APRIL 21, 1982

AUTOMATION CHANGES OFFSHORE ASSEMBLY RULES/92

VLSI packaging dominates the components conference/ 121

Standard software in silicon moves into real-time systems/ 137

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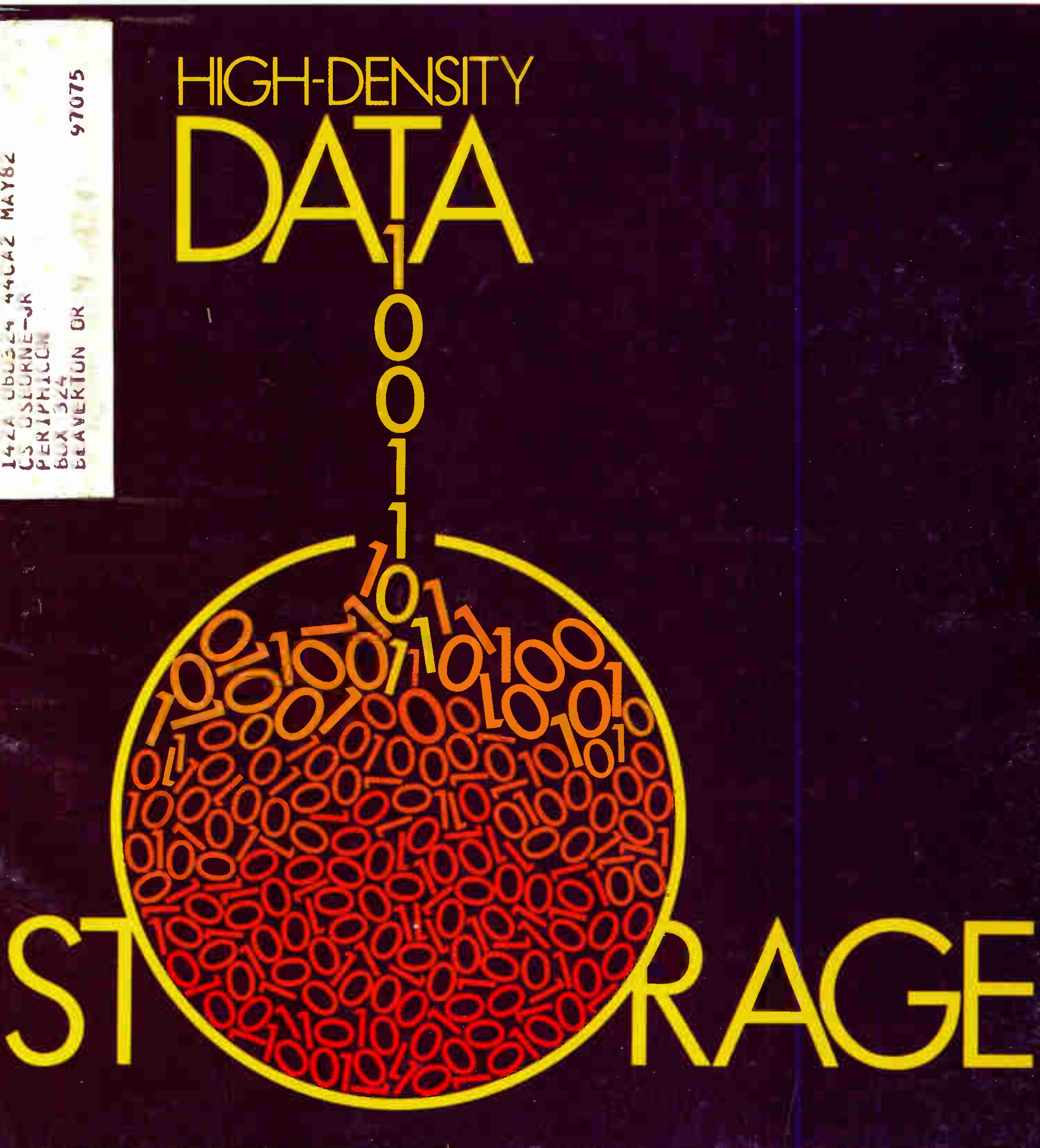

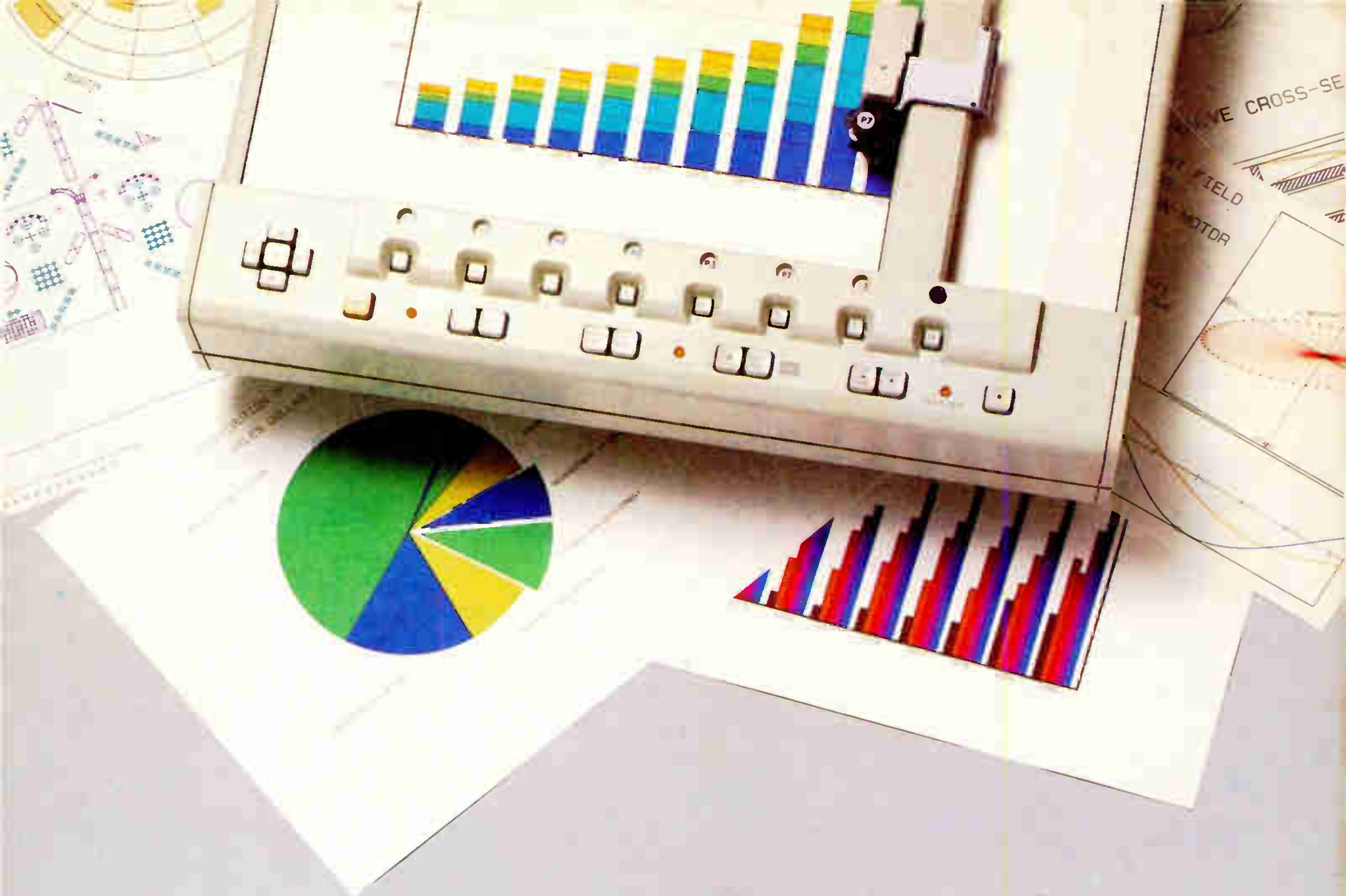

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Circle 1 on reader service card

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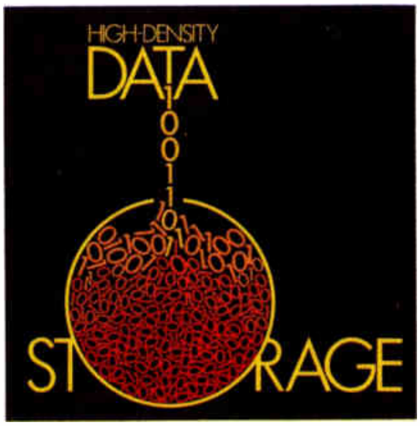

Cover by Art Director Fred Sklenar.

The Cover Story

Major New Developments

Highlights

Cover: Disk drives get smaller, denser, 106

The state of the art in magnetic-disk drives is advancing rapidly, as demand grows for ever denser data storage in ever less physical space. Among the new technologies are thin-film disks with a ferrite head (p. 108), a drive that combines the advantages of Winchester and removable-cartridge technologies (p. 112), and a flexible-disk drive with hard-disk speed (p. 117).

Data storage's next leap looks like vertical recording, 89

For densities as high as 200,000 bits per inch, the next step is likely to be vertical recording, in which the magnetized areas of the medium are oriented vertically, instead of in parallel to the surface. Researchers in the U. S. and Europe are at work, but the Japanese are unquestionably in the lead.

Components conference crosses many boundaries, 121

This year's Electronic Components Conference takes off from its base of new developments in components and hybrids to include such fields as packaging very large-scale integrated circuits, manufacturing processes, optical hybrids, and even semiconductor processing and technology.

Digital scope reaches into analog realm, 131

By using what is called a dual-rank flash-flash converter, a digital storage oscilloscope can handle nonrepetitive waveforms with components as high as 50 megahertz. Thus the scope has waveform-storage capability that is comparable to analog equipment.

Executive module for operating system fits on two chips, 137

A real-time multitasking executive, supplied in two ultraviolet-light–erasable programmable read-only memories runs identically on the 68000, the 8086 and 8088, and the Z8000, with a version for the 16000 on the way. This standardized operating-system kernel is a prime example of a silicon software component.

Virtual-phase clocking speeds up CCD image sensor, 141

A structure that uses a single level of clocked polysilicon gates working together with grounded junction electrode (providing a second, virtual phase) permits a single pulse train to shift electrons down charge-coupled-device registers in an image sensor. The CCD sensor can scan images line by line accurately at high speeds.

And in the next issue . . .

A system on a chip for subscriber-line interfaces in the telephone network . . . what's in store at Electro/82 technical sessions . . . high-speed data conversion: three approaches.

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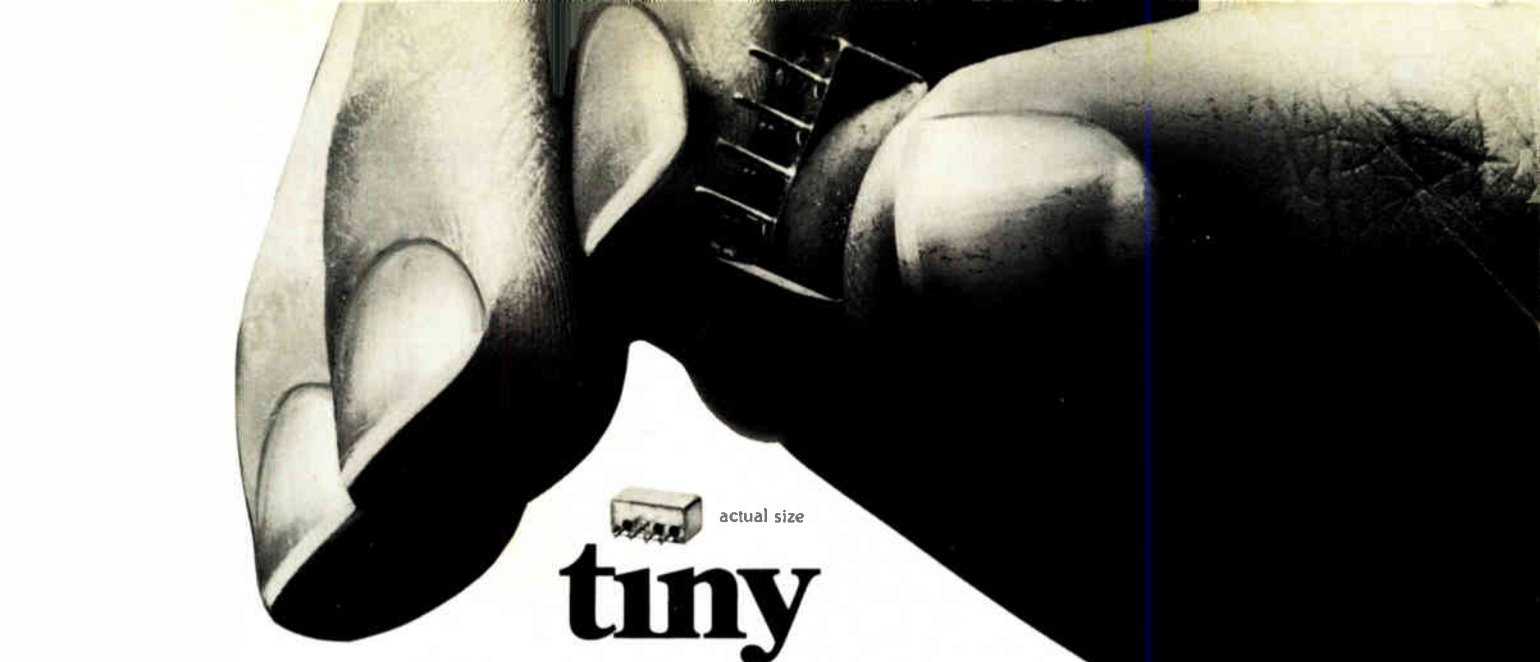

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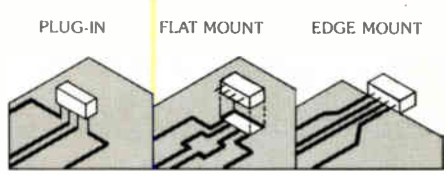

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Circle 5 on reader service card

Publisher's letter

The insatiable appetite of computers and microcomputers for memory continues to press technology to produce more and more bit capacity at ever lower cost. Semiconductor memories have dominated the pages of the press over the last few years, but most of the bits being moved and processed by today's computers are written into and stored in devices that depend on much older technology—namely, magnetic storage—and get their high performance from much less glamorous, but no less clever, mechanical engineering.

Despite the dependence on technologies with a longer history than semiconductors, however, there is yet much lively innovation, according to Computers & Peripherals Editor Tom Manuel.

Tom, who conceived, assembled, and edited the special report on high-density magnetic storage that begins on page 106, found plenty of evidence that this technology is not standing still. "One approach is to scale down the larger Winchester disk drives to 8- and 5¼-inch units and to squeeze performance from them, just as semiconductor manufacturers are shrinking memory chips and squeezing out more speed and capacity," he says.

"A second approach is to change form factors. Examples: the development of removable 5¼-in. Winchester cartridges by DMA Systems Corp., Santa Barbara, Calif., and the engineering of Winchester hard-disk performance and reliability by Iomega Corp. of Ogden, Utah, into a flexible disk in a removable cartridge that gives the advantages of both.

"The third branch of innovation is going into the magnetic technology itself," Tom says. "We're beginning to see the introduction of thin magnetic films in both heads and disks with great potential in increased storage density. Whereas thin-film–head technology is still coping with problems of yield and reproducibility, thin-film disks combined with ferrite heads appear to be headed for a successful launch."

In the course of preparing his report, Tom came upon a growing interest in a totally new approach to magnetic storage: vertical recording. This is a technique that can increase storage densities by an order of magnitude and has the potential of making obsolete all the current disks now on the market. You'll find out all about it in Tom's Probing the news on page 89.

It's called the Electronic Components Conference, but that hardly does justice to the scope of the 60 papers that make up this year's program, according to Jerry Lyman, our Packaging & Production Editor. Jerry's beat includes an annual assessment of this important gathering, and each year he's amazed at its expanding charter. "There are components papers to be sure," he says, "but there are also presentations on packaging, connector manufacturing, hybrids, soldering and bonding, reliability, semiconductor processing, and much more."

For those with a nostalgic affection for vacuum tubes, there's even a paper on a new high-speed cold cathode tube for high-power switching. You can read about the offerings starting on page 121.

Time to order your *Electronics* editorial index

The index of all editorial material that ran in 1981 (Vol. 54) is now available. To get your copy, simply circle No. 370 on the reader service card inside the back cover. If the card is missing, order by letter from Kathleen Morgan, *Electronics*, 1221 Ave. of the Americas, New York, N. Y. 10020. The 1981 index is free; indexes for previous years can be purchased from our reprint department for $4.00 each.

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Readers' comments

Reading, writing, and computers

To the Editor: Thank you for your badly needed article on the operating systems available ["Operating systems hold a full house of features for 16-bit microprocessors," March 24, p. 113], especially for the newer 16-bit machines on the market. However, I feel there was a big oversight in not mentioning such established operating systems such as the RT-11 from Digital Equipment Corp.

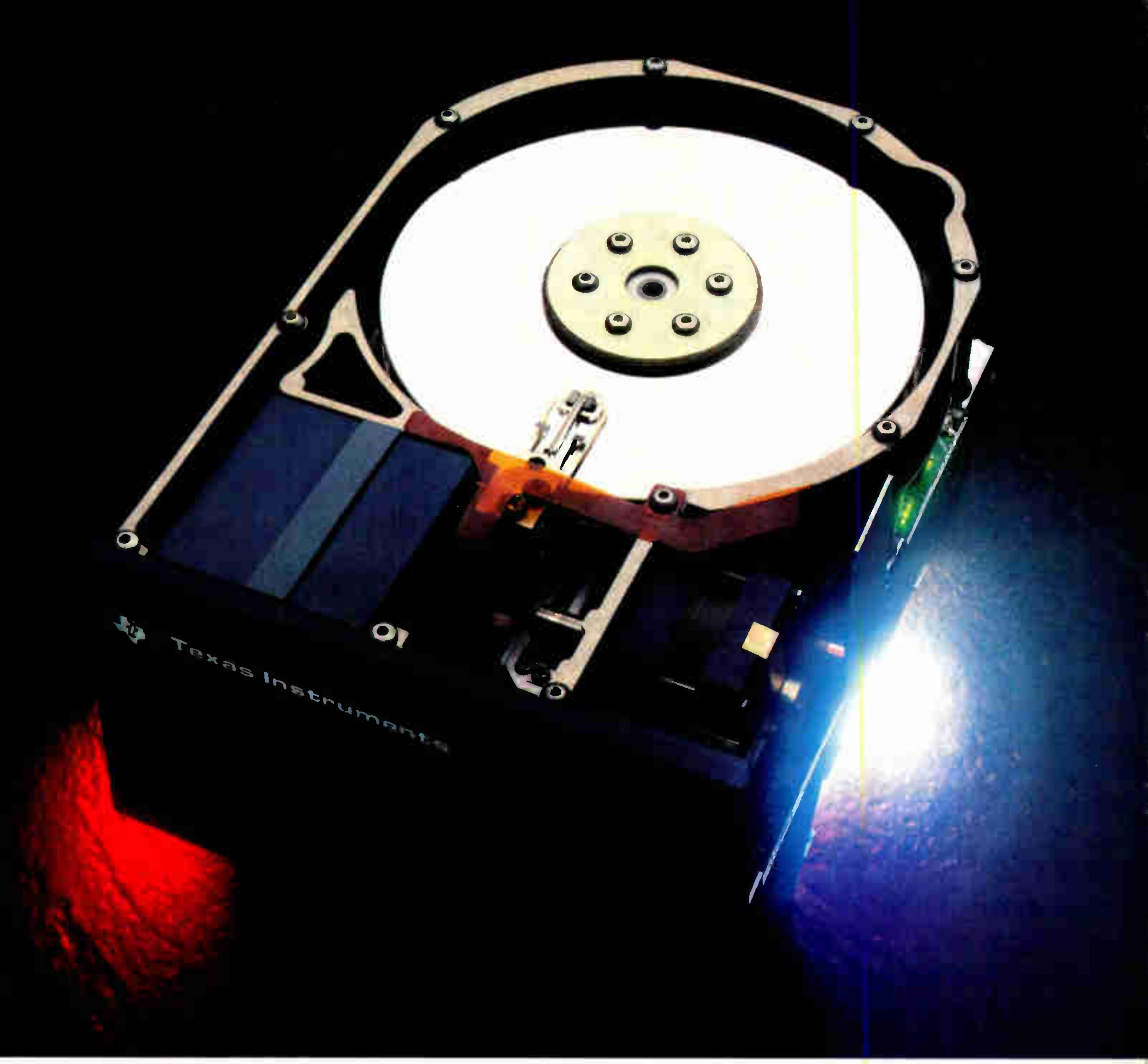
As a nonprofit foundation, we are packaging systems for schools centered on the Q-bus with 22-bit addressing. This approach allows all the students at a school to learn an operating system as they learn Basic, machine language programming, hardware concepts and word processing (or editing) and attain computer literacy. With RT-11, we have already done this in one rural school with some seventy 11th and 12th graders in 21 clock hours.

The operating system can run eight-user Basic in the foreground with, for example, a spooler in the background. More importantly, the RT-11's system generation capabilities allows students to build their own system monitors or operating systems in Fortan, Macro, Pascal, or other languages.

The operating system runs eight-and hardware options, it is very easy to overlook viable 16-bit (and 12-bit) options. By reading history, or in some cases, by living it, one finds it seems to take 8 to 12 years to debug and mature an operating system, although it appears somehow the new breed is zapping them to market in some six months. For the more skeptical, there are established systems from DEC, Data General, and Intel, among others. Because their listings can be purchased, studied and manipulated, some of these also have greater teaching value.

I am sorry my limited experiences do not allow me to present what I feel are equally valid arguments for other older and wiser vendors. I simply wanted to support my case, such as it is, with real examples.

Elmo Knoch
National Braille Resources Inc.
Harrison, Ark.



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TEXAS INSTRUMENTS

Circle 9 on reader service card

News update

■ Last month Sperry Univac moved out the general manager and laid off more than half of the research and development staff of its floundering Mini-Computer Operation. These moves have led to speculation that Sperry might throw in the towel, after investing at least $75 million, for its Irvine, Calif., operation.

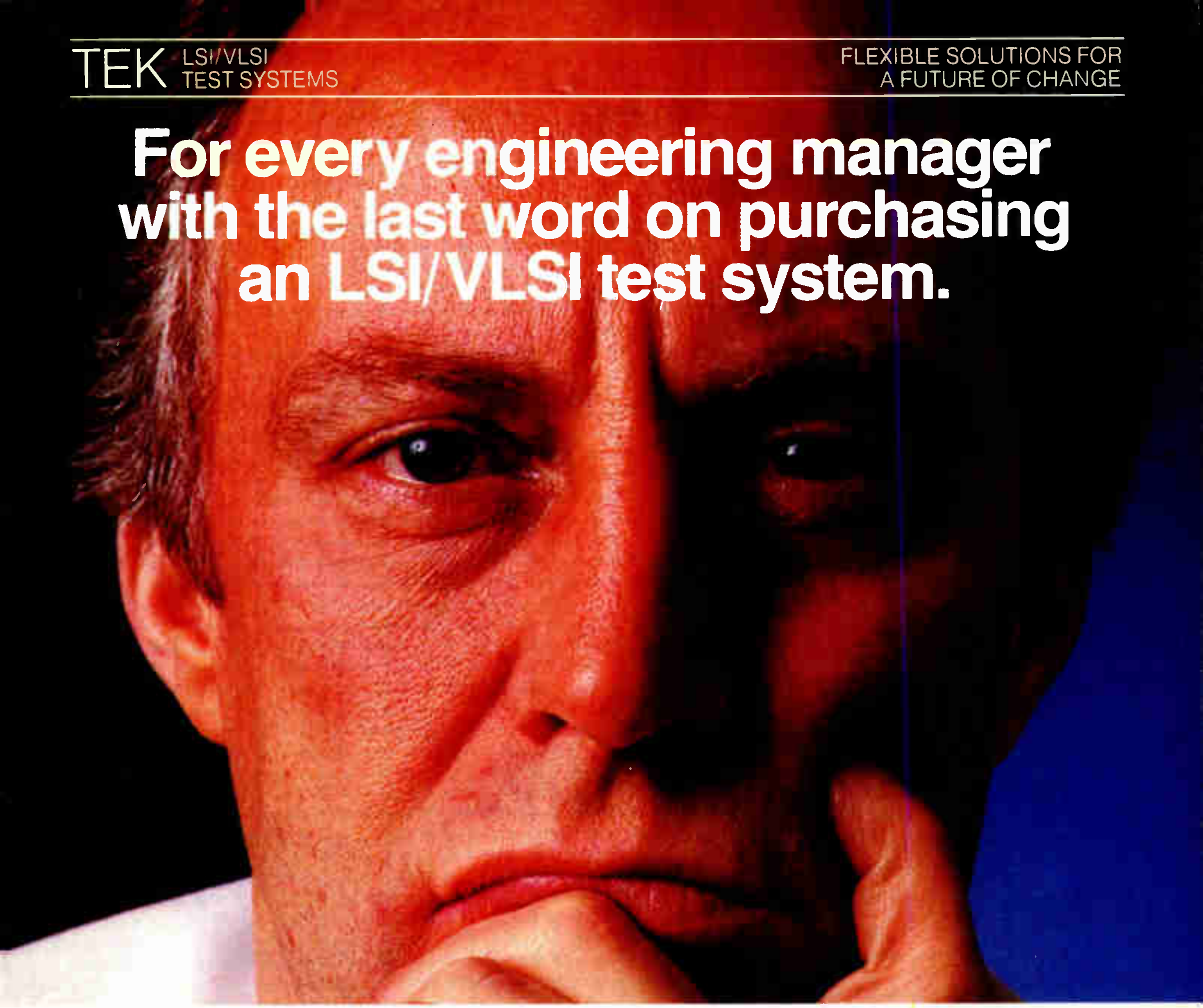
Only last year [*Electronics*, July 28, p. 48], Sperry Univac tried to revitalize the group with new management and a revised product line. "Nothing has changed. Minicomputers are not Sperry's natural habitat," says Ulric Weil, vice president at Morgan Stanley & Co.

Ex-general manager Neil Gorchow, a 25-year man at Sperry who now awaits reassignment, began a thrust to sell minicomputers into Sperry's mainframe base. His replacement, Eugene B. Rawles, named marketing vice president when Gorchow came aboard, concentrated on sales to original-equipment makers. Rawles, who also has 25 years at Sperry, joined the minicomputer operation after Sperry acquired it from Varian Associates in 1977 for $40 million.

Since making the purchase, Sperry has made little headway in increasing market share. For example, market-researching firm Dataquest Inc., Cupertino, Calif., does not list Sperry among the top 20 minicomputer firms. It notes that Sperry's overall computer operations grew by only 5.9% last year, and Sperry admits that "minicomputers have been hit harder [by the recession] than our other lines."

The layoffs drop the R&D staff to 225 and the total staff in Irvine to slightly below 300, a far cry from 1,200 only a year ago. Late last year, Sperry laid off 200 manufacturing personnel. It is in the process of transferring the remaining 300 to a Sperry facility in Salt Lake City.

However, Sperry pledges to "develop, build, and support" its V-77 family of 8- and 16-bit minicomputers. A 32-bit machine is set for introduction this month, but its prospects are not bright. "The market is flooded with 32-bit machines," notes Weil. **-Terry Costlow**



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COMMITTED TO EXCELLENCE

Why should the military settle for old technology?

The huge deficits being projected as a result of the Reagan economic program have justifiably brought military spending under intense scrutiny. The Administration's options on actions to close what appears to be an unacceptable gap between spending and income are beginning to focus on the immense proposed military budget. Part of the questioning of this budget centers on whether many of the programs being advanced are really needed. This is a strategic and political debate, and for the moment we'll leave the argument to those pundits who are more intimate with the pros and cons of that aspect of defense policy.

Another part of the doubts on military spending arises from the question of inefficiency, waste, and duplication in procurement practices. Seekers of savings question whether the nation is getting full value for the huge sums we the people are paying for our nation's defense. On this point, we submit, history provides no encouragement. The long and seemingly hallowed tradition of large cost overruns on military development and procurement programs—even when successfully completed—speaks for itself.

A major problem, not often discussed, stems from the long cycle time that is symptomatic of military procurement of large complex systems, a cycle time that often spans 10 years or more. While the specifications and the proposals and the brochures wend their way tortuously through the thickets of design definition, bid, acceptance, design prototype, and ultimately acceptance and production, the technology initially specified for use in the system may have undergone several generations of evolution or may have become entirely obsolete. The result is that the system that finally arrives in the field is operating with 10-year-old technology and 10-year-old specifications, with a performance capability far below what is technically possible.

Part of the problem is the inherent conservatism of the military establishment, and this is certainly justified and necessary. Obviously, the national defense cannot gamble with unproved technology, and we're not arguing that this be done. We are arguing, however, for the utilization of available technology a lot sooner than is happening right now.

We think it's possible, and so do a lot of industry executives—like the semiconductor-firm vice president who, at a recent quality-control conference, pointed out the experiences of the automobile and computer industries. "In many ways," he said, "their requirements and specs are tougher than the military's. They are tough customers; they demand a lot. But they're getting the latest technology, and we're delivering it—on time." However, the layers of bureaucracy, the painstaking paperwork, and the infighting among entrenched factions in various branches of the Department of Defense discourage many of the companies responsible for major innovation in electronics over the past decade from participating in defense procurement.

The Very High-Speed Integrated-Circuits (VHSIC) program is designed to make available to the services by the late 1980s state-of-the-art technology in the form of very large-scale ICs that can be used in a number of military systems. Even if those circuits are forthcoming on schedule, getting the services to accept them and design them in is where the real battle will be fought. There is a good probability that those VHSIC parts may be 10 years old when they see their first system. Surely such waste is unacceptable.

People

Santoro of Silicon Systems takes the custom-IC route

Carm Santoro expects some curiosity about his move from the job as vice president for integrated circuits at RCA Corp.'s \$240 million Solid State division to become president of Silicon Systems Inc., a \$13 million custom house. But he justifies the transition by saying, "Since 1975, I've held the fundamental belief that there was going to be a custom renaissance. And Silicon Systems has the rudiments to be at the forefront of it."

Renaissance man. Carm Santoro expects a resurgence in custom ICs and sees his firm in the vanguard.

This renaissance will cause "almost the same type of change as going from discretes to ICs," he notes. Santoro says that during stints as group operations manager for Motorola Inc.'s Solid State division and then group vice president for memories and microprocessors at American Microsystems Inc., he considered startups in the custom field but never found the right fit. He has been involved in MOS technology since receiving his doctoral degree in solid-state physics from Rensselaer Polytechnic Institute in Troy, N. Y., in 1967.

Santoro points to four aspects he feels a successful custom house must have. "The first thing you need is quick turnaround, using an elegant computer-assisted–design system. Second is design capability, or personnel. You also need a reasonable selection of technologies, and you've got to have fab," notes the 40-year-old executive. He says Silicon Systems has the first three, and its wafer fabrication facility should go on line this summer.

The wafer facility is being designed to support complementary-MOS and bipolar technologies, so the Tustin, Calif., firm will continue to go outside for expertise in n-channel and p-channel MOS. Additionally, Santoro says he will maintain external C-MOS and bipolar second sources. Internally, C-MOS was picked because at present "it's the ultimate technology," although bipolar is still important because of its speed. He is maintaining external sources for the other technologies chiefly because the wide-ranging nature of customized products requires a diversity of approaches.

Santoro this month completed his analysis of the firm and reorganized it to streamline management by grouping related operations. He has also selected areas he will step away from, saying they are or soon will be commodity items that will not call for custom chips.

"We'll no longer be in voice synthesis or voice recognition. They're like watch chips: they come from the Far East as standards. We won't participate in automotive markets either," he says. Instead, the nine-year-old firm will focus on "rotating memory—where we have a major market share in read-write circuitry—telecommunications, custom-owned tooling—where we'll be a foundry—and the military."

Casilli will use Genesis to create new companies

For Gerald S. Casilli, the cofounding of Millennium Corp. in Cupertino, Calif., some nine years ago was a dream—a dream that almost turned into a nightmare. Now, after a successful battle by Casilli and his management team to bring Millennium back to the \$13 million sales level of its heyday, he is ready to live another dream—as a venture capitalist in high-technology.

"I want to use my management

People

Venture. Gerald Casilli is ready with cash and management expertise for new firms.

experience to the benefit of these new businesses," says the 42-year-old Casilli. And some experience it has been. He helped to start Millennium, 10 years after joining General Telephone & Electronics Corp., and was president and chief executive officer of the high-flying maker of universal microprocessor development systems.

But then in 1979 its major customer, Tektronix Inc., decided to go into the development-system business for itself. Thus in a single swoop Millennium lost $11 million of its $13 million in sales for that year. Since then, the company has worked toward a comeback even as it was acquired by American Microsystems Inc. and AMI in turn was purchased by Gould Inc.

That experience behind him, Casilli, with a bachelor's in electrical engineering from the University of Pittsburgh, says that his new firm, Genesis Capital Corp., in Los Gatos, Calif., initially will have some $20 million in its fund, primarily from its limited partner, the First National Bank of Seattle. Casilli's preferences are new companies in computer-assisted design, computer-aided engineering, software, office and factory automation, communications, and other industries related to productivity enhancement.

"Venture capital is one place where one person can make a big difference," Casilli says. Now that he's gone from the Millenium to Genesis, he can help create some of that difference. □

Now for the first time you can drive an electromechanical relay directly with the signals of most logic families—including CMOS. That means simpler board layout problems and reduced components counts for greater reliability.

The new Centigrid relay incorporates a power FET driver in the input to amplify the signal, protects it with a large Zener diode, and packs it all together with a DPDT relay and coil suppression diode in a tiny Centigrid style can. And make no mistakes . . . it is a Centigrid relay designed to meet the requirements of MIL-R-28776. Its ruggedness and proven contact reliability are industry bywords.

Ultraminiature Centigrid relays have proven extremely effective in applications where high board density and close board spacing are critical. Low power requirements make them exceptionally valuable for battery operation, and they have excellent RF characteristics up through UHF.

The new Centigrid is available in both general purpose (116C) and sensitive (136C) versions. Call or write today for complete information or applications ideas.

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TEK DAS 9100 DIGITAL ANALYSIS SYSTEM

Tektronix introduces 132 state of the art logic analyzers, in one.

A new concept in logic analysis.

Now you can have a single logic analysis system that is both configurable and upgradable. All with unprecedented performance and flexibility.

It's the DAS 9100. A single mainframe that houses up to six card modules. With acquisition speeds up to 660 MHz, timing resolution down to an unprecedented 1.5 ns, data widths up to 104 channels and synchronous or asynchronous operations.

And for the first time, you can combine *pattern generation with data acquisition*. Pattern generation provides stimulus data widths up to 80 channels and speeds up to 25 MHz.

Need I/O capability? There's an option that adds RS-232, GPIB and hard copy interface. And another for a built-in magnetic tape drive system.

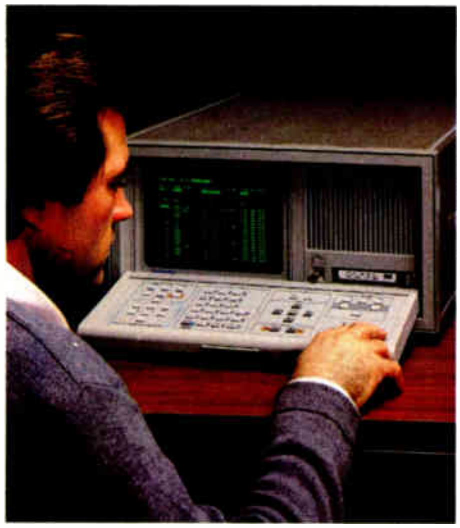
Select your own width and speed combination, for data acquisition.

DAS 9100 gives you four different data acquisition modules to use as building blocks. Each has its own data width and maximum speed: 32 channels at 25 MHz; 8 channels at 100 MHz with glitch memory; 4 channels at 330 MHz or two channels at 660 MHz. Modules can be combined to give you the performance you need.

Need high speed performance? One module can track your system clock (synchronously) at speeds up to 330 MHz or provide asynchronous sampling to 660 MHz. The eight channel module provides *both* synchronous and asynchronous sampling at 100 MHz. And the 32 channel module can be used to arm the trigger on those with higher acquisition rates.

To obtain the data width and speed your application calls for, simply select the appropriate combination of modules and add on later as your needs change.

To back it all up, there's powerful triggering, programmable reference memory and multiple clocks. Plus glitch triggering, with a separate glitch memory for



unambiguous glitch detection and our unique, new "arms mode" allows timing correlation between synchronous and asynchronous data.

DAS 9100 integrates the power of pattern generation with data acquisition.

At last, you can have a tool that covers your digital system debugging needs. By combining pattern generation and data acquisition modules, you can stimulate your prototype while simultaneously analyzing its operation. Allowing you to enter a whole new dimension of design analysis and verification.

Pattern generation capability is built around a 16 channel, 25 MHz module. Through additional expansion modules, you can raise the total to 80 channels while maintaining full system speed. The pattern generator allows interaction with the prototype through data strobe outputs and external control inputs, including an interrupt line. The generated pattern can even be changed based on the data acquired by the logic analyzer.

The DAS 9100 lets you start debugging hardware even before your software is available. Pattern generation makes it all possible.

With plenty of room for mainframe options to fit your application.

A powerful I/O option adds RS-232, GPIB and hard copy interface for full remote programmability. A built-in magnetic tape drive using DC-100 cartridges is also available, so you can save whole or partial instrument setups for recall. Pattern generation routines and reference memory data also can be stored.

DAS 9100 easy-to-use keyboard and menus tie it all together.

Operation of your DAS 9100 is simple and straightforward. Selectable menus help you set up trigger conditions, select data formats, and define voltage thresholds. You can even define your own mnemonics to fit the data under test.

How does it all go together?

In whatever combination your application calls for, or choose one of these pre-configured packages from Tektronix:

The DAS 9101. 16-channels of data acquisition at 100 MHz.

The DAS 9102. 32-channel of data acquisition at 25 MHz plus 16-channels of pattern generation.

The DAS 9103. 32-channels of data acquisition at 25 MHz plus 8 more channels at 100 MHz. And 16-channels of pattern generation.

The DAS 9104. 80-channels of data acquisition, with 64-channels at 25 MHz and 16-channels at 100 MHz. Plus a 16-channel pattern generator with a built-in DC-100 magnetic tape drive.

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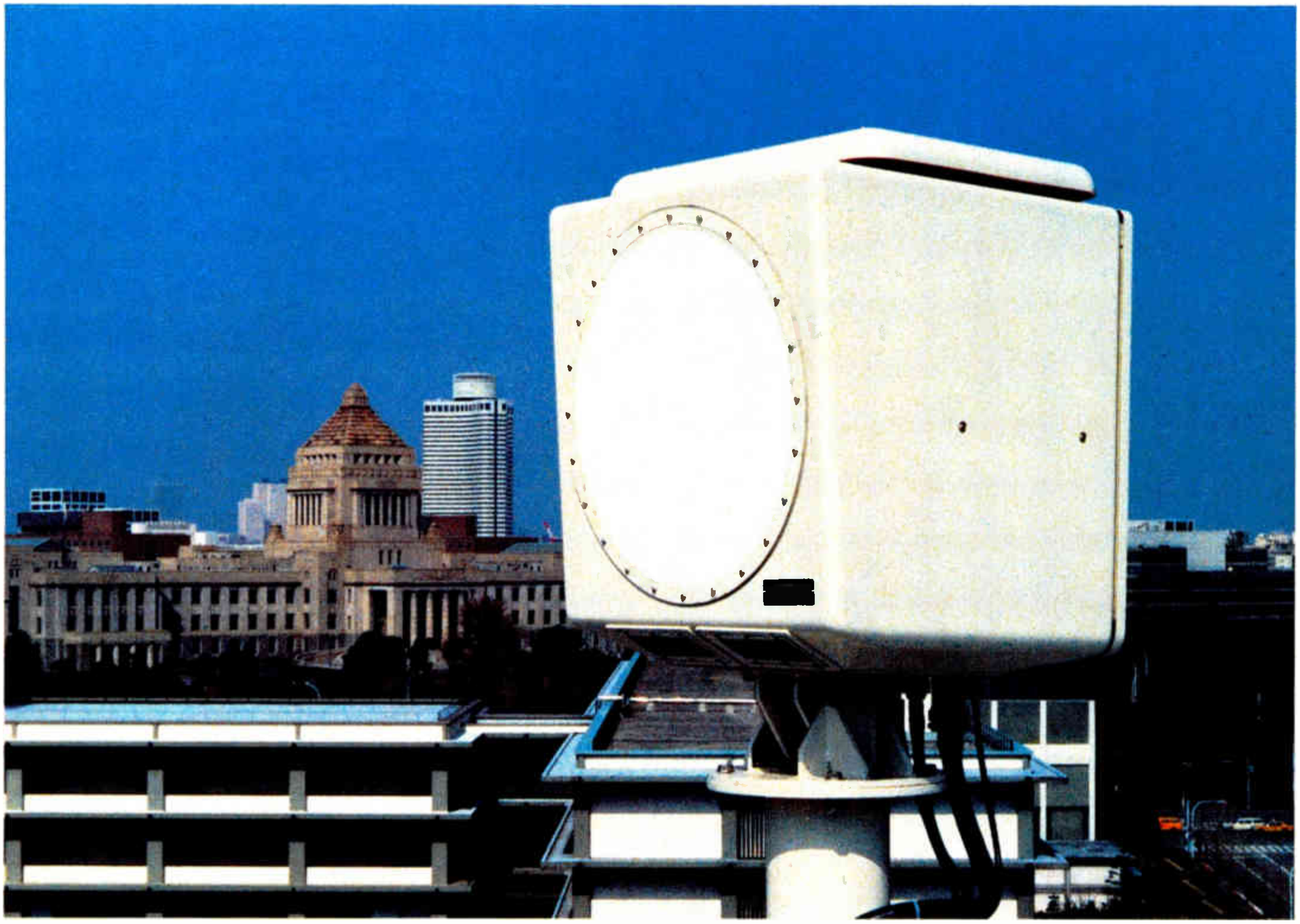


40GHz MULTIPLEX DIGITAL RADIO SYSTEM NOW IN SERVICE

The world's first 40GHz fixed multiplex digital radio system now links Japan's central government offices in Tokyo.

Developed by NEC, the system transmits information at a bit rate of 6.312Mb/s (equivalent to 96 VF channels). It consists of 40GHz multiplex radio equipment, PCM transmission terminals, and remote control and supervisory equipment. With looped main and standby routes, the system is fully redundant and is designed to operate even during such disasters as earthquakes and floods.

Millimeter wave digital radio is considered very effective as a short-haul information link, especially for urban areas. The millimeter wave permits broadband transmission and has good directivity, making interference-free system design and installation easy, as well as making possible a multiplex radio system. And equipment for millimeter wave communications are extremely compact.

In northern Japan, a university in Sendai plans to have its computer center connected to a campus 3.7 kilometers away by an NEC-equipped 40GHz millimeter wave digital radio data system.

NUMBER 123

NEC-EQUIPPED CRAFT DIVES TO RECORD DEPTH

By reaching a depth of 2,008 meters, a deep submergence vehicle has set a new Japanese diving record.

The Shinkai 2000, built for the Japan Marine Science and Technology Center, is 9.3 meters long, 3 meters wide, and weighs 24 tons. Its globular pressure hull is made of 3 cm thick super-high tensile strength steel to protect two pilots, one researcher, and electronic equipment from extreme water pressure.

NEC was responsible for integrating the control console of the Shinkai 2000. NEC also supplied underwater telephones, altitude/depth sonar, forward obstacle avoidance sonar, acoustic direction finders, a transponder and an emergency pinger.

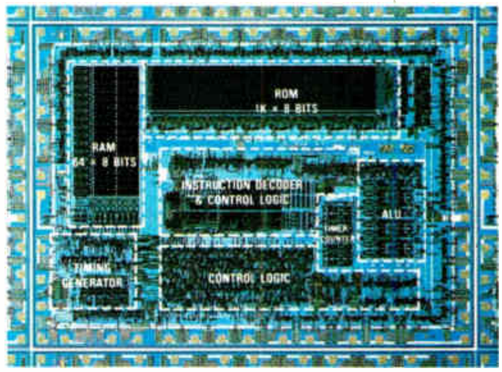
The 1,553-ton support ship was also NEC equipped, with a precision depth echo sounder, high resolution side-scan sonar, and underwater telephones.

The Shinkai 2000 will be used to collect data for prediction of underwater earthquakes, to study deep sea plants and animal life in Japanese waters, and to explore for mineral resources within the deep sea bed.

NEW STAND-ALONE 8-BIT MICROCOMPUTER USES LESS POWER

A new CMOS stand-alone 8-bit microcomputer contains all the necessary functional blocks: 1 k byte ROM, 64 byte RAM, 27 I/O lines, on-chip 8-bit timer/event counter, and clock generator.

Compatible with industry standard NMOS 8048 and 8748 products, the CMOS μPD80C48 reduces power consumption significantly. And its "Halt" and "Stop" modes further augment power conservation.



In the "Halt" mode, internal clocks and logic operations are discontinued. The oscillator, however, continues to function and all internal logic and control status prior to "Halt" mode engagement are maintained. Power consumption under this mode is less than 10% of that during normal operation and less than 1% of the power needed for the 8048 operation.

The "Stop" mode saves even more power by discontinuing oscillator operation and retaining only the contents of the RAM.

The μPD80C48 may also be employed together with other CMOS devices including I/O expander μPD82C43 and memories.

TELECONFERENCES GO BETTER WITH NETEC-X1

Enhanced teleconferencing is promised by NETEC-X1, a television interframe codec that converts NTSC color television signals with audio into low bit rate digital signals of 1.544Mbps.

NEC's new product has a data compression ratio as high as 1/40th of the conventional rate, so transmission cost is greatly reduced. In spite of this, NETEC-X1 reproduces pictures with excellent quality. The essential feature of the system is that it transmits only the difference between two picture frames through a unique interframe coding.

On the audio side, the system uses a broader band for signal transmission than that of telephones, so that subtle vocal nuances can be discerned.

The NETEC-X1 can also be connected with coaxial PCM transmission links, terrestrial digital microwave links and TDMA satellite links.

NETEC-X1 applications other than teleconferencing include educational television, traffic or security control and remote medical diagnosis.

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Are you designing a high-performance system? Call or write AMD. We're a whole lot faster than fast.

The International Standard of Quality guarantees these electrical AQLs on all parameters over the operating temperature range: 0.1% on MOS RAMs & ROMs; 0.2% on Bipolar Logic & Interface; 0.3% on Linear, LSI Logic & other memories.

INT-STD-123

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Computer innovation needs the university market

by **Kenneth G. Wilson,** *professor of physical sciences, Cornell University, Ithaca, N. Y.*

Universities and high-technology small businesses are closely linked. Small firms are often the only source of sophisticated computer equipment needed by universities, and universities are among the few buyers willing to take a risk on an innovative product. However, this link is being severely weakened by the decline in university financial support.

Small businesses face two problems following a product announcement: bringing the product to maturity to fully meet market needs and company survival as this "growing up" occurs. The university market plays a critical role in supporting new firms during this time. In addition, university personnel test the device and then feed back performance data to the company along with suggestions for improvement. They often demonstrate novel product uses as part of their effort to stay competitive in their research. Students are given time to work with immature systems, and the experience helps provide them with up-to-date training.

Universities also help win commercial acceptance for successful product designs. They accept inquiries and site visits from potential commercial customers, and they can even provide comparative information on similar designs. The open and public character of the university encourages such interchanges.

Unfortunately, universities are increasingly unable to perform these essential economic functions and the effects are beginning to be felt. For example, Digital Equipment Corp., Prime Computer, and Amdahl all received an early boost to commercial success from the university market. On the other hand, Denelcor Inc., a small computer and component company based in Aurora, Colo., may not be so fortunate. It has designed a supercomputer called HEP—a major advance in computer architecture. With additional development, HEP could lead to systems many times more powerful than even the proposed Cray-2 and so compete with Japan's proposed fifth-generation computer hardware. It should be noted that the major U. S. manufacturers have not yet entered this fray.

Although several universities are eager to buy the system—despite the fact that it is untested, not very cost-effective yet, and lacking in associated software—its $1.5 million price tag is too high for universities to receive financing from either Government granting agencies or private funding organizations. My fear is that Denelcor must now be less innovative so that its products can be sold immediately in commercial markets, thus slowing technological development.

Meanwhile, the Japanese fifth-generation computer effort will charge ahead. I fully expect that some top U. S. software designers will be eager to join this effort—once the Japanese hardware plans are clarified. Most ominously, Japanese industry is likely to learn how to use the awesome power of these systems before U. S. industry does.

The main hope the U. S. has to keep ahead of the Japanese challenge is to encourage collaboration between small businesses developing innovative computing systems and university research projects. This cooperation is particularly important for research projects that will demonstrate innovative uses of commercial systems, or for university computer-science research projects whose ideas are well-matched to a small business's computer design.

The growth in computing technology is straining the universities in other ways. For example, every computer purchased by industry or government leads to demands for more university-trained personnel.

To finance the many technological functions of universities, I propose a surcharge on all computing equipment sold in the U. S. that would be used for university support. It would enable universities to keep pace with the growth of computing technology and would help restore the vitality of new-product development to small businesses.

Electronics *will periodically invite the expression of outside views on this page concerning issues of importance to the electronics industries.*

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Meetings

National Aerospace and Electronics Conference, IEEE (M. J. Terbay, Naecon '82, 4126 Linden La., Dayton, Ohio 45432), Dayton Convention Center, May 18–20.

Northcon/82 Show and Convention, Electronic Conventions Inc. (999 North Sepulveda Blvd., El Segundo, Calif. 90245), Seattle Center Coliseum, May 18–20.

International Defense Electronics Expo '82, Kiver Communications (Information Center, P. O. Box 338, Whitehouse, N. J. 08888), Hanover Fairgrounds, Hanover, West Germany, May 18–25.

Vehicular Technology Society Conference, IEEE (Eddie Simon, 1970 B St., San Diego, Calif. 92102), Town and Country Hotel, San Diego, May 23–26.

International Semiconductor Power Converter Conference, IEEE (E. E. Von Zastrow, General Electric Co., Building 37-478, P. O. Box 43, Schenectady, N. Y. 12301), Hyatt Hotel, Orlando, Fla., May 24–27.

Electro '82, IEEE (Dale Litherland, Electronic Conventions Inc., 999 North Sepulveda Blvd., El Segundo, Calif., 90245), Boston Sheraton Hotel, May 25–27.

Semicon/West '82, Semiconductor Equipment and Materials Institute (625 Ellis St., Suite 212, Mountain View, Calif. 94043), Fairgrounds, San Mateo, Calif., May 25–27.

Microcomputer Show '82, Japan Electric Industrial Development Association (3-5-8 Shiba Koen, Minato-ku, Tokyo 105), Tokyo Ryutsu Center, May 26–29.

Trends and Applications 1982: Advances in Information Technology, National Bureau of Standards (Allen Hankinson, NBS Administration Building, A209, Washington, D. C. 20234), NBS, Gaithersburg, Washington, D. C., May 27.

Electron-, Ion-, and Photon-Beam Technology Conference, IEEE (P. H. P. Cheng, IBM Research Center, P. O. Box 218, Yorktown Heights, N. Y. 10598), New York, June 1–4.

Solar Technologies Conference and International Exposition, International Energy Society (American section of the IES, U. S. Highway 190 West, Killeen, Texas 76541), Albert Thomas Convention Center, Houston, June 1–5.

International Conference on Management of Data, Association for Computing Machinery (D. S. Batory, executive committee chairman, 512 Weil Hall, Gainesville, Fla. 32611), University of Florida, Orlando, Fla., June 2–4.

National Computer Conference, American Federation of Information Processing Societies Inc. (Betty Lou Cooke, Afips Inc., 1815 North Lynn St., Arlington, Va. 22209), Astrohall, Houston, June 7–10.

International Conference on Consumer Electronics, IEEE (Ken Barr, RCA Consumer Electronics, 600 North Sherman Dr., Indianapolis, Ind. 46201), Arlington Park Hilton Hotel, Arlington Heights, Ill., June 9–11.

Seminars

The VHSIC Packaging Seminar is being sponsored by the Solid State Products division of the Electronic Industries Association and the Joint Electron Device Engineering Council. The seminar will be held at Quality Inn Pentagon City, Arlington, Va., on May 18. For information, Call Daniel Amey at (201) 685-1600 or JEDEC at (202) 457-4971.

Beyond the Advanced Work Station, The Yankee Group, 89 Broad St., 14th floor, Boston, Mass. 02110. The event is being held at the Plaza Hotel, New York, June 1–2, and at the Hyatt Rickeys Hotel, Palo Alto, Calif., June 15–16. For details, call Lisa Caruso, (617) 542-0100.

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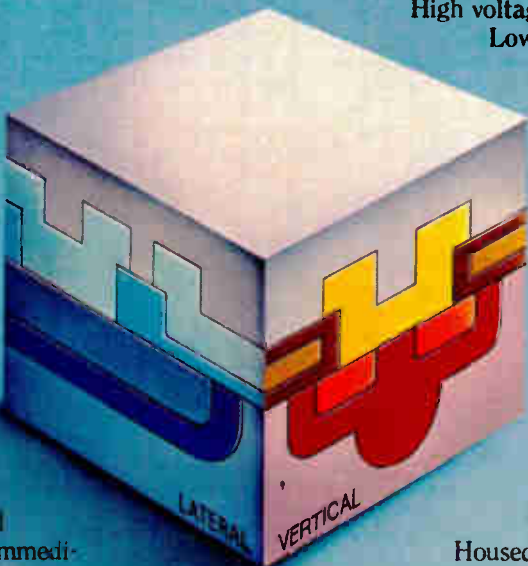

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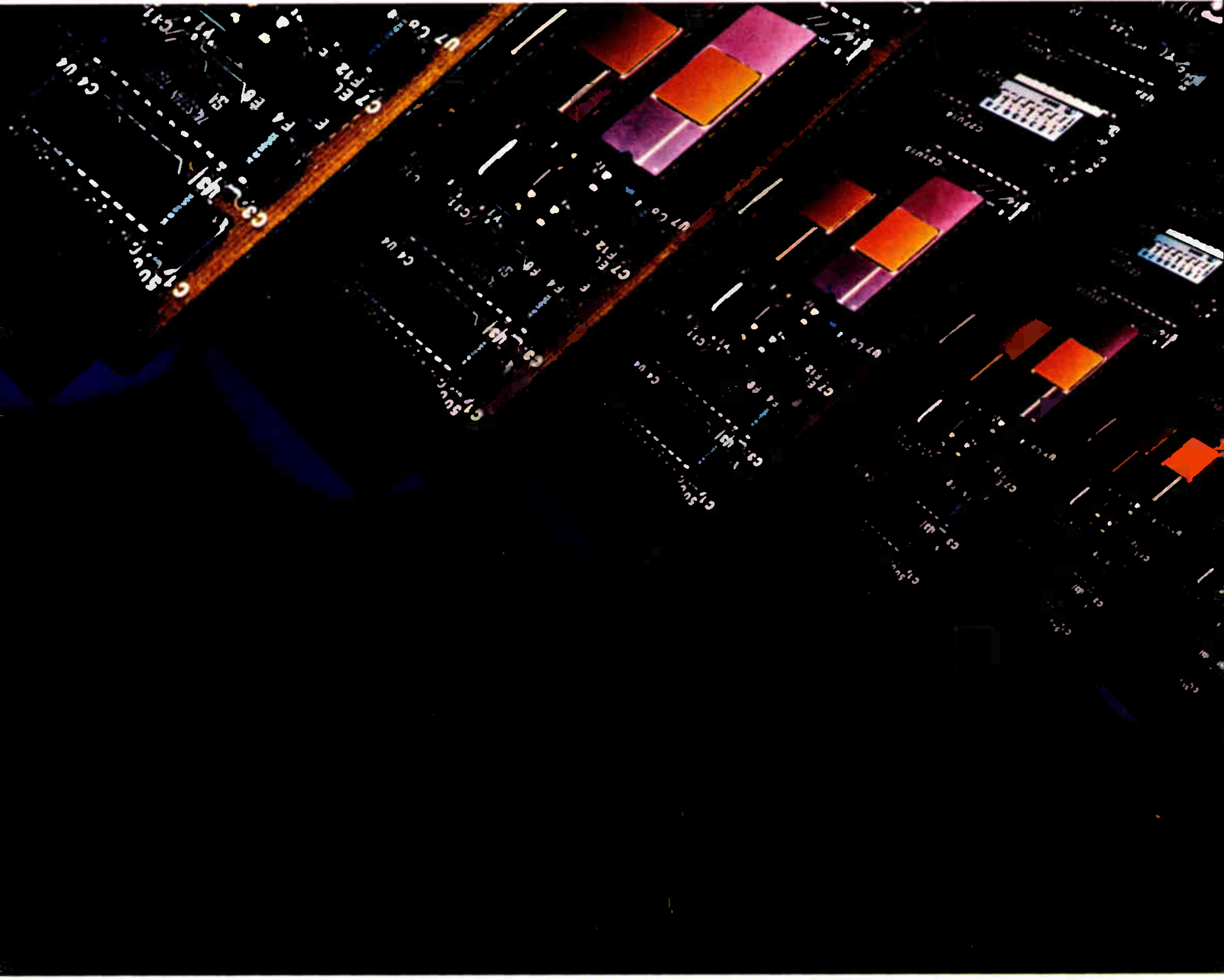

Smart color from Tektronix: Performance and clarity you should see for yourself!

The 4113 combines a crisp, clear color display with true zoom and pan, local segments, and the many other performance extras of the Tektronix 4110 Series. To appreciate the significance of the 4113, you must see it for yourself. No other color terminal so successfully merges high information density with comfortable viewability, or offers such powerful local capabilities at such an affordable price.

You'll see exceptional sharpness and image stability engineered into the 4113's 483 mm (19-inch), 60 Hz non-interlaced display. You can address a 4096 x 4096 point matrix, then zoom and pan to magnify any detail on the 4113's 640 x 480 display. As a result, plots developed on the highest resolution Tektronix displays, such as the 4114, are easily transferred to the 4113 for color enhancement.

You'll see how easy it is to access any of 4096 colors, or to command local graphics, using a minimum of host computer time. The Tektronix Color Standard makes color specification remarkably simple. Work with 8 colors on-screen at once or, with optional bit plane, as many as 16 colors.

Powerful, highly expandable local intelligence lets you retain pictures and picture segments in local memory, then redraw and manipulate with a short command from the host.

The 4113's operating system is wholly compatible with all other 4110 Series terminals, as is its optional, integral flexible disk mass storage. The 4113 is available in either pedestal or convenient workstation configuration. For fast start-up, easy maintenance, CPU and terminal independence, you can take advantage of the Tektronix PLOT 10 Interactive Graphics Library: the most popular implementation of the 1979 SIGGRAPH proposal for a computer graphics standard.

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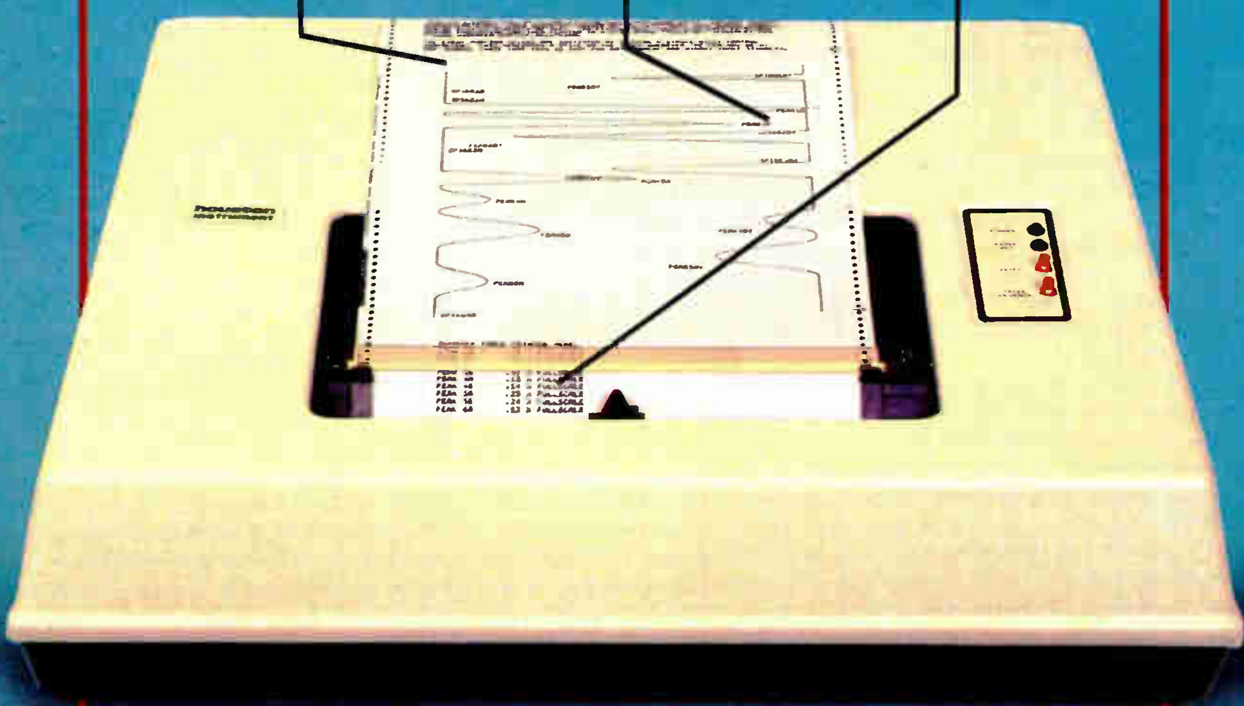

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Electronics newsletter

Sperry, CDC to unveil Z80-based computers

Following IBM Corp.'s lead, both Sperry Univac, Blue Bell, Pa., and Control Data Corp., Minneapolis, Minn., are readying small microprocessor-based computers to complement their mainframe lines. **Both are being offered in response to pressure from their customers** and will feature a Z80 microprocessor, CP/M operating system, and floppy disks for mass storage. These two, along with Hitachi's IBM Personal Computer look-alike, will be shown at the National Computer Conference in June.

Sales spurt seen for personal computers

Despite the lagging U. S. economy, personal-computer retailers remain optimistic about sales growth in 1982, according to a survey of over 400 dealers by Future Computing Inc., a market-research firm in Richardson, Texas. **Those polled last month indicated that they anticipate a 59% increase in sales.** The survey, which will be available in mid-May, also places the average 1981 sales of retail computer stores at $993,000.

U. S. software firm to set up shop in Japan

A major microcomputer software supplier in the U. S. will become by midyear the first such firm to launch a subsidiary in Japan. Micropro International Corp. of San Rafael, Calif., is currently selling software through four Japanese dealers and **hopes to substantially boost sales by translating all documentation into Japanese,** then modifying its software packages to permit kana syllabary input and output, and finally developing full kanji capability for sales to Japanese microcomputer makers.

Reactive-ion etcher yields 0.5-μm spacing

By combining properties of a plasma etcher and an ion-milling machine, Technics West Inc., a six-year-old San Jose, Calif., manufacturer of plasma-generation equipment for thin-film etching, has developed a unit that can etch aluminum interconnects 1 μm deep on 0.5-μm spacing. It is less complex than other such machines. Called a reactive-ion etcher, **it employs a concept developed by Bell Labs in which wafers are mounted on a hexagonal cathode** inside a stainless-steel bell-jar anode. Ions are collimated so that they strike the bottom of the etch pattern, rather than the side walls, essentially eliminating any metal undercutting.

Single chassis bridges differences in disks, backups

A single-chassis answer to proliferating differences between small Winchester disk drives and their tape backups is stirring interest even before its debut, reports its manufacturer, Distributed Logic Corp. The small Garden Grove, Calif., producer of disk and tape controllers says buyers of this equipment face widely varying requirements in power supplies, cooling, and mounting. **The heart of its "multiperipheral chassis" is a hybrid power supply** combining linear and switching features. The unit can handle 42 combinations of drives and backups from 12 manufacturers and sells for $1,700.

Zilog, Toshiba sign technology exchange

Zilog Inc. of Campbell, Calif., and Japan's Toshiba Corp. have signed a technology-exchange agreement under which Toshiba will build and market Zilog's Z80 8-bit and Z8003 and Z8004 16-bit microprocessors. In return, **Zilog gets Toshiba's advanced complementary-MOS large-scale-integration process.** The move is seen as a way for Zilog to get into the C-MOS microprocessor business without having to develop a new process.

Electronics newsletter

Toshiba is expected to announce a C-MOS Z80 by the first quarter of 1983 and a C-MOS Z8000 later that year. Zilog will have access to both designs. In the meantime, Zilog will soon start shipping the Z80L, an n-channel MOS low-power version of the Z80.

Xerox develops optical Ethernet

Xerox Corp. has put together the first fiber-optic version of its Ethernet local network. Known as Fibernet II, it is based on an interactive star architecture that provides signal reception, retransmission, distribution, and collision detection. **The 10-Mb/s prototype can handle up to 25 transceivers through duplex optical cables** with each serving up to eight computers through a multiplexer. A five-transceiver version is now operating at the Xerox Palo Alto (Calif.) Research Center.

Fairchild takes local net route for test management

Fairchild Systems Technology of San Jose, Calif., has climbed aboard the Ungermann-Bass local-network bandwagon with its own network, scheduled for introduction next month. For Fairchild, the move to the Ungermann-Bass–based scheme **represents a major shift in the computation and control of its test systems.** Fairchild will move from its own proprietary computer, the 24-bit FST-2, to a VAX 11/750 or 11/780, and it will shift its programming language from its proprietary Factor language to a superset of Pascal. The unbundled software required to turn its existing Sentry systems into network nodes will cost $100,000 to $170,000. With the computer and two network nodes, the network will cost $250,000.

Also, Teradyne Inc. in Boston is readying a multidrop communications network that is much faster than its RS-232-C–based nets, the TSA and TSM. Built around a PDP-11/44 host, Teranet will transfer data at 100 kb/s and will support up to 250 systems.

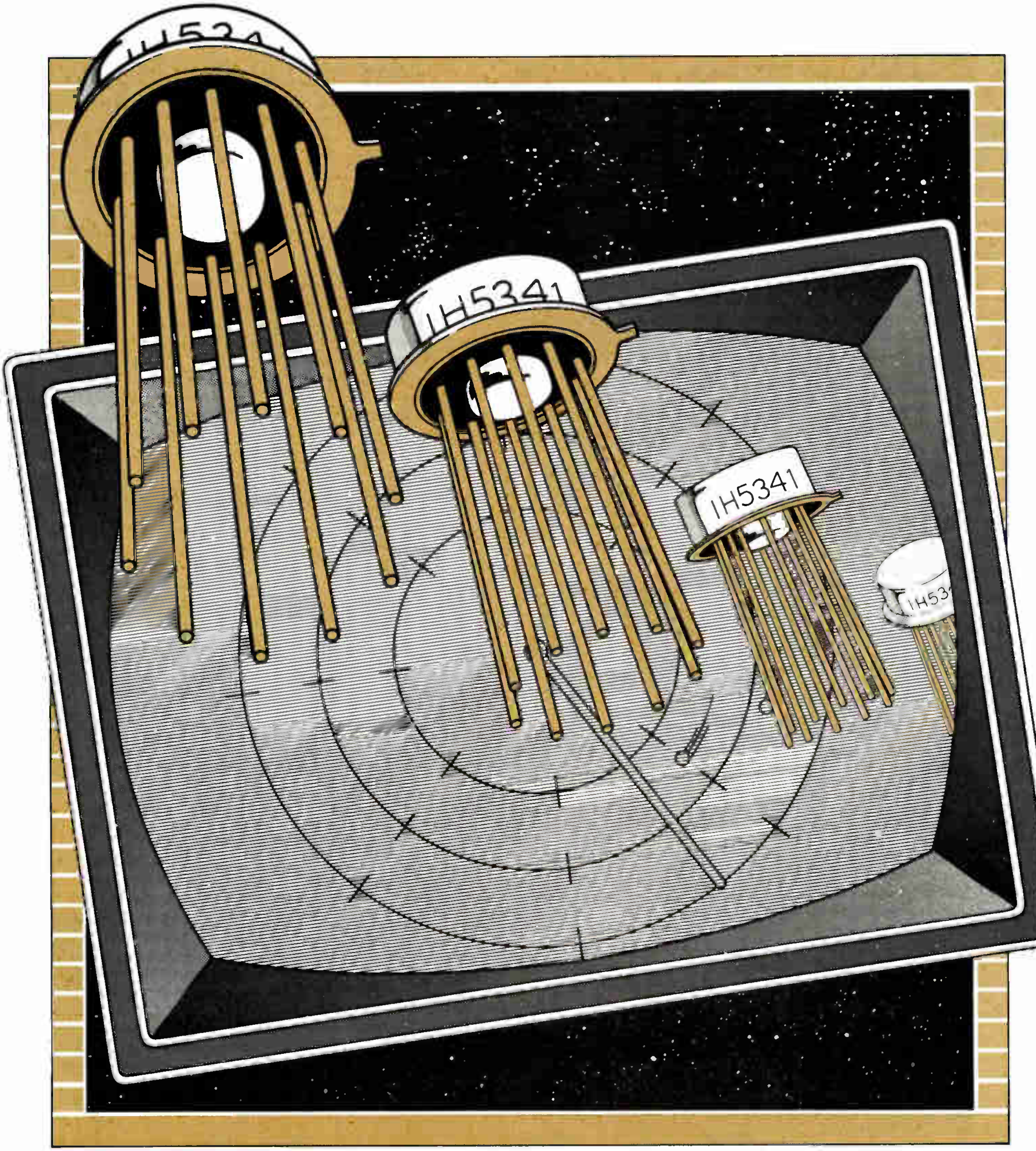
Intel gets license for software system

Informatics Inc. and Intel Corp. have signed a multiyear agreement under which the Woodland Hills, Calif., software house will license its TAPS transaction-processing package to Intel. **This software, an on-line software development system, will be used in Intel's iTPS transaction-processing system.** The iTPS will be unveiled next month by the newly formed Commercial Microsystems operation in Phoenix, Ariz.

Addenda

Scientists in Bell Laboratories' program to develop a single-mode fiber-optic communications system for the Atlantic Ocean floor have reached another milestone. **The Holmdel, N. J., group has transmitted a 274-Mb/s signal 101 km without repeaters.** At that rate—what is termed a T-4 rate—a fiber can carry 4,000 voice conversations. . . . Cherry Semiconductor Corp. of East Greenwich, R. I., **has signed on Analog Innovation Inc. in Los Gatos, Calif., as the West Coast design center for its semicustom bipolar linear integrated circuits.** The ICs, called Genesis arrays, are similar to chips produced by Exar Inc. and Interdesign Inc., both of Sunnyvale, Calif. . . . After reviewing corrective actions taken to fix previously announced testing compliance problems, the Defense Electronics Supply Center **has recertified National Semiconductor Corp.'s plants** in Santa Clara, Calif., and Tucson, Ariz., for the production of MIL STD M38510 devices. National is due back on the Qualified Parts List next month.

THE FIRST VIDEO SWITCHES



Linear designers get high-performance C-MOS gate arrays

by Stephen W. Fields, San Francisco regional bureau

Silicon-gate design runs faster, has lower offset than metal-gate devices, and offers closer component matching

Advanced-process development is the key to a new high-performance silicon-gate complementary-MOS array offering analog-circuit designers the same benefits digital-circuit designers have had with gate arrays—relatively low development costs and quick turnaround. With this array, designers can create many analog functions, including analog-to-digital, digital-to-analog, and voltage-to-frequency converters, and multipole switched-capacitor filters.

The array, which combines logic gates and linear-circuit elements, was developed by Telmos Inc., a year-old C-MOS gate-array house in Santa Clara, Calif. The company was founded by an old Silicon Valley hand, Jean Hoerni, the founder of Intersil Inc., and also a founder of the former Fairchild Semiconductor.

A custom analog circuit often takes over a year of development and costs $150,000 to $200,000. However, a gate-array design, where only the final metalization layer is tailored, can be turned out in 12 to 16 weeks for $30,000 to $50,000.

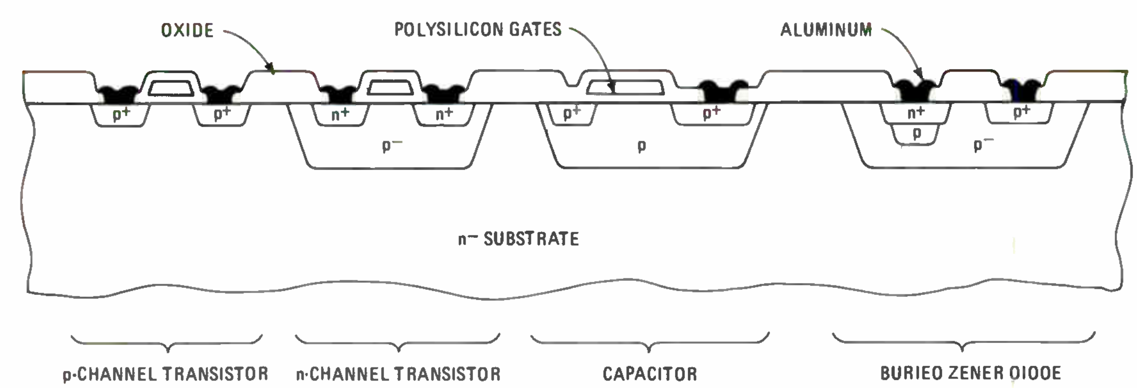
Telmos dubs its analog-digital array, which is the first of a series, the TM6000. It was designed to implement systems requiring a-d, d-a, and precision analog signal processing and interfacing.

It contains 12 operational amplifiers with offset voltages of only 2 millivolts, typically, an open-loop gain of 80 decibels, minimum, and bandwidths of 5 megahertz. In addition, resistor matching is 0.5%, capacitor matching is 0.1%, and current sources are matched to 1%.

Other components include bipolar transistors, zener diodes, a band-gap reference, 32 flip-flops, and 300 logic gates. The component makeup of future arrays will depend on what feedback Telmos receives from its customers, says Paul Nance, the firm's manager of engineering.

Process pluses. According to Nance, the TM6000's high performance comes from process innovation. "We employ ion implantation instead of diffusion for a tighter control over thicknesses—the p^+ implants are 0.75 micrometer deep, the n implants are 0.5 μm deep, and the gate oxide is 500 angstroms thick—and plasma etching for most nitride and polysilicon layers." The thin gate oxide and the shallow implants enabled the firm to get the bandwidth and low offsets, adds Nance.

Bipolar master-slice analog chips have been around for some time, but are not low-power devices. Recently, several metal-gate C-MOS gate arrays with analog elements have been introduced. But according to the linear-circuit design manager at a major integrated-circuit company, "These C-MOS circuits don't offer decent analog performance. Typically they have op-amp offset volt-



Array. Analog complementary-MOS gate array developed by Telmos Inc. places n-channel transistors in p wells, allowing the analog signals to switch above and below the well's bias point. The process also provides capacitors and zener diodes for the linear circuitry.

ages from 15 to 30 millivolts, which is relatively high, a bandwidth of only 1 MHz, and capacitor and current-source matching of only 5%."

The Telmos silicon-gate array employs a process specifically designed for analog circuits. In it (p. 39), n-channel MOS transistors are made in a p well implanted in an n-type substrate. N-channel transistors have better carrier-mobility characteristics than p-channel transistors and, as a result, are faster.

In the latest silicon-gate C-MOS processes used for digital circuits, the n-channel transistors are built directly into a p-type wafer. No well is used for them because the well adds capacitance, slowing the transistor's response. The p-channel transistors must then be built in an n well, but since most of the functions are built with n-channel transistors, this is a better tradeoff.

For analog circuits, however, there is an advantage to placing the n-channel transistors in a p well as Telmos does. The well can be biased at some voltage other than the substrate voltage. Typically it is biased at one half the supply so that an analog signal can swing positive or negative from this bias point.

Telmos engineers developed the process in cooperation with Synertek Inc. In return for allowing Telmos to use its facility, Synertek can market Telmos devices that are expected to be available later this summer. Nance expects Telmos to have a fabrication facility in 18 months.

Research & development

SIA research co-op kicks off in May

The multicorporate—and possibly multinational—Semiconductor Research Cooperative proposed last year by the Semiconductor Industry Association will begin operation May 3 with a $5 million to $7 million annual budget and 13 member companies initially.

Executive director of the cooperative will be Larry W. Sumney, who leaves Government service after 20 years, the last four spent launching and directing the military's triservice Very High-Speed Integrated-Circuits program [*Electronics*, Sept. 22, 1981, p. 89]. Sumney, 42, and a physicist by training, will be making his first move into the private sector. Donald Borlage, VHSIC deputy program manager, will become acting program manager.

Designed to provide contract support to U. S. universities in long-term semiconductor research, the cooperative's charter says it will open its membership to foreign companies "provided that they pay fees reflecting the total integrated-circuit production or consumption of the total company, and that all other members have equal rights to participate in similar cooperative programs in the foreign countries." Few takers are expected because countries like Japan are unlikely to allow U. S. participation in national research and development efforts.

The organization will differ significantly from the Microelectronics & Computer Technology Enterprises Inc. consortium recently proposed by Control Data Corp.'s William Norris [*Electronics*, March 10, p. 97]. SIA chairman Robert Noyce of Intel Corp. notes, for example, that the co-op will support basic research at universities while Norris's concept is more oriented to development and manufacturing techniques. Also, the research group will be a nonprofit organization, in contrast to the MCE consortium, which would be a profit-making enterprise.

Sumney, who will begin signing up new corporate cooperative members beyond the original 13 (see "SIA unveils its cooperative's stars"), says he expects the cooperative's annual budget to climb to a $15 million to $18 million level of support, and "realistically it will probably level off somewhere around $25 million." A site for the organization still must be determined, he adds.

Intel's Noyce believes that the cooperative should not be situated on either coast or near a heavy concentration of industry—automatically ruling out Silicon Valley. Sumney concurs, and both agree that the co-op's location should have good air-travel connections and an environmental appeal to help in recruiting staff. Because of these factors, Colorado Springs, Colo., is getting serious consideration.

To develop long-range research strategies, the co-op will assess the potentials of systems and packaging alternatives for very large-scale integration; optical, electron-beam, and X-ray options for lithographic systems; semiconductor materials; reliability; and computer-aided design. For the short term, it will examine causes and effects of IC microstruc-

SIA unveils its cooperative's stars

It was semiconductor star time in Washington, D. C., last week as Semiconductor Industry Association chairman Robert Noyce of Intel Corp. unveiled the association's Semiconductor Research Cooperative, its principal leaders, and the cast of supporting corporations.

IBM Corp.'s Eric Bloch, vice president for technical personnel development, is chairman of the 11-member cooperative board of directors. In addition to executive director Larry W. Sumney, the other nine directors of the organization are: Digital Equipment Corp. vice president C. Gordon Bell, Signetics Corp. president Charles C. Harwood, Fairchild Camera & Instrument Corp. director C. Lester Hogan, Motorola Inc. vice president William Howard, Intel chairman Gordon Moore, Honeywell Inc. senior vice president Carl Nomura, Control Data Corp. president Robert Price, Advanced Micro Devices Inc. chairman and chief executive W. J. "Jerry" Sanders, and National Semiconductor Corp. president Charles Sporck.

The steering committee of the cooperative will include representatives of three other member companies in addition to the 10 who hold director's chairs. The other corporations are Burroughs Corp., Hewlett-Packard Co., and Rockwell International Corp. **-Ray Connolly** ture defects. In the high-risk areas of technology, it will look, for example, at prospects for gallium arsenide technology and total X-ray lithography systems. -Ray Connolly

Business

Semiconductor sales turning upward

From New England to Southern California, the semiconductor business is up and has been since January. Both manufacturers and distributors agree that the increase stems partly from a replenishing of depleted parts inventories by equipment manufacturers. But there are some strong market segments, notably personal computers and programmable video games. The U. S. economy overall, though, is anything but inspiring, and semiconductor producers, as a result are still wondering whether the apparent upturn can endure.

According to James Barlage, vice president of research for Smith Barney, Harris Upham & Co. of New York, the increase in semiconductor sales is not surprising. The pattern he points out, closely tracks earlier recessions. Barlage terms the current upswing "classic phase one of the recovery cycle, which is unfolding quite nicely."

This phase comes when customers start buying devices after depleting their inventories. The buying rate roughly equals consumption, with much of the business coming from customers who usually buy direct from chip-makers going to distributors who may give terms and deliver from stock.

Strong bookings. The major distributors, by and large, are signaling this turn. Hamilton/Avnet, Culver City, Calif., says that its book-to-bill ratio for March ran about 1.25, with semiconductor bookings very strong. March was a strong month, too, for Hall-Mark Electronics Corp., a Dallas distributor. A discordant note is sounded, however, by Norman Hurwitz, vice-president of Apollo Electronics Inc., Cambridge, Mass. "It's been business as sub-usual," he reports.

Barlage thinks that the industry is now in a transition to phase two. This is characterized, he says, by lengthening lead times, which are now occurring in most segments of the semiconductor business. Thomas P. Kurlak, vice president for research at Merrill Lynch, Pierce, Fenner & Smith Inc., in New York, points out that "lead times [for dynamic random-access memories] have stretched out to anywhere from 3 to 6 months, with Hitachi quoting 120 days for new customers and Nippon Electric Co. nearly having to go on allocation."

Other products are becoming tight as well, according to Kurlak. He estimates demand for logic and linear devices "is up 25% over levels five months ago." John Finch, vice president and general manager of National Semiconductor Corp.'s Semiconductor division, reports that "lead times are out significantly, particularly in our logic business where it's in the 10-to-18-week ballpark for some devices."

East Coast companies see much the same situation. "We have had an increase in sales this fiscal year and there is an improvement in our book-to-bill ratio," says a spokesman for RCA's Solid State division in Somerville, N. J. "But we see it as a bump in a down curve and don't expect any real upturn until the general economy has an upturn." Harris Semiconductor, Melbourne, Fla., sees some signs of improvement in the last month, but is not yet ready to say an upward trend has set in.

Key factor. Getting to phase three, which Barlage describes as an all-out boom, depends on the overall economic environment: it must improve dramatically. Smith Barney's own projections have this happening late in the year, leaving a hole in the

West Europe shows an upturn, too

Semiconductor markets in West Europe generally lag behind those in the U. S., but they are basically in step at the moment. Cautious optimism was the consensus of solid-state companies at the early-April Salon International des Composants Electroniques in Paris.

"Book-to-bill ratios started to improve beginning in November and went above one during the first quarter," according to André Borrel, a corporate vice president of the Semiconductor Sector of Motorola Inc. and director of the company's European operations. At a press briefing held during the Salon, Borrel told reporters that Motorola could not tell whether the upturn was merely a mild spurt caused by the rebuilding of inventory at equipment suppliers or the beginning of a solid market recovery. "There is no long-term ordering," he said.

At National Semiconductor Corp.'s European headquarters outside Munich, West Germany, marketing director Douglas Newman reports a first-quarter rise in book-to-bill ratios. "And it wasn't because billings were poor," Newman notes. His plots of bookings suggest a stretch-out in deliveries, and he remains uncertain about the real strength of the upturn.

Jacques Bouyer, managing director of RTC-La Radiotechnique-Compélec, a Paris-based components producer for NV Philips Gloeilampenfabrieken says his firm registered a turnaround in the past two or three months. Again, the book-to-bill ratio improved but delivery times remained short. "End users are running out of parts inventory, and this may be only a technical pickup," Bouyer says.

Much the same view of the market comes from Yves Thorn, a vice-president at Thomson-Efcis, the semiconductor subsidiary of France's largest electronics equipment maker, Thomson-CSF. "Our book-to-bill ratio is up strongly," Thorn said at the Salon, "and March was our best month for billings ever." France has a semiconductor market less dependent on consumer electronics than neighboring Germany and thus less dependent on the overall economy. Still Thorn, like most others in the business, cannot say for sure whether or not the upturn is real. **-Arthur Erikson** semiconductor improvement cycle for the third quarter. But unless interest rates soon fall and spur investments in capital equipment, the recovery could abort.

Still, a negative factor is that the large computer manufacturers have not increased their semiconductor buying. According to Finch at National, "We see second-tier accounts as well as distributors buying product, but the big boys have not come back yet."

Bill Davidow, senior vice president for marketing at Intel Corp., Santa Clara, Calif., which had an improved first quarter, agrees: "We look out and see that some customers are not doing that well. There are some relatively new customers like the personal-computer and video-game manufacturers whose sales are up, but our traditional customer base [in data processing] is still soft."

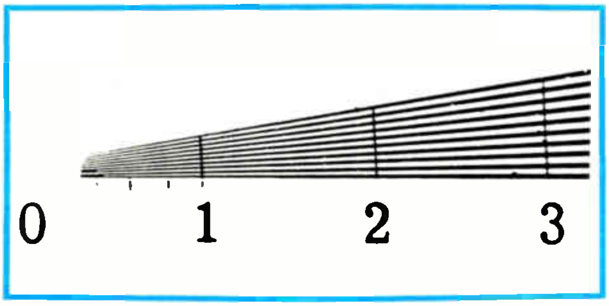
Paul Richman, president of Standard Microsystems Inc., in Hauppauge, N. Y., sums the industry mood up fairly well: "Our sales have been strong for three months. I don't know if it's a blip in the curve, but we're just thankful that orders are coming in." *-Electronics* staff

Materials

Coating will block light on photo chip

As more functions are integrated into light-sensitive semiconductors, chip manufacturers will be facing the task of blocking light from sensitive logic and control circuitry without obstructing the photodiodes.

To make this easier, Polytronix Inc., a semiconductor-packaging consultant in Richardson, Texas, has developed a light-blocking conformal coating that can be patterned directly on the wafer by conventional photoresist methods. The coating material, called PTX-205, can be placed on areas as small as 5 micrometers on a side, and the company anticipates that lines 3-μm wide or less could be painted as the material is improved.



Blockers. Test pattern shows the definition with which the PTX-205 coating can be laid down on a wafer. Numbers indicate the spacing in mils between the centers of the white areas.

"One of the great concerns facing photo IC makers is light getting to the wrong parts of a chip," points out Lawrence A. Murray, a semiconductor industry consultant in St. Louis, Mo. "One way around the problem is in the design stage—one transistor's leakage is made to balance another's. But this cannot always be done, and that's when companies begin looking for a way to block the light." The coating would be of particular interest to those concerned about pinholes in the insulation layer between a metal shield and the die surface, Murray adds.

Generally, photodetector chip makers use metal layers, such as aluminum or gold, to protect areas of circuitry from signal-distorting light waves. These layers are usually vacuum-evaporated onto the wafer at a high temperature.

Though these metals block light, they are also electrical conductors. Therefore, the wafer substrate must be insulated from them. The new light-blocking material, on the other hand, is a dielectric and can be placed directly on the substrate, according to Les Linton, marketing manager for the year-and-a-half-old firm. A 5-μm-thick layer of the polymer will pass less than 3% of the light across a spectrum of the ultraviolet, visible, and near infrared.

On a chip. According to Linton, the new material will make it easier to produce a photo integrated circuit with both the diode and other circuitry on the same die, reducing both cost and chip handling. Many companies have been putting the diodes on one chip and the circuitry on a second. The two are then mounted side by side on a motherboard or combined in a hybrid package.

Another hazard avoided is the potential for crosstalk posed by the metal layers, Linton continues. In addition, light reflected from the metal may affect the on-board photodiodes. The PTX-205 coating reflects no light. It is applied by either spin, spray, or roller-coating methods. Typically, the coating would be 15 μm thick, Linton says.

Next the coating is cured, and the photoresist placed on top. The protective pattern is then exposed onto the wafer using a conventional photo mask. After the photoresist is developed, the unwanted PTX-205 is washed away with warm water. The coating is then hardened by baking the wafer for one hour at 300°C. Polytronix says the material will provide light protection for temperatures up to 350°C.

Other than to describe its coating as a "thermosetting polymer with a base formulation," Polytronix is secretive about the coating's chemistry. It is the company's first product. A pint, selling for $400, will cover about 200 3-inch wafers, according to Linton. **-J. Robert Lineback**

Quality

Perception lag nags U. S. chip makers

As top quality-assurance officials of major semiconductor companies see it, the so-called performance gap between U. S. and Japanese parts largely has been erased. Now a new, and in many ways tougher, task confronts U. S. firms: how to correct the persistent, if misinformed, public opinion that Japanese components are still much less likely to fail.

"The situation has changed, but the perception of it has not," says

Joe Flood, who directs reliability and quality assurance for Motorola Inc.'s Bipolar division in Mesa, Ariz. Along with Willard Kauffman, vice president and director of component production and research, Intel Corp., Santa Clara, Calif., Flood gave views on these questions early this month at a Los Angeles conference on quality sponsored by the American Society of Quality Control.

Kauffman, in fact, questions whether any such gap actually existed to the extent it was perceived by Richard Anderson of Hewlett-Packard Co.'s Computer Systems division, who made public the results of his company's tests about two years ago [*Electronics*, April 10, 1980, p. 81]. Based on testing of 300,000 16-K random-access memories from three Japanese and three U. S. suppliers, the U. S. parts were deemed nearly six times more likely to fail.

A smarting U. S. industry reacted sharply, initiating many crash programs to foster quality. By year-end 1980, similar tests showed only a 2-to-1 quality gap, and the most recent data from HP, cited by Motorola's Flood, finds "almost no difference among 16-K parts."

However, according to Intel's Kauffman, the Japanese still excel in their "strategy to market quality." Proof of this is that industry opinion also ranks other products in the same category of success as the 16-K parts, he says. "We have to sell our quality in the same way. We have nothing to be ashamed of," he emphasizes.

Low returns. As an example, Kauffman offers Intel's 64-K erasable programmable read-only memory, "a hot item being shipped in quantity into Japan." Return rates from customers for this very complex integrated circuit, 198 mils on a side, show only 100 defects per million. This high level of quality had not been projected for the industry until the mid-1980s, he says.

Flood says his bipolar product lines showed overall defects down to 941 parts per million by the end of 1981. Only a year earlier this rate stood at 3,300 ppm, and it was up at 6,600 ppm in 1977 when quality programs were launched.

One user who can attest to quality improvements by U. S. component makers is Arch Pollino, director of the corporate test laboratories at Control Data Corp., St. Paul, Minn. He directs inspection of some 80 million to 90 million devices annually and reports that lot acceptance has reached 99% for major vendors, a figure he is exceptionally pleased with. "The key is close cooperation with suppliers," he says. In line with a top-management edict, CDC buys almost no Japanese devices.

Timely cooperation is an area where U. S. firms do lag the Japanese, notes Charles C. Harwood, president of Signetics Corp. of Sunnyvale, Calif. "Only a handful of our customers give us feedback. CDC is the exception," he notes. It is felt that U. S. industry cannot match the feedback achieved by its vertically integrated Japanese competitors.

Other U. S. executives not at the conference also regard the quality gap as a thing of the past. "It has almost retreated to a nonissue," says Gordon Moore, chairman and chief executive officer of Intel. "The industry overall has made significant improvements, but I don't believe there ever was a gap. The differences week to week from any one vendor were greater than the differences from nation to nation."

Adds Anthony Holbrook, senior vice president for operations at Advanced Micro Devices Inc., Sunnyvale, Calif., "Quality has not been an issue for close to a year. It's not the U. S. versus Japan anymore—now it's individual companies against each other." **-Larry Waller**

Another bubble maker in them thar hills

When National Semiconductor Corp. left the bubble-memory business last August, it appeared that Intel Corp. would be the only U. S. supplier. A look around Motorola Inc.'s Corporate Research and Development Center, however, shows that magnetics is alive and well in Mesa, Ariz.

"We are steaming ahead," says Leonard Call, marketing manager for bubble-memory systems. "We are shipping samples, are in limited production of a 256-K module, and are starting to sample a 1-megabit unit."

Motorola's entire bubble effort is in Mesa, where new fabrication equipment is being rolled in to step up production. The company will sell systems and subsystems, but not chips. Estimates have placed the annual U. S. market for bubble chips and their support circuits at anywhere from $10 million to over $50 million [*Electronics*, Sept. 8, 1981, p. 41]. Initially the devices found a niche in systems for harsh environments because of their wide operating temperature range, but that may be changing.

"The whole market is now firming up and taking off," reports David Shrigley, strategic marketing manager of Intel's Nonvolatile Memory division in Santa Clara, Calif. "We are seeing greater market acceptance in higher-volume applications, such as portable instrumentation and computers."

Along with Intel, both Fujitsu Ltd. and Hitachi Ltd. have been in a position to market parts in the U. S. The next big question is who will second-source whom. Given the flurry of dropouts last year, when Rockwell International Corp., then Texas Instruments Inc., and next National quit the commercial bubble scene, customers are pressuring for alternate sources. "The whole situation is still very fluid," advises Motorola's Call. "Present customer commitments are making marriages difficult. There may be more possibilities at the 4-megabit level." "Watch for second-sourcing announcements to come thick and fast in the next few months," says Intel's Shrigley. Who will go with whom is still anyone's guess, because "everyone is talking with everyone else," as Call puts it. **-Roderic Beresford**

System design

Timing verifier separates checkout

What do a comedian and a logic designer have in common? The answer is timing, though the former

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Circle 45 on reader service card

works for laughs while the latter fears them. That is why the first commercial introduction of a Timing Verifier should be of interest to designers of everything from board-sized systems down to a single integrated circuit.

The timing of a logic design so that everything happens in correct sequence and with safety margins is as important as the logic itself. Often as difficult, time-consuming, and critically important is verifying this timing. The new product is actually a $10,000 software add-on developed by Daisy Systems Corp., Santa Clara, Calif., for the Daisy Logician, a work station for simulating and verifying logic designs the company introduced last fall [*Electronics*, Nov. 3, 1981, p. 176].

Until now, timing must be checked on a logic simulator by simulating the entire logic for every change in timing or clock rate of concern. This uses up valuable computer time and cannot represent as complete a timing check as is possible with the Daisy verifier.

"You can't verify timing as completely as we can, even by building the system, because you can never purchase the worst-case parts intentionally," points out Daisy president Aryeh Finegold. "We have cleanly separated the logic simulation and timing into separate programs. There is no other commercially available way to do this."

Scald. Finegold has built the separation scheme on work done at the Scald project at Lawrence Livermore Laboratory in Livermore, Calif. [*Electronics*, July 31, 1980, p. 75]. But whereas the Scald relied on the laboratory's giant S-1 mainframe, Daisy's Logician distills it all down to a system built around two Intel 8086 8-megahertz, 16-bit microprocessors, 512-K bytes of random-access memory, and a bit-slice processor board. The price of each work station, including all software other than the verifier, is $75,000.

Finegold adds that the Daisy Timing Verifier is not selective as to the technology it works with. "It can handle MOS, complementary-MOS, ECL or other bipolar circuits, or any

News briefs

Ion-implant service opens in Silicon Valley . . .

Chip designers are getting a pair of new services in the Silicon Valley area of California. High-current ion implantation is being provided by a company in Sunnyvale calling itself The Implant Center, which has a medium-current (10 to 20 milliamperes) implanting machine dubbed the Nova. Wafers from 2 to 5 inches in diameter can be sent to the center via air express, to be returned the next day. Ions implanted include boron, arsenic, and phosphorus, as well as the more unusual neon, silicon, and argon dopants. Also accommodated are broken and irregularly shaped wafers and wafers of gallium arsenide and other materials. The Nova can also handle double-charged ions for requirements above 200 kiloelectronvolts.

. . . while a silicon foundry offers 3-μm C-MOS

Synertek Inc., the Santa Clara subsidiary of Honeywell Inc., is making available the state of the art in complementary-MOS logic—3-micrometer, silicon-gate technology. The company is looking for custom-design and foundry business, says Terry Leeder, director of custom marketing. It will be applying its H-C-MOS process, an n-well process optimized for 5-volt digital circuits. Gate delays are just under 1 nanosecond, Leeder says.

Motorola digs in for new IC plant

Testimony to its relatively sound position in the current semiconductor recession, Motorola Inc.'s MOS operation in Austin has broken ground on a second major production plant in the Texas capital city. Although no formal announcements have been made, Motorola is expected to move its Microprocessor division into the new complex, which will cost between $80 million and $100 million when completed in 1984. The MOS group hopes to begin moving personnel into the plant during the first quarter of 1983.

Florida software maker added to Comsat

Comsat General Corp.'s commitment to acquire a computer-aided design and manufacturing capability through acquisition of small companies was shown again early this month. Graphix Software Inc., an 11-employee, year-old Boca Raton, Fla., producer of computer-aided software, is the latest acquisition of Comsat General Integrated Systems Inc., itself only two years old [*Electronics*, Nov. 6, 1980, p. 55]. Graphix Software's principal product, called C-Logix, will be integrated with the CGIS effort known as Tegas, which involves computer-aided design and test of large- and very large-scale integrated circuits and circuit boards.

The acquisition is the third small company buy this year by Comsat General, the domestic communications subsidiary of its Washington, D. C.-based parent, Communications Satellite Corp. The earlier acquisitions assigned to the CGIS group in Austin, Texas, are: Amplica Inc., a Newbury Park, Calif., maker of solid-state microwave amplifiers, and Applied Silicon Technology, an Austin designer of IC masks.

Excimer lasers offer promise for lithography

The intense short-wavelength ultraviolet light of excimer lasers may help plunge optical lithography into the submicrometer region, scientists from International Business Machines Corp.'s San Jose (Calif.) Research Laboratory reported in late March. Precise 0.5-micrometer lines have been produced in resists using contact masking with exposure times as short as a few tens of nanoseconds with the lasers, whose wavelengths range from the near UV (350 nanometers) into the deep UV (under 200 nm), at an intensity that is over a hundred times that of conventional mercury or deuterium light sources.

Excimers also have less spatial coherence than most lasers, which eliminates the speckle, or interference, effects that have limited lasers' use in lithography so far. Semiconductor processors could up the speed of wafer exposure and obtain steeper wall profiles and more flexibility in choosing resist properties like resolution and etching characteristics.

Type MG Precision High Voltage Resistors from CADDOCK deliver 6 big advantages:

1. For maximum design flexibility, there are 19 standard models with 10 voltage ratings in the Type MG 'family'.

The Type MG family of high voltage resistors includes a selection of voltage ratings from 600 volts to 30,000 volts in various resistor lengths to provide maximum flexibility in the design of high voltage assemblies.

In addition to this wide range of voltage ratings, the Type MG family provides a selection of resistor diameters at many of the standard voltage ratings, as illustrated by the three models of 4,000 volt, 1-inch long resistors shown here.

Important performance specifications for all Type MG resistors include:

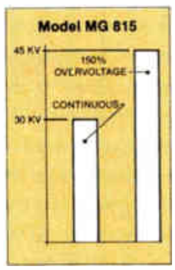
- Full power rating to + 125°C.
- + 225°C maximum operating temperature.
- Resistance values that cover the range from 200 ohms to 2000 Megohms.

2. The standard TC of 80 PPM/°C and resistance tolerances from 1.0 % to 0.1% combine to improve circuit accuracy.

Through the full range of resistance values from 200 ohms to 2000 Megohms, the Type MG resistors maintain a temperature coefficient of 80 PPM/°C over the range from − 15°C to + 105°C, referenced to + 25°.

The combination of precision and low TC achieves a significant improvement over other high voltage resistor technologies, particularly in the higher resistance values.

3. Overvoltage rating of 150% is standard for all models.

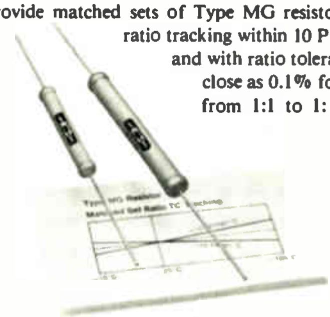


Every model of the Type MG resistors has a *standard* overvoltage/overload rating of 1.5 times the maximum working voltage where this level does not exceed 5 times the rated power. As an example, in the Model MG 815 this capability provides for short-term overloads as high as 45,000 volts.

And for even tougher applications, special factory conditioning can boost the maximum *continuous* operating voltage of many models to 160% above the standard specifications.

4. Matched resistor sets with 0.1% ratio tolerances and TC tracking as close as 10 PPM/°C from -15°C to +105°C.

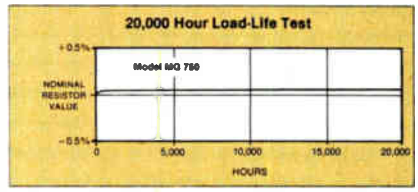
The temperature coefficient of Caddock Micronox® resistance films can be controlled to provide matched sets of Type MG resistors with ratio tracking within 10 PPM/°C and with ratio tolerances as close as 0.1% for ratios from 1:1 to 1:100,000.



For high voltage divider applications, 2% ratio tolerance is standard.

5. Extended-life stability that is typically better than 0.02% per 1000 hours.

20,000 hour *continuous* load-life tests have proven the exceptional stability of Caddock Micronox® resistance films. This graph illustrating the 20,000 hour test results of the 10,000 volt rated Model MG 750 shows extended-life stability well within 0.02% per 1000 hours.



A complete data summary of these test results is available on request.

6. Exclusive Non-Inductive Performance.

Caddock's Exclusive Non-Inductive Design is the answer wherever there are special requirements for excellent high-voltage pulse fidelity and wide bandwidths.

To keep the inductance to an absolute minimum, the special serpentine pattern provides for neighboring lines to carry the current in opposite directions to achieve maximum cancellation of flux fields over the entire length of the resistor.

Caddock's advanced film resistor technology is the source of these outstanding advantages - advantages that are matched by a 20-year record of outstanding 'in-circuit' reliability.

Discover how easily these problem-solving resistors can improve the performance and reliability of your equipment, too. For your copy of the 20th Edition of the Caddock General Catalog, and specific technical data on any of the more than 150 models of the 13 standard types of Caddock High Performance Film Resistors, just call or write to -

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CADDOCK

HIGH PERFORMANCE FILM RESISTORS

Circle 47 on reader service card

technology," he says. "The Scald verifier was set up for emitter-coupled logic alone."

At least one other company, however, is working on a similar system. Valid Logic Systems Inc., Sunnyvale, Calif., [*Electronics*, Nov. 17, 1981, p. 117] is developing Scald software to run on a variety of computers, but a date has not yet been set for an introduction.

Timing specs. The data base needed by the verifier is entered by the designer as the logic simulation is set up. For a printed-circuit-board product, for example, the designer puts in the timing parameters for each IC, taking them from the data sheets.

By plugging in successively higher system clock speeds, the designer can find out how fast the circuitry can go before it ceases to function. This kind of verification checks on things like race conditions, an all-too-familiar circumstance in which a logic pulse arrives on an input line either too early or too late. For example, a counter circuit that counts correctly at an 8-MHz rate may not maintain a proper sequence when operating at 10 MHz.

When circuits fail, the timing verifier points out which critical paths have been violated. The designer can then concentrate on improving the weakest parts of a circuit.

Check out. Circuit signals are analyzed to determine when they are changing, when they are stable, and whether the timing specifications of each component are being met. Taken into account are typical delays, as well as the minimum and maximum rise and fall times, wiring delay, clock skew, the three-state-enable delay, and, of course, the system's input specifications. Operation is also checked against the output timing requirements.

More specifically, the Daisy Timing Verifier checks setup and hold time, edge-to-edge relationships, minimum pulse widths, and the timing of overlapping signals, such as the relationship between the write-enable line and the address lines on a memory. One edge-to-edge relationship checked, for example, is the row-address-falling to column-address-falling time difference on a dynamic RAM. On shared buses, the verifier also checks for contention. After performing all these tasks, the software then documents its results, flagging all the errors it is able to locate. **-Martin Marshall**

Broadcasting

A-m stereo gets no standard

Much to the chagrin of U. S. broadcasters and radio makers, a-m stereo is heading toward a rather uncertain start April 26, when broadcasting may begin without any industry standard. Even more frustrating to station owners is that their own trade organization, the National Association of Broadcasters, was unable to choose a leader from among the five competing a-m stereo systems at its convention in Dallas earlier this month.

Placing the broadcast industry in this precarious situation is last month's decision by the Federal Communications Commission not to select a standard from systems proposed by Belar Electronics Laboratory Inc., Harris Corp., Kahn Communications Inc., Magnavox Consumer Electronics Co., and Motorola Inc. After years of studies, the FCC voted 6 to 1 to leave the choice up to "marketplace factors."

With the broadcasters dawdling, General Motors' Delco Electronics division may set a *de facto* standard. The giant automobile-radio maker intends to field-test all five systems. Delco will not make its choice known until July or later, reports Robert J. McMillin, director of engineering at the division in Kokomo, Ind., and it will be not until late in model year 1983, at the earliest, before GM offers a-m stereo in its car radios. Delco's decision could sway other radio makers to its choice.

At least one a-m stereo system representative in Washington, D. C., fears, though, that Delco may not move fast enough, and this will "give the ball to the Japanese car makers, and they are going to run like hell with it—just like they did on small cars."

Broadcasters with a-m radio stations, of course, will go for the system that offers the highest potential number of listeners. They see stereo as their last hope for survival in the battle with the booming fm industry. The a-m sets cannot match fm in fidelity, but they outdo fm at pulling in distant stations.

Meanwhile, the transmitter makers continue to pitch broadcasters, and radio makers are evaluating the decoder chips they will need for a-m stereo radio, which will add $2.50 to $5 to the producer's cost.

Wait and see. In Japan, the giant radio-receiver makers seem to be taking a wait-and-see attitude until standardization is in sight in the U. S. All involved parties agree that a-m stereo is a long way off in Japan, where national radio policy is extremely conservative.

The country has only two fm stations, for example, despite applications filed as long as 10 years ago to build more. It is also considered unlikely that the Japanese government will establish a standard for radio makers.

Harris, however, is aggressively peddling its system in Japan and says it will make a decoder on a chip available this summer. Motorola has developed a single-chip decoder for its system, as well as a stabilizer circuit for receivers with mechanical tuning systems. Pioneer Electronics (USA) Inc. has endorsed the Magnavox system. It says it has "no specific development plans in this area," but believes the industry must have a single standard.

Sony confirms it has developed a decoder chip that automatically switches among the five proposed formats and is working on bringing its cost down. National Semiconductor Corp., the only U. S. producer with an a-m decoder chip on the market (the LM1981 designed to be used with the Magnavox system), is waiting for orders.

"We feel that the industry must arrive at a decision," says Dan

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VMC 186 VIDEO MONITOR CONTROLLER 80 Character X 24 line alphanumeric and limited graphic display. Upper and lower case, Reverse, half-intensity, flashing, and underline attributes.

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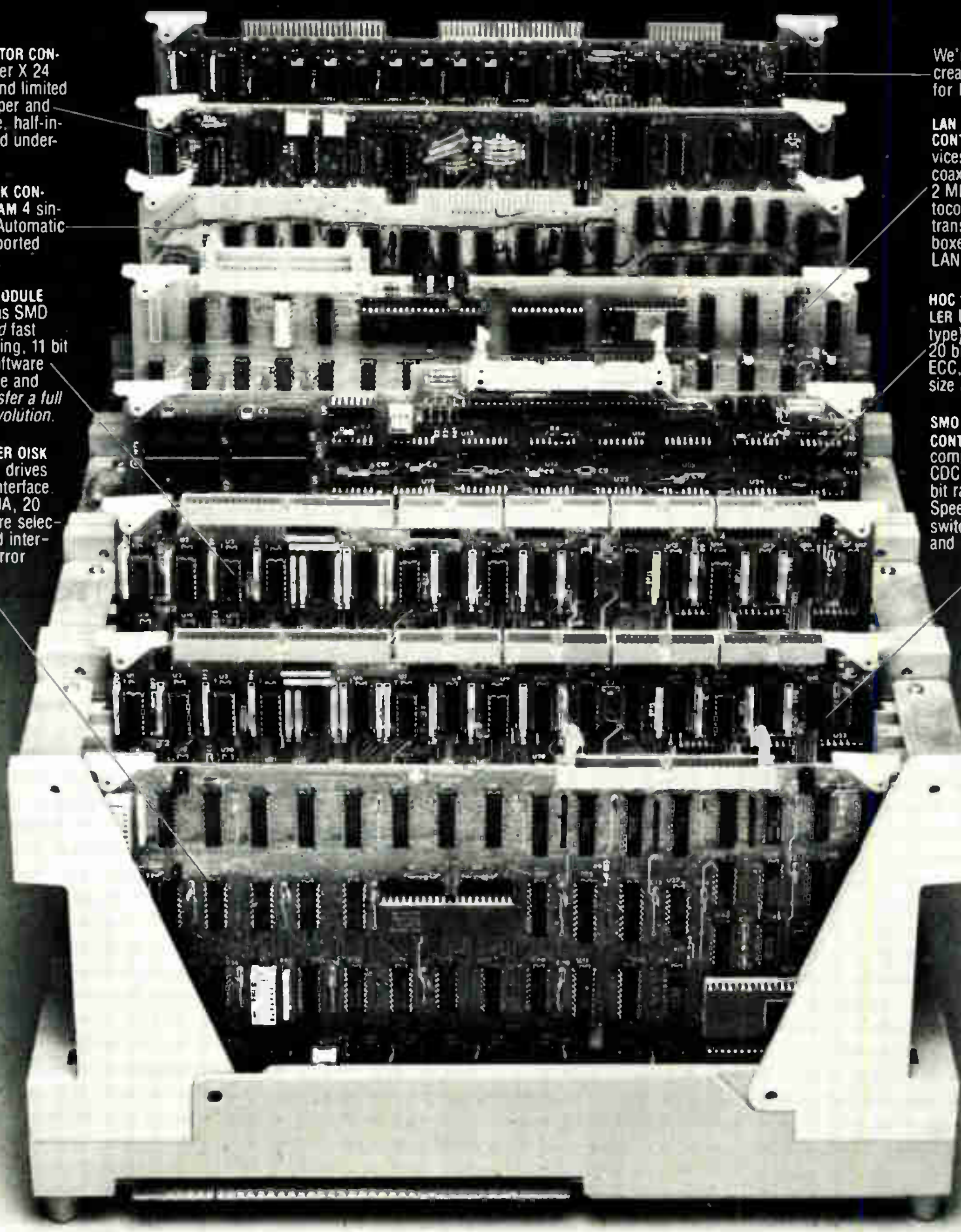

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Shockey, consumer linear marketing manager. "Once we get to the point where different systems are being promoted on the air and in the store, the public will get confused and lose interest." **-J. Robert Lineback**

Electric vehicles

Fund batteries, GAO tells Congress

Advanced batteries, not electric vehicles, should continue to get Federal research and development funds, reports the General Accounting Office. Its study shows that electric vehicles are only slightly closer to practicality than they were seven years ago despite a total of $181 million in Federal funding.

Electric cars cost twice as much as conventional gasoline- and diesel-fueled vehicles, says the GAO. In addition, they do not even halfway meet the minimum range, speed, acceleration, and battery-life goals of automobile manufacturers.

Though the GAO concurs with the Reagan fiscal 1983 budget plan to totally eliminate electric-vehicle funding, the accounting office urged Congress to continue granting funds for advanced battery technology for the long term as, it points out, Japan is doing. The Reagan budget is dropping this funding on the premise that the technology should be supported by private industry alone. However, the GAO notes that it is unlikely that battery companies will perform much R&D without Federal funds.

Candidates. The aluminum-air battery is identified by the investigators as the most promising candidate for future electric vehicles. This battery may allow a car 250 miles between charges and promises rapid refueling by simply replacing aluminum plates and adding water.

"Laboratory bench-scale cells have been produced and successfully operated" under the Department of Energy's R&D program, says the GAO. Three other long-term development candidates it points to include batteries using lithium metal sulfide, sodium sulfide, and zinc bromine.

The DOE, the study points out, has concentrated its near-term battery efforts on three types: improved lead-acid, nickel-zinc, and nickel-iron. The department's efforts have not funded any of the longer-term technologies.

Major U. S. automobile manufacturers and others have faulted Congress's 1976 legislative mandate for the DOE to design an electric vehicle as being "needlessly large." They said the DOE erred in concentrating only on near-term development and in testing prototype vehicles using batteries that could not produce significant increases in range, speed, acceleration times, and battery life cycles. **-Ray Connolly**

Minicomputers

Separate processors fill in for each other

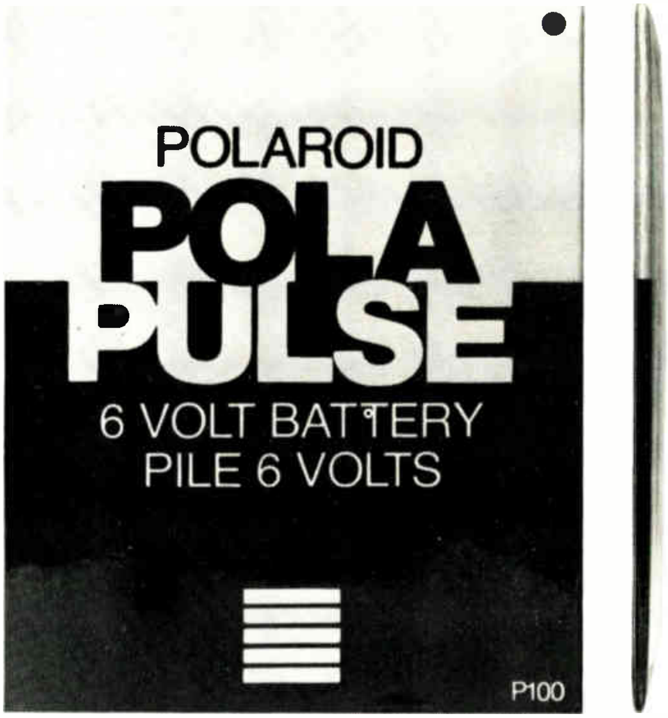
Large minicomputer systems often use multiple processors for either redundancy or to parcel out dedicated functions like handling a display screen or the system's input and output. However, Basic Four Information Systems division, Tustin, Calif., is taking quite a different approach in the minicomputer system it introduced earlier this month. It is using three identical 16-bit processors to share everything.

"The processors are like three secretaries in a typing pool. If there's just one job, only one works. But if there are three or more jobs, they all work, each going to the next task as soon as she has time," says David Seigle, vice president, business planning. "It facilitates throughput and permits us flexibility in making changes in the future."

A side benefit is less downtime, he adds. The system can limp along with just two processors, if one is down, since they all can handle any task that comes in.

Basic Four, which specializes in making a wide range of small business computers for end users, is applying this new architecture to

ACTUAL SIZE



SIDE VIEW

The 6-volt wafer-thin battery that can change the shape of things to come.

We've developed a battery at Polaroid called the Polapulse P100. It's thinner and lighter than any conventional battery we've ever seen.

It can make products thinner, lighter and more compact than if they used conventional batteries. In some cases it can make a product easier to use. It can even help, in some instances, to increase profits.

Less cost, more profit.

For example, take the prototype for a printing calculator.

The Polapulse battery's unique card-in-slot replacement feature requires a one-piece, rather than a three-piece mold, saving 33% of a manufacturer's plastic costs.

With less plastic the calculator is a sleek 6½ x 3⅜ x 1½", weighs only 11.2 ounces, and saves 38% of packaging and shipping costs.

And since Polapulse needs fewer contacts, a manufacturer saves 70% of contact costs.

Equally notable is the particular ability of the Polapulse battery to power a printing calculator's motor with a surge of high current at the beginning of each print. It can then satisfy the high surge demand with low internal resistance and fast voltage recovery.

Heavy duty lightweight.

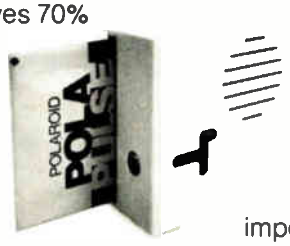
Design engineers at D.E.I. Teleproducts, a West Coast manufacturer of line drivers, developed test equipment with the Polapulse P100 battery. D.E.I.'s new interface monitor and tester is less bulky and more portable because Polapulse is four times lighter than the conventional power source.

Polapulse has 6 volts of power packed into a one-ounce 3.73 x 3.04" parcel only .18" thick and offers high surge at short pulse. This provides D.E.I.'s new equipment with brighter, easier-to-see LED's.

The interface monitor and tester, only 5¾ x 4⅜ x 1", has a larger face than comparable testers which permits bigger turrets spaced farther apart for easier connections.

Thin battery, wide appeal.

A new slide bolt, door-mounted burglar alarm owes its streamlined 4 x 3¼ x 1⅝", 8-ounce design to the Polapulse battery.



Again, the card-in-slot replacement feature makes an important contribution. The burglar alarm can remain in place at all times. Even when changing batteries.

It is also virtually impossible to short out the battery by accidentally reversing polarity of the contacts. The user does not experience perceived product failure. And, therefore, does not send the product back to the manufacturer for a repair that simply entails proper battery replacement.

Security is a Polapulse battery.

Every Polapulse receives 100% inspection, the sort of inspection reserved for major manufacturers' top-of-the-line power cells. Each Polapulse receives electrical and visual inspection at assembly and again after 60 days of controlled aging.

It also features a unique seal modeled on the Polapulse SX-70 film pack battery which boasts an infallible leakage record—no known leak damage in over 400 million SX-70 film packs.

Your chance to wield power.

Experiment with our Designer's Kit. It contains five Polapulse P100 batteries and a molded battery holder.

Send check or money order for $16.75* (plus applicable taxes) to Polaroid Corp., Commercial Battery Division, Dept. A494, 784 Memorial Drive, Cambridge, Mass. 02139.

For more information about the battery that can change the shape of things to come, call us at (617) 577-4228, or write to the above address.

Polaroid

Our inventions can be your components.

Circle 51 on reader service card

support up to 64 work stations in what it calls its 810 system. The system has a minimum of 1.5 megabytes of main memory and a 57-megabyte Winchester disk drive with a 0.5-inch streaming tape drive as backup. A work-station system with a printer sells for $117,679.

Bit slices. Basic Four uses three Advanced Micro Devices Inc. 2901 bit-slice processors. Selected for speed and low component count, they do not introduce the instruction-set limitation of an off-the-shelf microprocessor. "We could define our own instruction set and architecture," says Victor Mashikian, director of engineering, large systems, at the division, which is part of Management Assistance Inc., New York. "And if we choose, we can emulate a different set, not by changing hardware, but by using microcoding."

The processors work independently, each vying for work. They share all code in the system, including a single operating system. Flags built into the software select a processor for each task, taking 2 microseconds to pick it, if no blocking occurs.

When all three processors are busy, the operating system becomes the first piece of software picked up when one finishes its task. It then acts to apportion time as other processors complete tasks and are waiting for work.

Speed aplenty. Basic Four claims its combination of hardware and software creates throughput that is the highest of machines in the class of Digital Equipment Corp.'s VAX 750 and IBM's System 38. When all three processors are active, the model 810 can handle 15 million microinstructions per second. These microinstructions are 64-bit words written in a high-level version of Pascal used for the operating system. Expressed in machine instructions per second, the throughput ranges from 0.7 to 3.5 million instructions/s, depending on complexity.

The new computer extends Basic Four's product line at its high end and coincides with the company's introduction of a low-end $5,995 microcomputer. **-Terry Costlow**

SCIENCE/SCOPE

Transistorized series-resonant-inverter (SRI) technology has been advanced to a resonant operating frequency of 200 kHz in another step toward minimizing inverter size and weight for spaceborne power-conditioning applications. The new Hughes SRI design uses power field effect transistors, which permit higher switching speeds. The design allows use of smaller inductors and capacitors, resulting in faster response to transient load changes and input-voltage variation. The SRI could be used as a beam power supply of an auxiliary propulsion ion thruster, or as a power conditioner for a high-power traveling-wave tube.

A new software system can translate naval tactical messages into understandable form. Messages within a command, control, and communications (C^3) system are typically hard to understand because they are transmitted in telegram form and often omit subjects, direct objects, articles, prepositions, and punctuation. If grammatical errors creep in, messages can be rendered unintelligible. While conventional computer techniques can't make sense of a garbled message, a Hughes message understanding system called GRACIE can. Using artificial intelligence techniques, GRACIE understands general descriptions of flights of aircraft over ships, of attacks, and of encounters with hostile ships. It constructs grammatical sentences based on what it expects messages to be, referring when necessary to a "rule book" of examples. It can be adapted for other than naval use.

An advanced radio-telephone switching system for military shipboard communications eliminates the need for separate equipment for plain and secure voice channels. The Secure Voice Switch (SVS) system lets radio-telephone users select either secure or plain channels. It uses a microprocessor-controlled single audio switch. Large-scale integrated (LSI) circuits designed and manufactured by Hughes prevent crosstalk between the two kinds of channels. Hughes is producing the SVS system for the U.S. Navy for use aboard a wide range of ships, from frigates to aircraft carriers. The first production unit is being installed aboard the cruiser USS Long Beach.

A new family of compact helium-neon laser systems, with laser head and power supply contained in a single housing, has been introduced. The Hughes 3300 series lasers are available in six power ratings, from 0.4 to 6 milliwatts output power. They are suited for laboratory, research, industrial, and OEM uses -- including holography, data recording, spectroscopy, light-scattering, velocimetry, non-destructive testing, interferometry, and alignment systems.

Hughes is seeking engineers to develop advanced systems and components for many different weather and communications satellites, plus the Galileo Jupiter Probe. Immediate openings exist in applications software development, data processing, digital subsystems test, microwave/RF circuit design, power supply design, digital communications, signal processing, spacecraft antenna design, system integration test and evaluation, and TELCO interconnection. Send your resume to Tom W. Royston, Hughes Space & Communications Group, Dept. SE, Bldg. S/41, M.S. A300, P.O. Box 92191, Los Angeles, CA 90009. Equal opportunity employer.

VHSIC funding raised to nearly $80 million

A $14 million boost in fiscal 1983 funds for the Defense Department's Very High-Speed Integrated-Circuits program will raise its budget to nearly $80 million, says outgoing program manager Larry W. Sumney (see p. 40). The increase approved by the House Armed Services Committee **is expected to go unchallenged in either chamber,** even though it runs counter to the trend of sharp reductions in other military research and development areas. The VHSIC budget for fiscal 1982 stands at $65.7 million and at $61.5 million in the projected budget for fiscal 1984.

Navy acts to cut EMI on ships

The Navy is beginning to make design reviews of all shipboard radiators of electromagnetic energy **to reduce ship detection levels and eliminate interference between on-board systems.** A spokesman says the program, called Topside Design Review, will extend "what we have done for years with high-frequency systems to include all electromagnetic frequencies."

Ku-band satellite would bypass local phone net

Newly-formed Advanced Business Communications Inc. wants to orbit two Ku-band domestic satellites by 1986 to provide a new service with blanket geographic coverage. The Federal Communications Commission filing by the McLean, Va., company says its $260 million system will have 20 transmitters on each satellite. **Each transmitter would illuminate zones ranging from a quarter to half of the U. S. mainland,** depending on user demand, for improved cost efficiency. Customers, it claims, can select antenna sizes whose ultimate savings in local-loop usage would offset the transponder leasing costs. Frequency assignments sought are 14 to 14.5 GHz for the uplink and 11.7 to 12.2 GHz for the downlink.

Airline-industry satellite proposed to cut phone costs

The U. S. airline industry's telecommunications supplier, Aeronautical Radio Inc., is surveying its customers to see if they will support the company's plan for an industry-owned and -operated satellite network. George F. Mansur, president of the Annapolis, Md., company, believes **it has become essential for the airlines to defend themselves from ever-increasing communications costs** resulting from dependency on the Bell System's local distribution net. The Arinc proposal stems from the jolt airlines got last year when the phone company's low-cost Telpak bulk rates were declared illegal and the industry's total telephone bill jumped by $150 million. Arinc says the charges for private-line services alone run $12 million to $14 million a month. One senior airline official welcomes the plan, but says it may be deferred until the industry recovers from its severe economic slump brought on by the fare wars that followed last year's deregulation.

DOD to merge its data networks

Defense Data Network is Deputy Secretary of Defense Frank Carlucci's name for the new military system that will replace Autodin II. The DDN is expected to embrace not only the troubled automated digital communications network **but also the more successful Arpanet and the newer Replica communications systems as well.** A decision on the package is not expected before August, although Carlucci notified Western Union Telegraph Co. on April 2 that its Autodin contract was canceled.

Science and insecurity come together

The conflict between scientific freedom and national security is bubbling on the front burner of Federal policy makers. In fact, it is close to boiling over, as scientists challenge the premise of the Reagan administration that tough new controls on free discussion and exchange of research and development data are required to prevent the Soviet Union from acquiring more U. S. secrets.

The fire under this new brew of proposals was lit in January by Adm. Bobby Ray Inman, deputy director of the Central Intelligence Agency. The match was his comment to a meeting of technology leaders that they and their colleagues should voluntarily submit technical papers, reports, and data on sensitive subjects to the Government for prepublication review and possible classification. If they refused, he warned, mandatory controls might result to prevent the "hemorrhage of this country's technology" to the USSR.

The fire was stoked recently with President Reagan's executive order that tightens security classification rules to a point, says one Government source, where "the bureaucracy can now classify almost anything it can manage to lay hands on." The unpopular move, say its critics in and out of the Administration, reflects the insecurity of Government and much of America's high-technology industries as the economy slides downward while the challenge to U.S. technological leadership escalates.

Getting educators uptight

Academia is convinced that it, not industry, will suffer most from Inman's proposal and Reagan's ruling, even though the CIA deputy director later conceded to a House Science and Technology subcommittee that open scientific exchange accounts for only a few of the total of American technological secrets lost to Russia and others. About 70% is the direct product of Soviet espionage, Inman says, and most of the remainder is transferred—often unwittingly—by U. S. companies, including multinationals, anxious to do business abroad. Assistant Secretary of Commerce Lawrence Brady believes that the role of multinationals is on its way to becoming a major public policy issue.

Meanwhile, the Department of Defense is busy developing a new list of "military-critical technologies," using some inputs from the departments of Commerce and State. Fiber optics is reportedly near the top of that list, and it and the others on the list would be precluded from foreign licensing and export in most cases; public-meeting papers on them would be subject to prior review and censorship.

Rep. Albert Gore Jr. (D., Tenn.) opposes the Inman position. As chairman of the Science and Technology subcommittee on investigations and oversight, as well as a member of the permanent Select Committee on Intelligence, Gore argues that the U. S. must "not take even the first step down that road [toward a closed society] that makes Soviet research so pitiful."

One university leader says privately that the security issue threatens to widen, rather than help to bridge, the gap between high-technology industries and the academic community. Both sectors "have to work better together—indeed we have been told to do so in order to offset Government cutbacks in support for education and R&D," he points out. "But when companies keep their heads down on an issue as basic as this, educators resent it."

Private sector responds

Industries like electronics, however, are not unified on ways to address the security-control issue. Weapons makers, of course, favor tight restrictions, as long as they do not threaten foreign sales. Industrial and commercial electronics manufacturers say that existing statutes are sufficient to control illegal technology transfer if they are well enforced. Anyone familiar with the Export Administration Regulations and the International Traffic in Arms Regulations, to name but two, would have to agree that the laws now in place are adequate.

Nevertheless, a new panel of 18 leaders in U. S. science and technology is being formed by the National Academy of Sciences to take a year-long look at the relationship between academic research and national security [*Electronics*, April 7, p. 57]. It plans to identify two or three key technologies and use them as examples of the transfer of information and knowledge. At the same time, the Institute of Electrical and Electronics Engineers has formed a committee to do a parallel study of the issue.

It is to be hoped that all parties will conclude that the U. S. does not need one more big and expensive bureaucracy, composed of engineers and scientists, to review R&D before it can be publicly discussed, thereby delaying technological advance. American technologists may have to become more cognizant of the need to stem the draining of their most advanced work by overseas competitors. But the Reagan administration does not need to abrogate the Constitution to achieve that.

-Ray Connolly

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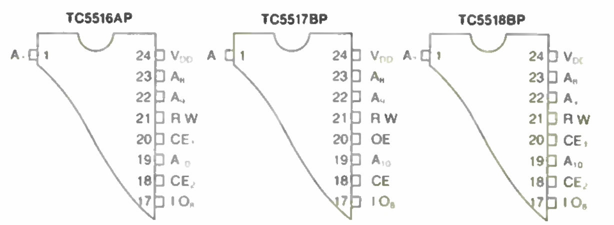

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Laser lays claim to 43% efficiency

Nippon Electric Co. says that a buried heterostructure laser now being used in its optical communications equipment has an efficiency of 43% at a 1.3-μm wavelength. **The Tokyo company's double-channel planar structure for the new laser is designed to efficiently block current from flowing through the regions on either side of the active layer,** leading to high measured efficiency. Currently available lasers have efficiencies of 20% or less because the high leakage current flowing through the blocking layer does not contribute to laser output.

U-groove isolation doubles device density

An isolation region shaped like a U can at least double the device density of bipolar large-scale integrated circuits, claims its developer, Japan's Hitachi Ltd. The new scheme decreases the minimum width of the isolation region from about 7 μm in the company's Isoplanar isolation process to about 3 μm. **Further, process-induced field-oxide imperfections known as birds' beaks are eliminated,** the company says. Also, isolation capacitance is cut by a factor of seven, increasing the speed of experimental circuits by up to 30%. Hitachi says that initially it will use the new process to increase densities in bipolar memories and that a process of this type will be necessary for 1-Mb MOS random-access memories.

Tape recorder calibrates itself

For its reentry into the wideband instrumentation recorder market, Racal Recorders Ltd., Hythe Southampton, Hants., UK, is introducing a 42-track high-performance instrumentation tape recorder that sets itself up. Calibration and equalization tasks are assigned to a microprocessor, thus reducing an operation that can take several hours to about 3 min. **The microprocessor also drives a small, built-in cathode-ray-tube display through which machine characteristics and recorder performance can be monitored.** Called Storehorse, the new 2-MHz wideband recorder can be used as a 14-, 28-, or 42-track recorder at tape speeds variable from 15/32 to 120 in./s with 15-in. coaxial spools and either 1- or ½-in. tape. It operates in intermediate band up to 600 kHz and wide band up to 2 MHz.

Flat-panel display for viewdata uses dc electroluminescence

A prototype 40-character-by-24-line flat-panel alphanumeric display that can display a viewdata page with a four-level grey scale will be offered to manufacturers before year's end by Phosphor Products Ltd., the Poole, Dorset, England, manufacturer of dc electroluminescent panels. Like ac electroluminescence, the technology produces an attractive, bright yellow-on-black legend, but at a potentially lower production cost. The dc version does not require capacitive coupling and, as a result, is cheaper and easier to fabricate. A viewdata display may cost around $550 complete with driver electronics, but would require a major volume commitment. **Impetus for this latest development is the availability of integrated-circuit drivers with the necessary 70-V, 100-mA output,** which were custom-designed with Royal Signals and Radar Establishment funds by Swindon Silicon Systems Ltd. and processed by Plessey Semiconductors Ltd. More immediately, Phosphor Products is readying a dc 8-line-by-20-character display, also employing the new drivers.

NEC builds fastest Josephson logic gate

Nippon Electric Co. of Tokyo has unveiled an experimental resistor-coupled Josephson-junction logic gate that it bills as the world's fastest. Instead of causing a gate to switch by reducing the critical current with an applied magnetic field, as in conventional Josephson technology, NEC injects a control current directly into the gate, exceeding the critical current and causing the junctions to switch out of the superconducting state. **Eliminating the extra circuits that created the magnetic field reduces the surface area to an eighth that of previous Josephson devices** and cuts power consumption to 11.7 μW. The switching speed of 10.8 ps at a 4.2 K temperature surpasses the previous reported best of 13 ps for such devices.

Solar module triples output

Increasing the output of commercially available solar-cell modules more than threefold, Munich-based Siemens AG will soon market a module putting out 120 W of power under full sunlight exposure. The new module, type SM 144, consists of 144 monocrystalline silicon disks, each 10 cm in diameter. **Large-diameter cells on a large module results in the increase over present maximum output of commercially available solar modules,** which is 35 W, Siemens says. Versions with nominal voltage ratings of 8, 16, 32, and 64 V will be available. The modules can withstand wind forces of more than 200 km/h and the impact of 25-mm-diameter hailstones hitting the module's surface at 80 km/h.

Betamax production beginning in Europe

Japan's Sony Corp. will soon begin manufacturing its Betamax video recorders in Europe. **Production starts at 5,000 units a month, but will be geared up depending on demand.** The first units are slated to come off its Stuttgart, West Germany, production lines in May. Also to begin this year is the construction by Sony of a video-cassette factory in Dax Pontonx, France. The Japanese company's total sales in West Germany last year came to about $290 million; the target for this year is a hefty $415 million.

AMD and Thomson set second-sourcing

A reciprocal sourcing agreement is in the offing between Advanced Micro Devices Inc. of Sunnyvale, Calif., and Thomson-Efcis of Paris, covering the AMD 29XX and 29XXX digital bipolar processor families and associated high-performance bipolar memories and Thomson data conversion and telecommunications circuits and microprocessor peripherals. **The first circuits to be transferred under the accord are AMD's 2901C bit-slice processor and 29516 16-by-16-bit multiplier for digital signal processors and Thomson-Efcis's 9340 video processor and companion 9341 character generator** for telematics applications. The agreement for both parties to manufacture pin-for-pin, fully compatible devices will run for five years with an option for two more.

Finland firm makes own ICs

Vaisala Oy has become the first Finnish company to begin manufacturing integrated circuits entirely with indigenous know-how and no foreign licenses. **The company's own complementary-MOS process and computer-aided circuit design will be used** for key components in its line of weather-observation instruments and humidity meters.

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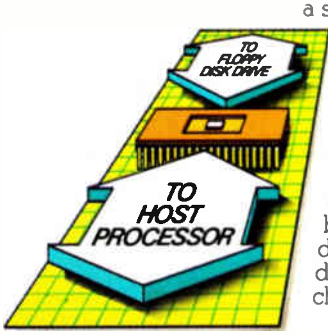

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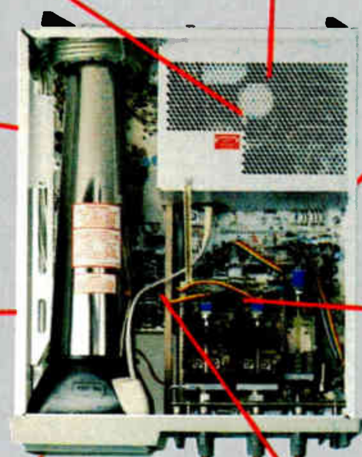
Next, board construction was designed with the ultimate sophistication: simplicity. High performance is



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High performance, positive attachment, 60 MHz and 10-14 pF at probe tip; light weight, flexible cables; new Grabber tips for ICs and other small diameter components.

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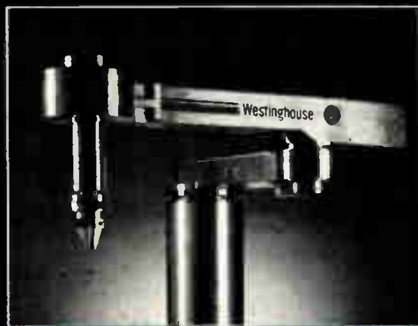

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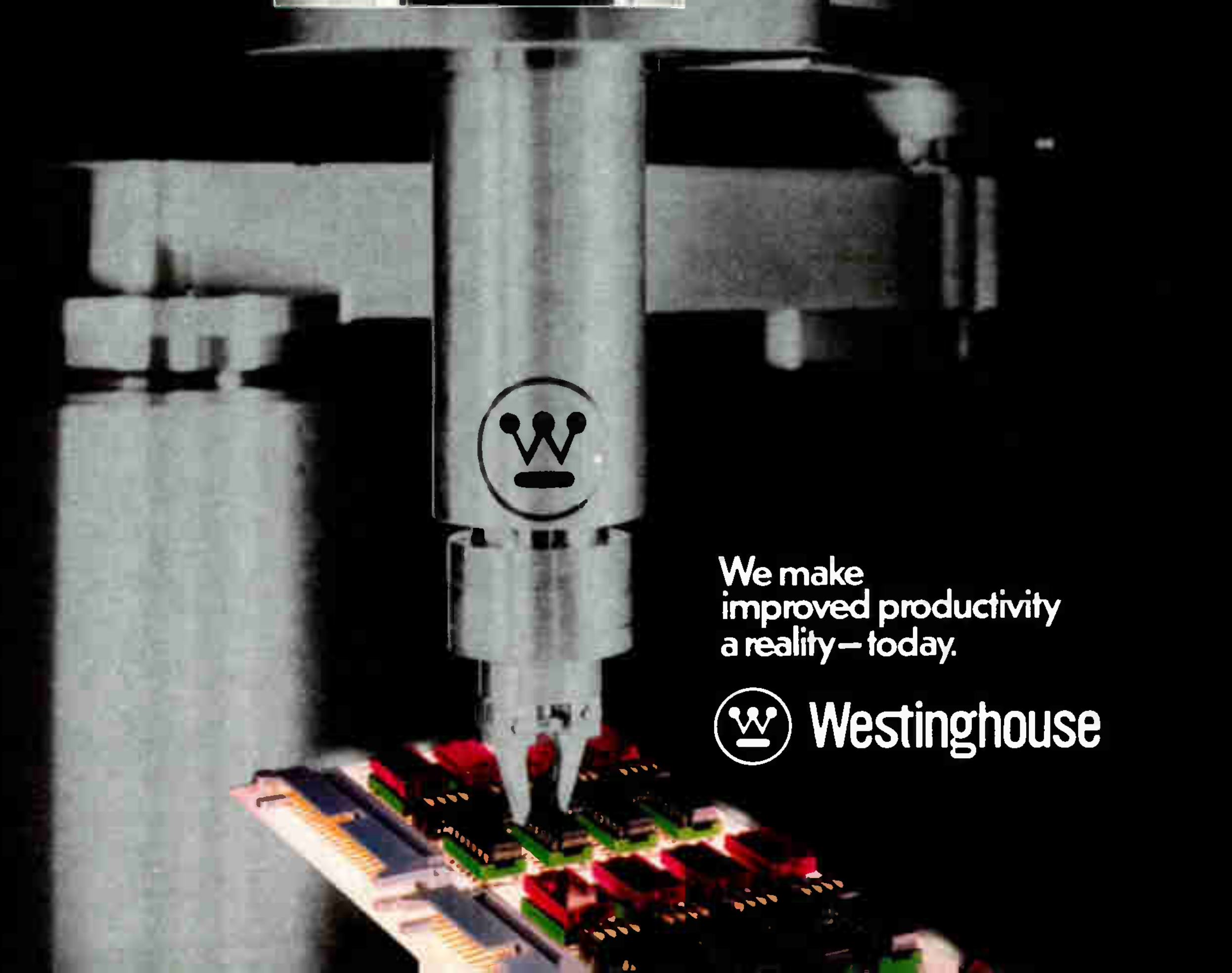

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East German E-beam system resolves to 0.5 μm

by John Gosch, Frankfurt bureau manager

Data-transfer rate topping 800 kilobytes a second pushes throughput up to eight 3-in. wafers an hour

When it comes to microlithographics, East Germany is truly world class. The latest example of its expertise in the field is an electron-beam exposure system that generates integrated-circuit patterns with 0.5-micrometer features under production-line conditions.

It is produced by VEB Carl Zeiss, the big Jena-based optics producer. Intended for mask fabrication and direct pattern generation on very large-scale ICs, the ZBA20 provides an up-to-tenfold improvement in productivity over its forerunner, the ZBA10/1, which is sold throughout the Eastern Bloc and in Japan.

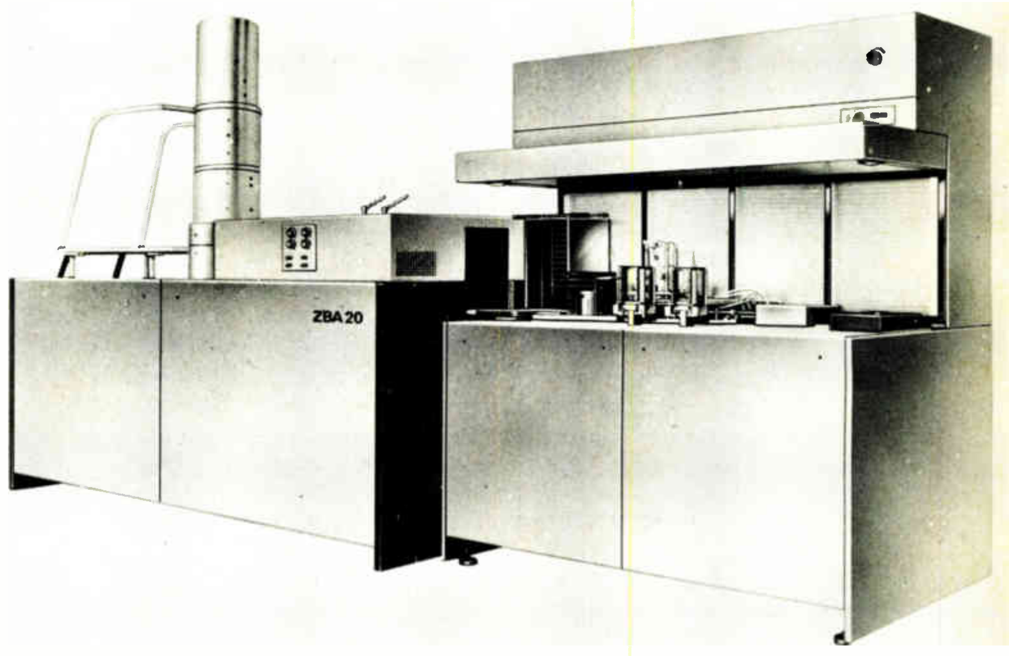
Capabilities. The second-generation ZBA20 handles, for example, up to eight 3-inch wafers per hour, with the wafers having circuits of a complexity typical for 256-K random-access memories and with the data transfer from the equipment's control processor better than 800 kilobytes per second—all referenced to line widths of less than 1 μm. "With that performance, we are, as far as we know, among the world's front-runners," says Knut Kaschlik, head of the Photo- and Electron-lithographic department of the Jena enterprise.

Introduced at the spring fair in Leipzig, East Germany, last month and to go into production this year, the ZBA20 uses the same basic concepts that have proven themselves in the ZBA10/1. These are vector-scan beam-deflection principles—in which only those areas on the wafer that need exposing are scanned—and a programmable-dimension rectangular beam. The latter's cross section can be varied between 0.1 and 12 μm on a side. This variable-beam concept is said to have been pioneered in Jena.

Also taken over from the ZBA10/1 are the stop-and-go wafer- and mask-displacement scheme based on laser-interferometric position measurements, as well as the coordinate transformation principles to obtain fine electron-beam alignment relative to the wafer or mask. "These concepts are prerequisites to achieving the up-to-tenfold productivity improvement with the new system," says Kaschlik.

To achieve the high data rate necessary for the high throughput, the ZBA20 uses more powerful hardware than did its predecessor, as exemplified by the system's data-processing gear. The kingpin item is the Soviet-built 16-bit processor Elektronika 100/25, a machine that is comparable to Digital Equipment Corp.'s PDP 11-34.

"Another development goal was to make the system capable of handling larger-diameter wafers to satisfy industry requirements," Kaschlik says. So, the ZBA20 accommodates not only 3- and 4-inch wafers, as does its predecessor, but also 5- and 6-in. wafers. Also, masks may be as



World class. The ZBA20 electron-beam exposure unit is designed for mask fabrication and direct pattern generation of VLSI circuits. It can handle wafers as large as 6 in.

large as 7 in. on each side. The system sports a maximum resolution of 0.2 μm and a registration accuracy of better than ± 0.15 μm.

Of particular note is the ZBA20's ability to write lines inclined at a 45° angle on the wafer surface, which are increasingly being used in VLSI circuits. Significantly, the unit can write them at the same speed as it does those that are parallel to the chip's horizontal or vertical axes. This feat is accomplished by a neat patented trick: what is called a turn lens is used to electromagnetically rotate the longitudinal axis of the electron beam by 45°.

The object table, with a 162-mm displacement range in both the X and Y directions and working in a start-stop mode has a drive system that considerably reduces the wafer or mask displacement time between two line-structuring operations. The maximum displacement speed is 25 millimeters a second, and the resolution of the interferometric position measuring system is up to 0.02 μm.

Italy

Personal computer uses 16-bit Z8001

What looked like simply a personal-computer launch when Ing. C. Olivetti & Co. SpA introduced its M20 was actually the beginning of a modernization of the Ivrea, Italy, company's entire middle range of computer systems. As is the M20, they will be based on the 16-bit Z8001 microprocessor from Zilog.

Thus it will be possible to use the M20 as an intelligent terminal with any of these forthcoming systems. As a personal computer, the M20 [*Electronics*, April 7, p. 64] is decidedly up-market, intended principally for small-business and professional applications.

"We are definitely somewhat away from the home computer market," says Steve Price-Francis, sales support manager for the M20. "But we plan to take 10% of the European personal computer market in 1983. And, since we are a late starter, our stance is very aggressive with regard to pricing."

The price for the basic M20 is $3,000. A configuration including two minifloppy-disk units, monochrome display, 128-K bytes of random-access memory and a printer goes for about $1,500 more. For the price, the M20 offers an impressive range of technical features, like a 16-bit bus for the Z8001, as opposed to the 8-bit bus that the IBM Personal Computer uses with its 16-bit microprocessor.

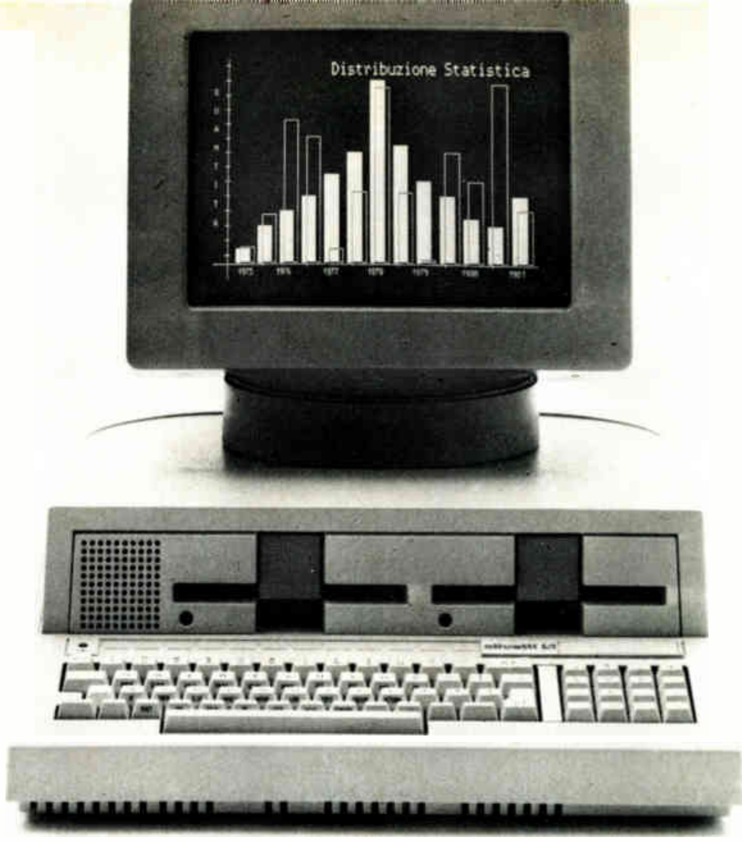
Window display. Other features include RAM expandability up to 224-K bytes, unformatted floppy-disk capacity of 320-K bytes or formatted capacity of 286-K bytes, and a display with bit-map technology that permits "windowing"—the division of the 511-by-256-point screen into as many as 16 independent displays. To achieve this, 16-K bytes of RAM are dedicated to the display. In the offing is an interface for a Winchester-type hard disk unit.

The company seems proudest of the user-friendly nature of the M20. "As there was no existing CP/M [operating system] for the Z8000, we particularly had an opportunity to study the user interface when we designed the M20," explains Leonardo Mauri, product manager for the computer.

"As a result, the dialogue between the system and user is so easy that an 11-year-old was able to teach himself to write simple programs within two weeks." The company calls its offering PCOS for professional computer operating system.

Sales plans. Olivetti plans to sell the system through its network of direct outlets and indirect distributors who now handle the company's line of office machines and information-processing products. In addition, it may use computer-store chains, systems manufacturers, software houses, and computer consultants. As well as being sold on the European market, the M20 will be introduced in the U. S. in May and will also be marketed in Japan at about the same time.

Software support for the M20 will include a group of broad-based programs for the world market. Already available are programs like Multiplan, a VisiCalc-like offering; Olivetti's own word-processing program; and a computer-aided instruction system for user programming. Other applications programs, written to the standards and rules of the relevant



Forerunner. Olivetti's new M20 personal computer, meant for business and professional applications, is the first of a new line of systems to be based on the 16-bit Z8001.

2205A Switch Controller

IEEE-488

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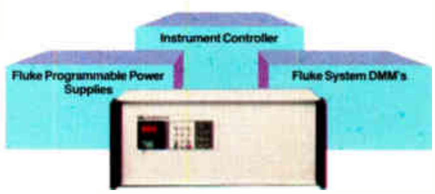

The 2205A also features 100 channels scanning capability in one mainframe, with 1000 in extension chassis and up to 125 channels per second scan rate.

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country, either by an Olivetti subsidiary or a local software house, are under development, and many will be introduced with the computer. Within the next few months, the company plans to have an emulation program that will simulate the protocol and line communication of five IBM terminals—the 2770, 2780, 3741, 2968, and 3780.

Peripherals for the M20 will come from Olivetti's already existing range of plotters, electronic typewriters, and thermal, dot-matrix, and daisy-wheel printers. "The M20 uses the RS-232-C standard interface," says Price-Francis, "so it can use all of our peripherals except some designed before we changed to this standard." -Robert Gallagher

Japan

Watch electrochromic display responds fast with a single plane of tungsten electrodes

The first commercial use of an electrochromic display, in a digital wrist watch, is being quietly test-marketed in the U. S. and Europe by Dainiseikosha Co. (Seiko). Unlike previous electrochromic displays that use top and bottom electrodes, Seiko's electrodes are positioned on a single plane, cutting response time. The display's performance also is improved with a new driver scheme.

Electrochromic displays are an attractive alternative to the commonly used liquid-crystal displays because they do not require a polarizer, and thus their dark-blue segments on a white background have higher contrast. Furthermore, without polarizers, they do not suffer from limited viewing angles.

They also have a memory characteristic that allows them to retain display information without continuous drive—more than a day for the Seiko unit. Although it is nonemissive, the watch display consumes slightly more than twice the current of an LCD.

Going blue. Like other electrochromic displays, Seiko uses tungsten oxide electrodes immersed in an electrolyte for the number segments. A negative potential connected to the electrode causes injection of positive metallic ions and electrons into the oxide film changing it to tungsten bronze, which is blue. The reverse process bleaches the electrode back to its transparent state.

The bleaching process usually limits the speed of response of the display, but researchers at Seiko have developed a new fabrication method that improves performance considerably. Instead of positioning the substrate perpendicular to the path of the tungsten oxide arriving from the deposition source, they rotated it so that the material arrives obliquely. This causes the deposited film to be anisotropic and the bleaching time to decrease.

For the optimum deposition angle, bleaching time reaches a minimum of one half to one third that for a display fabricated with the usual perpendicular orientation. Researchers further speeded up response with the single plane of electrodes. Actual response time is about half a second.

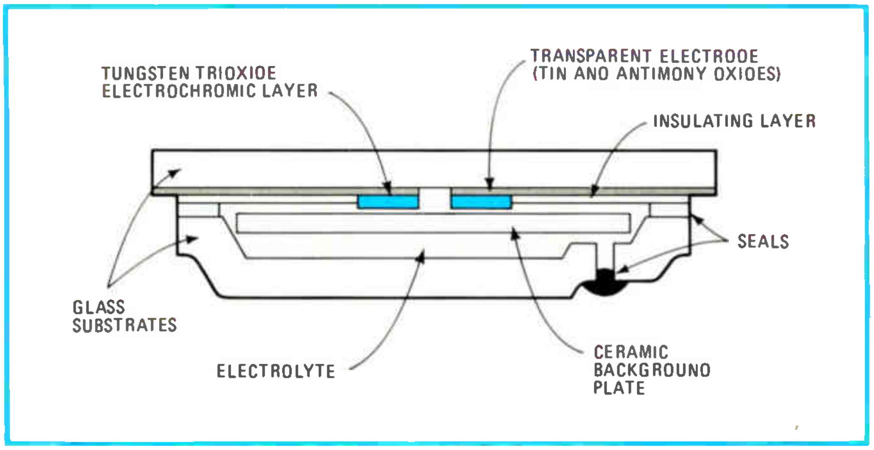
The transparent tin oxide electrodes are deposited on a glass substrate (see figure). The tungsten trioxide electrochromic electrodes are then deposited in a single plane overlaying them. Behind the electrochromic electrodes is a thin, white ceramic background plate.

The electrolyte consists of lithium perchlorate in an organic solvent. Because the assembly can be baked after fabrication, epoxy can be used to seal the glass plate, but low-temperature solder is used for the spot seal after filling the display with electrolyte.

Slow responders. A principal performance lag in some previously developed electrochromic displays was the inability to simultaneously turn segments on and turn others off. One solution—to add a large number of extra electrodes for simultaneous operation—suffers from slow response time and uneven optical density.

The driver circuits in the new display connect segments that must be turned on and those that must be turned off to opposite-polarity terminals of the power cells. Thus both operations are simultaneous.

In order to keep the display electrically and chemically balanced, the areas of segments being turned on must equal those being turned off. So each digit has three auxiliary (dummy) tungsten oxide electrodes hidden under the bezel. One of the auxiliary electrodes is about the same size as those in the number segments, and the other two are each twice as large giving an area that is



Quite a display. Electrochromic display gets its characteristic blue color when tungsten oxide film is turned to tungsten bronze by injecting positive ions and electrons.

equivalent to five segments.

Special high-current driver circuits, which occupy about a quarter of the watch chip, are needed for the display. However, since the display has inherent memory, the drivers can be turned off to save power, and therefore have three states—high, low, and floating, or don't care. The low-power decoder circuits, on the other hand, need only the standard high and low outputs.

To mate the two, circuits between the decoders and drivers compare the present signal for each segment with that for the previous time period; if they are identical, the driver is forced into a floating output state while the segment state remains unchanged. The comparator uses a static flip-flop, with 16 transistors each. **-Charles Cohen**

Great Britain

Ring-based low-cost local network uses token-passing scheme in fail-safe design

Weighing into the local-network race, Britain's Racal-Milgo Ltd., has developed a low-cost local net called Planet (for private local-area network). The token-passing net takes full advantage of custom large-scale integrated circuits to cut the price-per-data port to between $700 and $900—half to one quarter the cost of equivalent Ethernet ports.

Planet distributes computing power through a customer's premises by means of a twin coaxial-cable ring. To access the 10-megabit-a-second ring, a user has only to plug in a terminal access point, a compact microprocessor-based module measuring 17 by 19 by 3¼ inches that can comfortably fit on a user's desk and provides standard V24 computer interface ports.

Central director. Completing the system is a director unit, a compact module that sets up calls, monitors network performance, and manages the net. It, too, can be plugged into any cable access point in the net.

Initially, Planet is being offered with coaxial connections, but the technology is independent of the sending medium, says John Rance, who is head of hardware development in Bracknell, Berks. Both twisted-pair and fiber-optic links are under development.

Basically, Planet is a token-passing system, an approach that guarantees response time and latency. Such systems work by granting access to the bus to the only holder of a token. When the holder has dispatched a data packet, the token is handed down the line, preventing a user from hogging the system.

The alternative approaches are contention-based systems such as Ethernet in which conflicting accesses to the network are resolved by contention algorithms. Token-based systems like Planet provide a more orderly approach to handling data, says Rance, who adds that IBM now appears to be putting its weight behind legitimizing this local-net approach [*Electronics*, April 7, p. 32].

Planet is broadly modeled on the Cambridge ring and, like it, uses the notion of empty electronic packets circulating continuously around the ring network. A packet is filled at any operational station with the information to be transmitted, together with a destination address code and other control bits—in all some 42 bits per packet. It then circles the ring to its destination where it is emptied of data and then allowed to continue.

The address and control bits in every packet reduce the available data rate to 3.5 MHz, but that, says Bob Jermyn, senior product marketing manager, is adequate for most user applications. For example, each interface port will initially be capable of 19.2 kilobits/s.

Racal diverges from the Cam-

bridge-ring concept by investing more intelligence in the central director, thereby simplifying the port electronics. In fact, the terminal access point fits on a single custom VLSI chip, developed by sister company Racal Microelectronics Ltd., which is teamed with an Intel 8051 single-chip microcomputer.

The custom chip has been optimized to process data on the fly at 10-Mb/s, presenting extracted data packets through a serial interface to the microcomputer. Initially, the chip was implemented in gate-array form but, to further cut real estate and hence costs, the fully custom version has now been developed in Racal's proprietary Oxy-complementary-MOS process.

Failsafe. The network also differs in the way Racal engineers have tackled one major drawback of ring-based systems—the catastrophic effects of a failure of any one of the constituent parts in the ring. With a fine touch of showmanship, they demonstrate the consequence by cutting one of the coaxial-cable pair during a live demonstration—with no apparent interruption in service to the ring users.

Like a knotted string stretched tight between two fingers, ring integrity is maintained by looping the cable back on itself at any cable-access point. So a failure of any one access point or cable run is automatically isolated within a second by the healthy elements surrounding it. Failure of the director, too, can be guarded against by holding a second director on standby.

Another advantage of investing intelligence in the director is the provision of advanced network services. Aside from monitoring data packets and ring integrity, for example, the director initiates all call setups, advising participants as to the address they must use.

It can also set up third-party calls, drawing on the services of a protocol converter, if necessary. In addition, it can provide password and security facilities, assign resource priorities, establish closed user groups, and assign permanent circuits among network users. **-Kevin Smith**

GenRad announces TRACS.™ A revolutionary information system for improving the quality and yield of your P.C. boards.

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TRACS addresses the two most pressing needs in electronics manufacturing today. First, it remedies a couple of flaws in the test and repair loop itself. Namely, too much paper and not enough real-time information. As a result TRACS can reduce your actual cost to repair boards.

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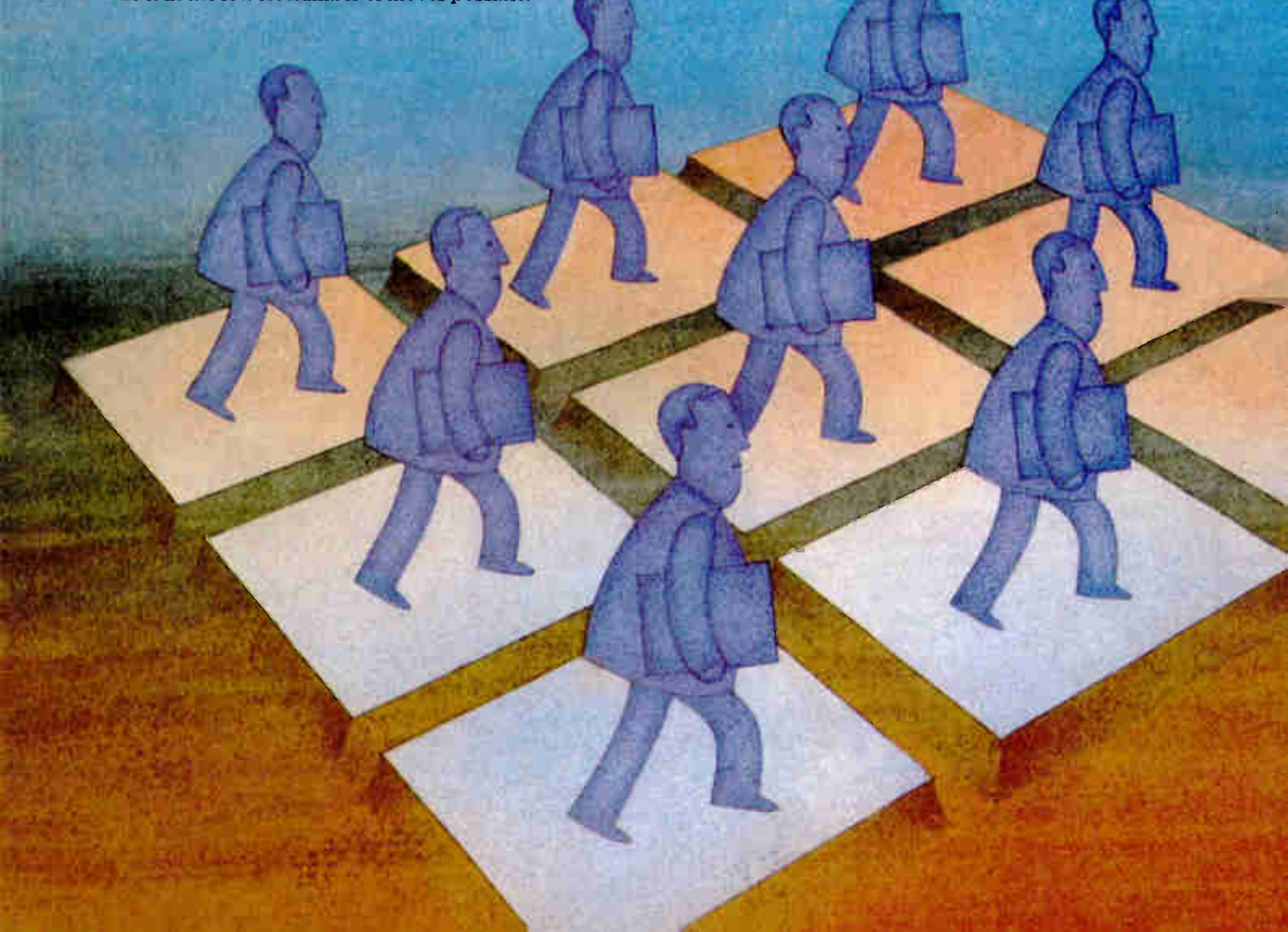

However, TRACS goes a lot further. It collects information generated along the entire test path and puts it to work. This data is fed back continuously to the people who can use it most—manufacturing. Giving them the chance to eliminate the cause of the defects before it's too late. And cutting down the necessity for repairs in the first place.

TRACS has three main hardware components. A central station, which acts as the master controller; a series of terminals for use by inspection and repair station personnel; and GenRad's high-speed data communications link, GRnet.™

Actually the system wouldn't be possible without GRnet, the first ATE network specifically designed for use in a high volume production test environment. GRnet is unique in that it can transfer data in parallel at a very fast rate and with high accuracy.

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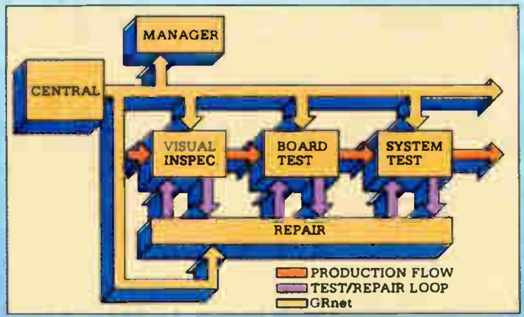

Automates the flow of information around the loop.

TRACS software is high-level and utilizes menu-type formats. Which makes the system literally turnkey. And gives it the ability to be tailored to match specific production requirements. TRACS also provides automatic reports such as test trends and test results summaries, detailed defect reports and productivity information on test repair times.

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Circle 83 on reader service card

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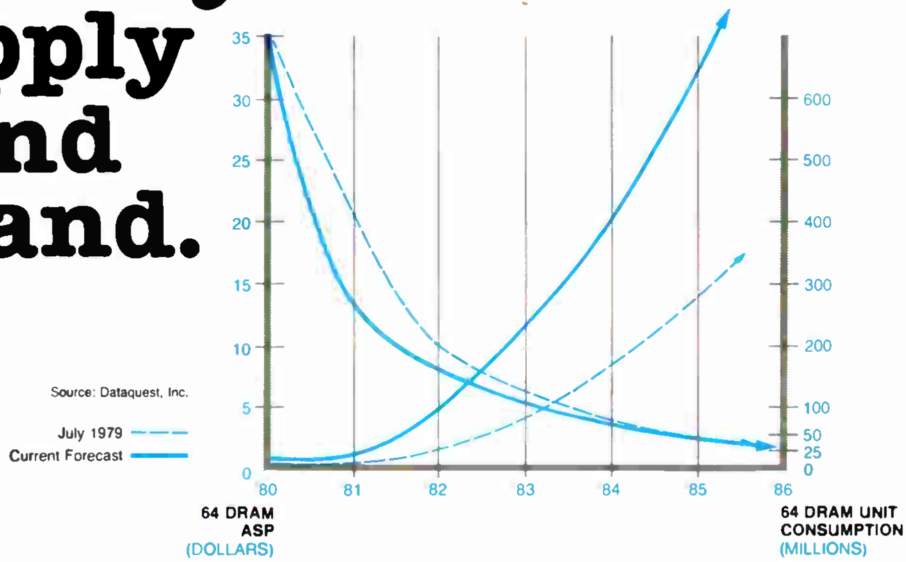

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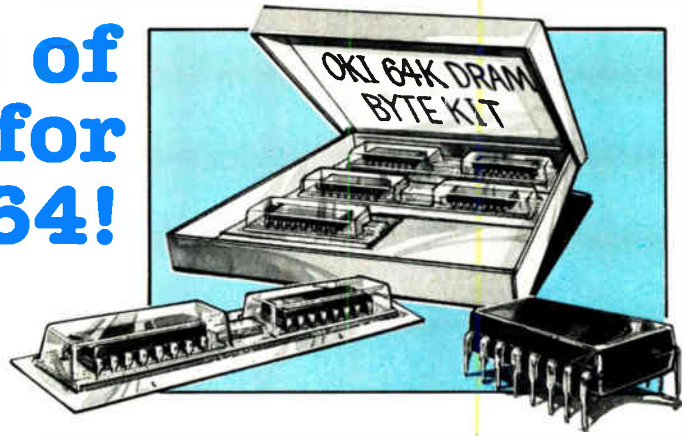

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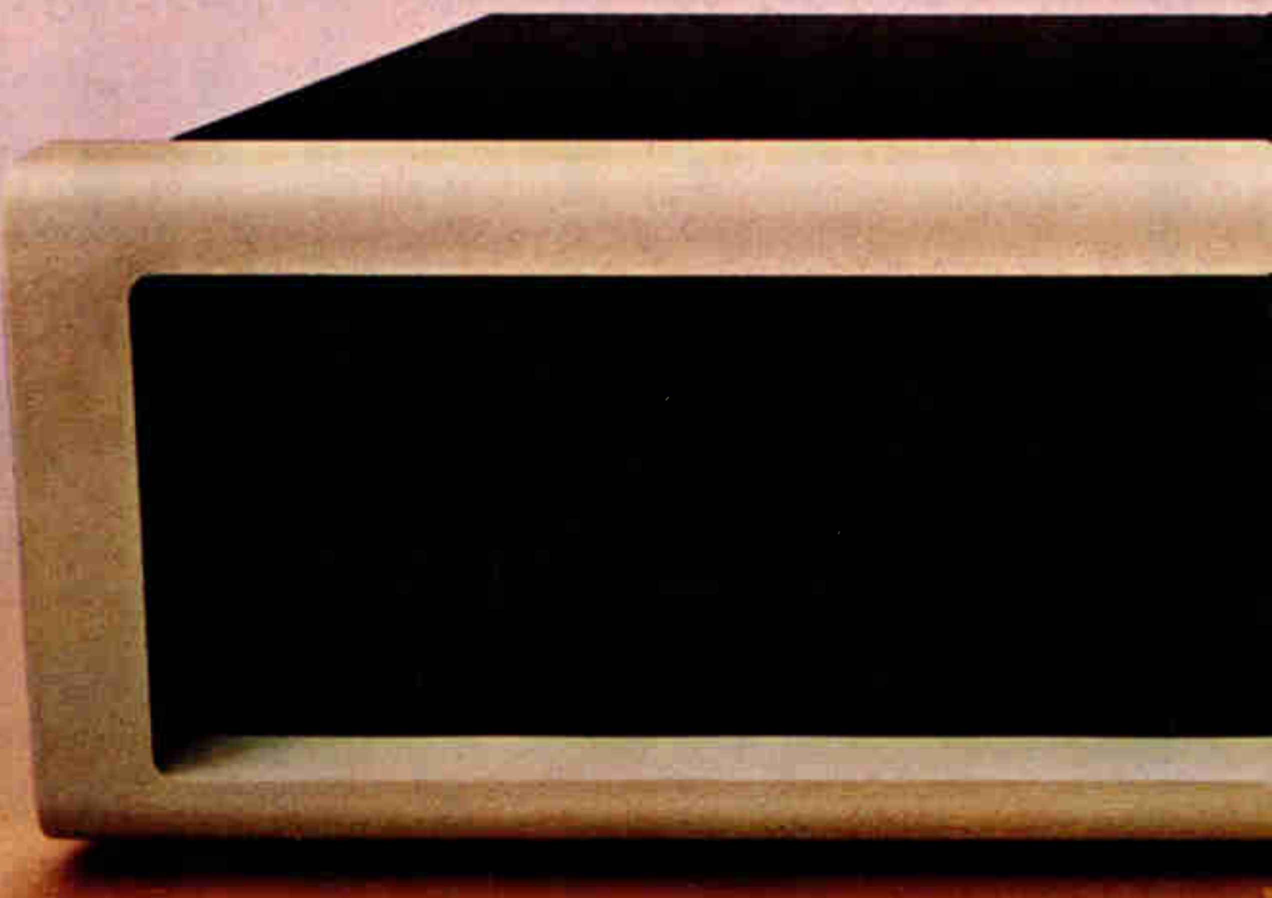

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Circle 87 on reader service card

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Vertical recording promises new era

Japanese have head start in technology that could increase densities of hard and floppy disks by order of magnitude

by Tom Manuel, Computers & Peripherals Editor

Magnetic recording is about to take another giant leap, and Japanese companies are out front. Propelled by a relatively new technique called vertical recording, linear bit densities could increase by an order of magnitude in both hard- and floppy-disk drives—from 10,000 to over 200,000 bits per inch.

With commercial products expected as early as next year, all the major Japanese computer companies are working on products. Several U. S. and European competitors are also in the race.

In today's horizontal (longitudinal) recording, stray fields in the medium demagnetize it during writing—demagnetization increases with density. However, in vertical recording, the demagnetized field shrinks as density of magnetized regions increases. Ultimate density is thus limited only by the magnetic-wall width separating two reversely magnetized domains.

The potential prize is a big one—a better shot at a significant share of an already huge, but still rapidly growing, market for data storage. One estimate of the 1982 worldwide market for hard- and floppy-disk drives is $12 billion, growing to $18 billion or $19 billion by 1984.

Ahead. Experts on vertical recording in the U. S. say that the Japanese are way ahead because they have been putting out a greater effort for a longer period of time. Serious work in vertical recording has been going on in Japan for seven years.

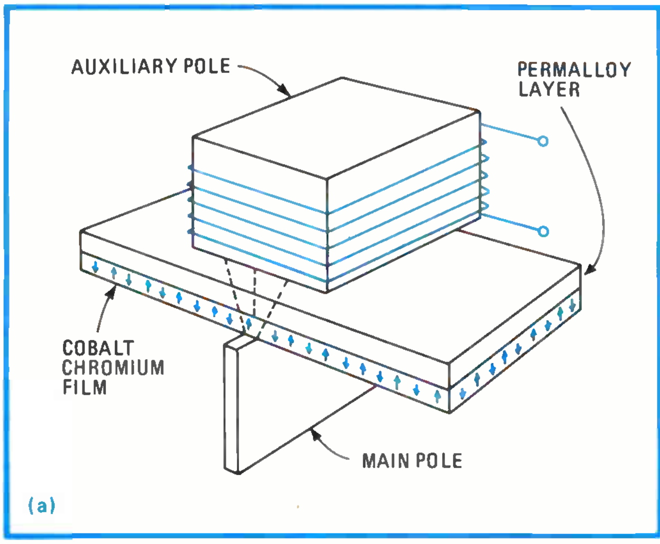
Dennis E. Speliotis, president of Advanced Development Corp., Lexington, Mass., a consultant on magnetic recording technology, says "there is an avalanche taking place, and we are sleeping over here." He estimates that the Japanese are making an effort in vertical recording that is "20 to 30 times greater than that in the U. S."

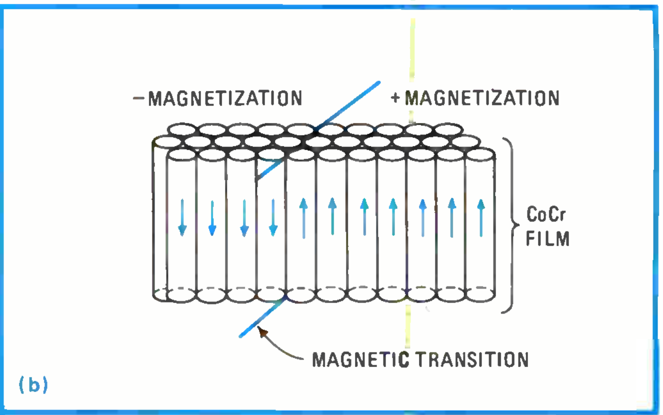
In addition, he sees several advantages enjoyed by the Japanese. One is that "there are at least a dozen Japanese universities working hard in this area, compared to only one—the University of Minnesota—in the U. S.

Another advantage Speliotis sees for the Japanese "isn't yet apparent, but it will be important in the long run. The Japanese virtually control the consumer marketplace, which the U. S. has given up, so they will be addressing the full range of consumer, as well as computer, applications for this technology, giving them a much stronger technological and marketing base."

Also noting that the Japanese "are very definitely much further ahead" is Paul Albert, a consultant in San Jose, Calif. "Except for IBM Corp., which has been working on vertical recording over the last three or four years, the U. S. is just getting started," he says.

At the 1982 Sendai Symposium on Perpendicular Magnetic Recording sponsored by Tohoku Uni-





Standing up. A common head type for vertical magnetic recording in cobalt chromium alloy film has a single pole on each side of the medium, (a). The structure within the cobalt chromium layer is columnar with perpindicular anisotropy (b).

versity last month, 20 of the 22 papers were presented by Japanese researchers representing all the major electronics companies there (Fujitsu Ltd., Hitachi Ltd., Matsushita Electric Industrial Co., Nippon Electric Co., Nippon Telegraph & Telephone Public Corp., Sony Corp., and Toshiba Electric Co.) and several universities. Two papers and four attendees were from the U. S. Three other attendees out of the total of over 300 were from Ing. C. Olivetti & Co., SpA, Ivrea, Italy.

Chorus. Chao S. Chi, manager of the magnetic recording department at Sperry Corp.'s Computer Research Laboratory, Sudbury, Mass., and Ted A. Schwarz, manager of advanced component technology for Magnetic Peripherals Inc., Minneapolis, Minn., are members of the chorus agreeing the Japanese are the leaders in vertical recording. But Schwarz does not think they will be able to capture the total market, at least to the extent that they have, for example, in some consumer products areas.

"We [U. S. industry] are going to turn the tables on the Japanese by going over and studying intensively what they are doing, so we don't have to cover all that ground," says Schwarz. Although the Japanese will make inroads and seize a share of the vertical-recording market, there will be major U. S. companies involved as well, he maintains. "There also could be a start-up U. S. company or two that could hit it big in this technology," he says.

At least eight U. S. companies are now working on high-density data-storage products using vertical-recording techniques. They are, International Business Machines, Hewlett-Packard, Sperry Univac, Burroughs (through Memorex), and Control Data and Honeywell (through Magnetic Peripherals, which they own jointly along with CII-Honeywell Bull of France). In addition, three start-up companies—Vertimag Systems Corp. of Minneapolis, Lanx Corp. of San Jose, Calif., and Ibis Systems Inc. of Duarte, Calif.—are working on products using vertical recording.

On the European scene, Olivetti and CII-Honeywell Bull are both investigating the techniques. Olivetti is working on floppy disks coated with cobalt and chromium, the material that so far has demonstrated in all research the best characteristics for vertical recording.

CII-Honeywell Bull is investigating very high-density hard disks with a multilayer medium where the perpendicular anisotropic layer (probably CoCr) consists of microcolumns with diameters of about 200 or 300 angstroms separated by demagnetized fields of 300 to 500 Å. CII-Honeywell Bull has developed a special thin-film head for vertical recording, though conventional heads can be used. With this head and the multilayer medium, CII-Honeywell Bull expects to achieve densities greater than 100,000 b/in.

Back in the U. S., Vertimag may be the company closest to offering a product. Its president, Clark E. Johnson, says the company now has a working system using vertical recording on a 5-megabyte, 5¼-in. floppy disk. Delivery of the system will begin in mid to late 1983 at an expected price of $500 each in quantity with the disks to cost $25, says Johnson.

Lanx and Ibis Systems are both working on small-diameter, large-capacity hard disks, while Magnetic Peripherals is building up its vertical-recording-technology group. Sperry Corp. is doing research on radio-frequency sputtered CoCr alloy, but, as Chi observes, "the sputtering process is probably going to be too slow for high-volume production."

Sperry, Vertimag, and the Japanese researchers are looking at other materials that could be applied to vertical recording by vacuum evaporation or chemical plating. Materials mentioned in papers presented at the Sendai symposium include cobalt ruthenium, cobalt nickel phosporus, cobalt nickel manganese phosphorus, cobalt chromium rhodium, and cobalt chromium tantulum.

While the Americans and Europeans are focusing just on floppy disks or small hard-disk data-storage devices, the Japanese are looking at everything. Clark Johnson of Vertimag says that the Japanese plan first to attack the markets they are already strong in, such as consumer electronics, with small video recorders and digital audio-disk products. These products will be introduced at the January or June 1983 Consumer Electronics Show, he predicts.

Serious contender. The opportunity and the technology are attractive. For that reason, companies with a big stake in the magnetic-storage business or those that covet one have their work cut out for them now that vertical recording is becoming a hot topic. "People are at least starting to take vertical recording seriously [in the U. S.]," says consultant Albert.

He hopes this new interest will ignite inquiries among the physics departments in U. S. universities so that research in vertical recording will start. And Advanced Development's Speliotis says, "First, U. S. companies must realize this technology is the coming trend and take it seriously. Large companies must dedicate far more resources to it." □

How dense can they get?

It is not clear yet just how much density can be achieved through vertical-recording techniques. Some of the earliest data-storage products, most likely 5¼-inch hard or floppy disks, are expected to have very conservative densities of 20,000 to 40,000 bits per inch. However, densities of 80,000 to over 100,000 b/in. have been demonstrated in the labs, and such products could quickly follow. There is also no reason that track densities cannot be increased to 1,000 to 2,000 tracks/in. In digital-audio applications, according to one observer, Sony Corp. has demonstrated an inferred density of 445,000 b/in. From a magnetics point of view (disregarding mechanical-tracking considerations) densities of about 6.5 billion bits per square inch are feasible, and the ultimate theoretical limit may in fact be 10 times that, claims Dennis Speliotis, president of Advanced Development Corp. in Lexington, Mass.

-Tom Manuel

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Business

Automation may erase offshore edge

Chipmakers debate return to U. S. as labor costs rise in Asia and packaging becomes more mechanized

by J. Robert Lineback, Dallas bureau

A mixed bag of international politics, factory automation, rising world wage rates, and greater chip complexities clearly promises to alter the role of offshore semiconductor assembly operations in the 1980s. But predictions of exactly what those changes might be remain worlds apart.

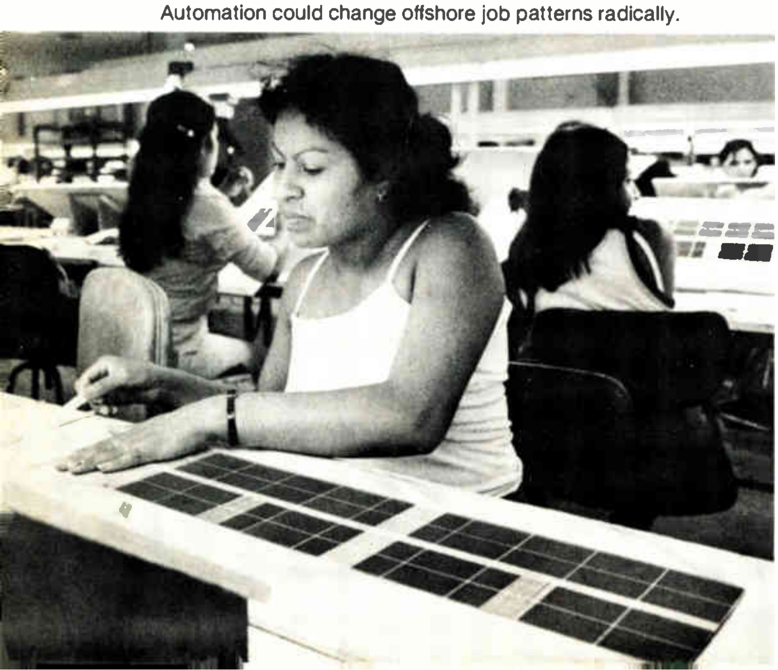
Since the 1960s, Third World assembly plants—many located in Southeast Asia—have provided U. S. companies with pools of low-cost labor essential to remaining competitive in crowded global markets. However, with the prospects of higher levels of mechanization, a number of industry leaders believe once-labor-intensive work may soon be returning to the United States.

U. S. assembly plants, many suggest, will not only reduce the distance between wafer fabrication and packaging operations, but they will also lessen turnaround times, costly inventories, and investment risks. The need for domestic assembly work also promises to increase as the electronics industries place more emphasis on low-volume semicustom and custom components.

Despite international inflation, rising Third World wages, and the potential for political unrest, a large number of American industry leaders continue to scoff at notions of a retreat from offshore production dependency. Some go even further to suggest a greater reliance on foreign factories, with wafer-fabrication lines soon moving closer to developing new markets, such as in Southeast Asia.

However, each new level of automation brings up the issue of onshore assembly, says Donald L. Elam, president of Stanford Microsystems International, the U. S. marketing arm of subcontract assembler Stanford Microsystems Inc. in the Philippines. "That topic seems to come up about every six months," Elam says. But each time it studies the issue, Stanford Microsystems concludes it remains advantageous to automate existing assembly lines in the Philippines, where labor costs still remain relatively low and its operations can run six days a week.

Getting it together. Workers at Texas Instruments plant in the Morazan Free Economic Zone in El Salvador on the assembly line. Automation could change offshore job patterns radically.



On the other hand, automation, faster turnarounds, and greater plant security were all factors influencing Indy Electronics Inc. to locate its integrated circuit subcontract assembly operation in Manteca, Calif., explains Jacob Ratinoff, president, who has been involved in offshore production for years. "I believe that by being in the U. S. we can offer fast turnaround since we are closer to the U. S. fabrication facilities, and we can offer assurance that we don't have revolutions and we don't have typhoons. We also have the highest quality through automation." Business has been so good for the year-and-a-half-old subcontract assembler that it plans to boost employment from 400 to 1,500 by 1983, Ratinoff says.

Togetherness coming. At Mostek Corp. in Carrollton, Texas, where over 90% of IC assembly is done overseas, president Harold L. Ergott Jr. says he expects to see assembly work move closer to U. S. wafer production. "I don't think that you will see that in the next four or five years, but with time, we are going to see those areas [Third World nations] developing high standards of living," he explains. "Labor rates are going to go up, and there will be a point in time that there is going to be a crossover between the cost of doing business in some of the less developed countries and high levels of automation here in the U. S. There's nothing that says a semiconductor cannot go from a wafer to a completed unit—assembled and tested—on a totally automated line. I do expect that there will be a time, and certainly this century."

Motorola Inc. is reportedly considering increased domestic assembly with the construction of a new highly automated IC plant. However,

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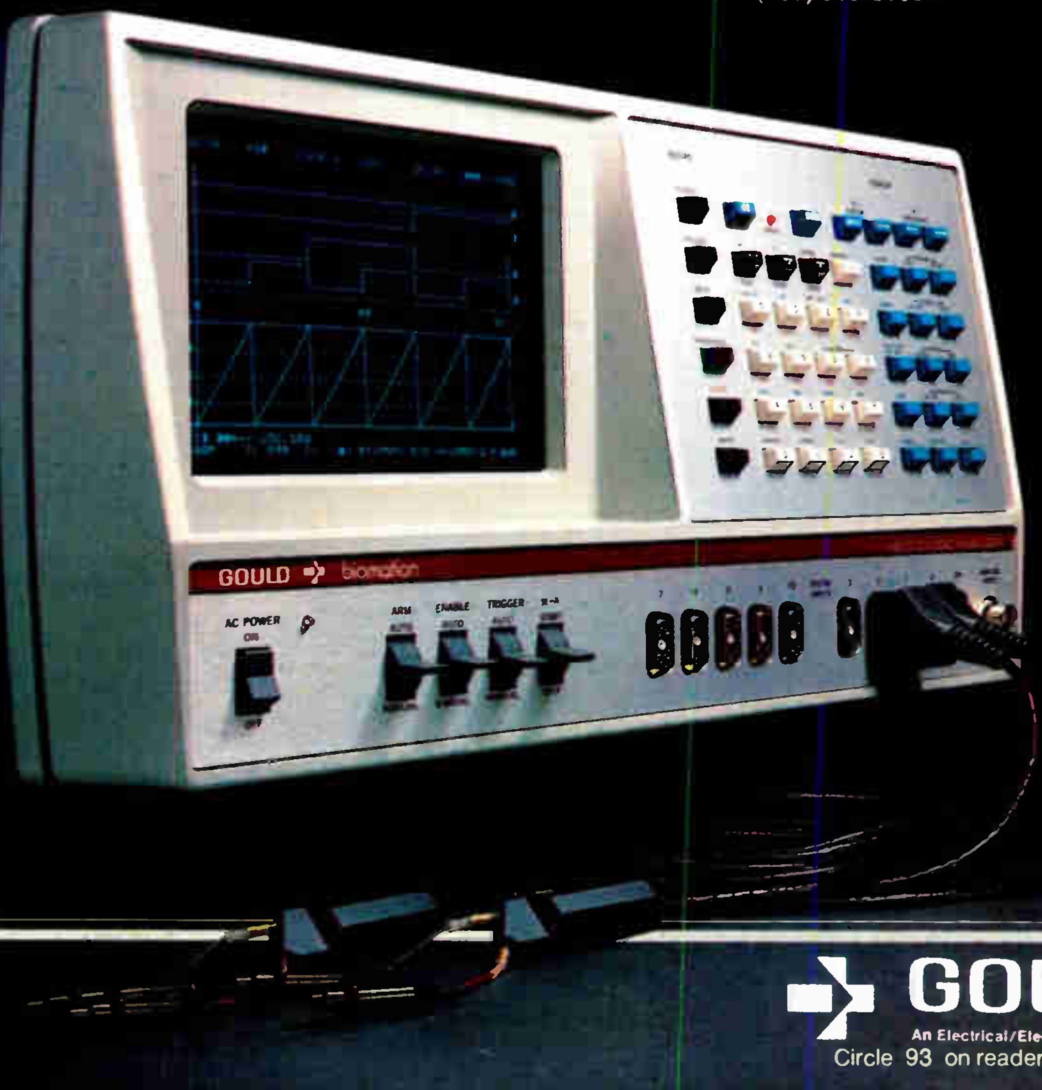

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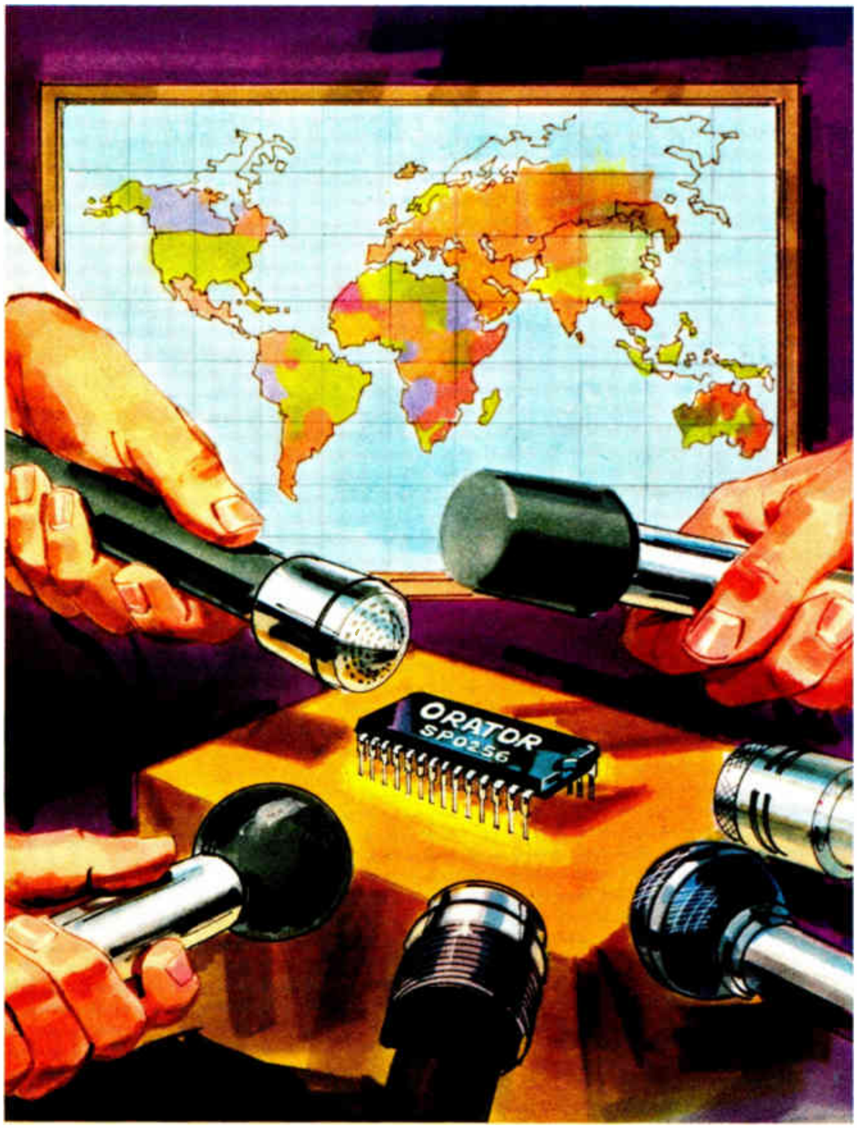

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Probing the news

Semiconductor Sector officials in Phoenix decline comment.

Meanwhile, Texas Instruments Inc. is pushing forward with its plans to install its first state-of-the-art wafer-fabrication line in Southeast Asia. The project, slated for Singapore in the next few years, is in line with the Dallas firm's efforts to establish semiconductor production lines in key geographical regions around the world. For years, TI has relied heavily on offshore fabrication lines in critical European and Japanese markets.

Taking a look. Intel Corp. of Santa Clara, Calif., has "toyed with the idea of putting wafer fabrication facilities offshore," says Eugene Flath, vice president and assistant general manager of the Components Group. "But this is a long, long program." Flath says no definite plans for offshore fabrication have been made, with the exception of a facility scheduled to open in Israel.

Many of the developing nations are now building their own electronics bases and may soon become the "new Japans," suggests Warren Davis, director of government affairs at the Semiconductor Industry Association. "It has come a long way since 1963 when Fairchild went into Hong Kong to do lead bonding," he recalls. "And in some of the countries, they have totally integrated their electronics with semiconductor operations and are now turning out black and white television sets."

Despite the continuing debate over long-term effects of automation, and rising offshore labor costs, most American firms continue to update assembly plants worldwide, says C. Scott Kulicke, president of Kulicke & Soffa Industries Inc. in Horsham, Pa. "If you are talking about the merchant suppliers, I would guess that probably between 85% and 95% of all devices are assembled off shore," he estimates. "It's been that way for 10 to 15 years and to me it doesn't look like it's going to change that quickly."

Not only are American firms continually updating assembly lines, but they are also rapidly installing burn-in ovens and final testing equipment so that shipments can be made from the plant directly to the customer—many of which are also offshore. "Certainly, they are getting away from just 'pure' assembly overseas in the low-cost labor areas," observes Jim Mulady, test systems marketing manager for Fairchild Camera & Instrument Co., San Jose, Calif. "A lot of companies are moving final test into offshore assembly plants. In the short term, I think you'll see an acceleration of that."

Satellite link. RCA Corp., which is already testing devices in its Southeast Asian plants, is planning to use satellites as a way of linking offshore test computers with a central U. S. site at its LSI test operation in Palm Beach Gardens, Fla., says Joe Rauback, manager. Test programs then could be updated every 24 hours for the Fairchild Sentinel testers. Currently, changes in test programs are loaded on a disk or tape and then shipped to the plant. "It takes approximately three weeks from the time the program is updated to the time it's on line," he says. "That could be shortened to 24 hours."

At Eaton's Corp.'s semiconductor equipment operation, James Bowen, vice president, says, "I think you will have a mixed review. My own feeling is that there is a high degree of patriotism setting in, which is good. But a lot of the statements made by people lately about automation solving all of their problems are probably premature. There are a lot of facilities in Southeast Asia and they cannot just abandon them."

HOURLY PAY RATES IN DOLLARS (1980)	
U.S.	8.09
Mexico	1.54
Hong Kong	1.26
South Korea	1.10
Singapore	1.00
Taiwan	.90
Philippines	.62
Indonesia	.45

Figures from Integrated Circuit Engineering Corp.

Bill Bottoms, president of the Semiconductor Equipment Group at Varian Associates in Palo Alto, Calif., says automation will lessen emphasis on inexpensive labor, and he doesn't expect to see "a new push into the next round of low-cost labor areas." Robert Graham, senior vice president of Applied Materials Inc., agrees, suggesting that future offshore plant locations will be linked more closely to key customer bases than they were in the past.

Joe Dibene, a consultant who also helps coordinate construction of offshore electronics plants, has "chased low-cost labor around the world" for his clients. Now he says, "I've reached the conclusion that it's not necessarily the problem anymore. The real issue is that not only do you need low-cost labor these days, but you must find ways of reducing materials costs." That can be done, he says, by Asian sourcing and more sophisticated automation, as well as low-cost labor.

Part of the current push to automate offshore facilities stems from rapidly increasing wages, says William I. Strauss, director of the Communications Group at Integrated Circuit Engineering Corp. in Scottsdale, Ariz. Strauss, who visited plants in the Far East last fall, estimates that on the average, semiconductor assembly wages in Southeast Asia have been climbing at 20% a year. "Of course, they are still much lower than in the U. S., but the rise is causing some subcontract assembly firms to move into other areas as well," he notes. "What we are seeing is that many of these houses are going into less-labor-intensive high-value types of services."

Keeping up. Like most contract assemblers, Dynetics Inc. has entered the testing business and increased automation throughout its Manila plant. Jerry Cheney, vice president for engineering and marketing in the U. S., says he expects to see some assembly work move back, but more complex chips and low-volume devices will be the root of that trend. Anthony Perrotta, president of Amkor Electronics Inc. in Valley Forge, Pa., says his firm is using increased levels of automation in its Korean plants as a means of keeping up with the more complex commodity chips appearing on today's market. "In many cases we make the capital decisions based not specifically on cost but rather on the need to maintain and optimize our quality level," he says. □

Electronics abroad

Buzzword in Taiwan is 'information'

Government helps consumer-oriented companies switch to ICs, computers, software, and telecommunications

by Robert Neff, Tokyo bureau

Taiwan's large consumer-oriented electronics industry is embarking on a major transformation. With strong guidance from the government of the Republic of China, the industry is putting far more emphasis on data processing, where growth will be faster, profit margins healthier, and employment opportunities greater for an increasingly sophisticated labor force. Not only will local companies become more innovative [*Electronics*, March 10, p. 100], but they will move much more aggressively into technology and development agreements with foreign firms.

In December, the National Economic Development Conference designated information, along with machine tools, as one of the nation's two strategic industries. "Information" is defined as integrated circuits, computer software and hardware, and telecommunications. The designation means a lot in a centrally planned economy like Taiwan's, where about half the capital spending is by the government.

Indeed, one recently adopted government plan calls for the expenditure of $1.3 billion over the next seven years to help develop the information industry. Much of the money will go toward installation of 10,000 computers throughout the country, which as recently as June 1979 had only 761 operating computer systems. Through other programs and institutes the government is spending in a variety of ways to train engineers and technicians, develop software design techniques, design, manufacture, and test mini- and microcomputers and integrated circuits, and provide research and development and investment incentives.

Fast growth. Chintay Shih, vice president of electronics trade group, says IC sales should come back this year after only modest growth in Taiwan's sluggish 1981 economy.

"For the electronics industry as a whole, the labor-intensive stage is gone," explains Shih-chien Yang, deputy director of the sectoral planning department in the government's Council for Economic Planning and Development. "Quality and diversification is the most important now." Yang supervised the creation of a 10-year electronics industry development plan that supposedly started in 1980 but is only now getting under way. The study comprises various measures to boost electronics production to $3.25 billion in 1989 from $840 million in 1979, while shifting the product mix to telecommunications, computers, and semiconductor production.

Signs of incipient change in Taiwan's electronics industry are already cropping up briskly:

- The domestic computer market is growing at an average 40% per year and a U.S. Department of Commerce–supervised study in 1980 projected a $115 million domestic market in 1982.
- Export of microcomputers has already started, and one study forecasts total computer exports of $360 million by 1985.
- Taiwan's first commercial IC fabrication plant, 100% locally owned, began operating in February.
- The government expects to achieve standardization of the internal code for Chinese-character computer input sometime during the course of 1982.
- Several local firms have recently developed and started marketing their own Chinese-language computer system and terminals, monitors, and emulators.

Computermania. "Nowadays in Taiwan, everyone wants to get into computers as a new direction of investment. It seems to be the coming thing," says Yvonne Kwoh Ni, general manager of Management Data Systems Ltd., one of the dozens of small software houses that have sprung up in the past few years. Most outside experts think the trend is healthy. Says an American economist based in Taipei, "What they can do is take existing technology and improve it, as Japan did 10 to 15 years ago. Once they get their feet wet in that kind of product development, they can get more innovative."

Integrated circuits are an example of cooperation with foreigners. In 1976, the government's Electronics Research and Service Organization licensed complementary-MOS design and production technology from RCA Corp. After several years of working with the technology, ERSO transferred it to United Microelectronics Corp. in return for a 10% share in the company. United, with $21 million in capital, opened Taiwan's first commercial IC plant in February.

Higher tech. With a capacity of 28,000 four-inch wafers per month, the plant is producing C-MOS and n-channel MOS chips for watches, calculators, and telephone dialers. "Starting from our second year, we expect to introduce more advanced products," says president Robert Tsao, a former deputy director of ERSO.

Sales in the first year will be aimed mainly at domestic and Hong Kong markets, with entry into the U. S. planned for late this year. Tsao's sales target is $6 million this year and $15 million to $20 million in 1983, 80% of which will be exports. He hopes to be profitable by then. "Yieldwise, we won't be inferior to any other IC producer in the world," Tsao claims.

Taiwan's current annual IC market totals about $100 million and had been doubling every year until 1981, says Chintay Shih, deputy director of ERSO. Growth was very modest last year, reflecting a generally sluggish economy, but should rebound this year, Shih adds. "It's not necessary to enter high-technology fields like memory devices and microprocessors," says Hsin S. Lin, editor of ERSO's electronics development monthly. "Mature products are more profitable."

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of the country's largest data-processing conglomerate [*Electronics*, Feb. 10, p. 14], is also growing with outside help. Born as the local distributor for Intel Corp., the six-company group now takes in about $35 million per year. Although Taiwan Automation has developed its own Chinese-language input terminals and software, it uses Digital Equipment Corp. minicomputers for its central processing units and Perkin-Elmer disk drives. Group chairman Matthew F. C. Miau claims to have sold more than 300 Chinese-language processing systems to date, including about a dozen to Hong Kong and Singapore.

Giant's steps. Tatung Co., Taiwan's largest electronics company, has lagged behind some more entrepreneurial firms in entering the information market. But president W. S. Lin reveals a host of plans, many of which involve Western partners. That the conservative, consumer-oriented Tatung is adopting such a strategy is strong evidence of the basic shift occurring in Taiwan. This year alone, says Lin, Tatung will:

- Establish a software house in a venture with a small U. S. company to write application packages and provide system support to purchasers of Tatung computers (now sold to original-equipment manufacturers).
- Start marketing a Tatung-designed and -developed personal computer, announced several years ago.
- Announce development of a minicomputer by a Tatung engineering group working in California.
- Decide on a U. S. or Japanese licensor for IC technology or a joint venture partner so Tatung can supply its own IC needs.

In addition, Tatung late last year opened a plant in Taiwan with Algol Technology Inc. of Redwood City, Calif., to produce video monitors and analyzers and computer terminals for export. Tatung is also designing its own Chinese character input terminal and plans to start exporting computer peripherals. Lin says he wants more than 10% of Tatung's sales to come from computer and IC products by 1985. Sales for 1981 are estimated at $600 million. □

Displays

SID to spotlight flat panels

Society for Information Display meeting to focus on liquid crystals and their thin-film drivers

by Roderic Beresford, Solid State Editor

When it comes to display technology, the solid state is not the only one worth watching—experts in all the phases of matter will be on hand in San Diego, Calif., May 10–14 for the 1982 meeting of the Society for Information Display. Thin films will lie down to help drive displays or emit light, gas discharges will glow, and liquids—the crystalline kind—will twist and turn in a variety of useful dances.

Nearly half of the 20 technical sessions will be devoted to flat-panel displays and their drive electronics. Though no single technique will receive all the attention, liquid crystals are clearly favored, and dozens of researchers will discuss thin-film-transistor arrays for driving dense matrixes of the low-power cells.

Still, plasma and electroluminescent panels will also be out in force, and one of the evening sessions will weigh the relative merits of these two types. The high-voltage drivers for these displays are now joining standard logic devices on silicon integrated circuits to make more compact and economical systems.

The venerable cathode-ray tube will not be lacking support either, as five sessions explore the advancing state-of-the-art projection-television systems, flight simulators, and even flat tubes. Rounding out the picture will be sessions on video disks, printers, and the man-machine interface.

Leading off the diverse presentations will be a keynote address by Francis Ford Coppola, the noted film director who is pioneering the all-electronic cinema at his Zoetrope Studios. "Zoetrope makes extensive use of video display technology to add flexibility in the production of feature films," says Michael Lehmann, manager of electronic cinema at the Hollywood, Calif., studios. Zoetrope uses the HDTV (high-density television) system that was developed by Sony Corp. and CBS Corp. for 1,125-line high-resolution video.

"We can instantly monitor what we shoot on a video system that has resolution approaching that of film," adds Lehmann. The film makers do trial editing with the video tapes, and the system keeps track of the corresponding film frames for the final production. Furthermore, scripts are edited on word processors, and video tapes of any scene may be called up on the same display for quick production decisions.

Besides the instant feedback of video monitors, Coppola also envisions high-resolution computer graphics capabilities for special effects. All in all, the talk will be highlighting a wealth of new display applications in the cinema.

Behind the picture. Meanwhile, the regular sessions will delve deeply into the basic technology that will support these coming generations of sophisticated display systems. Flat panels continue to receive intense scrutiny, with liquid-crystal varieties currently seen as the ultimate favorite for their low power consumption.

Much work on LCDs is aimed at getting around the multiplexing limitations on display size and at driving the dot matrixes efficiently. A static (that is, nonmultiplexed) addressing

SIGNIFICANT PAPERS ON FLAT PANEL TECHNOLOGIES AT SOCIETY FOR INFORMATION DISPLAY CONFERENCE

Papers	Subject	Company
10.1, 10.2	Photoconductor-addressed electrophoretic displays resolve 100 to 250 lines/in.	Tektronix, Xerox
10.5	Viologen-based electrochromic cells withstand 10^6 cycles.	Mitsubishi
12.4	Ac electroluminescent display's threshold reduced below 50 V.	NTT
12.6	Dc electroluminescent display built on silicon.	IBM
15.1	512-by-1,024-dot dc plasma matrix operates with 30-V drive.	Sony
15.2	1-m ac plasma panel has 1,200 by 1,600 dots.	Photonics Technology and Magnavox
16.6	Interconnection method doubles liquid-crystal-display driver's capacity.	Bell Labs
16.7	Liquid crystals are addressed without multiplexing.	Asulab
18.1, 18.2, 18.3	Channel-electron multipliers yield flat CRTs.	Philips
18.4, 18.5	256-by-256-dot vacuum fluorescent panels achieve 60-to-80-line/in. resolution.	Ise Electronics, Naruma China Corp.
20.2	Lasers address 2,000-by-2,300-dot liquid-crystal matrix in projection display	IBM
20.7	Charge-coupled device addresses 256-by-256-dot liquid-crystal array.	Hughes

Probing the news

technique will be demonstrated by Asulab in session 16. The Neuchâtel, Switzerland, laboratory says that the method is applicable to all types of crystals and yields better contrast, viewing angle, and response time than multiplexed driving.

Top density. One of the densest liquid-crystal panels ever will be displayed at session 20 by International Business Machines Corp.'s San Jose, Calif., research laboratory and General Products division in Los Gatos, Calif. A reflective smectic crystal for projecting images with a resolution of 2,000 by 2,300 picture elements is addressed by the heat from laser pulses. Eight gallium-aluminum-arsenide emitters scan the array through a fiber-optic cable assembly.

Building LCDs atop an array of passive or active control devices promises to extend the resolution of multiplexed displays to hundreds of dots. General Electric Co. of Schenectady, N. Y., will demonstrate a 180-by-240-dot matrix that is addressed through zinc oxide varistors. These devices are simpler to fabricate than thin-film transistors. Still, an array of transistors can yield much better performance. To achieve those benefits economically, the key is to fabricate active devices on cheap glass substrates. Many attempts to improve thin-film transistors produced that way will be shown in session 7.

Single crystals. Though more expensive than thin films, single-crystal silicon substrates are, of course, far more fully developed. Hughes Research Laboratories of Malibu, Calif., will show a 256-by-256-pixel LCD at session 20 that is controlled by a 1-square-centimeter chip of MOS charge-coupled devices.

Economical drive electronics have also been a stumbling block in plasma-panel development. Although the panels themselves are inexpensive to produce, the high voltages that are needed to drive the displays have required bulky and expensive discrete drive electronics.

Fabrication technology for integrating high-voltage MOS field-effect transistors with logic circuits is being studied by several companies [*Electronics*, Nov. 30, 1981, p. 108]. Those reporting on it in session 21 will include Texas Instruments, of Dallas, Telmos Inc., Santa Clara, Calif., Supertex Inc., Sunnyvale, Calif., and Hycom Inc., Irvine, Calif.

With widespread progress in driver technology, display makers are motivated to push ahead the basic panel techniques as well. Among the impressive advances that will be discussed in session 15 will be a 1-meter ac plasma panel. Custom-display producers Photonics Technology Inc. of Luckey, Ohio, joined forces with Magnavox Electronic Systems Co. of Fort Wayne, Ind., to produce the giant screen with 1,200 by 1,600 pixels. Panels as large as 512 by 512 picture elements with resolution of more than 100 lines per inch are also slated for the talk.

Vying with this effort for the highest-resolution plasma panel will be Sony Corp., Tokyo. It has developed a 127-line-per-inch dc plasma panel with a matrix of 512 by 1,024 dots.

Though plasma technology thus looks able to compete with CRTs in text display, the information-display workhorse is hardly resting on its laurels of many years of service. New techniques include flat CRTs and projection TV systems with high resolution.

Hitachi Ltd. of Mobara, Japan, will show a camera tube and CRT for projecting 1,125-line images on a 55-in. screen. Zenith Radio Corp. of Glenview, Ill., and Philips Research Laboratories of Surrey, England, will discuss high-resolution projection TV systems in session 11.

Size and power. Compared with conventional CRTs, those employing channel electron multipliers are lighter, smaller, and consume less power. Philips is well versed in this technology and will present three papers on it in session 18. It can achieve, for example, a 14-by-18-cm CRT just a few centimeters thick.

Session 9 on optical storage will provide several reviews of the status of laser recording on disks. In a novel development, Energy Conversion Devices Inc. of Troy, Mich., claims to have achieved an erasable optical disk, in which up to 1,000 write-erase cycles are possible using laser pulses. □

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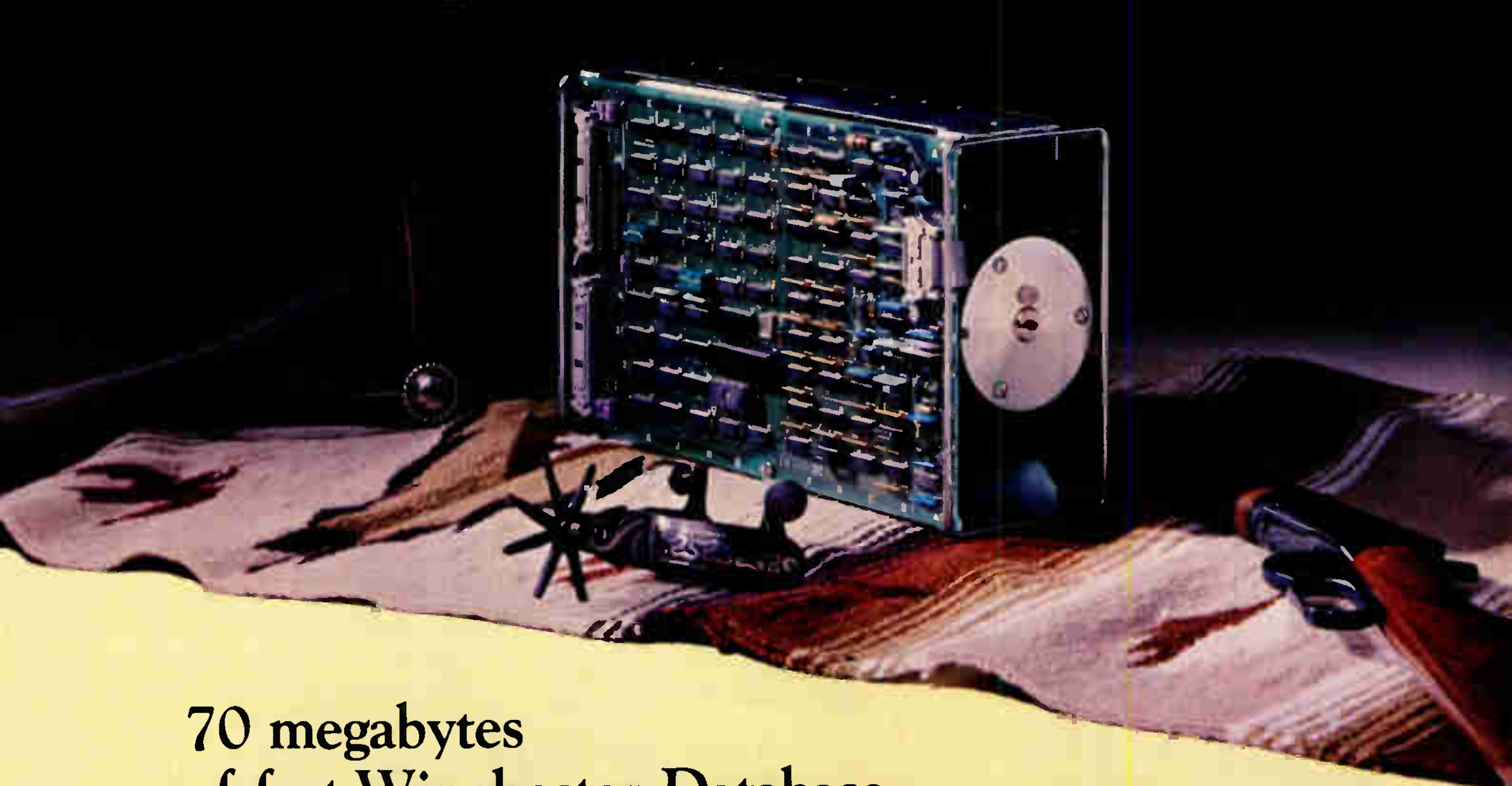

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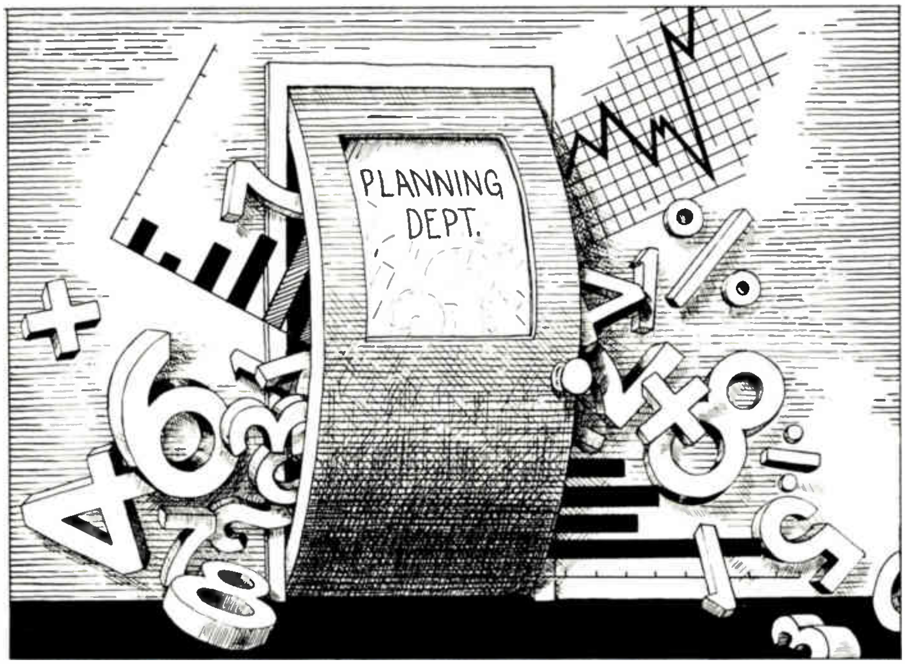

Three things to consider about long-range planning and market development.

The key question on market development is: "Who is supposed to do it?" The planning department? The sales staff?

The fact is, most planning departments don't really do planning at all. They do statistics, projections, financial forecasts, trend extrapolations, and other ruler jobs. And most sales staffs do not do market development. They negotiate with *known* customers or prospects about *known* (usually close-in) requirements.

Thus, we pay our planners for trend data (but that's not planning) and our salesmen for orders (but that's not market development). Who will do the planning/ market development job? We hope you'll find some of our thoughts on this question constructive.

1 The trouble with long-range planning.

Long-range planning is something everybody talks about, and very few do well. Long-range planning probably wastes more time and produces fewer results in our businesses than any other activity. Why?

- The 5-year-plan syndrome. We don't seem to be comfortable unless we have a 5- or 10-year financial forecast. So we get all balled up in statistics and sales/profit projections. We spend so much time massaging the numbers that we don't spend enough time really thinking about what we ought to do. And the more time we spend looking at those numbers, the more we tend to believe them—even though they weren't real in the first place. So if your banker or your board needs a 5-year plan, get out your ruler and give them one. That will leave you time to remember an important truth: We can forecast the future all we want, but that doesn't make it happen. *We have to go out and invent it.*
- Starting at the wrong end. In our planning, we usually start with what we are selling *now* (or what our competitors are selling) and try to figure out how much—and where—we can sell it in the future. What we *ought* to do is think about the possible world of the future, try to decide what will be needed or wanted, and then decide what we should do about it. We must stop internalizing our long-range goals ("How many ICs can we sell in 1987?") and start externalizing them ("What percentage of the factory cost of robots can we compete for with our technologies?").

department for that."

• "How's business?" "Don't ask." Our long-range planning and judgement is very much influenced by short-term business conditions. When we're hot, we hire people, build inventory, advertise like crazy, and produce spectacular 5-year plans. When we're cold, we play "keep the lights on" and our view of the future is mostly influenced by whether the telephone is ringing. When we're overbooked, our marketing people spend all their time expediting the factory. None of these situations is realistic. We must find a way to separate our growth objectives and activities from the day-to-day operation of the business.

2 The trouble with market development.

The main trouble with market development is that there just isn't enough of it. In electronics technology marketing, we find relatively few companies that have well-organized market development activities. Those that do seem to be the ones that are realizing the greatest growth and the highest profits. The payoff of market development shouldn't surprise us; we live in a business where the pace of technology provides new market opportunities almost every day. The trick is to identify and capture these opportunities. Proliferation, characteristic of the 1970's, will continue. Electronics technologies will continue to invade all kinds of industries, markets and applications where they are not an important factor today. This invasion will be led by microprocessors, microcomputers and computers in the home, office and factory. This will not happen by accident. To achieve the growth that is possible, we must go out and force it to occur. That's what market development is all about.

3 Some suggestions.

If you don't now have a formal market development program or are not satisfied with the one you have, there are some things you might think about.

• Start now. It's the only way to expand your customer base, increase market share and position your company to achieve greater profits as business improves.

• Organization. Market development should be separated organizationally from the ongoing business. An organization charged with creating earnings per share has great difficulty pursuing future growth on a logical, consistent basis. If the same organization tries to do both, and business is good, then growth goals tend to become unrealistically high, and the budgets inflated. If business is lousy, growth programs get sacrificed in the name of short-term earnings.

• Budgets. Establish and review budgets for market development over a time period long enough to assure continuity of enterprise. The same period you use for your R&D budget is probably about right.

• Objectives and goals. Establish and communicate a concise set of objectives and activities. In general, the objective should be to build profitable new businesses on top of your present base. The activities should include identifying opportunities, prioritizing them, figuring out how the opportunity can be cracked and who the customers will be, matching capabilities and technologies to the opportunities, finding partners if required, and then going out and doing something.

• Management. The market development organization should report to the chief executive or chief operating officer. Otherwise it won't get the attention it deserves.

What's our angle?

We have two reasons for publishing these notes:

• Market development is the key to continued growth in the Electronics Technology Market. Advertising is a good, low-cost market development tool. If more companies get more serious about market development, Electronics will get more advertising.

• Companies with good market development programs tend to take a longer and more consistent view of their total marketing programs—including advertising. We don't like boom-and-bust any more than you do. Consistent advertising is good for Electronics.

Electronics

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This is the first in a series of advertisements on important marketing and advertising objectives for the 1980's. Your comments are welcome.

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THE PUSH TO SMALLER, DENSER DISK DRIVES

The seemingly insatiable demand for mass storage is fine-tuning every aspect of disk technology

by Tom Manuel, *Computers & Peripherals Editor*

☐ As companies large and small race to computerize, their hunger grows for ever denser data storage occupying ever less physical space. Often, a low-cost microcomputer first whets a firm's appetite. Then, when it has successfully automated one function, it moves rapidly to automate the rest. At that point, a lot more storage capacity becomes necessary.

In response to this demand, suppliers of magnetic-disk drives are pushing hard to advance the state of their art. New materials, new ways of using those materials, and new drive mechanisms are emerging in a variety of new combinations. Some of these approaches are thin-film heads, thin-film–plated disks, vertical recording, and the application of big disk-drive head-positioning servos to the small drives.

Right now, flexible-disk drives (floppies or diskettes) come in two standard sizes, 8 and 5¼ inches in diameter. Their total storage capacities range from just over 100 kilobytes to 1.6 megabytes. Today's floppy-disk drives have track densities of 48 or 96 tracks per inch and linear bit densities ranging from about 2,500 to 6,800 bits per inch.

The 10-megabyte flexible-disk cartridge drive described in pages 117 through 120 by Roderick J. Linton of Iomega Corp., Ogden, Utah, pushes the state of the art in flexible disks. The Alpha 10, as it is called, combines the speed and reliability of hard disks with the convenience of removable storage. A unique head and disk interface achieves a linear bit density exceeding 24,000 b/in. and a track density of 300 tracks/in. However, at such a linear density, error correction becomes critical, and the article gives details of the efficient error-correcting scheme developed.

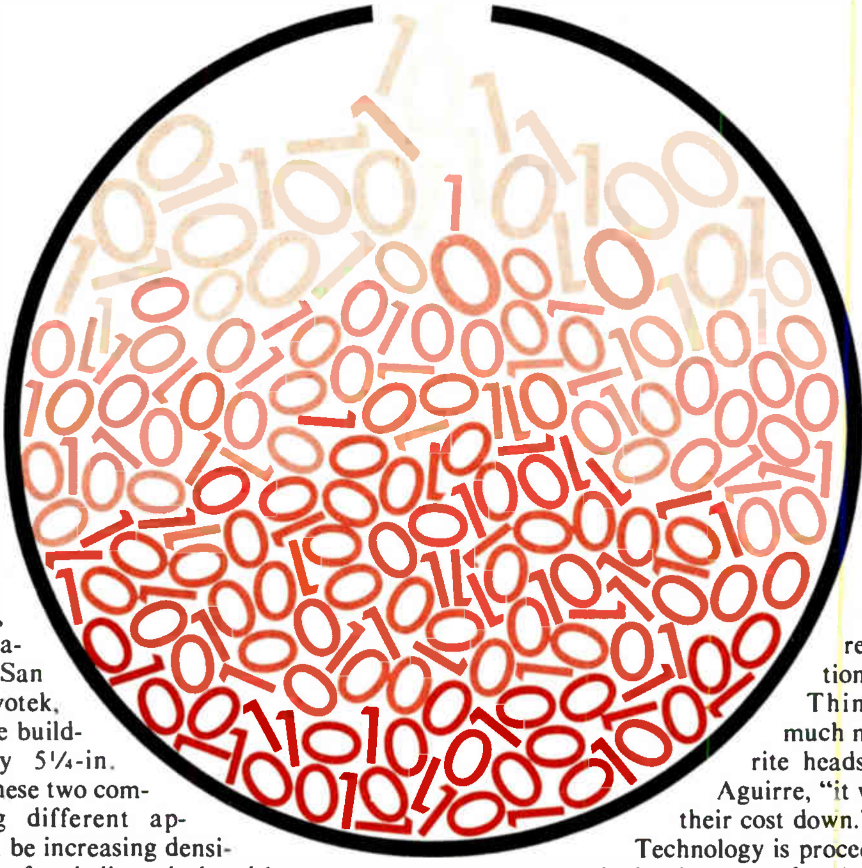
Hard-disk drives with much larger capacities and faster access come in three popular sizes—14 in. in diameter for medium-sized and large computer systems and scaled-down 8- and 5¼-in. diameters for today's prolific small computers. Capacities range all the way from 2.5-megabyte 14-in. cartridges and 5-megabyte 5¼-in. Winchester types up to the IBM 3380 and Storage Technology Corp.'s 8380 at 2,500 megabytes. Track densities of the smaller (5¼- and 8-in.) hard disks average about 200 to 300 per inch, using open-loop stepping-motor positioning mechanisms. Bit densities on the smaller drives range from 5,800 to 8,600 b/in.

On the very large disks, used in conjunction with dedicated closed-loop voice-coil positioning systems, track-per-inch densities are 800 or higher. Bit densities on the big hard-disk drives are about the same as the smaller ones, except for the very big ones where thin-film heads are used to get up to 15,000 b/in.

The article on pages 108 to 111 by Jack Taranto of Ibis Systems Inc., Duarte, Calif., describes a 5,000-megabyte drive that will use thin-film disks with a ferrite head. The first Ibis disk will have a linear density of 15,000 b/in., but the thin-film disk with ferrite-head technology promises densities greater than 20,000 b/in.

The small 8- and 5¼-in. Winchester drives offer the computer-system designer high capacity, quick access, and reliability, but flexibility is lost when all the storage is fixed within the drive—some alternative form of removable storage is needed for data and program input/output or for data backup. DMA Systems Corp., Santa Barbara, Calif., has therefore designed a new disk drive with 5 megabytes on one fixed disk and a 5-megabyte removable cartridge. In the article beginning on page 112, David Sutton tells how the drive joins the advantages of Winchester technology to those of removable storage. The bit density is 8,600 b/in., and an embedded track-following servo and voice-coil positioner help to achieve a track density of 450 to the inch.

Magnetic recording is far from being a mature technology. As this series of articles indicates, higher-density devices in a wide range of form factors are pushing it to even higher price-performance ratios. Though prices of individual drives do drop, the cost per byte comes down

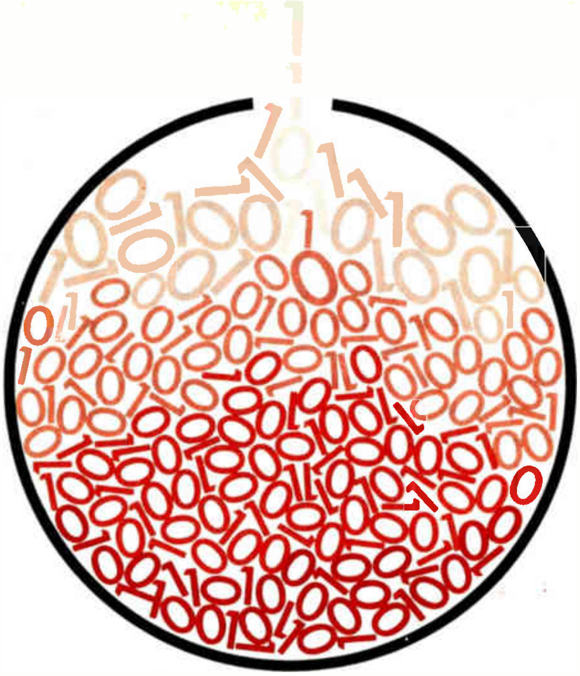


much faster as storage density continues to increase. Among many other firms working on advancing this trend, two start-up companies, Atasi Corp., San Jose, Calif., and Evotek, Fremont, Calif., are building higher-density 5¼-in. hard-disk drives. These two companies are taking different approaches. Atasi will be increasing density through the use of a dedicated closed-loop servo voice-coil positioner of the type used in big, high-performance drives to increase the track density. Though the open-loop stepping-motor positioners are accurate enough to achieve up to 400 tracks/in., the voice-coil servos can more than double that to 900 to 1,000 tracks/in. Atasi's initial 5¼-in. drive will likely sport 600 tracks/in. and 8,650 b/in. Future versions will use increased track-per-inch densities of 725, 825, and 900. A later version will use a thin-film disk to increase the bit density to 15,000 b/in.

Evotek's approach is to stay with the stepping-motor positioner and its associated 367 tracks/in., but to increase the bit density. At the top end, using a thin-film disk, the Evotek line will have 16,250 b/in.

Although firms have been working on the development of thin-film heads [*Electronics*, April 7, 1981, p. 57], the heads are not yet being manufactured reliably with high yields and low cost. According to Jack Taranto, thin-film heads may have a future, but it could well be remote in view of the work that has still to be done. Another disk-drive industry leader, Michael C. Aguirre, engineering manager of thin films at Storage Technology Corp. of Louisville, Colo., agrees. Aguirre says, "The biggest deterrent to thin-film–head use today is the lack of real volume production in the industry." Thin-film heads are much more costly than ferrite heads and, according to Aguirre, "it will take time to get their cost down." However, Storage Technology is proceeding with thin-film head development for both disk and tape drives, while researchers at STC and elsewhere are injecting more life into magnetic recording by investigating the properties of unusual magnetic materials and types of recording. The research center of CII-Honeywell Bull in the Paris suburb of Les Clayes sous Bois is experimenting with cobalt crystallized over chrome deposited on glass [*Electronics*, Nov. 17, 1981, p. 67]. The cobalt-chrome disk looks promising for densities in excess of 25,000 b/in. Also, research is under way at the laboratories of Ing. C. Olivetti & Co., Ivrea, Italy, in putting the cobalt-chrome combination on floppy-disk material.

After improvements in thin-film disks, thin-film heads, and head-positioning mechanics reach expected physical limits with the current longitudinal recording pattern, the next big jump in magnetic recording density looks to come from vertical recording. In this, the magnetized areas in the medium are oriented vertically through the thickness of the medium instead of in parallel with the surface (see p. 89). The bit density expected from vertical recording may be initially 40,000 to 60,000 b/in. and will likely top 100,000 b/in., with some possibility of even several hundred thousand.



Thin-film disks drive densities to new highs

This alloy-coated disk, overwritten by a ferrite head, promises more than 20,000 bits per inch, also proves easier to manufacture than thin-film heads

by Jack Taranto, *Ibis Systems Inc., Duarte, Calif.*

☐ In the push to higher data-storage densities and capacities, disk-drive designers have been casting around for the perfect combination of technologies for both head and disk. So far, the state of the art has been struggling to pair the newly devised thin-film head with disks coated with the more conventional ferrous oxide particles. Ibis Systems has reversed the pairing, however, combining a thin-film disk with a ferrite head. The company has been so encouraged by the new duo's potential for greater density, it has made a major commitment to a 5-gigabyte drive so constructed, prototypes of which are due out later this year [*Electronics*, Feb. 10, 1982, p. 39].

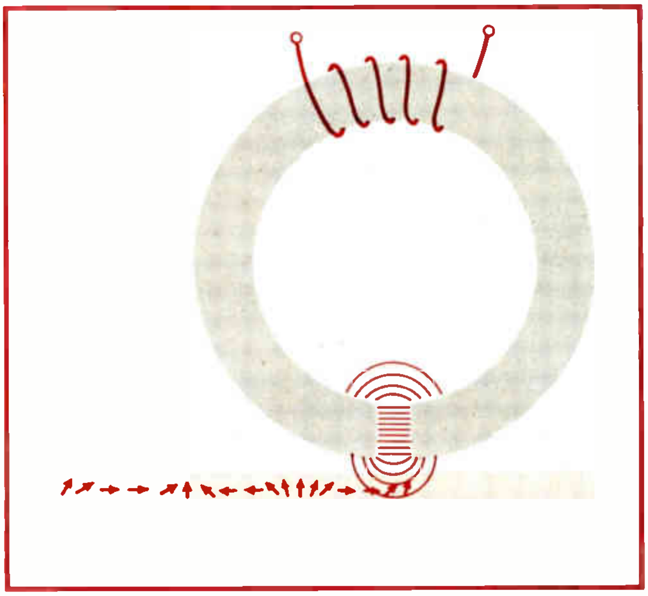
The new approach takes advantage of an improved, precisely controlled proprietary mix of thin-film disk-coating materials—nickel, cobalt, and phosphorus—that provides remanence of 8,000 gauss and coercivity of 500 to 600 oersteds for good signal conditioning. Although initial densities will be about 15,000 bits per inch, the company is setting its sights on a figure more in the region of 24,000 b/in.

In comparison, the IBM 3380 thin-film head and oxide-disk setup has a bit density of more than 15,000 bits per inch and a track density of slightly over 800 tracks/in. Both these densities have been attained by means of thin-film recording heads that record data at approximately 10,000 transitions or flux reversals per inch, which can be expanded to about 15,000 b/in. with a complex encoding scheme generally known as a run-length–limited code. However, for reasons that will be discussed later, thin-film heads have yet to fulfill their promise; further, they are hard to manufacture and require a heavy capital outlay in equipment.

The Ibis drive contains four head-disk assemblies, compared with two for the IBM 3380, and is housed in a cabinet that is only about 20% larger. The Ibis unit will transfer data as fast as the 3380, at 3 megabytes per second, and will be plug-compatible with it.

Recording is accomplished by magnetizing small regions of a film of magnetic material that has high coercivity and high remanence. The areas where the direction of magnetization changes are called magnetic transitions or flux reversals. Figure 1 illustrates the process schematically. Energizing the winding of the head produces a magnetic field that extends across the magnet's gap to magnetize the recording film. As the direction of the write current is reversed, the direction of local magnetization of the medium is also reversed, thus producing the transitions across which the direction of magnetization changes by 180°. The resulting magnetic transitions vary the flux distribution in the medium. Changes in flux direction and density can be sensed by the recording head when it is operating in reverse as a read head, producing a signal voltage across the terminals of the winding.

In high-performance disk drives the recording head is usually designed as an aerodynamic "air" bearing that



1. Magnetic recording. Passing a thin film of magnetic material by a recording head creates small magnets. Flux reversals induced many times a second across the magnets can store information that can be read indefinitely or erased and replaced with new data.

lifts the device to a predetermined flying height above the disk surface as the disk spins and drags the ambient air with it. Typical flying heights have been on the order of 20 to 40 microinches, although heights closer to 10 μin. have been incorporated in more recent designs.

Conventional recording heads have ferrite read-write elements, with the slider on which they are mounted made of ceramic or bulk ferrite. The slider is shaped by grinding and lapping, with glass bonding generally used to form the read-write gap and the whole slide assembly. The read-write coil in such heads is wirewound.

A thin-film head, on the other hand, is made by depositing all the magnetic elements of the head by sputtering, evaporation, or plating on a passive substrate that constitutes the air-bearing slider.

Media classification

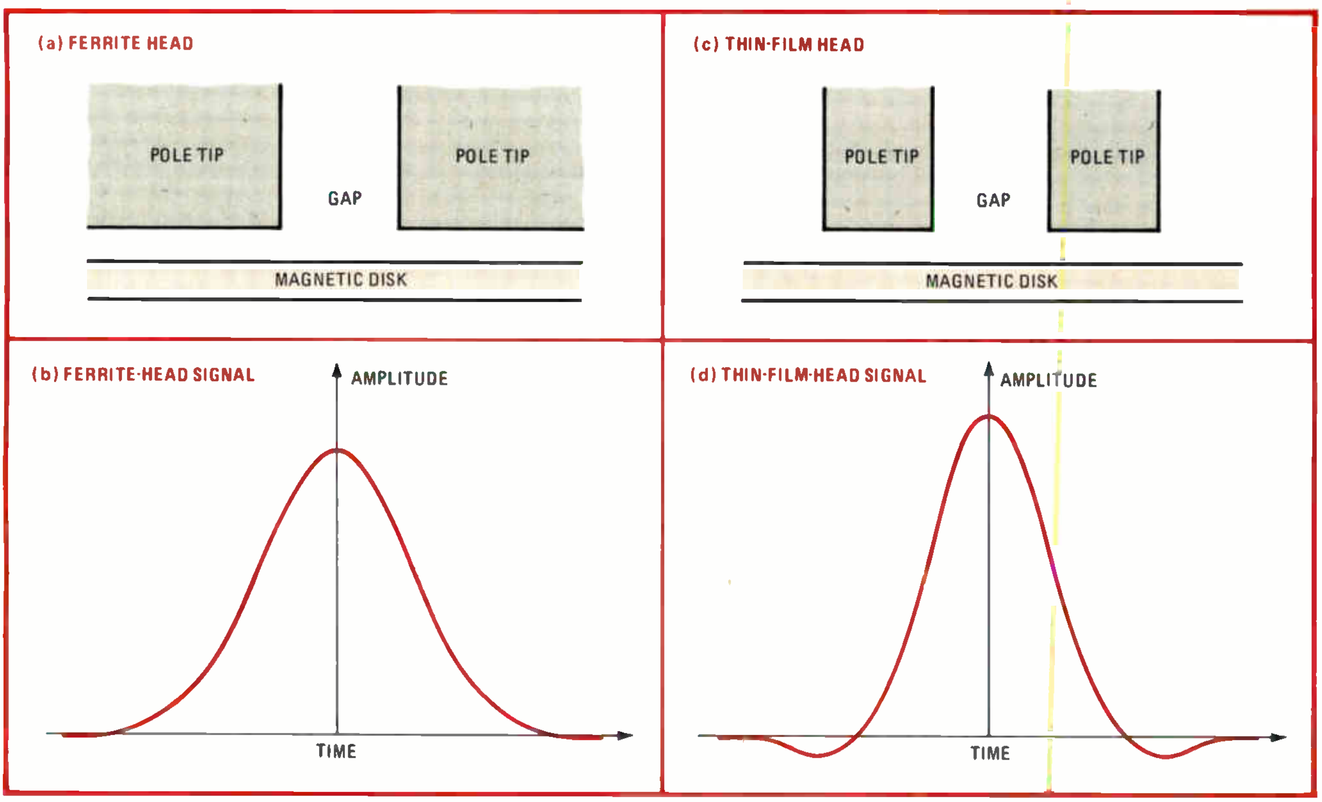
Media can also be classified in two broad categories, particulate and thin-film. The former, or oxide media as they are often termed, generally consist of iron oxide particles dispersed in an organic binder and applied to a polished aluminum disk in a coating 20 to 50 μin. thick. Such ingredients as aluminum oxide are often added in fabricating oxide disks to improve wear and abrasion resistance in the contact start-stop mode. Buffing or burnishing of the surface of the disk improves its finish, and a lubricating film gives the proper friction at the head and medium interface. Typical coercivities for iron oxide media are 300 to 500 Oe, with remanence on the order of 1,000 G. Any tailoring of these parameters has been limited as their range is largely determined by the physical properties of the iron oxide particles.

Thin-film media employ a continuous metallic film deposited by electroplating, electroless plating, or sputtering. The recording film is usually of cobalt or nickel or both, plus a certain amount of phosphorus. Controlling the total electrical charge in electroplating or the deposition time in electroless plating and sputtering makes it possible to produce recording films of any thickness—even down to 1 μin.

Varying the relative amounts of cobalt and nickel can increase the remanence, and adjusting the phosphorus content and certain other deposition conditions can act to raise the coercivity. As an example, on thin-film disks with a film thickness of 3 μin., remanence of 8,000 G, and coercivity of 500 to 600 Oe can be produced consistently in a manufacturing environment.

Thin-film disks are generally given a hard overcoat so that they will resist wear and corrosion. Most thin-film recording media are deposited over a nonmagnetic electroless nickel-phosphorus layer plated over the aluminum substrate. The electroless nickel-phosphorus layer, which is very hard, is polished so that it is smooth down to less than a microinch. Consequently, it interfaces well with the head.

The magnetic gap of a conventional head (Fig. 2a) has practically infinite pole tips; that is, the tip is much larger than the gap. Figure 2b shows the signal from this head for an isolated transition in the medium. Magnetic transitions are usually detected by differentiating the signal and finding the point of zero crossover that represents the position of the peak amplitude of the signal. Figure 2c illustrates the magnetic gap and finite-length pole-tip structure of thin-film head. Because of the mag-



2. Gaps and waveforms. Conventional ferrite read-write heads present what amounts to infinite pole tips and a small gap (a)—the signal waveform due to reading one flux transition with this head resembles (b). Thin-film heads with finite pole tips (c) produce a waveform like (d).

Other recording technologies in the crystal ball

As the limits of current magnetic recording technologies—generally known as longitudinal recording—are attained, the imagination strays to what the future has in store. The table compares potential densities in magnetic and optical recording.

For example, recent U. S. and Japanese developments in a new technology known as perpendicular, or vertical, recording point to bit densities exceeding 100,000 transitions per inch, achieved in sputtered thin recording films with perpendicular anisotropy. In vertical recording, the magnetic recording film can only be magnetized in a direction normal to the surface of the film. Because such adjacent magnetic regions aligned perpendicular to the surface and magnetized in opposite directions tend to attract each other, much higher transition densities can be attained compared with longitudinal recording, where the tiny magnets repel each other.

Vertical recording was first attempted by IBM researchers many years ago. More recently, since the mid-1970s, significant progress has been made by research workers in Japan, the U. S., and Europe. Professor Shunichi Iwasaki and his co-workers at Tohoku University in Sendai, Miyagi Prefecture, Japan, have demonstrated recording up to 100,000 flux changes/in. on a sputtered cobalt-chromium alloy thin film.

There is a growing interest in vertical recording. For example, an international symposium on vertical magnetic recording was held recently at Tohoku University. In addition, several Japanese and U. S. disk-drive and computer companies are working to develop vertically recorded disks. Ibis Systems is among them, having just formed a new division in Santa Clara, Calif., to develop mass-storage devices in the middle range of disk drives in the 100- to 500-megabyte category using vertical recording. The perfection of the technology could eventually pave the way for small drives with several hundred megabytes of storage.

Optical recording has also been a candidate for high-density recording. However, digital magnetic recording has been able consistently to provide error rates not exceeding 1 error in 10^{10}, and optical recording is still several orders of magnitudes away from achieving those levels. Furthermore, optical media are not erasable, making them incompatible with present magnetically based systems. Nevertheless, the optical technique is too promising to discard and will probably find its niche in the archival storage of images and documents, where high bit-error rates can be tolerated.

Although there are no announced data storage products using optical disk technology, quite a few companies are working on them [*Electronics*, May 5, 1981, p. 97]. Thus products are likely to appear in the near future.

MAXIMUM RECORDING DENSITIES ACHIEVABLE BY VARIOUS DISK TECHNOLOGIES

Technology	Density		
	Bits per inch	Tracks per inch	Bits per square inch
Longitudinal magnetic recording — thin-film heads (3380 type)	15,000	800	12×10^6
Longitudinal magnetic recording — thin-film disk with ferrite heads	25,000	1,200	30×10^6
Perpendicular magnetic recording	100,000	1,200	120×10^6
Optical recording	15,000	15,000	225×10^6

netic-field distribution of the finite-length pole-tip geometry, signals read by such a head from a magnetic transition show undershoots on both sides of the signal peak, as indicated in Fig. 2d.

In addition to signal amplitude, other important characteristics of the recording process are the signal-to-noise ratio and the timing of the signal. In order to read a magnetic transition in its true position, it must be detected within an interval known as the bit-cell time. Failure to read a magnetic transition within these tolerances results in a data error.

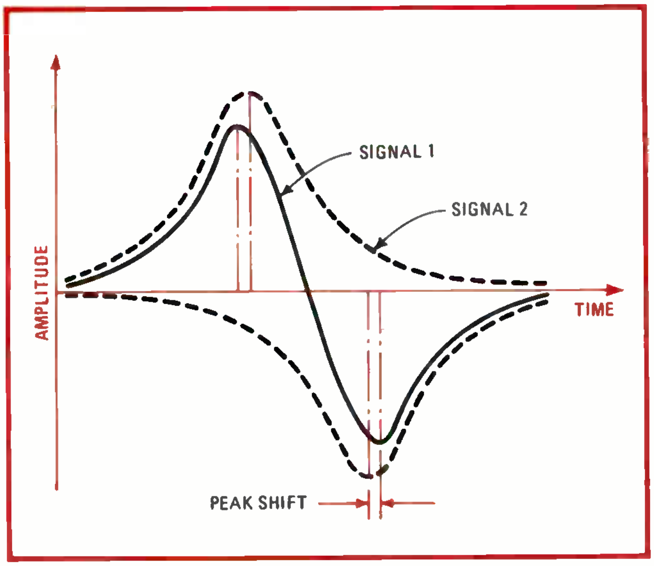
Displaced peaks

Several factors contribute to timing errors, which, if they exceed a certain portion of the bit-cell time, can also lead to data errors. The most significant timing error, known as peak shift, is caused by the superposition of signals from adjacent transitions. Figure 3 shows the relative motions of the peaks as superposition develops.

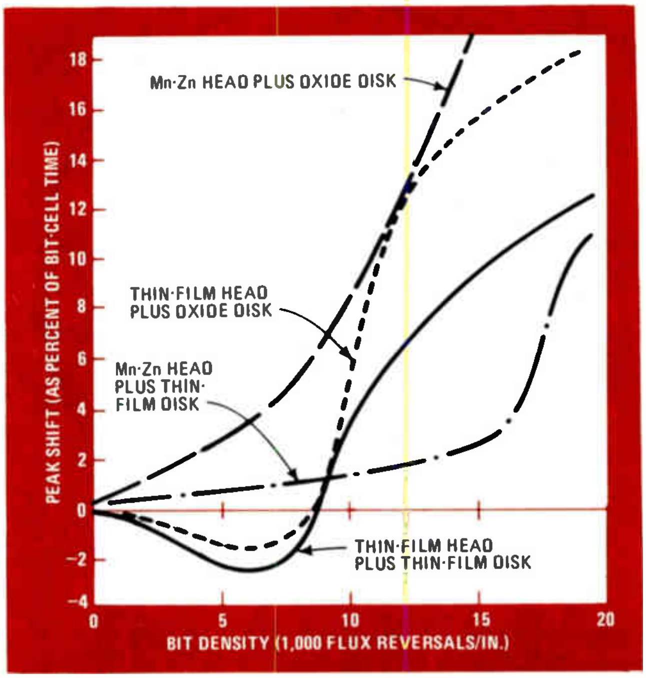
Generally, as the bit density increases, so also does the superposition effect, resulting in a larger peak shift. To obtain the total timing error, other time shifts introduced by the various data-channel circuit elements and correlated noise like overwrite residue must be added to peak shift. The superposition of gaussian noise on the signal produces additional timing errors and results in random data errors.

Figure 4 illustrates for various combinations of heads and disks the relationship between worst-case peak shift and recording density (expressed in terms of flux reversals/in.) using modified–frequency-modulation (mfm) encoded recording. Mfm recording is the simplest run-length–limited code where adjacent magnetic transitions can be as close to each other as one bit-cell time and no farther apart than two bit-cell times. The worst-case peak-shift pattern in any recording code is that which has transitions with the maximum spacing and the minimum spacing directly adjacent.

As can be seen from the first curve, the peak shift for a ferrite head and oxide disk increases sharply with transition density. It should be noted that the total time-window tolerance available in mfm recording is a quarter of the bit-cell time. A peak-shift value of about a tenth the bit-cell time is considered a reasonable limit if



3. Peak-shift problem. The peak of a signal waveform from the read-write head starts to shift as adjacent signals begin to crowd in. When the peak shifts get too large, the individual peaks become hard to identify, and consequently data errors increase rapidly.



4. Winning combination. Four combinations of head type and disk composition exhibit quite different peak shifts as a function of recording density in mfm recording. The MnZn head and thin-film disk show the lowest peak-shift rise as density increases.

acceptable error rates are to be expected. The first curve also indicates that transition densities more than 8,000 to 10,000 per in. encounter excessive peak shift, which means that ferrite-head technology cannot be extended beyond these densities with oxide disks. Run-length–limited codes can extend density somewhat beyond the 10,000-b/in. limit.

Signals from thin-film heads with finite gaps also exhibit peak shift from transition crowding. However, the undershoots of the waveform cause a negative peak shift at low transition densities that vanishes as density increases. Peak shift increases very rapidly beyond where it crosses zero. Similar characteristics are obtained with thin-film heads both on oxide and thin-film media, with somewhat better results on the latter, as seen in the second and third curves.

Recording characteristics of thin-film disks show greater capabilities for high-density recording than oxide disks because the first can be made much thinner, resulting in better definition of the signal waveform. Ferrite heads and thin-film disks show peak shifts (the fourth curve) that imply densities greater than 15,000 per in.

Going to the limit

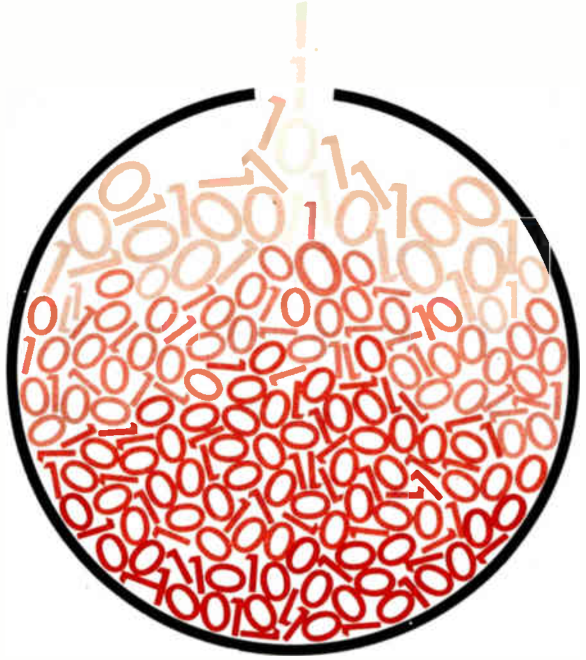
However, transition densities over 10,000 per in. with ferrite heads and oxide media show excessive peak shift and loss of signal resolution. Studies made on thin-film heads by both experiments and computer modeling have indicated that the general relationship between peak shift and transition density is not changed to any substantial degree by modifying the parameters of the heads within feasible ranges.

It has been found that the zero-crossover point for this curve for an oxide disk can be made to occur at transition densities below 10,000 per in., but cannot, for all practical purposes, be made to substantially exceed that number. As a consequence of the very rapidly increasing peak shift after this point, the only way to obtain high recording densities with thin-film heads has been to limit transition density to about 10,000 per in. and to increase the bit density by 50% (by resorting to more complex run-length–limited codes).

Thin-film heads may not be capable of appreciably exceeding the kind of densities currently provided by the IBM 3380 and similar disk drives. The disadvantage of utilizing them at these and greater recording densities are low signal amplitude, marginal overwrite, and narrow timing margins.

Both an advantage and a disadvantage, thin-film heads are made of Permalloy, which has high permeability of frequencies above 100 megahertz whereas ferrites exhibit decreased permeability at higher frequencies at data rates in excess of 30 to 35 megabits/s. Unfortunately, the thin Permalloy film in thin-film heads suffers from eddy-current losses that could greatly reduce permeability at higher frequencies. Therefore, to reduce eddy-current losses and keep permeability high, it is necessary to laminate the Permalloy films with dielectric insulation, similar to what is done in transformers, greatly complicating the manufacturing process. So far, attempts to fabricate heads with such laminated pole pieces in France and the U. S. have had very low yields.

In all, the lack of supply of quality thin-film heads has made the ferrite head–thin-film disk pairing more attractive to disk-drive manufacturers. Enhancing their appeal is the fact that besides much better timing tolerances at high recording densities, thin-film disks exhibit better S/N ratios and can be overwritten by the more efficient ferrite heads. Finally, laboratory experiments have borne out the possibility that transition reversals or bit densities of over 20,000 per in. can be achieved already with the present state of the art. □



Winchester cartridge challenges other backup systems

A 5.25-inch Winchester system stores 5 megabytes on a fixed disk and 5 megabytes on a removable cartridge

by David Sutton, *DMA Systems Corp., Santa Barbara, Calif.*

□ An idealist venturing forth with a small purse—say, under $15,000—might search in vain for a computer system that had a vast storage capacity packed in a small space, half of which was removable so that the fixed portion was easily backed up, and with both fixed and removable parts highly reliable.

Still, the idealist would hardly be accused of squandering his money if he were to settle on the Micro-Magnum 5/5 from DMA Systems Corp. Combined with 5 megabytes of fixed storage and a like amount of removable storage are input/output and a reliable Winchester-disk backup, all in a small, self-contained unit requiring no preventive maintenance.

The unit was designed with the ideal in mind. After surveying the market, the company picked its way carefully along a path fraught with design pitfalls in order to improve upon fixed Winchester-disk drives of similar size and capacity but with only external magnetic tape or floppy-disk drives for backup. This conventional backup setup suffered in reliability compared with the hard Winchester disk.

Compelling pluses

Yet there were other advantages. The all-Winchester combination eliminates the external backup device and its separate controller, decreasing space and power requirements significantly. Because the cartridge's transfer rate is as high as the fixed disk's, backup time is reduced. Further, as a result of the compact design, which uses the same technology for both the fixed and removable storage, some parts can double up on functions. For example, one spindle motor, one control subsystem, and one head positioner handle both disks. So, besides space, power, and backup time, fabrication cost is slashed. Another benefit is that the Micro-Magnum 5/5 cartridge conforms to the standard proposed by the American National Standards Institute—a feature that portends more than one source for the product.

The market survey queried system manufacturers and integrators, disk suppliers, and computer-industry consultants in order to generate the new product's design parameters. The survey led to some general specifications for the mass-storage needs of a desktop system for small business, word processing, networking, personal computing, intelligent terminals, and similar applications. Survey results strongly indicated that the ideal small-computer system should sell for $15,000 or less and include as its components a central processing unit, printer, 10-megabyte mass storage, one to four terminals, and a means for data input/output and backup. Every design decision was guided by the goal of a reliable and cost-effective solution to the problem of backing up mass storage.

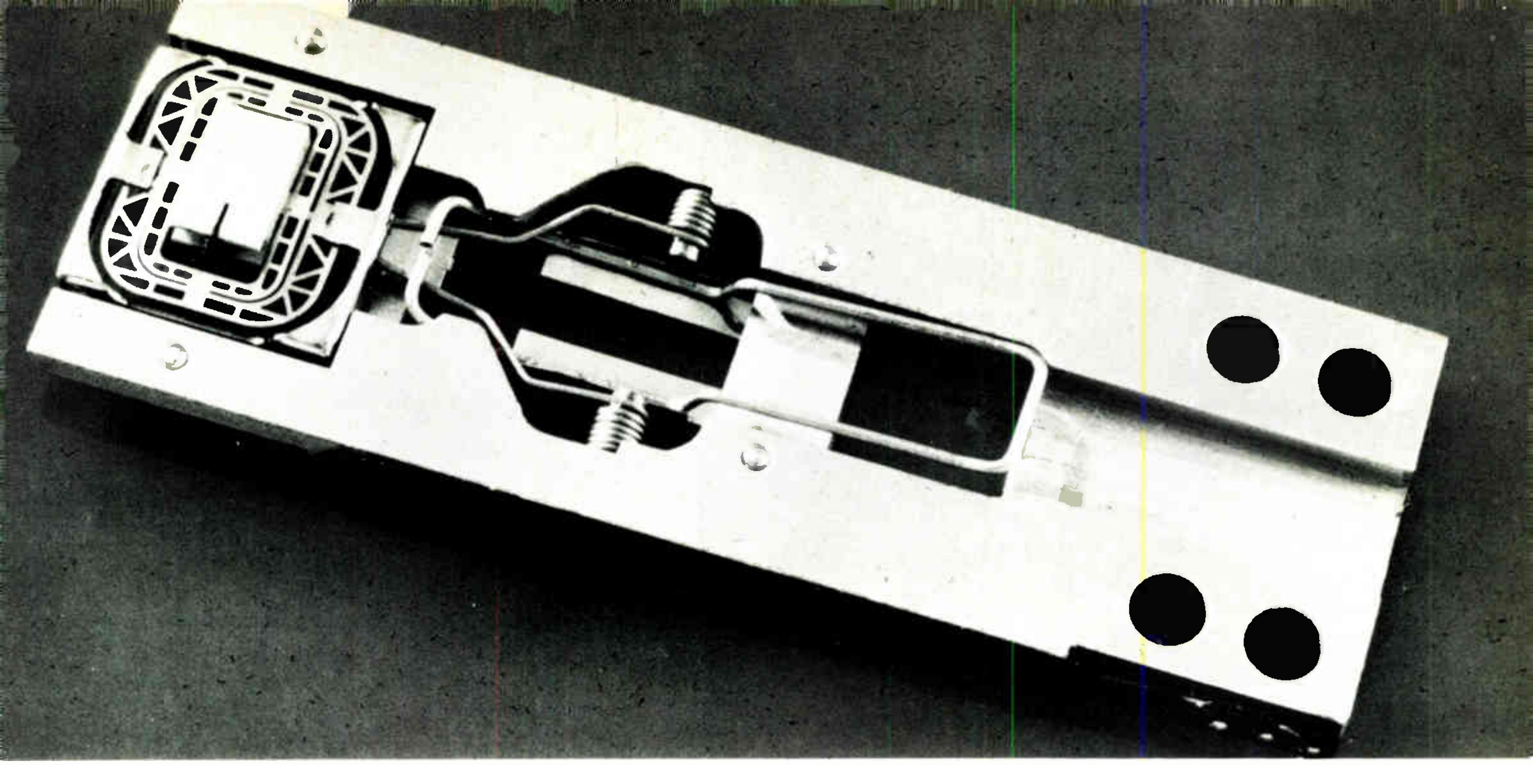
According to the survey, typical fixed-disk mass storage in a small-computer system incorporated either a flexible disk for I/O and backup or a flexible-disk I/O with tape backup. However, many computer systems of somewhat larger size were based on a 14-inch combination–fixed-and-removable-disk drive providing 5 to 10 megabytes of formatted capacity each for the fixed and removable media. No other means of I/O or backup was used. Reliability was the key factor in selecting fixed-and-removable-disk drives rather than other, external means for backup in systems of this class.

This fixed-removable disk concept became the cornerstone for the specifications of the Micro-Magnum 5/5, but it was also destined by its maker to be a drive that could fit into the same space as conventional 5.25-in. Winchester units.

Design challenges

To meet the product's design specifications, it was necessary to fit two 5-megabyte formatted disks, one fixed and one removable, into a package then being used for a 5.25-in., two-fixed-disk Winchester drive. The height and width constraints of this package were formidable challenges. The 3.25-in. drive height dictates a single disk cartridge, and the industry-standard spindle assembly would not allow a fixed- and removable-disk drive even with this cartridge, so a new spindle design was the first order of the day.

Five megabytes a disk with a conventional data track



1. Head of the class. In this composite head assembly, the ferrite core (left) is supported and protected by glass and ceramic. A patented flexure assembly holds the head allowing vertical motion while maintaining the all-important air bearing.

format meant 306 tracks of thirty-two 256-byte sectors on each surface. Allowing space for spare sectors, spare tracks, and an outside head-loading zone indicated a recording density of 450 tracks/in. and 8,600 flux changes/in., assuming modified-frequency-modulation encoding. The standard nickel-zinc-ferrite Winchester head was found to have insufficient signal output at these densities, and the manganese-zinc (MnZn) monolithic ferrite type was marginal. Thin-film heads were considered, but were rejected because it was felt the technology was not mature enough to merit a commitment to production.

From several viewpoints, the preferred head was a composite one. With a discrete MnZn core inserted and glass-bonded into a ceramic Winchester-type air-bearing shape, its mechanical durability is greatly enhanced, for the ceramic protects the core, while the glass bonding supports the core at its fragile edges.

Magnetically, the discrete MnZn core offered more signal output since it has a shorter flux path than the monolithic head and less parasitic inductance. Most important, the composite head is based on conventional manufacturing technology and so is at present available in volume production. The composite head assembly is shown in Fig. 1.

Obtaining 450 tracks/in. implied a track width of about 0.0017 in., which required that tracking errors be less than 200 microinches, including such effects as cartridge-registration errors, temperature gradients, spindle runout, and head track-width tolerance. This demanded a track-following servo system for head positioning because cartridge-seating error alone can exceed the maximum positioning error, if cartridge interchange and wear of the centering mechanism are considered.

The question arose as to whether to employ an embedded servo or a continuous track-following servo system. Embedded servo has track-following signals interspersed with the data, whereas continuous servo requires an entire disk surface to be dedicated to servo information only. With room for only one disk in the fixed area of the drive, the need for a full surface of servo information would mean doubling recording density on the other surface of the disk to maintain the same capacity.

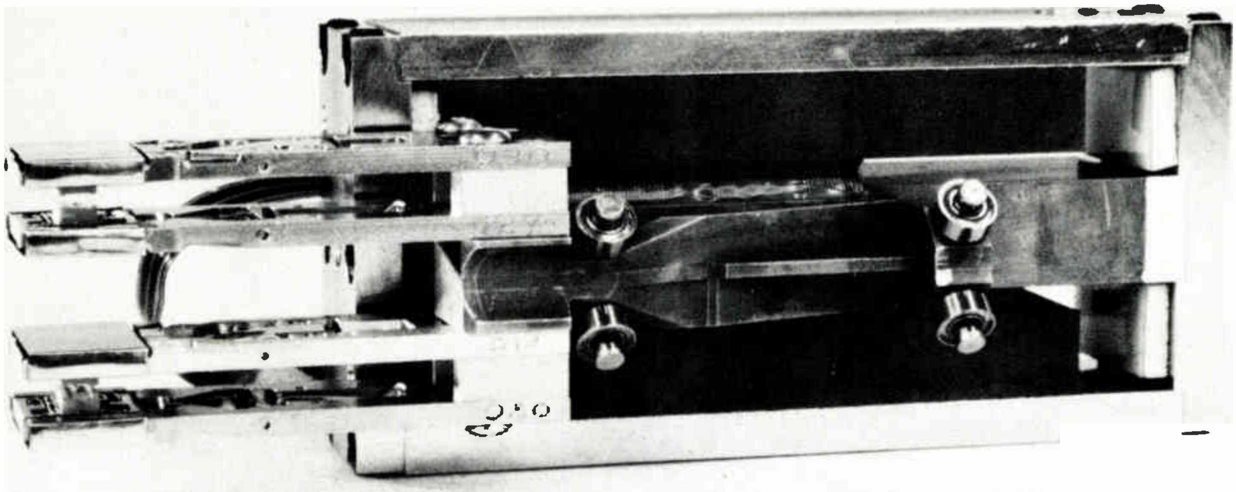
In addition, alignment differences among the four heads in a drive and from one drive to another represent possible errors from cartridge interchange. Precise adjustment of heads in drive manufacture and later in the field would be needed to keep these errors from causing trouble. However, such field-maintenance requirements would be unacceptable, according to the market survey.

Embedded servo digs in

Embedded servo eliminates the need for precise head alignment, increases the surface available for data recording, solves the problems of cartridge interchange and thermal-expansion compensation, and also makes it possible to increase track density in the future (see "The strait and narrow path to interchangeability," p. 116).

Of course, the decision was not free of compromise because sampled-data systems—such as embedded servo—require complicated electronics. Moreover, the added cost of writing servo data on both surfaces of every disk is not to be taken lightly. However, the technology for embedded servo is well established in contemporary products, so the basic technical risk was considered minimal.

There were additional design compromises associated with embedded servo—not least the extra time required to reposition the selected head over the track when switching heads, and the obligation for the maker to prewrite sector-header information (hard sectoring)



2. Put it there. Positioning the read-write heads to within ± 100 microinches, this unique linear-motor positioner has a side-mounted carriage for the heads. Compared with the conventional coaxial technique, the side-mounted approach shortens the drive depth.

because sector size is fixed at the time of manufacture by the embedded-servo fields.

Combining the need for a fast access time—50 milliseconds on average, according to the market survey—with the embedded servo track-following system mandated that a voice-coil head positioner be used. The choice was between either a rotary or a linear voice-coil positioner. If package length were the primary consideration—8 in. being the preferred length—a rotary positioner would have been used because it is compact and can be tucked into one corner of the drive. However, the company's major concern again was reliability, and here the rotary system came up short in several ways.

One problem was that its performance is very sensitive to the stiffness of the rotating arm and the mass of the head at the end of the arm. In most high-performance positioners of this type, the arm must pass over the surface of the disk in order to achieve the required stiffness. In a drive with a removable disk this would necessitate opening a whole side of the cartridge. In addition, the need to extract the heads from a cartridge for its removal further burdens the positioner design with an increased stroke length. A longer stroke means a longer arm and hence a greater likelihood of structural resonance problems.

Keeping out the riffraff

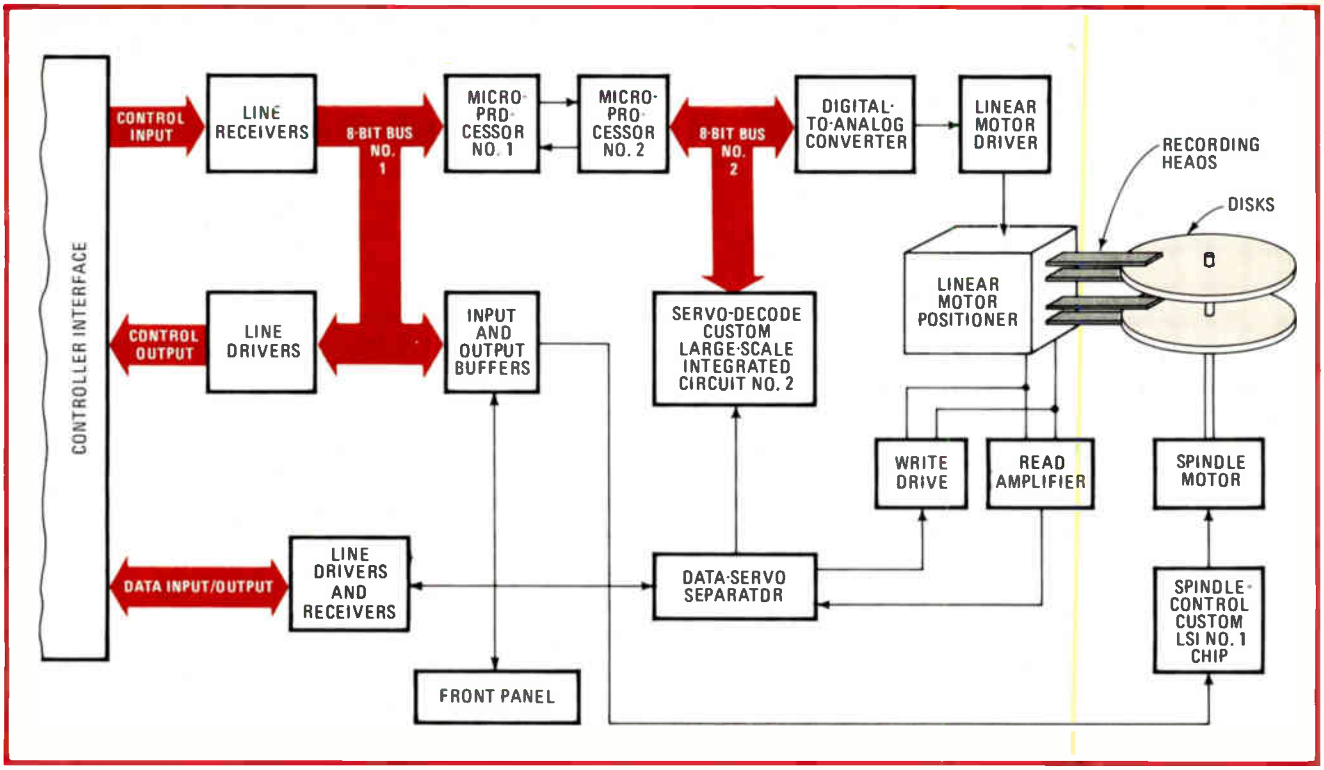
The nod to the linear motor (Fig. 2) was based first on the control it would give over contaminants that might enter a cartridge while it is outside the drive. With this motor, the opening in the cartridge can be much smaller and so also the risk of contaminant entry. Another advantage of the linear positioner is that the heads move on a radial line, giving the best possible tolerances for cartridge interchange. Also, structural resonances in the head-carriage assembly are easier to deal with.

The basic framework of the design was now in place: two disks, 5 megabytes fixed, 5 megabytes removable; head and media performance of 450 tracks/in. and 8,600 flux changes/in.; embedded servo; and a linear voice-coil positioner. The remaining design choices, as with earlier ones, were formulated largely on the basis of reliability—that is, the ability of the drive mechanisms to survive the design life of the product in the field without preventive maintenance.

An early move was to design the new head mechanics so the Winchester air-bearing head could be loaded dynamically. That is, the air bearing is launched onto the disk surface when the spindle is up to speed. Three reliability advantages are achieved by doing this:

- The head can be designed so the air-bearing surface never touches the disk. This was verified by high-speed photographic studies of head loading and unloading, shot at 4,000 frames per second.
- When the drive has been started and the purging cycle completed, heads can load without the stop-and-restart cycle required by the standard Winchester head, because there is no possibility of setting the air bearing down on contaminating particles.
- Heads can be completely retracted from the media and latched into their rest position when the cartridge is to be removed, the drive is shut down, or power is lost.

In the Micro-Magnum 5/5, the heads are retracted clear of the cartridge compartment during cartridge loading and unloading and whenever the drive is not running. Therefore the delicate head structures will not be damaged, and the heads will never contact the disk when the drive is transported. This marks a major improvement over most fixed-media Winchester drives where the heads are left on the disk surface. With such drives, shock and vibration during movement of the drive from one location to another can cause head motion and



3. Block party. Two microprocessors—the interface processor (No. 1) and the servo processor (No. 2)—and two custom chips, for servo decoding and for spindle control, pack in most of the electronics needed in the Micro-Magnum 5/5 disk drive.

damage to the disk surface that degrades the reliability of the system.

The need for control of contaminants within the disk enclosure was why the Micro-Magnum was endowed with a high-capacity closed-loop air system. One feature of this design is a fan at the bottom of the spindle motor that generates enough flow to pass the entire volume of air in the system through the recirculating filter once a second. During a purge cycle, this flow efficiently removes those contaminant particles that may have been introduced by the insertion of a cartridge. In contrast, most present fixed-Winchester drives rely on the rotation of the disks to cause air movement, an approach that simply cannot circulate air as effectively as a fan.

Clean room

The cartridge has a door that closes the head opening and a clamp that secures the disk hub to the cartridge housing, to exclude contaminants when the cartridge is outside the drive. Inside the drive itself a door closes, sealing the heads inside the clean-air system after they are retracted from the cartridge. This double-door system ensures that contaminants on the external surfaces of the cartridge and inside the receiver slot are excluded from the clean environment of the head-disk interface. On start-up, the total volume of contaminated air introduced into the system is limited to that inside the cartridge at the time of insertion.

The Micro-Magnum air system can in fact operate with some degree of air leakage at the cartridge. The fan impeller raises the pressure in the cartridge above ambient pressure so all leaks are outward and contaminants are prevented from entering the system. Leakage is made up by air pulled into the system through a specially designed breather filter. Both the recirculating and breather filters have a design life of five years with no filter change required in the normal office environment.

Several Micro-Magnum design choices were related to controlling the unit's internal temperature, another key element of reliable operation. One way to reduce heat was to use ±12-volt dc supplies for the spindle and linear motors. Another was to place motor drivers on a heat-sink board at the back of the drive, where it would be thermally isolated from the main deck. Also, provisions were made for air entry through the front panel of the drive so that a fan in the user's system could provide cooling air flow for the drive electronics.

Shock mounting of the drive had to be included because the unit is typically used in an office environment, where normal operator activity causes shock and vibration. As mentioned previously, vibration control during drive shipment is not critical, because heads are retracted when the unit is not in operation.

Usage alone will determine how successful the unit's design is in withstanding a projected maintenance-free five-year product life. The various mechanisms are expected to meet the following design goals: the number of cartridge insertions and removals in a drive will total 20,000; any single cartridge will withstand at least 5,000 in and out cycles in any drive; and the head and carriage assembly will load and unload the heads to the disks approximately 50,000 times.

Electronic packaging of the Micro-Magnum required that all the functions of a typical full-size 14-in. disk drive of the early 1970s fit into a case the size of a small shoebox. These functions are shown in the block diagram

The strait and narrow path to interchangeability

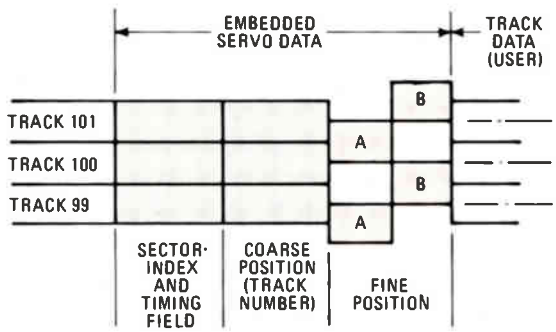
The embedded-servo approach makes it possible to achieve interchangeability of the removable disk cartridge within the Micro-Magnum family, regardless of the drive model into which it is loaded. The technique is so effective that it can adjust for errors due to thermal expansion of mechanical parts, friction in the cartridge, offset due to tilt of the drive, and runout of the disk.

The servo data is recorded on both the fixed and removable disks of the Micro-Magnum 5/5 to guide the unit's read-write heads. This data is "embedded" during the disk's manufacture and is contained in the 26 bytes at the start of each sector.

Positioning the head using the embedded servo is a two-step process. First, coarse positioning locates the proper track, and then fine positioning guides the read-write head in a path directly over the track's center.

The coarse-positioning process works digitally to move the read-write head to the proper track. Tracks are numbered from 0 to 310 (there are 5 spare tracks) and the code for each track number is prerecorded as part of the 26-byte embedded-servo format in each sector of that track. As the head crosses a track, it reads the servo data, and a software routine calculates a demand velocity based on the difference between current track location and target track. Demand velocity is converted from a digital signal into an analog one and applied as an input to the linear-motor servo that controls the head's velocity. As track difference decreases, the demand velocity is reduced to bring the head to rest at the target track.

When the head is within half a track of the target location, fine positioning takes over. It employs an analog method based on the format shown in the figure. Segments A and B consist of bursts of recorded signals displaced in time from each other. The edges of A and B are along the center lines of tracks, so that a head exactly centered on a track will read equal amplitudes from both segments. If the head moves to either side of center, one amplitude will go up and the other down. The difference is detected and used as an error signal to drive the linear motor servo. Therefore, the head always seeks a zero error and maintains its proper position down the center of the track, resulting in the best signal-to-noise ratio and lowest error rate.



of Fig. 3. Complicating the design were the embedded servo and voice-coil positioner.

Initial printed-circuit–board estimates pointed to a microprocessor-controlled system in order to minimize space requirements. In fact, a dual-microprocessor system was incorporated to conserve space and partition functions to make firmware design easier.

One microprocessor is dedicated to interface and status functions that include all controller input and output lines, front-panel functions, safety checks, and fault algorithms. In addition, it preformats seek commands into the form required by the second microprocessor, which controls all the internal command lines of the positioner servo system.

The second microprocessor receives embedded-servo information from the servo decoding circuit—a custom large-scale integrated circuit—so it has all the information required to perform the basic disk-drive servo functions such as track following and seeking, rezeroing, and loading and retracting the heads.

The partitioning of functions between the processors results in a faster response. For example, the second processor may perform a seek while the first one continues to handle all interface and safety functions, enabling emergency situations to be handled faster than could be done with a single microprocessor.

To achieve the needed packing density, two complementary-MOS gate-array custom ICs were developed. The underlying philosophy in this design effort was to limit the custom ICs to low-risk types to replace ones of small- and medium-scale integration. Also, the custom designs had to maintain functional isolation.

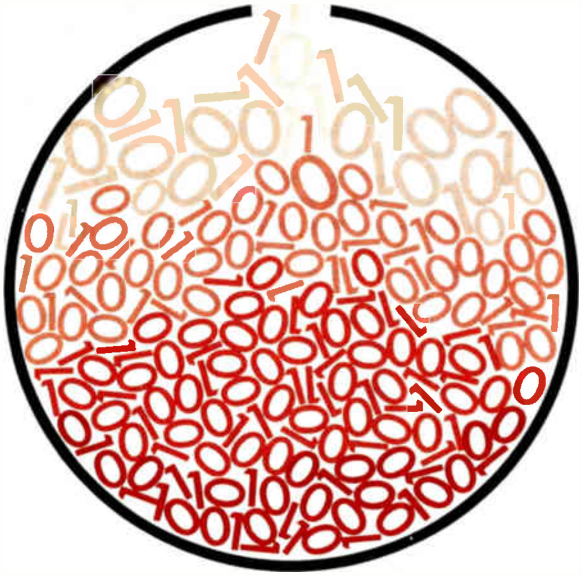
The first of the two functions to be committed to custom designs was the servo control of the spindle, which was accomplished by a 200-gate array that includes spindle-motor commutation circuits, a spindle-speed control servo, a speed-safety function, and a 10-megahertz crystal oscillator.

Decoding gate array

Second, to decode of the digital information in the embedded servo fields, a 500-gate array was developed. Functions included in this second array are detecting erase-gaps, decoding sector and index marks and track locations, checking timing, and generating sampling pulses for fine position information.

This chip also checks hardware to preserve embedded-servo information before clearing the way for a write operation, because if the drive were ever to overwrite the embedded-servo fields, data could be lost from either disk. Therefore a series of hardware and software safety checks must be found to be in agreement before a write operation can proceed.

The hardware functions are gated directly to the heads, responding in microseconds to any unsafe condition. There are also software checks used to enable the write function. The software will not proceed with a write operation until two successive embedded-servo sectors have decoded the same track identification and no fault conditions have been found in the drive. □



Flexible-disk drive closes in on hard-disk densities

Capable of correcting burst errors of up to 4,096 bits, the drives' unique parity-sector technique takes up only 1.6% of a 10-megabyte flexible disk

by Roderick J. Linton *Iomega Corp., Ogden, Utah*

☐ High densities and low error rates, always difficult to achieve in hard-disk technology, are even harder to attain in floppy-disk drives. Yet, using an 8-inch single-sided flexible disk in a hard plastic cartridge, the Iomega Alpha 10 has already managed to rival the performance of even Winchester hard-disk technology by storing as much as 10 megabytes of formatted data on a single disk with an average access time of 35 milliseconds and a reliability of under 1 nonrecoverable bit error in 10^{12} bits.

To obtain this performance, the designers of the Alpha 10 developed a new head-and-disk coupling system, based in part on the Bernoulli effect, that reduces the head-disk gap to 10 microinches (see "Bernoulli to a disk drive's rescue," p. 118). They also came up with a unique parity-sector error-correction scheme that stores parity information for a group of sectors in a special error-correction sector. The Bernoulli technology gives the unit a data density of 24,000 bits/inch; the parity-sector scheme makes such densities viable by permitting the drive to correct bursts of errors up to 4,096 bits long while using up only 1.6% of the disk's data space.

Other technological advances over standard floppy-disk drive design were required to realize the potential for greater bit and track density. An advanced analog read-write channel was designed to reliably handle the densely packed data bits, and a new accurate head-positioning servo control was designed so the Alpha 10 can handle a density of 300 tracks/in. (see "Staying in the middle of track," p. 119).

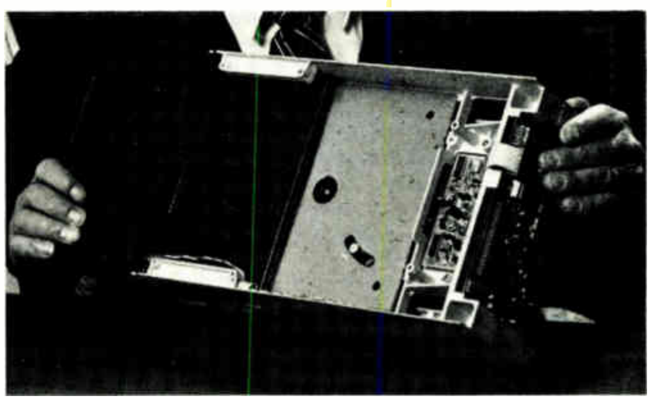
Thus, the Alpha 10 drive can accurately record data at over 18,000 magnetic-flux changes/in. on a higher-coercivity, oxide-coated, Mylar disk. Through the use of a proprietary run-length–limited (RLL) encoding scheme, the effective data-bit density is thus increased to over 24,000 b/in. The RLL encoding scheme translates the data-bit combination entering the drive into a compacted bit combination that is actually written on the disk. Translation algorithms that squeeze in more bits than the number of flux changes that can be recorded get complex, but in general, they are designed to minimize the number of flux transitions required to represent an incoming data-bit pattern.

At linear bit densities of 24,000 b/in. and higher, however, some new techniques also are needed to guarantee data integrity through the read-write channel and to correct errors that may result from such things as media defects and contamination.

Errors hard and soft

Data errors in both flexible and rigid magnetic-disk–storage systems may be classified as either transient (soft) or permanent (hard). Transient errors are typically caused by random electrical-noise bursts, contaminants that may temporarily disturb the head-disk relationship, momentary off-track positioning of the head, or other random phenomena. Such errors are typically not of concern to the error-correction scheme since they are by definition recoverable with retries.

Permanent errors, however, are typically the result of media damage. Such damage may be magnetic—that is, a transient noise burst may have created glitches in a section of prerecorded data, or stray magnetic fields in the system may have degraded the signal. Alternatively,



1. High concentration. The Alpha 10 disk-drive holds 10 megabytes of fully accessible data on an 8-inch flexible disk enclosed in a rigid plastic cartridge. The data can be accessed in 35 ms with reliability rivaling that of a Winchester-technology drive.

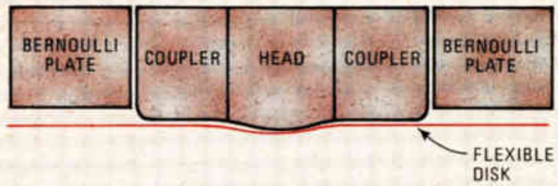
Bernoulli to a disk drive's rescue

The design of the Alpha 10 disk drive contains three unique stages of media stabilization to progressively reduce the amount of media flutter in the region of the read-write gap (see figure).

The first level of stabilization is the Bernoulli plate, whose action is based on the Bernoulli effect in fluid mechanics. Developed by eighteenth century Swiss mathematician Daniel Bernoulli, the effect states that the pressure of a stream of fluid (here air) is reduced as its speed of flow is increased. Thus, as the disk rotates in close proximity to this stationary plate, the natural pumping action causes air flow between the disk and the plate, and a low-pressure condition is created, which tends to pull the flexible disk toward the plate. By controlling the amount of new air introduced into the system at the disk hub, it is possible to prevent the disk from actually touching the plate. In this equilibrium position, the flexible disk assumes a relatively stable, flutter-free rotation.

The second level of stabilization comes from a small ring called the coupler installed around the read-write head. This coupler ring constitutes a smaller Bernoulli surface that draws the disk into still closer proximity and further reduces disk flutter in the region of the head.

Finally, the aerodynamic design of the head itself provides the third level of media stabilization. Over the read-write gap the disk achieves a flying height of less than 10 microinches.



it may be physical—caused by such damage as scratches, digs, and embedded contamination. The existence of some permanent errors requires a disk drive to have an error-correction scheme that can correct large burst errors if there is to be no data loss.

In typical 8-in.-disk systems with bit densities of up to 8,000 b/in., designers commonly adopt an error-detection and -correction scheme capable of handling error bursts up to 13 bits long. The overhead, or disk space, needed to record the correction bytes is usually 1% to 2.5% of the total disk capacity. Efforts to increase the number of bits that can be corrected using one of these common burst-error techniques will drive the overhead inexorably and dramatically upward.

The general approach to error-correction coding (ECC) on magnetic-disk storage systems involves the use of cyclic redundancy checksums (CRCs). One simple example of the use of CRCs is in error detection. A CRC generator may be viewed as a large divide circuit where the divisor is a polynomial that has been preselected for certain properties, the dividend is the data to be stored on the disk, and the remainder is appended to the end of the data string.

When the data is read from storage, it is divided again by the same preselected polynomial, and the remainder is compared against the previous remainder that was appended to the data record. If an error in the data has occurred during a read operation, the two remainders will not match and an error will be flagged.

Making a correction

For error correction, the same general method is used, in that a polynomial is selected and then used in the generation of error-correction bytes, which bytes are appended to the data written on the disk. On read-back, the correction bytes are regenerated and compared with those originally appended to the data field. The difference between the two data fields provides the necessary information for a mathematical correction of the data bits in error. The particular polynomial selected and the number of bits appended to the data, in general, determine the correction capability of the code.

Though a 13-bit correction scheme may be adequate for densities up to 8,000 b/in., it is inadequate for the much higher density of 24,000 b/in. of the Alpha 10 drive. The usual causes of errors on a disk—bad spots on the disk or dirt particles between the head and disk, for example—affect the same physical space on a disk independent of the disk density. In a system with three times the bit density, the same cause of error is likely to affect three times the number of bits. Thus in order to provide effective (and efficient) error correction at densities of 24,000 b/in. and greater, the Alpha 10 designers had to find a different approach.

Parity by sector

The Iomega parity-sector ECC is designed to handle losses of up to 4,096 bits of data. To understand how this ECC scheme works, it is necessary to examine the track and sector format of the Alpha 10 drive. Figure 2 shows the division of each data track into 70 identical sectors. Each sector contains a total of 648 bytes of which 512 are actual user data. The other bytes are for sectored-servo position information, synchronization bytes, identification fields, and so on. The data field is divided into two records of 256 bytes. Each 256-byte record contains its own variable-frequency-oscillator synchronization field (VFO/SYNC) and its own CRC field, which is used for error detection but not for error correction.

Only 64 of the 70 available sectors on the track are used for data. Five additional sectors are available as spares should any of the regular 64 sectors become unusable. In addition, one sector per track is reserved for error correction and is known as the parity or ECC sector. This sector is formatted exactly like all other sectors except that the information written into its two data records provides the correction code for all other sectors on the track.

The correction code is generated by performing a sector-parallel, exclusive-OR operation on all data sectors around the track and then writing the result in the data field of the ECC sector.

Staying in the middle of the track

The Alpha 10 disk drive uses a unique sectored-servo approach to control the head position with respect to the track. Each of the 70 sectors on the track contains a servo field that has been prewritten in the factory to provide positional information to the control system. These servo fields are offset from the data tracks by a half-track, as shown in the figure. When the servo code is read, the relative amplitudes of the A and B field peaks indicate how far the head is from a track center.

Servo peak detectors on the analog controller board check the amplitude of the A and B peaks and send the results to a differential amplifier. The difference between the amplitude of the A and B peaks is an error signal whose amplitudes will indicate the amount the head is off track. The digital controller uses this position error signal to determine what head movement commands it should send to the actuator across the servo-current command lines to maintain proper track following.

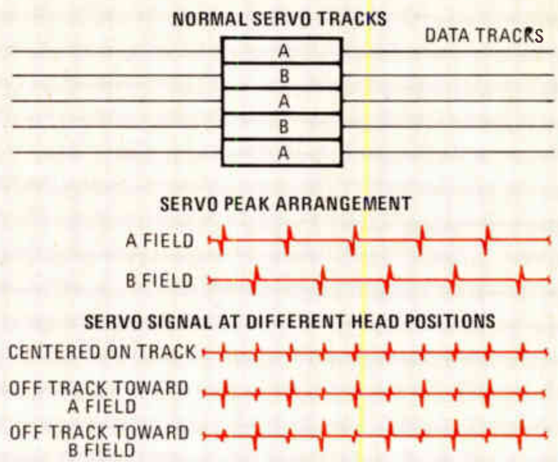


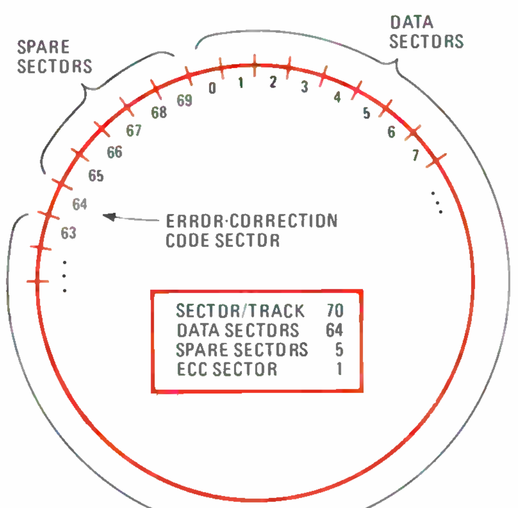
Figure 3 provides an example of the ECC-generation and data-correction techniques using ideally small sectors. The technique works exactly the same for 64 sectors of 512 bytes each. During ECC-generation, the ECC sector is generated by progressively exclusive ORing sectors 1 through 5. (An exclusive-OR operation is defined such that the result will be 1 if either of the other two input bits is 1 but not both.) During data correction an unreadable sector can be restored by using the same progressive exclusive-OR technique but substituting the ECC sector for the unreadable sector. These operations are performed in special registers within the Alpha 10 controller under microcode control.

Write operations on the Alpha 10 automatically update the ECC sector on the track being written. Any CRC checks that occur during read operations will automatically activate the error-correction system. All of these activities are transparent to the host system. Corrected data is always transferred to the host.

Parity for performance

The parity-sector technique is capable of restoring an entire data sector that is in error (512 bytes, all told). Also, since it generates correction codes separately for each of the two 256-byte data records within a sector, it can also correct more than one sector in error in a track, as long as the defects exist in different data records (for example, a defective record 1 of sector A and a defective record 2 of sector B). It cannot correct more than one

TRACK FORMAT

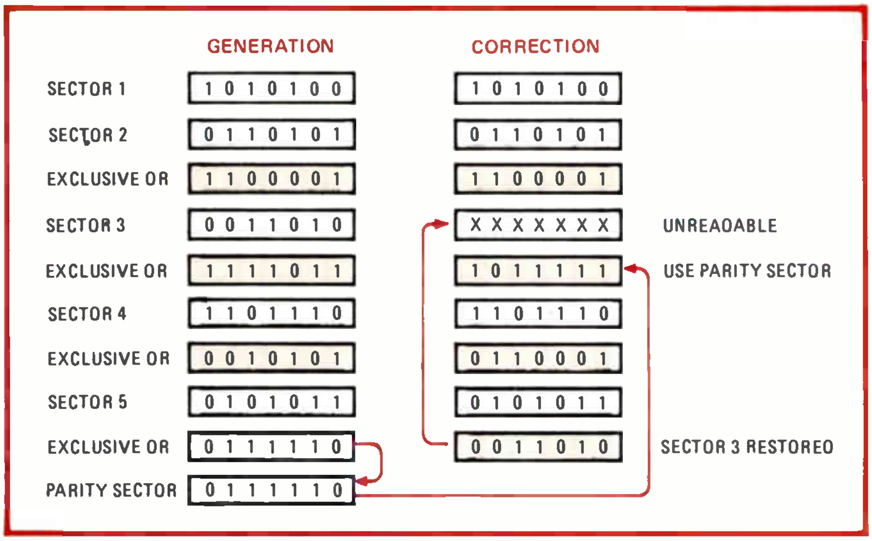


2. Fancy formats. The track of the Alpha 10 is formatted into 70 sectors, each with 512 bytes of data. One sector on each track, called the ECC sector, is used for error-correction coding, and five sectors are set aside as spares that can replace bad sectors.

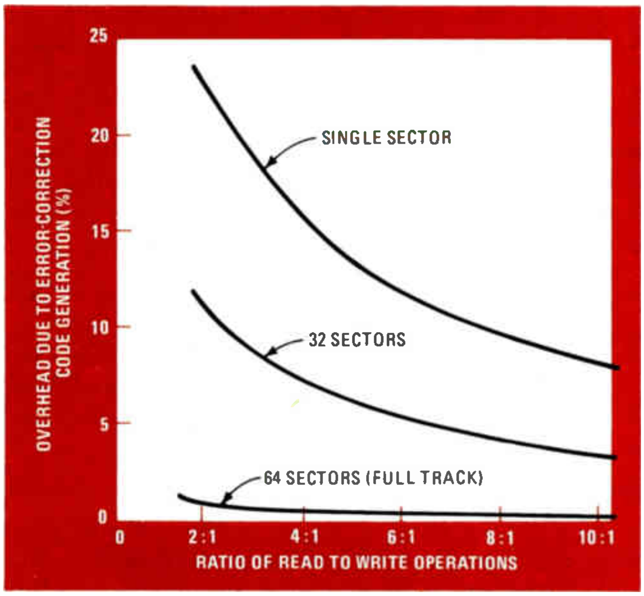
SECTOR FORMAT

	PAD	SERVO FIELD	GAP		SECTOR ID FIELD		GAP		DATA 1 FIELD		GAP		DATA 2 FIELD	
	PAD	SERVO FIELD	VFO	SYNC	ID	CRC	VFO	SYNC	DATA	CRC	VFO	SYNC	DATA	CRC
BYTES	24	40	20	1	4	2	17	1	256	2	22		256	2

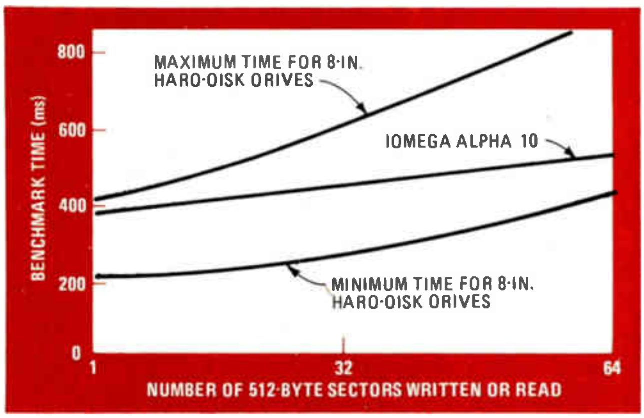
ID = IDENTIFICATION CRC = CYCLIC REDUNDANCY CHECK SUM SYNC = SYNCHRONIZATION VFO = VARIABLE FREQUENCY OSCILLATOR



3. Bit magic. This example of the parity-sector ECC scheme shows only a few ideally small sectors in order to illustrate the error-correction process, which works identically when applied to a greater number of large-sized sectors. An exclusive-OR of successive sectors produces the parity sector.



4. Cost-effective. The major cost of error-correction coding is the amount of time that it takes for generation of the ECC data. In the parity-sector ECC scheme for the Alpha 10, the cost becomes negligible when used over a full 64-sector track.



5. Reading and writing. A comparison of the performance of the Alpha 10 with various 8-inch hard-disk drives shows that it can keep up with them. The benchmark test was the time required to do one random writing operation and four random reading ones.

sector if the defective records are the same. A defect spanning a sector boundary and affecting record 2 of the first sector and record 1 of the second sector is correctable. Likewise, a defect spanning two records within a single sector is correctable.

Since each write operation to the Alpha 10 requires a corresponding update to the ECC sector on that track, there may be some performance overhead involved. However, the overall effect of the ECC on system performance depends on two factors: the number of sectors being written in a typical write operation and the overall ratio of write operations to read operations in a given system environment.

Figure 4 summarizes the ECC generation overhead in the Alpha 10 as a function of the number of sectors written and the ratio of read operations to write operations. It is estimated that for most typical system environments the number of read operations will be at least four times the number of write operations. For full-track writes (for instance, in copy or back-up mode), the performance impact is essentially zero.

Figure 5 compares the performance of the Alpha 10 with that of a group of high-performance 8-in. rigid-disk drives with both removable and nonremovable media. The benchmark test used to calculate the data is defined as the total time required to do one random write operation and four read operations. That time includes head seek, latency, write, read, and write verify times. The horizontal axis indicates whether the benchmark is tested with single-sector, 32-sector, or 64-sector write-read operations.

The minimum and maximum ranges were calculated from performance specifications published by the respective drive manufacturers. It can be seen that the Alpha 10 with parity-sector ECC compares very favorably with this class of high-performance rigid-disk devices. The ECC function of the Alpha 10 subsystem can be enabled or disabled by a system-level command at any time. Thus, a user may enhance the performance of the drive by running for periods of time without ECC protection. In addition, at the end of a work period, the cartridge can be ECC-protected, if desired, by the issuance of the ECC-enable command. □

ECC embraces more than components and hybrids

Fine-line thin-film substrates, integrated capacitors, and the laser processing of thick films are all topics at this year's Electronic Components Conference

by Jerry Lyman, *Packaging & Production Editor*

☐ As in past years, the stated purpose of the 1982 Electronic Components Conference is to present new developments in components and also hybrid circuits. But this year's ECC, to be held May 10–12 in San Diego, Calif., does much more.

The conference's 16 sessions also cut across technologies like VLSI circuit packaging, manufacturing processes, optical hybrids, and even semiconductor processing and technology. The first two of these topics dominate the conference, with three and two sessions respectively. But each of the single sessions, like those on optical hybrids and passive components, for example, contain much material of interest to the electronics specialist. There is even a paper on the development of a cold-cathode tube for high-temperature electronic operations in geothermal applications.

The three packaging sessions comprise 16 papers covering all aspects of the subject, from mechanical configurations to thermal and electrical considerations. Perhaps the most important paper comes from the Honeywell Corporate Technology Center in Bloomington, Minn. In it, J. P. Cummings, R. Jensen, and D. Kompelien take a look at the technology base that will be needed for packaging future very high-speed and very large-scale integrated circuits.

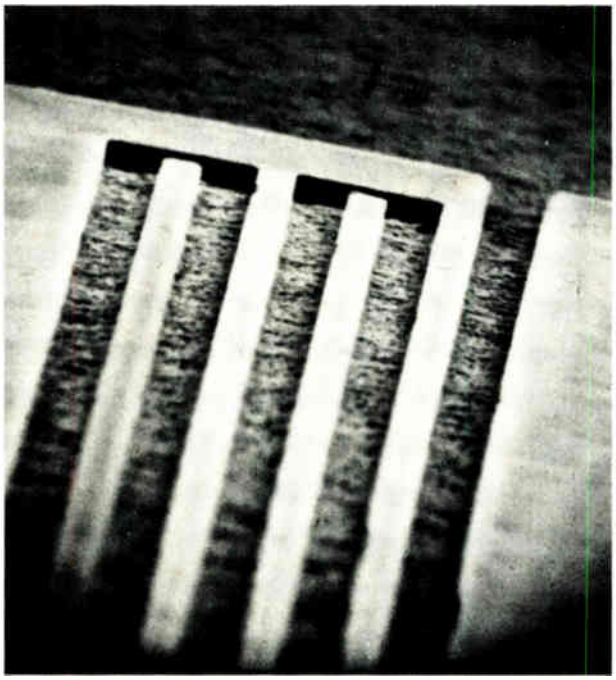
The three authors note that the advances currently being made in VHSIC and VLSI circuit densities necessitate the development of new concepts, designs, material systems, and processing approaches for IC interconnection and packaging. Circuits with 500 input/output connections and a clock rate of 500 megahertz are now being designed. Such a speed means that the conductor network in a package must be treated as a set of transmission lines. Line impedance, the critical line length for termination, ohmic drops, and interline isolation become critical to package performance, while the dielectric material in a multilayer configuration must be chosen carefully for an appropriate dielectric constant and loss.

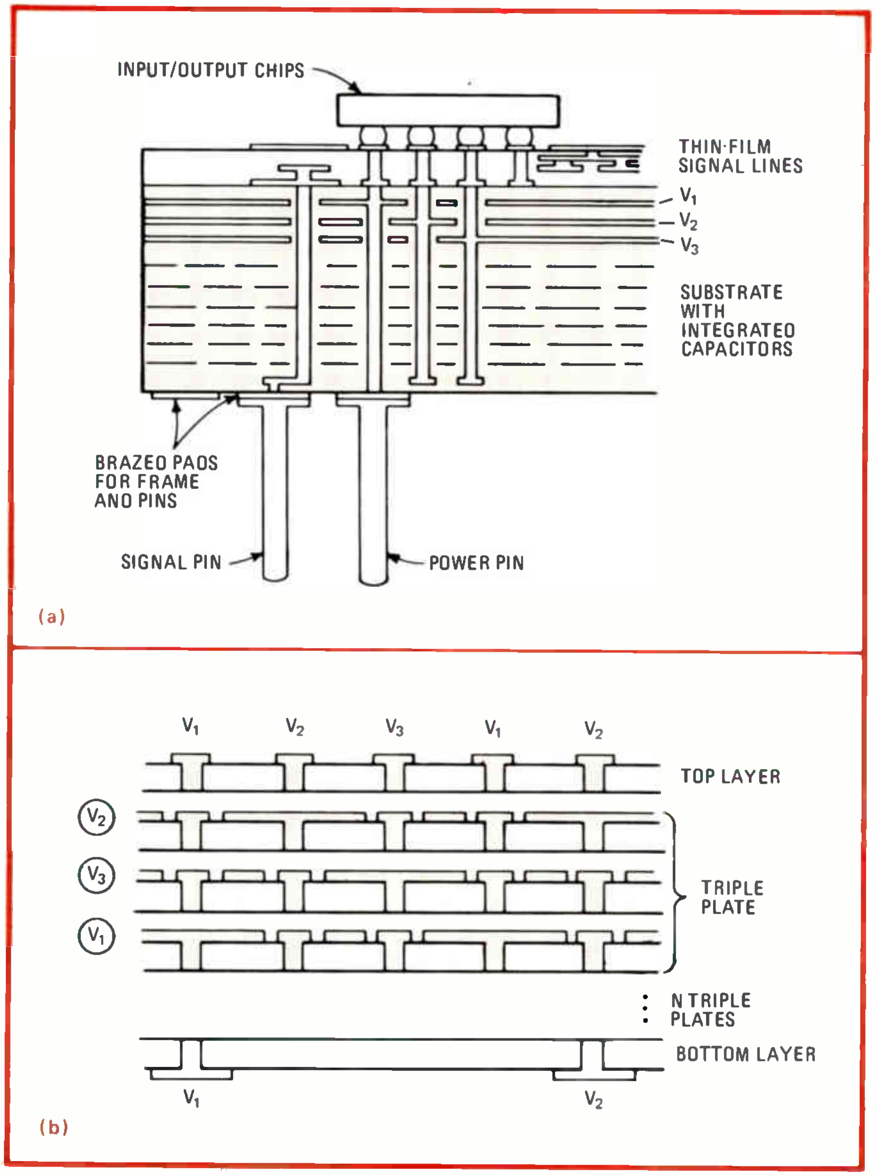
These design considerations led Honeywell's engineers to conclude that VHSIC and VLSI chip interconnection needs could best be met by a thin-film–based, single- or multi-layer package. A thin-film approach was chosen for its fine-line capability. With thin-film conductors, a chip with a relatively high gate count can be directly attached to a thin-film chip extender, so that fewer layers are required to interconnect a multichip or multilayer configuration than in a thick-film system.

Honeywell uses two approaches to generate lines about 10 micrometers wide and thick on ceramic substrates. Selective plating can achieve dimensions limited only by the resolution and thickness of the photoresist. Ion-beam milling, unlike selective plating, is a subtractive process and requires only a photoresist thick enough to withstand the milling operation. Sapphire, alumina, and silicon nitride ceramics were chosen as substrate materials, being relatively lightweight and possessing good thermal dissipation, electrical insulation, and mechanical strength. Some upgrading of the surface finish was found necessary to obtain the fine-line conductors.

Polyimide was selected as the dielectric material for the new package because of its relatively low processing temperature (less than 300°C) and its low dielectric

1. Dielectric for VLSI package. Honeywell's scanning electron photomicrograph shows a serpentine pattern with 10-μm-wide lines and spaces plasma-etched into a 6-μm-thick polyimide film—the dielectric layer of a multilayer thin-film substrate.





2. Horizontal capacitors. IBM's multilayer ceramic (a) has a horizontal-capacitor layer (b). To build this layer, green sheets first have vias punched and filled with metal paste. After paste is applied to the layers, the sheets are stacked, laminated, and fired.

constant (3–4), an asset for high-speed circuits. The polyimide was either spray- or spin-coated onto the substrate. Both wet chemical and reactive plasma processing was used to define the metalization of the multilayer packages. An example of plasma-etched polyimide is shown in Fig. 1.

Buried capacitors

Another extremely innovative packaging article is "A Ceramic Capacitor Substrate for High-Speed Switching VLSI Chips" by D. A. Chance, C. W. Ho, C. H. Bajorek, and M. Sampogna at International Business Machines Corp.'s Thomas J. Watson Research Center in Yorktown Heights, N.Y. The paper discusses the various forms of integrated-capacitor substrates that are essential to realizing multilayer ceramic chip-carriers.

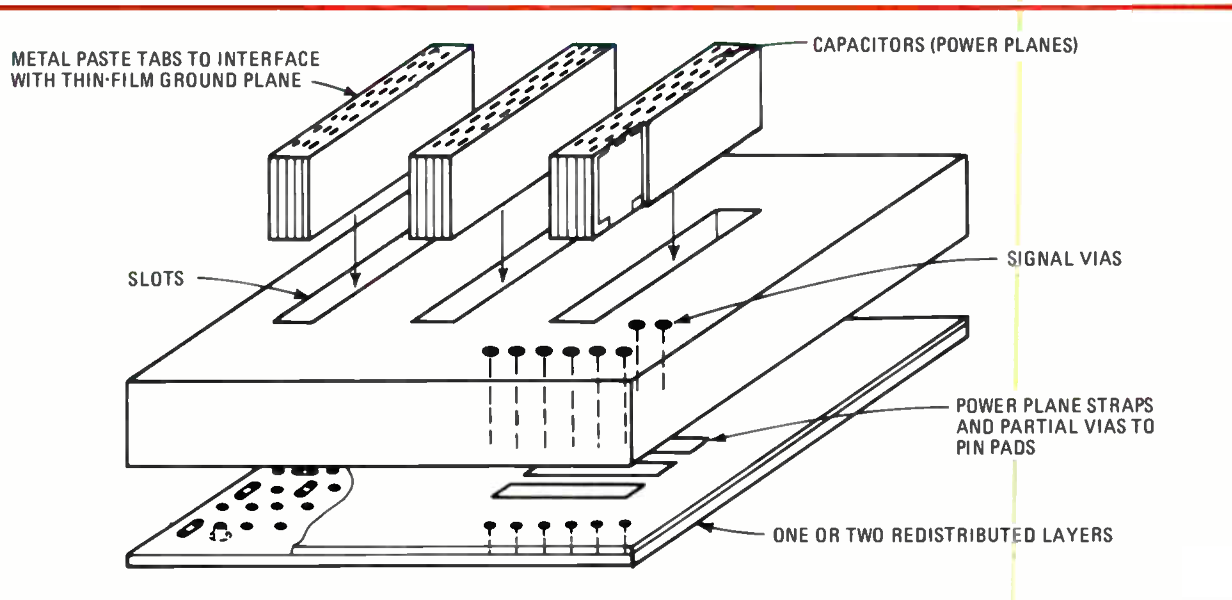
An integrated chip-carrier may carry up to 100 chips on a 10-by-10-centimeter substrate. If each chip requires a capacitance of 40 nanofarads, then the substrate needs a total capacitance of 4 microfarads. Future trends in high-performance systems point toward a quadrupling of the number of driver circuits and a decrease in rise times and voltage swings. The changes will require at least an order-of-magnitude reduction in the inductance of the current path through the package from the decoupling capacitor to the chip. This requirement can be satisfied only by low-inductance capacitor designs, close proximity of the capacitors to the chips, and an opposing current flow in those power contacts located close to each other.

The IBM authors discuss three approaches to this problem. One is a horizontal-capacitor substrate—the least revolutionary change from today's typical multilayer substrate. Next, an extremely low-inductance structure with vertical capacitor plates is presented. Finally, the concept of isolated individual capacitors buried in a substrate is suggested.

The horizontal-capacitor design is the traditional multilayer ceramic structure, in which the layers are arranged horizontally (Fig. 2a). Three voltage levels are shown on three planes. Vias through the planes are obtained by punching holes in the ceramic green sheets and filling them with a metalizing paste prior to lamination. Unscreened doughnut areas form the isolation dielectric between the vias and the voltage planes. Figure 2b shows the horizontal-capacitor layers of a multilayer ceramic chip-carrier. The capacitance required determines the number of sheets, their thicknesses, and the desired properties of the dielectric material.

The vertical-capacitor design represents an optimum configuration for an integrated-capacitor substrate with the lowest possible inductance. The current in the capacitor plates flows in opposing directions, so that inductance is reduced to its lowest levels.

Shown in Fig. 3 is an exploded perspective of the vertical-capacitor substrate. The top segments are the capacitor structure, with input and output current passing through tabs on the top and bottom of the metal planes. The middle segment is the body of the structure, which contains not only the slots for insertion of the top segments but signal and reference vias that also pass through the substrate. The bottom segment consists of layers for redistributing the signal and power vias to appropriate pins plus an upper layer with screened slots for capturing tabs of the capacitor plates. The capacitor



3. Up and down. Decoupling capacitors may be integrated vertically, as this exploded view of an IBM design shows. The capacitor plates are arranged, so that current in adjacent capacitor plates flows in opposing directions and mutual inductance is thus reduced to a minimum.

segments are separately laminated and sized prior to insertion into the slots.

The third proposal is for a dot-capacitor substrate. Small capacitors sandwiching material with a high dielectric constant between metal planes would be dispersed throughout the substrate. However, this idea has not yet been thoroughly evaluated.

Some preliminary results on switching noise for the integrated-capacitor substrates have been calculated on the basis of estimated effective inductances. The optimum substrate is shown to be the vertical-plane type.

Laser-fired thick films

The manufacturing sessions have a mix of 12 papers that range from an unusual application of the laser in a very practical fast-turnaround procedure to a down-to-earth description of a pressure-cooker test for chips in premolded plastic packages.

In one of the most outstanding papers of the conference, Takaaki Ohsaki, Etsuji Sugita, and Satoru Yamaguchi of Nippon Telegraph & Telephone Corp.'s Musashino Electrical Communication Laboratory tell how they used a neodymium: yttrium-aluminum-garnet laser to make a multilayer thick-film hybrid circuit with three times the interconnection density of conventional thick-film hybrids. The laser, under computer control, draws the pattern of conductors into a layer of thick film while simultaneously firing them. The same laser also drills extremely thin vias. This procedure speeds turnaround and lowers design costs since all artwork and screens are eliminated.

The starting point of the Musashino process is to print specially developed conductor paste over the entire surface of an alumina substrate. The covered surface is then irradiated by a scanning continuous-wave laser beam. Then the unirradiated surface is dissolved by an organic solvent. What remains is the desired conductor pattern for the first layer.

Next a conventional dielectric paste is screened over the entire surface and fired. Vias are then drilled in this layer by a scanning pulsed laser beam. These steps are repeated till as many interconnection layers as desired have accumulated on the alumina substrate.

The main mechanism for the conductor pattern formation is the thermosetting of the paste due to the laser beam's energy. Results show that this technology can create 30-μm-wide conductors, given a 20-μm-diameter beam and 10-μm-thick paste.

Via diameter was found to be a function of laser power and pulse rate. Consequently, 30-μm-diameter vias with a 30-μm-thick dielectric layer were fabricated by a pulse laser with a peak power of 2 kilowatts.

An actual multilayer substrate was fabricated using this technique. Measuring 80 by 80 millimeters, the substrate had two conductor layers and one dielectric layer. The conductors were 40 μm wide and the via holes were 40 μm in diameter. The circuits fabricated were highly stable and reliable in operation, according to the authors. This new technique is analogous to electron-beam lithography in IC processing and could be applied to packaging large multichip hybrids.

Another laser-oriented paper, by Allen E. Zinnes of Bell Laboratories, Allentown, Pa., describes a fast-turnaround procedure for fabricating limited quantities of prototype thick-film resistor networks within four to six weeks after receiving a schematic. Circuits with up to 18 terminals for 0.300-inch-wide dual in-line packages and with up to 12 terminals for 0.350-in.-high single in-line packages can be accommodated. This procedure is of particular importance when a given network's resistor values or interconnections or both might be changed after fabrication of the initial model.

In this system, resistors are placed at fixed locations on a substrate and connected by a dedicated conductor grid. A laser cuts open any unwanted lines in the grid. The resistors, all the same size and screened from standard pastes, are laser-adjusted over a wide range of values. A blocking-out technique removes unwanted resistor patterns from the standard resistor screens.

Up to four different circuits of the same type may be made at the same time. No custom layout is required for a given network; instead, a routine analysis is made to determine which conductor lines should be cut open and which resistor patterns need to be blocked.

Damp-proof premolded DIPs

Premolded packages have some distinct advantages over the postmolded type. For one thing, they can be more easily handled automatically. Secondly, they allow the encapsulation of the IC in a soft, compliant silicone compound. This material protects the chip from stress during package assembly, preventing cracking or piezoelectric effects. But there is still the doubt over whether the postmolded package can stand up under high-temperature or very humid conditions.

A paper by Arnold Rose and Manfred Fischer tells about testing 24-pin premolded DIPs at Signetics Corp., Sunnyvale, Calif. In the Signetics test, a passivated, fine-aluminum-line interdigitated array was wire-bonded to a premolded 24-lead DIP. The cavity of the package was filled with a silicone gel and sealed with a lid.

This packaging system was exposed to long-term steam pressure under both biased and unbiased electrical conditions at 121°C and 15 pounds per square inch gauge. Test data indicated that fewer than 10% of the chips underwent corrosion-induced failures in 1,000 hours of testing. Conventional postmolded epoxy devices under similar conditions experienced a 50% failure rate in less than 100 h.

Optical hybrids, the topic of session 4 of the ECC, is a technology of increasing importance. However, building an optical hybrid raises problems even for engineers knowledgeable in standard thick- and thin-film circuits.

For example, a conference paper by John Williams of Bendix Corp.'s Kansas City division in Missouri describes the manufacturing problems and solutions that are involved in making a hybrid-circuit light detector.

The detector uses a ¾-by-1-in. transparent sapphire substrate on which a thin film of metal is deposited and selectively etched to produce conductor patterns and an optical window. A photodiode is mounted with a transparent adhesive over the window on the component side.

Four areas presented problems here: the adhesion of the metallization to the sapphire substrate; wire bonding to metallization on sapphire; finding a transparent adhesive for attaching the photodiode; and finally sealing the final hybrid thin-film light detector.

Two thin-film metallization systems were evaluated—chrome plus gold, and titanium plus palladium plus electroplated gold. Samples of both were subjected to different combinations of the following process conditions: 900°C firing, tantalum nitride underlayers, and resistor stabilization. The results indicated that the adhesion of the chrome-gold metallization to sapphire was superior.

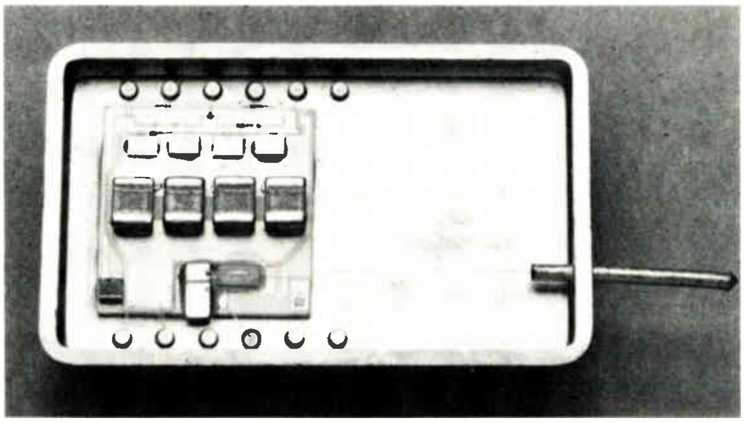
After this step, a wire-bonding evaluation was undertaken for this metallization. Gold wires 1 mil thick were thermosonically bonded to various components, including ICs, diodes, transistors, capacitors, and resistors. The bond pull strength was evaluated before and after a 96-h 150°C bake. Both pre- and post-bake pull strength was excellent.

Sylgard 186, a silicone-based transparent adhesive, served to attach the photodiode to the sapphire material. The tensile strength of the adhesive was evaluated by using different thicknesses and subjecting them to environmental tests. Excellent pull strengths resulted through all phases of the evaluation.

Solder sealing had no bad effects on the sapphire substrate. Seven packages were solder-sealed to the gold-chrome metallization with no damage to the sapphire.

An optical-pulse generator hybrid

A directly coupled optical-pulse generator is described in a paper by Geoffrey Herrick of Tektronix Inc., Beaverton, Ore. The hybrid is used for fiber-optic testing. Its package allows efficient coupling of a laser diode output into a graded-index optical fiber with a 50-μm-diameter core. The system is designed for easy alignment in manufacturing and for mechanical stability in the field.

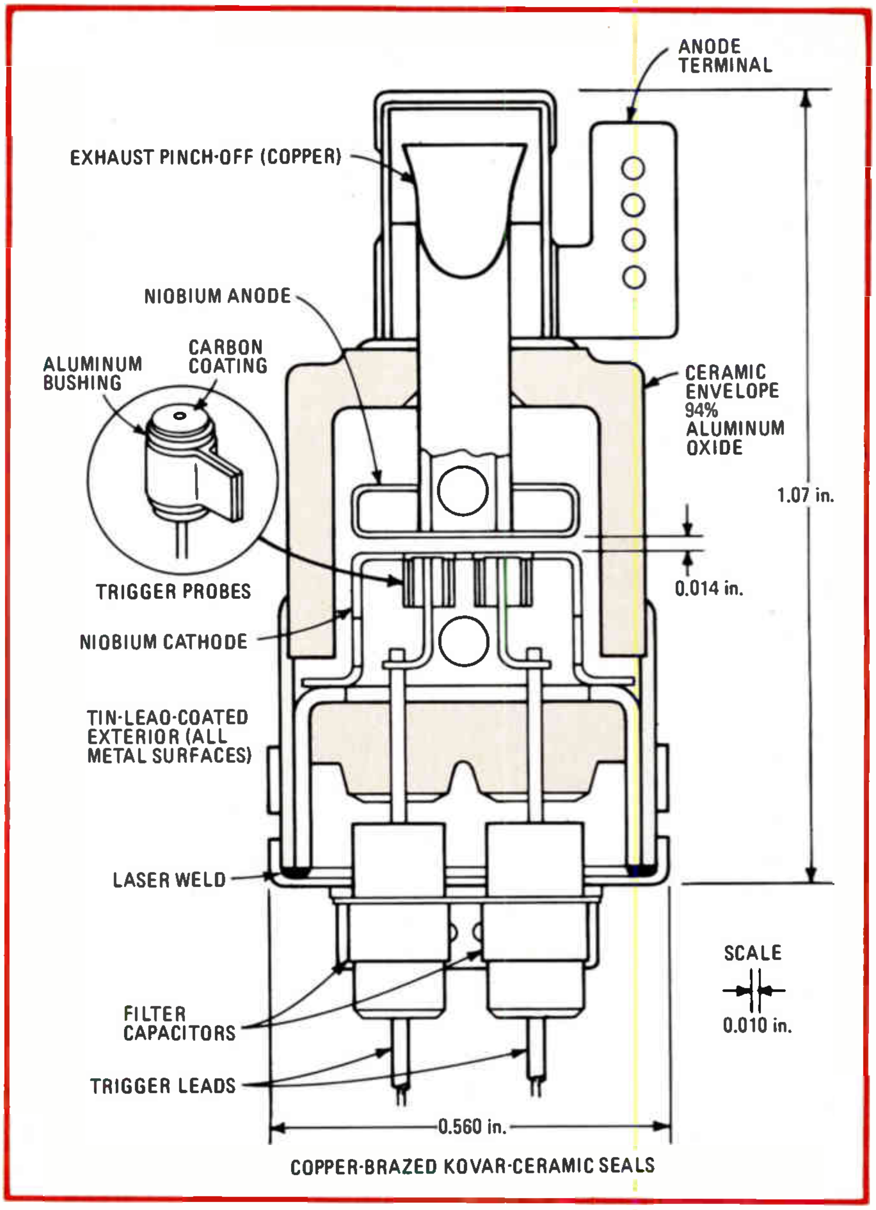


4. Optically pulsed. A direct-coupled optical-pulse generator hybrid fabricated at Tektronix uses thick-film gold on a beryllium oxide substrate and houses four double-diffused MOS field-effect transistors, four chip capacitors, and a laser diode. The laser beam is fed out through the optical fiber.

The complete optical-pulse generator is diagrammed in Fig. 4. The hybrid consists of a low-impedance thick film of gold on a beryllium oxide substrate, four high-power double-diffused MOS field-effect transistors, four chip capacitors, and a gallium-aluminum-arsenide laser diode. The laser chip is bonded to a BeO submount, which in turn is mounted on the substrate. The optical fiber is fed through a Kovar tube and is bonded to an alumina standoff. A chip resistor protects the gates of the static-sensitive FETs.

Optical coupling of the laser is done by aligning a 4-foot-long optical fiber with the output beam of the laser diode. After the fiber end has been cleaved and aligned with the laser output beam and then epoxied to the standoff, the fiber is sealed in the Kovar tube with a

5. Sprytron. Sandia National Laboratories has developed this ceramic cold-cathode tube for 250°C operations. All its elements use high-temperature materials. The tube is used to switch high-power pulses in the non-destructive evaluation of geothermal wells.



low-permeability epoxy.

This optical-pulse generator produces square waves at an nominal wavelength of 820 nanometers. The maximum pulse width is 50 nanoseconds at a 5-kilohertz pulse rate. The hybrid will switch up to 20 amperes at 8 volts into the laser diode with a rise time of less than 5 ns.

High-temperature electronic components and circuit design is one topic covered in session 15, which nominally concerns resistors. A paper given by Hsi-Tien Chang of Sandia National Laboratories, Albuquerque, N. M., covers an aspect of electronic circuits capable of operating up to 250°C that is seldom touched upon—high-power circuitry.

Surprisingly, to implement this circuitry, Sandia is in the process of developing a high-power, high-speed cold-cathode tube to be used as a substitute for silicon controlled rectifiers or thyratron tubes. The tube will be used for various nondestructive evaluations of the casing and cement of geothermal wells.

For fast electronic switching of high current levels, an SCR is commonly used in transistor circuit design. Unfortunately most SCRs are rated only up to 125°C, for at higher temperatures they will conduct even without a trigger pulse.

The thyratron is another candidate for high-power, high-speed switching. But as a hot-cathode tube, it requires a lot of energy, which it is not practical to transmit from the earth's surface to a logging instrument at the bottom of a deep well.

Sandia's cold-cathode vacuum-discharge tube comes closest to the characteristics of an SCR yet can operate at high temperatures. Called a Sprytron, it is distinguished by a fast response time, short recovery time, and high hold-off voltage.

Sprytrons work as well at 250°C as at normal ambient temperatures because they are made with high-temperature materials. In the geothermal well's temperature range, these materials exhibit no significant change in their properties.

Figure 5 is the cross section of a Sprytron. To remove gaseous impurities, the tube is exhausted at 600°C for several hours during processing. To operate it, a fast-rising trigger pulse is applied to the probe to cause a spark, initiating plasma across the carbon film between the trigger pin and cathode. This trigger plasma expands into the vacuum between the electrodes and results in a vacuum arc discharged between them.

The main discharge produces a high current limited only by the external circuit and the tube's voltage drop, which is in the 10-to-30-V range. The high-current arc also vaporizes the cathode material and gradually erodes the cathode. This shortcoming, however, is being overcome in a Sandia program to upgrade the cold-cathode tube. Recently a prototype tube successfully ran for 200,000 switching operations.

Moreover, the Sprytron was initially designed for only 200 operations, for which it required a minimum anode potential of 200 to 300 V depending upon circuit parameters, for a guaranteed arc discharge. Since that high voltage might cause the insulation of a logging cable to break down, it would be desirable to be able to operate the tube at only about 100 to 150 V for those 200,000 operations. Sandia is investigating tube design modifications to this end. □

State-variable filter trims predecessor's component count

by James H. Hahn
Interface Technology Inc., St. Louis, Mo.

A state-variable active filter, even though it requires three operational amplifiers and eight passive components, is widely used because it is less sensitive than other filter designs to component changes, provides high Q and gain, and can operate at fairly high frequencies. A new design using fewer parts simplifies the standard filter[1] yet provides the same bandpass characteristics and low sensitivity.

A conventional state-variable circuit (a) is composed of summing amplifier A_1 and integrators A_2 and A_3. When high-pass output E_2 is eliminated and the first integrator is treated as the summing amplifier, the bandpass transfer function of the revised circuit (b) becomes:

$$H_{bp}(s) = \frac{E_3}{E_1} = \frac{-s/C_1R_1}{s^2+sa+b}$$

$$\text{where } a = \frac{R_2C_2(R_3+R_4)+R_4C_1R_5}{R_2R_5C_1C_2(R_3+R_4)}$$

$$\text{and } b = \frac{R_4(R_1+R_5)}{C_1C_2R_1R_2R_5(R_3+R_4)}$$

In addition, the two-pole bandpass form of the circuit is preserved. If R_5 is eliminated and left an open circuit, the a and b terms simplify to:

$$a = \frac{R_4}{C_2R_2(R_3+R_4)} \text{ and } b = \frac{R_4}{C_1C_2R_1R_2(R_3+R_4)}$$

Comparing the transfer function to the general form:

$$H_{bp} = \frac{s\omega_oH_o/Q}{s^2+s(\omega_o/Q)+\omega_o^2}$$

When H_o is the value of H_{bp} at $\omega = \omega_o$ and Q is the quality factor:

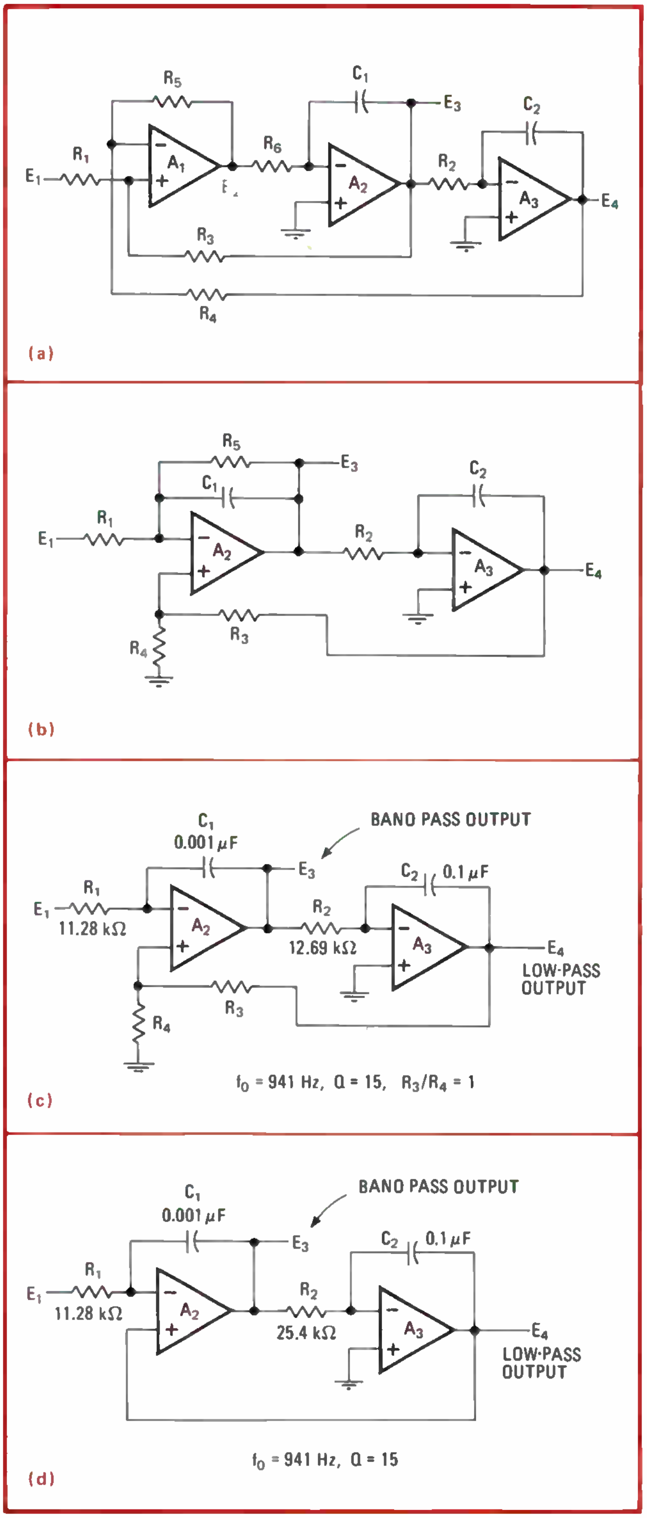
$$\omega_o = \left[\frac{R_4}{C_1C_2R_1R_2(R_3+R_4)}\right]^{1/2}$$

$$\text{and } H_o = -Q^2 = \frac{-C_2R_2(R_3+R_4)}{C_1R_1R_4}$$

Solving for R_1 and R_2:

$$R_1 = \frac{1}{\omega_oQC_1} \text{ and } R_2 = \frac{R_4Q}{(R_3+R_4)\omega_oC_2}$$

With the above equations, a two-pole active bandpass filter (c) is realized by choosing C_1, C_2, and R_3:R_4 for the given value of ω_o and Q and then computing R_1 and R_2. If the passband gain is high, an attenuator can be used at the input with R_1 serving as the attenuator's



Reduced. The conventional state-variable filter (a) is simplified (b) when highpass output E_2 is eliminated and integrator A_2 is treated as a summing amplifier. This circuit is further reduced by creating an open circuit across R_5. A reduced two-pole bandpass state-variable filter for f_o = 941 Hz, Q = 15, and R_3/R_4 = 1 is shown in (c). A version with R_4 and R_5 open and R_3 = 0 is shown in (d).

equivalent series resistance. The circuit can be further reduced (d) by letting R_4 be an open circuit and $R_3 = 0$ ohm. This modification gives:

$$\omega_o^2 = \frac{1}{C_1C_2R_1R_2} \text{ where}$$

$$R_1 = \frac{1}{\omega_o Q C_1} \text{ and } R_2 = \frac{Q}{\omega_o C_2}$$

The simplified configuration uses much less power and fewer components than the conventional circuit to achieve the same low sensitivities. If C_2 is greater than C_1, the circuit's near ideal performance will not be degraded by second-order effects, such as finite amplifier gain. The filter is also useful for low-pass applications. □

References

1. J. Graeme, G. E. Tobey, and L. P. Huelsman, "Operational Amplifiers—Design and Applications," McGraw-Hill, 1971, p. 304.

High frequencies, winding setup improve voltage conversion

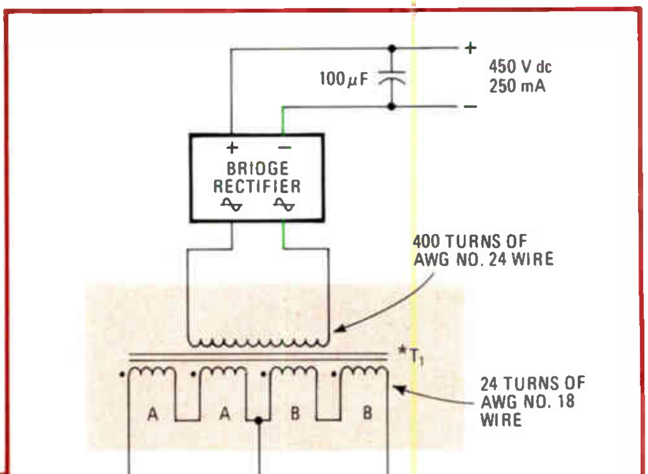
by David W. Conway

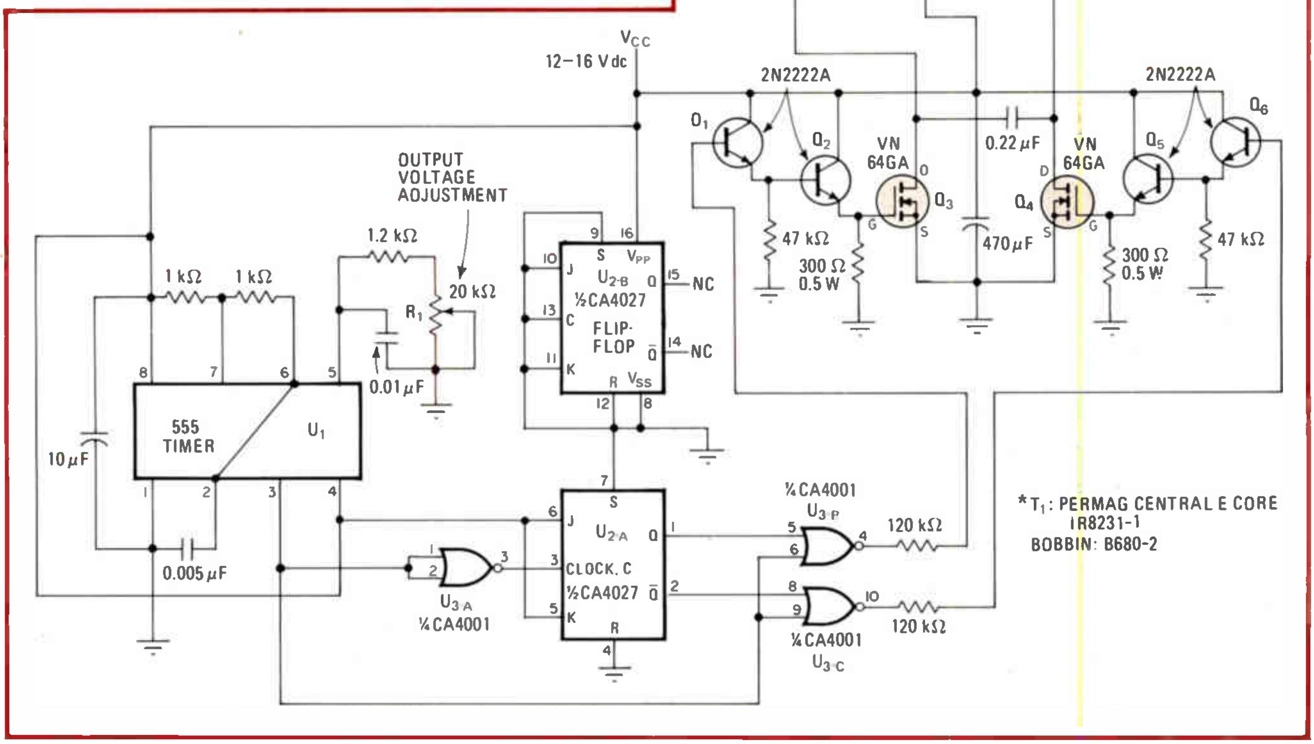
Universal Engineering Corp., Cedar Rapids, Iowa

Designed to meet high-voltage requirements, this efficient and inexpensive dc-to-dc converter finds use in devices like photoflash equipment and capacitive-discharge ignition systems. The design produces 450 volts at 250 milliamperes from a 12-to-16-v dc supply. The high-power output and high efficiency of the circuit is attributed to high-frequency operation and the use of insulating tape between the layers of the transformer's secondary winding.

A push-pull–amplifier configuration comprising power field-effect transistors Q_3 and Q_4 is driven by integrated circuits U_1 through U_3. Oscillator U_1 generates 150 kilohertz, which is halved to 75 kHz by flip-flop U_2. The high-voltage output is adjusted with potentiometer R_1. When R_1 is at its minimum resistance, the output voltage is at its highest.

This converter is much smaller than competing designs because high frequencies are used. The output transformer's secondary is first wound on the bobbin. In





High-voltage converter. Oscillator U_1, frequency divider U_2, and buffer U_3 drive power FETs Q_3 and Q_4 in a push-pull configuration to generate 450 V at 250 mA. A power efficiency of about 90% is attributed to transformer's winding techniques and the use of high frequencies.

addition, 400 turns of the secondary winding are composed of eight layers of about 50 turns a layer, with each layer insulated from the other. 3M's Permacel 0.0025-inch–thick insulating tape separates the layers.

The two layers of wire that make up the primary winding are referred to as sections A and B. A 48-in. piece of AWG No. 18 wire is folded in half to obtain a bifilar strand, 24 in. long, that is wound as section A on the bobbin. Six bifilar turns fill the cross section of the bobbin to form this layer. Similarly, section B is wound with six bifilar turns of AWG No. 18 wire on top of Section A. The windings are interconnected in series and properly phased to form a 24-turn primary winding. Scaling the turns ratio can provide additional output voltages as necessary. □

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 $75 for each item published.

Diode plus op amp provide double-threshold function

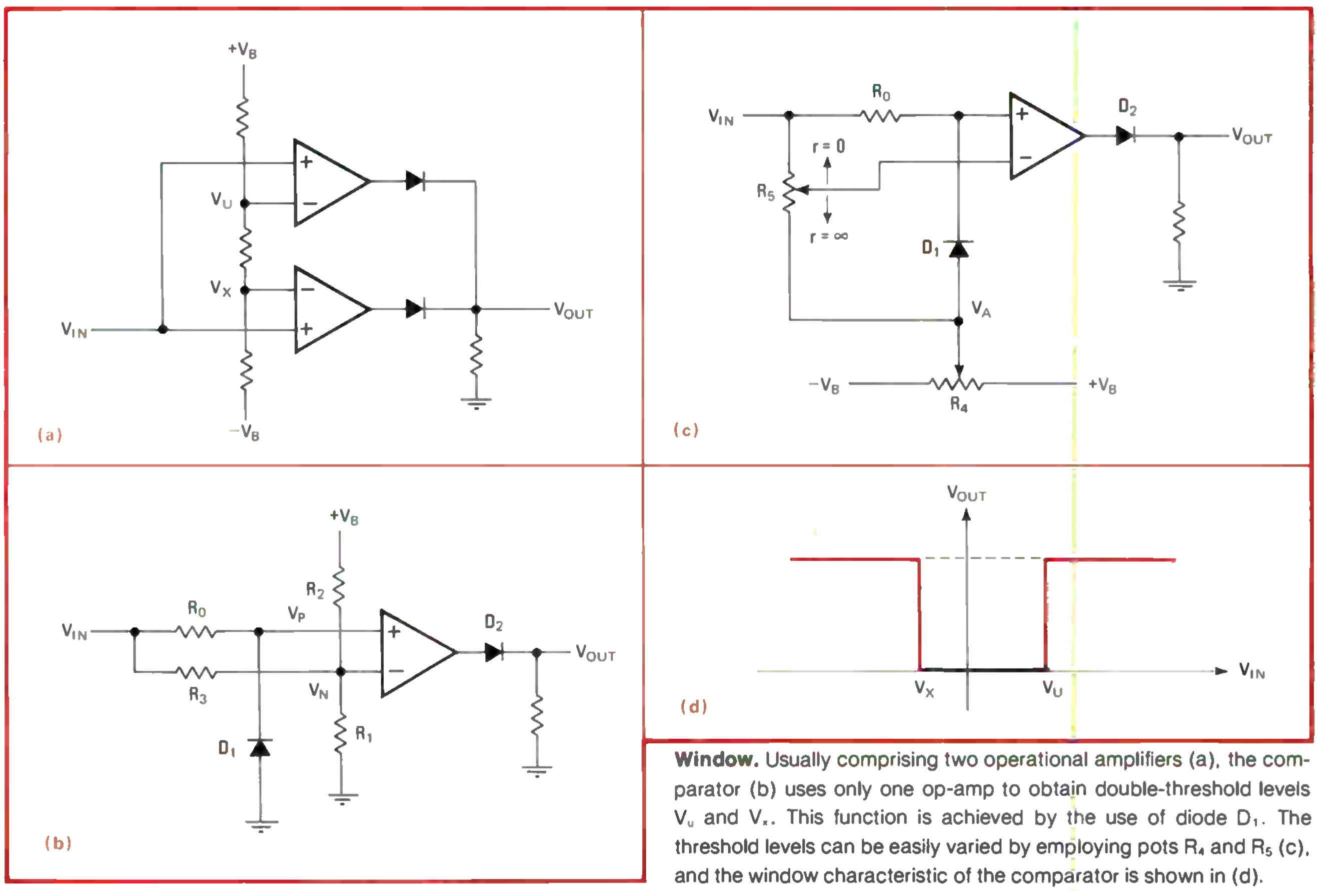
by Pavel Novak
Fraunhofer Institute for Solid State Technology, Munich, West Germany

Medical instruments that produce a signal or alarm when physiological measurements like heart rate or blood pressure reach undesirable levels need window comparators, which usually comprise two operational amplifiers each (a). But a new circuit cuts the op-amp requirement by half and achieves the comparators' double-threshold function by means of a simple diode.

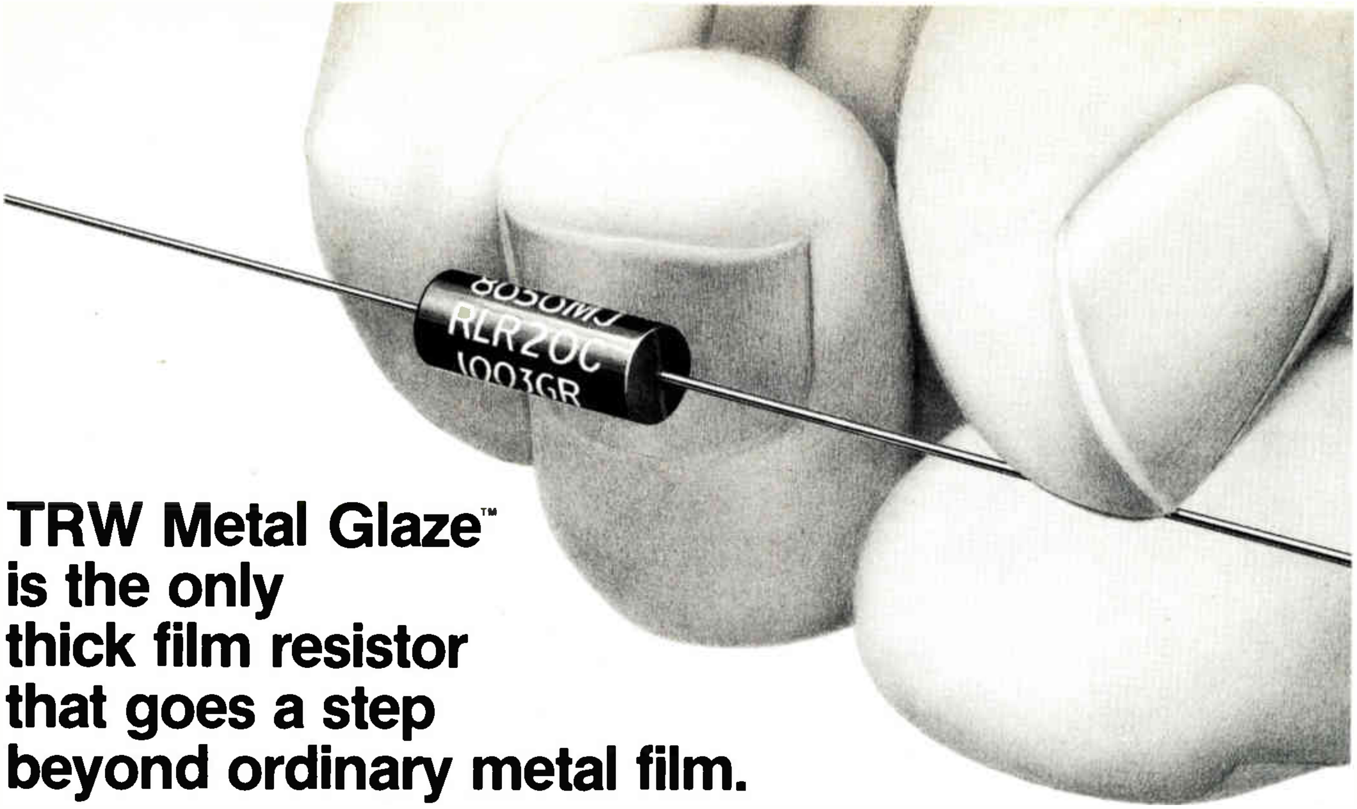
When input voltage V_{in} reverse-biases diode D_1, V_{in} appears at the op amp's noninverting input (b). In addition, inverting input voltage V_n is the sum of supply voltage V_b and V_{in}. For this condition, $V_{in} = V_p$ (noninverting input voltage), and switching occurs when $V_p = V_n$. As a result, the upper threshold voltage V_u is now written as $V_u = V_bR_1/(R_1+R_2)$.

On the other hand, when the input voltage forward biases D_1, the voltage at the noninverting input is $-V_d$, where V_d is the voltage across the diode under a forward-bias condition. The relationship for this second threshold voltage is now: $V_x = -V_b(R_3/R_2) - V_d[1 + R_3(1/R_1 + 1/R_2)]$ when $V_u \geq 0$ and $V_x \leq -V_d$.

This particular circuit leaves no room for threshold-voltage adjustment, but may be modified through the use of two potentiometers (c). Potentiometer R_4 sets D_1's reference potential, V_a. In addition, resistors R_1 and R_2 are replaced with pot R_5. The new set of threshold voltages are given by: $V_u = V_a$ and $V_x = V_a - V_d(1+r)$, where $r = R_3/R_1$. The window $V_u - V_x$ is valid when it is greater than or equal to V_d. Its characteristics are shown in (d). □



Window. Usually comprising two operational amplifiers (a), the comparator (b) uses only one op-amp to obtain double-threshold levels V_u and V_x. This function is achieved by the use of diode D_1. The threshold levels can be easily varied by employing pots R_4 and R_5 (c), and the window characteristic of the comparator is shown in (d).



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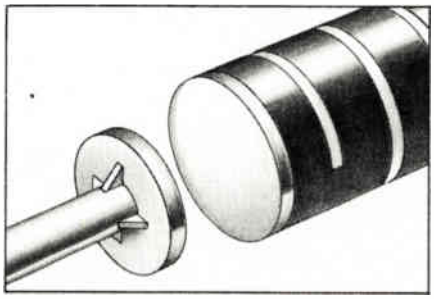

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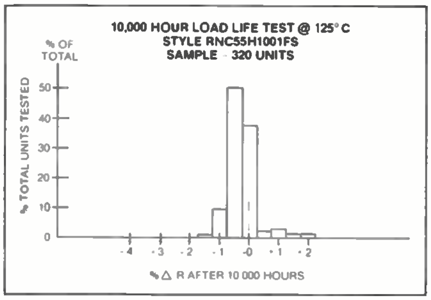

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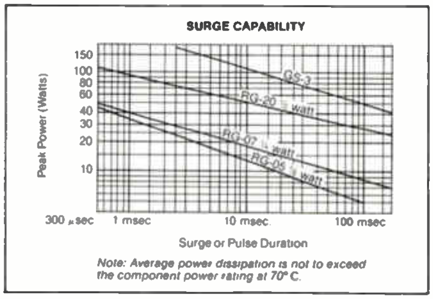

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Digital scope invades analog domain

Using a new type of converter, emitter-coupled-logic memory, and a low-jitter sample-and-hold circuit, scope traps waves with 50-MHz components

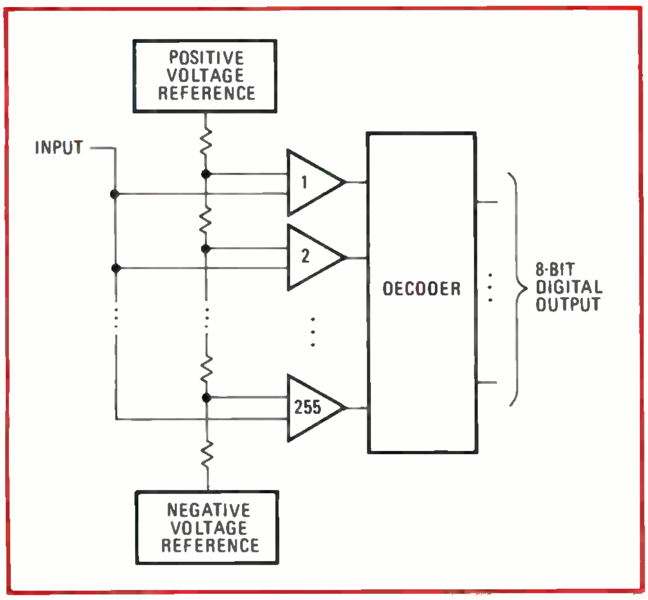
by Jack Caldwell, *Gould Inc., Instruments Division, Santa Clara, Calif.*

☐ The domain of the digital oscilloscope has traditionally been the low-frequency transient area; above approximately 10 megahertz, digital scopes have never displaced their analog forebearers. But through the design of a new type of analog-to-digital converter, the recently introduced Gould Biomation model 4500 [*Electronics*, March 24, 1982, p. 166] is able to accurately digitize nonrepetitive waveforms having frequency components as high as 50 MHz. Thus, it makes possible waveform storage comparable with that of analog scopes while affording the waveform manipulation and analysis that only digital processing can easily provide.

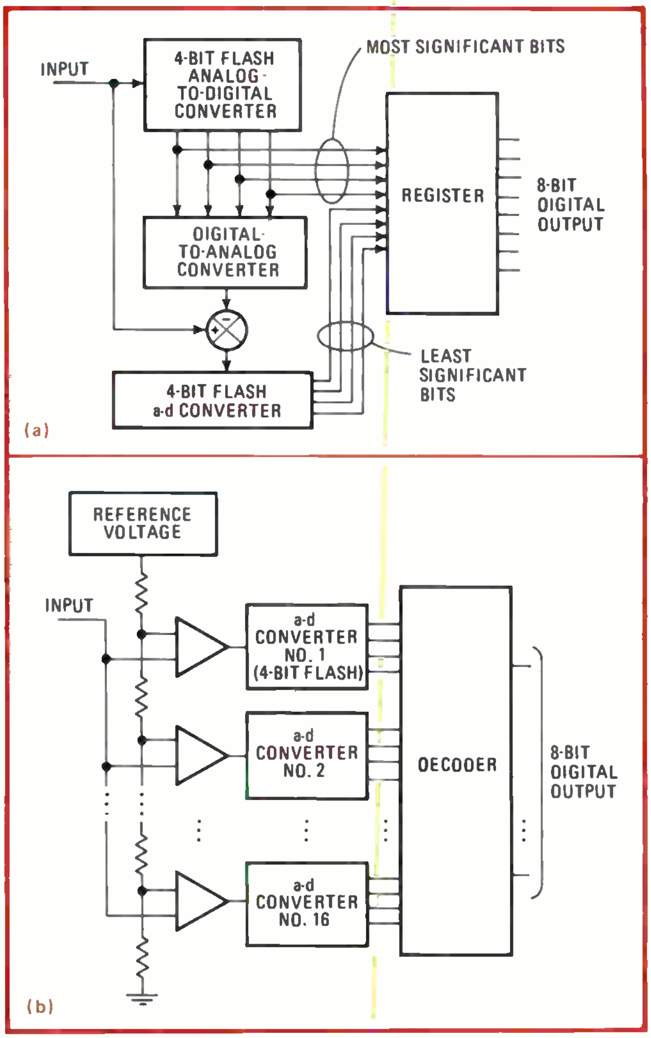
The most widely used a-d converters are, in ascending order of conversion rate, the integrating, tracking, and successive-approximation types. And while the fastest of these is capable of providing very high resolution—on the order of 12 bits—maximum conversion rates are on the order of 500 kilohertz, or 2 μs. Since it was a design goal to achieve a conversion rate of at least 100 MHz using a converter capable of 8-bit resolution, these types were quickly eliminated from consideration.

The fastest practical a-d converters available today are parallel, or flash, converters. Since these are less common, it is useful to examine their operation.

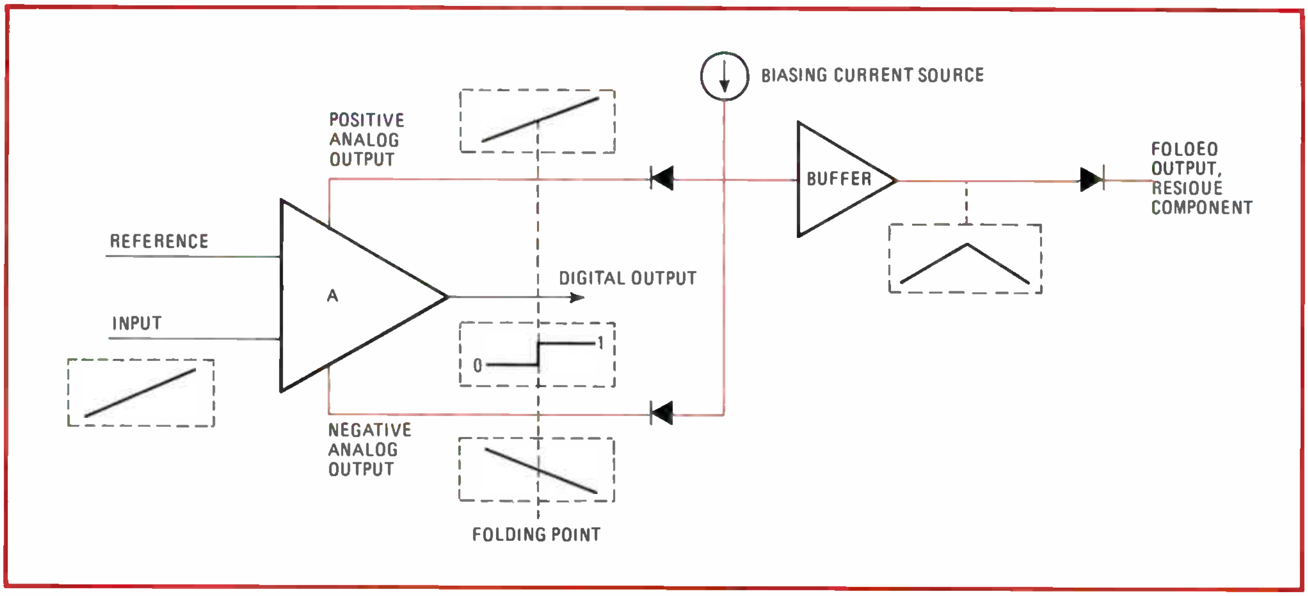
As shown in Fig. 1, flash converters usually have two voltage references, a chain of highly accurate and stable



1. Flash back. The fastest conversion technique possible today is the flash, or parallel, converter shown above. However, to get an 8-bit output, 255 precision comparators and 256 precision resistors are required, often making the cost of such units prohibitive.



2. Rankings. The dual-rank converter in (a) uses only two 4-bit flash converters but loses speed because of the need to reconvert the output of one. The single-rank converter (b) works at a 100-MHz sampling rate, but is still too expensive.



3. New to the fold. A new type of circuit devised for the model 4500, the folding circuit (shown in color above), produces a residue proportional to the level of the input (shown here as a ramp). The residue represents the segment of the overall input not resolved by the comparator output. Once the comparator changes state, the residue is inversely proportional to input.

resistors, and $2^n - 1$ comparators, where n is the number of bits the converter can resolve. The inputs to each comparator are a precisely known voltage picked off from a point in the precision-resistor chain and the signal to be digitized. The precision voltage inputs, and hence the resistor values, are chosen so that there is established an increment of exactly 1 least significant bit for each comparator stage.

Working in parallel

The entire input signal is fed to each comparator stage simultaneously (hence the name, parallel converter), and if it exceeds the reference voltage for that comparator, the comparator puts out a logic 1 signal. Thus in a short space of time—about 2 nanoseconds—there is a bar-graph-like output of 1s up to the comparator whose voltage reference input is slightly more than the actual input. The comparator outputs are then converted into a binary-coded output by translational logic.

One of the best commercial flash converters is the Am6688 from Advanced Micro Devices Inc., Sunnyvale, Calif. This unit, which has built-in precision references and decoding circuitry, is able to operate at 100 MHz, but produces only a 4-bit output. It is possible, however, to combine such converters in a number of ways to obtain 8-bit outputs.

One way that designers often choose to obtain an 8-bit output is by using what is called a dual-rank converter (Fig. 2a). In this design, the output of the first flash converter, or rank, is reconverted into an analog signal and subtracted from the actual input. The residual voltage is then fed to the second rank, and the result is an 8-bit signal, with the first rank providing the most significant bits and the second the least significant bits. However, converting the first rank's digital output using a d-a converter adds to the total conversion time; with the fastest parts available today, the best conversion rate that can be obtained is about 50 MHz.

A second possible configuration was developed and considered during the instrument's design—a single-rank converter. Seen in Fig. 2b, this design can operate at 100 MHz, but has the disadvantage of requiring sixteen 4-bit flash converters, which would make the resulting units very expensive.

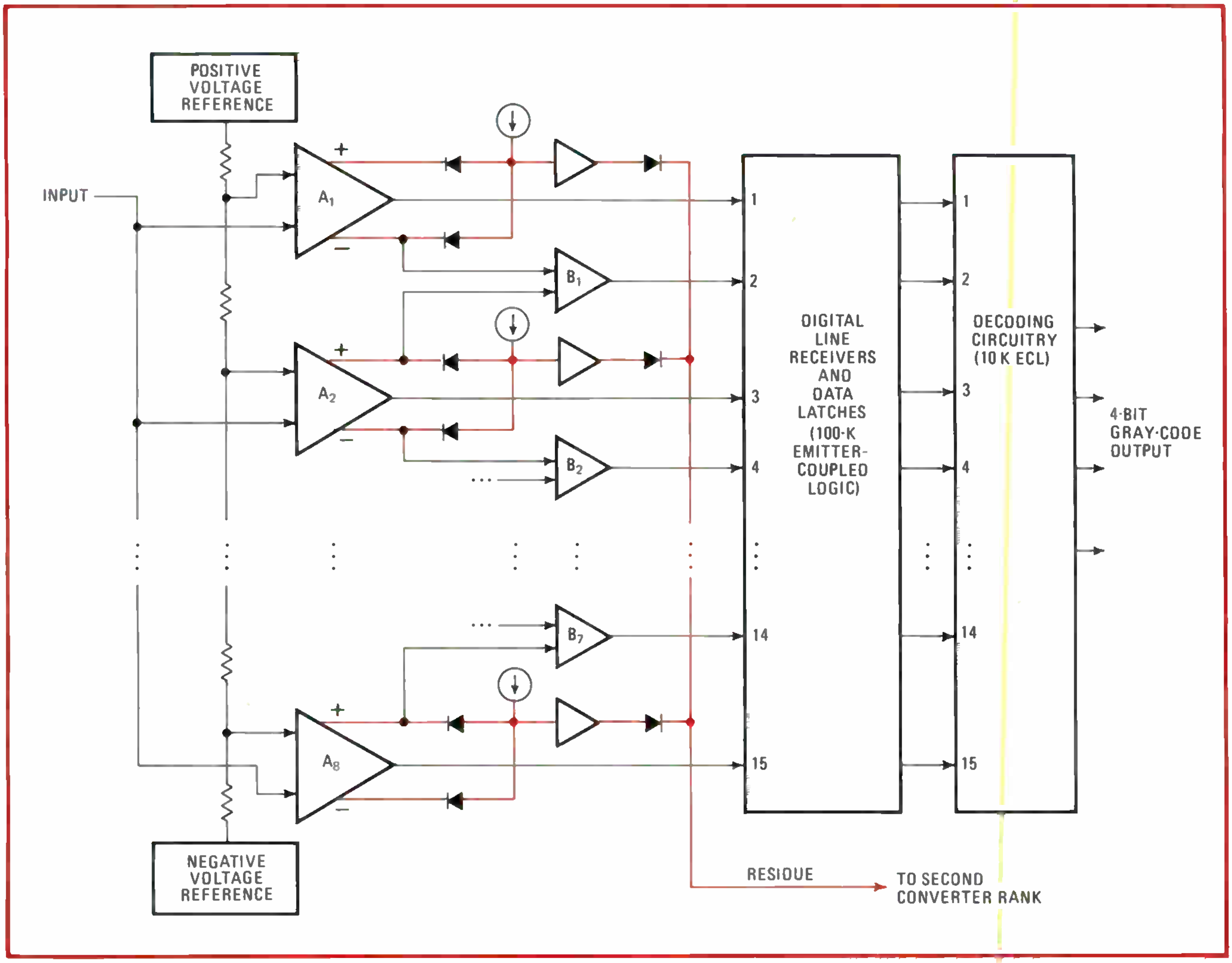
To combine the cost advantages of a dual-rank converter with the speed of the single-rank converter, the 4500's designers devised a new form of converter, which is called the dual-rank flash-flash converter. The unique advantage of the DRFF converter is that the first stage's output does not have to be reconverted into analog form; the analog residue is created at the same time as the digital output so that both halves of the conversion are performed almost simultaneously.

Back in a flash

Key to this performance is the operation of the comparator element, which produces analog residues that can be combined almost instantly. As seen in Fig. 3, the comparator not only produces a digital output, but a positive and negative image of the input signal. This image tracks the form of the input, but its levels are determined by the level of the input current source, which tracks the input reference level.

The blocking diodes serve to fold the analog output about the input point at which a logic 1 is produced—hence the name folding circuit. In the first rank of the converter (Fig. 4), eight such circuits are used, and their individual analog outputs are combined to produce the analog residue, which is the input to the second rank.

To further increase the resolution of the first rank, a digital comparator is connected between the negative analog output of one major stage and the positive output of the next lower stage. In this way 15 outputs differing by 1 LSB are derived in the first stage, which allows the decoding circuitry to produce the four most significant bits, which are expressed in Gray code format.



4. Flash, flash. Using the folding circuit of Fig. 3, a new converter type, the dual-rank flash-flash, can be built for less than a single-rank flash converter. It works at 100 MHz because the folding circuit produces an analog residue that is passed to the next rank without conversion.

As seen in Fig. 5, a half-sine-wave input will produce residues in eight distinct segments, or windows. The residue represents the difference between the four most significant bits and the remaining, undigitized analog segment of the signal. Since the residue is fed directly to the second rank of the converter, the digital outputs from both ranks appear almost simultaneously—generally within less than 2 ns of each other.

However, the code forming the second stage is a 4-bit binary one. These mixed codes are strobed into memory in less than 4 ns, and when the data is to be displayed, the scope's microprocessor decodes them into a straight 8-bit binary code. Since the scope display is of the raster-scaning rather than the direct-writing type, there is ample time for this decoding process.

Cutting costs

The result of using this type of converter is that only two 4-bit flash converters are needed, and even with the extra line receivers, data latch, and folding circuitry, the cost is approximately one half that of a single-rank 8-bit converter. Using the converter's 100-MHz sampling rate, an effective resolution of better than 5.4 bits was achieved when the half sine wave that was used to test the instrument had a frequency of 35 MHz.

Since the converter can work at a sampling speed of 100 MHz, the memory that stores converted data, and its associated circuitry, must be capable of handling 8-bit codes every 10 ns. This is accomplished by overlapping memory sections with 20-ns cycle times. The basic building blocks for this waveform storage are 256-by-4-bit random-access memories, organized in two groups of eight per channel. The resultant memory array makes available 1-K byte of storage for each channel when both channels are used, or 2-K bytes for a single channel.

Accurate reflection

At the front end of the converter, the signal being digitized must remain stable and jitter-free if the digitized results are to accurately reflect the signal under analysis. A sample-and-hold network preceding the converter is thus used to freeze the input long enough for it to be converted without incurring an excessive amount of error. However, a major problem is that the sample-and-hold network must be able to charge up and settle to within better than $\pm 0.15\%$ of the level (± 1 part in 512, or $\pm \frac{1}{2}$ LSB) in less than 10 ns.

Since it takes about 3 ns to charge the hold capacitor,

The digital scope and the digitizer: what's the difference?

Technologically, there seems little difference between the digital oscilloscope and the digital waveform recorder or digitizer. Today both rely heavily on the performance of hybrid analog-to-digital converters, high-speed memory, and microprocessors to capture and analyze unknown signals. In addition the hard performance specifications—digitizing rate, effective bits, memory size—are critical to the ultimate capabilities of both.

But while the units are similar in many respects, the applications for which they are intended make them different in significant ways. The waveform recorder is basically designed to work only as part of a system. For such applications, it is generally assumed that, if a waveform display is needed, some other element in the system—such as the controlling computer or a plotter—will present it visually. Thus, the digitizer does not have an integral cathode-ray tube.

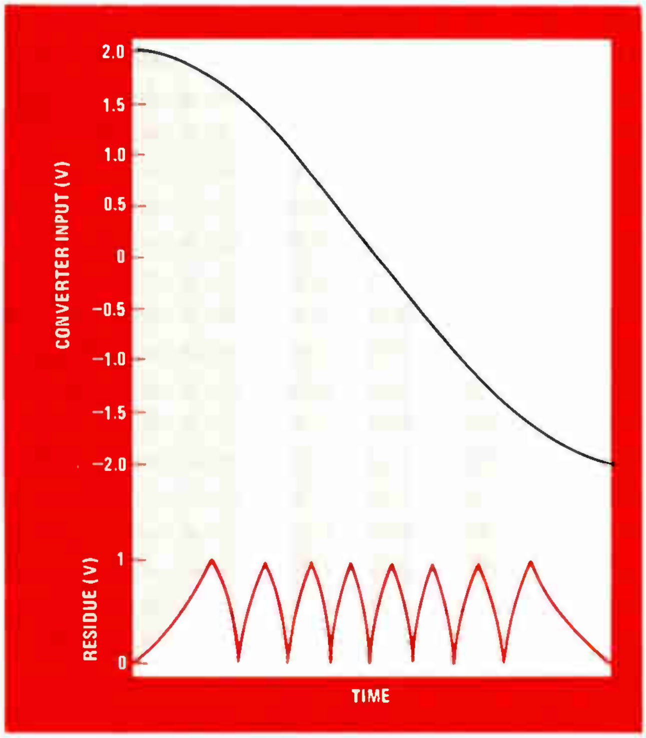
In addition, since a system is likely to have a controller, the software and controls needed to manipulate waveform data are not part of the digitizer's design. Also, it is generally assumed that the user of such systems is fairly sophisticated, and the digitizer's controls can thus be oriented more toward an engineer than a technician; the primary targets for digitizers are the research lab, the designer's bench, and automated test systems. The latest digitizer, HP's 5180, has a 10-bit, 20-megahertz converter that provides 7.5 effective bits at 10 MHz.

The digital oscilloscope, on the other hand, is intended to bridge a variety of applications. Though it can also serve as part of a system, its integral display and data manipulation routines also make it a production tool. In most cases, anyone familiar with an analog scope should be able to use a digital one, and in cases where there is a menu for setting the digital scope up, even untrained users can quickly become proficient.

Since the scope generally will not be tied to an external computer, its internal processor is usually capable of performing certain common operations. The unit usually has cursors that let a user pick out values on a waveform it then can display numerically. Some units even can calculate peak-to-peak readings and frequency. Such ease of use is not only beneficial in the factory, but makes the digital scope a sensible field-service tool as well.

At present, it is necessary that potential buyers carefully consider the range of applications for which they will need an instrument before they make a purchase. But as modular design advances, users will be able to configure digitizers with the software and displays they need, and the distinction between the digital scope and the digitizer will be in the hands of the user. **-Richard W. Comerford**

the associated amplifier circuitry must settle very quickly, in 7 ns or less. Also, the amplifier section needs to be extremely well balanced in order to inject no current into



5. **Residue.** The residue voltage, seen in solid color above, swings through a 1-V range in each window (alternating bands), which correspond to the ranges of comparators A_1 through A_8 in Fig. 4. The folding points correspond to the midpoints of each window and also the trip points of B_1 through B_7.

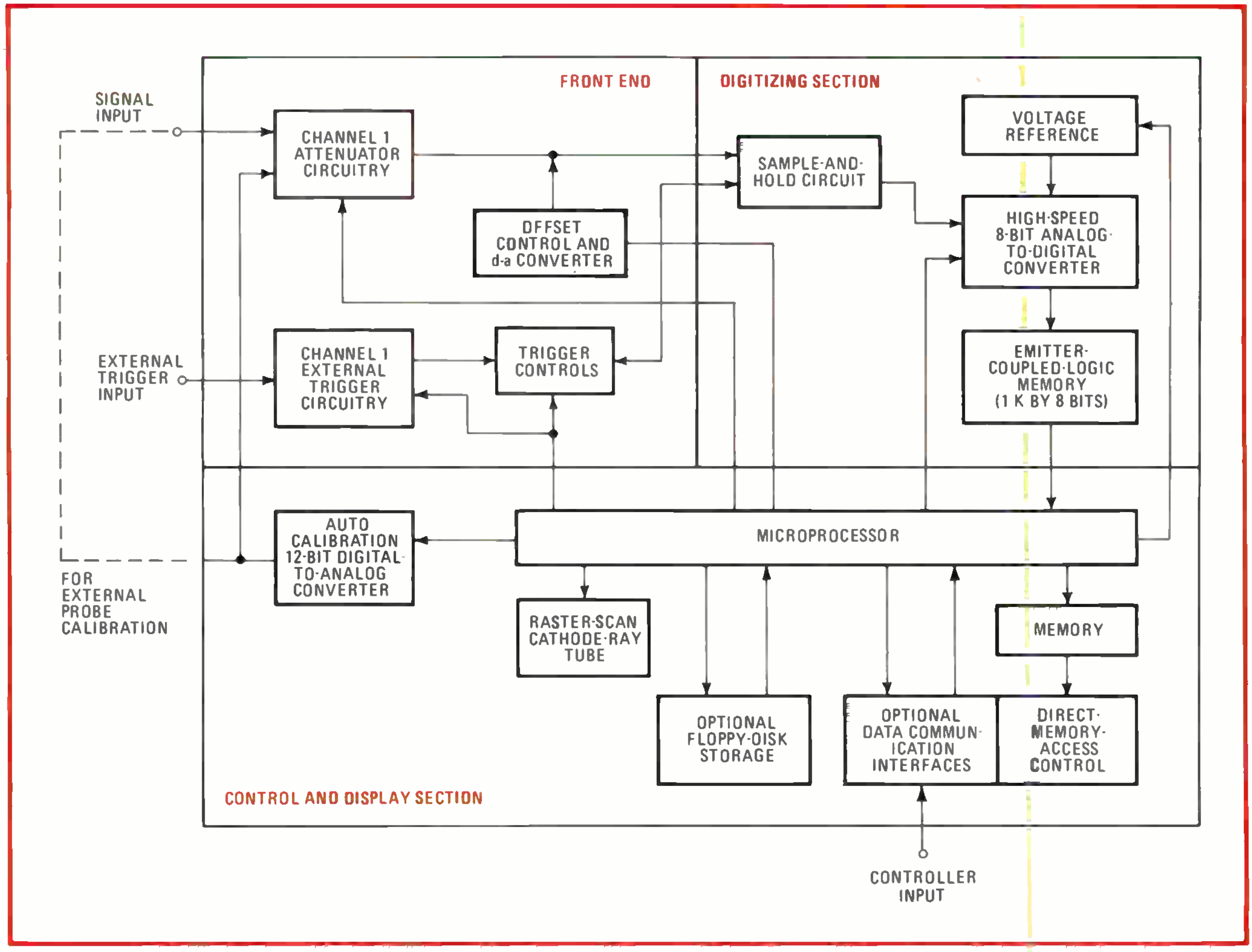
the capacitor: even a very small amount would appear as a direct error component in the measurement.

The sample-and-hold network is built around a monolithic Schottky-diode bridge driven by a bootstrapped, balanced amplifier and emitter-coupled-logic–compatible circuitry with a 350-picosecond rise time. The diode bridge is compensated by a feedback loop to balance it and prevent unwanted charge from being deposited on the sample-and-hold capacitors, a phenomenon usually refered to as blow-by. The net result of using this circuit configuration is a network with less than a 40-ps aperture uncertainty and a resolution of more than 7 bits at 10 MHz. To make this accuracy meaningful, the amplifier circuitry that precedes the sample-and-hold circuit must also be highly accurate.

Front-end circuitry

In many instances, the front end of conventional oscilloscopes suffers in performance because of problems caused by thermal time constants in the differential amplifier sections. Usually, these effects are reduced by placing emitter resistors in the differential pair. Then several RC combinations are placed across the emitters to help equalize the total time constants; an accuracy to within 1% can be achieved if enough are used.

For the 4500, the overall accuracy specification calls for a major reduction of thermal constants, to less than 0.1%—a difficult goal to achieve with front-end and attenuation circuitry that will not only accurately track waveforms with rise times as low as 10 ns but also keep over- and under-shoot to less than 0.1%. The solution is to use a proprietary circuit that is biased so that the instantaneous power dissipation in the differential pair is always equal. No resistors are placed between the



6. Full scope. Controlling the converter (upper right) and the front-end circuitry (upper left) is an 8-bit 8085 microprocessor. The processor also feeds a 12-bit d-a converter (lower left) whose output is used for automatic internal calibration and can also be used for probe calibration.

emitters, and each transistor instantly matches the power dissipation of the other.

All three front-end amplifiers contain this circuit, along with an operational-amplifier servo control to suppress dc effects, two independently regulated voltage supplies that bias the load resistors, and controlled current sources in the differential pairs. The internal bandwidth of each amplifier is much greater than 35 MHz, guaranteeing that the amplifier will remain very stable when measuring waveforms at very high frequencies. The roll-off at 35 MHz is set by an internal filter and helps to further stabilize the front end while providing a measure of protection against aliasing caused by signal components higher than 50 MHz.

Controlling offset

The offset control circuit is another that differs from the norm. Even in high-quality oscilloscopes, offset is frequently off by 3% or more of full scale. For the model 4500, the specification calls for a maximum error of ±0.2% of the offset range, plus ±0.5% of the difference between the selected offset and the zero reference level. The circuitry used to accomplish this includes a 12-bit d-a converter and digital command inputs, with the offset being applied immediately after the first amplifier section. The relationship of all these circuits can be seen in Fig. 6.

To maintain overall accuracy over prolonged periods of time, it is necessary to compensate for errors caused by thermal drift and component aging. With conventional equipment this implies a need for periodic calibration, and for highest accuracy, calibration before each experiment or measurement. The 4500 solves this problem by including a microprocessor-controlled autocalibration loop in its circuitry, as shown in the figure.

The microprocessor instructs a 12-bit d-a converter to generate a high-precision plus– or minus–full-scale voltage that is measured by the front-end circuitry and converted by the a-d converter. The microprocessor then compares the a-d converter's digital output to the expected value, adjusting the voltage levels at each voltage reference until the output matches the expected value to more than an 8-bit resolution. In this fashion, any gain inaccuracies in the front-end circuitry are compensated by adjusting the a-d device's full-scale "window," providing high accuracy for the total system performance. In addition to the internal gain adjustments, automatic calibration capabilities may be extended to include probes connected to the inputs, thus compensating for the entire measuring system. □

Real-time operating system puts its executive on silicon

A software component as standard as a TTL device, this kernel runs identically on three 16-bit microprocessors

by John Tinnon, *Hunter & Ready Inc., Palo Alto, Calif.*

☐ The invasion of real-time applications by 16-bit microprocessors would be advancing much faster if standard operating-system software were available. As things are, programmers find they can spend up to 60% of their time on just writing the basic mechanisms needed to support a real-time system's multiple concurrent tasks.

These support mechanisms are, however, common to all real-time systems, so they are a prime candidate for time-saving standardization—especially in the form of silicon software components, which are as easy to use as hardware. The Versatile Real-Time Executive, or VRTX (pronounced "vertex"), is just such a silicon software family. Read-only-memory chips containing VRTX are already available for the three most popular 16-bit microprocessors, the 68000, the 8086 and 8088, and the Z8000. A fourth version for National Semiconductor's 16000 is under development.

Prepackaged real-time multitasking executives, also called operating-system kernels, are nothing new. Vendors of single-board computers have been supplying them for several years. But unlike VRTX, these earlier executives are designed to run only on a specific target board and require a particular host system for development. Also unlike VRTX, they generally do not permit custom designs unless the user is willing to buy the source code and modify it extensively.

VRTX offers interrupt-driven task scheduling, intertask communications and synchronization, dynamic as well as static memory allocation, real-time clock support, and character input/output. It is also compact and fast, occupying only 4-K bytes of memory and taking only about 100 microseconds to switch tasks (Table 1).

Supplied in two 2716 ultraviolet-light-erasable programmable read-only memories, this operating-system kernel is a true silicon software component. Like an Ada package, it serves as a building block out of which larger systems can be constructed. And unlike executives supplied on disk that require modification in order to adapt to a particular hardware configuration, it makes no assumptions about the board on which it will be running.

In effect, it simply adds 22 high-level instructions to the processor's existing repertoire (Table 2). Being written entirely in position-independent code, it can be located anywhere in the user's address space and as a result can easily be retrofitted to an existing design. Its interface with the target board is an external configuration table that may occupy as few as 28 bytes of main system memory.

More than that, this silicon kernel was designed from the start to reach beyond the microprocessor board. A uniform mechanism exists for supplementing it with both user-defined system calls and user-defined interrupt handlers. As a result, it is possible to add not only simple, device-dependent interrupt handlers but also more complex logical functions, such as administering a file structure.

Task management

The basic logical unit controlled by VRTX is the task, which is a logically complete execution path through user code that demands the use of system resources. A task is not the same as a program, which is merely a section of code, whereas several tasks may share the same code.

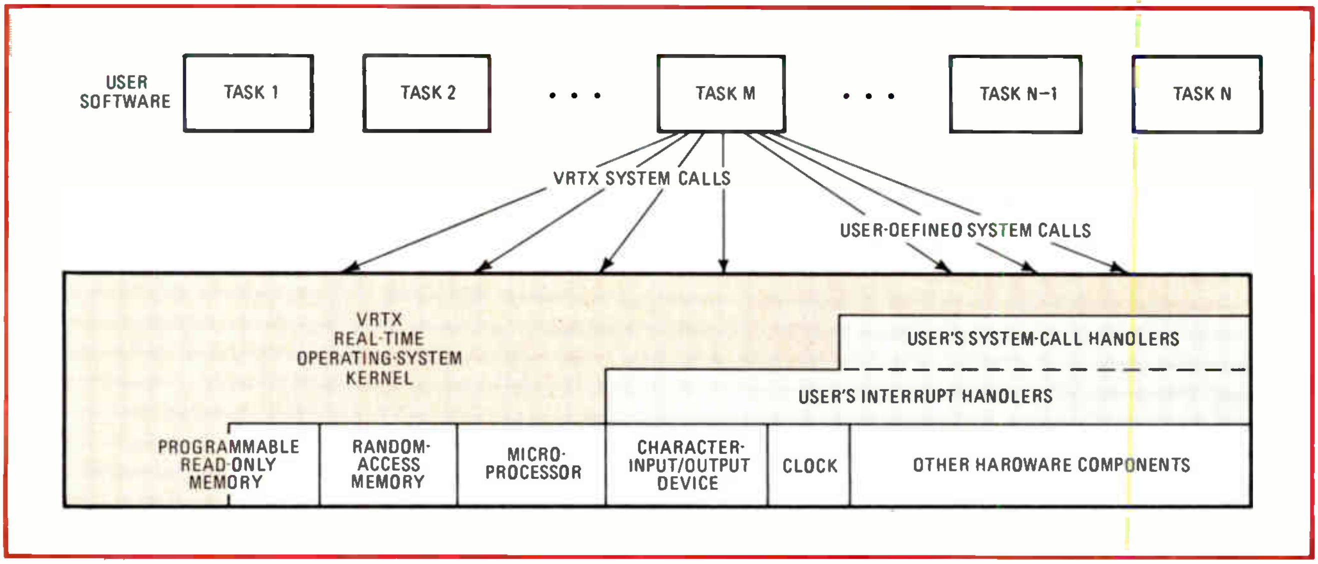
The user may write as many as 256 unique tasks to run under VRTX. He or she assigns each task a priority

TABLE 1: PERFORMANCE DATA FOR VRTX REAL-TIME EXECUTIVE FOR THREE MICROPROCESSORS*

Operation	Execution time (μs)*		
	VRTX/8002	VRTX/68000	VRTX/86
Create a task	128	144	191
Send message (with task switch)	129	143	173
Send message (without task switch)	53	59	111
Receive message (task waits)	110	130	133
Receive message (message waiting)	32	38	66
Maximum time interrupts are off (no time slicing)	13 + 6n†	14 + 7n†	16 + 8n†

*Clock rate is 8 MHz. †n = number of tasks.

TABLE 2: THE 22 VRTX SYSTEM CALLS FOR CONTROLLING USER'S TASKS	
Task control	
Task create	creates a ready-to-run task with the specified priority and start address plus (optionally) an identification number
Task delete	deletes a specified task from the system
Task suspend	suspends a specified task by setting its status as suspended
Task resume	resumes a previously suspended task by resetting its status as ready-to-run
Task priority	changes the priority of a specified task
Task inquiry	obtains the ID number, priority, and/or status information about a particular task
Communication and synchronization	
Post message	sends a message from one task to another via a specified mailbox location
Pend for message	receives a message via a specified mailbox location either from another task or from an interrupt handler; if no message is immediately available, the calling task is suspended until a message is received
Character input/output	
Get character	receives the next input character from the designated I/O device
Put character	transmits the next output character to the designated I/O device
Wait for character	suspends the calling task until a specified character is received from the designated I/O device
Clock management	
Task delay	suspends the calling task for a specified number of clock intervals
Get time	obtains the current value of the system clock
Set time	sets the current value of the system clock
Time-slice	enables round-robin scheduling among tasks of equal priority
Memory management	
Get block	allocates a block of memory
Release block	de-allocates a block of memory
Interrupt interface	
Post from interrupt	sends a message from an interrupt handler to a task via a specified mailbox location
Exit from interrupt	invokes a task rescheduling upon completion of interrupt handling
Timer interrupt	used by an interrupt handler to signal expiration of a clock interval
Receiver interrupt	used by an interrupt handler to signal receipt of an input character
Transmitter interrupt	used by an interrupt handler to signal its readiness to transmit an output character



1. VRTX architecture. The real-time multitasking executive, VRTX, provides 22 system calls that can greatly simplify the embedded system programming of 16-bit microcomputers in real-time applications. The user supplies his own interrupt handlers and device drivers.

level, and VRTX allocates control of the processor sequentially to the highest-priority task that is ready to execute. The kernel supports as many as 256 levels of priority. It employs an event-driven, round-robin scheduling algorithm and, if a clock is present, also permits task delays to occur.

Tasks may create other tasks, and they may delete, suspend, resume, and change the priority of themselves or other tasks. They may also need to send messages to one another. Two simple system calls, SC_POST and SC_PEND form a completely general mechanism for communication and synchronization. Tasks can send or receive 2- or 4-byte values to or from any memory location (which may, of course, be pointers to large data structures). If a location is empty, a task trying to receive will remain pending until a message arrives.

These communication and synchronization mechanisms are similar to the corresponding mechanisms in Data General Corp.'s Real-Time Operating System (RTOS), a widely used minicomputer operating system. The approach obviates the need for complex predefined entities (or objects) such as mailboxes, semaphores, message headers, and exchanges. It also makes mutual exclusion and resource locking easy to perform. For instance, resource locking can be implemented simply by arranging for all the tasks trying to use a resource to remain pending at the same location; as each task finishes with the resource, it sends a message to that location waking up the next task.

Real-time support

A real-time system must by definition respond quickly to external interrupts. Under VRTX, user-supplied interrupt handlers can adjust the scheduling of critically important tasks to unexpected events.

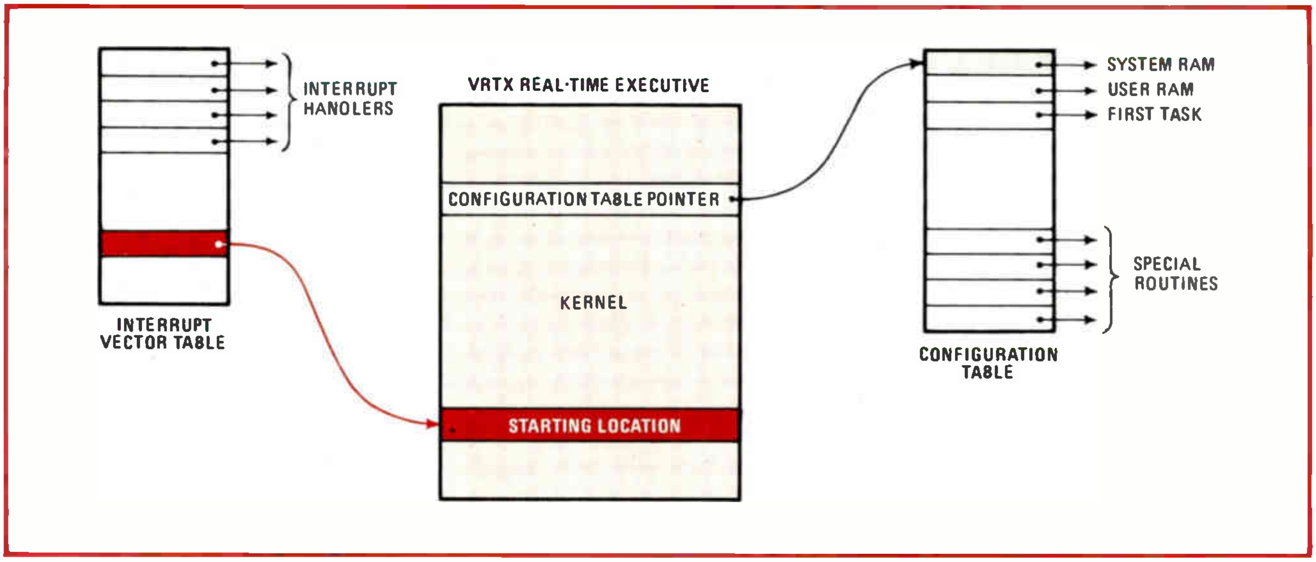
By analogy with the intertask communication mechanisms just mentioned, the UI_POST command allows an interrupt handler to post a message to a waiting task upon the occurrence of a significant event. The UI_EXIT command forces immediate rescheduling after the interrupt handler finishes. These two commands serve as a general interface between VRTX functions and device-dependent service routines.

Like the microprocessor itself, the silicon software kernel makes no assumptions about the interrupt structure that the user will choose to implement. The Z8000 uses a data structure called the new program status area (NPSA) to define the addresses of user-supplied interrupt-service routines. Aside from requiring that system-call traps be routed through VRTX, the user is completely free to use the NPSA directly to specify the entire interrupt structure. Similarly, VRTX/86 uses 32 vectors from the interrupt vector table leaving all other interrupt vectors to the user. VRTX/68000 uses trap 0 in the exception vector table. The kernel occupies a position that is hierarchically above the interrupt service routines, as shown in Fig. 1.

Going by the clock

Many VRTX applications will require a real-time clock and at least one character-oriented I/O device such as a terminal. Therefore, support for these devices is fully integrated into VRTX. The user need supply only a small hardware-dependent interrupt-servicing routine for each such device. VRTX, in turn, will manage all the logical operations needed to supply user application tasks with a full repertoire of associated clock management and character I/O commands. It is important to realize, however, that this kernel has been designed to operate quite satisfactorily independently of these devices—even the clock is not essential.

The VRTX commands to support character I/O and a clock fall into two categories: calls from user tasks and calls from interrupt handlers. For the clock, VRTX recognizes four user calls (SC_GTME, SC_TIME, SC_TDELAY, and SC_TSLICE) and one call from the clock service routine (UI_TIMER). Employing the first two calls, user tasks can get the value from the clock counter and set a new value for the counter. The remaining two user calls implement task delays and round-robin scheduling. The



2. System integration. Only two connections are required to interface VRTX with other system software—a pointer to the location of VRTX, and a pointer with the location of the configuration table that resolves all the hardware dependencies of the host environment.

UI_TIMER call, issued from an interrupt handler, simply notifies VRTX that a time interval has expired.

For character I/O, VRTX supplies three user calls (SC_GETC, SC_PUTC, and SC_WAITC) and two calls from interrupt handlers (UI_RXCHR and UI_TXRDY). The first two implement standard system-call get-character and put-character functions. The third user call allows a user task function as a "watchdog" for a particular character (for example, CONTROL-C). The two calls received from interrupt handlers will implement the necessary handshaking functions.

Managing memory

One of the basic functions provided by a real-time executive is memory management. VRTX supports dynamic as well as static allocation of memory blocks. In dynamic allocation, the two system calls allow user tasks to get and release blocks of memory. A separate stack is provided for each task.

The Z8000 status lines can distinguish among four address spaces for system code and data and for user code and data. Similarly, the 68000 distinguishes among supervisor program and data and user program and data. The kernel has been carefully designed to ensure complete compatibility with boards that actually effect such a separation. Of course, nothing precludes the use of VRTX with designs that do not utilize separate memory spaces. In addition, VRTX/86 is also compatible with the 8086 segmented memory architecture.

The user-supplied configuration table along with simple, device-specific user-supplied interrupt handlers interface VRTX with its environment. The table is VRTX's window on the rest of the board. It occupies 42 bytes on the 68000, 32 bytes on the 8086, and as little as 28 bytes on the Z8000. With it, the user can specify all the parameters needed by the kernel for a configuration.

One location in VRTX points to the base of the configuration table, and one vector in the interrupt vector table points to the VRTX starting location. These two pointers are the only links between the silicon kernel and the rest of the board. Values in the configuration table specify the start of system RAM and of user RAM, the length of user memory, the maximum number of tasks, and the location of any special routines that the user might wish to be invoked whenever a task is switched, created, or deleted, or the system is initialized. Figure 2 is a diagram of the relationships among VRTX, the configuration table, and the interrupt vector table.

Users who may want to add system calls to support special I/O devices have only to add a one-word pointer to the configuration table. Entries in this table can also be made to specify user routines for initializing special devices at system start-up or saving the state of custom devices on task switches. For example, if the user has a floating-point processor in the system, it will be necessary to save its registers on a context switch. Almost no other operating systems, even the user-configurable ones, give the designer the option of easily adding user save routines and initialization routines to the system scheduler. When VRTX was designed it was realized that easy extendability would be a key requirement for silicon software components, so these hooks were included.

Hooks and handlers

Next on the list of future silicon software components to be developed by Hunter & Ready is a file handler. This component will manage disk files—reading, writing, allocation, and so forth—in a manner similar to Unix. It will be hierarchically structured and will include schemes for fast access, possibly using what are called Indexed Sequential Access Methods. In addition, it will be supported by a library of hard- and floppy-disk drivers also cast in silicon. Together, they will enable users to implement a sophisticated file system by selecting from a catalog of standard components. In fact, VRTX already has the hooks installed to allow the file handler to be grafted onto existing designs without sacrificing throughput. Beyond the file handler are component data-base managers, network interfaces, and communications packages. □

Virtual-phase structure simplifies clocking for CCD image sensor

Grounded junction electrodes work with single level of clocked polysilicon gates to shift signal electrons down the charge-coupled-device registers

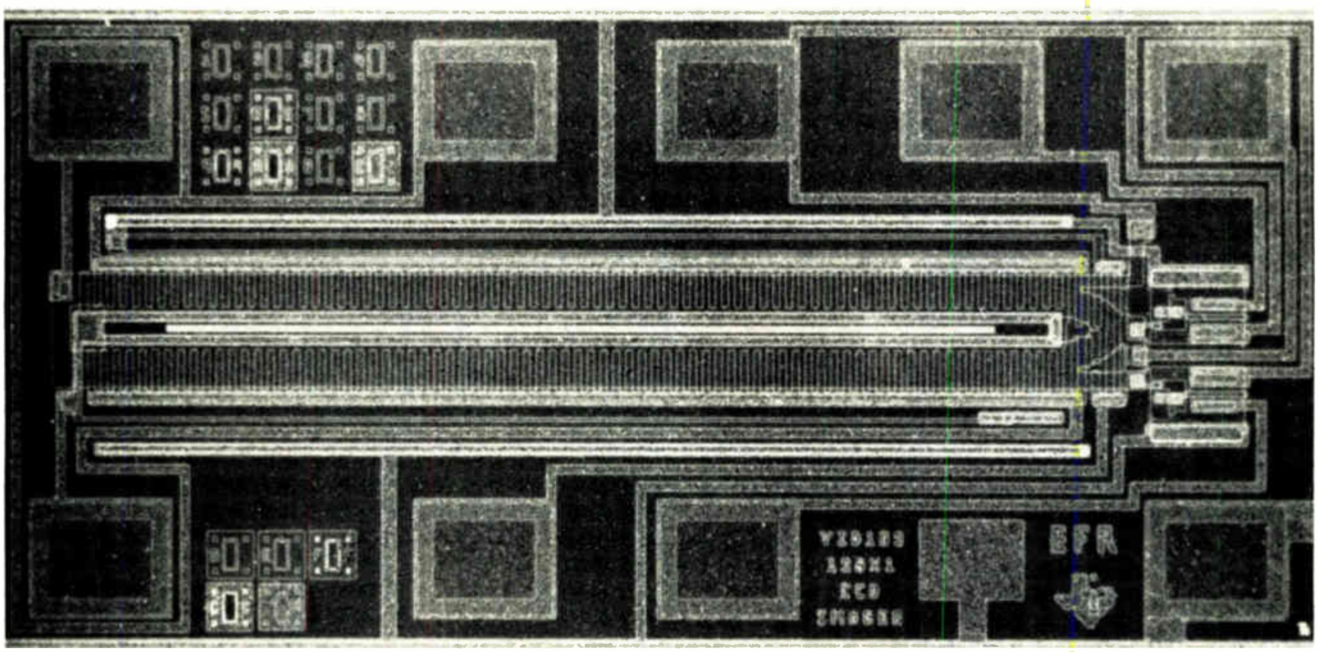
by Eugene F. Rybaczewski,
Texas Instruments Inc., Central Research Laboratory, Dallas, Texas

□ Ever since semiconductors replaced vacuum tubes in signal processors, engineers have sought to replace optical-imaging tubes with solid-state devices to get small size, low power consumption, positional stability, reduced cost, and compatibility with solid-state logic. A first step in solid-state image sensing—useful for facsimile transmissions—is a device that can accurately scan, at high speed, one line of an image and generate a proportional electrical signal.

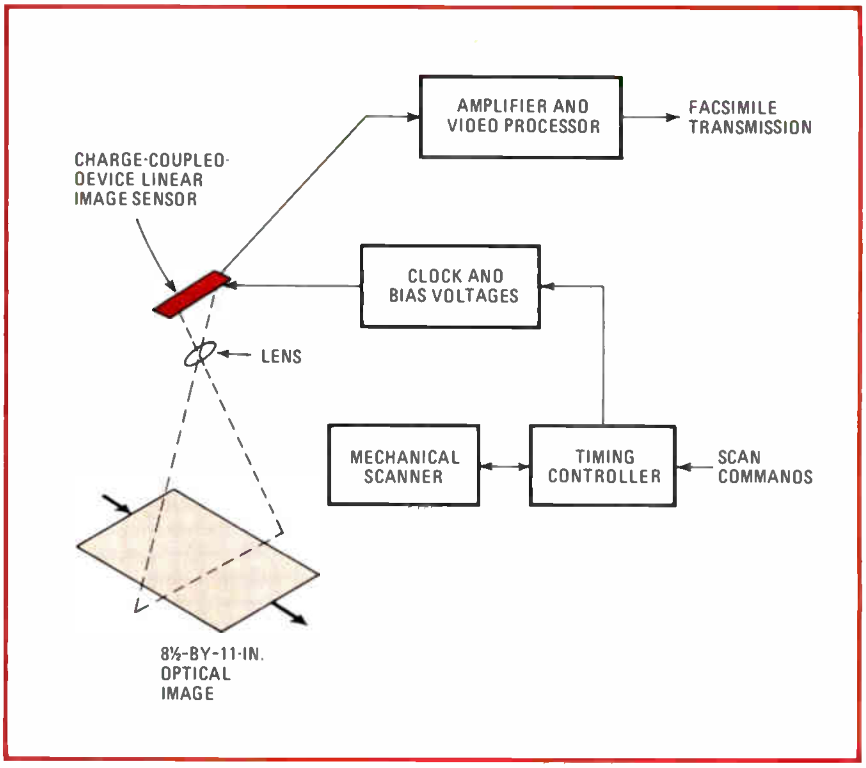
Thus considerable research and development has gone into charge-coupled-device image sensors, which can scan images line by line fast and accurately and give position-sampled data that may be controlled and processed by digital logic. Now headed for commercialization is the virtual-phase CCD sensor chip (Fig. 1) with the simplest clocking yet: a single pulse train applied to one level of polysilicon gates.

As well as simplifying clocking, this design [*Electronics*, Jan. 27, 1982, p. 39] reduces noise and increases sensitivity to light, compared with other charge-coupled technologies. The virtual-phase structure uses a pn junction (a virtual electrode) biased at the substrate dc potential, instead of a second level of clocked polysilicon gates. This virtual phase produces the same charge-packet transport function as does the second clock in conventional two-phase CCDs.

In the basic image-sensing system shown in Fig. 2, a standard 8½-by-11-inch document is scanned a line at a time by being moved past the CCD sensor. The image is reduced by a 10× lens and focused on the sensor. Each line is read out as an analog signal that goes to a video processor, which converts the data into formats suitable for transmission to such equipment as a printer, telephone, or display. Using the CCD clock signals, the timing controller selects the readout rate and vertical resolution and the exposure time, which is synchronized with the scanning of the document. For this system,



1. Line of sight. A 128-element charge-coupled-device linear image sensor uses a single level of polysilicon gates in its shift registers. The narrow rectangle in the center defines the photosites; flanking finger-like structures are the CCD transport registers.



2. Electronic mail. The major components of an electronic mail system are pictured here. A mechanical scanner moves the optical image in front of a CCD image sensor, whose output is processed for transmission to a terminal, printer, or other display.

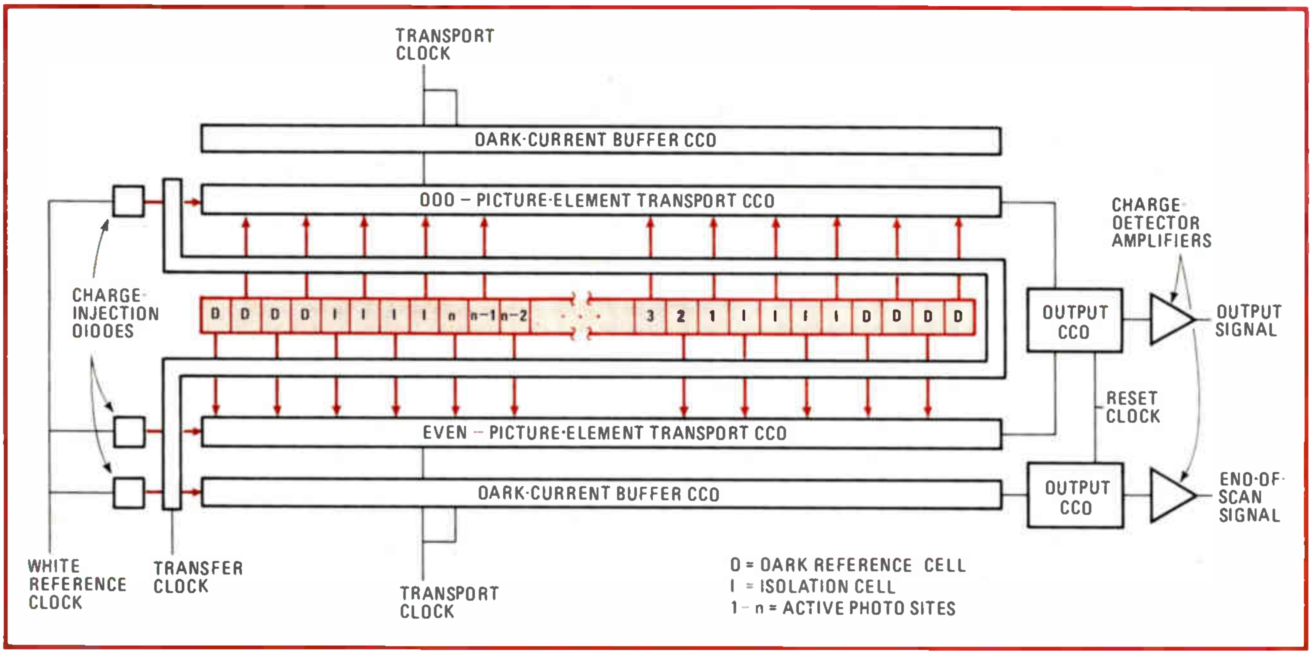
using an exposure time of 10 milliseconds per line and a 200-kilohertz data rate, the document could be completely scanned with a resolution of 200 points per horizontal inch and 200 lines per vertical inch in 22 seconds. Faster scan rates can be readily achieved by reducing the exposure time and also increasing the clock frequency.

With an eye on this class of applications, Texas Instruments has been actively involved in CCD fabrication since the early 1970s. In 1979, TI's Jaroslav Hynecek announced the virtual-phase structure. The virtual-phase device's fabrication and clocking differ substantially from all other CCDs: only a single layer of polysilicon gates, and hence only a single clock, is necessary to transfer charge packets along the register (see "Virtual-phase CCDs revealed," p. 143). Other types of CCD configurations require two or three overlapping layers of gate electrodes, as well as two to four separate clocks for charge transfer.

This improved technology makes for lower-cost sensors with simpler clock circuits, giving uniform images, low dark currents, and high quantum efficiency throughout the visible spectrum. Like other CCDs, these parts consume little power and operate stably and reliably.

All commercial CCD imagers from TI now use the virtual-phase process, and a standard family of linear image sensors is being developed. The first two members are the TC102 128-element sensor, shown in Fig. 1, which could serve as a character reader, and the TC101 1,728-element unit, which can scan an 8½-in.-wide page with a resolution of about 200 points/in.

Except for the number of photoelements, the 101 and 102 are constructed and operated in the same manner. In them (Fig. 3), the photosensitive areas, or photosites, are



3. Sensor architecture. Signal charge (indicated by solid color) enters the transport shift registers under control of the transfer clock and is shifted through them to the output amplifiers. A white-reference signal is injected at the beginning of each scan.

Virtual-phase CCDs revealed

The virtual-phase charge-coupled device is a variation of the conventional buried-channel CCD. It replaces one layer of polysilicon gates with a virtual electrode—a heavily doped p-type region near the silicon surface. As shown in the figure, a virtual barrier and well are created under this grounded virtual electrode by varying the dose and position of n-type implants.

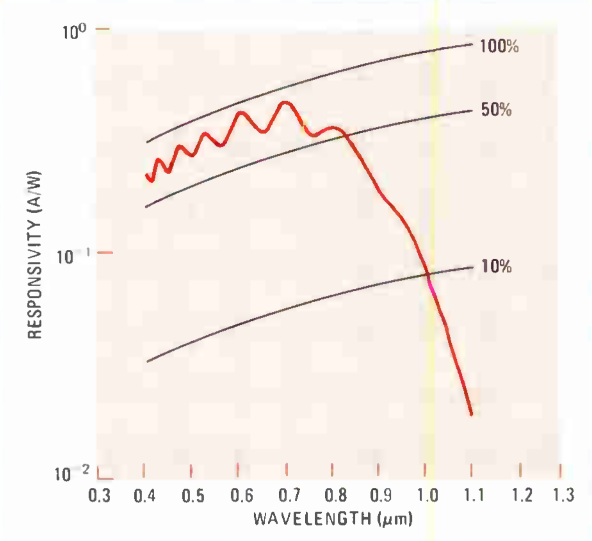
The device's clocked electrode is fabricated in much the same way as in a conventional two-phase CCD. A shallow n-type implant is placed under the clocked electrode, producing the clocked well region. The remaining portion of the clocked electrode is the clocked barrier region.

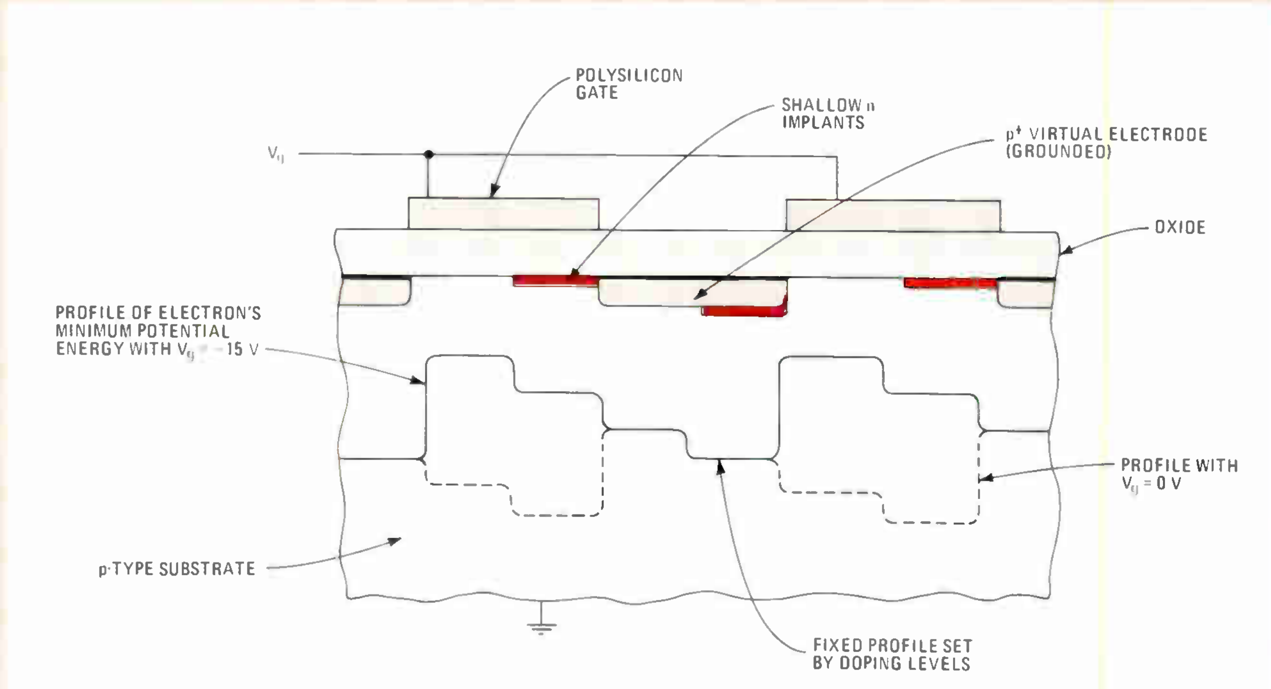
The combination of the clocked barrier and well and virtual barrier and well form the elementary structure of a CCD. When light is incident on the device, electron-hole pairs are generated in the depletion region and electrons accumulate in the potential wells. Then the clocked electrodes transfer the charge by moving their corresponding potential wells above and below the levels of the virtual electrodes' barriers and wells.

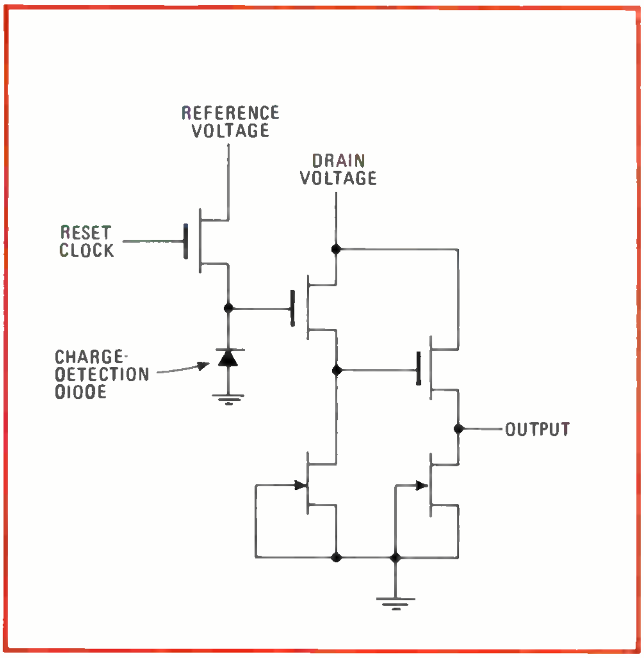
The charge-transfer efficiency, which is related to the fraction of the signal charge transferred from one well to the next, is just as high as in the two-phase structure, allowing these devices to operate at the same high frequencies—above 10 megahertz. The elimination of one of the clock phases simplifies not only the drive circuits, but also the silicon processing. Without overlapping gates, device yields are higher: shorts between the overlapping electrodes are a common failure in two-phase CCDs.

Because virtual-phase technology eliminates one layer of polysilicon, fewer photons are absorbed in the electrodes. This results in a higher quantum efficiency for all wavelengths—particularly important for the short ones (blue and green) that are usually greatly attenuated. The improved spectral response is illustrated in the graph, where it can be seen that the quantum efficiency of a virtual-phase CCD is near 70% at 0.4-micrometer wavelengths. The efficiency of conventional two-phase CCD can be as low as 20% at this wavelength.

Finally, virtual-phase CCDs typically have much lower dark currents than do two-phase structures—2 nanoamperes per square centimeter, compared with 10 nA/cm² or more. The main source of dark current is the energy states at the silicon–silicon-dioxide interface. The effect of these interface states is eliminated in the virtual-electrode region because they are filled with holes and the electron lifetime is very short. The states under the clocked electrode generate dark current only when the transfer gate goes high—a small fraction of the total cycle time. The net dark current is thus less than in two-phase CCDs.







4. Charge detector. A simple FET amplifier converts signal charge packets into voltage levels for transmission or recording. Charges from the CCD shift register change the voltage on the reverse-biased diode. Two source-follower stages buffer the resulting signal.

0.5 mil on a side, arranged on 0.5-mil centers. Light falling on the photosites creates electron-hole pairs in the single-crystal silicon. Channel-stop diffusions isolate adjacent photosites, so that electrons collect in them in proportion to both the incident light intensity and the exposure time of a scan.

For each photosite, the saturation light intensity is about 27 microwatts per square centimeter for a 10-ms exposure to a light source with a color temperature of 2,854 K, modified by a 2-millimeter-thick infrared filter. This saturation level gives a nominal output signal of 1 volt. In order to maintain the high spatial resolution of the sensor and hence of the scanning system, the light source should emit in the blue-green region of the visible spectrum, where quantum efficiency and modulation-transfer function are high.

The charge packets are transferred from the photosites, labeled 1 through n in Fig. 3, to the transport CCDs for serial shifting to the output amplifier. The exposure time is controlled by the transfer clock. When this clock goes high, the charge packets move into the transfer-gate region from the photosites. When it returns low, the charge packets are transferred into the CCD transport shift registers.

The line of photosensitive elements has a transport register on either side, with the odd-numbered photosites feeding one register and the even-numbered sites feeding the other. The charge packets are transported down these two shift registers and reconstructed in the original serial sequence by the output CCD in preparation for a charge-to-voltage conversion by the output-signal charge-detector amplifier (Fig. 4).

Even without incident light, thermally generated electrons tend to accumulate during a scan and form background noise that adds to the image-signal output. In order to monitor the magnitude of the dark signal independently of the light intensity, dark-reference picture elements (labeled D in Fig. 3) are at both ends of the linear image sensor. Isolation pixels (labeled I in Fig. 3) separate the image pixels from the dark-reference pixels. The dark pixels provide one of two reference levels, the other being a white-reference signal output that typically is about 70% of the maximum signal. These two reference levels are useful for exposure control and signal-level evaluation in the video-processing circuit that handles the image-intensity data.

Dark-current noise

Thermally generated electron noise also occurs in the chip's periphery, and to protect the data-transport registers from this noise, two additional CCD shift registers flank them. Also, one of these dark-current buffers carries a reference end-of-scan charge that provides a 0.5-V signal alerting the controller that a line scan has been completed and the system should begin a new cycle.

The white-reference signals are injected into the transport CCD shift registers at the same time that the end-of-scan signal is injected into its buffer CCD, by the combination of the transfer and white-reference clocks. The first white-reference signal arrives at the output at the same time as the end-of-scan signal.

In addition to the white-reference and transfer clocks, the device requires reset and transport clocks. The high and low voltage levels of the transport, reset, and transfer clocks are nominally 0 and −15 V. Each of these three clocks is shunted by an on-chip resistor protecting the respective gates from damage by static charge.

The voltage of the white-reference clock, which drives the charge-injection diodes, is always positive. This voltage is 12 V or higher and drops to about 6 V to inject charge. Voltage values less than 5 V may cause charge flooding and loss of charge-packet definition.

Just two dc voltages—the amplifier drain voltage and amplifier reference voltage—are required. The charge-detector amplifier requires approximately +18 V to bias the amplifier drains. The drain current is about 6 milliamperes under normal operating conditions.

When the reset clock is high, the charge-detection diodes are biased to the reference voltage, about 6 V. The current that flows in the reference-voltage line includes the charge in the end-of-scan shift register and the signal charge from the two transport CCD registers. The total current is normally less than 5 nanoamperes. However, the reference must be able to deliver up to 10 microamperes for operation at high data rates.

For high-speed operation, the signal and end-of-scan outputs should be buffered by low-impedance amplifiers that provide the current required. In digital applications like facsimile transmission, the transport, reset, and transfer clocks may all use the same high and low levels. However, for applications that need very low clock feedthrough and high optical output uniformity, the high and low levels of each clock should be adjusted independently. The white-reference signals can be used to monitor the charge-transfer efficiency. If the clock voltage levels are too low, a drop in the transfer efficiency will be reflected in this signal. □

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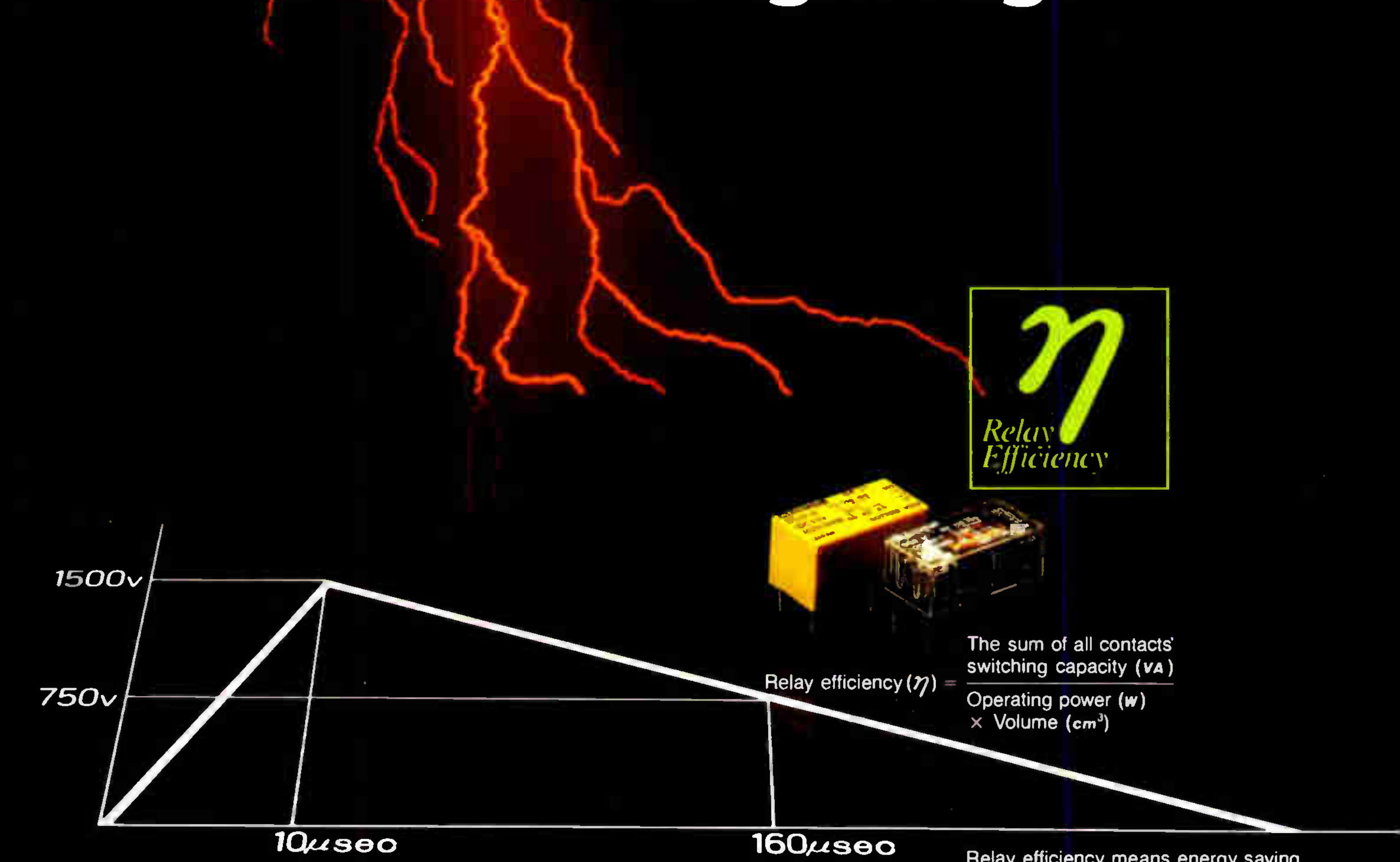

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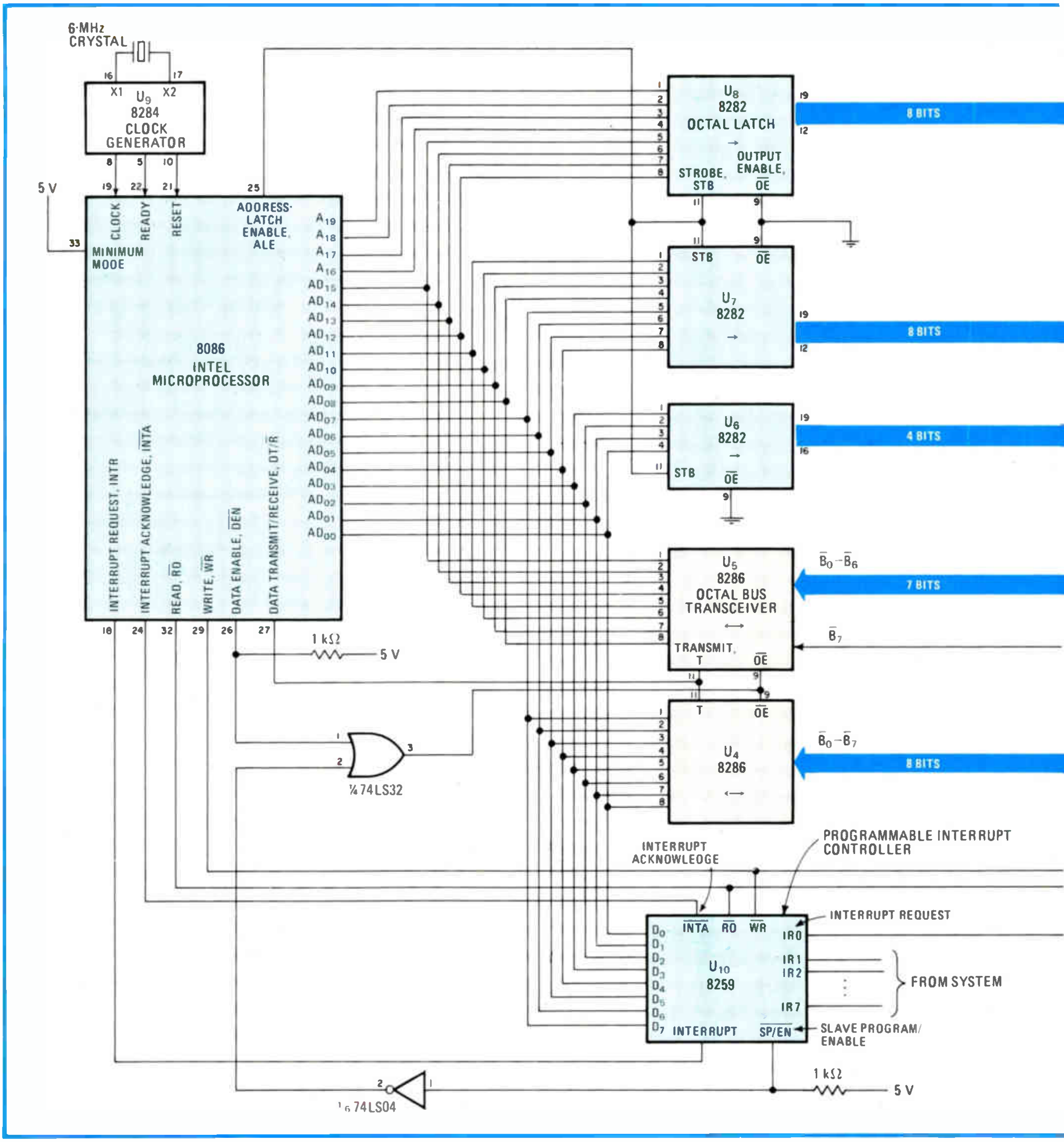
Circle 145 on reader service card

134

Interfacing 10-bit a-d converter with a 16-bit microprocessor

by Sorin Zarnescu
Westwood, Calif.

Eight-, 10-, and 12-bit analog-to-digital converters cannot easily impart their knowledge to 16-bit microprocessors, like Intel's 8086, because the received output is not in 2's complement form and the sign bit has to be extended. However, a match can be made with this design, which can offer programmable interrupt control. In addition, only one input instruction is needed to read the contents of the a-d converter. As an example, Analog

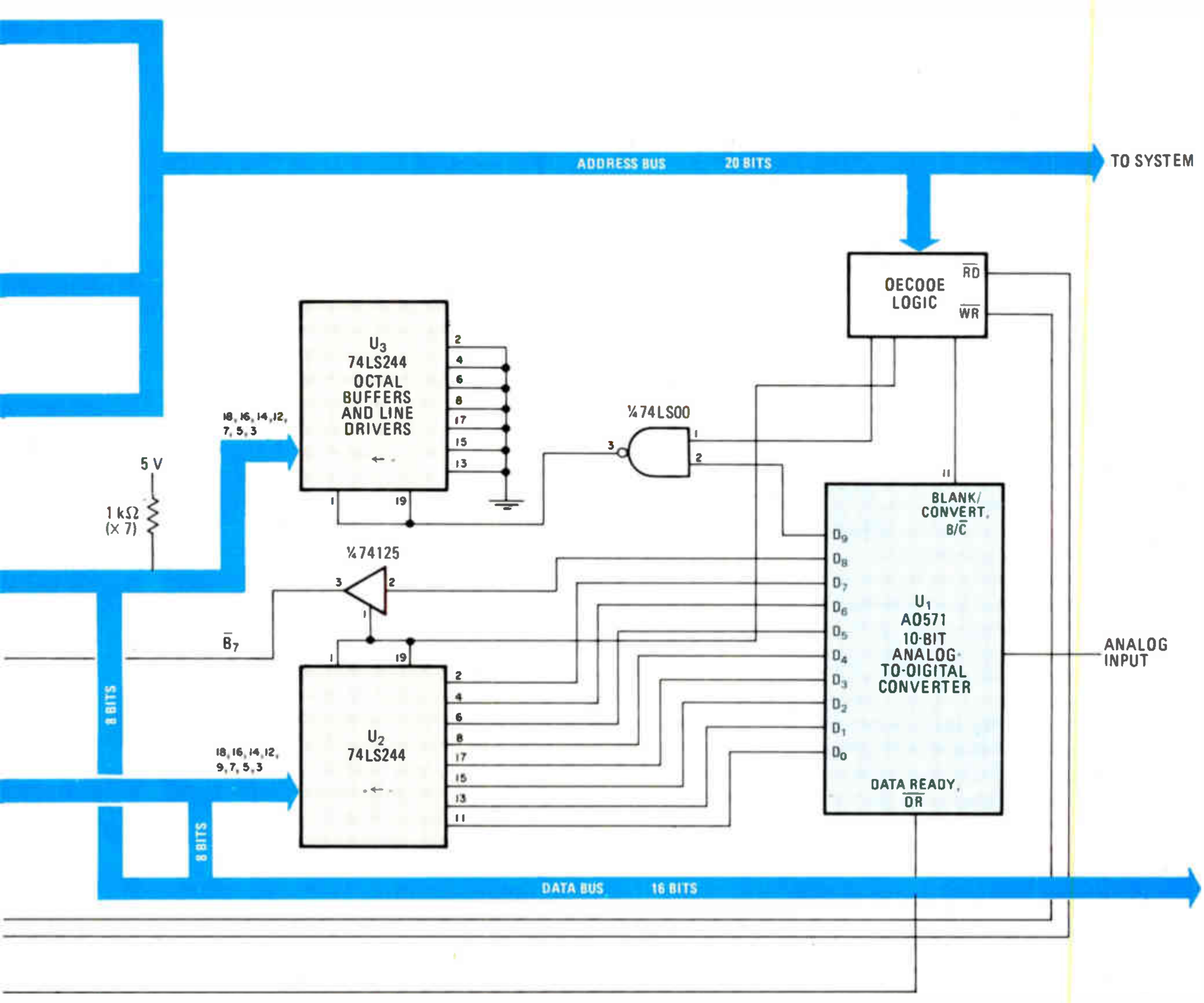


Devices' 10-bit a-d converter, AD571, is used.

Because the a-d converter's output code is offset binary, the most significant bit is inverted and used to control octal line driver-receiver U_3. When the input is positive, the MSB is zero and the octal driver is open. As a result, seven MSBs are 0. On the other hand, when the input is negative, the octal driver is in its tristate mode and the MSB is 1, resulting in seven MSBs also being 1.

After receiving the data-ready interrupt through programmable interrupt controller U_{10}, the microprocessor

Interface. The circuit provides an easy and fast way to interface Analog Devices' AD571 10-bit a-d converter with Intel's 16-bit 8086. The decode logic provides the a-d converter with signals for reading the data and starting the conversion.



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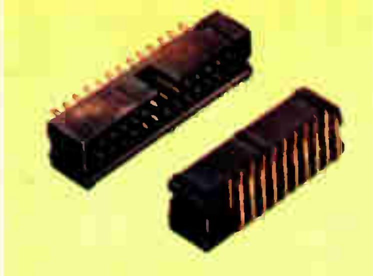

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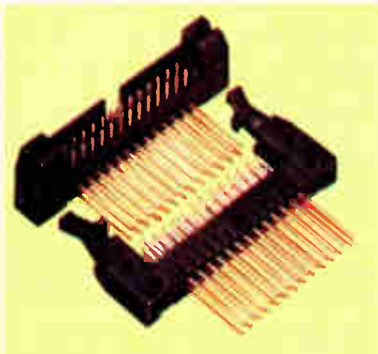

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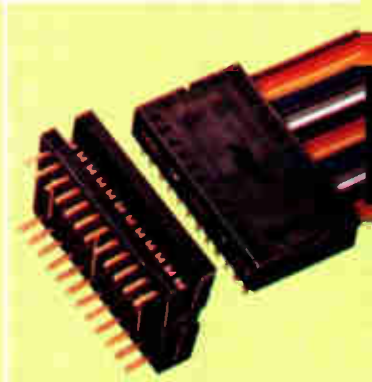

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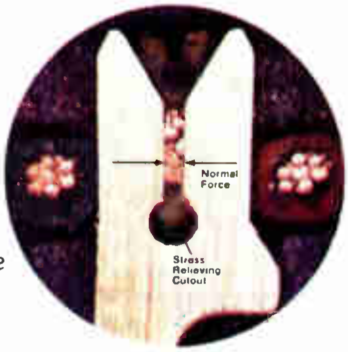

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A SEQUENCE FOR THE INTERRUPT ROUTINE		
Mnemonics	Symbolic address	Comments
INP	CONV	; READ DATA
OUT	CONV1	; B/$\overline{C}$ LINE BROUGHT HIGH
⋮	PROCESSING	
OUT	CONV2	; B/$\overline{C}$ LINE BROUGHT LOW (START CONVERSION)
IRET		; RETURN

reads the data through an input command also supplied by U_{10}. Since the 8086 has a multiplexed address and data bus, U_6, U_7, and U_8 are used as latches for the address. In addition, the address-latch–enable output of the processor clocks U_6, U_7, and U_8. Octal bus transceivers U_4 and U_5 provide buffers for the data bus.

The direction of data on this bus is controlled by the data transmit-receive pulse that is generated by the processor. In addition, the data-ready output from the converter is used as an interrupt-request input for U_{10}. The decode logic provides the signals for reading the data and starting the conversion (see table). □

Access control logic improves serial memory systems

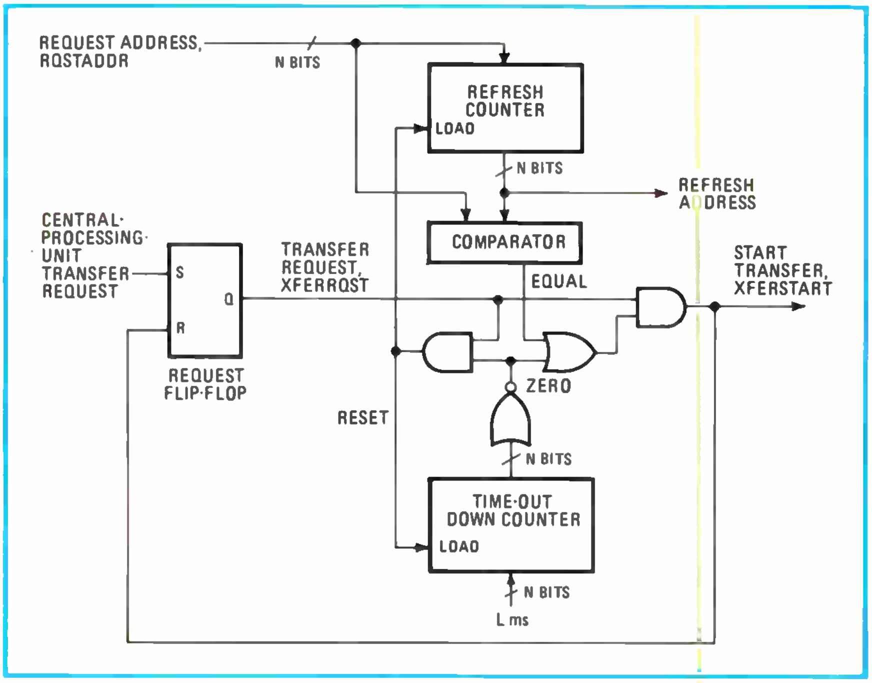
by Robert G. Cantarella
Burroughs Corp., Paoli, Pa.

File storage systems used in large scientific processors or computers need serially organized dynamic random-access-memory systems to transfer blocks of data from one memory unit to another in a serial order. Dynamic RAM devices used in such secondary stores need to be refreshed in a fixed cyclic order to keep the cost and latency low. This refresh logic loop further reduces latency, while retaining the cost advantage of a serial organization, and refreshes the memory at twice the minimum rate. In addition, zero latency is guaranteed with block transfers of at least L milliseconds.

When an initial transfer request XFERRQST occurs, the requester's address RQSTADDR is loaded into the refresh counter, which resets the refresh loop. This setting initiates the transfer (XFERSTART) with zero latency. The refresh address is then held in the refresh counter. Because the refresh loop is cycling at twice the required frequency, all bits are properly refreshed within L ms. The reset is then enabled only after a full cycle has completed when the time-out down counter is loaded with L ms. However, this action only occurs when the time-out down counter is zero.

After the transfer request is initiated, access is granted either when the requester's address is identical to the refresh address or when the time-out down counter is zero. Thus latency is a function of the requester's address and the time since the last reset. As a result, a block transfer of L ms guarantees that the next transfer request will be granted immediate access.

The system performs like a random-access memory but retains the cost advantages of a serial-memory system. The constant refresh rate results in a steady current drain, thereby reducing the cost of the power-supply system and storage cards. □



Access. The access control logic refreshes the memory at twice the requisite frequency to keep the latency low. Access is granted when the requester's address is identical to the refresh address or the time-out down counter is zero, whichever occurs first. Block transfer of L ms guarantees zero latency.

Build-it-yourself unit monitors ionized-air blowers

An analytical tool that monitors the static neutralizing performance of ionized-air blowers can be built from standard electrical and mechanical components. It is used to help protect static-sensitive electronic components during assembly. The test unit, called an ion-flux monitor, consists of a 6-in.-square metal plate charged to 3,000 V dc positioned behind and parallel to a 6-in.-square metal grid with a 0.25-in. mesh. The metal grid is connected through a nanoammeter to ground. **Because the grid is grounded, it acts as an electric shield for the highly charged plate, limiting the sampling of ions** to those physically propelled through the grid. Ion distribution from any ionized-air blower can be monitored by placing the blower at the end of a work table and then positioning the ion-flux monitor sampling grid at various points on the table. More information on building the monitor is available from 3M, Static Control Systems, Department ST82-13, P. O. Box 33600, St. Paul, Minn. 55133.

Reset circuit keeps program running

A simple reset circuit developed by Dan Stern of Bayly Engineering in Toronto, Canada, restarts a microprocessor when its program fails. The technique depends upon a watchdog pulse from one of the input/output lines that is present as long as the program is running in the normal routine. **When this pulse is missing, the circuit sends a reset pulse to the microprocessor that restarts the program.** Two retriggerable monostable multivibrators with clear features are used to generate this reset pulse. The watch pulse is fed through a NAND gate to the first one-shot, whose output is used to control the second one-shot. When the program fails and the watchdog pulse disappears, the output of the first one-shot triggers the second to generate a low pulse at its output. This pulse is then fed to the $\overline{\text{RESET}}$ input of the microprocessor. A feedback technique is used to repeat the process until the watchdog pulse reappears.

Tested chip carriers on motherboards ready in two weeks

"Speedy delivery" is the name Hybrid Services gives its two-week turnaround service for chip-carrier motherboards that are designed to customer specifications. The North Reading, Mass., company **can package any monolithic integrated circuit into chip carriers and test them for electrical and mechanical integrity and reliability.** Packages consist of dual and single in-line multilayer ceramic carriers that maximize space utilization and reduce interconnections on printed-circuit boards and improve circuit performance and yield. The service is available for both high and low volumes.

What's the weather like?

Before transporting, storing, installing, or using a product, manufacturers should have a detailed knowledge of both natural and man-made hazards, according to "Classification of Environmental Conditions, Part 1." For example, a product could be damaged through severe changes in climate, **be impaired through contact with chemicals, or have its efficiency reduced through electromagnetic disturbances.** The report, which classifies environmental parameters and their severities, is put out by the International Electrotechnical Commission, 1, rue de Varembe, 1211 Geneva 20, Switzerland and costs 44 Swiss francs.

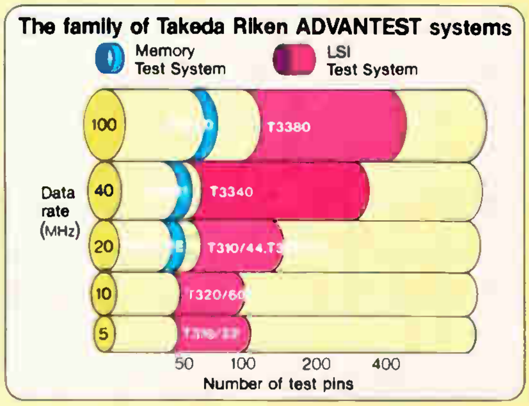
-Steve Zollo

Hard Facts on the T3340 for the Hard-Pressed Test

The Most Advanced Architecture — Now Available in a 40MHz VLSI Test System

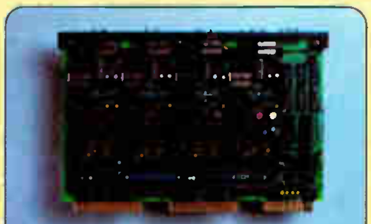
The Takeda Riken engineers are proud to present the T3340 — a VLSI test system with the 40MHz data rate and 256 pin test capacity to handle the ICs you're faced with today and those that tomorrow's device technology will likely present. All of this capability is the product of the Takeda Riken ADVANTEST concept and provides the troubled test engineers of todays IC device manufacturer with the ability to perform characterization, Q/A reliability testing, and incoming inspection while maintaining a respectable level of cost performance for a system of such versatility.

And the Takeda Riken engineers won't leave you high and dry — this system is fully backed up in the US by the ADVANTEST Division, a highly capable sales and service organization.



Guaranteed Overall Timing Accuracy of ±800ps

The ADVANTEST concept of overall timing accuracy provides an extremely tight guardband, thereby contributing significantly to test repeatability. The T3340 VLSI test system features a integrated system of timing error compensation for extremely high overall accuracy. Accuracy, of course, that shows up in the driver/comparator specs for skew. And, more than that, timing generator non-linearities, jitter, and comparator errors that cannot be electrically prevented are also improved.


Advanced circuitry keeps Takeda Riken ahead in VLSI testing.

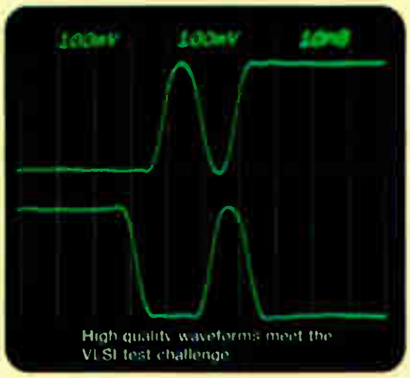
This guaranteed timing accuracy spells ±800ps accuracy for the high speed test station, with test repeatability held to within ±100ps, thereby providing pin-point covergence.

40MHz VLSI Test Systems Engineer.

T3340 Capabilities

40MHz Testing of 256 Pin Devices
The T3340 is just not another tester claiming a 40MHz data rate. This 40MHz system is backed up by the fact that any pin may be used as a full I/O pin with programmable active load. This is the key to achieving a high throughput in testing VLSI devices with a large number of pins.

Cross-Boundary Single-Range Timing Generator
Clocks and strobes can be set cross-boundary with 125ps resolution, and no dead band exists in either the present or the next test cycle.


High quality waveforms meet the VLSI test challenge

The digitally controlled timing generator used in the T3340 is designed to be able to generate all conditions for data rate, clock and strobes using a single range, providing schmoo plots and margin data unheard of before. These timing features satisfy virtually all VLSI timing requirements.

1+16 DC Test Units for High Throughput
The T3340 test system may be fitted with one Universal DC Test Unit and up to 16 (for 256 pin systems) Multi-DC Test Units, cutting the time required for parametric testing of large VLSI devices to 1/20 normal.

64K Vector Buffer and 16M Bytes of Storage
To facilitate the use of CAD-generated test data, a 64K deep stimulating and expected vector buffer is available in addition to 16M bytes of pattern storage (the optional super buffer memory). The system is designed to eliminate overhead time required to transfer such pattern data.

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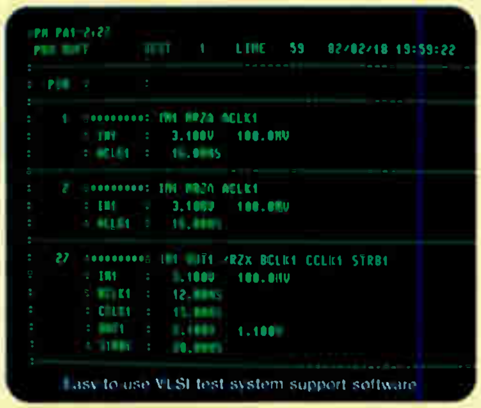
The easy-to-use, field-proven MOST-XII software system is the ideal medium to support operator-to-DUT communications. Even after compilation, a process completed 3 to 5 times faster than with most test systems, the test plan may be freely and interactively modified at the source program level. The system manages the TP-1 32-bit super-processor and supports multi-user operation.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Circle 153 on reader service card

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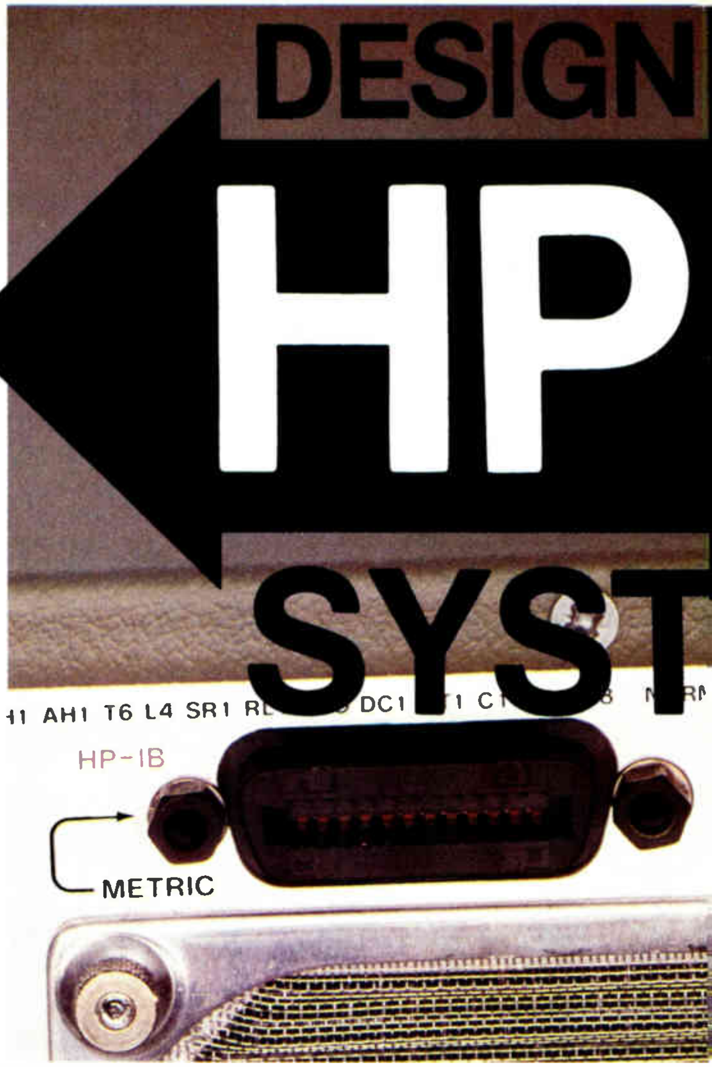

The familiar HP-IB (Hewlett-Packard Interface Bus) symbol is HP's way of identifying instruments and computers that conform to the IEEE-488 standard. But it means much more than just bus architecture and system compatibility. The HP-IB symbol also stands for the documentation and support that helps you get a measurement system operational in weeks instead of months.

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Choose HP when you need a measurement system and you get these advantages: 1) All devices and all documentation come from a single source which means consistency in design and documentation. 2) Every member of the HP-IB family of instruments and computers — over 140 in all — is designed for and tested to rigid HP-IB standards of compatibility. 3) Just as important, every HP-IB device comes with complete and comprehensive documentation that's easy to follow and consistent in its approach to implementation. You'll receive service manuals and operating manuals that typically include a guide to the implementation of computer based systems. 4) You can choose from more than 100 HP application notes. Many of these will teach you how to accomplish specific measurements in conjunction with the controlling computer. Software examples are included in a number of these to help you get to a solution even faster. In fact, one of these examples may be just what you need for your exact application. And many HP application notes list the results of performance tests to help you verify proper system operation. 5) HP also offers training, system engineering support and on-site service . . . assistance from start to finish. But these aren't the only reasons HP is the logical choice for measurement system development.

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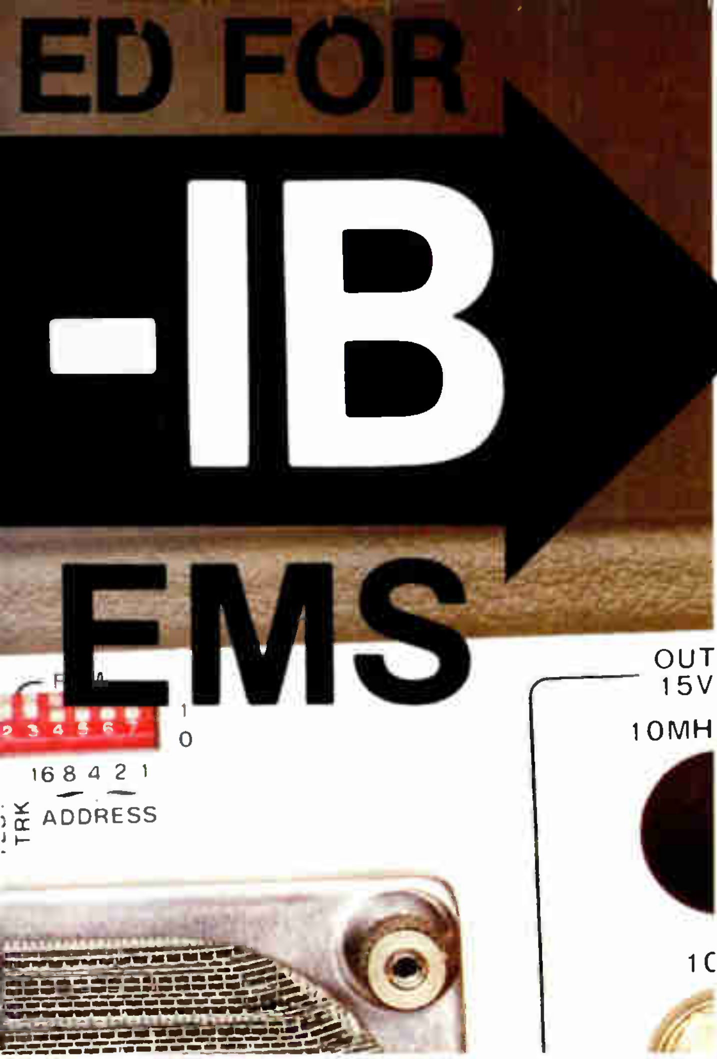

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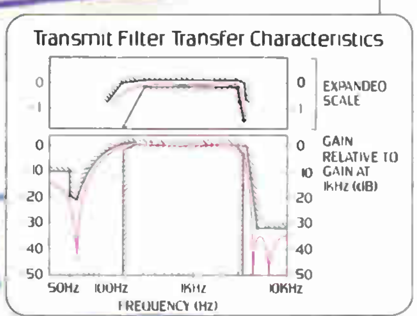
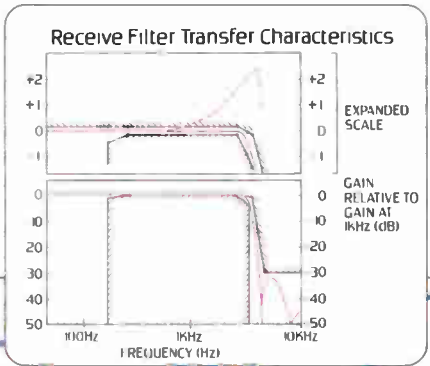
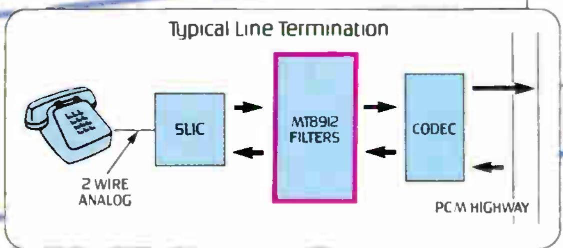
All in all, it's a case of hot specs guaranteeing you hot performance.

Find out more about what the Mitel MT8912 can do for your application by contacting your local Mitel sales office.







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BUILDING BETTER COMMUNICATIONS

Circle 158 on reader service card

Modems of all types proliferate

Low-cost 300-b/s parts, multi-megabit/s broadband units, and those filling other gaps turn up, despite market uncertainty

by Harvey J. Hindin, Communications & Microwave Editor

Modem manufacturers refuse to listen to naysayers and blithely proceed to introduce products at a breathtaking rate (see "Whither modems?," p. 160). These range from megabit-per-second units suitable for broadband local networks and IBM-type equipment to inexpensive 300-b/s devices designed for direct connection of home computers. Recent introductions illustrate the diversity of these devices, which are vying for portions of a market projected to be $1 billion by 1984.

Typical of high-end units is a modem series from Interactive Systems/3M. It permits communications between the commonly used IBM 3274 terminal-control unit and up to 32 remote terminals over a single RG-62 coaxial cable. In other words, the 3M model 6600 series IBM-attach modems, as they are called, permit expansion without adding more cables.

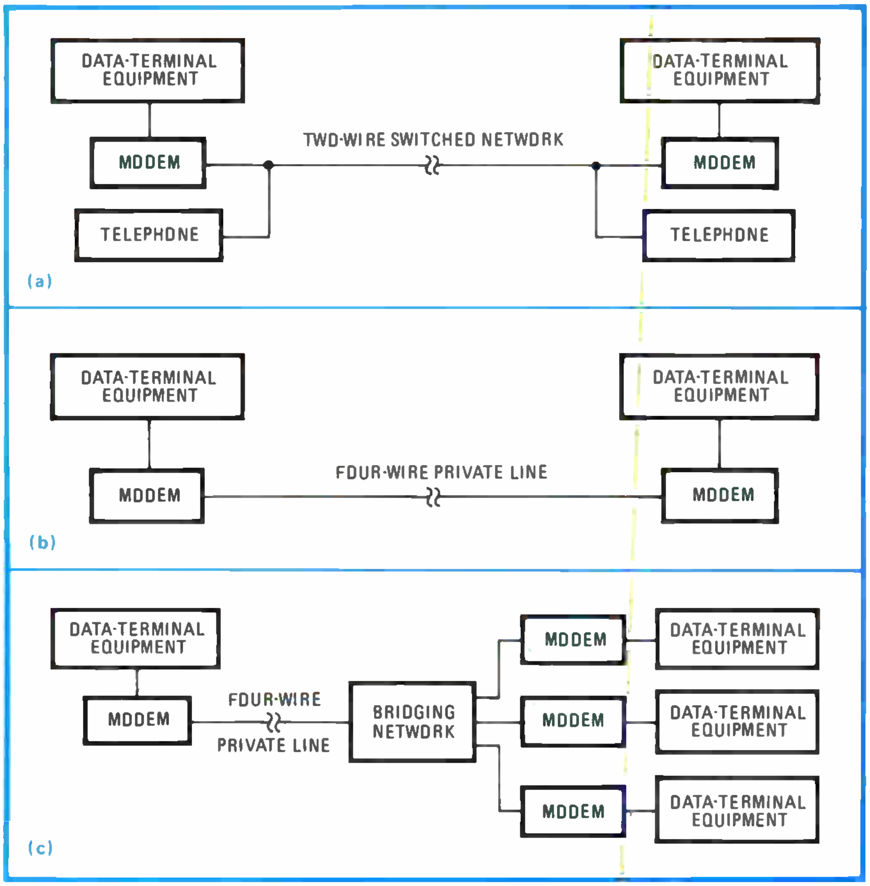
To implement this expansion, the data must be multiplexed from a group of 3274 controller ports into one serial port over a single (usually existing) cable. At the remote-modem locations, the data stream is demultiplexed back into the separate bit streams and distributed to each terminal.

Slow alternative. Of course, it has always been possible to locate 3274 control units remotely. Although this tactic eliminates the need for additional cable, it also reduces throughput because communication takes place over a relatively slow link.

The 6600 modems offer another possible advantage. When baseband data-communications networks can no longer handle additional terminals, data-communications users can upgrade to a broadband network with greater capacity. The 6600 series modems are designed to be reconfigured from baseband to broadband and are available in 32-, 8-, and 4-port configurations. The price of a 32-port unit is $6,632. Quantity discounts are available and delivery is from stock.

A small firm, Anchor Automation, has addressed the other end of the market spectrum with what it says is the world's first under $100 direct-connect modem intended for personal computers. The $99 Signalman Mark I is available from stock and designed to operate from a self-contained 9-V battery. A wall-plug power-supply module is also available.

Both voice and 300-b/s full-duplex data can be handled in an asynchronous format with a direct connection to the telephone line. The



Flexible. The Rixon TA208A/B modem can handle half-duplex communications over a standard two-wire switched telephone network, and performs automatic answering functions (a). Various configurations are possible when a four-wire private line is used (b and c).

RS-232-C cable from the modem to the computer is built in. An audible tone, instead of the usual light-emitting diode, indicates the presence of a carrier signal.

Also geared to the home computer but designed to handle viewdata, the 1180 modem family has been announced by the International Telephone & Telegraph Corp. Available in sending or receiving configurations, the 1180 (see photo) functions at up to 300 b/s full duplex on switched telephone networks and meets recommendation V.21 of the International Consultative Committee on Telegraphy and Telephony (equivalent to the U. S.'s RS-232-C).

Dual units. The originating unit is designated the 1180A, and the answering unit is the 1180B. For viewdata needs (transmission at 75 b/s and reception at 1,200 b/s), the 1182A modem is available for use in full-duplex split-speed operation on standard switched telephone facilities. Its companion modem, the 1182B, provides the required transmission at 1,200 b/s and reception at 75 b/s. Both modems have an automatic connect and disconnect feature.

According to their maker, the 1180 family units are optionally available with TTL- and complementary-MOS-compatible interfaces.

Viewdata applications. ITT's series 1180 modems are designed to link home or office users with viewdata information services. Data travels one way at 75 b/s and the other way at 1,200 b/s.

Whither modems?

Modem manufacturing is a tough business. Intense competition with dozens of suppliers—many selling identical products or relabeling the work of others—are old problems. The incorporation of modems in data-generating and -receiving gear and the appearance of large-scale integrated circuits that perform many or all modem functions when incorporated in terminals are both factors that add to the modem marketing manager's woes. What's is more, American Telephone & Telegraph Co.'s Dataphone Digital Service (DDS)—if it becomes popular—will eliminate the need for modems in many installations at data rates up to 56 kb/s—the bulk of the market.

One estimate of the modem market's size (complicated by the cross-sales and label-changing mentioned), from General DataComm Industries Inc. of Danbury, Conn., says that total worldwide modem shipments in 1981 were $820 million, and that this figure will grow to $1,411 million by 1984. The loser here is the low-speed modem market, which will drop from $42 million to $31 million. In contrast, 9,600-b/s modems will soar from $270 million to $456 million, with similar growth at 1,200, 2,400, and 4,800 b/s.

The major long-range uncertainty for the modem manufacturer is the effect of AT&T's end-user-oriented Dataphone Digital Service. Connecting 96 cities with a 56-kb/s digital data capability, the service may drastically reduce the need for modems. However, installation of DDS has not been speedy, and, so far, its effect has not been seen by most manufacturers. In fact, taking advantage of the situation, some of them have asked the Federal Communications Commission for permission to provide some DDS interface—until now an activity only of AT&T. Needless to say, AT&T has objected; the FCC's decision is expected this year. The modem vendors also hope to make connection equipment for AT&T's Advanced Communications Service (ACS) as it comes on board. **-H. J. H.**

Power can be supplied from the modems' associated data-terminal equipment at ±12 and 5 v dc, or from an external supply.

The 1180, when it is used as a viewdata modem, couples a human to a computer. Butler National Corp. has also come up with a modem for such coupling, but its Adas VIII, a voice and data modem, can communicate with the user in English by means of voice synthesis.

When interfaced with a host computer, Adas VIII can be used to perform standard originate and answer modem functions. It is connected by a self-contained telephone coupler circuit to a standard telephone line. At the other end of the transmission line, the modem connects to the host via an RS-232-C interface, through which all instructions to the Adas can be issued and status indications and modem data communicated. Adas VIII costs between $2,500 and $3,500, depending on software options; delivery is in 120 days.

Closed-circuit television and some office-of-the-future applications call for a different breed of modem, synchronous units operating at megabit/s data rates. Comtech Data Corp. is offering such a broadband modem as part of its 500 series. These modems are designed for transmitting high-speed digital data with individual data rates from 56 kb/s to 7 Mb/s over a single cable. The M500 can handle three full-duplex circuits in a broadband local network. It is available in 90 to 120 days and costs up to $4,650.

Midrange. Medium-speed modems with state-of-the-art features are also turning up. Penril's Data Communications division has designed a modem to provide data communications over short-distance nonloaded metallic cable pairs or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Circle 161 on reader service card

local channels at 2,400, 4,800, 7,200, 9,600, or 19,200 b/s. It is expected to be available midyear for $595.

The Penril 8192 provides automatic adaptive equalization of the received signal. This eliminates the manual equalization setup required on most other short-haul modems. The automatic equalization also facilitates multipoint operation by independently equalizing the signal from each remote modem, doing away with operator intervention. The 8192 features remotely controlled digital loopback testing and a pattern generator and detector for self-test capability. Options allow the selection of special operating characteristics in the field.

Another contender. Also in the medium-speed class (4,800 b/s) the TA208A/B from Rixon Inc. transmits and receives synchronous serial binary half-duplex data over AT&T's two-wire switched network or full-duplex over four-wire private lines (see diagram, p. 159). In the private-line mode, optional voice- and data-alternating equipment may be added.

When the switched network is used, the modem features automatic answer under control of the data terminal. In this mode, use of a standard 500- or 565-type phone enables use of the alternate voice or data option without additional equipment. Availability is from stock for $1,695 for the unpackaged card version.

Anchor Automation, 16130 Valerio St., Van Nuys, Calif. 91406. Phone (213) 997-6493 [401]

Butler National Corp., Suite 204, 800 West 47 St., Kansas City, Mo. 64112. Phone (913) 888-8585 [402]

Comtech Data Corp., 350 North Hayden Rd., Scottsdale, Ariz. 85257. Phone (602) 949-1155 [403]

Interactive Systems/3M, P. O. Box 33600, St. Paul, Minn. 55133. Phone (612) 736-2701 [404]

ITT, Data Equipment and Systems Division, Suite 8927, One World Trade Center, New York, N. Y., 10048. Phone (212) 839-0500 [405]

Penril Corp., 3204 Monroe St., Rockville, Md. 20852. Phone (301) 984-8225 [406]

Rixon Inc., 2120 Industrial Parkway, Silver Springs, Md. 20904. Phone (301) 622-2121 [407]

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The new Data I/O 1310A/1320A Digital Troubleshooting System allows a technician to verify correct data streams and identify failed components simply by probing test nodes and watching or listening for a correct indication. It eliminates practically all documentation.

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DATA I/O

Circle 163 on reader service card

Wafer processor saves space and time

System's floor-space needs and throughput are improved; a compact oven, cleaning module, and intelligence are also added

by Linda Lowe, Boston bureau manager

A second generation of wafer-processing equipment from GCA Corp. will be unveiled at next month's Semicon West in San Mateo, Calif. With 30% to 50% better throughput and improved uniformity and reliability, the Wafertrac II system outperforms the company's Wafertrac system, which was introduced in 1976 and currently has an installed base of about 1,000 systems. The new system also occupies as much as 56% less floor space, according to the firm. Senior sales engineer Bruce I. Donsker estimates that production will be well under way by the third quarter.

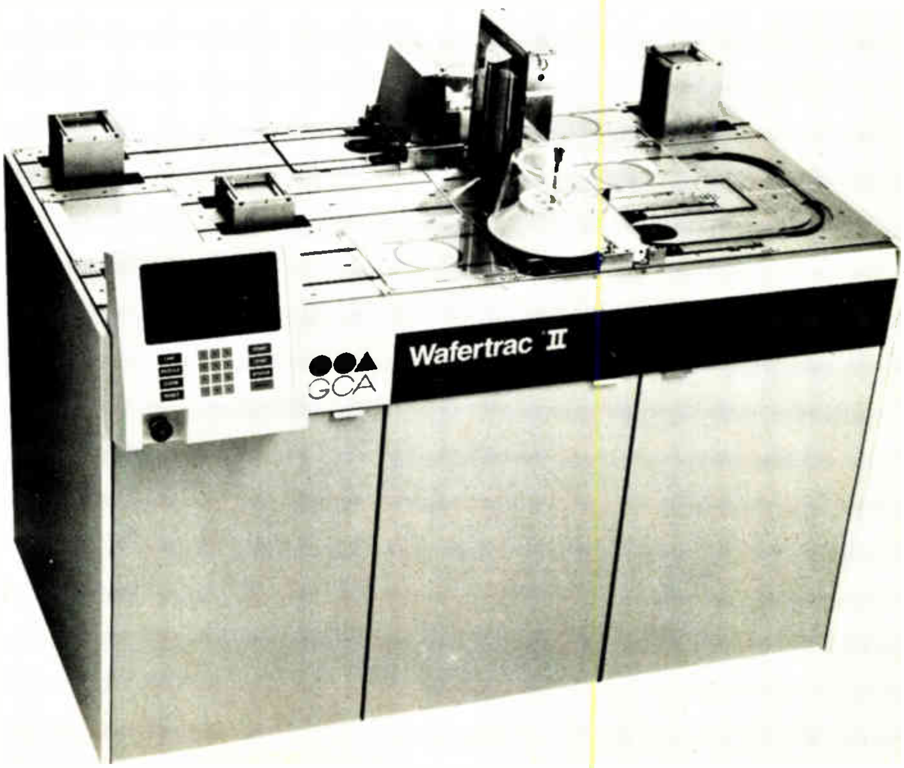
Wafertrac II also departs from its predecessor in introducing intelligent process modules and a host computer, says Donsker. "In fact, each Wafertrac II module contains more memory capacity than does Wafertrac I's system controller," he asserts. The modules, equipped with Intel 8085 microprocessors and 16-K bytes of random-access memory, communicate with each other and with the 8086-based Wafertrac II host via RS-232-C links.

The host, which can support six Wafertrac II systems, develops process programs off line for downloading to the individual systems. It adds redundancy to the systems, intervening in the case of a communications failure among the system modules, and it performs system diagnostics either on or off line if a module should fail. The host processor has 64-K bytes of RAM, 16-K bytes of erasable programmable read-only memory, 256-K bytes of floppy-disk storage (more can be added), and an intelligent controller interface. Several hosts can communicate with one another in compiling and storing processing-line histories.

New modules in Wafertrac II include a cleaning unit and a redesigned oven for drying and baking wafers at various points during processing. The 9-by-9-in. cleaning module contains a transducer head that applies ultrasonic energy uniformly to a cleaning solution flowing over the wafer. This process removes dust and other particles, smudges, and fingerprints, typically in 20 to 30 seconds, half the time required by high-pressure air-jet cleaners of the kind used on the original Wafertrac, asserts Donsker. The cleaner can operate three different dispensing lines, making possible programmable applications of different chemical solutions for different processes or at different points in one process.

Wafertrac II's oven serves to dry wafers after cleaning, cure photoresists applied to wafers, and bake exposed and developed photoresists prior to etching. It also measures 9 by 9 in., whereas the first Wafertrac system's oven is 45 in. long, Donsker points out.

The oven returns to a relatively old method for baking wafers, the hot plate. But this hot plate has holes through which a vacuum chuck pulls wafers tightly onto the plate, increasing the uniformity of contact and thus the speed and uniformity of heating. Wafertrac II typically takes two to three seconds to heat a wafer from room ambient temperature to 130°C, reducing the time required to cure a photoresist on the wafer to 35 or 40 s from the first Wafertrac's typical 800 to 1,000 s, Donsker says. He adds that uniformity across the wafer is within ±½°C for a 4-in.



wafer and $\pm 1^{\circ}C$ for a 5-in. wafer. "That's five to six times better than anyone else, including the original Wafertrac." The oven's speed pays multiple dividends, Donsker notes, "because it's used more often in the process cycle than any other module."

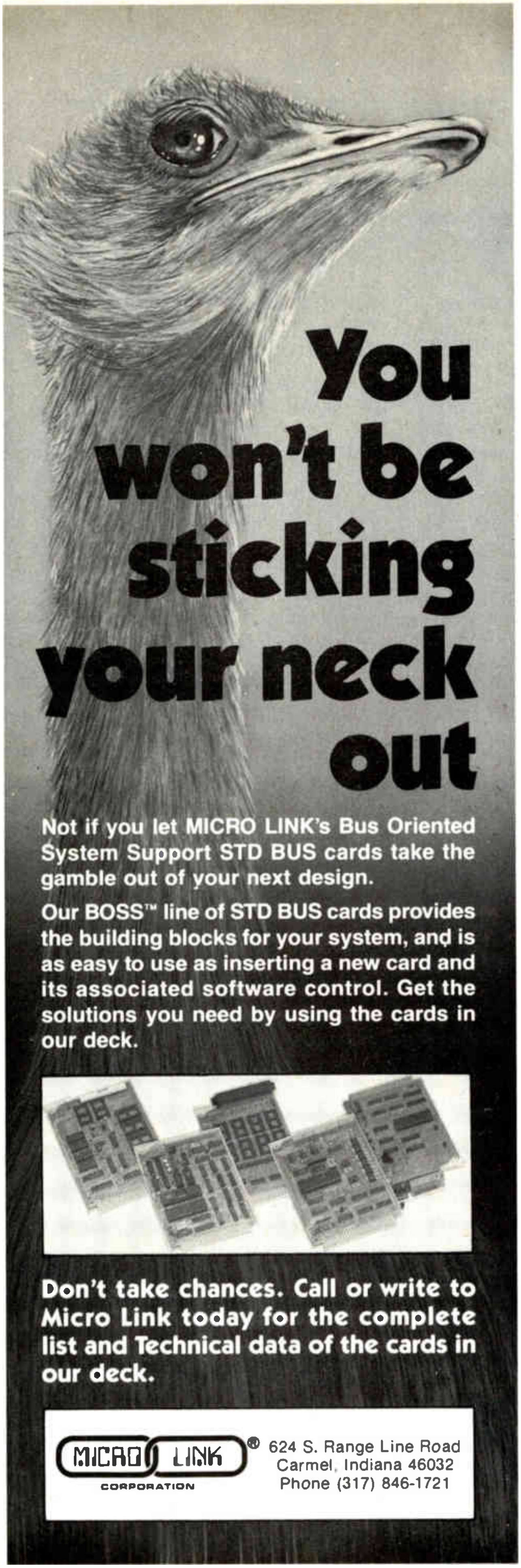
Other of Wafertrac II's modules, like the photoresist-coat and -develop units, remain much the same as on the first version, except for being scaled down and repackaged. All the system's modules are simple plug-in units, Donsker notes: "Undo four screws and pull one out—that's all there is to it." The virtue of such simplicity, he adds, is that a failed module can be "removed with minimal disruption of precious uptime."

Another of Wafertrac II's strong points lies in fault detection, according to Donsker. "Over half the system's original software is for diagnostics, which the host computer can run on or off line down to the board level of any module. Our goal within the year is to take that further, down to the function level."

Recipes. He also takes pride in the system's documentation. "GCA will supply baseline processing-characterization data on the operation of all modules on the system. I don't know any other supplier that is willing to guarantee that this or that 'process recipe' will yield specific, detailed results." The baseline data will not cover all possibilities, but it will allow users better control as they generate their own process programs. He adds that the host computer's software "makes software changes in process programs an order of magnitude easier than in the original Waftertrac system."

Pricing of the Wafertrac II, while not yet firmed up, will be "roughly comparable to that of the earlier system—within 10%," estimates Donsker. GCA currently has a number of the systems in evaluation at customer sites, and several more evaluation units are expected to be available by the time of the system's Semicon West introduction.

GCA Corp., IC Systems Group, 208 Burlington Rd., Bedford, Mass. 01730. Phone (617) 275-9000 [338]



Instruments

Pulse generator is easy to use

50-MHz instrument flags incompatible settings, has 5-ns rise and fall times

Digital techniques are taxing the capabilities of pulse generators more and more as faster and more complex logic devices are designed into electronic equipment and enter markets like the automotive and machine-tool sectors. Built to cope with the demand for higher performance and more versatility is a general-purpose pulse generator from Hewlett-Packard GmbH, the Böblingen (West Germany) arm of the Palo Alto, Calif., company.

Priced at $4,780—far less than existing general-purpose pulse generators, claims the firm—the HP8112A is an easy-to-operate instrument that is fully programmable through an IEEE-488 bus. It has a 50-MHz repetition rate and puts out pulses from 100 mV to 32 V peak to peak. Pulse rise and fall times as short as 5 ns (between 10% and 90% of amplitude) suit the unit for stimuating of fast logic devices.

The instrument's various trigger and external-modulation modes add much sophistication to test operations in research, development, and production, points out Wolfgang Flender, product marketing manager for logic-signal sources at the Böblingen facility, which is the center of HP's pulse and function-generator development and manufacturing activities. The 8112A also promises to extend the application range beyond that of competitive pulse generators. Simultaneous use of trigger and modulation modes allows simulation of complex signals like pulse trains that are amplitude-modulated with low-frequency noise.

Speed. The fast transitions permit measuring, for example, the slew rate of operational amplifiers and driving integrated circuits made with TTL, complementary-MOS, and n-channel MOS technologies. Because transitions are less than 3.5 ns from 20% to 80% of amplitude, the unit is fast enough even for emitter-coupled–logic devices.

In addition to the fixed 5-ns transition mode, the 8112A boasts a variable linear and cosine transition mode. The linear mode facilitates evaluating, say, trigger circuitry with ramps or sawtooth signals, and the cosine mode eases simulating smooth-transition signals without high-frequency components (like data stored on disks or tape).

"We have found that many users want a pulse source that, besides a strong digital capability, gives good analog performance," observes Walter Benger, product marketing engineer for the 8112A. To meet this need, the instrument offers features for analog applications, such as offset and various analog-modulation modes for digital signals. The device's high offset—up to 15.9 V with amplitude variable down to 200 mV—comes in handy for setting the correct bias points for checking diode and transistor performance.

Delay mode. Effective over the full 50-MHz range are the modulation modes for pulse period, width, delay, and amplitude. Of particular note is the delay mode, realized for the first time in a pulse generator, says Benger. It provides a convenient means for simulating, for example, propagation delay time or the delayed signals such as are encountered in radar systems, a job that until now required dedicated or custom-made instruments.

Jitter simulation. The pulse-period control mode works over a 1:10 range, so a linear one-decade sweep can be generated by applying a 1-to-10-V ramp to the control input. With a low-amplitude sinusoidal input signal, jitter can be simulated for testing the performance of phase-locked–loop circuits.

The 8112A provides a constant–duty-cycle mode that is programmable in 1% steps from 1% to 99%. With only one command, signals of constant energy can be generated. Thus, damage to sensitive components due to excessive energy input is avoided. For example, light output from a light-emitting diode can be optimized without overloading the LED.

Many users may find the instrument's ease of operation the strongest reason for buying the 8112A. As Flender points out, pulse generators often tax the operator's patience because parameters like pulse period delay, width, and pulse leading and trailing edges tend to affect each other. Also, specific relationships among various parameters must be maintained. For example, the pulse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And because all coating requirements are not alike, Miller-Stephenson offers a choice of acrylic, silicone, urethane and varnish. All are in aerosol containers for easy application in controlled areas.
Coatings are clear for component identification and all provide excellent electrical insulation and resistance to moisture and fungus. Products protected with the coatings can still be repaired, reworked, and resprayed.
To select the right coating for your special application, send for our Conformal Coatings Comparison Chart. We'll also send you our full-color catalog of the complete line of Miller-Stephenson products for electronics. Write: Miller-Stephenson Chemical Company, George Washington Highway, Danbury, Connecticut 06810. Or phone: (203) 743-4447.
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width must always be smaller than the pulse period. It is often difficult to keep tabs on these relationships.

But with the 8112A, error-free pulse waveforms can be set up as easily as can a sine wave with a function generator. A mere touch of the set key generates a stable pulse train with a 50% duty cycle, minimum delay, and with the transition time either at 10% of period or 5 ns, depending on the selected mode.

Watchdog microprocessor. A microprocessor selects a specific ratio of the timing parameters according to the period and maintains that ratio when the period is varied. Final parameter values are entered with three vernier keys, each key acting on one digit of the instrument's 3½-digit LED display that shows the selected parameters.

The 8112A generates a warning when incompatible front-panel settings are made or wrong instructions are sent over the IEEE-488 bus. In manual operation, flashing LEDs indicate which parameter or mode combinations are not permitted. When an incorrect command is received over the bus, a service request is transmitted. When subsequently interrogated, the instrument puts out an error description—for example, "level error" or "pulse-width error."

Flender attributes the instrument's low cost to two factors. In addition to his company's long-term experience in signal-generator design, he cites the use of custom large-scale integrated circuits. A number of ICs perform several tasks—for example, pulse-rate generation, pulse-width and pulse-delay control, and error recognition. Besides cutting costs, the use of custom ICs helps reduce equipment weight and size. As a result, the 8112A weighs in at only 13 lb and measures 9 by 21 by 45 cm.

Given the instrument's price-performance ratio, Flender is convinced his company can maintain its competitive edge in the hotly contested pulse-generator market. Worldwide, that market climbed to an estimated $31 million last year. It is predicted the market will grow an average of

This computer-enhanced image of an infra-red thermograph shows heat distribution in the fusible link of a Buss fuse during special testing. The geometry of each fuse link is designed by Bussmann engineers to provide protection during specific electronic conditions.

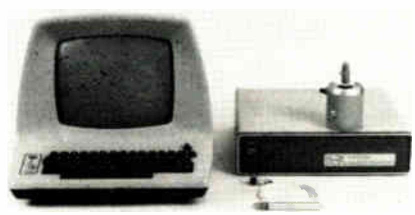
12% to 13% annually during the coming years. Delivery time for the HP8112A is 12 weeks.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [351]

Hewlett-Packard SA, Ch-1217 Meyrin 2, Geneva, Switzerland [352]

Vibration analyzer tests structures

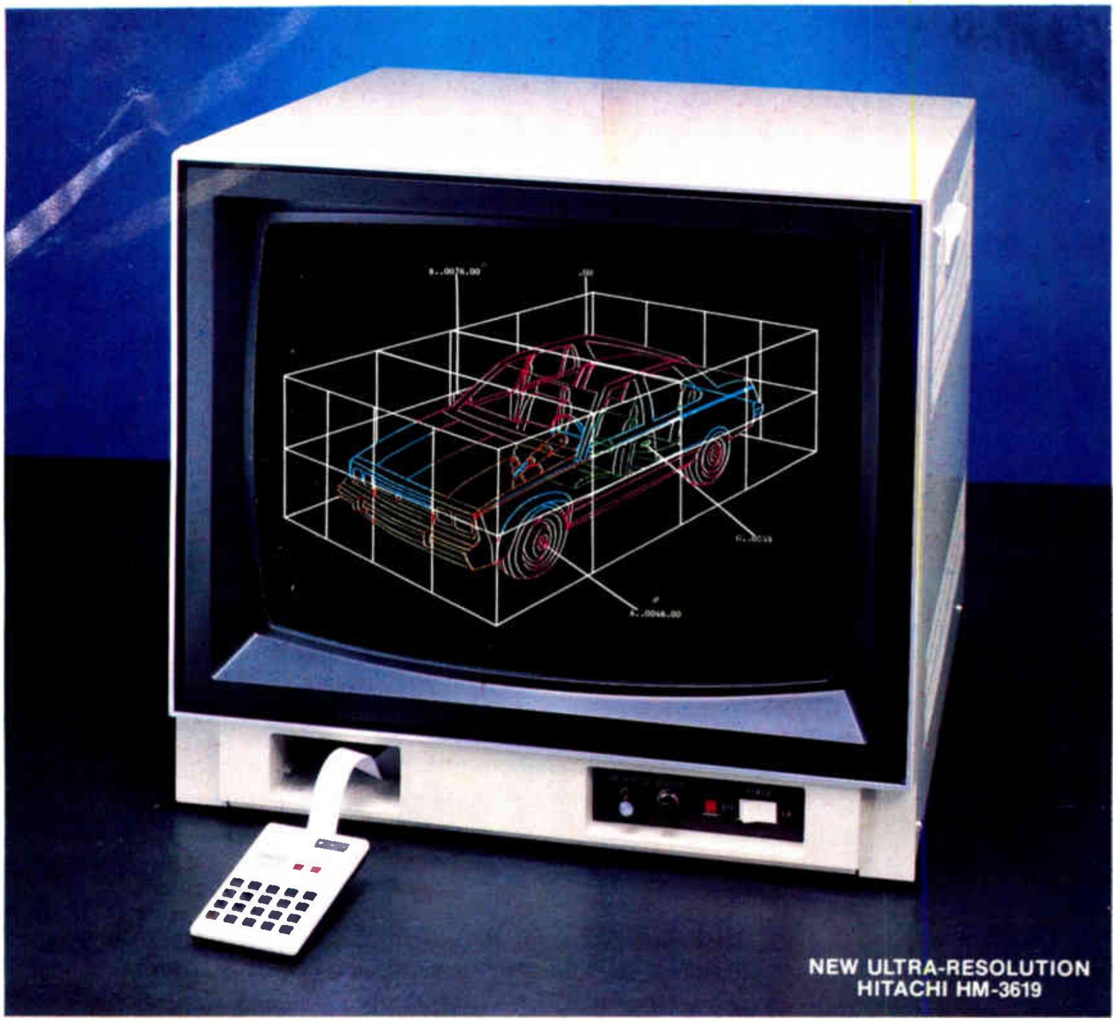
The Modal Investigator is a vibration analyzer for mechanical structures that automatically excites and measures the test article over a frequency range of 1 to 8,000 Hz with a ±0.1% resolution. The unit is equipped with a shaker table, drive-point sensor, analysis probe, and display terminal. An RS-232-C interface is standard, permitting the instrument to be interfaced with a calculator, computer, or printer. Larger shakers and other sensors may be directly integrated.



Specific functions include survey, which rapidly scans a specified frequency band and identifies resonances, antiresonances, damping factors, and modal coefficients; track, which servo-locks on a single mode and reports changes in its parameters that result from structural modifications; and map, which traces out node lines and modal motion with a manually guided analysis probe. Other functions allow for forced-response analysis, mass cancellation, and comparison of two analyses, each containing as many as 20 modes. The device has self-testing diagnostic features and comes in English and French versions.

Designed for quality-assurance screening, isolating product faults, and measuring manufacturing variability, the complete system is priced

innovation*



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Leaving the competition in the stone-age is the new Hitachi HM-3619 ultra convergence ***1,000 line*** RGB color monitor. With an amazing ***Digital Dynamic Convergence***™ of within 0.3mm it offers images of superior sharpness throughout the entire screen—another example of Hitachi's technological leadership.

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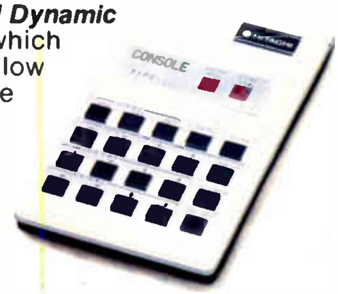

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HITACHI AMERICA LTD. 1982

at $9,880. Delivery takes 30 days after receipt of order.

Fox Technology Corp., 45 Old Hook Rd., Westwood, N. J. 07675. Phone (201) 666-5105 [353]

Single meter measures many passive-circuit aspects

Rolling many functions into one unit, the IMF-600 digital impedance and multifunction meter measures voltage and current (dc and true root-mean-square), resistance, capacitance, inductance, conductance, dissipation, and (optionally) frequency. The only other general-purpose instrument needed in addition to the IMF-600, the maker claims, is an oscilloscope.

Included with the unit are a companion limits comparator for selecting all functions on a go/no-go basis; four-terminal shielded Kelvin connectors for measuring very low or high impedances; and analog and optional digital outputs. In addition, the IMF-600 is fully protected on all functions, and its 1-kHz crystal control ensures a basic accuracy of within 0.1%.

The option to measure frequency from 200 Hz to 20 MHz sells for $169, while the digital-output option adds $149 to the basic unit's $929. Delivery takes six weeks.

IET Labs Inc., 534 Main St., Westbury, N. Y. 11590. Phone (516) 334-5959 [354]

Voltage standards unit offers 2-ppm/year stability

Bridging old and new standards technologies, the Trancell-III/SC, a transportable solid-state dc voltage reference standard, can be used to compare and trace the legal volt with both the older saturated-cell and the more recent electronic voltage standards.

The instrument is available with one, three, or four diode-cells, each of which provides reference outputs of 1.01814 V, the voltage across the diode (V_z), and a buffered 10 V. V_z

When reliability is imperative.

Where conditions demand the ultimate in power supply dependability, Abbott has been the outstanding choice for over 20 years. The "V" Models (60 Hz to DC) offer you this proven reliability plus many important features that make them ideal for exacting military applications where MIL-STD-810C performance is called for.

ENVIRONMENTALLY PROTECTED. Hermetically sealed and encapsulated to meet the severe environments of humidity, salt spray, sand, dust, etc.
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ENGINEERING SUPPORT. Abbott factory-direct salesmen are electrical engineers and provide professional help in solving your particular power source problems. In addition, our application engineers are experienced electronic system designers. This team is available to assist you in making the proper power supply selection.
SERVICE AFTER SALE. Abbott service does not end with delivery. Our application and customer service engineers make sure our products function successfully in your application, Another good reason to specify Abbott. Abbott Transistor Laboratories, Inc., Power Supply Div., Western Office: 5200 W. Jefferson Blvd., Los Angeles, CA 90016. 213/936-8185. Eastern Office: 1224 Anderson Ave., Fort Lee, NJ 07024. 201/224-6900.

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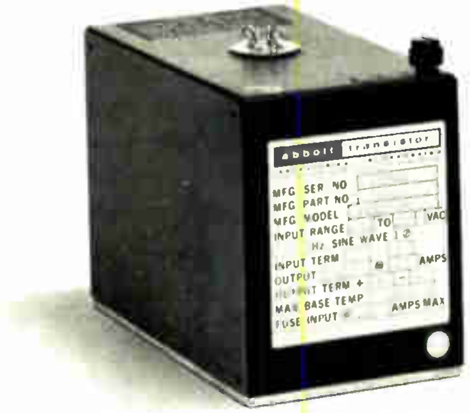
1,355 MODELS



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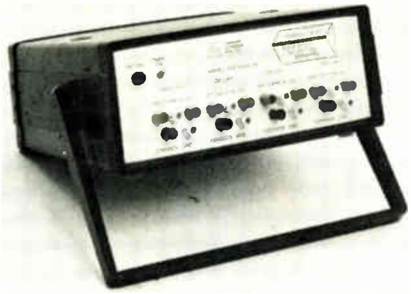
Circle 175 on reader service card



stability is better than 2 ppm/year, the 10-v buffered output is stable within 5 ppm/year, and the 1.01814-v output is generated across a fixed-ratio divider whose ratio is stable within 2 ppm/year. Two potentiometers on the rear panel let users adjust for any changes or drift in the 10-v and 1.01814-v outputs.

For comparing a saturated cell with values traceable to the National Bureau of Standards, the 1.01814-v output is used. For comparing NBS-traceable values with another solid-state reference bank, the V_z and 10-v outputs may be employed. All three outputs may be compared with each other through a Kelvin-Varley divider.

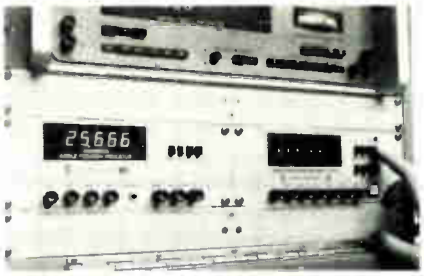
Prices range from $2,500 for single–diode-cell units to about $9,500 for four–diode-cell versions. Delivery takes three months.

Standard Reference Labs Inc., Coan Place, P. O. Box 388, Metuchen, N. J. 08840. Phone (201) 549-9280 [355]

Units join forces to test synchro-resolver signals

An automatic test system, comprising the model 5310 synchro-resolver simulator and the model 8810 synchro-resolver angle-position indicator, simulates, measures, and reads out synchro-resolver information. Packaged in tandem for 19-in. rack-mounting, the system forms the basis of an automatic and/or manual test set for simulating, calibrating, and monitoring most synchro-resolver–related systems and components.

Standard features of the 5310 include full remote programmability for line-to-line level, reference levels,



synchro or resolver mode, and output angle. The 5310 has 36-arc-second accuracy and a 3-V ac output.

The model 8810 has 0.001° resolution, automatic ranging for 11.8-, 26-, or 90-V line-to-line synchro or resolver signals, automatic phase correction, and a bright 0.55-in.-high gas-discharge planar display. The type II tracking converter has front-panel control and input terminations but retains rear-connector input/output programming.

The packaged system, delivered 12 weeks after receipt of order, sells for $8,015.

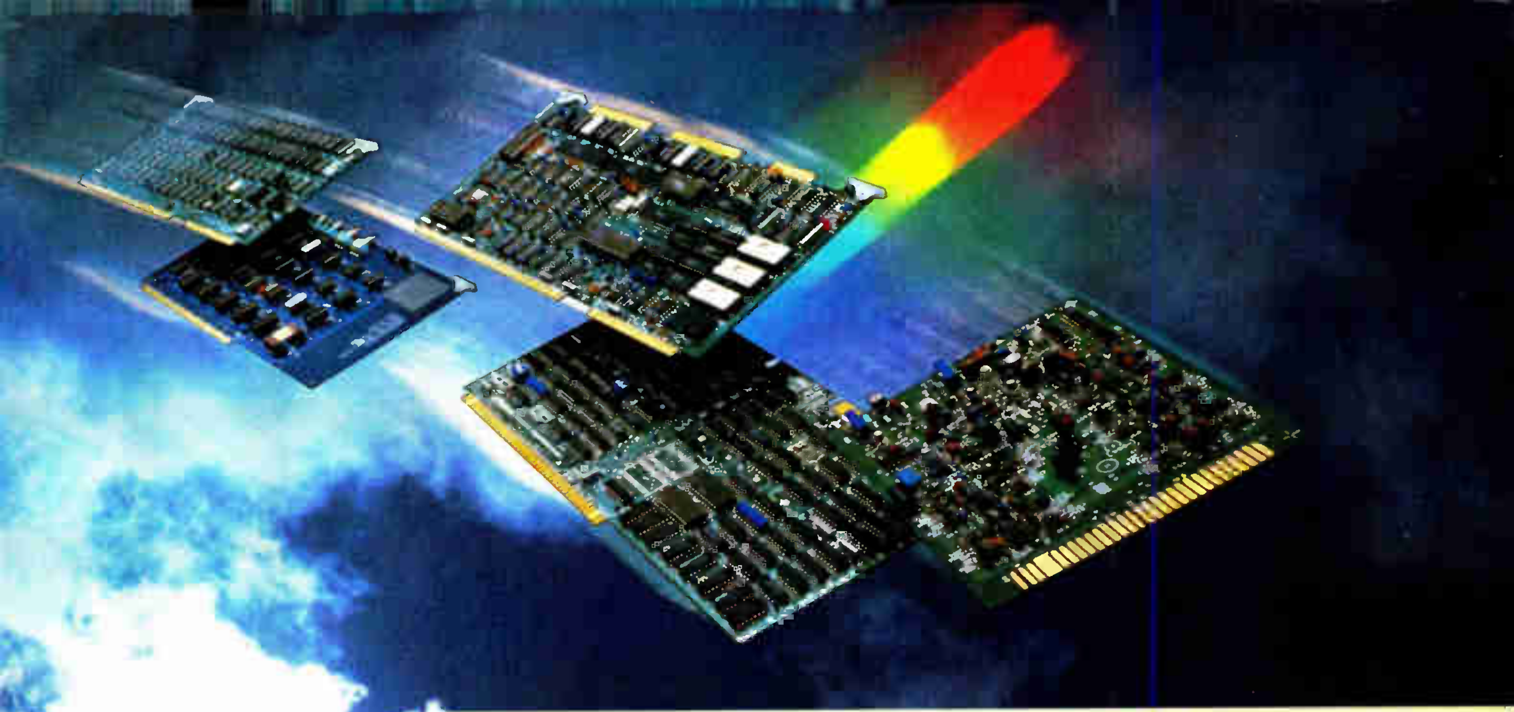
North Atlantic Industries Inc., 60 Plant Ave., Hauppauge, N. Y. 11788. Phone (516) 582-6500 [356]

IEEE-488-to-Multibus interface bows at under $600

Entering the market with a $595 price tag, the ZT 85/18 IEEE-488 controller interface for Multibus systems enables such a system to hook multiple IEEE-488-compatible instruments, peripherals, and computers to a single input/output slot. All Multibus systems, including those based on the 8086 and 68000, can be equipped in this way to direct the operation of attached devices and receive data from them.

The card boasts a 40-kb/s programming I/O speed, but does not support direct memory access. Accessories supplied with the interface include software-driver routines, manual, and cable. A phone-in consulting service is provided to aid users with problems. The ZT 85/18 will become available in May.

Ziatech Corp., 3433 Roberto Ct., San Luis Obispo, Calif. 93401. Phone (805) 541-0488 [357]



Introducing the Zehntel Series 300.

A revelation for those who think they can't afford in-circuit testing.

Buy only the analog/digital test power you need now.

Now there's an alternative for manufacturers who covet larger test systems but can't justify the cost.

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Or upgrade your current in-house test system by adding the in-circuit test power of the Series 300.

For high-volume testing without the expense, several Series 300 testers can be linked to a host computer for a network of dedicated test stations.

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Write or call Zehntel, Inc., 2625 Shadelands Drive, Walnut Creek, CA 94598, 415 962-6900.

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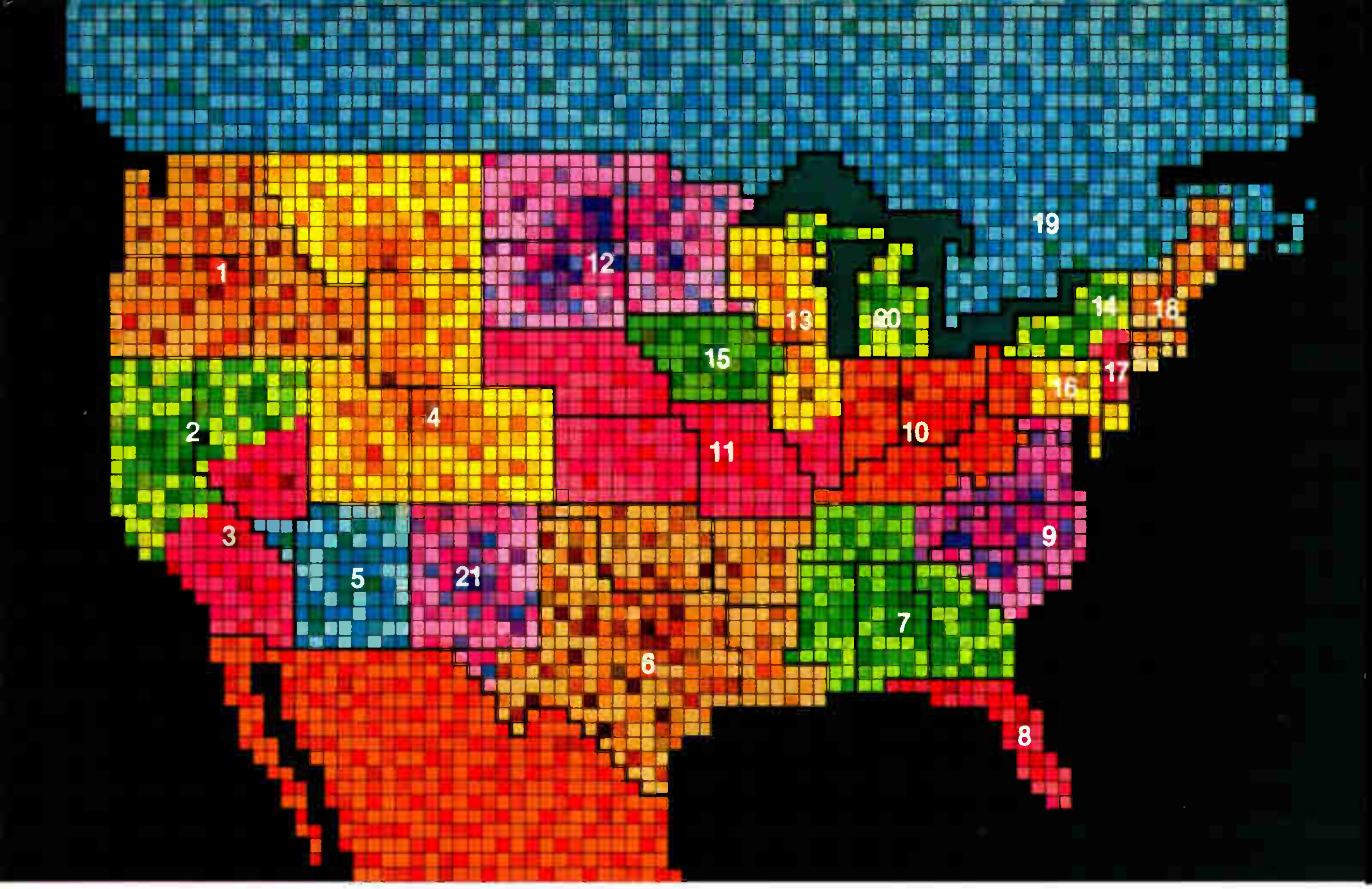

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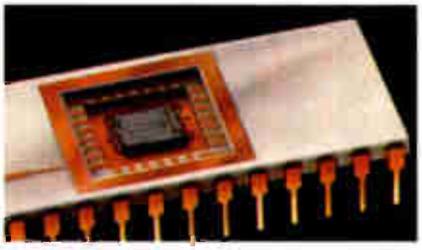
With twenty-one MNOS patents since 1972, NCR has designed and developed seventeen non-volatile memory devices. And from our MNOS products to our exciting new SNOS (Silicon Nitride Oxide Silicon) 4K NV-RAM, you can count on NCR innovation.

2. We're in the merchant market to stay

NCR's commitment to the merchant market is long term. We're spending $155 million on the expansion of existing chip making facilities. That's because we're thinking about the future—as you are—and preparing for it.



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4. NCR semiconductors—quality you can count on

Our ten years of experience as a manufacturer of semiconductors has taught us quality and reliability are essential elements of any chip. It's no wonder we're one of the world's leading manufacturers of MNOS non-volatile memories.

NCR—NV MEMORY GUIDE

Device No.	Organization	Type
2051	32x16	WAROM
2055	64x8	WAROM
7033	21x16	WAROM
1400	100x14	WAROM
3400	1024x4	WAROM
2811	2048x4	EAROM
2168*	2048x8	EAROM
2161*	2048x8	WAROM
4485	512x8	NVRAM

*Pin conservative bus structured devices

MNOS p-channel description:
WAROM—Word alterable ROM
EAROM—Electrically alterable ROM

Industrial and Military temperature ranges available

For more information, call your local NCR Microelectronics representative. Or contact Dave Major at NCR Microelectronics Division, Box 606, Dayton, Ohio 45401. Our toll free number is (800) 543-5618, in Ohio (513) 866-7217.

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Circle 180 on reader service card

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Computers & peripherals

5¼-in. unit holds 26 megabytes

Four-disk Winchester drive accesses in 90 ms, average, performs own diagnostic tests

A 5¼-in. Winchester-technology disk drive that packs in 26.67 megabytes of unformatted storage is, says Rodime Ltd., the largest capacity available in any 5¼-in. unit today. Be that as it may, there is no disputing the Winchester's compact physical size, at 8 by 5¾ by 3¼ in., is comparable with most 5¼-in. floppy-disk drives, allowing direct physical replacement. It also can use the same 5- and 12-v dc supplies.

Designated the RO 200 series, the new range is largely based on the RO 100 series launched last fall [*Electronics*, Oct. 6, 1981, p. 181] and consists of four basic models ranging from the single-platter RO 201 to the four-platter RO 204. Each platter accommodates 5.25 megabytes of formatted or 6.67 magabytes of unformatted data.

Targets. From the outset, says Malcom Dudson, marketing manager of the firm, "our design target was to achieve 5 megabytes per platter." But to get their four-disk-per-drive Winchester off to a smooth production start, the firm first introduced it as a 16-megabyte system—then a pacesetter. With capacity now boosted 60%, data stored on mini-floppy-disk drives such as Digital Equipment Corp.'s RLO 1 or RLO 2 will directly and economically map onto Rodime's disk drive (with 256 bytes per sector and 32

New products

sectors per track). "It's going to give us a lot of muscle in the DEC market," says Dudson.

To stretch the data capacity of its RO 100 series, the company has merely increased the resolution of the actuator mechanism and the actual recording area of the disk, while also reducing the head track width. The number of bits per inch is increased from 8,100 to 8,700. Though the number of tracks on each surface is increased from 192 to 320, the average access time is up only slightly—from 85 to 90 ms.

High speeds. High access speeds are achieved by microprocessor control of the stepper motor. In addition to selecting and implementing fast-access algorithms, it controls actuator damping and removes mechanical hysteresis by always moving to the selected track from one direction. Data is transferred at a rate of 5 megabytes/s.

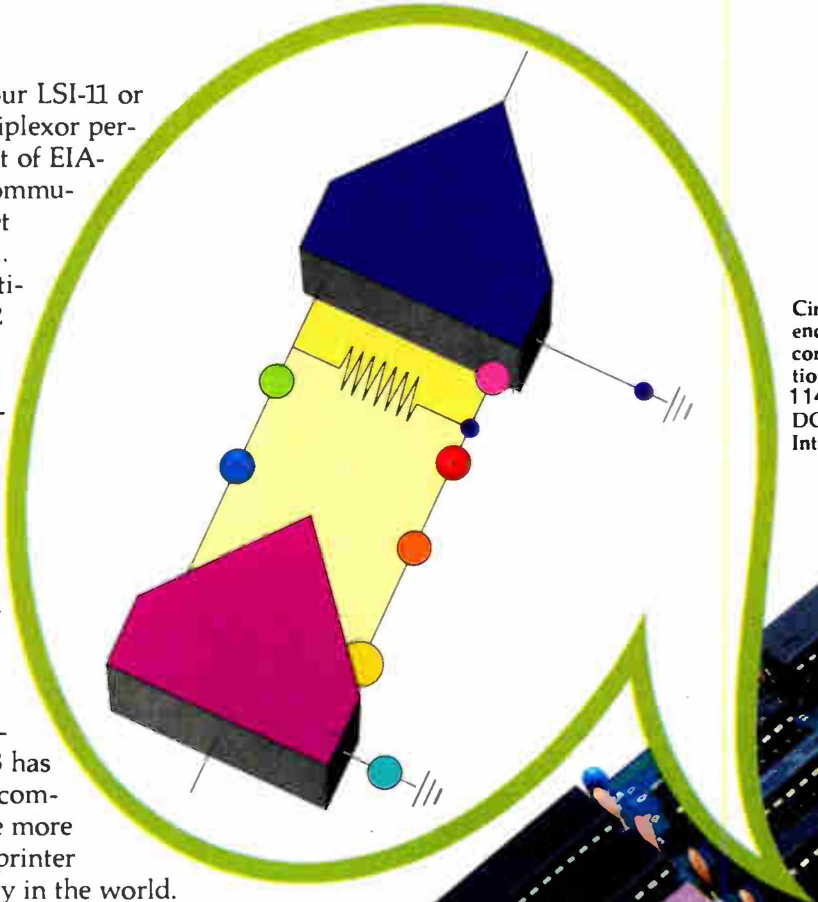
Like other Winchesters, the drive uses an open-loop controller to position the head, so the move from 260 to 360 tracks/in. will exploit to the fullest the firm's elegant mechanical design. This features an extremely rigid rotary-head actuator rather than a linear actuator. Also unique is its two-chambered construction, which keeps all moving parts away from the disk surfaces. Filtered airflow between the two chambers is designed to ensure a uniform temperature.

Like its predecessor, the RO 200 series requires no mechanical adjustments and features a microprocessor-controlled diagnostic unit. Status codes are indicated by light-emitting diodes on the front panel. During start-up, it can identify 10 fault conditions relating to the power supply, the controller, or the drive by flashing the LED display. Mean time between failures for the RO 200 series is in excess of 12,000 hours, claims Dudson.

In the U.S., the small Scottish company has already won market acceptance. Its Winchesters are manufactured under licence by Ampex, and Rodime is also selling in its own right through its El Toro, Calif., subsidiary. Most recently, Compu-

The only DZ11 Compatible Multiplexor for LSI-11. And it has RS-422 plus RS-232 and current loop capability-

MDB makes the difference!



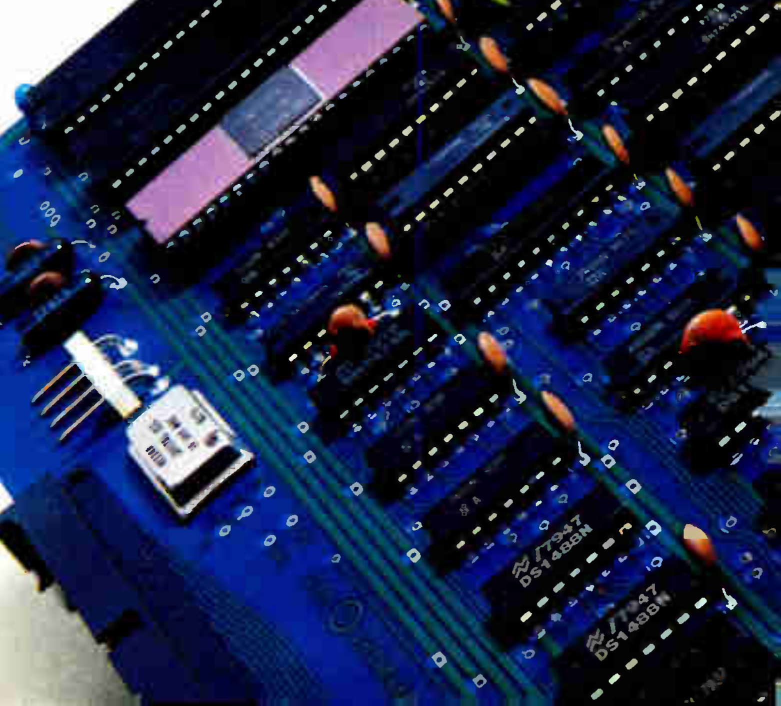
Now you can have it all for your LSI-11 or PDP* 11 system! Full DZ11 multiplexor performance with the added benefit of EIA-RS-422 long line capability—communicates at distances to 3000 feet (914.4m) at rates to 19.2K baud. What's more, MDB's DZ11 multiplexors let you combine RS-422 with EIA-RS-232 in any combination up to a total of eight lines on a single board. Or combine RS-232 with current loop in the same way. Eight and sixteen channel RS-232 DZ11 multiplexors are also available. No more doubling up on boards, distribution boxes, rack space or price. You see the results in your system's performance and cost.

And that's not the only difference we can make to you. MDB has line printer controllers that are completely self-testing and we make more controllers for more computer/printer combinations than any company in the world. MDB offers PROM modules with window mapping, communications interfaces that support X.25 and a unique LSI-11/23 system with 22 bit addressing and up to 4 Mbytes of memory. From purely compatible to purely incredible all MDB products are built with exceptional quality and responsiveness to customer requirements. Our boards are warranteed for a full year, many are available off the shelf and they can be purchased under GSA contract #GS-OOC-02851.

Call or write for all our specifications—the MDB differences that make a difference.

*Trademark Digital Equipment Corp.

Circle 111 for referenced product. For complete information, circle 112 for PDP, 114 for LSI, 113 for DG, 116 for P-E, 115 for Intel, 117 for IBM.



MDB SYSTEMS INC.
1995 N. Batavia Street
Orange, California 92665
714-998-6900
TWX: 910-593-1339

think has chosen the disk for the Eagle multitasking Unix-based microcomputer system. Rodime expects to ship 20,000 units in 1982 and is expanding facilities to achieve outputs of 60,000 per annum.

Eventually, Dudson sees Rodime moving to other recording media, such as thin films. Other manufacturers are already moving in that direction. "It was our original aim with the RO 100 series to provide for later enhancements by setting ourselves the highest engineering standards, particularly on actuator accuracy," says Dudson.

Prototypes will be available in May, and volume deliveries will begin in August. In single-unit purchases, the 201 is $1,145 and the 204 is $2,005; in lots of 500, they are $680 and $1,190, respectively.

Rodime Ltd., 12-14 Edison House, Fullerton Road, Glenrothes, Fife KY7 5QR, Scotland [361]

23591 El Toro Rd., Suite 208, P. O. Box 1122, El Toro, Calif. 92630 [362]

Single-sided optical disk holds 1,250 megabytes

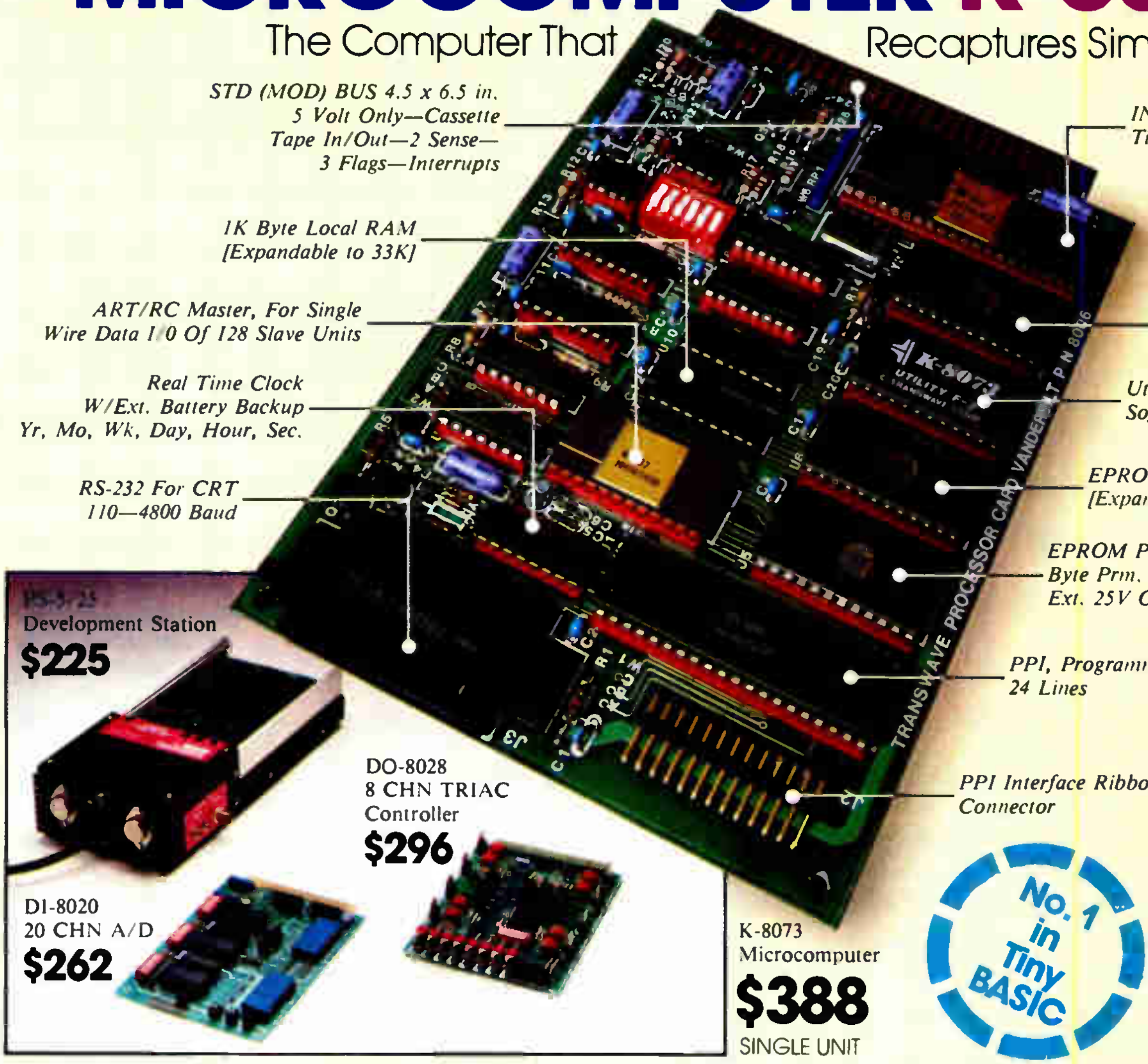
Having the storage capacity of fifty 14-in. double-sided magnetic disk platters, the single-sided 12-in. Drexon II optical disk can store up to 1,250 megabytes of data. Data is recorded on the disk by melting 0.5- to 5-μm-diameter holes in its reflective surface with a laser. The archival life of the disk is expected to exceed 10 years because of the material's stability. This material may be used for laser recording over the entire visible spectrum and into the near-infrared range—440 to 830 nm.

Control information may be recorded on the disk through ultraviolet polymer molding of a transparent dielectric pattern on the surface of the disk or by using photolithographic processes when the disk is manufactured.

A typical Drexon II disk, the 30-cm D-1201B will sell for $700 each in lots of 30. When production reaches 100,000 units a year, the

TRANSWAVE'S Tiny BASIC MICROCOMPUTER K-8073

The Computer That Recaptures Simplicity



INPUT ▶▶▶▶▶▶ DECISION ▶▶▶▶ OUTPUT

TODAY'S NEEDS

How many times have you thought about designing or purchasing the ultimate intelligent control system but were discouraged by the R&D time or price? Transwave took the initiative of designing one for you. Combining versatility with low cost, the K-8073 Tiny BASIC Microcomputer has already taken the lead in the process control market. Programming is reduced to mere hours because of the on-chip Tiny BASIC Microinterpreter. I/O is extended to previously unheard of limits because of the on-board ART/RC (Asynchronous Receiver Transmitter/Remote Controller).

This processor-like chip provides bi-directional serial communication between the K-8073 and its remotely located peripheral I/O devices. In addition, the K-8073 can operate in a stand-alone, satellite, or host mode. When interfaced thru RS-232, you can utilize your host computer, large or small, for polling, editing and mass data storage.

INPUT

The DI-8020 is a 20 channel A/D input module designed to collect data from remote sensors monitoring temperature, humidity, light, pressure, etc. Each A/D module is capable of monitoring 16 analog and 4 digital signals. Remarkably versatile, the DI-8020 is adaptable to any environment.

In addition to an extensive input range, this A/D module eliminates the usual installation hassles because of the unique ART/RC communications route. A single twisted pair or coaxial wire serves as the bi-directional DPW (Data Pathway) between the DI-8020 and the K-8073 Tiny BASIC Microcomputer.

DECISION

After receiving data, the K-8073 executes from your EPROM based Tiny BASIC program.

OUTPUT

Completing the cycle of I→D→O is the DO-8028; an 8 channel TRIAC Control Module. This board features 8 optically isolated TRIACS with a maximum rating of up to 300 Watts AC control per channel. Receiving commands from the K-8073 via the full duplex DPW, you can daisy chain as many as 128 of these "slave" stations.

STAND ALONE SIMPLICITY

Whether you free your mainframe, free your mini or start from scratch, you can let closed loop control be the minimum configuration it should be. These cards are exactly the fundamental pieces needed for today's control applications. To order your K-8073 or for further information on the Vanderbilt Series 8000 Product Line, write or call:
TRANSWAVE CORPORATION, Cedar Valley Building, Vanderbilt, PA 15486
Phone: **(412) 628-6370**.

TRANSWAVE
COMPUTER DIVISION OF UTSC

Circle 185 on reader service card

manufacturer claims that each disk is expected to cost around $100.

Drexler Technology Corp., 2557 Charleston Rd., Mountain View, Calif. 94043. Phone (415) 969-7277 [363]

Low-cost computer terminal sets up link automatically

The ZT-1 terminal connects to telephone lines with a modular connector and can automatically dial, gain access to a computer, and request information. In addition, the ZT-1 can be used as an electronic typewriter with a printer connected to its parallel interface.

The VT52-compatible terminal's modem can also be used as an automatic dialer for voice calls. Telephone numbers, computer-account numbers, and passwords need only be entered once. Afterwards, they can be used by selecting the letter of the alphabet from the menu that matches the number.

The terminal eliminates the complicated procedures—escape codes setting the bit rate, manually dialing phone numbers, entering account numbers, and character control for password entry—that are necessary each time a standard terminal is used.

The ZT-1, with a 62-key keyboard and ZVM-121 video monitor, sells for $695 and will be available next month.

Zenith Data Systems, 1000 Milwaukee Ave., Glenview, Ill. 60025. Phone (312) 391-8181 [364]

100-character/s printer supports ZT-1 terminal

In support of Zenith's ZT-1 terminal comes a series of printers capable of printing at a minimum speed of 100 characters per second. The printers are fully compatible with all of the functions, capabilities, and operating modes of the ZT-1.

One model in the line, the MPI 88G, sells for $749 and is supplied as standard with both tractor and fric-

500 Watt Switchers

Probably the most cost effective power supplies in the world.

RSF Series

Sub-Modular construction, an ACDC exclusive, assures high MTBF and low MTTR. The latest LSI inverter circuitry, power semiconductors and fault/error detection IC'S reduce parts count for a truly modern, cost effective design. Quality is assured through a 48-hour burn-in and hard copy test data with every unit. RSF units are also available with an optional filter to meet FCC 20780 and VDE 0871 requirements. At about a dollar per watt in OEM quantities, you can't beat it.

Feature	Function	Benefit
Sub-modular construction	Eliminates internal wiring; lowers production cost.	Higher reliability, low MTTR; easy to test and trouble shoot. Lower cost; quick delivery.
Design based on proven product.	The best features of our highly popular "RS" and "EAGLE" series in a new 500W package.	Low risk . . . a new product with proven reliability.
Proportional drive	Switching transistor drive circuit.	Switching Transistor failure does not damage control circuit. Few components, thus higher MTBF and lower cost.
A complete 500W family	Singles, dual, triples and quads.	One supply to replace multiple supplies or upgrade system.
High power dual model	Two 400W channels (500W total max.)	Ideal for CMOS, Micro processors, ECL, or test systems.
External switch for 115/230 VAC	Easy conversion of 115/230 VAC.	Universal usage; no additional cost.

Additional Features and Benefits• Bi-directional forced air • Designed to meet MIL spec shock and vibration in shipping • Inhibit, remote sense, margining, over voltage, over current protection • Extended hold-over • Vacuum impregnated, high frequency shielded magnetics • Low ESR output caps • Inrush protection • Outputs of 2 thru 28 VDC • Options include power fail, crowbar, output out-of-tolerance, VDE0804 hipot, reverse air • 100% screening of primary active devices • Steel chassis and cover provide strength, EMI suppression

RSF 501 SINGLE OUTPUT UNIT	
OUTPUT VOLTAGE	MAX OUTPUT CURRENT IN AMPS
2	100A
5	100A
12	42A
15	35A
24	21A
28	18A
SINGLE OUTPUT $575.00	

RSF 102 HI-POWER DUAL OUTPUT UNIT	
Combine any 2 of the following (500W max.)	
OUTPUT VOLTAGE	MAX OUTPUT CURRENT IN AMPS
2	50A
5	80A
12	33A
15	27A
24	17A
28	15A
HI-POWER DUAL OUTPUT $739.00	

RSF 502 DUAL OUTPUT 500W MAX.		
OUTPUT VOLTAGE	MAX. CURRENT RATINGS IN AMPS	
	OUTPUT 1	OUTPUT 2
2	N/A	16A
5	80A	16A
12	33A	16A
15	27A	14A
24	17A	8A
28	15A	7A
DUAL OUTPUT $650.00		

RSF 503 TRIPLE OUTPUT/RSF 504 QUAD OUTPUT 500W MAX.				
OUTPUT VOLTAGE	MAX. CURRENT RATINGS IN AMPS			
	OUTPUT 1	OUTPUT 2 & 3	OUTPUT 4	SEMI-REG. OUTPUT 4
2	N/A	8A		
5	80A	8A	5A	
12	33A	8A	2A	
15	27A	7A	2A	
24	17A	4A	1A	
28	15A	3.5A	1A	
24		*		24V @ 4A 6A PEAK
TRIPLE OUTPUT $695.00/QUAD OUTPUT $745.00				

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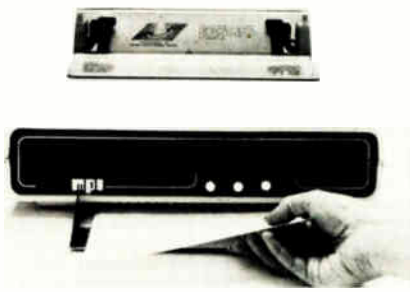
Circle 187 on reader service card

tion paper feed. The dot-matrix printer, which comes with a parallel and an RS-232-C serial interface, is currently available.

Micro Peripherals Inc., 4426 South Century Dr., Salt Lake City, Utah 84107. Phone (801) 263-3081 [365]



Color terminal accesses videotext services

A videotext data terminal for most time-sharing and data-base computer networks includes a built-in modem for relaying communications through the user's telephone. It also has provisions for displaying alphanumeric and graphic information on a television screen.

Among the unit's features are a 58-key alphanumeric keyboard with two user-definable keys and a 16-key calculator keypad. Other features include color graphics, a resident ASCII or dynamically redefinable character set, reverse video, a software-selectable large-character format, and an expansion interface for peripherals. In addition users can write and store programs in Basic, Fortran, Pascal, and Cobol.

The resident character sets may be displayed in either a 40-character-by-24-line or 20-character-by-12-line format. Color graphics allows individual characters and background to be displayed in one of eight selectable colors.

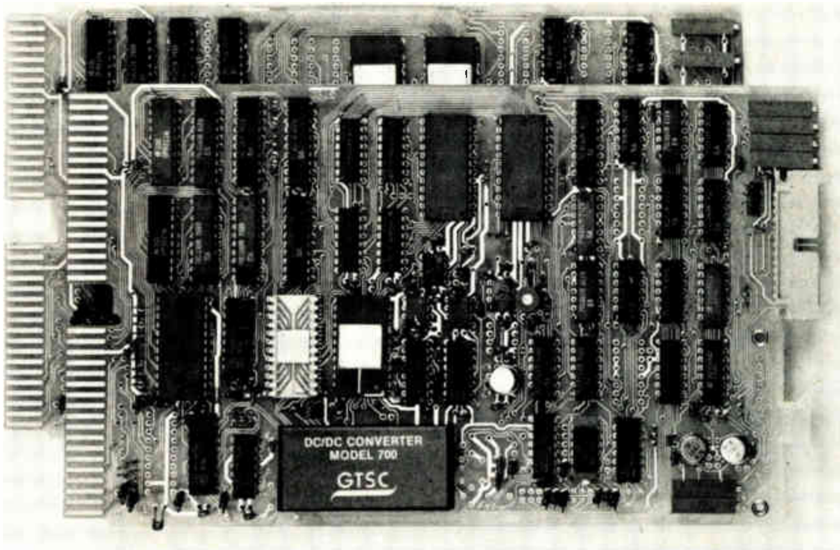
The VP-3501 lists for $399 and is available now.

RCA Solid State Division, Route 202, Somerville, N. J. 08876. Phone (201) 685-6423 [366]

Data acquisition

Analog I/O cards plug into Q-bus

16-channel cards accept any combination of differential or single-ended inputs



Joining the ranks of data-conversion suppliers is a Chelmsford, Mass., startup, Grant Technology Systems Corp., whose first products are two series of analog boards for Digital Equipment Corp.'s LSI-11, -11/2, and -11/23 and Falcon single-board microcomputer systems. According to A. L. Grant, president of the firm, both series afford a wider range of features than do comparably priced competition. He says the boards are also unique in accommodating the four-level–interrupt architecture that DEC recently introduced for its Q-bus systems.

Subsystems. Models 116, 117, 118, and 119 are a series of 12-bit analog-input and analog-input/output subsystems built on a standard DEC dual-height board and are capable of 30,000-sample/s speeds. They contain 16 analog-input channels, and the software supports wiring of the boards for any combination of single-ended, pseudo-differential, and differential inputs on a single board. Channel addressing takes place in selectable auto-incrementing or parallel-loading modes.

The 116–119 series boards' input channels accept four software-selectable input ranges: ±5, ±10, 0 to 5, and 0 to 10 V. An optional programmable-gain amplifier permits software selection of signal gains of 1, 2, 4, and 8 in the models 116 and 117 and of 1, 10, 100, and 1,000 in the 118 and 119 models. Input linearity error is ±½ least significant bit maximum with no missing codes over the full-scale range. The common-mode-rejection ratio for pseudo-differential and differential inputs is 76 dB, minimum.

The series also accommodates applications that use low-level, slowly varying dc inputs (5 mV full scale) to high-speed high-level dc inputs (10 V full scale). An on-board dc-to-dc converter permits operation from a host's 5-V power supply.

Models 118 and 119 of the series additionally include two channels of 12-bit digital-to-analog conversion for outputs of up to ±10 V full scale. Jumper-selectable output ranges are 0 to 10, ±5, and ±10 V. Output offset error is less than ±0.2% of full-scale range, and an on-board potentiometer can adjust that to zero. Maximum output settling time to within ½ LSB takes 2 μs for a 1-LSB change and 10 μs for a full-scale change. Output nonlinearity is a maximum of ±½ LSB with no missing codes over the full range.

Other features of these boards include internal and external triggering, random- and sequential-mode access, and register and vector addressing. The boards, available next month, will cost from $650 to $910 in lots of one to nine. Delivery is from stock to 30 days.

The firm's models 202 and 204 are analog-output boards with optional digital I/O capabilities. Also supplying 12-bit resolution and packaged on dual-height boards, the 202 with its two output channels and the 204 with its four channels have jumper-selectable ranges of 0 to 5 or 10, ±5, and ±10 V. Output linearity error is ±½ LSB maximum, and differential linearity is to ±1 LSB with no missing codes. The ±0.2% offset error is adjustable to zero. Both boards have standard oscilloscope-control circuitry and an on-board power converter for operation using a host's 5-V supply.

Options. The models 202 and 204 optionally include eight open-collector digital I/O lines, configurable in any desired combination of inputs and outputs. Other options include 4-to-20-mA current-loop outputs for process control applications, a TTL-compatible output for driving graphics peripheral devices, and third-wire ground-sensing circuitry for protection of digital-to-analog outputs in remote applications.

Models 202 and 204 are priced at between $525 and $675 in quantities up to nine. Delivery takes a maximum of 30 days.

Grant Technology Systems Corp., 11 Summer St., Chelmsford, Mass. 01824. Phone (617) 256-8881 [381]

Monolithic d-a converter reaches 16-bit resolution

The HI-DAC16, a 16-bit monolithic current-output digital-to-analog converter has accuracy, temperature stability, and 16-bit performance comparable to those of expensive

Fact:
The best 96 TPI 5¼" floppy is now better than ever.

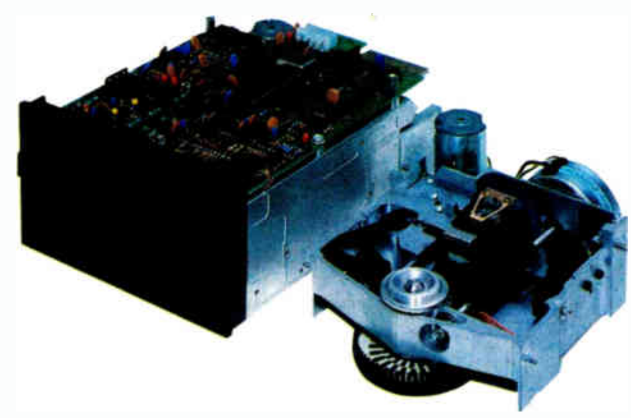
Our Second Generation Floppy

It's a recognized fact that Micropolis is the undisputed leader when it comes to 96 Track-Per-Inch 5¼" floppy disk drives. We've delivered over 300,000 — more than all the others combined. And our drives are used by most media manufacturers as reference standards.

We designed our drives for double track density from the beginning, using a multiple step, silent stainless-steel leadscrew for highest positioning accuracy, a temperature compensated loop, and a superior diskette clamping mechanism.

A Chassis Within a Chassis Plus Industry Standard Mounting Holes and Bezel

Our new 1115, second generation 0.5 (single head) and 1Mbyte (double head) floppies have a unique "chassis within a chassis" for unparalleled electrical shielding and reduced mounting stress. We've added a jewel follower to our positioning leadscrew for less friction and wear, and have reduced track-to-track access time to a solid 6 ms. The motor tach is no longer necessary since speed control is taken directly from the spindle pulley. This eliminates the need for an electrical adjustment as well as variations over time from belt and pulley wear.



Left: Model 1115 with industry standard mounting holes and bezel. Right: Inner chassis, model 1105, available separately for integration into OEM systems.

Another plus—our drive is micro-processor controlled, so there are no electrical adjustments, time drifts or pot settings, and field replacement of the PC board is a snap.

All this means longer life, greater environmental tolerances, higher reliability, faster throughput, less service, and easier upgrading, adding up to one conclusion: With Micropolis you can step up to 96 TPI with confidence.

Twice the Capacity at Less Than 30% More Cost

You can step up from 48 TPI to a solidly engineered Micropolis 96 TPI drive with no packaging or chassis modifications, and minimal hardware and software changes, immediately getting a 100% increase in capacity for less than 30% more cost. And it's easy to do with our new 1115 floppy which has industry standard mounting holes and bezel.

Also, you save valuable space. 1Mbyte in our 5¼" floppy compared to 0.5Mbyte or less in 48 TPI drives.

So step up to Micropolis, get more capacity for the dollar in the same space, with minimal investment in engineering.

Soon We'll be Shipping 2,000 Double Track Density Drives Daily

Another reason why you can step up to 96 TPI with confidence is Micropolis' ability to deliver field proven double track density 5¼" floppies in very large quantities. Our new 60,000 square foot plant is dedicated exclusively to the production of these drives. We are well on our way to delivering 2,000 each day.

Proven Performance, Lowest Cost per Byte, Multiple Sources

Multiple competitors are geared up to supply a market demand that will more than triple during 1982. You can compare before choosing, and once you do, we're sure you'll choose Micropolis to upgrade to 96 or 100 TPI and improve your system performance and customer appeal.

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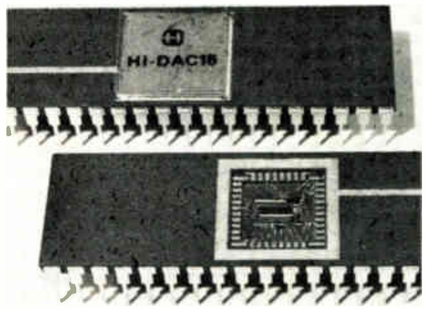
Circle 191 on reader service card



hybrid converters. The circuit is offered in two versions: -DAC16B and -DAC16C. Both have a 16-bit resolution and are compatible with complementary-MOS and TTL.

Dielectrically isolated, the devices have a leakage current specification 30% better than equivalent geometries, and internal parasitic capacitances of only 10 pF, typically, that help achieve rise and fall times as low as 10 ns. This isolation also eliminates the need for silicon controlled rectifiers and thus provides freedom from latchup. The devices' maximum current-settling time is 3 μs; typically it is 1 μs.

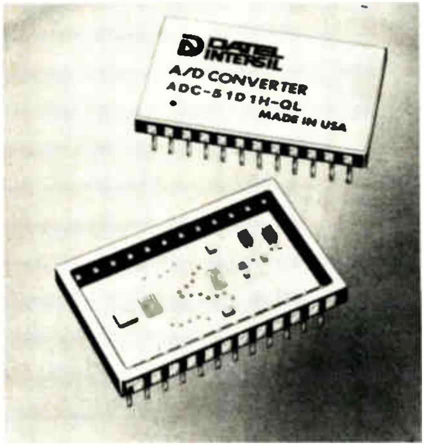
The B version, priced at $100 each in 100-unit quantities, is monotonic to 16 bits at room temperature and 15 bits over a 0°-to-75°C operating range. Its integral nonlinearity over its 0°-to-75°C operating temperature range is ±0.0045% of full scale for 14½ bits of relative accuracy.

In comparison, the C version, at $60 each in like quantities, is monotonic to 15 bits at room temperature and 14 bits over its 0°-to-75°C operating range. Its relative accuracy is 13½ bits. Both units are available from stock.

Harris Corp., Semiconductor Group, P. O. Box 883, Melbourne, Fla. 32901. Phone (305) 724-7800 [383]

8-bit a-d converter is adjustment-free

Requiring no adjustment, the ADC-5101 8-bit analog-to-digital converter operates over the full military temperature range of −55° to +125°C. In addition, versions sub-



jected to 100% screening in accordance with methods 5004, 5008, and 5009 or MIL STD 883 Class B (as amended by MIL-M-38510) are available.

The successive-approximation technique gives the -5101 a conversion time of only 900 ns, maximum. Its full-scale absolute accuracy error is only ±½ least significant bit, maximum, at 25°C and only ±2 LSBs maximum, over the full military temperature range.

The device has nine pin-programmable input-voltage ranges and its output, available in serial or parallel, is TTL-compatible. Output coding is straight binary for unipolar operation and offset binary for bipolar operation.

The -5101 is also available in commercial and industrial grades—all models are housed in 24-pin hermetically sealed ceramic packages. In quantities of 1 to 24, pricing ranges from $185 to $294 each. Delivery takes up to six weeks.

Datel Intersil, 11 Cabot Blvd., Mansfield, Mass. 02048. Phone (617) 339-9341 [384]

14-bit d-a converter multiplies in all quadrants

A unique bit-decoding technique gives the MP3140 multiplying digital-to-analog converter an integral linearity within 0.004% and a differential linearity within 0.003%. The 14-bit complementary-MOS device, integrated on a single chip, is monotonic over the commercial and mili-

*SA 600 disk drive photo and media platters courtesy of Shugart Associates, and head arm assembly courtesy of INFOMAG

Literate IC's for your Winchester disk drive.

SSi's first read/write Winchester IC developed in 1976.
In 1976, Silicon Systems developed its first read/write monolithic bipolar integrated circuit for the IBM-type 3350 Winchester disk drive. Dubbed the SSI 104, it integrated all of the required read/write, control, and data protection functions on one chip in a flat pack that could be mounted directly on the head arm assembly. The SSI 104 soon became the industry standard.

Now meet the SSi family of IBM-type Winchester IC's.
Today, SSi offers a whole family of IC's for the IBM plug-compatible Winchester market. The SSI 104 and 105 read/write circuits and associated servo amplifier are available now for use with the IBM-type 3340/3350 ferrite-head series; and two new circuits, the SSI 114 and 116, are soon to be introduced for the new IBM-type 3370/3380 thin-film-head series. SSi's "literate" chips not only read and write data on the disks, but they also detect fault conditions and provide for head selection.

IC's for micro's, mini's, streamers, and tape drives too.
For the rapidly expanding 5¼-inch micro and 8-inch mini-Winchester market, Silicon Systems offers its SSI 115; and for 14-inch IBM non-compatible drives there's the SSI 108. In fact, SSi has also developed more than a dozen custom IC's for rotating memories of various designs, including floppies, streamers, and tapes. So if the exact chip you need is not already in our line—we have the technology and experience to make it for you.

- ☐ Please call me.
- ☐ Please send me product information on your SSi family of disk-drive read/write IC's.
- ☐ Please send me a copy of your "Custom Integrated Circuits" brochure.

If you're in a hurry, call Roger Budris at (714) 731-7110, Ext. 135.

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Circle 195 on reader service card

tary operating temperature ranges.

The chip's transfer function is divided into 16 segments (determined by bits 1 to 4), each consisting of 1,024 discrete voltage levels (determined by bits 5 to 14). Bits 1 and 4 are digitally decoded into 15 bits that drive 15 equal current sources. As a result, the matching accuracy requirement is reduced for the resistors and C-MOS switches.

The device, housed in a 20-pin ceramic dual in-line package, accepts ac or dc reference voltages, multiplies in all four quadrants, and has latchup protection. In quantities of 25 to 99, the military-grade version sells for $89. The commercial-grade version is available for $30 in like quantities. Delivery takes two to four weeks after receipt of order.

Micro Power Systems Inc., 3100 Alfred St., Santa Clara, Calif. 95050. Phone (408) 247-5350 [385]

Unit links optically isolated transducers to computers

A parallel input/output interface, the Opto 22 module, can link up to 24 ac or dc industry-standard optically isolated solid-state relay modules and transducers with computer systems. The I/O lines are bidirectional and are for Cosmac Microboard computer systems.

The complementary-MOS device dissipates little power—typical current draw is 10 mA from a 5-V supply—and requires no special cooling machinery. The module's output stage can sink 14 mA and source 20 μA. It operates over the −40°-to-+85°C temperature range.

A built-in interrupt structure allows the software to generate an interrupt signal in response to changes in one or more signal lines. Interrupts can be selected for low-to-high and high-to-low transitions. In addition, interrupts can be masked on a bit-by-bit basis. In lots of 100, the CDP18S662 sells for $173 and is available now.

RCA Solid State Division, Route 202, Somerville, N. J. 08876. Phone (201) 685-6423 [386]

Power play.

Six ways to handle your power supply needs ...from B&K-PRECISION

Now you can choose from six B&K-PRECISION lab power supplies and have the supply that's exactly right for your needs.

For high TTL loads, choose the new 1654. With an output that's variable from 2-6 Vdc, the 1654 packs 10 amps in reserve. Features include remote sensing, to measure and regulate output voltage directly at the load, and overvoltage protection. For CMOS and linear circuitry the 1652 dual-output supply provides two 0-25 Vdc outputs at 1.5 amps. With opto-isolator controlled auto-tracking, it's even more versatile than two separate supplies.

The B&K-PRECISION 1650 is one supply that can replace three. It features a 5 Vdc, 5 amp output for digital needs and two auto-tracking 0-25 Vdc outputs. The outputs are fully isolated.

The popular 1601 is ideal for a wide range of solid-state applications. It supplies 0-50 Vdc with up to 2 amps. It's high voltage counterpart is the 1602. The 1602's primary output is 0-400 Vdc at 200 mA, complemented by a 0 to −100 Vdc bias supply and 12.6/6.3Vac outputs.

Rounding out the field is the compact 1640. Designed specifically to power mobile equipment, it delivers 11-15 Vdc at 0-3 amps.

All B&K-PRECISION power supplies feature voltage and current metering, full overload protection and floating outputs. They're all designed for cool power, so you won't be buying a bench warmer. The prices are attractive too.

If you need a power supply fast, you can score with immediate delivery at your local B&K-PRECISION distributor. For details, call toll-free **1-800-641-4627** (in Illinois 312-889-8870).

Circle 197 for free demonstration

Circle 253 for additional information

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The rule:

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It's the difference between catching a defective component at incoming inspection for 30 cents, or completing your circuit board before discovering it. Now the cost is $3.00. Install the board in the equipment and repair costs jump to $30. Let it get into the field, and the rule still applies. You can see that it doesn't take long for your profit to take a beating.

Start at the beginning

Test your components before you install them in the board with a low-cost 252 LRC bridge from ESI. You'll be able to test passive components for L, R, C, G and even D. That means you can structure your test to the factors that are important to your application.

With a basic accuracy of 0.25%, you'll have confidence in your tests. When the part reads good, you can be sure that it really is.

To get more information fast, give our Measurement Engineer, Steve Blum a call, toll-free. He'll show you how to beat the power of ten rule with an ESI 252 bridge.

The leading edge in LRC testing

esi® Electro Scientific Industries, Inc.

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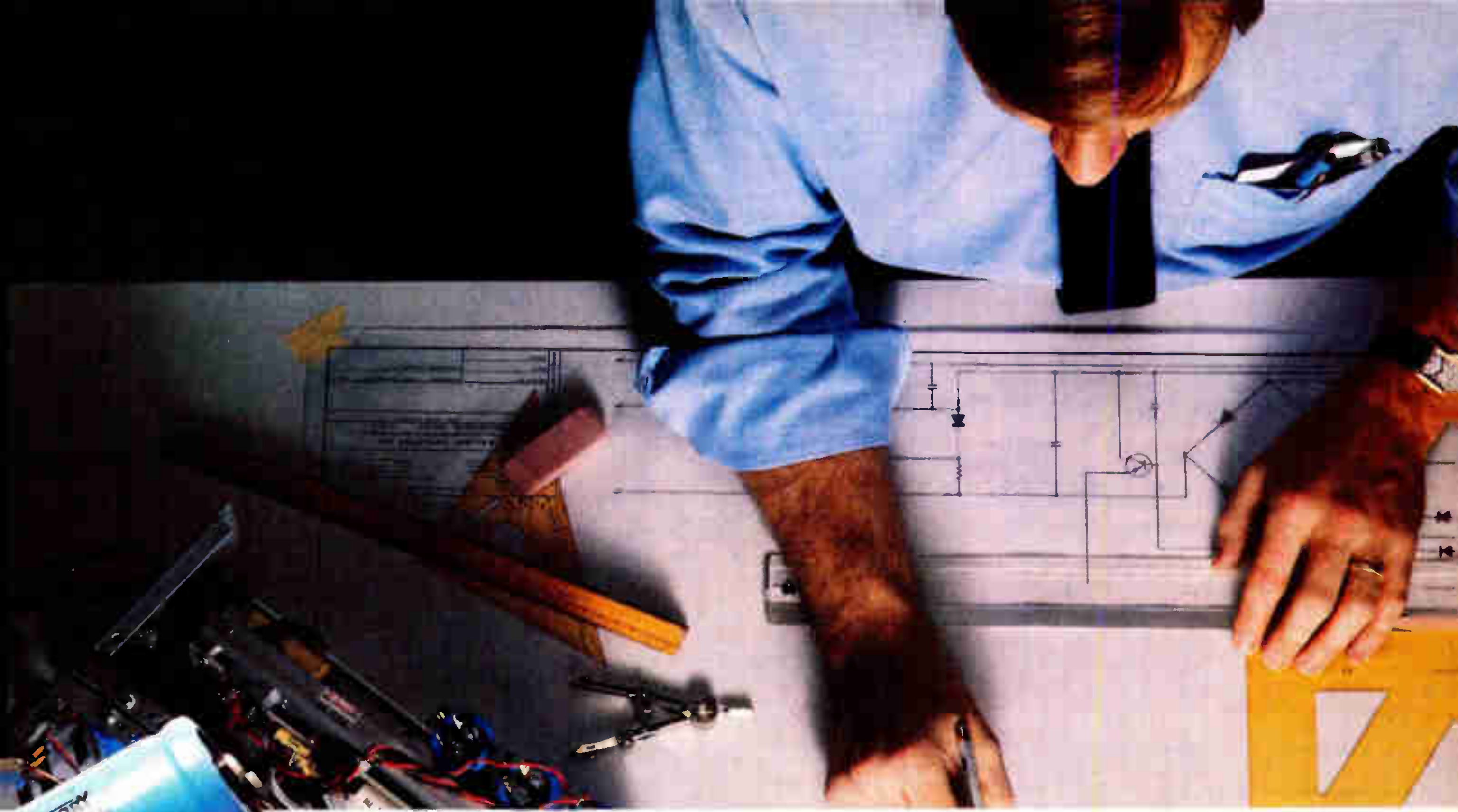

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Mallory's comprehensive line of aluminum electrolytic capacitors simplifies your search for switching regulator power supply capacitors. You have the convenience of one source supply for virtually any electrical and environmental characteristics you need. And the reliability of the Mallory name.

– The new CGO output capacitor with symmetrical capacitance and controlled ESR for high frequency operation.

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DESIGNS FOR YOU.

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Circle 199 on reader service card

100 MHz CLOCK RATES. THE WORD'S GETTING AROUND FASTER THAN EVER.

Introducing the RS-680.

You probably think it's enough just to be the electronic industry's first 100 MHz digital signal generator.

But the RS-680 is also the industry's first stand-alone, 8-channel parallel programmable timing generator capable of operating with 10 ns resolution. And the first 16-channel parallel programmable data generator capable of operating at 50 MHz rates.

It will generate even the most complex timing waveforms (perfect for checking out sophisticated IC's). And it has 50 ohm outputs for both ECL and TTL levels. Use it as a bench instrument. Use it within an ATE system as a synchronizer, modulator, trigger or gating generator.

As a word generator you get one, two four, eight or sixteen channels with up to 4 K bits.

As a timing simulator you get up to 256 states on up to eight simultaneous channels with resolution as low as 10 ns.

You can trigger it automatically or manually; or use it in a continuous, single cycle burst (up to 4 K cycles), or single-step word modes.

Finally, there's one instrument that does it all. With speed. With power. And with innovative circuitry that combines ECL, MOS and Bipolar technologies.

If you don't need all this capability, our companion Model RS-660 is available at lower cost. You get 20 MHz clock rates in the word generator mode and 50 ns resolution in the timing simulator mode. Most other features are similar.

The RS-680 and RS-660. A descriptive brochure is available for each model, so call or write for the one you'd like. That's the fastest way to get more words.

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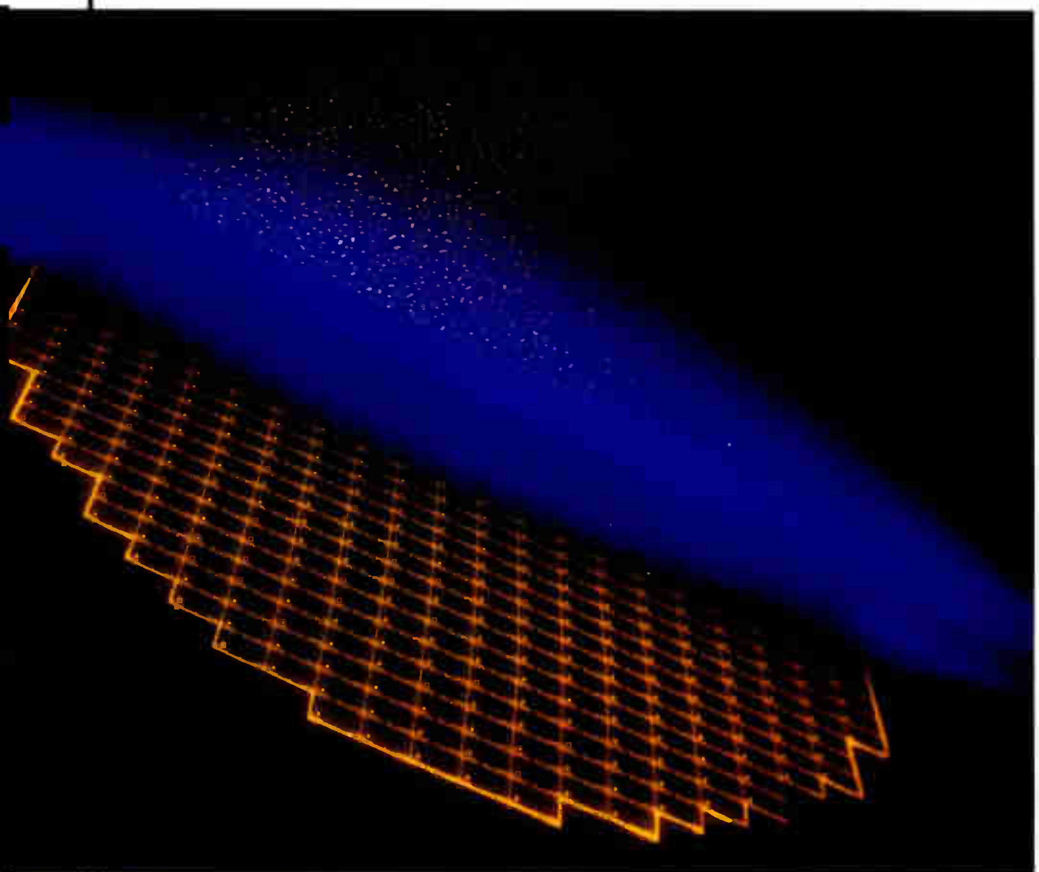
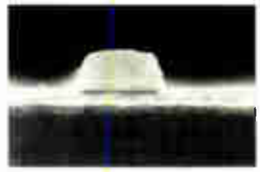
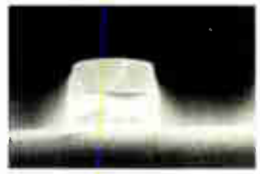
Omni-Etch™: tomorrow's machine for tomorrow's processes...today.

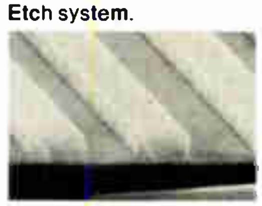




| 2μm |



Top SEM shows resist pattern, lower SEM shows results of aluminum etching with Omni Etch system.



ETCH RATE: 5000 Å/min.
SELECTIVITY: Oxide 20:1
Resist 7:1
PRESSURE: 1.2 torr
POWER: 2.0 W/cm^2
FREQUENCY: 13 MHz

Why develop tomorrow's processes on yesterday's equipment? Perkin-Elmer's Omni-Etch 10000 lets you develop your dry etch processes on the same machine you will use on the production line to meet your advanced VLSI production requirements.

The sophistication of the Omni-Etch approach allows you to develop two separate processes at the same time on the same machine! Because all key process elements are cross calibrated and tightly controlled, the process you develop in the lab transfers directly to any Omni-Etch machine on the production line anywhere in the world.

Only the Omni-Etch offers cassette-to-cassette operation, 32-bit minicomputer controlled single-wafer etching, automatic alignment with no edge contact, and individual end point control. Etching can be anisotropic or isotropic, at up to sixty wafers per hour. A unique chamber-within-a-chamber design allows simultaneous wafer descumming, etching and stripping.

Plus, there's a whole library of software you can use to shorten development time.

If you want a head start on tomorrow's processes, today, contact Perkin-Elmer, Semiconductor Operations, 50 Danbury Road, Wilton, Connecticut 06897.

PERKIN-ELMER

Circle 201 on reader service card

BOONTON'S NEW RF MICROWATTMETER

Simple, But Not Simple-Minded

Most instruments with microprocessors work like a charm under controller command — but they can be a real puzzle when you try to operate them manually. Boonton's new 4210 is microprocessor-based, but with a difference: It is designed to simplify **manual** r.f. power measurements.*

- Zeroing is automatic: one button stores and corrects for zero offsets.
- Ranging is automatic: select either Power or dBm mode and the 3½ digit display and annunciators show the value.
- Ratios are automatic: any reading may be used as a reference, and later readings displayed in dB relative to that reference.

The 4210 may be ordered with a variety of Boonton power sensors. Diode sensors, featuring high sensitivity, low drift, and a 70 dB dynamic range, are available for power levels from 1 nW (-60 dBm) to 100 mW (+20 dBm) and frequencies from 200 kHz to 18 GHz. Thermocouple sensors, with true r.m.s. indication, cover 1 µW (-30 dBm) to 10 mW (+10 dBm), 10 MHz to 18 GHz.

For more information, or a convincing demonstration, call Boonton Electronics or your local representative ....keep the puzzlement out of measurement!

*For **programmable** applications, ask about the Model 4200. It offers full bus compatibility, and is available with dual input channels for direct measurement of reflection coefficients.

BOONTON ELECTRONICS CORP.
PO Box 122, Parsippany, NJ 07054
(201) 887-5110

Circle 202 on reader service card

Microcomputers & systems

Unit programs 256-K E-PROMs

High-end PROM programmer permits editing, has module for MOS microcomputer work

Designers are already planning systems that will use 256-K erasable programmable read-only memories and Kontron Electronic Inc. is keeping up with them. It will cope with larger memory chips by offering the Engineering PROM Programmer (EPP), which is compatible with personality modules created by the company for its MPP 80 programmable logic programming mainframe. The EPP mainframe has the basic capabilities of the MPP 80, but adds features like a 16-character 5-by-7-dot matrix display.

The EPP also introduces a search mode that allows the user to key in a search for data resident in the EPP's random-access memory. In addition, it has a list mode, which can display the program data in binary, octal, hexadecimal, or decimal formats. A new multidevice performance module, the MDM (for MOS development module), allows for 16-bit data to be split into 8-bit data blocks, or it allows 8-bit data blocks to be interlaced into 16-bit blocks.

Display mode. Rather than the standard display mode, which demands that both starting and ending addresses be defined each time a device is programmed, the EPP has a compressed display mode in which a single keystroke can be used to implement most operations over the entire address range of the specific device being programmed.

When programming programmable array logic, a designer sometimes wants to protect his design by blowing the last fuse on the PAL part, and the EPP allows the user to do this with a single function key. Once the last fuse is blown, the PAL will perform its logical functions, but it will no longer be readable as an array of fuses. This function key is implemented as a shifted mode of the hexadecimal keyboard, and there is room for other specialized functions to be added.

Logic functions. There is also a logic mode on the EPP that allows the user to change stored data systematically using AND, OR, and exclusive-OR conventions. If, for example, one has 8-bit characters in RAM in which only the first 7 bits define the ASCII character, the user may want to ensure that the 8th bit is kept at logic 0. The logic mode would allow him to perform an exclusive-OR operation with 7F, which would reset the last bit on every byte to 0.

A small ultraviolet-light eraser is built into the EPP and its erase time can be set by software at up to 99 minutes. Its display shows the remaining erasure time.

When a cathode-ray-tube terminal is connected, the EPP provides a built-in cursor-controlled line editor. The standard unit has one interface for RS-232-C or current-loop communications, and a second RS-232-C interface or a parallel interface can also be purchased as options. Transmission rates up to 2,400 b/s are selected with a switch in a dual in-line package, as is parity on-off, odd-even, and the choice of one or two stop bits.

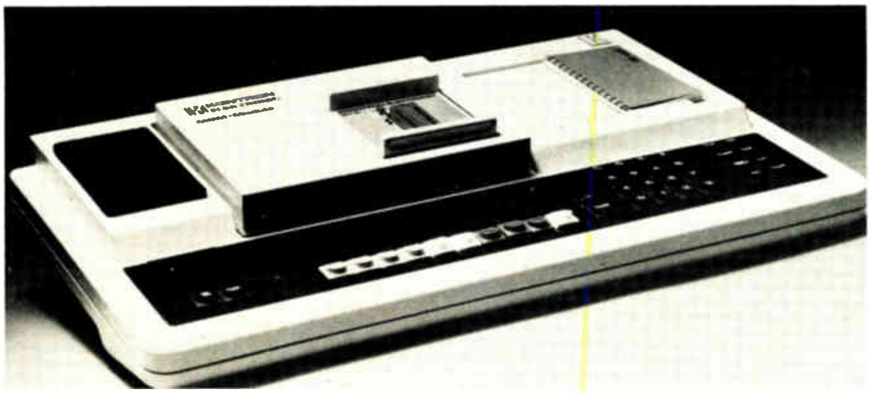
The EPP mainframe price is set at $3,000. However, prices for the optional RS-232-C interface, the Centronics-compatible parallel interface, and the IEEE-488–bus interface have not been set yet.

To make sure that a device is programmed properly, the EPP has a number of checking capabilities. It performs a cyclical redundancy check on both address and data and has provisions for error recovery. It checks telephone-line delays for remotely programmed data and includes echo-suppression capability.

Checkout. The unit also checks for reversed devices and shorts on-chip power-supply lines and displays an error-current message when they are wrong. It tests the address and data lines for shorts and displays an error-data or error-address message if it finds one. It also checks the socket adaptor of the MDM to make sure that the right kind of device has been inserted.

The MDM performance module allows the programming of 25 different MOS and complementary-MOS devices, including 40-pin single-chip microcomputers. "To handle that many devices on our previous PROM programmer, we would have needed several performance modules," observes Keith Barnes, general manager of Kontron's Redwood City, Calif., facility. The MDM will be priced at $1,295, and, as with the EPP, delivery is in 45 days.

Kontron Electronic Inc., 630 Price Ave., Redwood City, Calif. 94603. Phone (415) 361-1012 [371]



16-channel unit lets Apple sample 20-kHz waveforms

Transforming an Apple II microcomputer into a precision laboratory instrument, the Applegrator II includes specific applications software for chromatography, spectroscopy, colorimetry, and flow measurement, as well as general-purpose software for pulse integration and data acquisition. Professional reporting, extensive use of video graphics, floppy-disk storage of raw data and results, interrupt-driven sampling, and thorough documentation distinguish this

software, the developer claims.

The instrument includes a 16-channel, high-speed, 12-bit analog-to-digital converter and a precision timer. It can sample waveforms at rates up to 20 kHz and store up to 10,000 data points. While sampling, the Applegrator also plots the data on the screen and computes the both true sum and sum of squares for each channel.

After sampling, data may be reviewed in either expanded or compressed form. Integrals of selected portions of the sampled waveform may also be computed, and peak-detection routines allow reporting of peak heights, widths, areas, and retention times. Available now as an upgrade package, Applegrator sells for $3,980 and with the Apple, for $6,480.

Dynamic Solutions Corp., 61 South Lake Ave., Suite 309, Pasadena, Calif. 91101. Phone (213) 577-2643 [373]

Synthesizer speaks as text is entered

With an unlimited English vocabulary, the Prose 2000 text-to-speech converter, a speech synthesizer board, converts ASCII-coded text into immediately intelligible, clearly enunciated speech output. The manufacturer's proprietary synthesis-by-rule firmware, resident in the unit, allows words and sentences to be spoken with human-like intonation.

An 8086 microprocessor, a single-chip formant synthesizer, and 108-K bytes of erasable programmable read-only and random-access memory are used to produce spoken English in real time at rates up to 250 words/min. Additional on-board circuitry performs data input/output, digital-to-analog conversion, and audio amplification to directly drive a loudspeaker. The Prose 2000 board is Multibus-compatible and contains an RS-232-C port.

The Prose 2000 text synthesizer does not contain or require a stored speech vocabulary. Text is converted to speech using a five-step process: text normalization, phonemics, allophonics, prosodics, and speech parameter generation.

The Prose 2000 is available in two forms: a single Multibus-format board costing $3,500 and as a peripheral in an enclosure with a power supply and connectors for $4,800. Shipments begin this month.

Telesensory Speech Systems, 3408 Hillview Ave., P. O. Box 10099, Palo Alto, Calif. 94304. Phone (415) 856-8255 [374]

Card lets Personal Computer run CP/M, adds memory

A combination of a circuit board and software, called Baby Blue CPU Plus, makes the IBM Personal Computer compatible with programs produced for other microcomputer systems. It has a built-in memory of 64-K bytes, a Z80B microprocessor, and software that enables it to run CP/M-80–based programs.

Baby Blue makes available more than 20,000 existing software packages that the Personal Computer owner is presently unable to use. In addition, when not used with CP/M-80 programs, Baby Blue's onboard memory is functionally identical to an IBM 64-K-byte memory board, and provides that much additional storage to the computer's native central processing unit and operating system.

The Baby Blue card is simply plugged into an existing slot in the Personal Computer. The $600 card is available now.

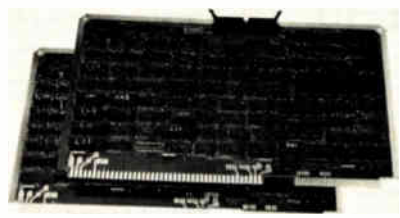
Xedex Corp., 645 Madison Ave., New York, N. Y. 10022. Phone (212) 247-1400 [376]

Array processor gives Multibus units 1 million operations/s

Users can get 1 million floating-point operations/s out of a Multibus microcomputer system by plugging in the Micro Number Kruncher. The SKYMNK-M, a 32-bit floating point array processor, is packaged on two single-board computer modules that plug into the Multibus backplane.

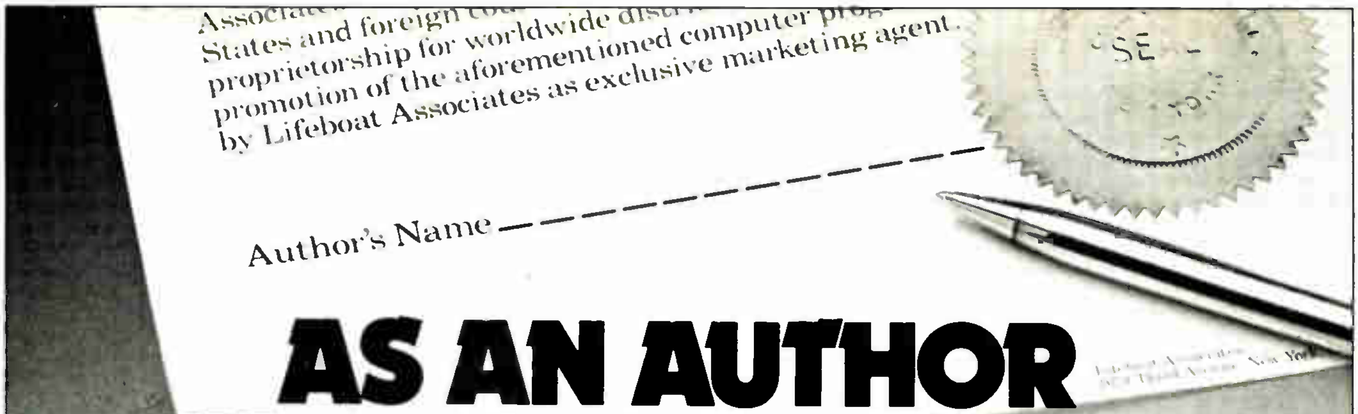
With the processor, a Multibus system is capable of performing up to 1 megaflop with 32-bit single precision and, for computations subject to roundoff error, 48-bit extended precision. This speed allows scientific and engineering users of microcomputer systems to perform arithmetically intensive operations interactively on real or complex data using a variety of supported mathematical alogrithms such as digital filtering, convolution, fast Fourier transforms, and thresholding.

The unit is tightly coupled to the host microcomputer through the Multibus, which enables it to share the host's memory and operate under the control of the host's operating system. This approach eliminates the need for special memory as part of the array processor and makes it



unnecessary to move data between processors before each function. The SKYMNK-M is priced under $4,000 in large quantities, and is available in 30 days.

Sky Computers Inc., Foot of John Street, Lowell, Mass. 01852. Phone (617) 454-6200 [375]



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Circle 209 on reader service card

Components

DIP switch has low profile

Automatic insertion equipment handles 8-position switch in dual in-line package

Stacking density for circuit boards requiring switches in dual in-line packages can be improved with the K40 switch from American Research & Engineering. The eight-position single-pole, single-throw switch comes in a low-profile 16-pin package that is only 0.160 in. high, which the firm says is some 50% lower than competitive DIP switches.

At a width of 0.300 in., the K40 is also about 25% narrower than competitive switches. Because its profile matches that of a typical integrated-circuit package, it can be used with standard automatic insertion equipment, points out James Liautaud, president of the firm.

The K40's low profile is due to a design that also gives it only quarter the parts count of some other switch designs, Liautaud says. At the same time, the design improves reliability by bifurcating each switch contact, thus adding redundancy to each on-position connection. Each switch contact in the K40 travels 0.040 in. over the hot contact surface, as against 0.010 in. in some switch designs, thus eliminating the intermittent-connection problems experienced with some DIP switches, the firm says.

Contacts. Beryllium copper contacts are plated with 30 mils of gold over 100 mils of nickel. Initial contact resistance is 50 mΩ, and resistance after the rate life is 100 mΩ

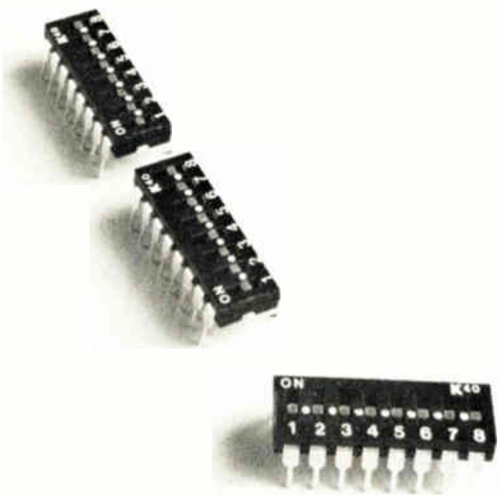
The K40 was developed initially for use in programming a microphone to adapt to various types of mobile-radio equipment employed in the European market. However, it is expected to find use in a variety of applications in which its low profile and capacity for automatic insertion will be an advantage.

The eight-position switch is 0.840 in. long and has leads on standard 0.100-in. spacings and row-to-row centers of 0.300 in. Leadframes are molded into the housing.

Switch actuators on the K40 are flush with the housing. Rated switch life is 2,000 actuations. The operating temperature range is 0° to 190°F.

The K40 is priced at 79¢ each in any quantity and is available now from stock.

American Research & Engineering, 1500 Executive Dr., Elgin, Ill. 60120 [341]



Keyboard features low profile for use in portable equipment

Conforming to the new DIN profile-height standards (0.5 in.), MK059-001 boosts compact key spacings (0.7 in.). The off-the-shelf keyboard is targeted for portable terminals and desktop applications. Measuring 4½ by 10¾ in., the keyboard uses the sealed domeswitch technology.

The patented construction activated by a 3.5-oz force provides hys-

teresis that eliminates teasing. The unit's breakaway feel gives the typist comfortable key feedback, according to the company.

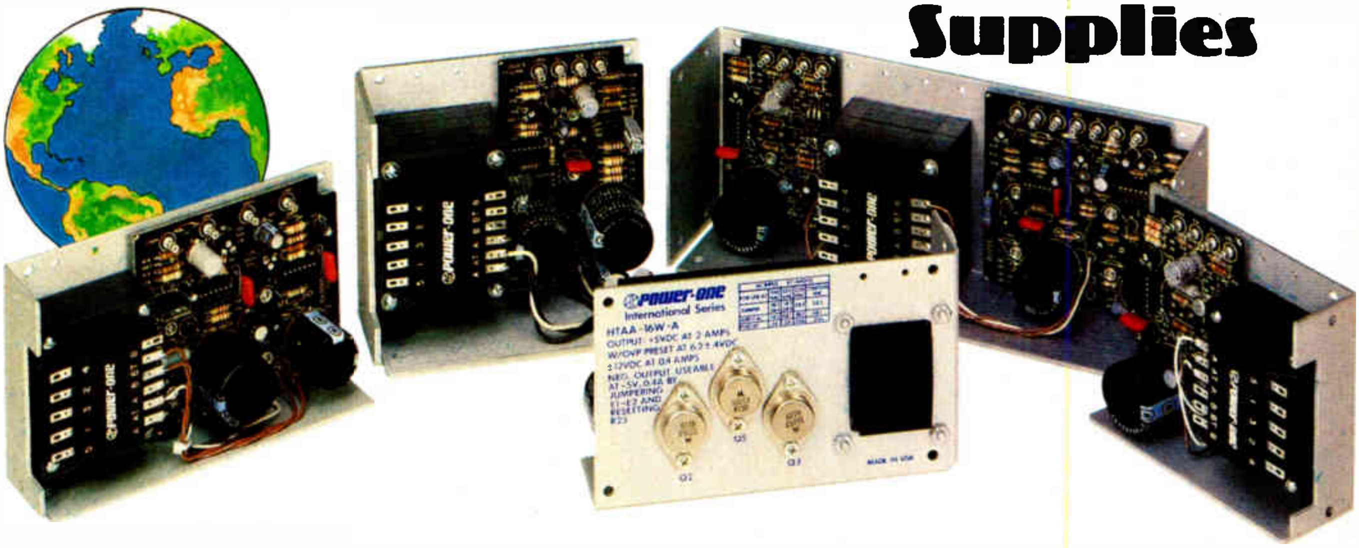
The electrical-switch-matrix output of the MK059 is compatible with the RCA CDP 1871 C-MOS keyboard encoder; custom microprocessor interfaces will be provided at additional cost. Switch outputs are terminated at 0.025-in. straight pins located on the back of the printed-circuit board. Delivered from stock, the MK059 sells for $41.50 each in 1,000-piece quantities.

Advanced Input Devices, West 250 A. I. D. Drive, Coeur d'Alene, Idaho 83814. Phone (208) 765-8000 [344]

Green light-emitting diode gives 60-mcd intensity.

An improved gallium phosphide green light-emitting diode gives General Instrument's series of high-efficiency, solid-state green lamps a luminous intensity as great as 60 mcd, two to three times brighter than the first generation of green lamps. The devices have a viewing angle as great as 100° and, at an ambient temperature of 25°C, they

Power One's International Series-The New World Standard in D.C. Power Supplies



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Spacings, Live Parts to Dead Metal: 9.0 mm
Other than Field Terminals: 5.25 mm

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Input to Outputs: 3750 VAC
Outputs to Ground: 500 VAC

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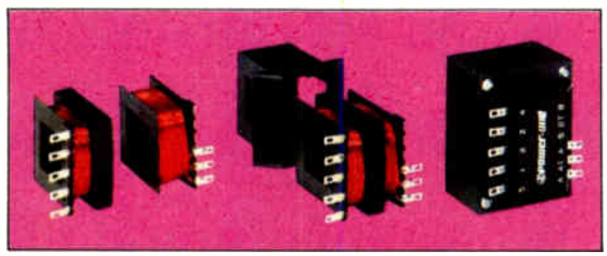

Power-One's patented International Series transformers feature separate, fully enclosed, primary and secondary coils. Meets safety requirements of VDE, UL, CSA, BPO, IEC, CEE, and ECMA.

SINGLE OUTPUT MODELS

MODEL	VOLTAGE/CURRENT	PRICE (1-24)
5 VOLTS		
HB5-3/OVP-A	5V @ 3A	$ 32.95
HC5-6/OVP-A	5V @ 6A	$ 54.95
HN5-9/OVP-A	5V @ 9A	$ 74.95
HD5-12/OVP-A	5V @ 12A	$ 84.95
HE5-18/OVP-A	5V @ 18A	$119.95
12 VOLTS		
HB12-1.7-A	12V @ 1.7A	$ 32.95
HC12-3.4-A	12V @ 3.4A	$ 49.95
HN12-5.1-A	12V @ 5.1A	$ 69.95
HD12-6.8-A	12V @ 6.8A	$ 79.95
HE12-10.2-A	12V @ 10.2A	$109.95
15 VOLTS		
HB15-1.5-A	15V @ 1.5A	$ 32.95
HC15-3-A	15V @ 3A	$ 49.95
HN15-4.5-A	15V @ 4.5A	$ 69.95
HD15-6-A	15V @ 6A	$ 79.95
HE15-9-A	15V @ 9A	$109.95
24 VOLTS		
HB24-1.2-A	24V @ 1.2A	$ 32.95
HC24-2.4-A	24V @ 2.4A	$ 49.95
HN24-3.6-A	24V @ 3.6A	$ 69.95
HD24-4.8-A	24V @ 4.8A	$ 79.95
HE24-7.2-A	24V @ 7.2A	$109.95
28 VOLTS		
HB28-1-A	28V @ 1A	$ 32.95
HC28-2-A	28V @ 2A	$ 49.95
HN28-3-A	28V @ 3A	$ 69.95
HD28-4-A	28V @ 4A	$ 79.95
HE28-6-A	28V @ 6A	$109.95

DUAL OUTPUT MODELS

MODEL	OUTPUT #1	OUTPUT #2	PRICE (1-24)
±12 TO 15 VOLTS			
HAA15-0.8-A	12V @ 1A OR 15V @ 0.8A	-12V @ 1A OR -15V @ 0.8A OR -5V @ 0.4A	$ 42.95
HBB15-1.5-A	12V @ 1.7A OR 15V @ 1.5A	-12V @ 1.7A OR -15V @ 1.5A OR -5V @ 0.7A	$ 54.95
HCC15-3-A	12V @ 3.4A OR 15V @ 3A	-12V @ 3.4A OR -15V @ 3A	$ 87.95
HDD15-5-A	12 TO 15V @ 5A	(-) 12 TO 15V @ 5A	$129.95
5 VOLTS PLUS 9 TO 15 VOLTS			
HAA512-A	5V @ 2A	9 TO 15V @ 0.5A	$ 49.95
HBB512-A	5V @ 3A	9 TO 15V @ 1.25A	$ 59.95
HCC512-A	5V @ 6A	9 TO 15V @ 2.5A	$ 94.95

TRIPLE OUTPUT MODELS

MODEL	OUTPUT #1	OUTPUT #2	OUTPUT #3	PRICE (1-24)
HTAA-16W-A	5V @ 2A	9 TO 15V @ 0.4A	(-)9 TO 15V @ 0.4A OR -5V @ 0.4A	$ 54.95
HBAA-40W-A	5V @ 3A	12V @ 1A OR 15V @ 0.8A	-12V @ 1A OR -15V @ 0.8A OR -5V @ 0.4A	$ 75.95
HCAA-60W-A	5V @ 6A	12 TO 15V @ 1A	(-)12 TO 15V @ 1A OR -5V @ 0.4A	$ 89.95
HCBB-75W-A	5V @ 6A	12V @ 1.7A OR 15V @ 1.5A	-12V @ 1.7A OR -15V @ 1.5A OR -5V @ 0.7A	$ 99.95
CP131-A	5V @ 8A	12V @ 1.7A OR 15V @ 1.5A	-12V @ 1.7A OR -15V @ 1.5A OR -5V @ 0.7A	$119.95
HDBB-105W-A	5V @ 12A	12V @ 1.7A OR 15V @ 1.5A	-12V @ 1.7A OR -15V @ 1.5A OR -5V @ 0.7A	$134.95

DISK DRIVE MODELS

MODEL	OUTPUT #1	OUTPUT #2	OUTPUT #3	PRICE (1-24)
CP205-A	5V @ 1A	-5V @ 0.5A	24V @ 1.5A/1.7A PK	$ 75.95
CP206-A	5V @ 2.5A	-5V @ 0.5A	24V @ 3A/3.4A PK	$ 99.95
CP162-A	5V @ 3A	-5V @ 0.6A	24V @ 5A/6A PK	$129.95
CP323-A	5V @ 2A	12V @ 4A		$ 79.95
CP379-A	5V @ 6A	-5V @ 1.2A OR -12V @ 1.2A	24V @ 3.5A/8A PK	$129.95
CP384-A	5V @ 9A	-5V @ 1.2A OR -12V @ 1.2A	24V @ 2A/8A PK	$129.95

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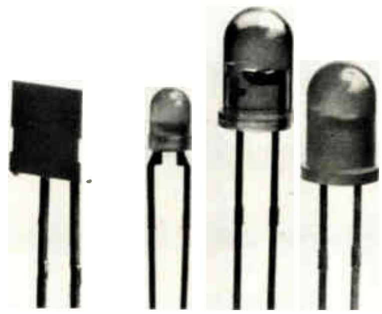
Circle 211 on reader service card

dissipate 120 mW, maximum.

The green lamps, comparable in brightness with the firm's red LEDs, are available in a T-1 (MV54XXX series) lamp size with a diffused lens; a T-1¾ (MV64XXX series) size with a diffusing and a nondiffusing lens; and in a rectangular shape (MV54XXX series), 0.250 by 0.150 in., that can be stacked on end in an



X or Y direction on a lead spacing of 0.100 in.

All the green LEDs are direct pin-for-pin replacements for the first-generation lamps, as well as replacements for comparable devices from Hewlett-Packard Co. The manufacturer claims that all have a wider viewing angle and are brighter than comparable lamps. In 100-unit quantities, pricing ranges from 28¢ to 48¢ each, and the lamps are available from stock.

General Instrument Corp., Optoelectronics Division, 3400 Hillview Ave., Palo Alto, Calif. 94304. Phone (415) 493-0400 [343]

Intelligent LED module can be viewed from 8 ft

Said to have from two to four times the display area of conventional units, the DL-3416 light-emitting-diode display with 0.225-in.–high characters is targeted for use in instrumentation that is to be viewed from a distance (typically up to 8 ft). Each intelligent module consists of a red four-character 16-segment (plus decimal) LED with a built-in complementary-MOS integrated circuit.

The IC contains memory, an ASCII read-only-memory decoder, multiplexing circuitry, and drivers. Data entry is asynchronous. Further, a display system may be built with any number of devices since each position can be addressed independently and will continue to display the character last stored until replaced by another.

The module, which comes in a solid plastic package, measures 0.8 by 1.3 by 0.5 in. It operates from a 5-V power supply and draws up to 200 mA peak, 150 mA typically. It has a 500-ns access time and is compatible with standard TTL levels. The DL-3416 has a ±40° viewing angle and is specified for operation from −20° to +65°C. In 100-piece quantities, it sells for $29.95 each, with delivery from stock.

Siemens Corp., Litronix Division, 186 Wood Ave. South, Iselin, N. J. 08830 [346].

Snap-action switch fits in many standard sockets

Unlike conventional switches, which operate with standard preformed metal bistable blades, the series 551 data-entry switch contains a patented snap-action blade that provides a tactile and audible signal on use. The switch is particularly well-suited to printed-circuit-board applications, because its terminal-pin layout is compatible with dual in-line packages, permitting it to be plugged into many standard sockets.

With the patented blade, contact pressure alone causes over-center snap action. The blade is forced over center by the contacts, so a slow break is unlikely. In addition, over-center snap action has no performance degradation over time, the manufacturer claims, and, coupled with high contact pressure just before break and on make, gives the switch tease-proof performance.

The series 551 meets MIL-STD 3786 and can be used in avionics and many other applications. With a tested life of over 1 million cycles, the unit sells for $3 each in large quantities. Delivery is in four weeks.

Hoffman Engineering Corp., P. O. Box 300, Old Greenwich, Conn. 06870. Phone (203) 637-1719 [347]

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Now you can add the proven, high-speed computation abilities of Analogic's AP400 Series array processors to your Hewlett-Packard HP9845 Desk-Top Computer.

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• High Throughput Speeds

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• High Performance Computing with a Portable System

This powerful, yet economical, computing system is also portable. The AP445-HP9845 combination can handle real-time signal processing in the field or at remote stations. The flexibility provided by the ruggedness of this high performance computing system also permits real-time signal analysis out on the factory floor or in high-performance test cell operations.

• HP Basic Programming

The high-speed computing power of the AP445 is accessed by programs written in HP BASIC, including data acquisition inputs directly to auxiliary ports of the AP445.

Free Information

Write today for further information on the AP445 and AP400 Series array processors. Our data sheet includes typical system throughput speeds and a sample program using the AP445-augmented HP9845. Or call Marketing Manager at (617) 246-0300 X2217.

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- **Large On-Board Memory—** 64K words of 24-bit bipolar RAM is standard.
- **Simple Hookup—** Connects to the HP9845 with a single cable and HP98032A interface (included).
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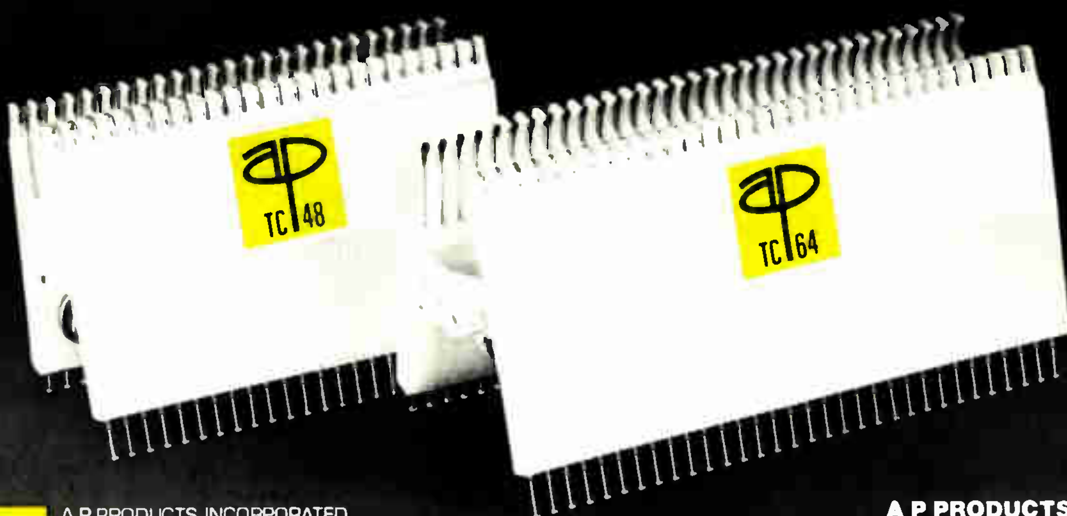

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New literature

Telecommunications books. Available now, the 1982 Telecom Library catalog claims to be a central source for all books, training materials, research reports, periodicals, and training seminars on aspects of telecommunications, data communications, distributed data processing, and office automation. Contact Telecom Library, 205 West 19th St., New York, N.Y. 10011, call (212) 691-8215, or circle reader service number 421.

Rules to write by. To help authors understand the requirements and procedures for presenting and marketing software, Lifeboat Associates is offering "Guidelines for Software Authors." The guide provides authors with a logical, step-by-step outline that details procedures and considerations addressed by a publisher on receipt of software. Also a question-and-answer section tells how an author may submit a software program. For further information, write to Lifeboat Associates, 1651 Third Ave., New York, N.Y. 10028 or call (212) 860-0300. [422]

Video primer. Understanding the fundamentals of video and the associated waveforms is eased with the TV–video-sync primer, application note 5953-3900. Special sections include the U.S. National Television Systems Committee broadcast standards and nomenclature, a discussion of NTSC, PAL (phase-alternation-line), and Secam (Séquential Couleurs à Mémoire) systems of color transmission, and a glossary of TV and video terms. For a copy, write to Hewlett-Packard Co., 1820 Embarcadero Rd., Palo Alto, Calif. 94303. [423]

In the pocket. The "Pocket Computer Newsletter," now entering its second year, provides information for users of pocket computers like the Sharp PC-1500 and Radio Shack PC-2 that are programmable in Basic. The publication regularly provides equipment and software reviews, operating tips, practical programs, technical information, and reports on the experiences of users. For subscription information, contact The Pocket Computer Newsletter, 35 Old State Rd., Oxford, Conn. 06483 or call (203) 888-1946. [424]

Software for Harris computers. Users of any of Harris Corp.'s computers will be pleased to see the fourth edition of its software directory. The directory lists and describes the broad range of application and system software available for the entire family of Harris high-performance super-minicomputers. The 108-page directory is available at no charge from the Marketing Communications Department, Computer Systems Division, Harris Corp., 2101 West Cypress Creek Rd., Fort Lauderdale, Fla. 33309 at (305) 974-1700. [425]

Fun and games. Capitalizing on the popular VIC 20 and the anticipated popularity of the new Ultimax, Commodore's Computer Systems division will publish "Power/Play." The magazine will contain information on new products, applications, games, programming tips, home learning, telecommunications, users clubs, and any other helpful information. The premier issue will be available in the spring and publication will be quarterly in 1982. For subscription information, contact Commodore Business Machines Inc., 681 Moore Rd., King of Prussia, Pa. 19406. [426]

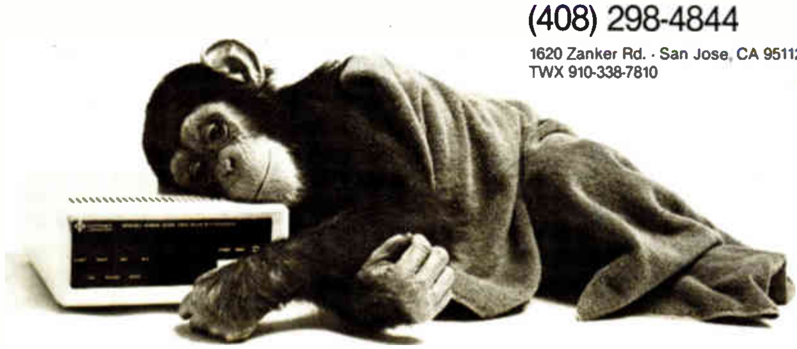
Using logic analyzers. A free application note, No. 112, gives an overview of the various types of logic analyzers available and defines the kind of digital-system design and development problems that each type of analyzer can solve. The brochure describes the features and uses of the time and data domains of multipurpose logic analyzers. For a copy, contact Gould Inc. Instruments Division, 4600 Old Ironsides Dr., Santa Clara, Calif. 95050. [427]

PAL handbook. An updated and expanded handbook for designing with programmable-array–logic circuits includes specifications and de-

sign instructions for 20- and 24-pin PAL circuits as well as the recently introduced hard-array logic and hard-array–logic medium-scale integrated devices. The 680-page guide provides an introduction to PAL, including data sheets, logic diagrams, and more than 50 applications. Priced at $12, the handbook may be obtained from Monolithic Memories Inc., Advertising Department, 1165 East Arques Ave., Sunnyvale, Calif. 94086. [428]

Using ultrasonics. The 24-page "Industrial Ultrasonics User's Guide" explains ultrasonic theory and the principles of operation of ultrasonic level and flow devices in specific industrial applications. In addition, the booklet describes the capabilities and options that enable ultrasonics to be incorporated into a variety of automated control systems. For a free copy, contact Wesmar Industrial Systems Division, Box C19074, Seattle, Wash. 98115 or call (206) 285-2420. [430]

Data-communication devices. Collected in the 1982 Black Box catalog are over 200 items specifically designed for today's data-communications system, including detailed product descriptions, photos, and prices. The catalog highlights such items as three models of IBM-compatible protocol converters, a programmable communication adapter, over 20 models of interface converters, and 22 different data switches. It may be obtained for free from Black Box Catalog, Mayview Road at Park Drive, P. O. Box 12800, Pittsburgh, Pa. 15241. [429]



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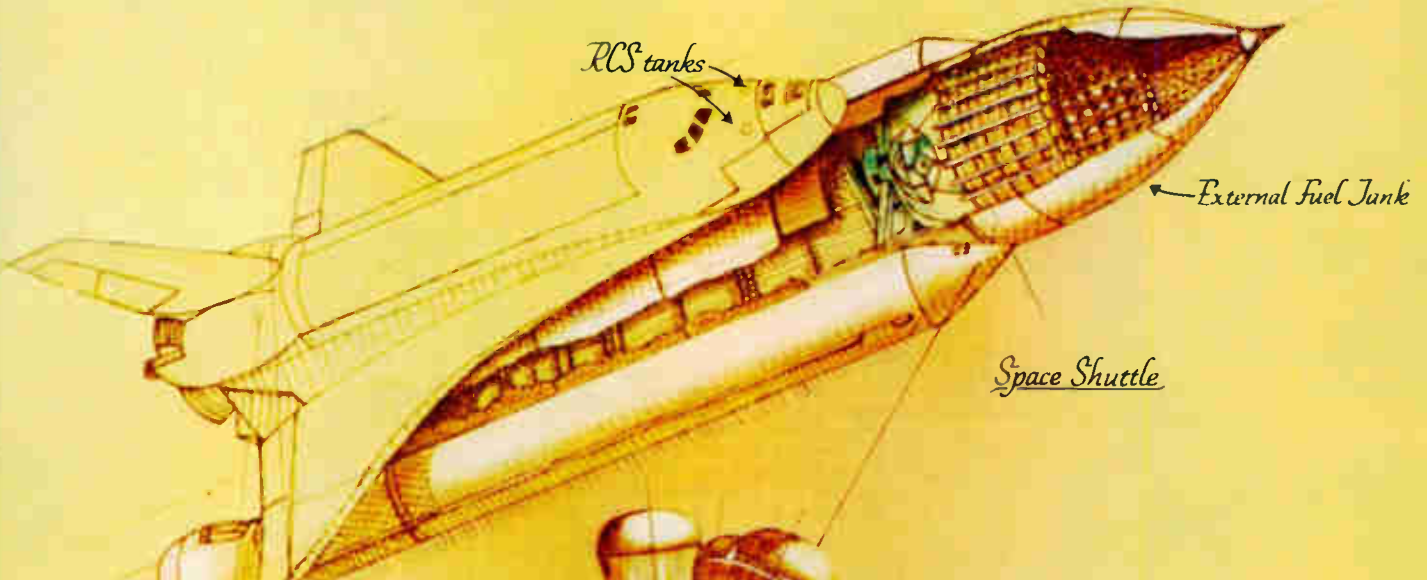

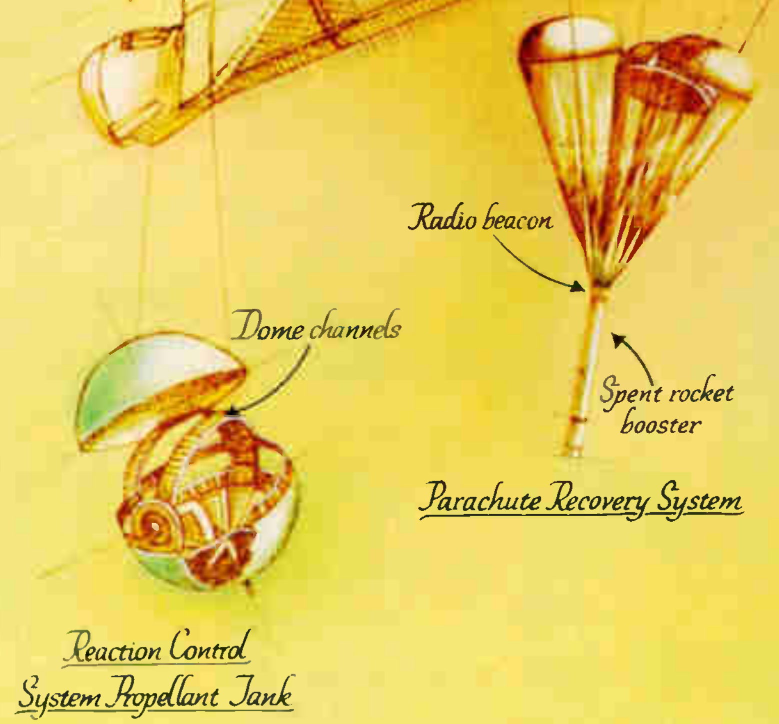

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Products Newsletter

Test monitor combines three instruments

Within three months, Tektronix Inc., Beaverton, Ore., will begin delivering a three-in-one portable test monitor that combines the functions of a waveform monitor and vectorscope (standard television trouble-shooting tools), and oscilloscope. The monitor is being **targeted at countries that use the National Television Standards Committee guidelines.** The portable 380 NTSC test monitor is priced at $5,150 and is now being made in Japan by the Sony-Tektronix joint venture. An optional battery pack is available for $800.

5¼-in. drive uses Sony cartridge format

Look for Tandon Corp. to expand its line of 5¼-in. floppy-disk drives with a cartridge drive employing the Sony cartridge format. The drive, tentatively set for announcement at the National Computer Conference next month, **will have a 256-K-byte capacity, and is expected to be a half-height model,** permitting two drives to be mounted in the space taken by a standard 5¼-in. unit. The drive, still unnamed and unpriced, uses cartridges rather than standard media for greater durability.

Interface links voice and data switching system to X.25 nets

An X.25 interface is being added to the family of InteNet Packet Controllers for format and protocol conversion supported by InteCom Inc.'s Integrated Business Exchange, IBX S/40. With the X.25 IPC addition, to be announced at the International Communications Association show next month, users of the Dallas, Texas, firm's voice and data switching system will have access through asynchronous devices to packet data networks like Telenet and Tymnet. **The X.25 controller will employ the packet assembly/disassembly function to access the networks.** Also supported are X.3, X.28, and X.29 protocols. When available in the first quarter of 1983, the X.25 addition will cost IBX S/40 users about $20,000.

Mail system gets high-, low-end options

Amtel Systems Corp., of Sunnyvale, Calif., has announced two new options for its Messenger II electronic mail and message-delivery system [*Electronics*, Feb. 10, p. 249]: **a low-cost message light that notifies users of messages and an 80-column page printer for users who frequently receive long messages.** The $100 message light option is designed for users who receive a relatively small number of incoming messages. The device simply flashes on and off to let the user know when he has messages waiting, rather than printing out the full text. The page printer is intended for users at the other end of the spectrum—those who receive a large number of long messages, such as those that are sent over TWX and Telex networks. Priced at $1,990, the device prints out messages on full-size fan-fold paper.

Screen editor's price increases

Effective May 1, Rational Data Systems is raising the prices for Scred and RDS Pascal, software products for Data General systems. **New license fees for RDS Pascal range from $3,000** for a version for the RDOS or DOS operating systems to $4,500 for the AOS or AOS/VS versions, up from $2,500 to $3,500. Prices for Scred, the New York firm's screen editor, range from $950 to $1,200, up from $850 to $1,000.

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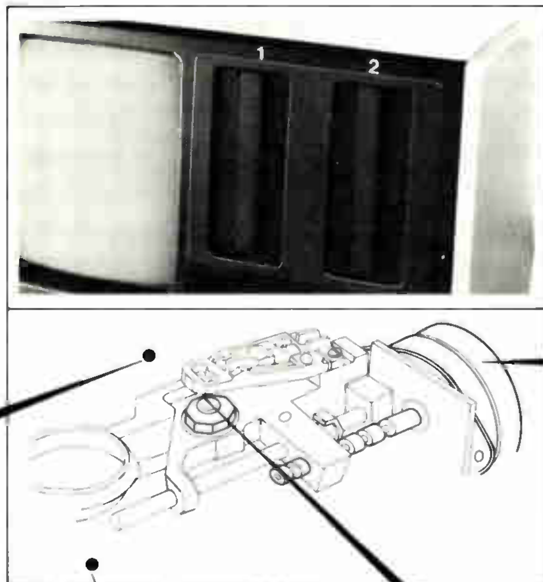

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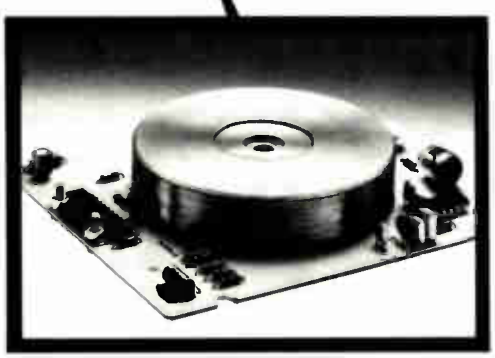

• Sankyo Direct Drive Brushless Servomotor.

For more information, write to Sankyo at the address below:

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Sankyo Seiki Mfg. Co., Ltd. **Electronic Equipment Div.**
Export Dept. 17-2, 1-chome, Shinbashi, Minato-ku, Tokyo 105, Japan,
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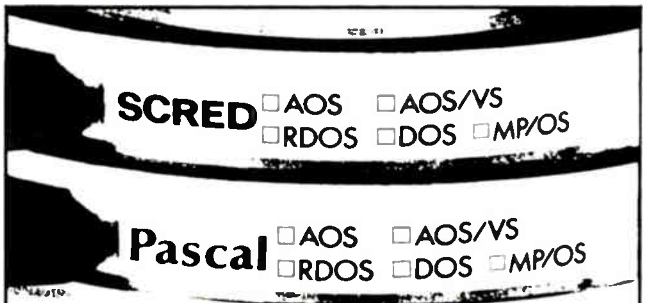

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Career outlook

IBM is top choice

What engineer has not gone through the exercise that begins, "If I had it all to do over . . ."? Part of the fantasizing that follows invariably concerns the ideal place to start one's career.

A survey of beginning engineers has just surfaced that helps answer that question. Conducted by Deutsch, Shea & Evans of New York, a recruitment advertising and consulting firm, and Graduating Engineer magazine, the survey was based on responses from 1,790 student readers of the magazine in all disciplines—80% of them bachelor-level students, mostly seniors, 16% at the master's level, and 3% working for their doctorates. Of the respondents, 13% were women.

Not surprisingly, the No. 1 finisher among all disciplines, with 16% of the soon-to-be engineers considering it the ideal employer, was International Business Machines Corp. Next, with 11%, was Bell Laboratories, and third, with 10%, was Exxon Corp. Among electronics (253 persons), electrical (287), and computer scientists and engineers (154), IBM and Bell Labs also finished first and second. However, although electronics and electrical engineers agreed that Hewlett-Packard Co. ranked third, computer majors saw things differently and placed Digital Equipment Corp. in third place and HP fourth.

Interestingly, with the survey divided into seven disciplines plus an eighth listing for all combined, electronics-related companies led all but two lists. IBM topped five, and General Electric Co. was first choice of 387 prospective mechanical engineers. Nonelectronics leaders were Bechtel Group Inc. for 208 future civil engineers and Exxon for 193 students with majors in chemical engineering.

EMPLOYER CHOICES* BY BACHELOR- AND GRADUATE-LEVEL ENGINEERING STUDENTS (IN %)

All student respondents (1,790)		Electrical students (287)		Electronics students (253)		Computer science and engineering students (154)	
International Business Machines	16	IBM	24	IBM	28	IBM	43
Bell Laboratories	11	Bell Labs	18	Bell Labs	26	Bell Labs	24
Exxon	10	HP	16	HP	20	Digital	14
General Electric	9	TI	12	TI	12	HP	13
Hewlett-Packard	8	GE	11	Motorola	12	Intel	12
Boeing	7	Westinghouse	8	Intel	10	TI	8
Texas Instruments	6	GTE Sylvania	7	Digital	8	Honeywell	7
Lockheed	5	Harris	6	GE	8	Harris	7
Bechtel	5	Honeywell	6	Honeywell	8	Lockheed	7
Rockwell	5	Digital	6	Fairchild Industries	6	Wang	7
Fluor	5	Intel	6	Harris	6	GTE Sylvania	6
Du Pont	4	Rockwell	5	Rockwell	6	GE	5
General Dynamics	4	Lockheed	5	GTE Sylvania	5	Data General	5
Westinghouse	4	Schlumberger (1)	5	Hughes	5	Hughes	5
Digital	4	Hughes	4	Westinghouse	5	NCR	5
Intel	4	General Dynamics	4	Boeing	5	Atari	4
Honeywell	4	Fairchild Industries	4	Xerox	4	Motorola	4
Eastman Kodak	3	Sperry Univac	4	Martin Marietta	4	Sperry Univac	4
National Aeronautics and Space Administration	3	NASA	4	NCR	4	TRW	4
General Motors	3	Du Pont	3	TRW	4	United Technologies	4
U. S. Navy	3	Eastman Kodak	3	GM	4	General Dynamics	3
Stone & Webster	3	Houston Lighting & Power	3	General Dynamics	4	NASA	3
Hughes	3	Martin Marietta	3	Wang	4	(3)	
GTE Sylvania	3	(2)		United Technologies	3		
United Technologies	3			RCA	3		

*Ranked by total mentions for first, second, and third choice as employers. Notes: (1) Includes Fairchild Camera and Instrument. (2) Exxon, GM, Motorola tied for 24th with 2.8%. (3) American Telephone & Telegraph, Exxon, Fairchild Industries, Martin Marietta, and Tektronix tied for 23rd with 2.6%.

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Electronics

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Electronics April 21, 1982 This reader service card expires July 21, 1982

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d ☐ Aerospace, Underseas Ground Support
e ☐ Test & Measuring Equipment
f ☐ Consumer Products
g ☐ Industrial Controls & Equipment
h ☐ Components & Subassemblies

5 Source of Inquiry—DOMESTIC

j ☐ Independent R&D Organizations
k ☐ Government

Your design function (check each letter that applies):

x ☐ I do electronic design or development engineering work.
y ☐ I supervise electronic design or development engineering work.
z ☐ I set standards for, or evaluate electronic components, systems and materials.

Your principal job responsibility (check one)

t ☐ Management
v ☐ Engineering Management
r ☐ Engineering

Estimate number of employees (at this location): 1. ☐ under 20 2. ☐ 20-99 3. ☐ 100-999 4. ☐ over 1000

1 16 31 46	61 76 91 106	121 136 151 166	181 196 211 226	241 256 271 348	363 378 393 408	423 438 453 468	483 498 703 718
2 17 32 47	62 77 92 107	122 137 152 167	182 197 212 227	242 257 272 349	364 379 394 409	424 439 454 469	484 499 704 719
3 18 33 48	63 78 93 108	123 138 153 168	183 198 213 228	243 258 273 350	365 380 395 410	425 440 455 470	485 500 705 720
4 19 34 49	64 79 94 109	124 139 154 169	184 199 214 229	244 259 274 351	366 381 396 411	426 441 456 471	486 501 706 900
5 20 35 50	65 80 95 110	125 140 155 170	185 200 215 230	245 260 275 352	367 382 397 412	427 442 457 472	487 502 707 901
6 21 36 51	66 81 96 111	126 141 156 171	186 201 216 231	246 261 338 353	368 383 398 413	428 443 458 473	488 503 708 902
7 22 37 52	67 82 97 112	127 142 157 172	187 202 217 232	247 262 339 354	369 384 399 414	429 444 459 474	489 504 709 951
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
9 24 39 54	69 84 99 114	129 144 159 174	189 204 219 234	249 264 341 356	371 386 401 416	431 446 461 476	491 506 711 953
10 25 40 55	70 85 100 115	130 145 160 175	190 205 220 235	250 265 342 357	372 387 402 417	432 447 462 477	492 507 712 954
11 26 41 56	71 86 101 116	131 146 161 176	191 206 221 236	251 266 343 358	373 388 403 418	433 448 463 478	493 508 713 956
12 27 42 57	72 87 102 117	132 147 162 177	192 207 222 237	252 267 344 359	374 389 404 419	434 449 464 479	494 509 714 957
13 28 43 58	73 88 103 118	133 148 163 178	193 208 223 238	253 268 345 360	375 390 405 420	435 450 465 480	495 510 715 958
14 29 44 59	74 89 104 119	134 149 164 179	194 209 224 239	254 269 346 361	376 391 406 421	436 451 466 481	496 701 716 959
15 30 45 60	75 90 105 120	135 150 165 180	195 210 225 240	255 270 347 362	377 392 407 422	437 452 467 482	497 702 717 960

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d ☐ Aerospace, Underseas Ground Support
e ☐ Test & Measuring Equipment
f ☐ Consumer Products
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3 18 33 48	63 78 93 108	123 138 153 168	183 198 213 228	243 258 273 350	365 380 395 410	425 440 455 470	485 500 705 720
4 19 34 49	64 79 94 109	124 139 154 169	184 199 214 229	244 259 274 351	366 381 396 411	426 441 456 471	486 501 706 900
5 20 35 50	65 80 95 110	125 140 155 170	185 200 215 230	245 260 275 352	367 382 397 412	427 442 457 472	487 502 707 901
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9 24 39 54	69 84 99 114	129 144 159 174	189 204 219 234	249 264 341 356	371 386 401 416	431 446 461 476	491 506 711 953
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