31.9 ± 1.0	L-6-OV-28	5	4	3.75	3.40	L-12-OV-28	11	8	7.50	6.80	L 20 OV-28	16	11.20	10.50	9.50					
30	33.5 ± 1.0						L-12-OV-30	11	8	7.50	6.80	L-20 OV-30	16	11.20	10.50	9.50					

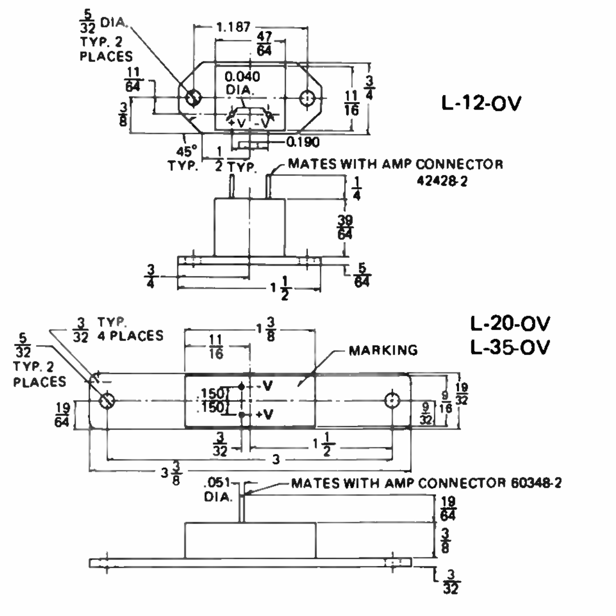
^A VOLTAGE TOLERANCE MAINTAINED OVER 0-71°C DUE TO POWER DESIGN

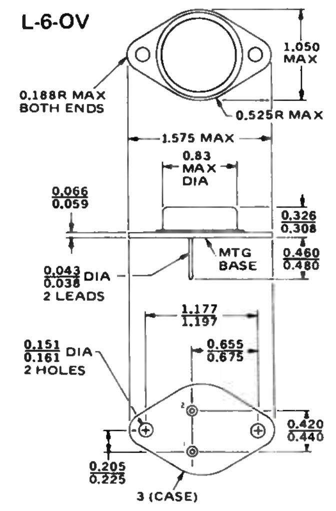
Outline Drawings

L-6-OV

L-12-OV

L-20-OV
L-35-OV





PIN CONNECTIONS

1. No connection — but this pin must be left floating for proper operation of OV
2. +V — disconnect to reset
3. (Case) — V

SPECIFICATIONS

Regulated voltage

regulation, line . . . 0.15% for 105 to 125 VAC
regulation, load . . . 0.15% for 100% load change
ripple and noise . . . 1.5mV RMS, 5mV pk-pk with either positive or negative terminal grounded
remote programming resistance . . . . . . 200 ohm/volt
temperature coefficient . . . . . 0.03%/°C

AC input

line . . . . 105-125 VAC/210-250 VAC, 47-440Hz (derate 10% at 50 Hz). Consult factory for operation at frequencies other than 47 to 63 Hz.

Efficiency

minimum. . . . . . . .25% for 5V, 6V models. 35% for 12V, 15V and triple output models. 48% for 20V, 24V, 28V and dual output models

Overshoot

no overshoot on turn-on, turn-off or power failure.

Ambient operating range

continuous duty from 0° to 60°C

Storage temperature range

-20°C to +85°C

Controls

simple screwdriver output voltage adjustment over voltage range.

Remote sensing

provision is made for remote sensing to eliminate effects of power output lead resistance on DC regulation. Connected for local sensing at factory.

Overload protection

external overload protection; automatic electronic current limiting circuit limits the current to a preset value

Tracking Accuracy

(Dual and Triple Output Models Only) 2% absolute voltage difference, 0.2% change for all conditions of line, load, and temperature.

Mounting

three mounting surfaces on packages Z, Y, X, W; two mounting surfaces on packages V & R; three mounting positions (all models).

Finish

Gray, Fed. Std. 595 No. 26081

Physical Data

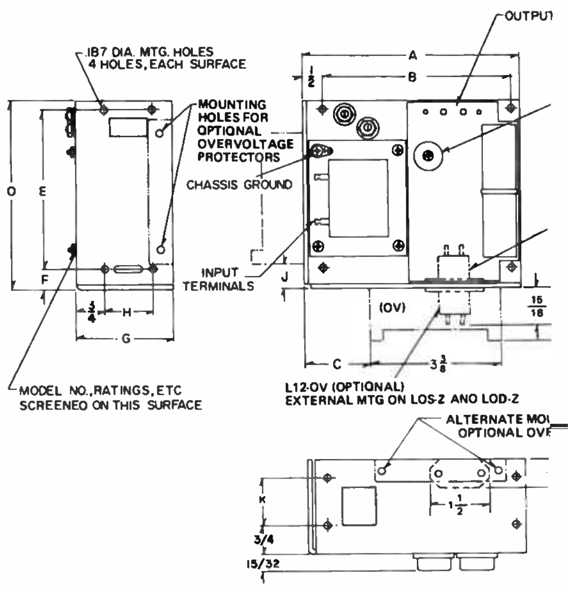
PACKAGE MODEL	WEIGHT LBS. NET	LBS. SHIP	SIZE (INCHES)
LO-Z	2	2-1/4	4-7/8 x 4 x 1-5/8
LO-Y	4	4-1/4	5-5/8 x 4-7/8 x 2-1/2
LO-X	6-1/2	7	7 x 4-7/8 x 2-3/4
LO-W	7-3/4	8-1/4	9 x 4-7/8 x 2-3/4
LO-V	10-1/4	11-3/4	4-7/8 x 13-3/4 x 4-7/8
LO-R	14-3/4	16-1/4	4-7/8 x 16-3/4 x 4-7/8

Guaranteed for 60 days

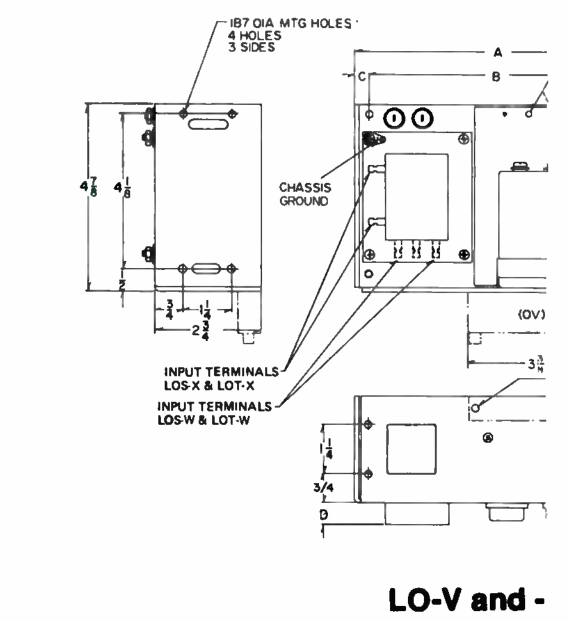
60 day guarantee includes labor as well as parts. Guarantee applies to operation at full published specification at end of 60 days.

DIMENSIONAL DRAWIN

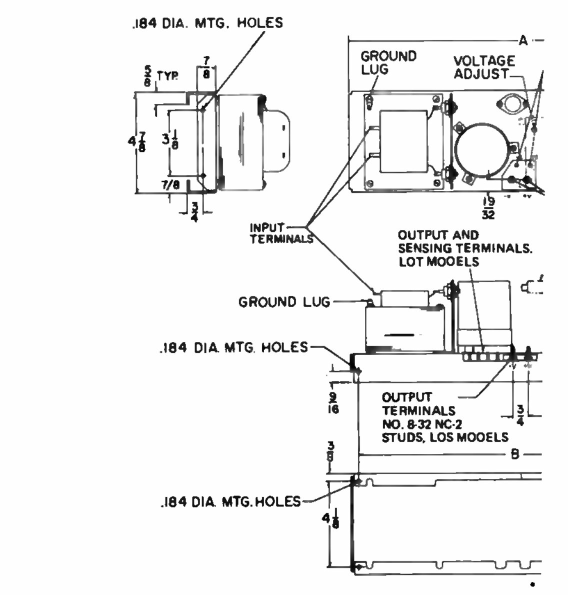
LO-Z and



LO-X and

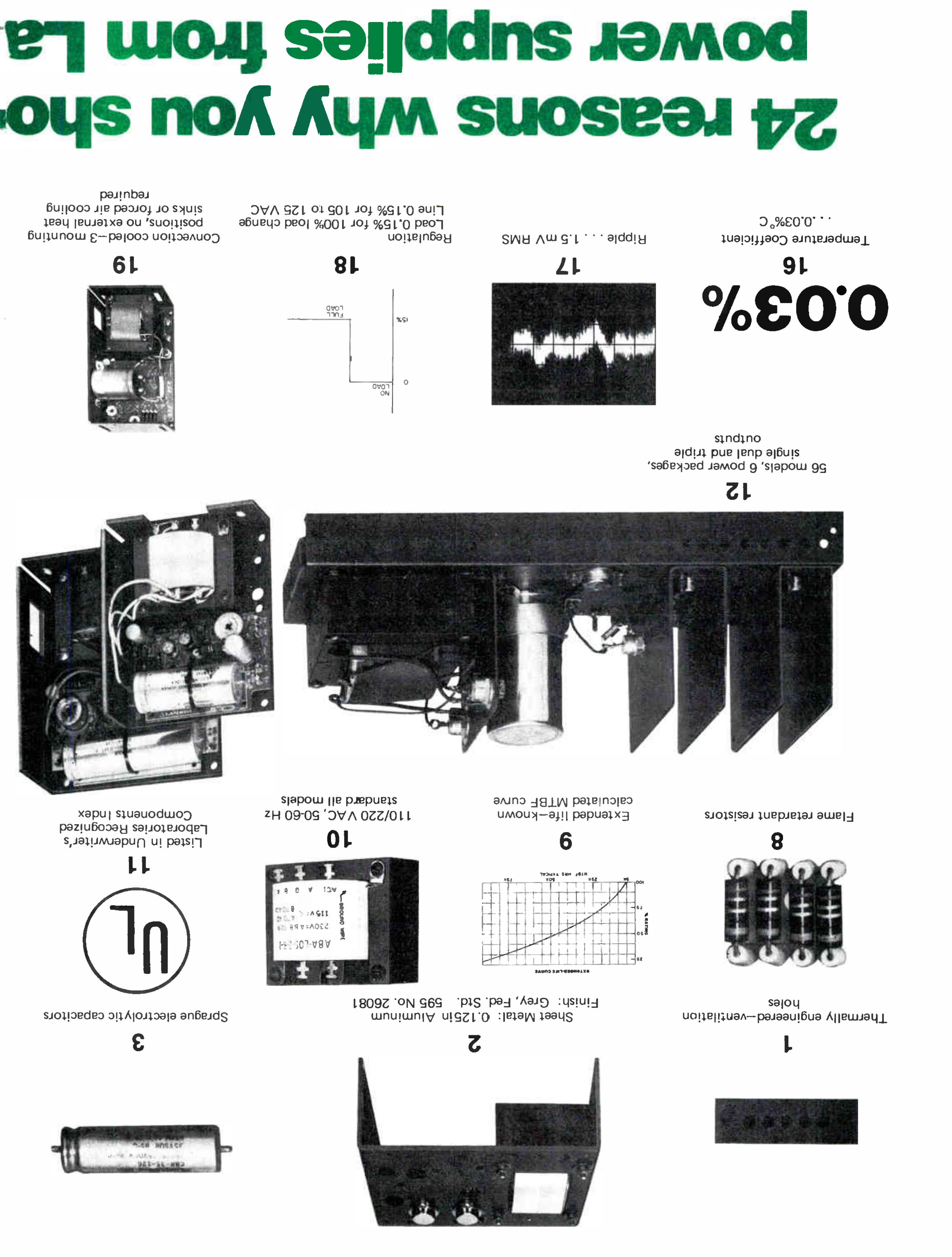


LO-V and



LAMBDA ELECTRONICS
DIVISION of Veeco INSTRUMENTS INC

OEM Users
New Reduced Prices For LAMBDA LO Series Effective Oct. 1, 1977

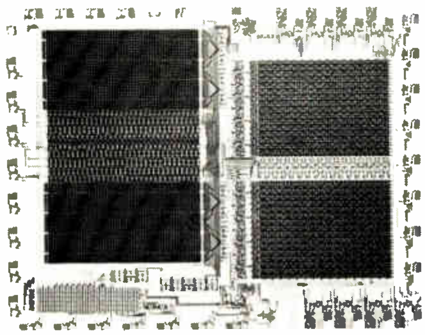


Microprocessors

Microprocessor interface has its own clock

Designed to be used with Signetics' 2650 microprocessor, the model 2656 system memory interface (SMI) is a single monolithic chip that incorporates its own memory, input/output ports, and clock generator. The circuit includes 16,384 bits of read-only memory, 8,192 bits of read/write memory, eight multipurpose I/O pins, and a clock generator that can be controlled by a crystal, an RC circuit, or an external signal. Each of the multipurpose I/O pins can be either a chip-select pin or a data port. Like the contents of the ROM and the frequency divisor of the clock circuit, the function of the I/O pins is determined by mask programming during chip manufacture.

A particular feature of the 2656 is the ease with which it lends itself to multiple-chip configurations. As an example, up to seven additional circuits can be added to the basic two-chip system with no need for any special interfacing circuitry. Furthermore, more than one SMI can be used with a single microprocessor when additional memory, I/O capability, or clocking is needed.



The SMI is housed in a 40-pin dual in-line package and operates from a single 5-V supply. It sells for about $17 in lots of $1,000 or more pieces.

Signetics Corp., 811 East Arques Ave., P. O. Box 9052, Sunnyvale, Calif. 94086. Phone Rick Eklund at (408) 739-7700 [401]

XYBasic interpreter runs on 8080-based computers

Capable of running on any 8080-based microcomputer with 8 kilobytes of memory, an XYBasic interpreter allows users to write and debug programs easily in a high-level language (XYBasic), instead of working in inconvenient assembly language. Among the especially valuable features of the language and the assembler are a delay command, which essentially duplicates the functions of a real-time clock; a direct-access mode in which a single command gives the user or the computer access to a specific input or output port; and TRACE and BREAK commands, which make possible one-step debugging.

After loading the interpreter, which can be done in as little as 5 seconds, the user needs only to run through a brief initialization dialogue to be ready to start programming. Because the editor and assembler are part of the package, there is no need to load them separately.

The interpreter is available on paper tape or floppy disk, complete with a manual and a programming guide, for $295. The manual is offered separately for $20.

Mark Williams Co., 1430 W. Wrightwood Ave., Chicago, Ill. 60614. Phone (312) 472-6659 [403]

Terminal develops programs for 8080-based systems

The HP 13290B cathode-ray-tube terminal is designed to aid programmers who develop, test, and debug programs for microcomputers built around 8080-type microprocessors. With a software package that is loaded into its random-access memory from a tape cartridge, the terminal allows a user to display and change the processor's registers and any portion of his program.

Programs up to 44 kilobytes long can be accommodated by the

abbott POWER SUPPLIES

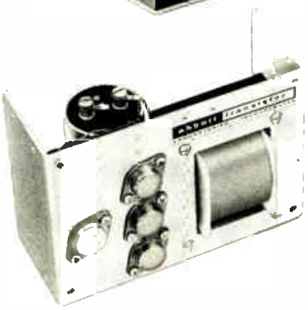
Come to the specialist.

We started out pretty small back in '61. But we were big on product quality and reliability. Had to be. Uncle Sam was our only customer. Over the years we stuck with our own technology. We grew. Became specialists. And we kept on improving our power supplies.

It all paid off. Just look at Abbott today.

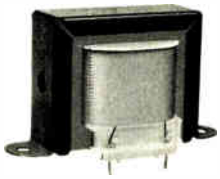
Militarized Power Supplies — Our early bread-and-butter line has grown to over 1500 versions. Some we stock. Yet we're equipped to provide fast delivery on any number of high efficiency, hermetically sealed, single or dual output power supplies and switcher modules. That includes our popular 60 and 400Hz and DC versions with outputs from 3VDC to 740VDC, 1 to 250 Watts. And prices go as low as $174 for 2-4 units.

For Catalog Circle Card Number 100



Industrial Power Supplies — Ours isn't a big line yet — only 279 models. But you won't find a better quality of OEM power modules anywhere. (It's just our hi-rel way of thinking.) We provide covered/open frame, AC to DC single, dual and triple output versions, with outputs of 5 to 36VDC, 0.5 to 320 Watts. Plus DC to AC converters with 50 to 60Hz outputs. Competitively priced? You bet. As low as $35 for up to 24 units.

For Catalog Circle Card Number 101



Transformers — For the do-it-yourself power supply designer who wants our kind of quality for his own military, industrial and pcb application. If you're one of them, we offer over 800 standard transformers, with instructions on how to specify for your custom units. Included are 60 and 400Hz, single phase input versions. Prices start as low as $5.10 for up to 9 pieces.

For Catalog Circle Card Number 102

See Power Supply Section 4000, and Transformer Section 5600, Vol. 2, of your EEM catalog; or Power Supply Section 4500, and Transformer Section 0400, Vol. 2, of your GOLD BOOK for complete information on Abbott products.

abbott transistor

LABORATORIES, INCORPORATED

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5200 W. Jefferson Blvd., Los Angeles 90016
(213) 936-8185 Telex: 69-1398

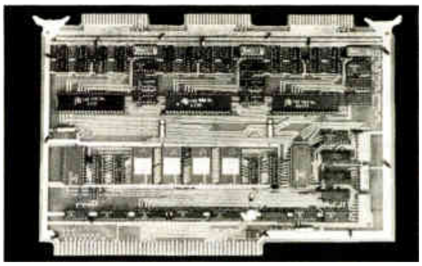
Eastern Office
1224 Anderson Ave., Fort Lee, N.J. 07024
(201) 224-6900 Telex: 13-5332

13290B, which comes equipped with 64 kilobytes of 400-ns RAM and 22 kilobytes of read-only memory. The development terminal's selling price is $6,950.

Inquiries Manager, Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94304 [404]

Memory and I/O board works with TM 990/100M computer

A board designed to expand both the memory and the input/output capability of Texas Instruments' TM 990/100M microcomputer contains 2,048 16-bit words of erasable programmable read-only memory,



1,024 words of static read/write memory, and three TMS 9901 programmable systems interface chips, which provide input, output, and interrupt lines. The result is that the board provides 48 I/O lines programmable as inputs or outputs in groups of two. In addition there are 18 other inputs, 12 of which have optional input latches for edge-triggered signals. The I/O lines may be buffered or power-inverted or have pull-ups, pull-downs, or standard terminations. There are 15 possible interrupts on each TMS 9901, with each group code readable through an auxiliary input port.

Production quantities will be

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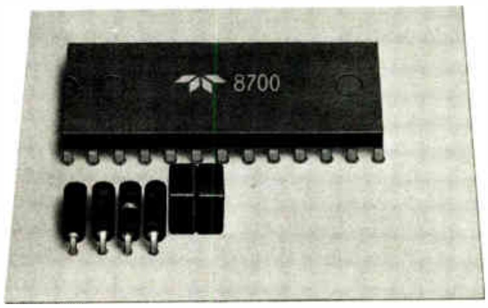

For specific information on individual A/D converters, please circle the appropriate Reader Service number, as indicated.

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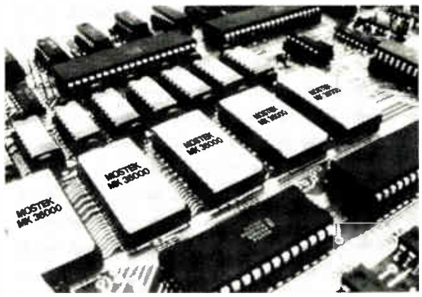
available within 30 days. Small-quantity pricing will range from $395 for a board with unbuffered inputs and outputs and no memory to $635 for a buffered and fully populated board.

Digital Interface Systems Inc., P. O. Box 1446, Benton Harbor, Mich. 49022 [407]

65,536-bit ROM has 200-ns access time

Although it consumes a maximum of 200 mW in its active mode (25 mW in standby), the MK 36000 65,536-bit read-only memory has an access time of only 200 ns. Organized as 8,192 bytes, the ROM is powered by a

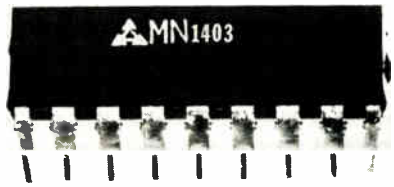


single 5-V supply—two factors that make it especially suitable for modern microcomputer applications. The unit's three-state output can drive two transistor-transistor-logic loads and 100 pF. It is housed in a standard 24-pin dual in-line package.

Mostek Corp., 1215 W. Crosby Rd., Carrollton, Texas 75006. Phone Derrell Coker at (214) 242-0444 [405]

50-instruction computer is aimed at toys, appliances

The MN1403 microcomputer is a 4-bit circuit intended for use in such low-cost, high-volume applications as toys, TV sets, and home appliances. Although housed in a compact 18-pin dual in-line package, the computer boasts such user-oriented features as a 50-instruction repertoire, a two-level subroutine stack, one 4-bit parallel input port, one 4-bit parallel output port, one



input sense line, four discrete output lines, and operation from a single 5-v supply. The four discrete outputs can be used to activate relays or indicator lamps.

Included on the n-channel metal-oxide-semiconductor chip are 16 words of read-write memory, of which four are directly addressable, 512 words of read-only memory, a clock generator, and an arithmetic/logic unit. The instruction cycle time is 10 μs.

Panasonic, One Panasonic Way, Secaucus, N. J. 07094. Phone Bill Bottari at (201) 348-7276 [406]

Language is designed for 6500 microcomputer family

A systems implementation language, CSL/65, which resembles PL/1 and Algol, has been developed for the 6500 microcomputer family offered by Rockwell, Synertek, and MOS Technology. Versions are currently available for the Rockwell System 65 development system and any PDP-11 using the RT-11 operating system. Other versions will be announced later this year. CSL/65 produces assembler code rather than object code. This allows the programmer to optimize the program at the assembler level and indeed to drop into assembly language whenever he or she feels it is necessary. Output from the CSL/65 compiler is passed to the assembler, which is part of the System 65 monitor, or to the MINmic assembler, which is required by users of the PDP-11. The CSL/65 compiler sells for $1,000; the MINmic 1165 assembler goes for $900.

Computer Applications Corp., 413 Kellogg, Ames, Iowa 50010. Phone (515) 232-8181 [408]

New products/materials

Reversible digital decals will change from a blank readout to a calibrated temperature readout when heated above a threshold and then will go blank when the temperature falls under the minimum calibrated level. The threshold temperature may be selected from 40°C to 70°C. The self-adhesive devices may be used on transformers, motors, reactors, switch disconnects, and appliances. A free evaluation sample and catalog are available upon request.

William Wahl Corp., 12908 Panama St., Los Angeles, Calif. 90066 [480]

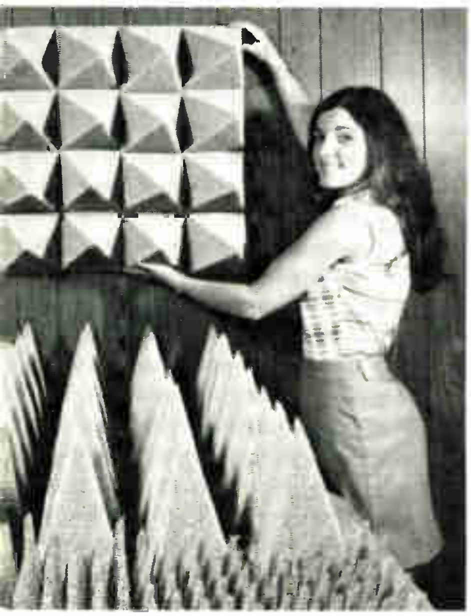
A two-part gold epoxy adhesive designed for microelectronic chip-bonding applications has a noncritical 1:1 mixing ratio by weight or volume. H81E has a two-year shelf life at room temperature and a three-day pot life after mixing at room temperature. The curing process takes 5 minutes at 150°C and 90 minutes at 80°C, and can be applied mechanically or by screen printing. Its volume resistivity is 0.0004-0.0008 ohm-cm. Half-ounce evaluation kits sell for $170.00 each. Deliveries are from stock.

Marketing Department, Epoxy Technology Inc., P. O. Box 567, 14 Fortune Dr., Billerica, Mass. 01821 [476]

A durable-dielectric coating cleaner will remove surface contaminants from coatings such as detector trimmers, color-separation filters, beam splitters, and most infrared filters. This material contains no silicones, which could adhere to the coating and cause nonuniform spectral characteristics. It cleans away fingerprints, as well as most smudges, scum, smears, film, and soil. It sells for $5.25 per can with a minimum order of two cans.

Marketing Department, OCLI, P. O. Box 1599, Santa Rosa, Calif. 95402 [477]

Two microwave absorbers work equally as well in both indoor and outdoor uses. These open-cell foam materials can handle high-power illumination indoors and can shed rain easily outdoors, with absorption capability of up to 10 watts per square inch. The standard base size for both products is 24 by 24 in.



Prices are available upon request.
Microwave Products Division, Emerson and Cuming Inc., Canton, Mass. [478]

A caulking and sealing compound can be used for isolating terminals from contact with potting compounds or for sealing molds on the production line. Eccobond 211's good dielectric properties make it useful for temporary bonding of components and circuitry, as well as weathersealing for radomes, glazing, and acting as a spot adhesive for a microwave absorber. This one-part material will stick to virtually any material, including polyethylene, polypropylene, and polytetrafluoroethylelene, which normally defy adhesion. The material has a dielectric strength of 300 volts/mill (11.8 kilovolts/millimeter) and a dielectric constant of 10^3 to 10^{10} hertz. Eccobond 211 comes in 20-foot rolls at $12 per roll.
Emerson & Cuming Inc., Canton, Mass. 02021 [479]

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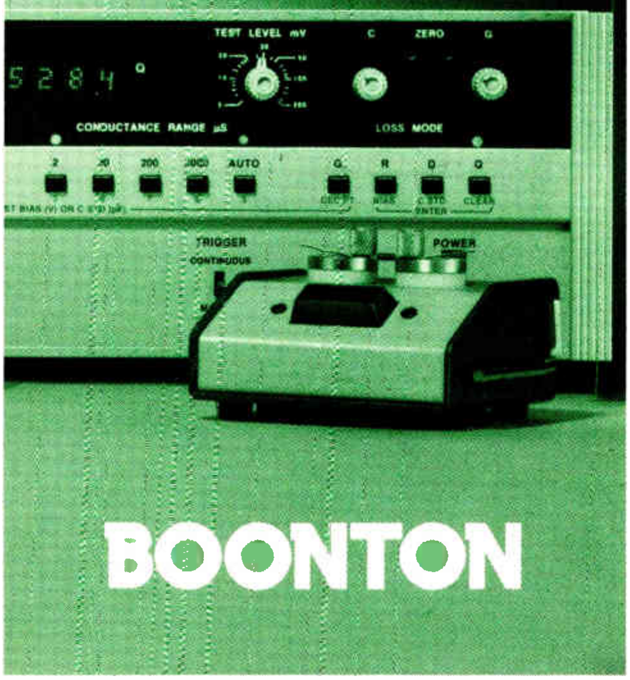

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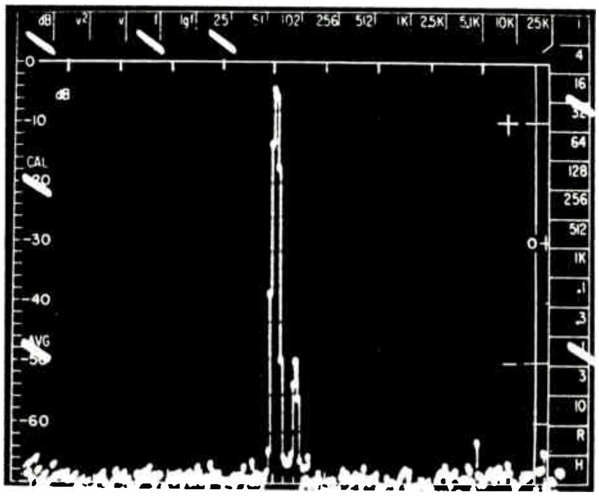

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New literature

Thick-film materials. A product guide gives information on thick-film materials systems for hybrid microcircuits, resistor networks, cermet trimmers and potentiometers, and gas-discharge displays. A selection guide makes it easy to meet performance, processing, and cost requirements. Basic information on the properties of thick-film resistor, conductor, dielectric, solder and braze, and conductive-epoxy compositions is also included in the 16-page guide. Order by serial number E-04869. Du Pont Co., Electronic Materials Division, Wilmington, Del. 19898 [424]

Components. Over 1,600 rectifiers, rectifier assemblies, zener voltage regulators, high-voltage rectifiers, Klipvolt surge suppressors, and selenium rectifiers are described in a 19-page catalog. A more in-depth discussion of devices that are used in X-ray equipment, electrostatic precipitators, motor controls, magnetic clutches, microwave ovens, and radar transmitters is provided. ST-Semicon Inc., 415 College Ave., Bloomington, Ind. 47401 [425]

Display-prototype sheet. A 9-by-12-inch adhesive-backed sheet allows a designer to simulate full-size planar gas-discharge displays for clock and front-panel readouts. The PGD letters, numbers, and symbols are printed in neon orange on a black

New literature

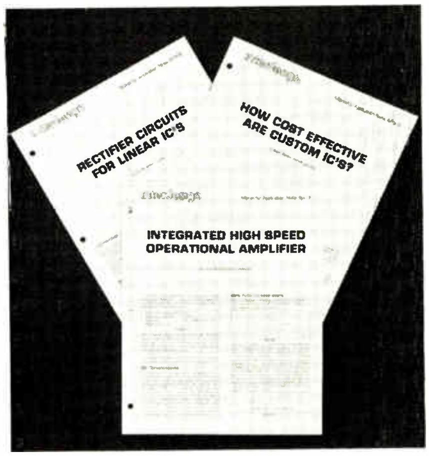
background. Beckman Instruments Inc., Helipot Division, P. O. Box 11866, Santa Ana, Calif. 92711 [426]

Indicator lights. Several types of indicator lights, including solid-state, neon and incandescent, midget screw and rear-mount, Snaplite and rectangular, along with specifications and ordering information, are described in a publication from Leecraft Manufacturing Co., 21-16 44th Rd., Long Island City, N. Y. 11101 [427]

Meters. Descriptions and specifications for Airpax meters with particular emphasis on the construction of the meters are given in a 39-page brochure. The Airpax design is used in several types of meter housings, including rectangular, edge-reading, and medallion panel. Outline and mounting dimensions for each type of meter are also included. Airpax Controls Division, 6801 W. Sunrise Blvd., Fort Lauderdale, Fla. 33313 [428]

Materials. A 40-page handbook that covers over 300 metals, alloys, and nonmetallic materials is geared toward engineers who use thin-film evaporation and sputtering processes. For engineers working with the evaporation method, starter sources, vapor deposition charges, and metal-feed wire are listed; for sputtering-process users, round and rectangular-shaped targets as well as S-gun and ring configurations are given. Basic information on sputtering, evaporation, and material fabrication technology is supplied, along with reference data. Materials Research Corp., Orangeburg, N. Y. 10962 [429]

Application notes. Information about integrated circuits is given in three monochip application notes. Of particular importance is APN 5, "How Cost-Effective Are Custom ICs?" which compares the economies of circuit designs using discrete components vs semicustom integrated-circuit designs at various volume levels. Rework, supervisory over-



head, inventory maintenance, quality assurance, and purchasing and stocking costs are analyzed. APN 6, "Rectifier Circuits for Linear ICs," discusses techniques for designing rectifiers using the components available on semicustom ICs, and APN 7, "Integrated High-Speed Operational Amplifier," explains how high-speed, high-stability circuits can be constructed using semicustom technology. Interdesign Inc., 1255 Reamwood Ave., Sunnyvale, Calif. 94086 [422]

Connectors. Specifications and dimensional drawings are provided for the series 1,000, 2,000, and 3,000 connectors. They are designed for printed-circuit boards, flat cables, and wrapped-wire systems. Methode Electronics Inc., 1700 Hicks Rd., Rolling Meadows, Ill. 60008 [430]

Test instruments. General and technical information covering such devices as frequency counters, universal counter-timers, digital and sweep generators, spectrum analyzers, and microwave components is being of-

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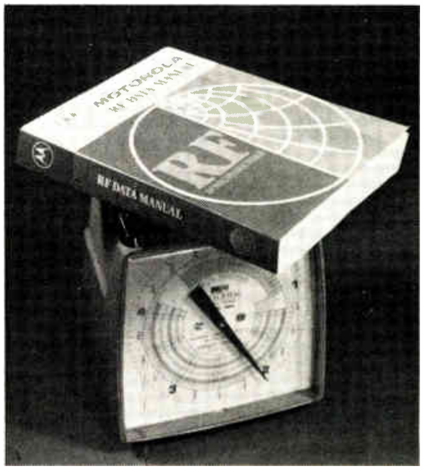
New literature

fered by Systron-Donner Corp., 10 Systron Dr., Concord, Calif. 94518 [431]

Radio-frequency data. A 736-page data manual describes: radio-frequency power transistors with outputs of up to 150 watts and ranges from 1.5 megahertz to 1 gigahertz; linear hybrid amplifier modules for cable and master-antenna television as well as general-purpose uses; and power hybrid amplifiers with up to 30-w output in the very-high and



ultrahigh frequency range. Detailed application information is given for impedance matching networks, mechanical rf construction techniques, biasing, and noise-figure and gain-optimization procedures. The manual can be obtained at $3.50 each from Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. 85036

Technology. "Semiconductor Measurement Technology," a 119-page booklet, describes what the National Bureau of Standards is doing to develop measurement methods for semiconductor materials and processes. Supplementary data listing staff, publications, workshops and symposia, standards committee activities, and technical services is also included. Copies can be obtained for $1.85 each. Order by number 003-003-01759-1 from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20234

Instruments. A 60-page four-color catalog lists and describes analog and digital panel meters, meter relays, controllers, and test instruments. Technical data including stock ranges and specifications is provided. Simpson Electric Co., 853 Dundee Ave., Elgin, Ill. 60120 [432]

Microwave-frequency counters. A 13-page application note discusses the four principal down-conversion techniques for extending the frequency range of counters into the microwave region. The first section of the note details the techniques of prescaling, heterodyne conversion, harmonic heterodyne conversion, and use of transfer oscillators. The second section compares measurement speed, accuracy, sensitivity and dynamic range, signal-to-noise ratio, a-m and fm tolerance, and amplitude discrimination for the four techniques. Also discussed are some factors to be considered in selecting a microwave counter and several applications. Inquiries Manager, Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94304 [433]

Power semiconductors. Everything you always wanted to know about power semiconductors is contained in a 432-page reference guide. It is designed to save users time and money when specifying, buying, installing, testing, maintaining, troubleshooting, servicing, identifying, and replacing power semiconductor devices. Among the topics covered are safety factors, device protection, military and high-reliability products and applications. Technical data is supplied for all products, and a separate section gives information on high-power rectifiers, transistors, thyristors, and assemblies. Included are a product cross-reference index, product outlines with both U. S. and metric dimensions, product selector guides, and a service directory. The reference guide sells for $6.50 each ($7.50 outside the U. S.). Delivery time is from 2 to 4 weeks (4 to 12 weeks outside the U. S.). Westinghouse Electric Corp., Semiconductor Division, Youngwood, Penn. 15697

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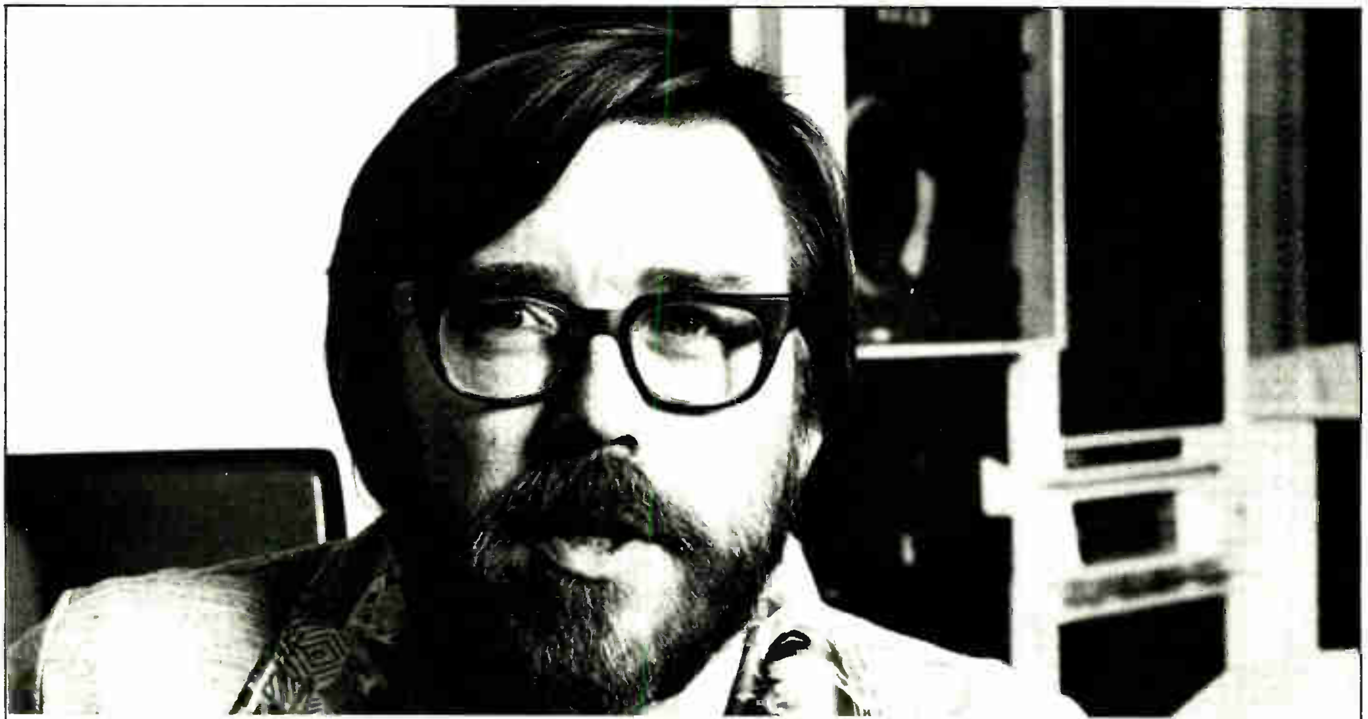

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Will be engaged in the design and integration of large scale Communications Systems. Must be capable of developing preliminary system concepts and architecture. Requires a BS or MS in Electrical or Mechanical Engineering with experience in any of the following areas: (1) HF receivers, exciters, power amplifiers and logic circuits; (2) RF Systems Engineering in the HF, VHF and/or UHF area; (3) Digital device and circuit design; (4) Microprocessor and minicomputer applications and knowledge of computer peripherals; (5) System design, hardware and software implementation; (6) Antenna design and analysis; and (7) Thermal analysis and system integration packaging.

SYSTEMS ANALYSTS

Responsibilities include programming and system development support for applied research projects on new microprocessor based instruments. Involves some hardware/software interface. Requires BS in EE, Mathematics or Computer Science with experience in any of the following areas: (1) Queuing/congestion analysis; (2) Probability/statistics; (3) Linear systems; and (4) Modeling and simulation.

PROGRAM MANAGERS DOMESTIC AND OVERSEAS

Responsible for providing engineering lead for major programs/proposals with Profit and Loss accountability. Positions involve preparation of proposals and customer presentations, negotiation, fiscal planning and scheduling. Requires BS, MS or PhD in EE and at least five years industrial experience, preferably in the areas of: (1) System design; (2) Hardware and software implementation; and/or (3) Project Management.

NUMEROUS OTHER OPENINGS EXIST FOR DEGREED EE's, ME's AND IE's.

Please submit resume including salary history and requirements in confidence to:

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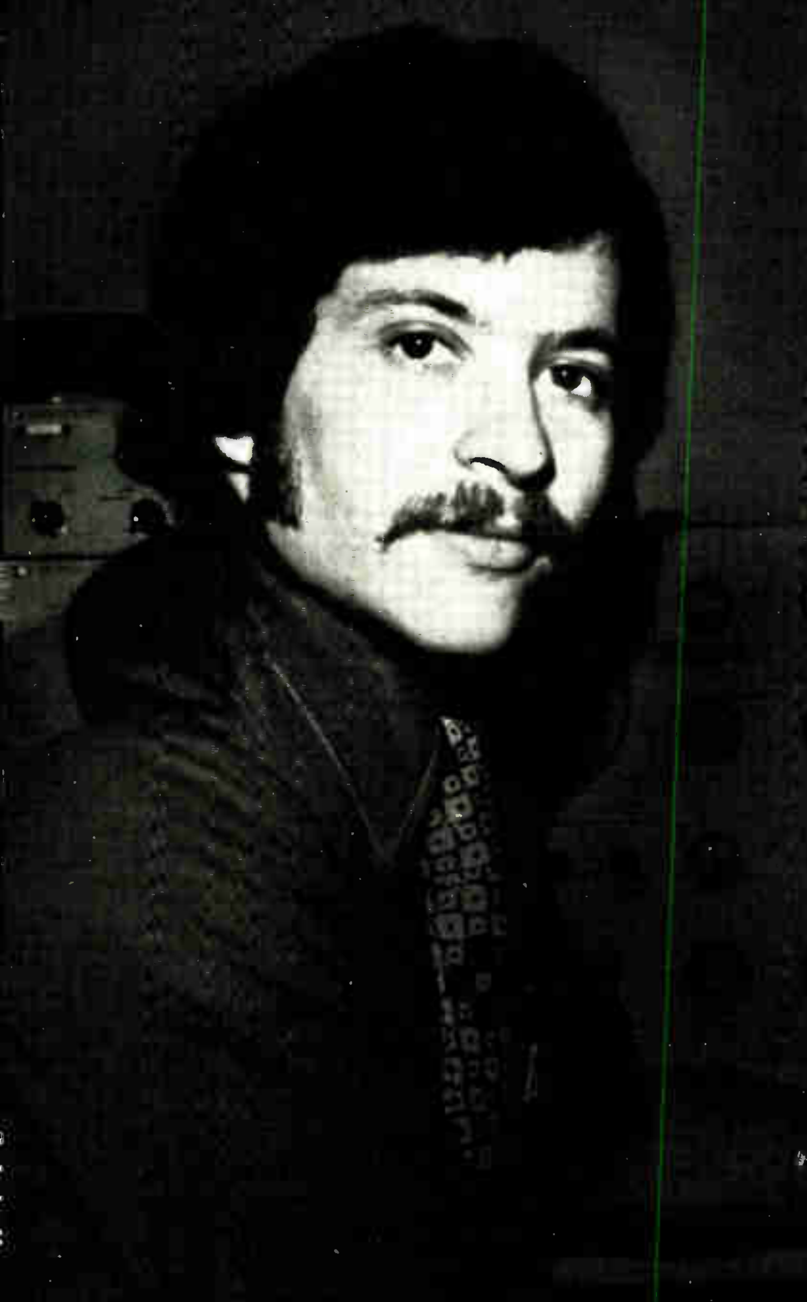

It's a good feeling to be in the vanguard of technology with employment stability through dynamic growth and diversification!

For Immediate Openings In:

Circuit Design Engineers
Experienced in RF, IF, Video, and A/D circuit design for use in Signal Processing in both airborne and space applications.

Digital Logic Design Engineers
Experienced in design and development of digital circuits using TTL, STTL, ECL and CMOS technologies.

Software Development Engineers
Experienced in the development of software for special purpose digital processors. Digital hardware background experience desired.

Product Design Engineers
Experienced in extremely high density physical and thermal designs for airborne and spaceborne signal processing.

Project Engineers
Experienced in the management of all aspects of a project including management of subcontracts and remote manufacturing facilities.

Digital Module Test Engineer
Experienced in developing software for automatically testing digital modules.

Digital Associate Engineer (Non MTS)
Having good rapport with digital logic design, logic schematics and the conversion of these to a computerized interconnect data base.

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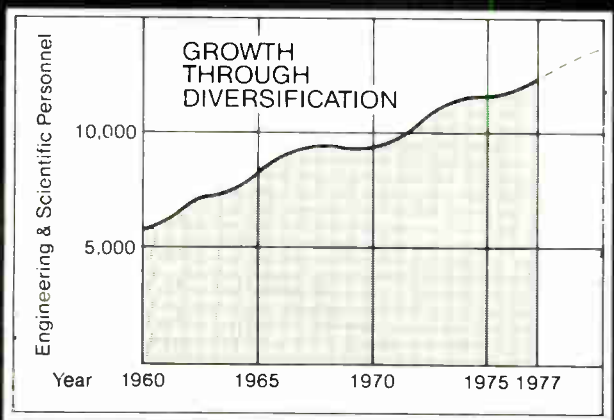
This chart indicates the Company's extraordinary record of growth with stability in the dynamic electronic technology industry.



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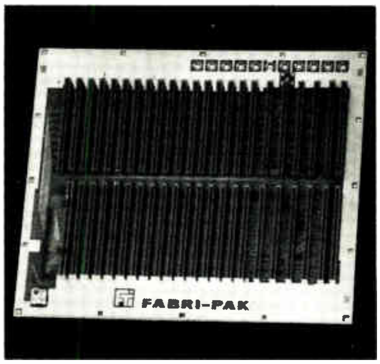
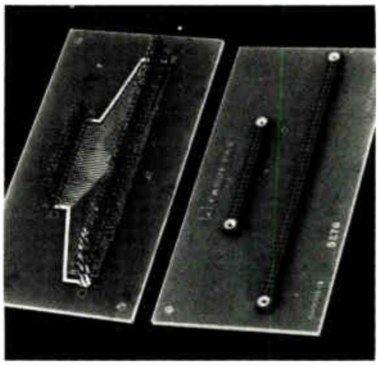
COMMERCIAL VERSION: Unlimited choice of PC edgecard terminations. .100, .125, .150, .156 grid.





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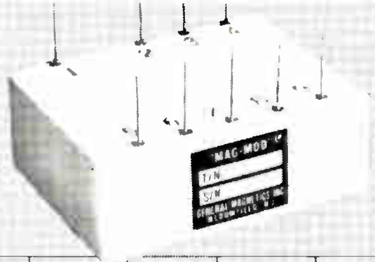
Solid State Sine-Cosine Synchro Converter

This new encapsulated circuit converts a 3-wire synchro input to a pair of d-c outputs proportional to the sine and cosine of the synchro angle.

- Complete solid state construction.
- Operates over a wide temperature range.



UNIT	DMD 1436-1	DMD 1430-1	DMD 1403-2	DMD 1361-6	DMD 1361-4	DMD 1193-4	DMD 1361-8	DMD 1446-1	DMD 1193-5	DMD 1193-6	DMD 1361-10	DMD 1472-2
L-L SYNCHRO INPUT (VRMS)	11.8	90	95	90	11.8	11.8	11.8	11.8	11.8	11.8	11.8	90
FREQUENCY (Hz)	400	400	60	400	400	400	400	400	400	400	400	60
FULL SCALE OUTPUT (VDC)	± 10	± 10	± 3	± 3	± 3	± 10	± 10	± 10	± 10	± 10	± 10	± 10
OUTPUT IMPEDANCE	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<10Ω	<1Ω	<1Ω	<1Ω	<1Ω
L-L INPUT IMPEDANCE	>10K	>30K	>5K	>30K	>5K	>5K	>5K	>5K	>5K	>5K	>5K	>5K
REFERENCE VOLTAGE (VRMS)	26	115	115	115	26	115	26	115	115	115	26	115
ACCURACY SIN/COS (+25°C)	± 6MIN	± 6MIN	± 6MIN	± 6MIN	± 6MIN	± 6MIN	± 6MIN	± 0.5%	± 6MIN	± 6MIN	± 6MIN	± 6MIN
FULL TEMPERATURE RANGE ACCURACY SIN COS	± 15MIN	± 15MIN	± 15MIN	± 15MIN	± 15MIN	± 15MIN	± 15MIN	± 0.5%	± 15MIN	± 15MIN	± 15MIN	± 15MIN
D.C. SUPPLY (VDC)	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15
D.C. SUPPLY CURRENT	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA
BANDWIDTH	>10Hz	>10Hz	external set	>20Hz	>5Hz	>10Hz	>10Hz	>10Hz	>2Hz	>40Hz	>5Hz	external set
SIZE	1.1x3.0 x1.1	2.0x2.25 x1.4	1.1x3.0 x1.1	1.5x1.5 x0.6	1.85x0.85 x0.5	2.01x2.25 x1.4	0.85x1.85 x0.5	2x2.25 x1.4	2x2.25 x1.4	2x2.25 x1.4	2.15x1.25 x0.5	1.1x3.0 x1.1
NOTES	—	dual channel unit	—	—	—	dual channel unit	—	dual sine output	dual channel unit	dual channel unit	—	—
TEMPERATURE RANGE	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C	–40°C to +100°C

High Precision Analog Multipliers

PRODUCT ACCURACY (MCM 1519-1) ± ½% OF ALL THEORETICAL OUTPUT VALUES OVER FULL MILITARY TEMPERATURE RANGE OF –55°C TO +125°C. ZERO POINT ERROR FOR ANY INPUT COMBINATION IS ± 2MVRMS

Features:

- No external trims required
- Distortion free AC output over entire dynamic range
- Linearity, product accuracy and zero point virtually unaffected by temperature
- All units are hermetically sealed and are not affected by external fields
- High analog product accuracy and wave quality allows dual multiplier assemblies to be matched with 1% of point over the specified temperature range
- Full four quadrant operation
- Package size, power supply requirements and other specs. may be altered to your exact requirements at no extra cost.

Specifications:

- Transfer equation: Eo=XY/10
- X & Y input signal ranges: 0 to ±10V PK
- Maximum zero point error (X=0; Y=0 or X=±10; Y=0 or X=0; Y=±10): 2MVRMS
- Input impedance: Both inputs 20K min.
- Full scale output: ±10V peak
- Minimum load resistance for full scale output: 2KΩ
- Output impedance: 1Ω
- Short circuit duration: 5 sec.
- Frequency response characteristics (both inputs) 1% amplitude error: DC to 1200 Hz (min.) 0.5 DB Amplitude error: DC to 3500 Hz min. 3 DB point: Approx. 10K hz Roll off rate: 18 DB/octave
- Noise Level: 5MV PK-PK @ 100K Hz approx.
- Operating temp. range: See chart
- Storage temperature range: -55°C to +125°C
- DC Power: ±15V ±1% @ 30MA
- Dimensions: 2" x 1.5" x .6"

Type No.	Product Accuracy	Operating Temperature Range
MCM 1519-1	0.5%	–55°C - +125°C
MCM 1519-2	0.5%	–25°C - +85°C
MCM 1519-3	0.5%	0°C - +70°C
MCM 1520-1	1.0%	–55°C - +125°C
MCM 1520-2	1.0%	–25°C - +85°C
MCM 1520-3	1.0%	– 0°C - +70°C

Precision AC Line Regulator

Total Regulation 0.15% Max.

Features:

- Low distortion sinusoidal output
- Regulation control better than ten times superior to commercial AC voltage regulators transformer product lines
- No active filters or tuned resonant circuits employed resulting in immunity to line frequency changes
- 6.5 watt output level
- Small size
- Output set to ±1% accuracy — this includes initial set point plus line, load, frequency and temperature changes
- Foldback short circuit protection provided resulting in protection against overloads and short circuits of any duration
- Low profile package with straight pins makes the unit suitable for PC board mounti[ng] (unit is hermetically sealed)
- Transformer isolation betwe[en] all power inputs and the outputs.

*Other units available at different power levels. Information will be supplied upon request.

Specifications Model MLR 1476-2:

- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Output: 26V RMS ±1% (for any condition)
- Load: 0 to 250 MA, RMS
- Total regulation: ±0.15% maximum (any combination of line, load or frequency)
- Distortion: 2% maximum
- AC input line current: 100 MA. max. at full load
- DC power: ±15 V DC ±5% @ 15 MA. max.
- Phase angle: 1° max.
- Temp. Range: -40°C to +85°C
- Case Material: High permeability nickel alloy
- Terminals: Glass to metal hermetic seal pins

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8 23 38 53	68 83 98 113	128 143 158 173	188 203 218 233	248 263 340 355	370 385 400 415	430 445 460 475	490 505 710 952
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