MAY 25, 1978

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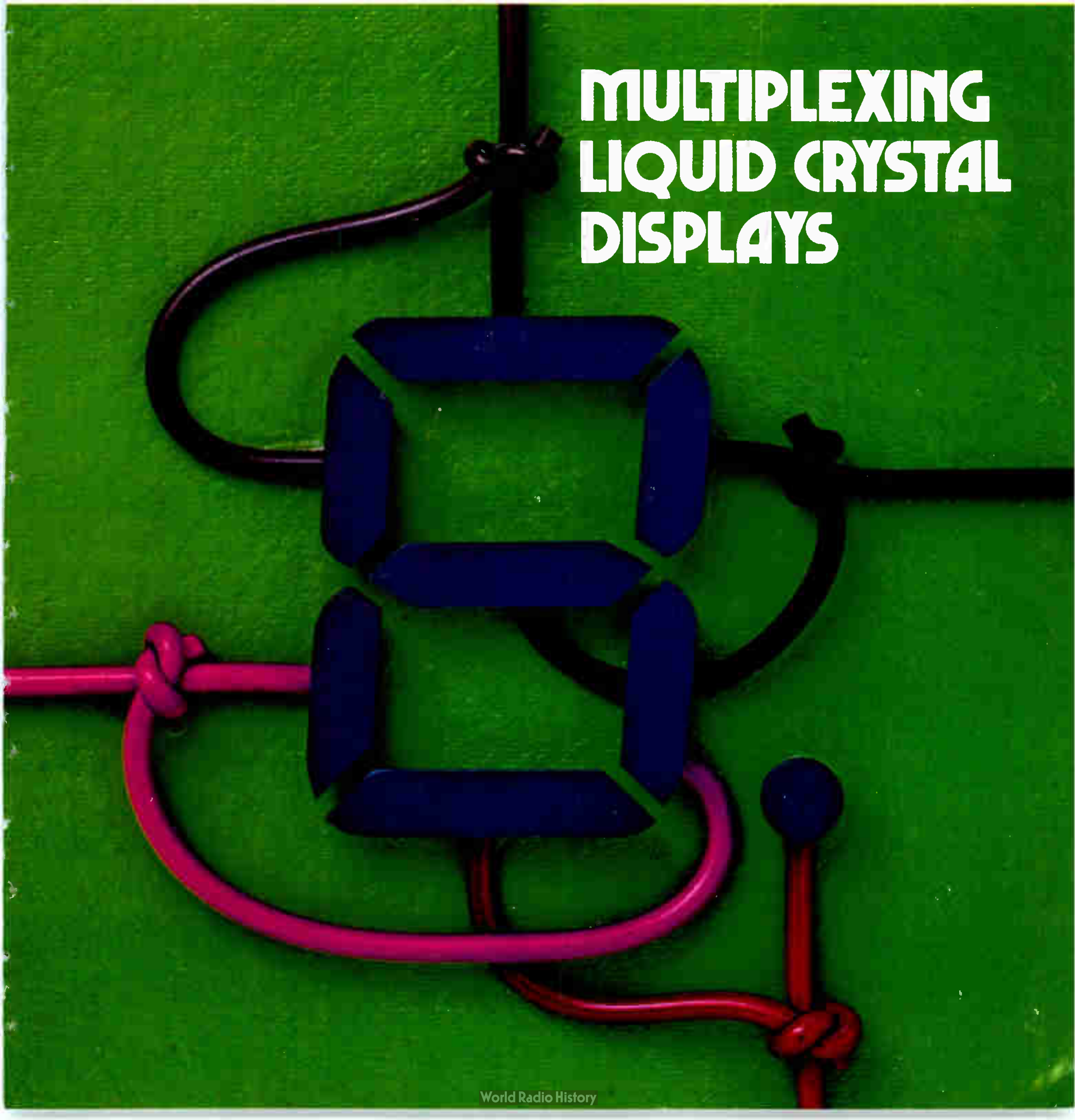

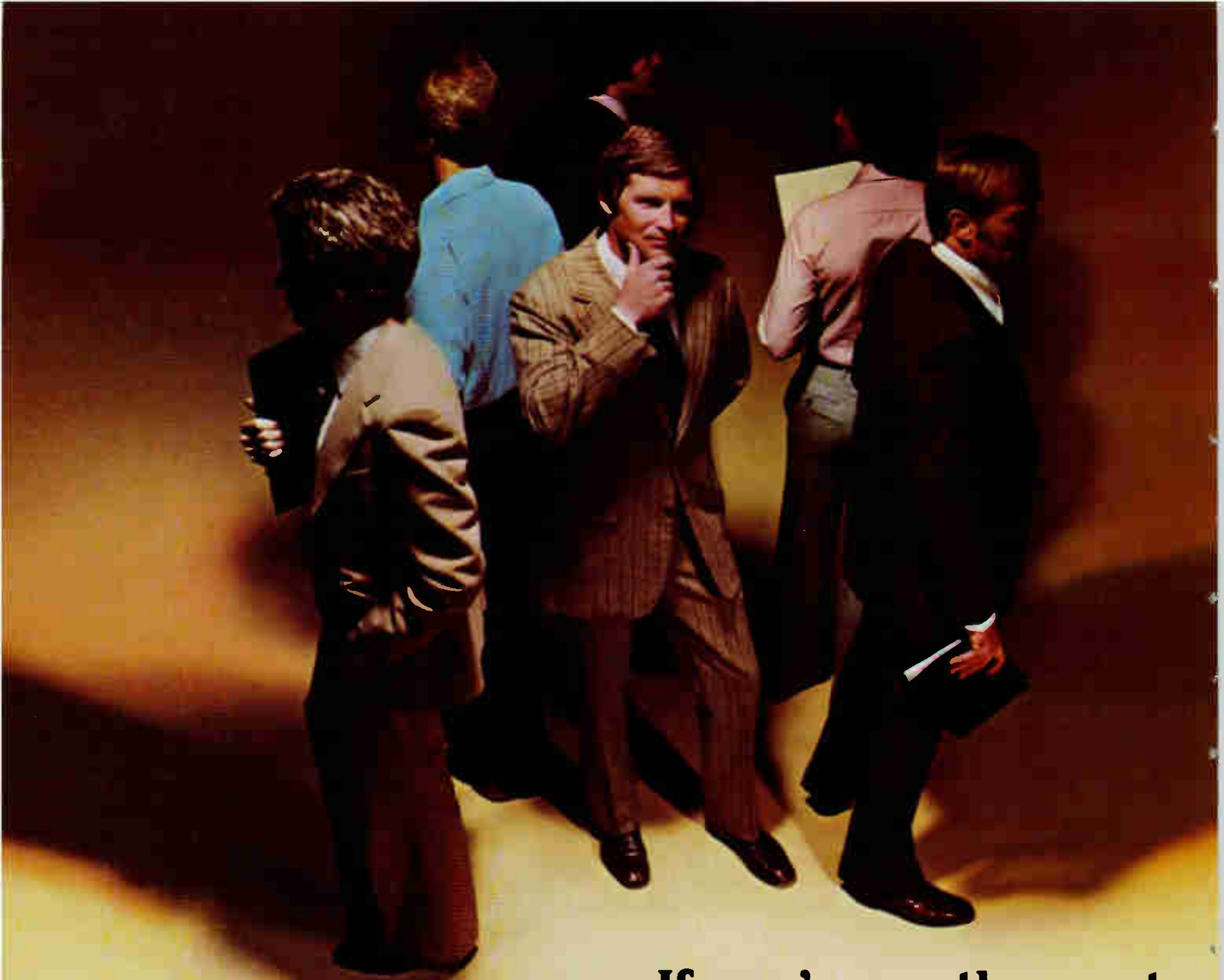

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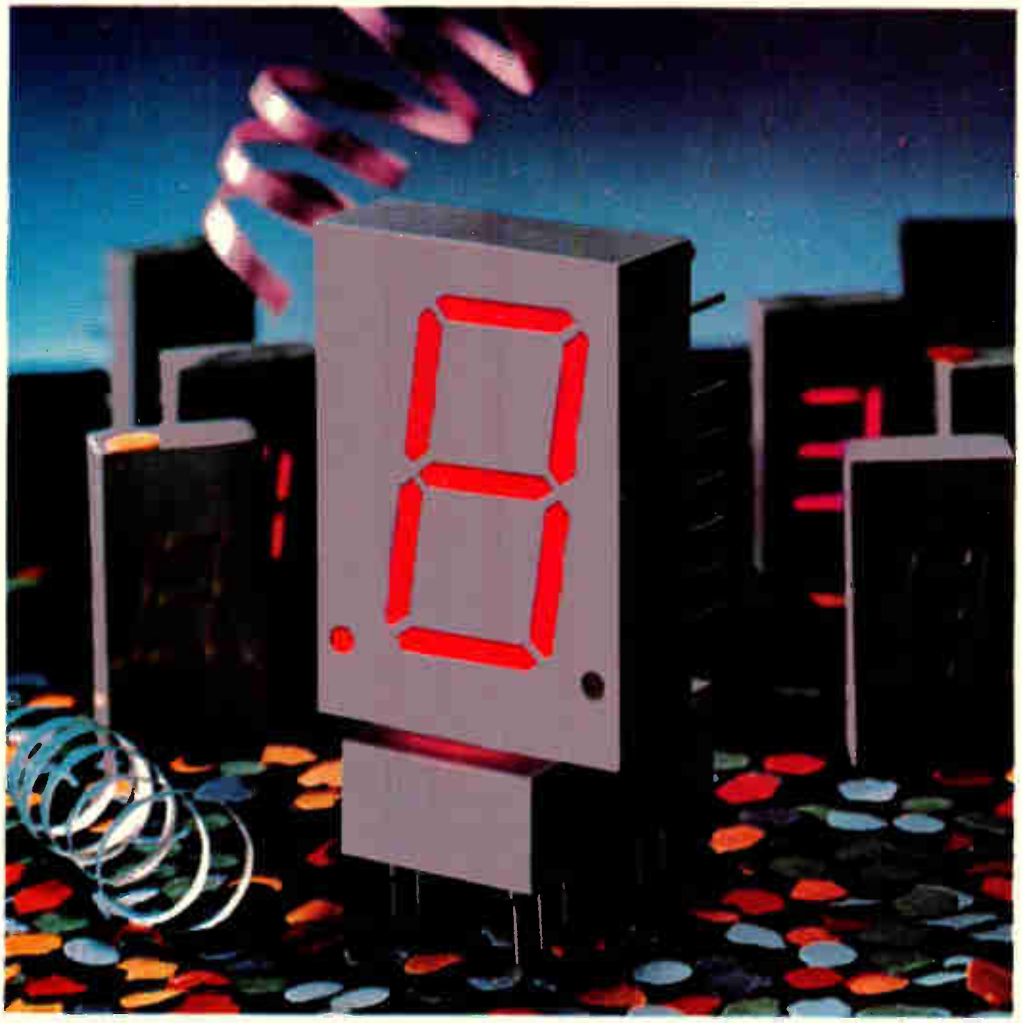

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Electronics

The International Magazine of Electronics Technology

Vol. 51, No. 11 • May 25, 1978

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Highlights

Cover: How to multiplex LCDs, 113
Multiplexing can solve the cost problems of using liquid-crystal displays in large multiple-character applications. The trick is to choose the right multiplexing technique and the right LCDs.
Cover by Robert Strimban

Europe mulls TV broadcast by satellite, 99
The technical problems of a multinational satellite to beam television broadcasts in Europe are well on their way to solution. That leaves only the political problems, which may result in various countries going it alone, separately or jointly.

Microcontroller incorporates a-d converter, 122
A single-chip microprocessor aimed at high-volume control applications includes all the hardware for analog-to-digital conversion. The result: a microcomputer that cuts interface software and component count to achieve a minimum system cost.

NCC spotlights new computer roles, 157
The role of computers in solving the world's energy crisis, plus the effects of the computing industry's growth, are the major themes at this year's National Computer Conference. For an incisive review of the program, turn to page 157, and for a thoughtful overview of equipment that will bow, turn to page 171.

And in the next issue . . .
LSI tackles data-link management . . . a product-development profile on a microprocessor-controlled digital voltmeter . . . a look at bi-FET technology.

Electronics

Publisher's letter

In the fall of 1976, when Intel Corp. introduced the 8021 single-chip microcomputer, the follow-up to the device was virtually ordained. "We saw at the time that future parts built around the 8021 would need two things," says Jeff Miller, product manager for the 8020 series. "The first was a 5-volt dynamic random-access memory and the other was an analog-to-digital converter."

The result is the 8022 one-chip microcontroller, reviewed in the technical article starting on page 122. The 8022 is a case study in product planning, from concept to final design and production. Project manager Gene Hill articulated the basic 8021 concepts. He was instrumental in the 8022 product definition and worked closely with coauthor Miller.

Co-captains of the design team were engineers Bill Check and Mark Hollen. While Check did the logic layout, Hollen worked on the designs of the RAM, which was proved out on the 8021, and the a-d converter. Ed Cheng also assisted on the layout of the converter.

Because of the nature of the RAM and the converter, product development was rather unusual, Miller comments. A test-chip version of the part was actually fabricated way back in the beginning of last year, so that by midsummer most of the reliability and feasibility studies had been accomplished.

"At that time, we knew that the RAM and the converter worked, and we were ready to get the 8022 into production," Miller adds.

Technology updates serve as quick surveys to bring you up to date on a particular product category. While we have regularly been covering different forms of automatic wiring, packaging and production editor Jerry Lyman felt it was time to do a wrap-up.

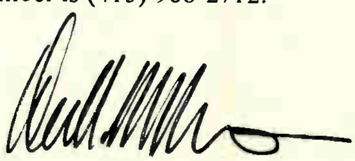
The result, which starts on page 134, describes how the hardware and production methods have evolved. Included in the article is a chart covering all the major automatic-wiring techniques now available. This chart was originally put together by Linda Jardine of Gnostic Concepts Inc. in Menlo Park, Calif., and Steve Grossman, formerly with the same firm but now at Moser Associates of Palto Alto, Calif.

"The chart updated me too," Jerry observes. "Tiers [for Through Insulation Electronic Reflow System] seemed new to me, but actually it's a reemergence of an older concept spurred by recent growth of high-density packaging."

1000 Elwell Court, Palo Alto, Calif. That's the address of our new editorial offices for field editors Bill Arnold and Rob Brownstein covering the San Francisco region. This arrangement puts our reporters much nearer to the many electronics firms on the Peninsula without hampering their ability to move around the rest of the region.

"Rather than being 'up there' in San Francisco, an hour's drive from the main concentration of news sources," says bureau chief Bill Arnold, "we're now in the action."

Incidently, the new telephone number is (415) 968-2712.



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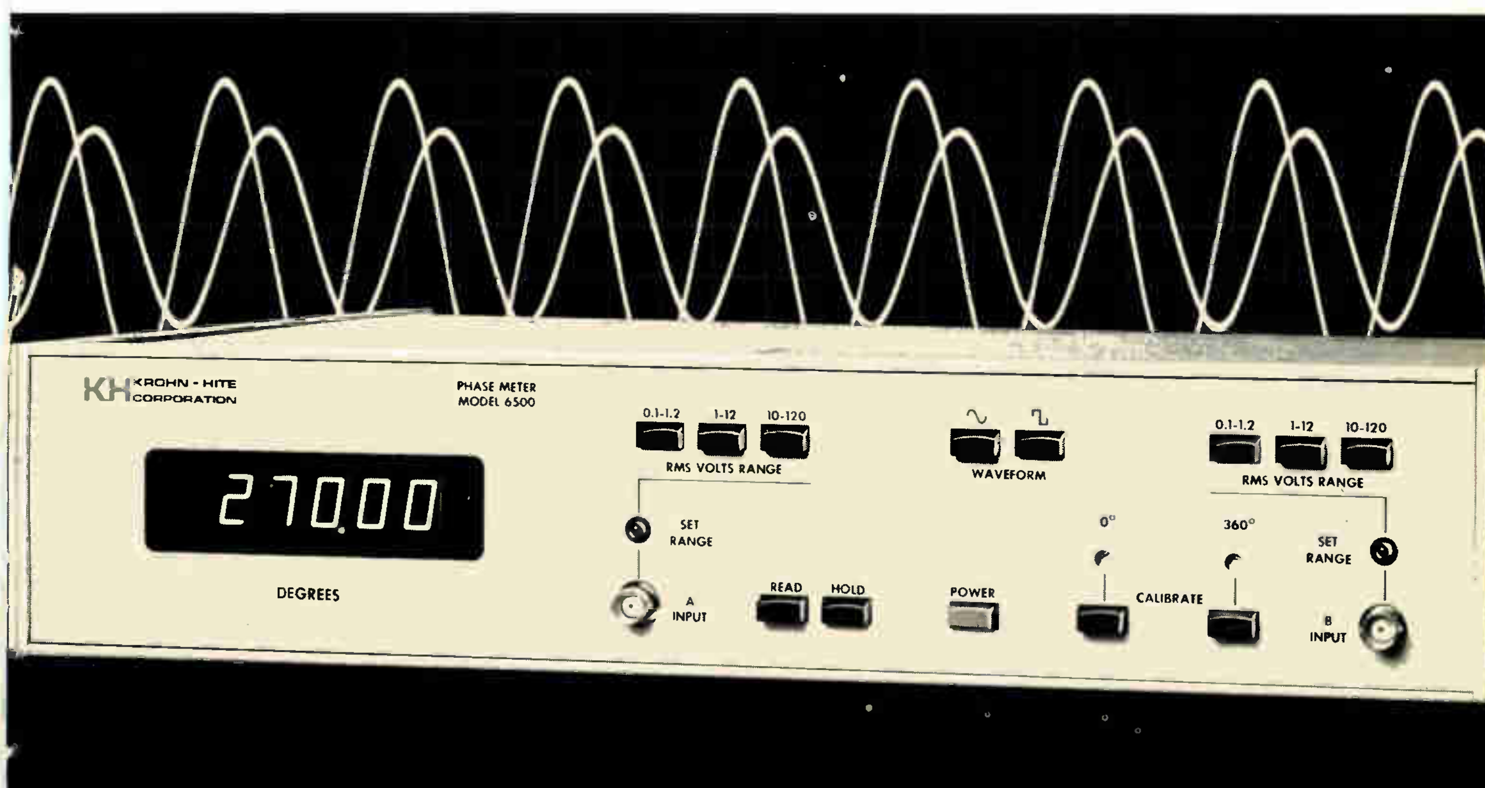

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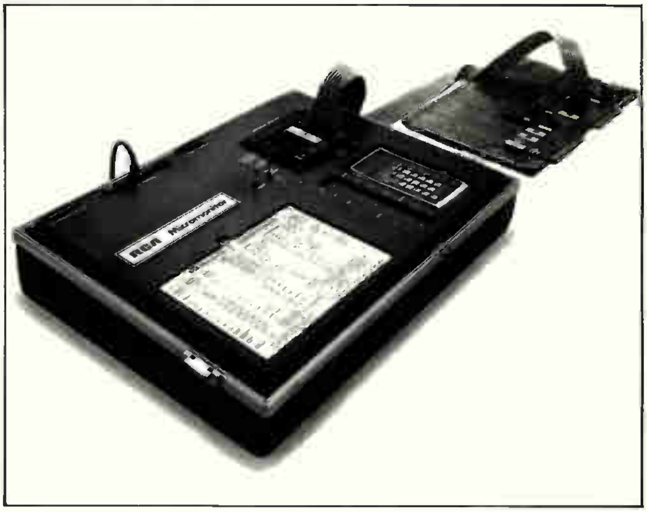

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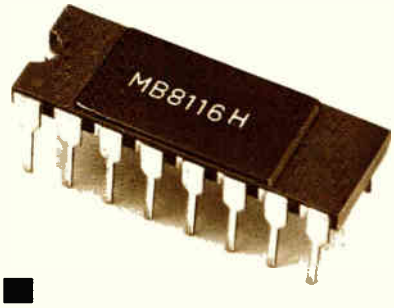

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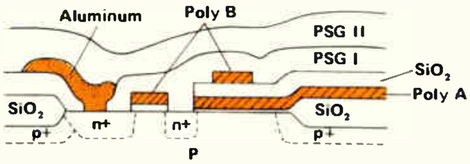

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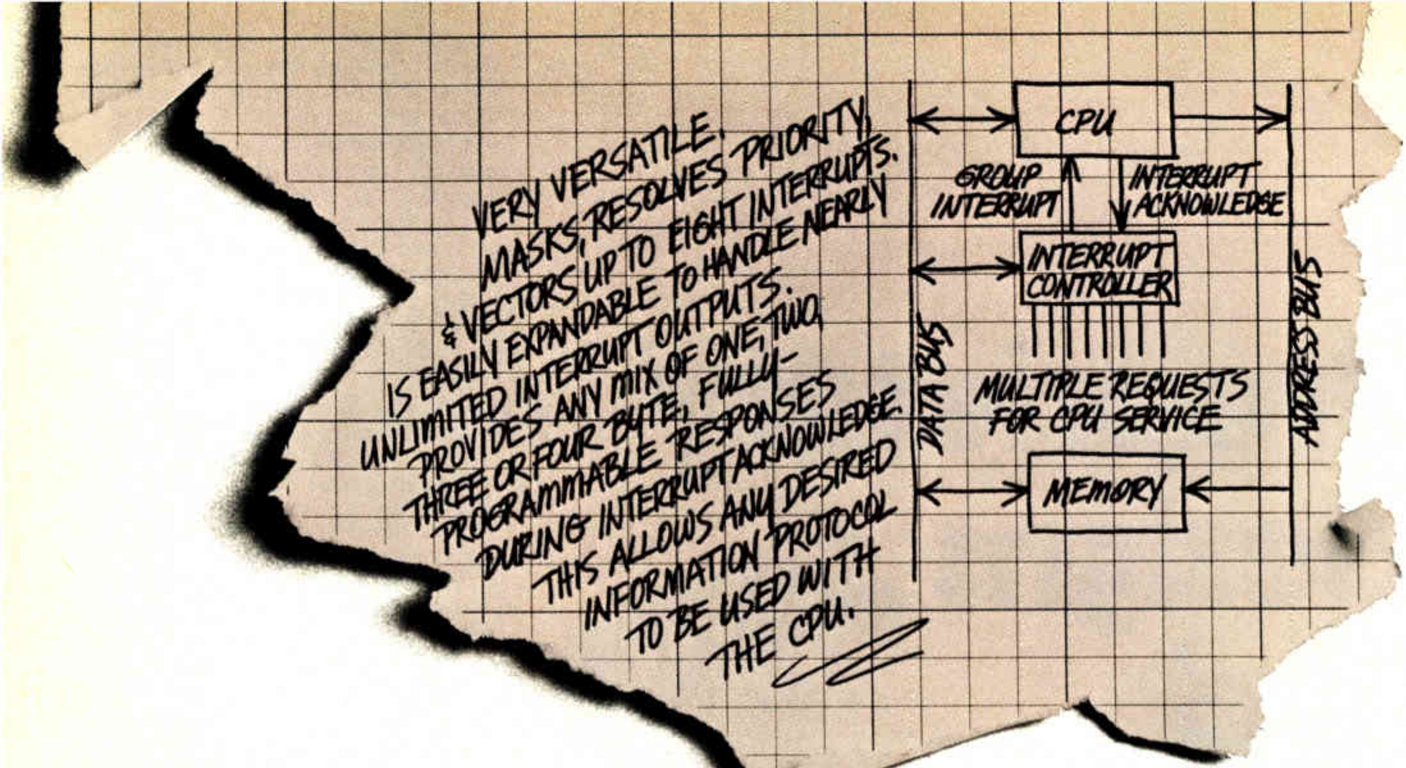

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People

Computer lines are blurring says National's Robinson

By now it is almost a truism that the distinct lines of demarcation between microcomputer, minicomputer, and mainframe systems are difficult to discern, points out Daniel N. Robinson, 43, director and general manager of the new System/400 product line at National Semiconductor Corp., Sunnyvale, Calif. Moreover, he anticipates even more blurring of the lines as his firm and others expand their product lines in the OEM markets.

"In the early 1970s, between 60% and 80% of the minicomputer market was to original-equipment manufacturers, who put the minis in systems to solve some control problem," he says. "With the advent of 8- and now 16-bit microprocessors, that OEM market began to erode for the minicomputer people, and expand for the semiconductor manufacturer turned microcomputer system maker." As a result, the market has become fragmented.

Products like the System/400 or Two Pi Co., V/32 [*Electronics*, May 11, p. 84/228] muddy the waters even further, in the opinion of the former engineering director at Xerox Corp. These new systems look, smell, and taste like minicomputers but have capabilities that inject them into the midst of the mainframe market. Suddenly, there are lines of competition that pit the microcomputer/integrated-circuit makers against the massive data processing giants.

Fourth slot. For their part, the minicomputer manufacturers are reacting by shifting the product lines into this newly emerging fourth slot, the one between the traditional mini and mainframe system. An example here is a system, like Digital Equipment Corp.'s VAX, with its expanded word widths.

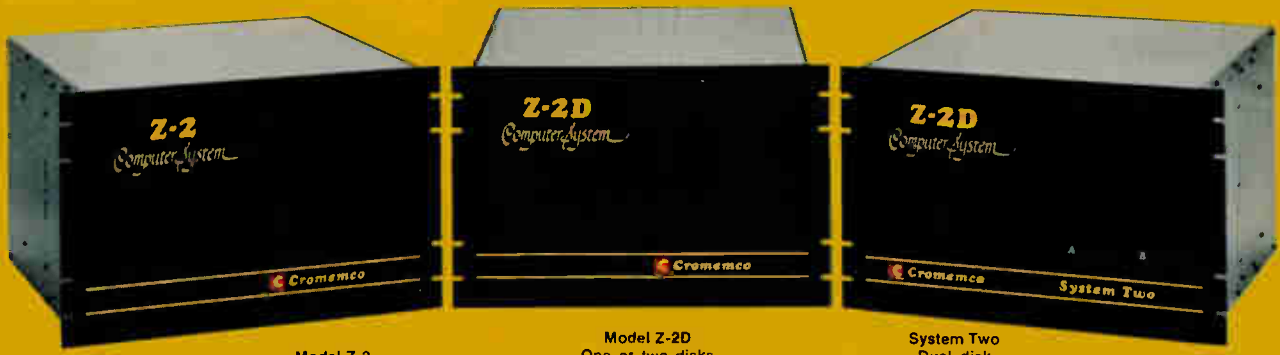
At the top, IBM is pushing down, with aggressive assaults on the minicomputer marketplace with a variety of small- to medium-scale systems. "At present, IBM has less than a 1% share of that minicomputer market, but by 1980 they are likely to have about 15%," Robinson says. He sees more changes in store as manufacturers respond to the marketing pressures from top and bottom.

Emerging is a redefined computer systems industry, with the three levels of products beginning to merge across what had once been wide chasms of functional capabilities. Besides the fourth level positioned between mini and mainframe, there is likely to be a fifth, positioned between micro and mini. It will come about as the IC makers keep packing more functions onto slabs of silicon and replace 16-bit systems with a single printed-circuit board, Robinson believes.

Adm. Briggs wants electronics his recruits can handle

When Secretary of Defense Harold Brown stresses the need for increased reliability and better and simpler maintenance of weapons systems as he has done this year, Rear Adm. Edward S. Briggs finds himself in complete agreement. The Navy's recruiting commander, Briggs believes too few electronics hardware designers appreciate that the operational environment also includes the "software" known as

Plea. Hardware designers should pay more attention to skills of Navy users, says Briggs.



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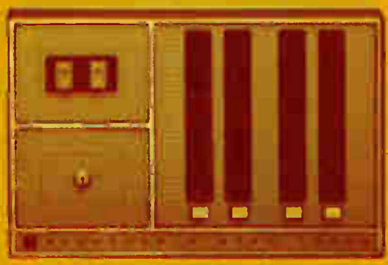

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operators and maintenance personnel—many of them 17 to 21 years old and without a high school diploma. The degree of electronics sophistication in a Navy ship or airborne system doesn't matter, he points out coolly, "if, when you turn it on and it doesn't work, you can't find someone qualified to fix it."

High school grads. The Navy is pushing hard to recruit high school graduates for operations and maintenance training, he says, because "their retention rate is twice that of non–high school grads" when it comes time to ship over (Navy talk for reenlistment). Not only does the Navy get a bigger return on its investment in technical schooling, he points out, but the fleet and shore stations also get better performers than they do from the sailors without high school diplomas.

"Jobs like missile, sonar, and fire-control technicians are the toughest to fill," Briggs points out, because training in these areas is perceived as having relatively little application in the civilian job market to which most recruits will ultimately return. On the other hand, many recruits—who now can pick their specialties before signing up with the all-volunteer force inaugurated after Vietnam—clamor to become data processing or electronics technicians, where service openings are more limited. "What is often misunderstood," Briggs says, "is that fire-control trainees get at least as much electronics schooling, sometimes more, than the more popular ratings."

Avionics and aircraft specialties—even including pilots' positions in which the Navy has the biggest training investment—are getting tougher to fill, says the admiral, who has spent 33 of his 51 years in the service as a pilot and a commander of destroyers, frigates, and cruisers. That problem is one he attributes to the upturn in civil aviation manufacturing and air travel [*Electronics*, May 11, p. 58]. Another factor is that military electronics contractors offer the Navy's most skilled performers higher-paying jobs closer to home. "That," Briggs says, "is a problem that will always be with us." □

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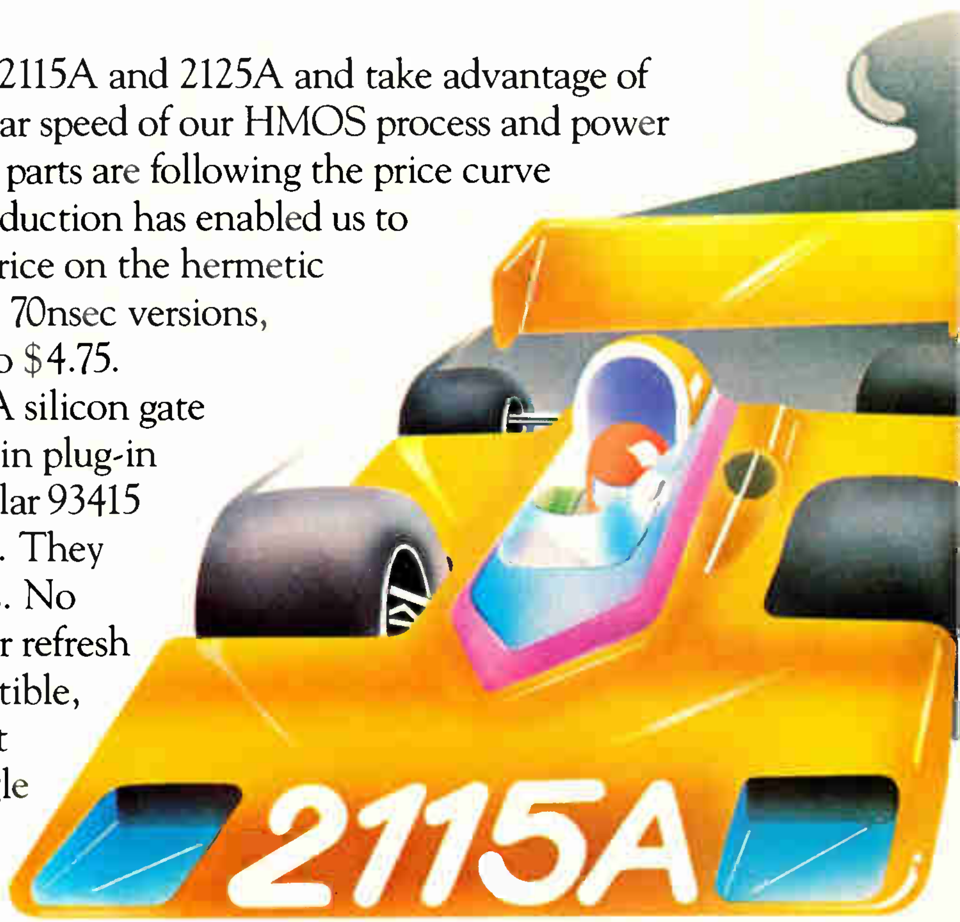

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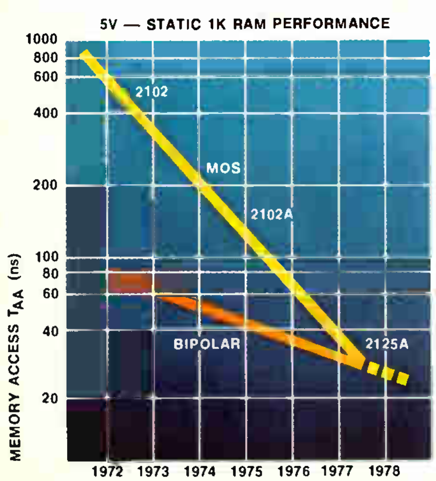

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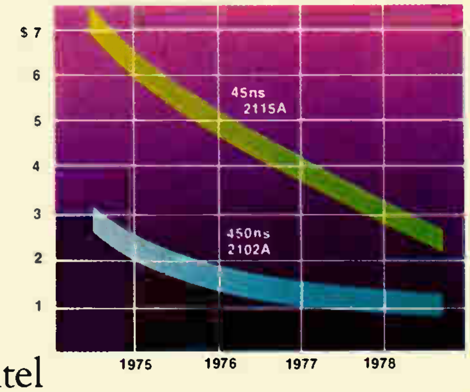

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Circle 23 on reader service card

Editorial

Western Europe takes aim at the IC market

Say this for Western Europe's semiconductor makers: they don't give up easily. Outdistanced in the crucial technology of integrated circuits by the big American companies and falling behind the Japanese as well, they have been struggling for years to find a way to catch up. Now they are counting on stepped-up backing from their governments to do so, and some are also investing in the U. S. market through outright acquisitions and joint ventures. If these moves do the trick, American producers of ICs could one day see their market share trimmed in Western Europe and even to some extent in the U. S.

The national programs look fairly impressive. The West German government, for example, this year winds up a $140 million program to abet research and development in semiconductors, an ante that presumably will go higher for the next five-year program. France this year gets started on a $130 million, five-year effort aimed at building a solid native IC industry. Department of Industry officials in the United Kingdom are working on a support scheme that could add up to $100 million in aid over the next five years. There will also be money for ICs in the $450 million program that the Italian government has in mind to strengthen its country's electronics industries.

It is a mistake, though, to think that these programs could somehow cure Western Europe's chronic IC deficit. At the very best, they will make it possible for semiconductor houses to stay close to the state of the art, particularly in very-large-scale integration, and pass that competence along to equipment makers so they can stay competitive. No national market in Western Europe is large enough to nurture a world-class IC house, and efforts to put together "European" computer companies and semiconductor companies have been so disastrous that no one dares suggest the idea anymore.

So despite the backing they are getting from their governments, European semiconductor makers now are down to just two strategies if they want to stay in the IC business and not lose a lot of money at it. One is to specialize—find a niche and stay small—something no major company wants to do. The other is to tie up with an American firm and gain access not only to the technology but to the experience of no-holds-barred IC marketing.

Philips Gloeilampenfabrieken of the Netherlands, far and away the largest electronics group in Europe, did just that when it bought up Signetics Corp. three years ago. The strategy has really paid off, for, among other things, Signetics' sales have nearly doubled and Philips has boosted its IC sales in Europe. Since then, Siemens AG, West Germany's largest electrical/electronics firm, has more or less followed suit and taken a minority holding in Advanced Micro Devices Inc. Great Britain's General Electric Co. (no relation to its U. S. namesake) or Plessey Ltd. may well wind up in a joint venture with a U. S. firm and the British government's National Enterprise Board.

Even in France, where technological independence is particularly cherished, government planners are trying to sign on American partners for their IC plan. Since West European firms are wary about doing business with Japanese semiconductor houses, it seems the only way.

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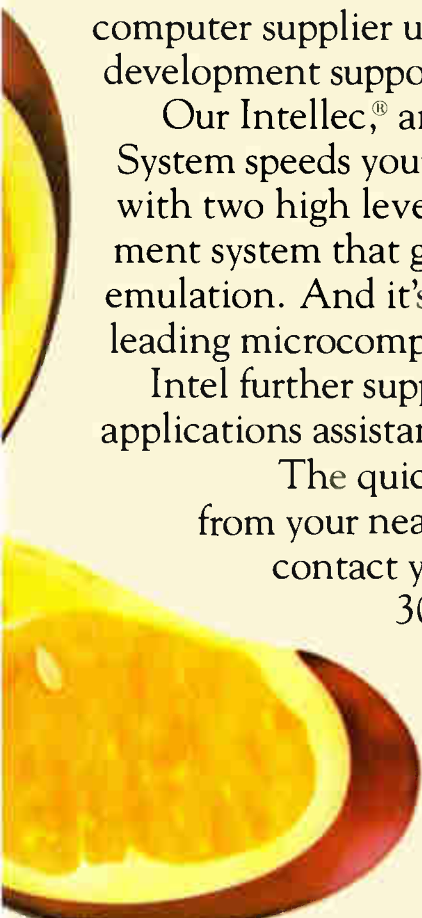

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Circle No. 29 for more information

Motorola announces 12 UB types to complement the #1 CMOS B-Series

Nine gates, two buffers, and an array are now available from Motorola in conformance with the JEDEC CMOS B-Series standard for UB devices. The six major gates (see table) are now available both ways, as B or UB. That's buffered or unbuffered. Although construction of these devices differs, pinouts are the same.

The UB listings are included with all the recent updating in our new revision of the CMOS Pocket/Wall Selector Guide, just off the press. And, when we talk about reliability, we back it up. The details are now compiled for 1977 and spelled out in our new report on CMOS IC Reliability, 1978.

Copies of both these new pieces, plus new UB data sheets are yours for the asking. Send your letter or the coupon from this ad to Motorola Semiconductor Group, P.O. Box 20912, Phoenix, AZ 85036. Please specify which items you want.

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Responding to demand, Motorola shipped industry record quantities of CMOS units in 1976 and 1977 from our ultra-modern, high-capacity facilities. In doing so, we earned that big number 1.

We earned it by delivering over 100 million units in 1977 alone, and by shipping about a third more product than *anyone* else for the past two years. Our nearest competition claimed 200 million pieces of CMOS over 10 years of its manufacture.

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We're committed to doing whatever it takes to serve you better in CMOS.

Motorola UB CMOS

Part No. MC1xxxx	Function	UB Data Sheet Available	B-Series Available
4000UB	Gate		
4001UB	Gate	✓	✓
4002UB	Gate	✓	✓
4007UB	Array	✓	
4011UB	Gate	✓	✓
4012UB	Gate	✓	✓
4023UB	Gate	✓	✓
4025UB	Gate	✓	✓
4049UB	Buffer	✓	
4069UB	Buffer	✓	
4501UB	Gate		
4572UB	Gate		

TO: CMOS
Motorola Semiconductor Group
P.O. Box 20912, Phoenix, AZ 85036

Please send me:

☐ CMOS Pocket/Wall Selector Guide, Spring, 1978
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Mostek first to sign for Microcobol

The first customer for Microcobol, a British-developed version of the popular business language that's scaled down for microcomputers, will be Mostek Corp. The Carrollton, Texas, microcomputer manufacturer **will first use the language on its Z80-based AID-80F development system,** to be shown at the National Computer Conference in Anaheim this June. The developer of Microcobol is CAP-CPP of London, which has agreed to split fifty-fifty a $3.6 million development program to promote Microcobol. Britain's National Research and Development Corp. and the National Computing Centre have thus far contributed nearly $1 million in development funds to the project.

New crucible delivers 5 ingots before replacement

A modified silicon-crystal-growing furnace fitted with a recharging mechanism that can deliver not the customary one but five crystals or ingots without replacement of the crucible has been demonstrated by the Lexington Vacuum division of Varian Associates. The Lexington, Mass., division has a contract from the Department of Energy for continuous Czochralski growth of silicon aimed at reducing the cost of solar cells for terrestrial use. As part of the effort, administered by the Jet Propulsion Laboratory, Pasadena, Calif., Varian engineers designed a hopper, vacuum system, and vibratory feed mechanism that recharges the Varian model 2850 furnace while the most recently completed crystal is cooling in a chamber above it.

The technique has cut conventional hand-fed loading and melt-down time before crystal growth is started from 2½ to 1¾ hours. More important, however, it has shown that up to 100 kg of crystals can be produced without crucible replacement. That's a considerable improvement: five times better than today's conventional methods, which require quartz crucible replacement—at a cost of $190 to $240—after each 20-kg crystal is pulled.

Philips readies PCM audio set

Philips of the Netherlands is preparing to jump into the pulse-code-modulation audio systems market. What it calls its compact disk system will be available in Europe first and then in the U. S. in the early 1980s and consists of a player and disks that are played back optically by means of a diode laser in the pick-up arm. The system's audio information will be stored on the smallest disk yet introduced in the market: **with a diameter of 11 centimeters, it plays for one hour** in stereo. It has a variable speed, but a constant tangential velocity of 1.5 meters per second. Information is stored digitally with a 14-bit PCM encoding system.

$33.4 million goes to TRW for tracking sites

An initial $33.4 million contract for five sites for the Ground Electro-Optical Deep-Space Surveillance System has been awarded to the Defense and Space Systems Group of TRW Inc., Redondo Beach, Calif., by the Electronic Systems division at Hanscom Air Force Base, Bedford, Mass. The real-time system, **which will pinpoint and track man-made objects in space at 3,000 or more nautical miles** [*Electronics*, Jan. 6, 1977, p. 34], includes a sophisticated telescope equipped with electro-optics, a television camera, and a computer as well as system-related electronic and communications equipment.

Intersil unveils versatile one-chip counter

One of the first of a flurry of chips due from Intersil Inc. is a single-chip counter to be introduced this summer. Capable of directly driving a light-emitting-diode display, the universal counter does it all: **frequency and time measurements and counting at a speed of up to 10 MHz.** The Cupertino, Calif., company says that the part, which is built with complementary-metal-oxide-semiconductor technology, will replace hundreds of dollars worth of hardware that goes into the more sophisticated period/frequency-measuring instruments.

High-speed modem from Racal aims at distributed processing

A high-speed modem for pooled distribution data networks, where large numbers of terminals are sequentially called up, has been developed by Racal-Milgo Inc. in Miami. The modem can handle 9,600 bits per second, **and a custom microprocessor accomplishes line equalization in less than 30 ms via a parallel-processing technique.** Conventional modems take 70 to 250 ms. Optional features available include multiporting and dynamic port allocation, modem sharing, and dual secondary channels.

Rockwell prepares to go commercial with C-MOS on sapphire

After using silicon-on-sapphire for complementary-MOS devices in limited quantities for its own military electronics programs, Rockwell International's Microelectronics division is eyeing the commercial market, where interest in the long-delayed technology is building. Rockwell, however, contemplates coming out with brand-new commercial designs rather than converting existing military configurations, says a spokesman. Currently, the Anaheim, Calif., unit is defining specifications for "fast computational microprocessors using C-MOS-on-sapphire silicon-gate technology **for communications and data processing, where speed is important,"** the official says. No schedule is nailed down, since a business plan for selling the devices remains to be set up. Rockwell would build the SOS semiconductors in its Newport Beach, Calif., facility, the center of all its commercial production, rather than at the Electronics Research Center in Anaheim, which is limited to small-run military orders.

Addenda

Siecor Optical Cables Inc., the joint venture spawned by Siemens AG and Corning Glass Works, has just slashed up to 40% off the price of its fiber-optic cables. The best bargains, of course, are in the long runs—10 kilometers of one-, two-, or four-fiber cable can now be had for $1.75 per meter, reduced from $2.90 per meter. Among the reasons for the drastic discounts, says the Horseheads, N. Y., company, are **manufacturing expertise and skyrocketing sales;** and though Siecor won't say, several very large contracts apparently in the offing are also responsible. . . . Now that AT&T and Bell Laboratories have pronounced their joint experimental optical-fiber communications link in Chicago a success, **AT&T says it will have a light-wave link in regular operation by the end of 1980.** A site hasn't been selected, but being considered are Chicago, Washington, D. C., New York, Los Angeles, Pittsburgh, and a line between Rochelle Park and Union City, N. J. . . . RCA Corp. is expanding its line of home video cassette recorders. Among the new models is one, the VCT400, **that can be programmed to record up to four shows on different channels over a period of seven days.** The new machines, like the rest of the firm's VCR line, are built to RCA specs by Matsushita.

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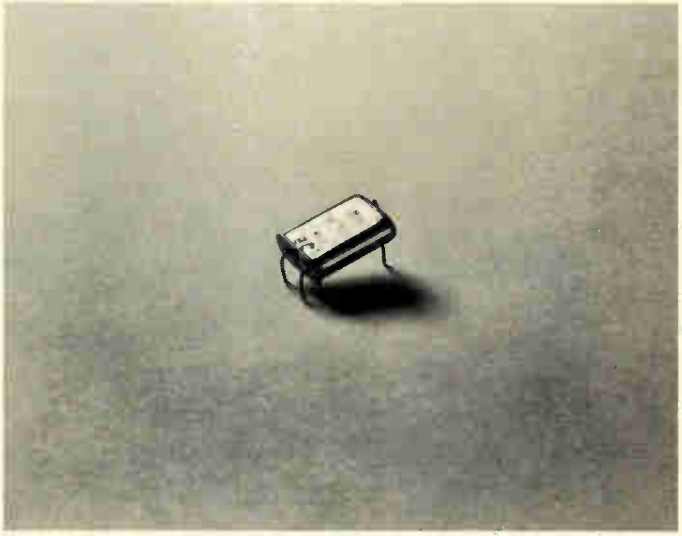

National's new DP 8350 CRT controller needs only one.

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If you'd like to know more about the DP 8350, you're not alone. So we suggest you fill out the coupon today.

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To earn your continuing support, we are now employing HTRB Hi-Rel testing for every diode used in the SRA-1, at no increase in cost to you. So, for the same low price of $7.95, you can purchase our SRA-1, with a two-year guarantee, including diodes.

To ensure highest system reliability demand highest quality diodes on your source-control drawings and purchase orders. Specify SRA-1 mixers, with HTRB tested diodes from Mini-Circuits'.. where low price now goes hand-in-hand with unmatched quality.

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Freq. range (MHz) **LO** - 0.5-500, **RF** 0 5-500, **IF** dc 500

Conversion loss (dB)		**Typ.**	**Max.**
One octave from band edge		5.5	7.0
Total range		6.5	8 5
Isolation (dB)		**Typ.**	**Min.**
Lower band edge to	LO-RF	50	45
one decade higher	LO-IF	45	35
Mid range	LO-RF	45	30
	LO-IF	40	25
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Circle 38 on reader service card

ROM program process may beat EPROMs in turnaround time

Boron-implant technique from Standard Microsystems fixes data in memory after wafer is virtually completed

That David among semiconductor industry Goliaths, Standard Microsystems Corp., is changing the way it fixes data in read-only memories. And as a result, it will start offering by the end of the summer "very fast turnaround on both standard and custom MOS devices, particularly mask-programmed read-only memories and microcomputers," says the company's president, Paul Richman.

He is not yet able to specify the exact turnaround times, but Richman feels he will have "a low-cost alternative to the erasable, programmable ROM as a separate chip or incorporated in a single-chip microcomputer." More expensive than ROMs, erasable PROMs are generally used during prototyping, when debugging a system requires changes in its program.

The small Hauppauge, N. Y., company, with $8 million in sales last year, calls its new process Clasp, for Coplamos last-stage programmable. Coplamos in turn refers to another Standard Microsystems process, licensed by several industry giants, for fabricating high-speed, high-density n-channel metal-oxide-semiconductor integrated circuits.

Completed wafer. Clasp is able to speed turnaround time because, in effect, it fixes the data in the memory very late in the process, "essentially after the wafer is virtually completed," according to Richman. That is markedly different from most other approaches, which code the ROMs early in the production process, "frequently during the very first photolithographic, or masking, operation," he points out. "In effect, each part is a custom part from that point on."

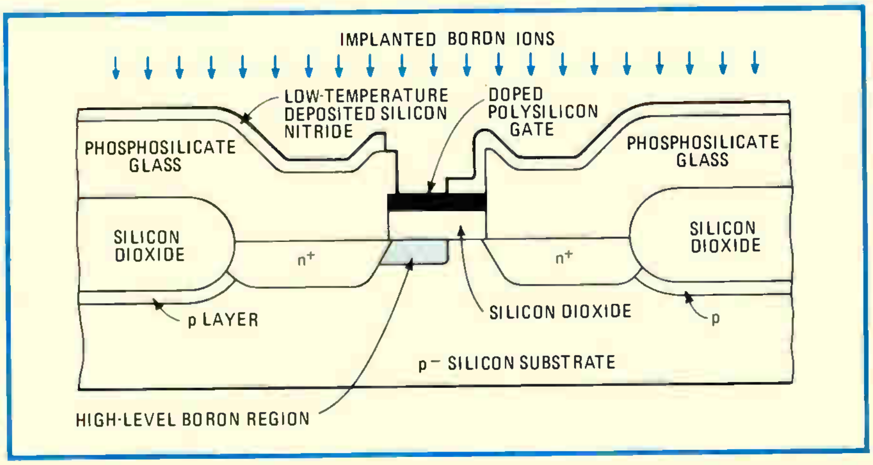
His new process, which involves a high-energy boron implantation, will allow storage of undiced wafers fabricated with final metalization and silicon-nitride passivation layers. "At that point, each ROM is flooded with 1s," he says.

When it receives an order, Standard Microsystems will reach into its inventory of almost-completed parts and code them during a final photolithographic operation. The final step is generally used to expose, or open, the bonding pads so that leads can be attached.

However, additional small openings are made in the passivation layer, positioned over bit locations where 0s must be created. These are made by implanting boron, a commonly used p-type semiconductor dopant, so that it penetrates the polysilicon gate and the underlying silicon-dioxide gate insulator, as shown in the diagram.

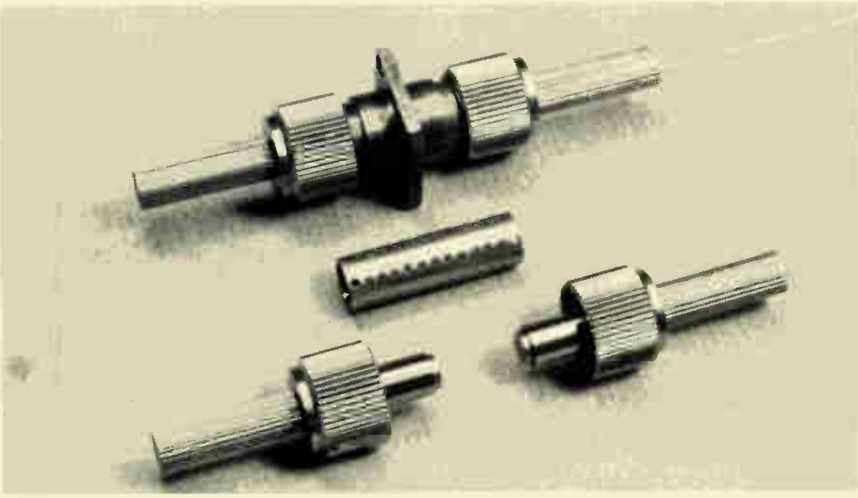
Cut off. The boron also penetrates the top surface of the silicon substrate, creating a high boron concentration region in the channels, increasing the threshold voltage of the selected devices, and cutting off conduction between their drains and sources. The threshold voltage can be increased in this manner to a level equal to or greater than the maximum positive power supply voltage applied to the n-channel devices, Richman explains, "and this results in turning into 0s bit locations that were 1s."

Initially, the Clasp process is being used in a soon-to-be-introduced high-speed, video-display attributes controller for cathode-ray-tube terminals. Called the CRT 8002, this 20-megahertz-plus chip



Memory. Clasp process puts 0s in memory via a high-level boron implant that creates a high threshold for the device, blocking the flow of current between drain and source.

Connection. Alignment sleeve, center, is used to join two halves of single-mode fiber connector. Complete unit, top, averages only 0.47-dB loss after 1,000 connect cycles.



but it is the first of its kind for the single-mode strand. Moreover, it has a relatively low loss and is readily detachable.

The loss, including reflection at the two fiber ends, averages 0.47 decibel even after 1,000 connection cycles, according to the company. This is about what would be expected with connectors for the larger-diameter fibers. The company expects to use the connector in its future fiber-optic transmission systems but has no plans to sell it as a component. Other organizations have developed connectors for single-mode fibers, but so far these devices have been limited to use in the laboratory.

Modulation scheme. Musashino makes the connection by using a mechanical modulation technique. One end of the fiber is placed in a connector plug and illuminated at its far end. A lens system magnifies the light emerging from the fiber on the plug side and directs it through two vibrating orthogonal slits. The slits convert the fiber's position into a modulated light signal.

The vibration frequency component is photoelectrically detected while the fiber is being centered in the plug so as to minimize the signal amplitude. Aligning the fiber with the plug's center to within a 0.3-μm average accuracy establishes a zero reference.

The fiber is aligned within the plug using a two-eccentric-tube mechanism first employed for multimode-fiber connectors. Epoxy holds the whole assembly together. The process is repeated for the other half of the connector. The two halves are connected by a sleeve-and-ball-bearing arrangement that can be disconnected easily.

Modulation rates of tens of gigabits are theoretically obtainable for single-mode fibers, whereas only tens or hundreds of megabits are typical for multimode fibers. However, until some means for modulating at the higher rates is readily available and the need for it increases, multimode fibers will continue to be used because they are still more practical mechanically. □

Why bother with 10-μm-wide fibers?

Why is Nippon Telegraph and Telephone working with small-diameter single-mode fibers when multimode fibers are wider by an order of magnitude or more and, therefore, easier to handle? Because single-mode fibers propagate optical signals in a way that offers wider bandwidth. With its constant refractive index throughout, only one electromagnetic field is transmitted along the direction of propagation. The smaller the diameter, the less likely that unwanted field configurations or modes will be set up.

The thicker fibers have either stepped or continuously varying indexes of refraction across their cross sections. They can transmit many field configurations simultaneously. Bandwidth is limited here by the delay, dispersion, and distortion associated with the different modes caused by the different distances that the signals travel along the fiber. In other words, bandwidth is limited by the different arrival times at the detector.

Solid state

Signetics readying 2,000-gate array

While other semiconductor manufacturers enter the growing gate-array market with chips featuring up to hundreds of gates each, Signetics plans to push even further ahead next month by offering an array of 2,000 gates made with integrated injection logic. Unlike the others, who peg their speedy arrays toward the demands of computer mainframes [*Electronics*, April 27, p. 83], Signetics is targeting its new 8A2000 at medium-speed random-logic applications. Here, fewer interconnections are even more important than blinding speed.

With its 2,000 gates, the 8A2000 can replace about 35 small-scale and medium-scale integrated packages on a printed-circuit board, says John Woodman, strategic marketing manager for custom LSI programs in Sunnyvale, Calif. He is aiming at applications in terminals, magnetic media, stand-alone processors, digital multiplexers, instruments, and input/output interfaces.

Two-year life. These are products that change every two years, according to Woodman. This short a product life argues for a quick development time. A completely custom design would be inappropriate because volume is likely to be low. The gate arrays let a customer interconnect a "custom" design through the final metalization layer placed on an array of unconnected gates.

Although the smaller arrays for the mainframe market employing emitter-coupled logic are faster, Signetics' I²L process is reasonably quick. Typical propagation delays are 15 nanoseconds, so that with an injection current of 0.15 milliampere the speed-power product is typically 2.3 picojoules. This equals the performance of low-power Schottky transistor-transistor logic on an equivalent function basis.

One beauty of the gate-array approach is that a customer can see working prototypes in less than four months, as against 12 to 18 months with custom large-scale integrated circuits of comparable size. Moreover, Signetics maintains that the array, with two layers of metalization for interconnecting, is easy to hook up. "If an engineer can lay out a two-layer printed-circuit board, he can lay out this gate array," Woodman tells potential customers.

Yet the 8A2000 gives a customer considerable design power. On a chip measuring 190 mils by 230 mils there are 1,920 three-collector I²L gates, 60 Schottky transistors for high-fanout logic, and 38 multifunction input/output cells. Each of the cells can be programmed for three-state, active pull-up or open-collector outputs. For inputs, the pnp configuration features high impedance and high noise immunity. Of course, a designer would not use all of the gates. Woodman says that a highly regular structure might use 1,400 gates, a highly random one less than 1,000.

Design charge. A $30,000 total design cost includes 1,000 parts; additional parts cost less than $18. Woodman concedes that an SSI- or MSI-based circuit might be cheaper, but the 8A2000 offers better reliability and in effect a higher speed because there are no interconnections over large areas of board space.

Signetics is actually honing its bipolar expertise to cover a gamut of custom-array approaches. On the low end—low speed and fewer functions—it already makes field-programmable logic arrays and field-programmable logic sequencers in low-power Schottky. It will target the 8A2000 at a few select customers before making it more generally available. Besides the I²L 8A2000, it plans next year to offer another array in an advanced I²L process (see "Signetics readies combination process"). And it will continue to make fully custom bipolar chips, which it has been doing for years. □

Signetics readies combination process

Also in the works at Signetics Corp. are the first devices made with a new process developed at Philips Gloeilampenfabrieken, Signetics' parent concern in Eindhoven, the Netherlands. Called ISL, the process is a cross between the high speed of Schottky transistor-transistor logic and integrated injection logic. The results reported so far by Signetics reflect the combination: gate delays are a quick 3.5 nanoseconds, and each gate draws only 400 microamperes.

"The approach started as an attempt to create Schottky logic with I²L technology," explains Ron Treadway, design manager in the Logic division of Signetics in Sunnyvale, Calif. Although the new process is not quite as dense as I²L, it makes several important changes in conventional I²L technology. First, the transistors have been changed from an inverted configuration to a normal one. Second, the current-source transistor is replaced by a resistor in all configurations except those where a specific operating point is needed. Lastly, the multiple-collector outputs have been replaced by a single collector with multiple Schottky diodes, which improve speed and fanout.

ISL is "a more forgiving technology," to quote Treadway. "For one thing, it tends to current sharing among collectors." Other advantages over I²L include less noisy operation and the elimination by the Schottky diodes of the dependence of speed on load current.

Signetics' first commercial device, due early in 1979, will be a 1,200-gate array to compete with gate arrays made with emitter-coupled logic. It will offer the same design benefits as the 2,000-gate I²L array (see story) but, with its higher speed, it will be aimed at mainframes. And it will surpass emitter-coupled logic in density, power, and price, says Signetics.

Communications

Air Force works to ready digital phone

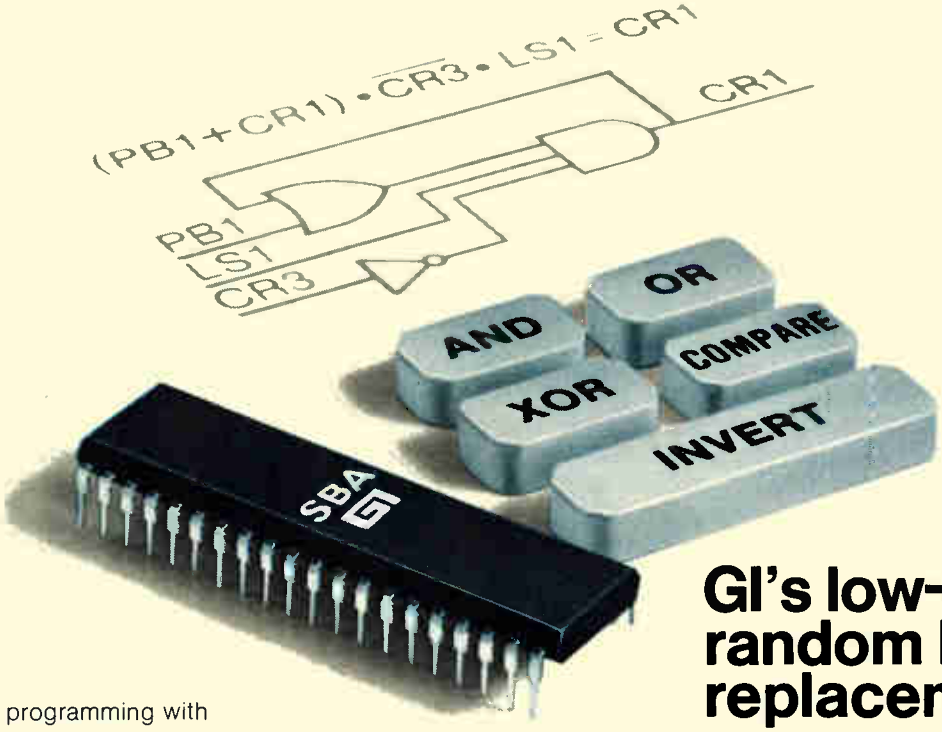
Especially in tactical military situations, digital telephones have a number of advantages over analog ones. That's why the Air Force is going digital for its primary field phone in the Joint Tactical Communications System wherever secure transmission is not required.

As the first step, the Air Force Systems division awarded a $730,000 validation-phase contract to Electronic Communication Inc. of St. Petersburg, Fla. But Capt. Bradley Spink, the phone project manager, says a request for proposals for full-scale engineering development will be issued in fiscal 1979 to other companies as well.

Thirty phones. The validation phase, meanwhile, will be completed in September when ECI, a division of E-Systems Inc., delivers the final 5 of 30 phones for the Tri-Tac system. According to Spink, who works at the Electronics Systems division's Combat Theater Communications office at Hanscom Air Force Base, Bedford, Mass., and William Brown, deputy program manager for Air Force Tri-Tac tasks at Analytical Systems Engineering Corp., digital phones are potentially cheaper than analog sets furnished with similar capabilities. In addition, digital versions are more flexible and do not degrade speech quality over long distances as do the analog systems. ASEC, in Burlington, Mass., is technical adviser to the Air Force for the validation phase.

The flexibility comes in the digital

The SBA programmable controller.



GI's low-cost random logic replacement

Simple direct programming with logic statements, and a low price tag are leading features of GI's new SBA. Sequences are written using familiar Boolean logic equations as a "programming language." Now you can program timing and control functions in a range of products.

The single-chip, one-bit SBA microcomputer has 30 TTL compatible pins that can be assigned as inputs, outputs, or multiplexed input/outputs. And a 1023-word memory stores your program. A logic unit teamed with a 16-element stack interacts with a 120-element read/write memory to produce programmed outputs a term at a time.

A cost-effective alternative to 4-bit and 8-bit microprocessors, the SBA performs decision-oriented tasks efficiently at millisecond speeds.

As for applications, consider using the SBA in process timers and monitors, machine controllers, security or telecommunication systems. The SBA will do wonders for electronic games and household appliances. What's more, you can put the SBA to work converting and processing routine data in microprocessor-based systems.

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phone's ability to handle conference calls and differing priorities. The validation-phase phone can have up to four levels of priority. For instance, a tone indicates when a higher-priority call is waiting, or the call taking place can be overridden, depending on the would-be caller's rank and the urgency of his message.

The modulation technique yields the potential cost savings, according to Brown. The Tri-Tac program uses continuously-variable-slope delta modulation, because the coding-decoding algorithm associated with it is simple to implement in logic. "It's an asynchronous type of modulation that doesn't require costly synchronization circuits," Brown points out, "and it's relatively immune to noise." He adds that the technique is being used commercially by the Bell System in some rural carrier systems.

Use of CVSD modulation also allows simpler signal conditioning for satellite communications than other forms of modulation for analog phones; Brown says, "because we can interleave such signals as voice, television, and teletypewriter and condition them in bulk digitally much cheaper than would be possible with analog signals."

Sectional. There are three main sections in the phone, each contained essentially on one circuit board. A coder-decoder section digitizes analog voice signals during transmission and decodes them back into analog when receiving. A signaling section does the signal processing to establish the link between the phone and switching center, including detection of the code peculiar to each phone that will make it ring. Finally, to prevent phase inversions that could distort the signal, a modem section imposes a diphase type of modulation on the transmitted signal and strips that modulation away upon reception.

The codec section is built with integrated-injection-logic circuits, with the signaling and modem sections using complementary metal oxide semiconductors. Spink says, "The I^2L and C-MOS combinations meet the off-hook power dissipation requirement of 1.5 watts." Off-hook means with the handset in use; power dissipation with the handset in the cradle is to be less than 100 milliwatts.

The only part of the modem that does not use C-MOS is the section with the line drivers. They are bipolar because of the higher power needed to send signals over the maximum loop length of 4.5 kilometers to a switching system.

This digital nonsecure voice telephone will be linked to Tri-Tac switching systems such as the AN/TTC-39 being produced for the Army by GTE Sylvania Inc., Needham, Mass., or the AN/TTC-42 unit-level switchboard being developed for the Marine Corps by ITT Defense Communication division, Nutley, N. J.

Spink is quick to emphasize that bidders for full-scale engineering development will not be limited to the ECI implementation. Meeting the Air Force's cost figure of between $200 and $500 per phone, based on production estimates of 20,000 to 70,000, is the goal. □

Digital. Electronic Communication Inc. has delivered 25 digital telephones to the Air Force for the Tri-Tac system. Phone's three main sections are on three circuit boards.

Automotive

Optical system checks out axles

Ford Motor Co. has a new kind of worker on its assembly line—an automated optical inspection unit. A pair of film-projector bulbs and a silicon photodiode-detector array controlled by a microprocessor are checking gear ratios of axles being built at Ford's Sterling Heights, Mich., axle plant. And soon, the system may be improved to the point where it checks all the axle's features, even determining the car model it is destined for.

"We went to the axle inspection system to cut the number of axles we have to rework in the plant and to reduce warranty problems in the field," says Dennis G. German, advanced gaging engineer for Ford's Transmission and Chassis division.

Ford is also counting on the system to reduce potential recalls. Government regulations now specify speedometer accuracy and exhaust

The new SM-Relay:
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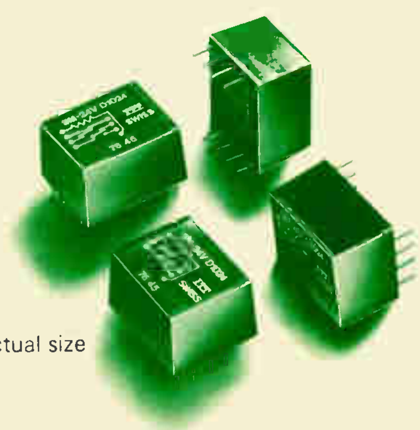

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emission, which both can be thrown off if an axle with the incorrect gear ratio is installed.

Setup. The new equipment is mounted on a gantry straddling one of the three axle production lines at Ford's 21,000-axle-a-day plant. As the axle moves under the gantry, it trips one limit switch that starts the system reading and then a second that activates a marking system that sprays a line of color that identifies the axle's gear ratio. It should match the color chalked on the axle by the employee who earlier loaded the gear assembly into the axle housing.

"We identify the gear ratio by identifying a component that's amenable to electro-optic inspection," says Walter J. Pastorius, vice president of Diffracto Ltd., the tiny Windsor, Ontario, firm that developed the system for Ford. In this case, a sensor sees the unique tooth geometry of each ring gear as it is spotlighted by two quartz halogen lamps. The 256-by-256-element photodetector array detects the gear's features.

The digital pulse train from the detector array is routed to a cabinet next to the production line where, after some signal conditioning, an Intel Corp. 8085 microcomputer compares it to a table of values that identify the ratio. It displays the ratio or an error code on a 3½-digit light-emitting-diode readout and turns on the marking system.

More. Although the optical doublecheck may seem a trivial task for the relatively sophisticated microprocessor that Ford chose, Ford opted for Intel's device so it will have enough computing capability for further automation. The car maker has already begun installing a machine that automatically fills the housings with axle lubricant and will use an optical package to detect the level of the fluid. In the future, Ford plans to add enough optics to see the diameter and width of the axle's brake drums, the length of its emergency brake cable, and the number and location of its suspension brackets.

The new installation will automatically print the model number on the paper tag that accompanies the axle to the automobile assembly plant, thanks to an A. B. Dick high-speed printer. The Ford team also has demonstrated a laser engraver that churns out permanent metal tags that will be placed on the axle. They will specify model number, axle ratio and diameter, and manufacturing date and shift. □

News briefs

CDC exec named Stromberg-Carlson president
Frederick F. Jenny has been appointed president of telecommunications equipment manufacturer Stromberg-Carlson Corp. of Rochester, N. Y., a subsidiary of General Dynamics Corp. Formerly vice president of aerospace operations at Control Data Corp., Jenny succeeds Leonard A. Muller.

Globe-Union, Square D set merger accord
In a move intended to prevent further purchases of its stock by UV Industries Inc. of New York, electrical and electronic components manufacturer Globe-Union Inc. of Milwaukee has agreed to be merged into Square D Co. of Park Ridge, Ill. A producer of switches, relays, and other electrical and electronic controls, Square D plans to acquire Globe-Union through a cash and stock transaction valued at nearly $240 million, including the purchase of up to 45% of Globe-Union's common stock at $37.25 per share. Globe-Union, whose operations include the Centralab Electronics and Globe Battery divisions, posted a net profit of $13.7 million on sales of over $227 million in its first half ended March 31, 1978. Square D earned over $116 million on sales of more than $610 million in fiscal 1977.

IBM scientists form very small bubbles
Scientists at International Business Machines Corp.'s Research division in Yorktown Heights, N. Y., say they have demonstrated that present materials, techniques, and technologies can form stable magnetic bubbles as small as 0.4 micrometer in diameter. Only 3- to 5-μm bubbles are now available commercially for data storage. The approximately eightfold decrease in bubble size, say the IBM scientists, holds the potential for a dramatic increase in the amount of information that could be packed into a bubble device in a given area. Whereas a square inch of garnet with 3-μm bubbles today can hold 3 million bits of information, "in the near future," they note, "a square inch of garnet material may be able to hold 100 million bits of information" using the 0.4-μm bubble.

Distributors' component orders jump 20% in March
Dollar value of distributors' orders for components other than semiconductors jumped more than 20% between February and March, according to a survey of 36 U. S. manufacturers conducted by the Electronic Industries Association. EIA figures for tubes and passive and other components show March orders were 15.4% above the same month in 1977.

Communications

Digital technology protects voice links

The advent of inexpensive scanners that monitor police and other radio frequencies has made eavesdropping a hobby—and has limited the usefulness of radio for law enforcement officials. But that problem, coupled with recent changes in Federal Communications Commission regulations, promises to spawn a new generation of voice-scrambling equipment that is better able to keep radio traffic from unauthorized ears.

"The technology has evolved to the point where voice protection in land-mobile radios is feasible at a reasonable cost, and that technology is digital," says H. Anthony Hennen, manager of voice-security systems engineering at Motorola Inc.'s Communications Group in Schaumburg, Ill. Earlier this month, the firm took the wraps off a new series of top-

of-the-line two-way radio gear for the ultra- and very-high-frequency bands that comes with built-in voice-protection circuitry [*Electronics*, May 11, p. 33].

Coming down. Protection does not come cheap, but security now costs less than it used to. The Motorola radios equipped with the encoding-decoding functions command a $1,400 price premium, says Rick Paggeot, product manager for the new equipment. The scrambler circuit is based on a multiregister nonlinear combiner algorithm that provides up to 2.36×10^{21} unique, unrelated codes. This is a high level of security that previously cost $2,000 to $10,000 if purchased as an add-on analog scrambler, Paggeot says.

Further, analog encryption devices are too bulky to build into handheld portable radios unless they are very simple, like frequency inversion scramblers. "And that type, which we have sold in the past, can be defeated by a $35 decoder attached to a $35 scanner," he says.

Opened up. But it was the action by the FCC to permit as of late March high-speed digital data transmissions in all land-mobile radio services, as well as digital voice on the police and fire frequencies, that has opened up the secure-communications market to digital scramblers.

Motorola views the market as enormous, although Paggeot will not say exactly how large he thinks the business will be. He points out that the FCC will probably eventually extend its ruling to include business users as well as the public safety services. Other U. S. land-mobile radio makers, including General Electric Co. and RCA Corp., are eyeing digital voice-protection gear, and the industry believes Harris Corp.'s entry in the U. S. is imminent.

Motorola is first, however, and with systems that include portables, mobiles, base stations and repeaters, and console interfacing hardware, as well as the satellite receivers, comparators, and microwave-compatible multiplexers needed for area coverage systems. All told, the firm has more than 100 different pieces of transmitting equipment, all type-approved by the FCC.

Both Motorola and Harris have been marketing their new systems outside the U. S. and to Federal agencies that are not FCC-regulated. In addition, under a special FCC developmental license, Motorola has installed a $2.4 million police system in Salt Lake City, Utah.

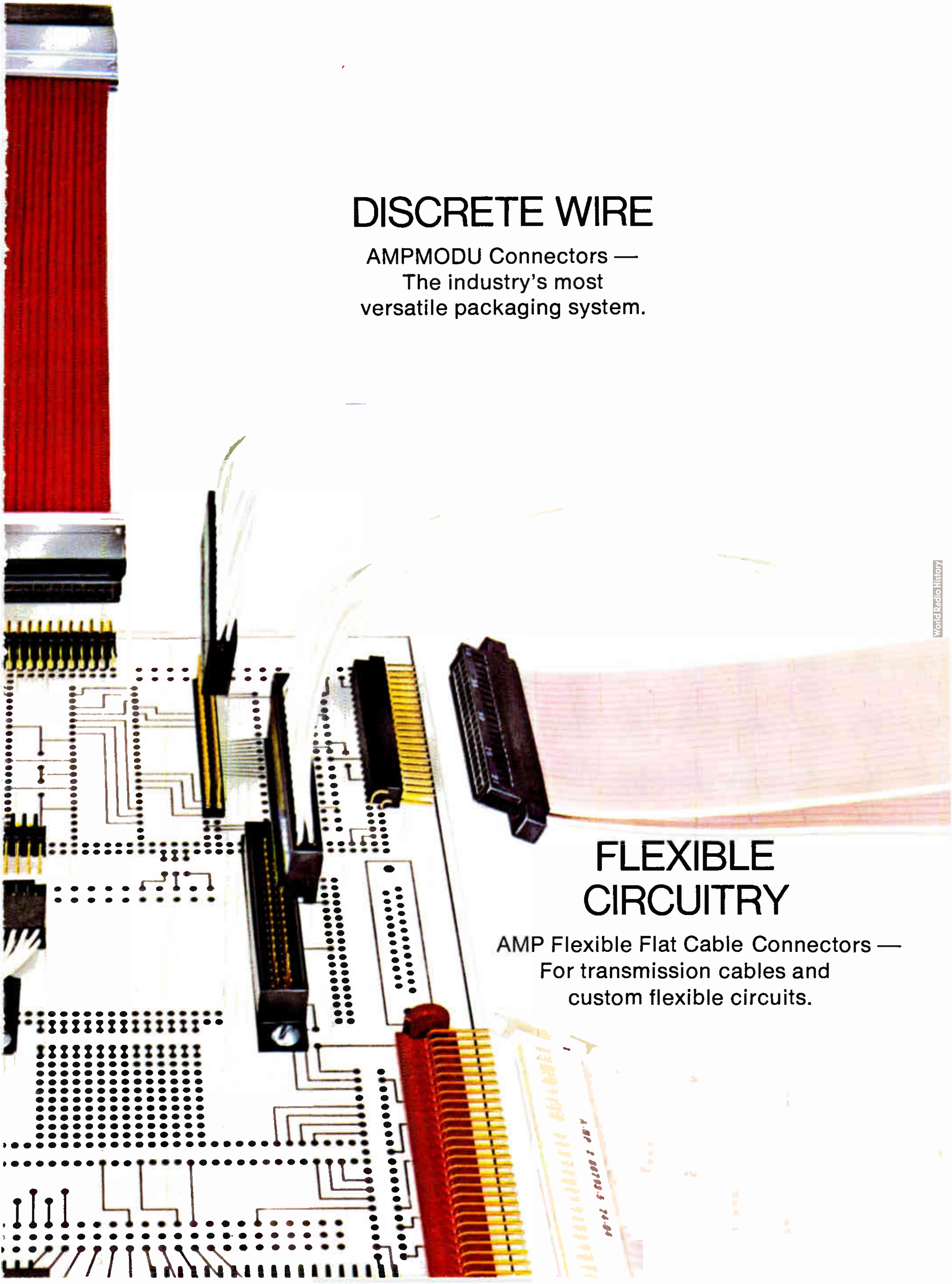
New design. Motorola came up with completely new designs for its radios, "although we salvaged as many existing parts as possible," engineering manager Hennen says. The new equipment matches the specifications of Motorola's existing gear, but provides a dual audio path. That way, since they can operate in both the clear- and scrambled-voice modes, the new radios can be used in existing communications nets. Receivers switch automatically between coded and clear channels when they are not set in the transmitter's mode.

The new radios use two additional custom complementary-metal-oxide-semiconductor chips. The first uses a continuously-variable-slope delta modulator to convert the incoming voice signals to a 12-kilobit/second binary bit stream, Hennen says. The second manipulates the bits according to the algorithm and the 24-digit code that is stored in the on-chip memory. The code can be altered only by plugging the radio into a $1,350 handheld code inserter. □

Medical

Analyzer streamlines search for antigen

Designers of clinical laboratory gear now routinely build in microprocessors to control their instruments, to diagnose machine failures, and to handle the tiresome calculations that most clinical chemistry requires. Abbott Laboratories, the giant pharmaceuticals firm, is no exception. But engineers there have come up with a couple of new tricks that strip much of the complexity from an instrument that until now has been a repairman's nightmare of fans,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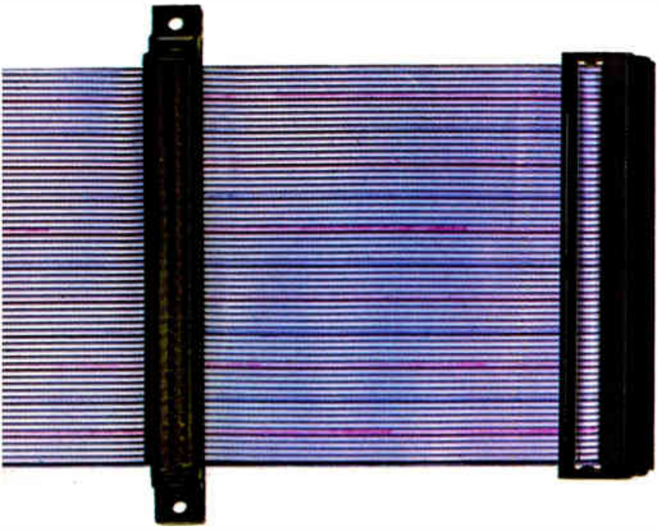

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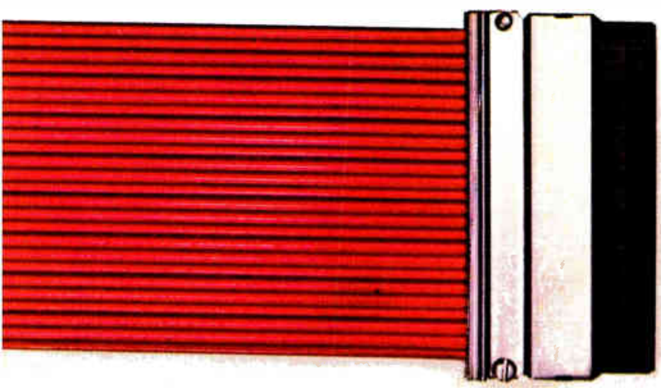

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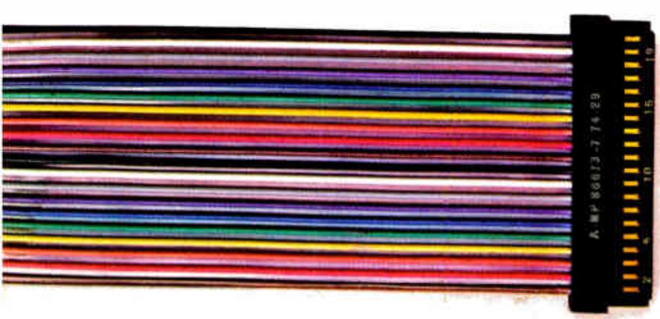

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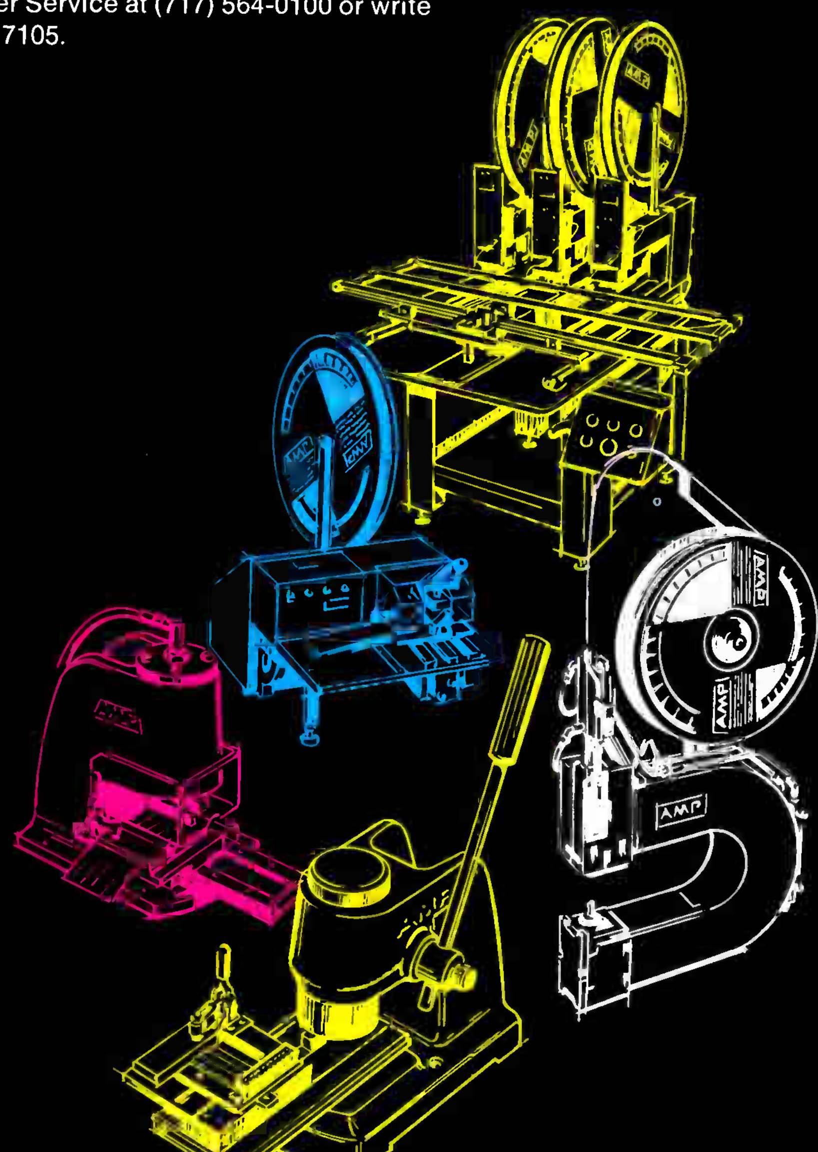

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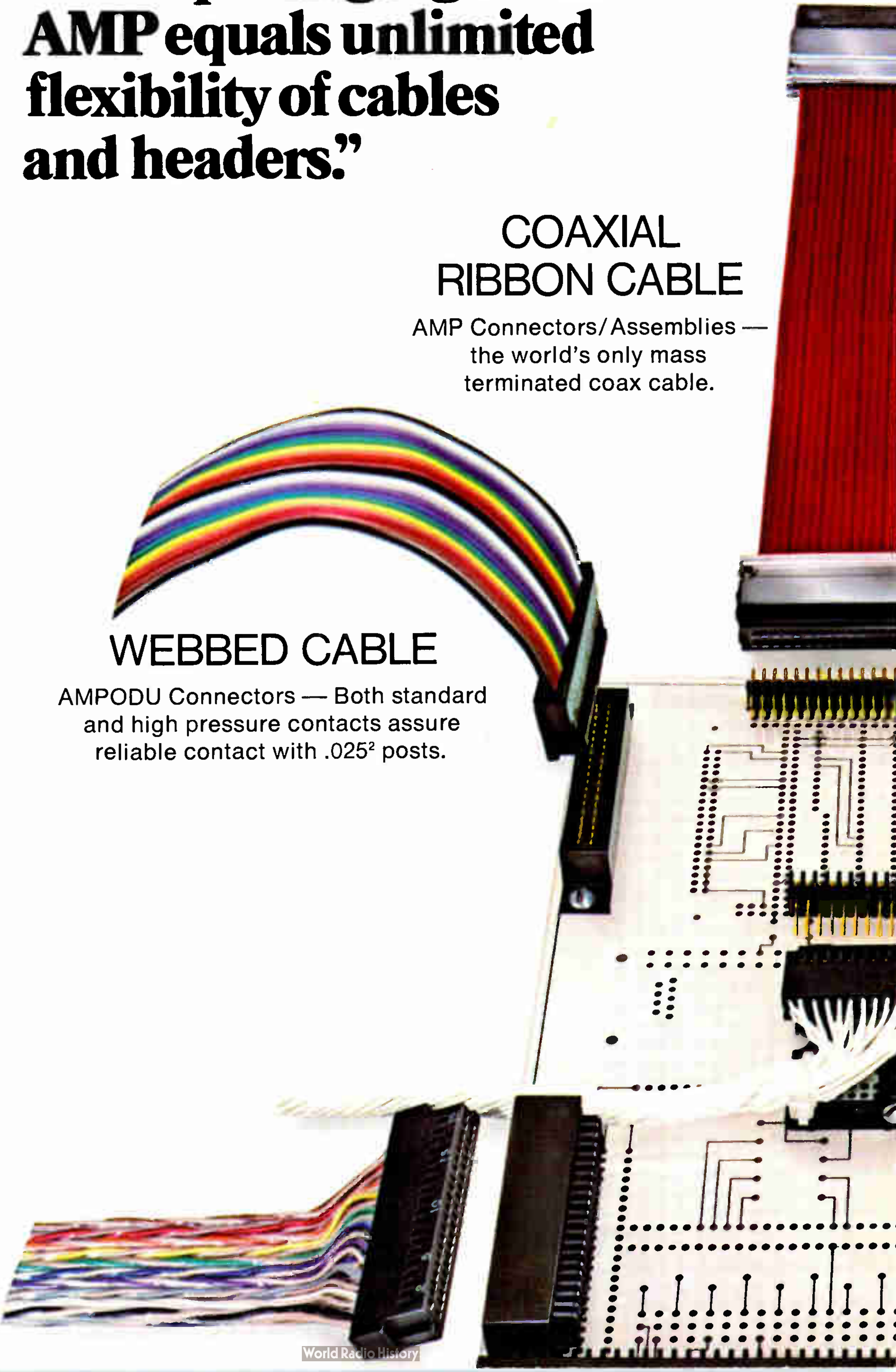


pumps, and vacuum lines.

The instrument is an enzyme immunoassay analyzer, essentially a desktop photometer that detects the color changes that occur in samples of blood serum when they are mixed with enzyme-labeled antibodies. When the known antibody mates with a specific antigen, or foreign substance, that may be in the blood, the enzyme catalyst converts the colorless reagent to a color-absorbing solution that indicates the presence of the antigen.

Hepatitis. Abbott developed its analyzer to help run a new enzyme immunoassay test that spots serum hepatitis in blood drawn for transfusion. Both the instrument and the reagents were introduced last month at Analytica 78, a biochemistry and analytical instrumentation exhibition in Munich, West Germany.

Abbott's analyzer is streamlined because it can make its measurements using the disposable test tube in which the chemicals are mixed. Usually, they are mixed in one tube, then "sipped" out and made to flow into a carefully calibrated measuring tube, or cuvette. Hence the need for the paraphernalia that also washes out the cuvette automatically.

For its system, Abbott resorts to a photometer sensitive to a pair of wavelengths. The colored reagent absorbs light coming through a 492-nanometer filter. Scuffs and fingerprints on the test tube absorb 492- and 600-nm beams, but the effects of such defects are subtracted.

"The dual-wavelength principle allowed us to replace the sipper system, but the microprocessor gave us the confidence to do it," says David M. Kelso, a project engineer at Abbott's Diagnostics division in North Chicago, Ill.

Consultant. Abbott turned to Martin Research, a Northbrook, Ill. consulting firm, for the system's electronics. Martin designed the instrument around Zilog Corp.'s Z80 microprocessor set and its own multitasking software. The processor converts signals from photodiode detectors to absorbance units, averages positive and negative control samples to calculate a calibration

Tube test. Tube in which chemicals are mixed is inserted into Abbott's enzyme immunoassay analyzer, which has a dual-wavelength photometer to detect antigens.

curve for each batch of samples, and displays and prints out results for unknown samples, flagging those that contain the hepatitis antigen.

But Abbott has put the processor to some unconventional tasks as well. "The precision and linear range demanded by the chemistry would have required a 21-bit-wide a-d converter," Kelso notes. Instead, the analog-to-digital conversion is done in two steps. First, the photocells' analog output voltage is converted to frequency with a single-chip voltage-to-frequency converter. Then the processor completes the conversion using a Zilog counter-timer chip.

Abbott, with revenues in the $1 billion-plus class, dominates the market for hepatitis antigen screening in this country with its radioimmunoassay test—an older technique that tags antibodies with radioisotopes instead of enzymes. The firm is targeting its new analyzer first for Europe.

Literally hundreds of tests using radioimmunoassay techniques have been developed, including tests that reveal hypertension and fertility hormones, vitamins, infectious diseases, and therapeutic drugs. □

Communications

Congress rethinking telephone reforms . . .

Signals from Capitol Hill about broad competition in the telecommunications industry have an unexpected message for industry enthusiasts—"go slow." With only days before the scheduled introduction of legislation to rewrite the 1934 Communications Act, one of the bill's sponsors, Rep. Lionel Van Deerlin (D., Calif.), is now talking in terms of a competitive "transition." Most industry sources see Van Deerlin's statement as a hint that the chairman of the communications subcommittee of the Interstate and Foreign Commerce Committee intends to restructure the industry through a time-consuming series of bills, not just one as had been expected.

House committee staffers deny industry and some congressional interpretations that transition equates with a competitive slowdown. "That sounds a bit paranoid to me," says one, but concedes that a rewrite of the 1934 bill that set up the Federal Communications Commission "probably won't go as fast as originally expected" because of the increasing complexity of telecommunications technology and the variety of service offerings.

A member of the congressional Office of Technology Assessment, which is examining the issues of competition, concurred by noting that Congress "wants to do this thing right. You don't change the world's best telecommunications system overnight and make it better at the same time." □

. . . while support cools for PIC

At the same time that the House Interstate and Foreign Commerce subcommittee is preparing to introduce a communications reform bill, the Federal Communications Commission is weighing adoption of the so-called primary instrument concept. That concept, first advanced by American Telephone & Telegraph Co., calls for telephone companies to provide the first telephone installation in a single or multiline system.

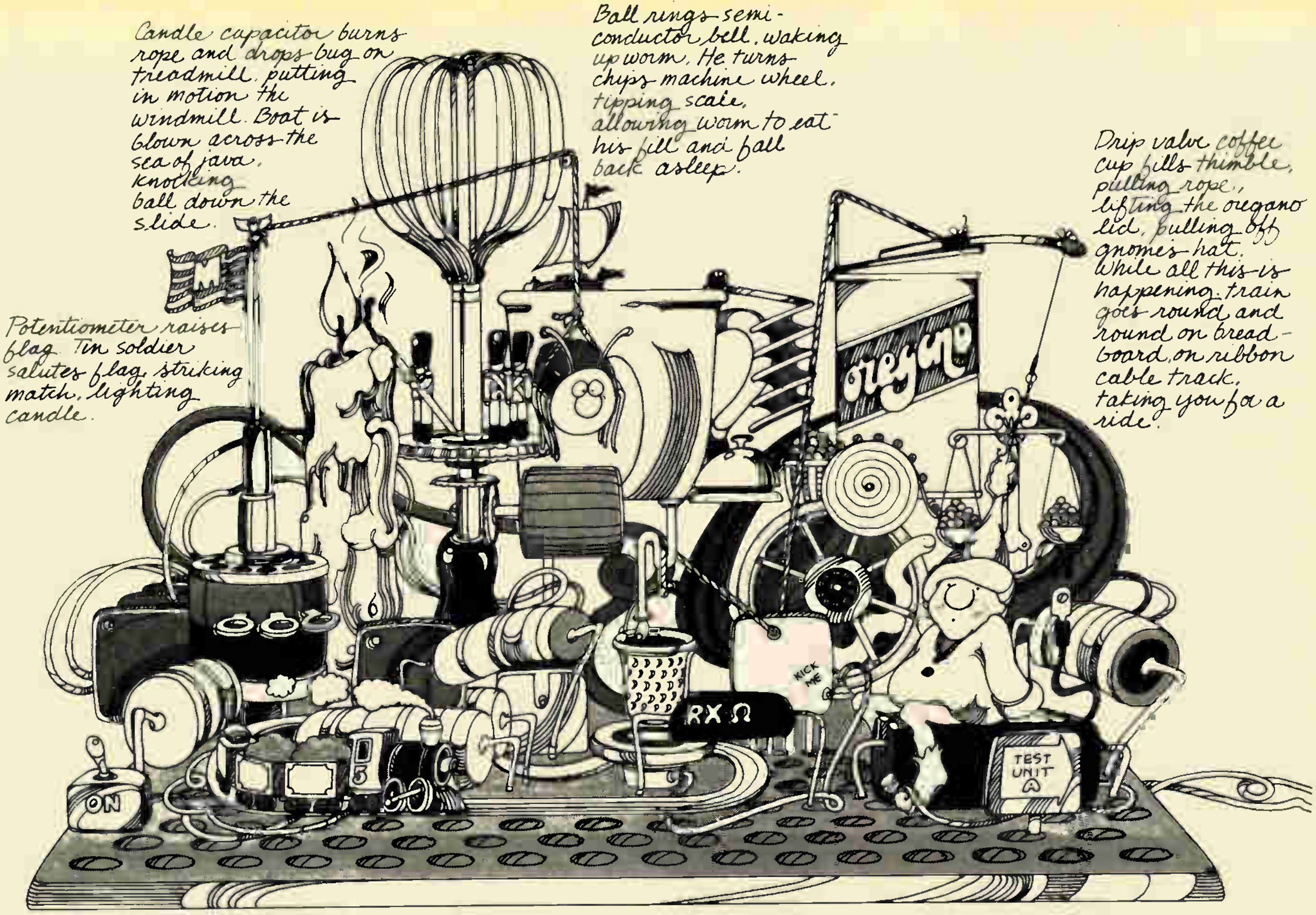
Surprisingly, responses in mid-May to the proposal, FCC common carrier docket No. 78-36, showed not only strong opposition from industry and Government agencies, but also cooling support from previous backers. The North American Telephone Association of independent equipment suppliers, for example, dropped its neutral position and called the concept "pernicious." Citing the absence of hard data from PIC supporters, NATA contends that "the proposal is nothing more nor less than an attempt by the telephone industry to preserve its monopoly position."

Telephone retailers, through the National Retail Merchants Association, offered qualified support for PIC, because it limits the supplier's maintenance liability for handsets by providing a means of determining whether malfunctions were caused by the retailer or by the equipment itself.

International Business Machines Corp., on the other hand, told the FCC that it views PIC as a reversal of earlier Carterfone and equipment registration decisions encouraging competition. Beyond that, IBM sees handicapping the development of multipurpose instruments as a threat to new terminal markets that incorporate both audio communications and "other functions such as credit authorization."

CCIA support. The Computer and Communications Industry Association supports PIC with one reservation. Anyone should be able to provide the primary instrument, they believe, as long as it meets the same quality standards and has the same static and dynamic test characteristics as those employed by telephone common carriers.

The prospect that PIC may violate antitrust laws by requiring the tie-in sale of a primary instrument has been advanced by some opponents, including the General Services Administration. As the country's largest telephone customer, the GSA called the proposal "inconsistent with the Carterfone decision" approving competition and added that extending PIC to multiline subscribers "would have a significant and adverse impact on the Government's executive agencies." □



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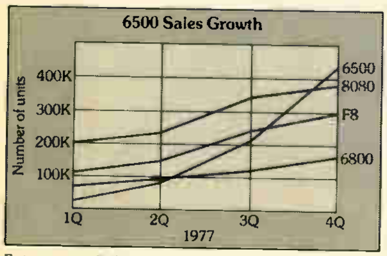
The highest performance, microprocessor is now

The 6500 outsold 8080, 6800 & Z80 in the fourth quarter of 1977 according to estimates just released by Dataquest, a highly regarded source of semiconductor factory shipments information. And there are good reasons why.



Estimates supplied by DATAQUEST, Menlo Park, California

The 6500 is lowest cost because

· Smaller die than the 6800, 8080 or Z80.

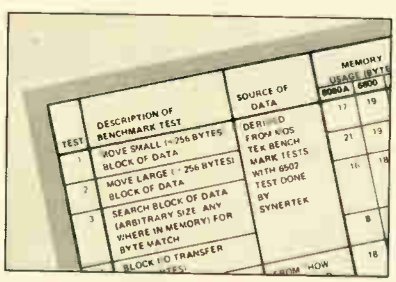
· 28-pin versions available. This offers a lower package cost over the 40-pin microprocessors. The 6500 family is first with 28-pin microprocessors.

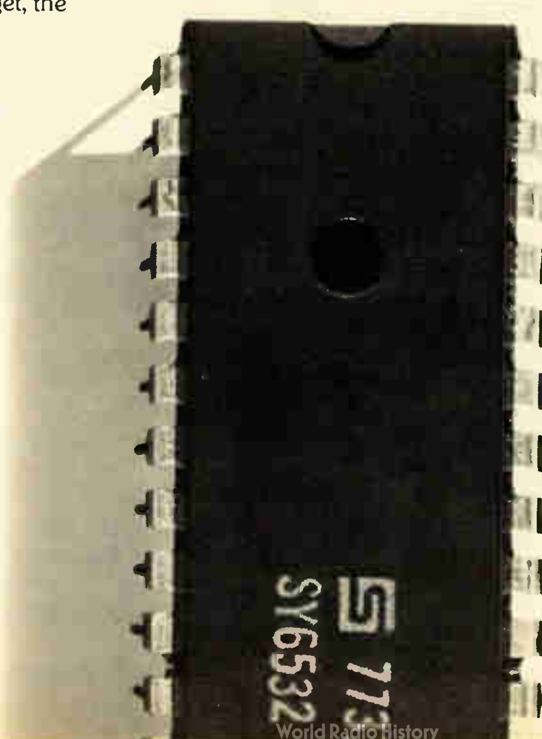
· We are a high volume producer. The more we make, the better we get, the less expensive the 6500.

Highest performance.
At 2MHz, the 6500 has a potential throughput about twice that of the 6800 and 8080A. In fact, for twelve different benchmarks selected by various sources (excluding Synertek), the results were:

- Execution times for the 8080A are 2.5 times longer than for the 6502.
- Execution times for the 6800 are 62% longer.
- In the same tests, the 6502 also used far less memory.

Write for a complete document on the twelve benchmarks. The results are impressive.

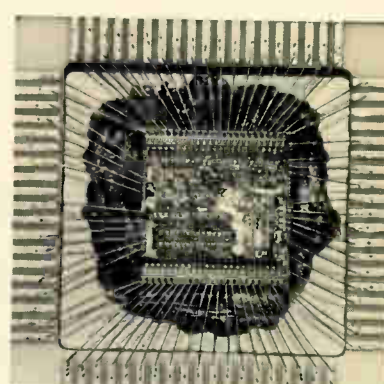




True pipeline architecture. Unusual in low cost microprocessor. As the 6500 is interpreting one instruction, it is accessing the next instruction. By doing its tasks in parallel, the 6500 attains tremendous system throughput, and overall performance you'd expect to cost much more.

Thirteen addressing modes. The 6500 has thirteen different addressing modes including zero page and indirect indexed, features you'd not normally look for in a low cost microprocessor, but we have them. The flexibility of these addressing modes allows you to get the job done in fewer microprocessor cycles and even saves you some program memory code.

And a comprehensive development system, the System 65. This is an ideal system for use in developing 6500 software and hardware, and includes two built-in mini-floppy disk drives. 16K bytes of user memory (expandable to 64K) and 16K bytes of resident operating system. Ask for our System 65 brochure.



GAO says Air Force spent $7 million on canceled ALS . . .

The Air Force spent $7 million trying to fix a complex logistics system of communications hardware and faulty Control Data Corp. computers for nearly two years after Congress ordered it canceled, the General Accounting Office reports. But the congressional auditors say that "despite explicit direction from the House and Senate Appropriations Committees to terminate the program," **it was not legally binding on the Air Force, since it was not written into the defense appropriations bill for fiscal 1976.** Congress acted in December 1975 to kill development of the Advanced Logistics System network for worldwide management of $13.8 billion maintenance inventories after the Air Force proposed a $563 "get-well plan" for the troubled development program, on which $250 million had already been spent.

. . . and charges portions were mislabeled essential

The ALS program's last elements were shelved in September at the urging of the Air Force comptroller general, **some three years after serious development problems were identified in the program** managed by the Air Force Logistics Command. "These included," the GAO says, "unclear definitions of requirements, the inability of CDC to deliver operable computers and software, incomplete testing, concurrent development of operating and application software, the use of unified data-base concepts that were new and unproven, system design changes, and others" despite 2½ years of contract work.

Congress ordered the Logistics Command to buy for $68 million the 14 CDC Cyber 70 computers already in place in order not to lose the $55 million already accrued in credits. It also ordered the service to restudy the program and come up with a new one based on newer technology, continuing only those parts essential to the mission. The GAO says the Logistics Command continued its work by mislabeling multiple program elements as essential while evolving a five-year interim plan that incorporated most of the get-well plan projects.

FDA orders recall of 242 lasers from two makers

Spectra-Physics Inc. and Oriel Research Corp. have been ordered by the Food and Drug Administration to recall and repair 242 laser systems **that fail to comply with Federal performance standards.** The FDA's Bureau of Radiological Health says 202 Spectra-Physics ion lasers—models 164, 165, 166, and 171—lack required safety interlocks. The 40 Oriel Research lasers, model 6611, lack warning labels, information on maintenance, statements of maximum power output, complete control listings, and a user warning statement.

Four companies picked for Seek-Talk design

The Air Force is getting its jam-resistant Project Seek-Talk off the ground with four competitive system design contracts to E-Systems Inc., General Electric Co., Hazeltine Corp., and Magnavox Corp. Seek-Talk is a secure air-to-air-to-ground tactical communications system scheduled for production in 1982. Following completion of design competition this fall under the contracts, which total $700,000, **the Air Force will pick three companies to build advanced development models** for testing by the Rome (N. Y.) Air Development Center. Two will be selected later to build competitive prototypes to determine the winner of the production award.

Washington commentary

Jimmy Carter and capital gains

The White House is ready to concede on legislation that proposes to stimulate investment of risk capital by rolling back the capital gains tax on investments to pre-1969 levels of 25%. That is the word being given out by at least one White House economics adviser about the Investment Incentive Act of 1978 now pending in Congress. "The President will sign it," the analyst says flatly, "but I suspect he won't say much about it. The President may have campaigned as a populist, but he is a capitalist by training and experience. And he needs a tax bill."

The concession undoubtedly brightens the prospects of the youthful, high-risk, high-technology electronics industries and the engineers they employ in the U. S. Yet it is astonishing since the bill in question has yet to be voted on and was introduced in both houses of Congress by Republicans.

On the House side, H. R. 12111 is known as the "Steiger bill" after Wisconsin's William Steiger. The identical Senate version was put into the legislative mill by Wyoming's Clifford Hansen and 59 cosponsors, an apparent guarantee of passage in that 100-member chamber. Floor passage seems likely in the house, too, following clearance by the Committee on Ways and Means. The California-based American Electronics Association, formerly known as WEMA and a principal lobbyist for the legislation, is understandably elated.

Creating new jobs

Senator Hansen drew heavily on the association's arguments when introducing S. 3065 earlier this month, on May 11. "Some segments of the private sector—the small businesses—are the most capable of creating new jobs," Hansen argued. Citing AEA's study on capital and job formation earlier this year [*Electronics*, Feb. 16, p. 42], Hansen noted that "young companies create jobs much faster than mature companies. Specifically, the employment growth rates for the young companies less than 10 years old were 20 to 115 times greater than the companies more than 20 years old."

Hansen also raised the very real specter of foreign takeovers of U. S. technology leaders if a scarcity of domestic venture capital persists. That shortage, he said, "has forced many American companies to turn to foreign capital sources—particularly in countries that encourage investment by having low or no capital gains taxes. This often resulted in foreign investors gaining control of the U. S. companies and their most promising new technologies, enabling the foreign competitors to catch up with U. S. companies in important market areas." Of course, AEA is not the sole industry proponent of the bill, but it certainly appears to be the most effective if the observations of Sen. Hansen and Rep. Steiger are any measure.

Not yet law

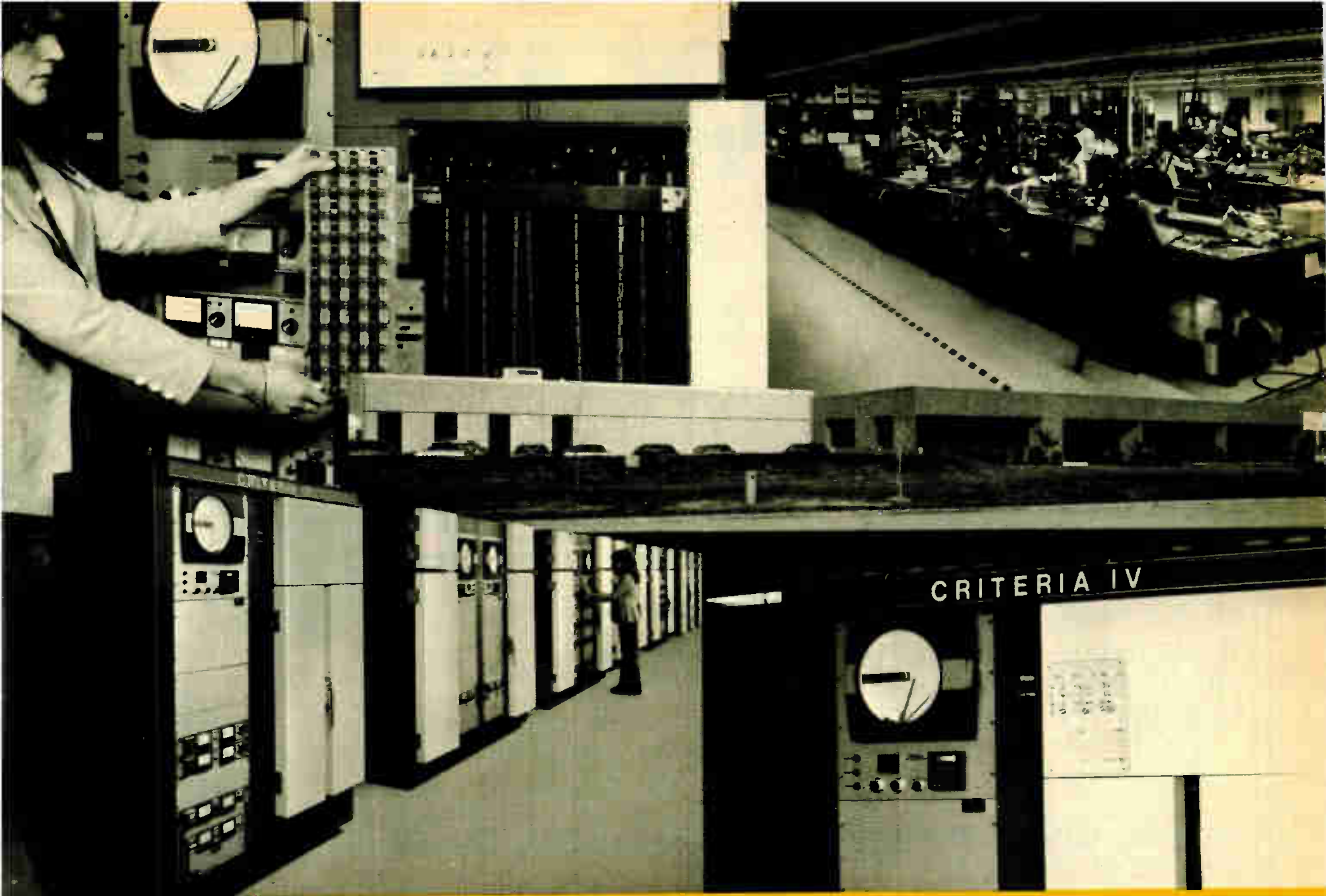
Growing congressional support for reducing taxes on capital gains to the 25% level is an encouraging sign. So is the apparent acceptance of the measure by the White House. But appearances can be deceptive and they certainly do not make laws; the legislation is still not past the bill stage. It needs broader support from the electronics industries, a collection of diverse enterprises whose common interests are expensive high technology and a consequent need for venture capital.

Electronics manufacturers must provide, for example, more effective answers to the questions still asked by opponents of the tax cuts in the Carter Administration and the Congress: how will industry use the new investment money that would become available by cutting capital gains? Would it be used to spur domestic research and development and plant modernization? Or will it be spent for on setting up more manufacturing facilities offshore in places like Singapore and Malaysia?

The real issue

More to the point, the electronics industries need to convince their Washington critics that the true value of this tax incentive will be its encouragement of the formation of new companies dedicated to developing new technology. In the long run, after all, the issue comes down to this: how is the U. S. to maintain its technological leadership, and is the Federal government ready to help?

Ray Connolly



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For this ad we wanted to use that sweet thing that poses for that relay company's ads . . . but she was tied up in "management conferences." Besides, the agency couldn't figure out how to work her in with our being "America's Largest Burn-in Facility. . ." (although they thought they could do something with "and still growing"). Nevertheless, we are the largest. Since 1968 we've been efficiently meeting the burn-in needs of leading OEM's, distributors and IC manufacturers. We've gained their confidence with the experience generated from over 10 BILLION device hours of burn-in on our **CRITERIA®** equipment. And we are still growing . . . At our new 45,000 sq. ft. facility in Houston, plus facilities in California and Singapore, we're processing over 6 million components per month, as well as manufacturing and selling a complete line of burn-in systems to meet virtually any user's in-house needs. Whether you need burn-in services or your own in-house burn-in system, it pays to know Reliability. Call or write and we'll show you why we're number one. (We'll keep working on that sweet thing for our next ad.)

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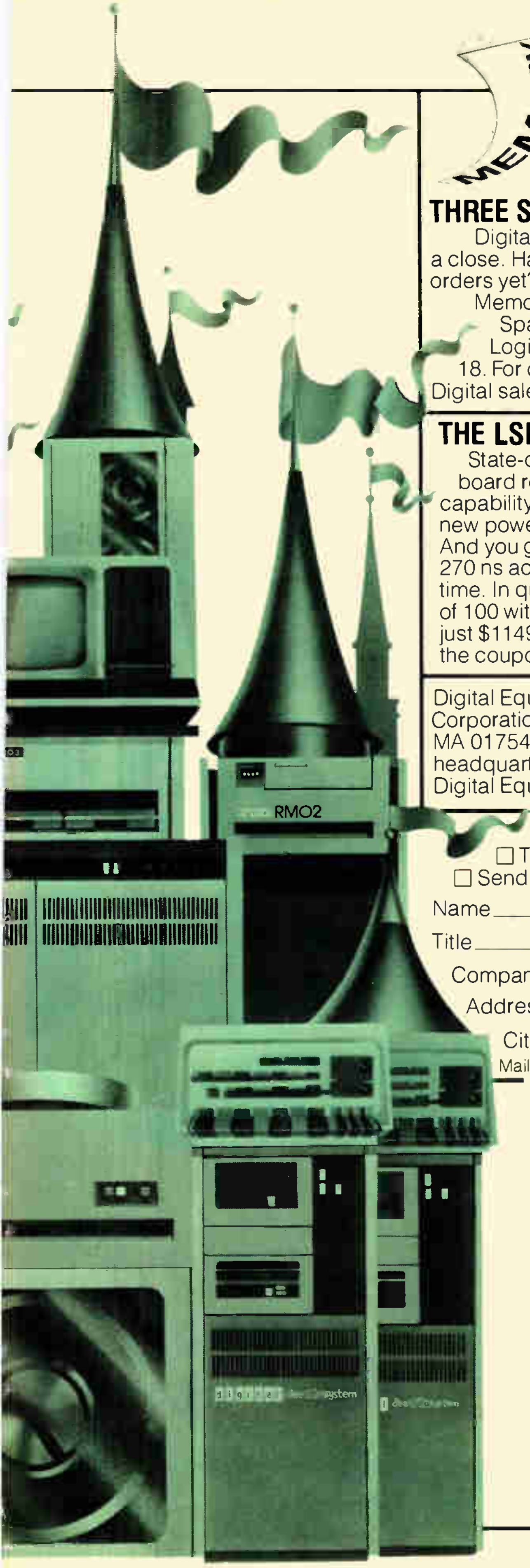

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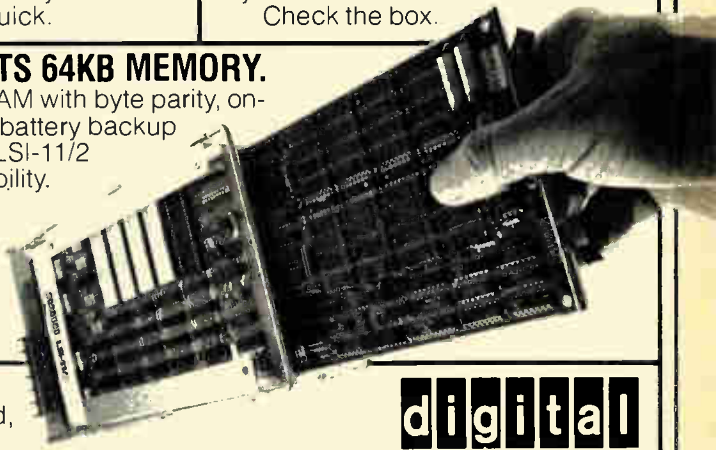

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SIEMENS

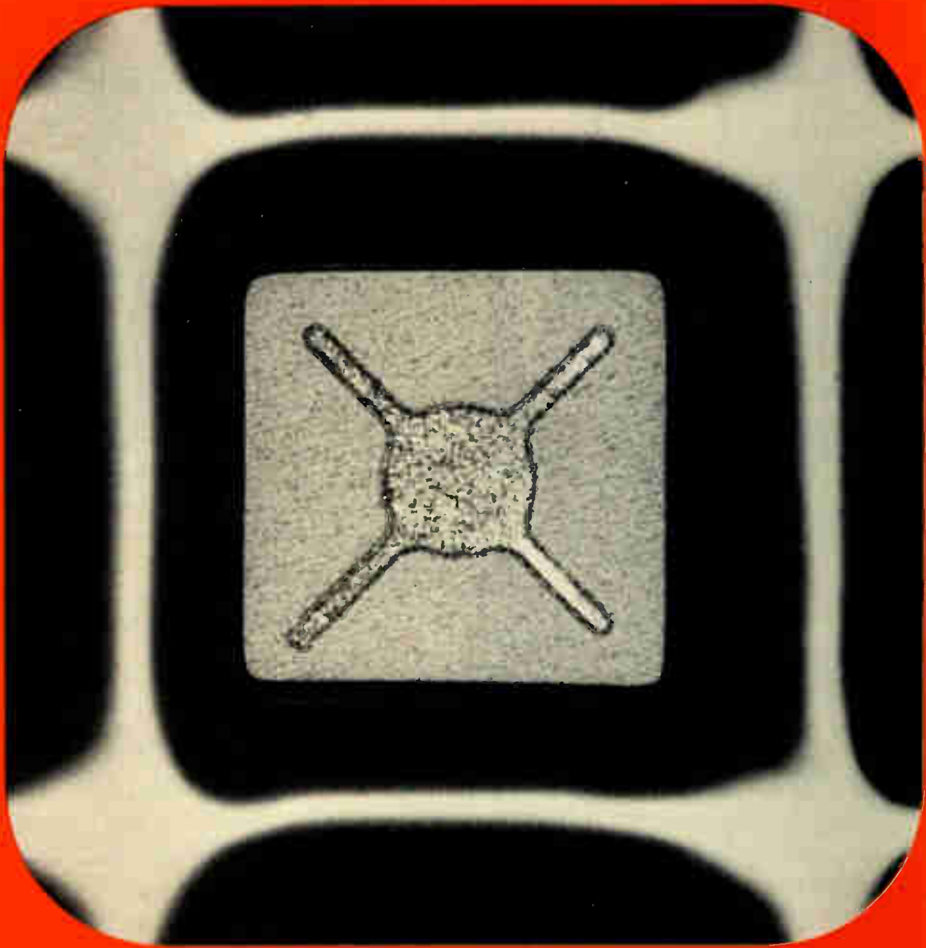
Infrared remote control for TV sets was only the beginning

Infrared rays: until a few years ago they were associated almost exclusively with heating, drying and healing, perhaps with infrared photography, but certainly not with remote control of crane trolleys in factories, sensing systems in packaging machines, pulse-operated light barriers and transmission of TV sound or simultaneous interpretations of conference speeches to cordless headphones.

Today, infrared transmission has taken up its place alongside radio and ultrasound for short range applications – thanks especially to outstanding advances in the development of optoelectronic components at Siemens. Examples of this progress are the "superbright" infrared LEDs, the associated fast and highly sensitive silicon planar PIN photodiodes, and low-cost npn silicon phototransistors of high sensitivity.*

Development does not stop here. Still larger ranges and frequency bandwidths will soon open up further applications for infrared transmission. And infrared components from Siemens will play a major part in this process.

* Families of types
IR LEDs: LD 242, LD 261, LD 271
Photodiodes: BPW 34, BP 104
Phototransistors: BP 103B, BPX 81



Highly efficient GaAs emitters for the infrared range. The IR power is up to 20 mW/ sr (forward current 100 mA) at a wavelength of 950 nm – twice that achieved with conventional technologies – and coupled with increased life expectancy. Actual chip size: edge length 500 μm.

Optoelectronic components from Siemens

Circle 68 on reader service card

B 7810.101

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Better than 1458 on performance. The 3240, like the 3140, delivers the benefits of MOS/FET input. Such as ultra-high input impedance and very low input current. It also gives you bipolar speed and high supply voltage operating capability: 4 to 44 V, dual or single supply. And much more.

Available now. In volume. Just a few months after its introduction, we're making the 3240 in volume...more proof of BiMOS ease of manufacture. So you can get as many as you want. Now.

For more information, contact your local RCA Solid State distributor. Or contact RCA Solid State headquarters in Somerville, NJ; 1130 Brussels, Belgium; Sunbury-on-Thames, Middlesex, England; Quickborn 2085, W. Germany; Ste.-Anne-de-Bellevue, Quebec, Canada; Sao Paulo, Brazil; Tokyo, Japan.

Duel of the Duals

Type (with single supply)	Input Common-Mode Voltage Range	V_{OM}^+	I_I	Slew Rate	Gate Input Protection Diode
BiMOS CA3240E	0 to (V^+–3V)	1 to (V^+–3V)	50 pA	9 V/μsec	Yes
Bifet TL082CP	5 to (V^+–5V)	5 to (V^+–5V)	400 pA	12 V/μsec	No
CA1458E	3 to (V^+–3V	5 to (V^+–5V)	500K pA	0.5 V/μsec	—
MC1458SP	3 to (V^+–3V)	5 to (V^+–5V)	500K pA	16 V/μsec	—

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RCA

Circle 70 on reader service card

Samples coming of high-speed 2900 version

Samples of Nippon Electric Co.'s higher-speed version of the AMD 2900 4-bit-slice bipolar microprocessor will be available in July in both Japan and the U. S. Pin-compatible with parts from Advanced Micro Devices, the μPB2901AD central processing unit has a 60-ns cycle time that is 40 ns faster than its American counterpart. **Engineers at NEC say current-mode logic achieves the higher speed, while a Schottky TTL interface maintains compatibility with other 2900 devices.** In spite of the speed increase, there is no change in power consumption because of improved processing and logic design in which several CML gates operate in series from the 5-V power supply. When full-scale marketing starts later this year, NEC will be offering 10 peripheral parts in addition to the CPU and will add more parts later.

ICL and Hitachi exchanging data

With no fanfare, Britain's International Computers Ltd. and Hitachi Ltd. of Japan are starting an exchange of technical information on various aspects of computer development. **Under a two-year agreement signed in April, a team of five Hitachi engineers has already visited** the UK for discussions with ICL's Technology division. It is the first under a program of exchange visits.

4-hour cassette for VCRs preludes a 5-hour unit

In what looks like a game of one-upmanship in the video-cassette-recorder field, Grundig AG is about to launch a 4-hour VCR for consumer use on European markets. The new model also will be sold under license in the United Kingdom by ITT Consumer Products Ltd. **Moreover, the German company is readying a 5-hour cassette for a fall debut.** Grundig's plans come hard on the heels of Philips' recent announcement of 3-hour cassettes and of Sony's introduction in Europe of its Betamax 3⅓-hour recorder [*Electronics*, May 11, p. 63, and April 27, p. 66]. Priced about the same as Sony's $1,400 equipment, the SVR4004 boasts infrared remote control of the drive system, automatic station search, and programmable channel selection and timing as long as 10 days in advance. Its 4-hour cassette, which uses a 570-meter-long, 16-micrometer-thick tape, will sell for about $33 on the German market.

Bogen may outfit second plant for Soviet Union

The West Berlin firm Wolfgang Bogen GmbH and the Soviet ministry for communications technology are holding exploratory negotiations that **could lead to Bogen's outfitting a second Russian manufacturing facility for magnetic recorder parts.** Like the first, the second plant would be equipped with Bogen-supplied machinery for producing magnetic heads and related devices. Bogen, a leading European magnetic-head producer, says the first plant in Kiev recently went on stream, manufacturing heads under license.

Eurospace sees way to cut costs of satellite communications

Countries that do not need or cannot afford full participation in satellite communications systems would be the beneficiaries of a new scheme of Eurospace, the European industrial space study group. Rather than requiring participating countries to invest in the systems, **the plan envisions renting transmitter channels .** To finance the hardware, Eurospace is proposing a new organization called Spacecom. A spokesman says that the Eurospace plan calls for domestic coverage only, so it would not compete with Intelsat's international services. To help lower costs further, Spacecom's satellites would use 4-m earth antennas, rather than the 11-to-13-m antennas used by Intelsat B.

Terminal business booms in Germany; IBM is No. 1

Roughly 124,000 terminals were in place in West Germany as of the beginning of this year, with nearly three quarters of them featuring video display units. That's one conclusion of a soon-to-be-released market study from the Frankfurt-based computer-consulting firm Diebold GmbH. **By far the biggest contender in the terminal field is IBM, with 47% of the total installed to its credit.** Next in line is Siemens AG with 16.5%, and the ITT affiliate Standard Elektrik Lorenz AG checks in as No. 3. However, in terms of the value of terminals installed, Kienzle Apparate GmbH occupies the third slot behind IBM and Siemens. Diebold predicts that by 1985 there will be some half a million terminals installed in the country.

Apple computers go to England with ITT linkup . . .

Joining the fast-accelerating personal-computing bandwagon in the United Kingdom is ITT Consumer Products Ltd., which will market the Apple home computer modified so that it plugs into British TV sets. **The basic unit will cost less than $1,630,** and optional peripherals will include the Heuristics Inc. voice-recognition systems. ITT expects the UK market to jump from 5,000 units this year to 75,000 by 1980.

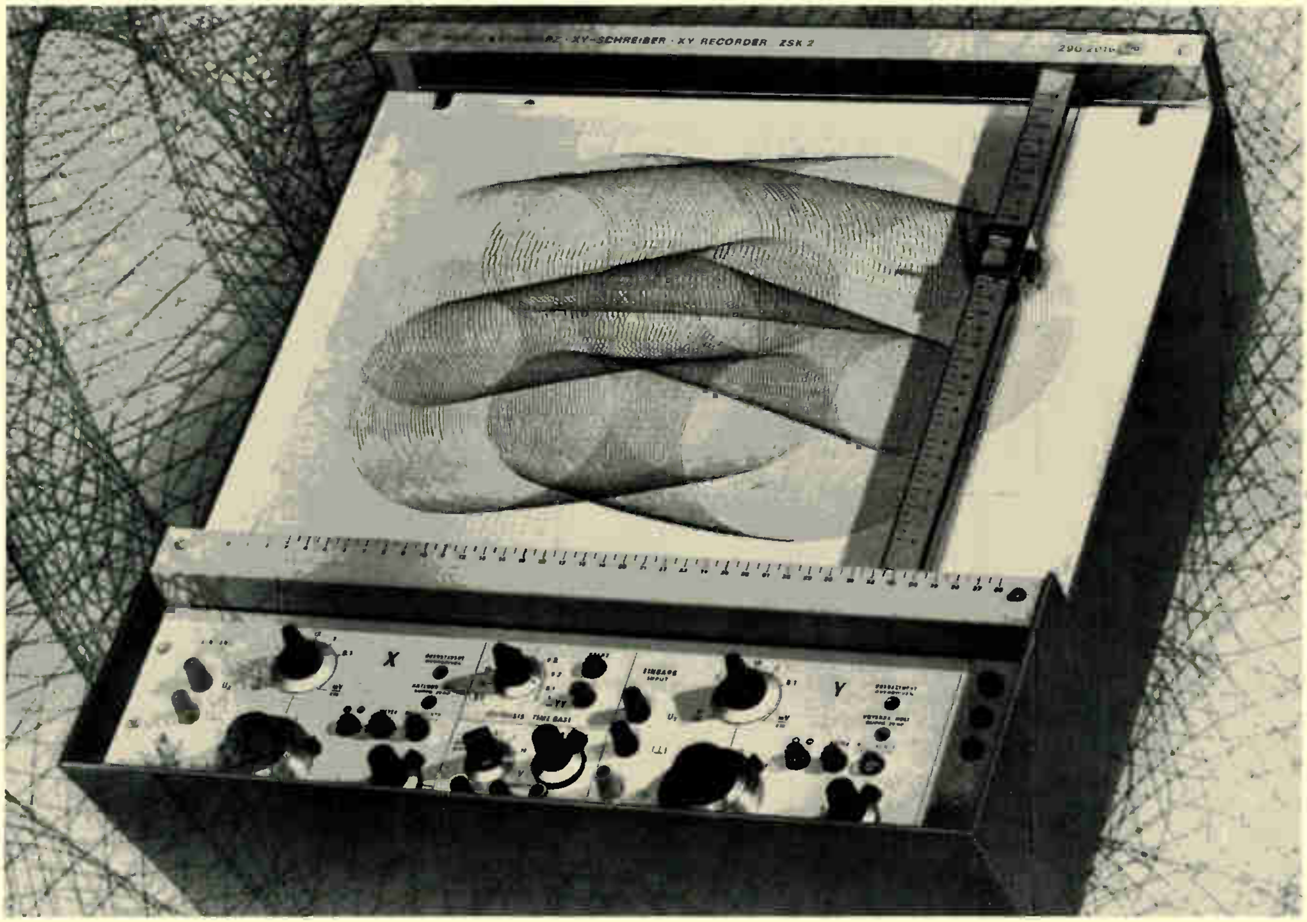
. . . as sales flourish among many group of users

Most home computers in the United Kingdom aren't going into homes, says Commodore Systems, which launched its $1,250 PET unit in February. The firm says sales are running **roughly a third each to educational and small-business markets, about a fifth to the industrial and scientific market,** and the remaining tenth to hobbyists. So far about a dozen companies, some of the U. S.-based like Commodore, are in the UK market or have announced entry plans.

Addenda

Britain's International Computer Ltd. will offer the Siemens 21,000-line-per-minute **ND2 laser printer as part of its worldwide product spectrum.** Said to be the world's fastest nonimpact printer, the ND2 also is part of a marketing agreement between Siemens and Japan's Fujitsu Ltd. [*Electronics*, May 11, p. 63]. . . . Saudi Arabia has awarded a contract for construction and maintenance of a 360-km microwave line-of-sight link to the Sudan to the Italian firm Telettra, a part of the Fiat group. **The $9 million system will include solar-cell generators for repeater stations** and will provide 300 telephone and telegraph lines and relay of color TV programs. . . . A Swedish consortium of 13 commercial banks is ordering a $15 million network of on-line automatic teller systems, said to be Europe's first. **With terminals from Philips Data Systems and minicomputers from CII-Honeywell Bull,** the system will replace a number of existing cash-dispensing machines and will permit customers of all the banks to use the same terminals. . . . Jostling single-chip TV games in British shop windows this Christmas will be the first shipments of programmables, from the U. S. firms Fairchild Semiconductor and Atari. Nevertheless, the Fairchild importer, Adams Imports Ltd., **says the big volume this year will be in the much cheaper dedicated six-game multichip systems** such as the ones it will offer from GIM.

New recorder family: precision priced right



For XY and YT plots there's now the recorder ZSK 2 in five different models so you can choose exactly the right one for your application, and at the right price.

ZSK 2 works on the principle of a self-balancing potentiometer. This gives minimal non-linearity (0.1%) and guarantees good reproducibility (0.05%). The high writing speed of >110 cm/s on both axes combined with fast acceleration produces superior dynamic characteristics. Deflection factors calibrated between 10 μV/cm and 11 V/cm, electronic limiting of the writing area for DIN A3 and A4 plus governable zero offset make operation easier, whilst inputs for remote control and ratio recording mean greater variety of use.

The models differ in their inputs:

Universal model 02
Sensitivity 10 μV/cm; floating input amplifiers with guard; timebase generator.

Standard model 04
Sensitivity 5 mV/cm; differential amplifiers for both inputs.

Lab model with timebase 06
Sensitivity 100 μV/cm; floating input amplifiers; timebase generator; offset-voltage source.

Lab model 08
Sensitivity 100 μV/cm; floating input amplifiers.

System model 10
Sensitivity 100 mV/cm; direct inputs Z_{in} 20 kΩ.

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Phased-array radar has new circuit technique for 60-MHz control

Voltage-controlled oscillators with 10-W outputs, plus PLL regulation and i-f shifting of phases, could slash costs

Those phenomenally expensive phased-array radars may start coming down in price, and it will all be thanks to a clever circuit technique that uses phase-locked loops and harmonic locking techniques, plus integrated-circuit microwave technology. A team of researchers at Britain's University College, London, has come up with a setup in which most of the radar's operation is at 60 megahertz, permitting much more precise operation than at radio frequencies.

Moreover, each element in the array has its own solid-state radio-frequency source: relatively low-cost Gunn oscillators that have the power necessary for some radar applications. The University College group is now getting a useful 300 watts for its arrays.

Such a power level is adequate for many radar systems. Moreover, the price is right: "What we are aiming for is a price per active-array element of under $200," says John R. Forrest, head of the research group. That sounds expensive, but it is almost an order of magnitude cheaper than present phased-array costs.

Replacements. The team is using voltage-controlled Gunn oscillators as frequency sources, replacing the high-power traveling-wave tube and bulky, expensive phase shifters that supply the rf signals to the individual elements of the antenna array. Similar approaches are coming into use in top-security U. S. radar systems. In fact, support for the research team comes from the U. S. Air Force Office of Scientific Research and the Plessey Co.

What is the novel element in the team's approach is the way that all the rf sources in the array are locked to a common frequency and that the phase relationship among elements is achieved. The group combines several techniques: harmonic locking, the use of phase-locked loops to regulate the VCOs, and the employment of a heterodyne intermediate frequency that permits phase shifting at an easy-to-use 60-MHz level, rather than the more difficult gigahertz level.

Harmonic locking was the initial breakthrough [*Electronics*, Nov. 8, 1971, p. 11E]. It is a technique of locking the radiating source to a harmonic of a reference frequency, not to the near-fundamental reference, as in a crystal-controlled oscillator. For a controlled rf source locked to the fourth harmonic, there would be four stable states. Also, the controlled frequency can be

Ir detector traps heat leaks and sounds alarm

In this energy-conscious age, detecting heat leaks is more than just a way of keeping the blood circulating. Thus Cryo-Technik Labor Serwatzky, a seven-man, Bonn-based firm specializing in infrared systems, has come up with an easy-to-handle heat-leak finder that sounds an alarm, as well as indicating the temperature of the leak.

How the alarm is sounded may be easily surmised: the output of an ir detector that responds to heat is amplified and fed to an acoustical device. There it triggers the alarm when a preset temperature is exceeded. Throwing a switch on the instrument feeds the ir-detector output to the temperature indicator.

To be sure, highly sophisticated heat-detection systems, including some from the Bonn firm, are on the market. But these cost $100,000 and more, and the new unit will sell for less than $1,800 on the German market, the firm says.

kicked from one state to another by the application of a voltage pulse to the VCO. This basic technique has been built into a heterodyne PLL that acts both as a transmitter and as a receiver.

The operating frequency of the rf source is close to 10 GHz. However, introducing a superheterodyne mixer into the control loop lets the majority of the components operate at the 60-MHz level. The harmonic locking is now carried out at an intermediate frequency, which allows much finer phase shifts, such as 22°.

Phase shifters are entirely eliminated, thus avoiding rf losses. The only rf components are the varactor-tuned pulsed VCOs, the radiating element, and the combined circulator and mixer.

Sending. For transmission, a translation PLL synchronizes the rf sources for the radiating elements to the locking line for the array. The phase comparator applies digital phase-shift increments at the i-f level. In this way, the shift pulse can be readily achieved by the application of transistor-transistor-logic levels to the comparator. A computer sets up control signals, which switch elements in accordance with beam-forming data stored in a read-only memory.

For reception, the elements' rf sources are not used. Instead, an rf reference signal converts the received signals down to i-f, and the phase comparator is now used as an i-f mixer. The harmonically locked VCOs apply the correct phase shift to the received signal.

The new technique could find a first application on ships to track communication satellites, Forrest says. It would keep the ship's antenna pointing at the satellite, adjusting both for pitch and roll. A modest 30-element array would produce a 3° beam that could be scanned under computer control through a 40° arc.

The group has demonstrated an eight-element array using varactor-tuned Gunn oscillators operating at 10 GHz. Forrest says additional elements could be easily bused together, increasing both the 10-w power and the beam shaping. □

West Germany

Plastic disk makes transducer excel in calculating distances by ultrasound

The fertile field of materials science is sparking growth in electronics technology, spawning new materials that can extend the capabilities of existing devices. A case in point is a transducer prototype just unveiled by West Germany's Siemens AG.

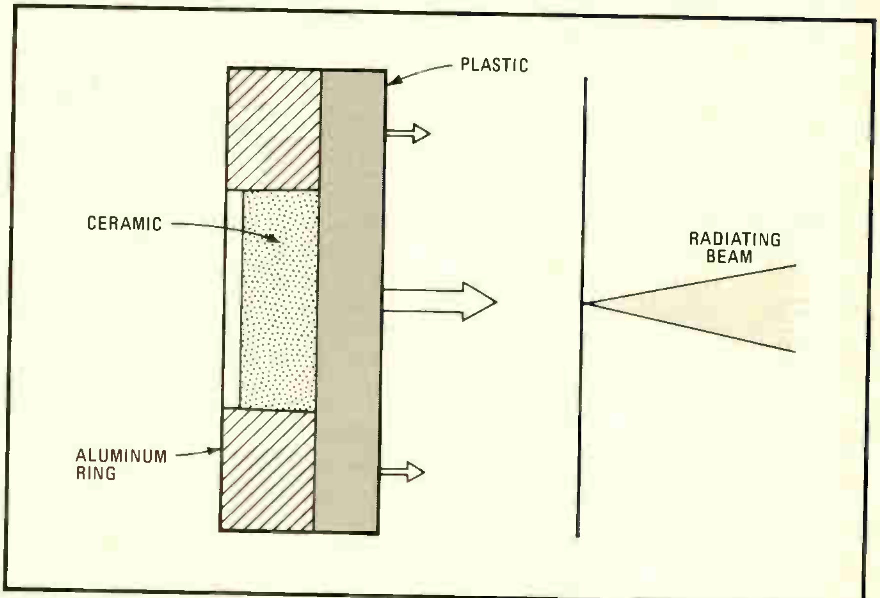
By using conventional piezoceramic materials with a new plastics compound, researchers have developed an ultrasound transducer that combines high directivity and sound pressure in a robust and compact package. Moreover, the device operates at much higher frequencies than existing transducers.

What it all adds up to is a unit that should extend ultrasound distance-measuring techniques further into industrial control tasks. Such applications have been hampered by the inadequate performance of existing electro-acoustical transducers that act as radiating and receiving elements, Siemens says. They tend to offer an unacceptable tradeoff: if their directivity is good, their sound pressure is too low to bridge adequate distances, or else their excellent sound pressure is accompanied by poor directivity.

In the prototypes from the firm's research laboratories in Munich, the ultrasound wave emanates from the transducer as a pencil beam with a half-power width of only 5°, a beam sharpness obtainable only with normal or infrared light. What's more, for a transducer operating at 30 kilohertz, say, the sound pressure is better than 140 decibels 1 meter away from the transducer.

High frequencies. "The transducers operate at frequencies that thus far not have been used in practical ultrasonic applications," says Peter Kleinschmidt, head of the research team. The present samples operate at up to 300 kHz, "and we are now working on devices using even higher frequencies." Depending on their frequency, the transducers emit useful ultrasound signals out to distances of 30 m.

Because of their narrow beam, the units can be precisely oriented towards an object whose distance is to be measured. Their high frequen-



Good going. Impedance coupling leads to high ultrasound pressure for good transducer performance. Deformable hollow glass spheres in the plastic disk give high resonance.

cies make for good noise immunity and high measuring accuracy. The accuracy with which the object's distance can be determined is 1% plus or minus three wavelengths of the ultrasound signal traveling through air.

As Kleinschmidt explains it, the new transducer (see p. 76) consists of a piezoceramic disk, an aluminum ring, and a plastic disk all held together by a special glue. A typical transducer is roughly 6 mm thick with a diameter of 18.5 mm. Generally, the diameter is from 12 to 15 times the wavelength of the signal that the transducer emits.

The key. The plastic disk is responsible for the transducer's excellent characteristics. Called an acoustical adapting layer or resonating coating, it consists of a mixture of epoxy and hollow glass spheres, each about 50 micrometers in diameter. These spheres provide a relatively large volume of air within the material, and this, in turn, results in a low material density. Such low density together with the spheres' minimal wall thickness—typically 3 μm—make for low sound velocity, which helps lower the material's acoustic-wave impedance.

This low impedance and the piezoceramic disk's inherently high impedance translate into a high transformation ratio under resonant conditions. That explains the transducer's ultrasound pressure, some 20 dB higher than for a conventional transducer, Kleinschmidt says.

Unlike those conventional flexural transducers, the Siemens version is what is called a coupling type. The ultrasonic oscillations produced in the piezoceramic disk at radial resonance are coupled to the plastic disk, which is a quarter of a wavelength thick. The radial resonance of the former combines with the quarter-wavelength longitudinal resonance of the latter to, in effect, yield a half-wavelength transducer. Such a transducer can easily be made to operate at high frequencies simply by giving it the proper dimensions.

The transducer's high resonating quality stems from the deformable glass spheres in the plastic disk's material. Its mechanical strength results from the epoxy-glass sphere mixture and the tough ceramic material in the piezoceramic disk.

The transducer's aluminum ring serves to shape the ultrasonic waves into a well-defined pencil beam with highly suppressed side lobes. The side-lobe suppression is at least 20 dB, Kleinschmidt says. □

France

Thin-film read/write head promises to hike storage densities for disk drives

Even as development of bubble memories advances, researchers are hard at work improving disk memories. At the French laboratories of CII-Honeywell Bull, work is progressing on a new type of thin-film read/write head that promises much higher bit densities on hard disks.

The research group has made a number of design improvements, starting with a glass-bonded assembly of two substrates, each carrying a set of the heads. Overlapping of the sets allows much closer head settings. Moreover, the heads are narrower than conventional units and this, plus the closer settings, makes for greater track density.

One big problem with such precise settings is getting the heads to stay on the tracks. To increase tracking accuracy, the research team at the lab in Les Clayes sous Bois, some 25 miles west of Paris, has devised a setup with two servo heads, one on each side of the read/write unit.

The CII-HB engineers have achieved recording densities of 24,000 bits per inch, compared to current high-density hard disks with 6,000 to 8,000 b/in. Combined with track widths about a third of the common 45 micrometers, this means that recording density could be increased by a factor of nine.

"The trouble is, we've yet to find a disk drive to cope with the sort of data rate this would give," says Michel Helle, an engineer on the project. However, he anticipates lab trials of a disk drive incorporating the new heads by the end of the year.

To achieve the track widths of 15 μm, Jean Pierre Lazzari, head of the research group, has come up with an ion-beam technique that replaces the conventional machine trimming of the pole pieces. The new technique provides a gap accuracy of ±1 μm, more than adequate for reading and writing and cheaper than machining.

Another use of the ion beam is to etch the head's profile to allow a

4-megabyte bubble memory to fill phone role

Magnetic-bubble memories are now big enough to enter the real world, as evidenced by one with a capacity of 4,194,304 bits from the Musashino Electrical Communication Laboratory. In an operating system, average read access time for successive 32-bit words is only 7.7 milliseconds, compared with 14.3 ms for the magnetic drum that it will replace in the file memory of the D-10 electronic switching system of Nippon Telegraph and Telephone Public Corp., to which the lab belongs.

The memory is a modular unit with a basic system size of four units totaling 512 kilowords, expandable in 256-kiloword jumps. The maximum size in one rack is 2,048 kilowords, arranged as two systems.

Each memory chip has 132 minor loops, with 128 for 65,536 bits of storage, 1 for check bits, and 3 for redundancy. Each unit has 80 chips, including 2 for parity and 14 for redundancy. Semiconductor integrated circuits are used for the read and write amplifiers and the logic circuits. Codeveloper Hitachi Ltd. will make the memories.

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Circle 78 on reader service card

lower flying height. The beam etches 5-μm-deep groves between the pole pieces. Air passes through the grooves, permitting the heads to hover a mere 0.5 μm above the surface of the disk.

For accurate reading and writing, head stability is a key, particularly under disk acceleration and over relatively uneven parts of the surface. So the center of gravity must be kept as low as possible, and the heads themselves as thin as possible.

To achieve these features, the researchers polish the top surface of the head assembly, thus exposing the tops of the heads. Then copper is deposited to form the contacts. This approach reduces head thickness to 1.8 millimeters, a 30% to 40% reduction over conventional heads. And, the thinner the head is, the lower the center of gravity is.

Two servos. One of the most critical parameters in high-density disk drives is servo tracking, necessary to align the head assembly on the data tracks and to haul it back into place if it slips away by so much as a micrometer. Because there are so many heads on one assembly, CII-HB has incorporated servo heads on both sides of the assembly. This setup increases tracking accuracy compared to conventional designs where the single servo head is separate from the read/write heads.

A byproduct of the Lazzari group's work is a multichannel head that covers a number of tracks on a disk at one time. Read/write operations may be switched electronically from one track to another. Such a design could be particularly useful in drives that have a vertical arrangement of head assemblies, one for each disk in a stack and covering a number of tracks on each disk. Electronic switching could slash the number of carrier arm movements necessary to move the assembly of multiple multichannel heads.

So far, the CII-HB engineers have been working with nine-channel heads. "But there is no reason why this should not be increased," says Helle. Despite good reliability results with the multichannel design, the engineers expect that the first production models probably will be single-channel units in order to minimize any operational problems. □

Great Britain

Transducers provide a sound way to modulate signals in multimode optical fiber

A sound and light show that no tourist will ever see is getting a lot of attention at an English laboratory. Researchers there are combining simple piezoelectric transducers with a single-strand multimode optical fiber to provide a potentially inexpensive yet flexible method of collecting data from many locations.

The transducer couples a high-frequency acoustic wave through the fiber's cladding to phase-modulate the optical signals by varying the refractive index and hence the path length of short sections. Furthermore, the additive nature of phase modulation means that a succession of transducers, operating at different subcarrier frequencies, can be tapped into the fiber.

The technique has the great attraction that signals may be applied without breaking the fiber, so there is no input insertion loss. However, it still is highly experimental, with several hurdles to leap before it becomes practical.

Work. Though simple in concept, a working system calls for some advanced communications engineering. For example, one fundamental requirement is to provide some form of local-oscillator signal at the photodetector in order to decode the phase modulation. The researchers at the University College, London, initially thought of providing a reference on a separate fiber. But they found that a multimode fiber provides its own reference, since the individual propagating modes are each differently modulated by any one transducer. Consequently, the receiving photodetector could extract the reference beam from its mixed inputs.

The technique leads to a particularly simple transmission system, says project leader S. A. Kingsley. Already the lab setup has transmitted good-quality color television video and audio signals.

Problems. However, the system was subject to deep fading caused by mechanical and thermal phase-modulation effects. To overcome this drawback, the researchers resorted to space-diversity techniques.

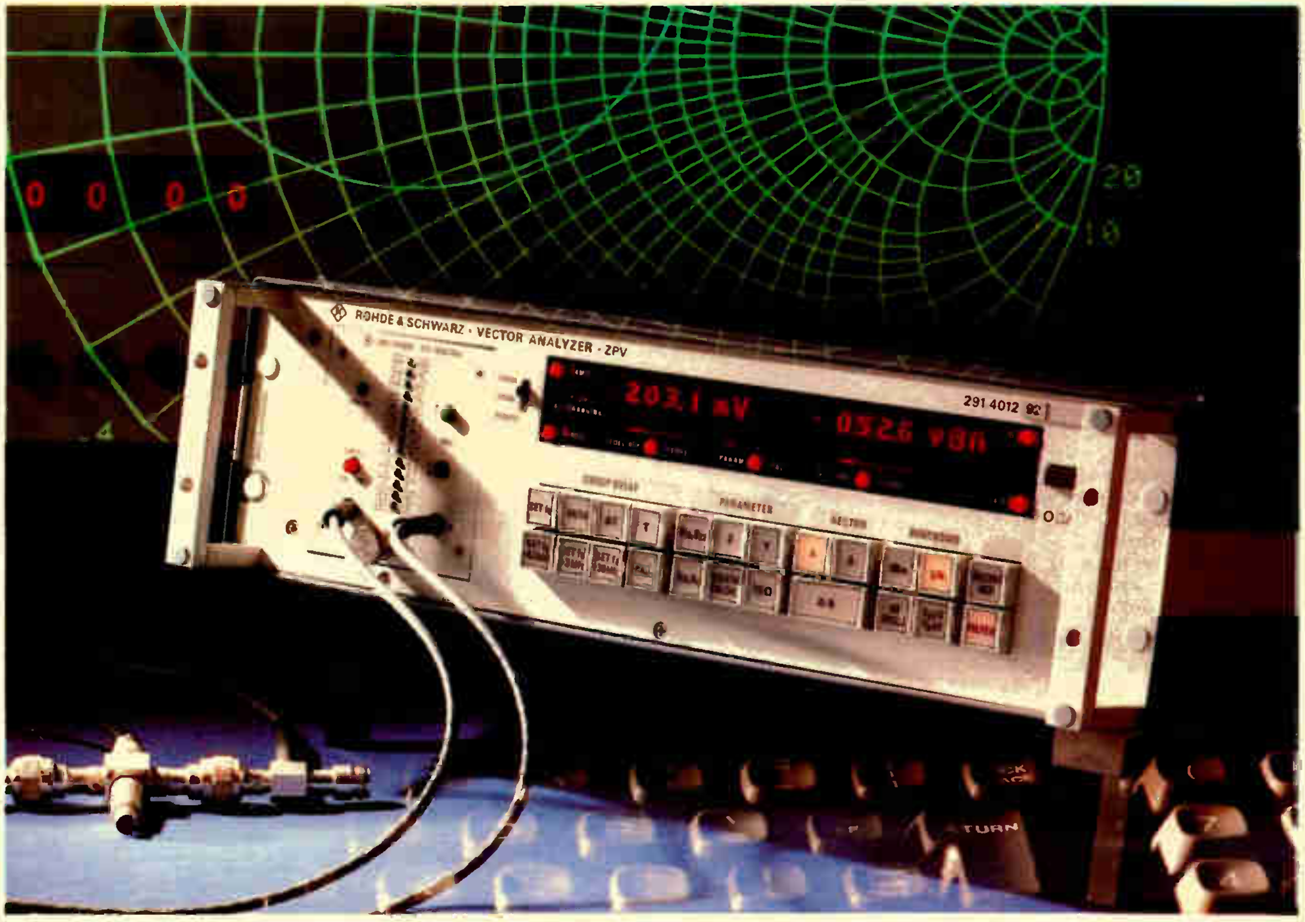
Such an approach is standard practice in microwave links, where redundant paths ensure reliable reception despite fading on any one path. In the fiber-optic system, this reliability is achieved by using an integrated-circuit four-quadrant photodetector from Integrated Photomatrix Ltd. The detector divides the propagating modes into four separate paths, and a subsequent signal processing reduces fading to acceptable levels, says Kingsley.

Further work by the researchers will include development of a suitable solid-state light source. The present source is a 2-milliwatt helium-neon laser that produces a highly coherent radiant source suitable for phase modulation. Kingsley says that integrated gallium-arsenide lasers offering sufficient coherence are close to development. His group is working with Standard Telecommunications Laboratories Ltd. of ITT on characterizing them.

The work is backed by the government's Science Research Council and the Ministry of Defence. Also, STL, General Electric Co., Plessey, and the Central Electricity Research Laboratories are providing support.

The researchers also will be looking at alternative digital-transmission techniques. In fact, the lab has a pulse-code-modulation system under construction. Also, for industrial applications, a cable with a low-loss attenuation matched to the operating frequency must be developed—and STL is interested in this. □

Going new ways: vector analyzer ZPV



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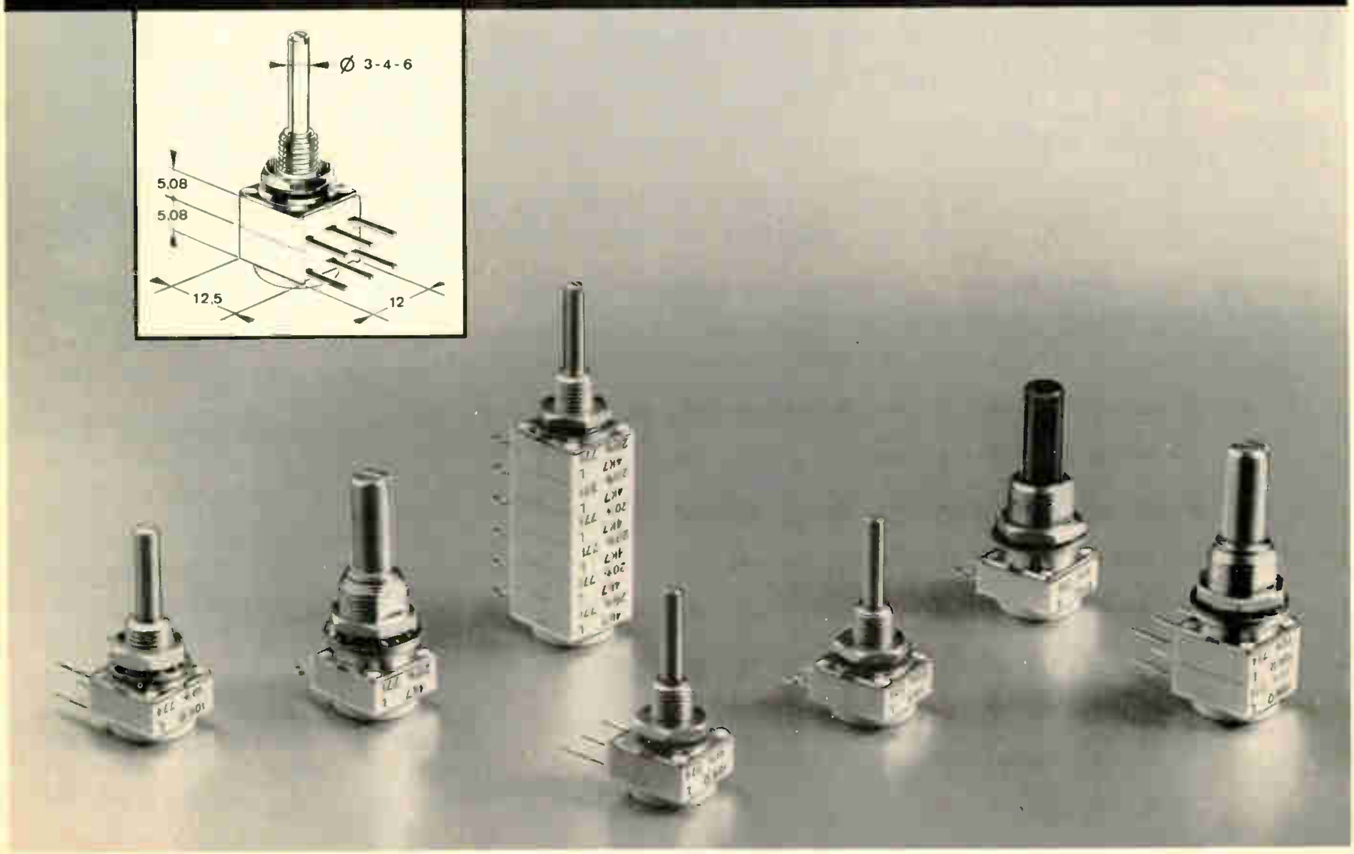

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Growing PABX race attracts German competitor

by John Gosch, Frankfurt bureau manager

Switch matrix meets stringent requirements with the reliability of MOS technology

For all its technical merits—like good transmission properties, high reliability, low resistance, and tolerance of excessive voltages—the mechanical contact for speech path switching in private automatic branch exchange systems is losing ground. It is giving way to semiconductor switches because they exhibit decided advantages.

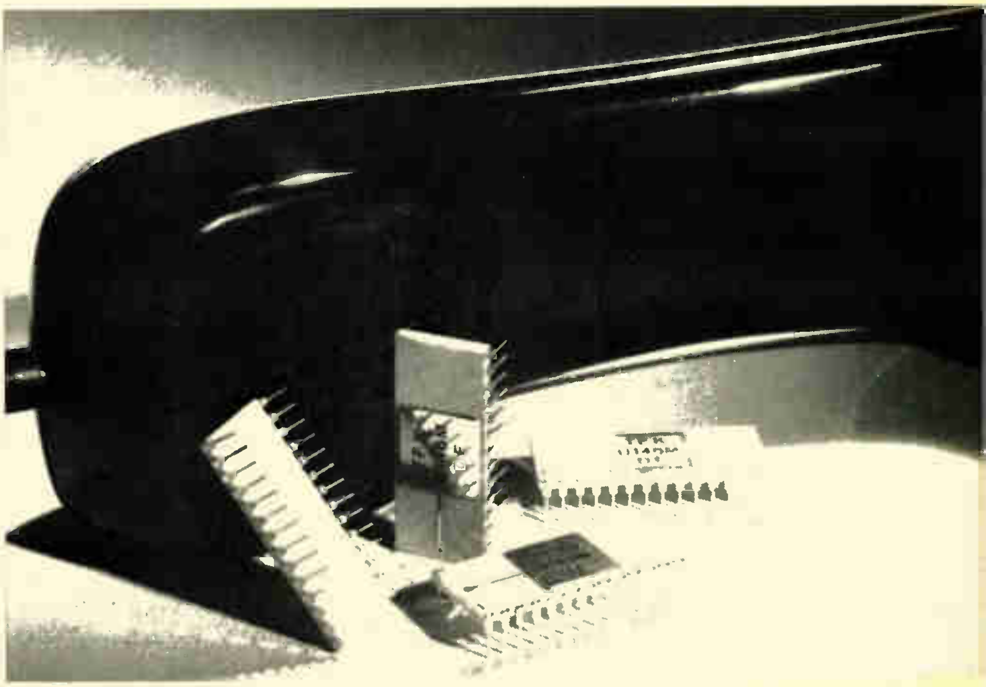
Less costly to fabricate than their mechanical counterparts, semiconductor switches are not hampered by contact bounce and are insensitive to mechanical shock. What's more, they are smaller in volume, consume less power, and have relatively short switching times. Little wonder, then, that a number of semiconductor houses are turning their attention to solid-state devices for speech path switching in PABX systems [*Electronics*, May 11, p. 39].

One company in the still small league of producers of solid-state speech-path switches is AEG-Telefunken and, with its new U145M monolithic integrated crosspoint array, the firm believes it has a winner on its hands. The device's most attractive feature, the company says, is that it can meet those stringent requirements imposed by communications equipment firms with a standard process—the well-established and easy-to-implement p-channel metal-gate MOS technology. This helps to keep the device cost down. Besides, with MOS, no dc bias is needed in the speech path—this in contrast to, say, bipolar switching devices.

Developed at AEG-Telefunken's research laboratories in Ulm and now in production at its semiconductor facilities in Heilbronn, the U145M incorporates ten crosspoints in a symmetrical five-by-two matrix, with each crosspoint made up of two MOS transistors, one per wire of a two-wire pair. The 20 transistors, together with the signal paths, are integrated on a 16-square-millimeter chip that also contains 10 memory flip-flops in addition to the control circuitry.

Some electrical characteristics for the device are: switching times of less than 100 microseconds, a crosstalk attenuation figure of better than 115 dB, and an inherent noise value of less than 86 dB. Housing the chip is a 28-pin dual in-line ceramic package. In lots of 500 units, the device sells on the German market for 75 Deutschmarks apiece—roughly equivalent to $36 at the currently prevailing exchange rate.

The U145M was originally designed for the Frankfurt-based communications equipment maker Telefonbau und Normalzeit, an AEG-Telefunken affiliate. It is currently incorporating the crosspoint array into its space-division-multiplexed PABX system 4030. "Working with a systems house like TN from device conception to prototyping has been of tremendous value," says Jürgen Dangel, head of the engineering team in Ulm that developed the crosspoint array. "It enabled us to



find out what the system requirements are and to come up with an optimum device solution as regards matrix organization, reliability, attenuation, insertion loss, and many other factors."

So it is no wonder that the company's sales engineers at the Heilbronn facilities feel that "what's good for TN should also be good for other communications systems makers." In this spirit, the U145M is being offered to companies pursuing space-division multiplexing concepts for PABX equipment similar to TN's.

Applications for the U145M extend far beyond speech path switching, however. Dangel sees other uses for the device, particularly in broadband applications in the TV area—for example as a video coupling matrix. Another use would be in studio equipment. There, the device, functioning as a coupling element, could replace crossbar distributors.

Aside from its being a standard process, AEG-Telefunken has settled on MOS technology for still other reasons. With MOS, the switching transistor's control gate is isolated from the signal path, and this prevents the control circuitry from interacting with that path. Also, the drain and source are exchangeable, which makes for a nondirectional speech path. Furthermore, with MOS being a well-established technique, it makes possible the high device yields that are necessary to provide cost advantages over mechanical switches.

The p-channel method, together with ion implantation techniques, allows setting the threshold voltages such that enhancement and depletion transistors can be realized. For one thing, this permits the device to be directly driven from transistor-transistor-logic circuits. For another, by using depletion load transistors, a high noise immunity is achieved.

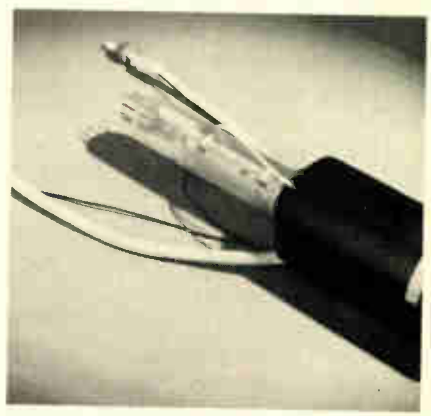
The U145M's five-by-two matrix organization represents the best compromise between cost per crosspoint and chip size, Dangel says. A five-by-one matrix, he explains, would be too small and costly for optimum integration. A five-by-four matrix, on the other hand, would occupy too much chip area and would call for a multilayer wiring technique—one that cannot be implemented by a standard process. The five-by-two matrix, however, not only proved to be the optimum size, it also lends itself best to making a square-area chip.

Of the chip's 16-square-millimeter area, about 50% is taken up by the 20 switching transistors, 10% by the control logic circuitry and 40% by the pads, the voltage level converters, and the wiring. Of the package's 28 pins, 14 are for the speech paths, 7 for driving the matrix, 4 for the control signals and 2 for the operating voltages of +5 V and −24 V and 1 for ground. The power consumption at these voltages is typically 150 mW.

To protect the logic inputs against high static voltages, the chip integrates protection circuits consisting of resistors and large-area diodes. These can handle negative surge voltages of 1 kV and positive surge voltages of up to 2 kV.

Only a diode can be used to protect the switching transistors in the speech path, since a resistor would alter the transistor's low-resistance characteristics. The speech path is protected against voltage surges of about 5 kV of either polarity.

AEG-Telefunken, Theresienstr. 2, 7100 Heilbronn 2, W. Germany [441]



The type TH 9663 TV camera tube uses a 16-mm photocathode to pick up images with light levels down to 10^{-5} lux. Bloom-resistant and rugged, it can be used with vidicon optics and deflection cells. Thomson-CSF, 38, rue Vauthier, 92100 Boulogne-Billancourt, France [466] microprocessor-based products

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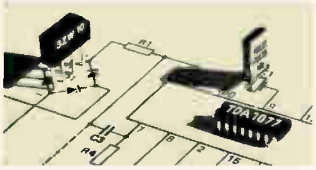

The TDA1077 generates low frequencies of 697, 770, 852 and 941 Hz, and high frequencies of 1209, 1336, 1477 and 1633 Hz. Supply voltage derived from the line is 3,5 V maximum. The device is available in plastic or ceramic 16-pin dual-in-line encapsulations under the type numbers TDA1077P and TDA1077D, respectively.

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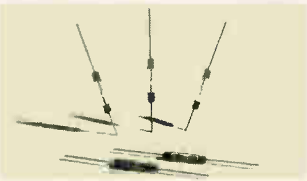
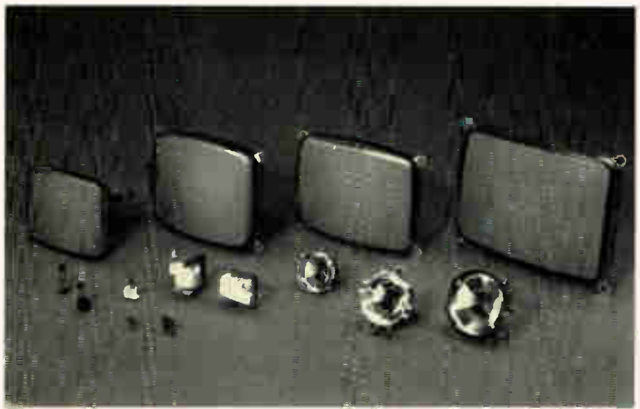


CIRCLE 255 ON READER SERVICE CARD



From left to right: 9" and 12" (90°) and 12" and 15" (110°) cathode ray tubes.

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The Microcomputer Cross Assembler Program (MCCAP) which has been specially developed to support the 8X300 is given in-depth treatment; MCCAP provides many powerful features including macros, automatic subroutine handling, and conditional assembly. Programming examples and the 8X300 program library are included in the manual, together with numerous application examples of the 8X300.

Interested readers are requested to write for a copy on their company letterhead to: Philips Industries, Elcoma Dept., Market Promotion, Building BFp, Eindhoven, The Netherlands.

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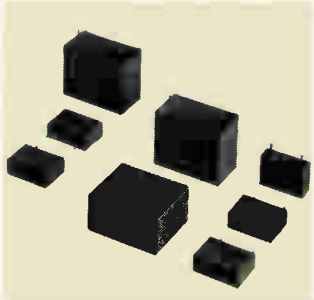

Where high voltages are combined with steep pulses and high currents, particularly in the deflection circuits of television receivers which combine high peak currents with line frequency, and in a.c. motor control and switched-mode power supplies, the 357 6...., 357 7.... and 357 8.... series can be used. These new capacitors are rated at 630 V, 1000 V and 1500 V, respectively. Each of these three covers values up to 0,35 µF with tolerances of 5% and 10%. Series construction has been employed using polypropylene film, aluminium foil and metallized polypropylene film. For all types it is possible to get special capacitance and tolerance values on request.

CIRCLE 257 ON READER SERVICE CARD

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Eindhoven - The Netherlands

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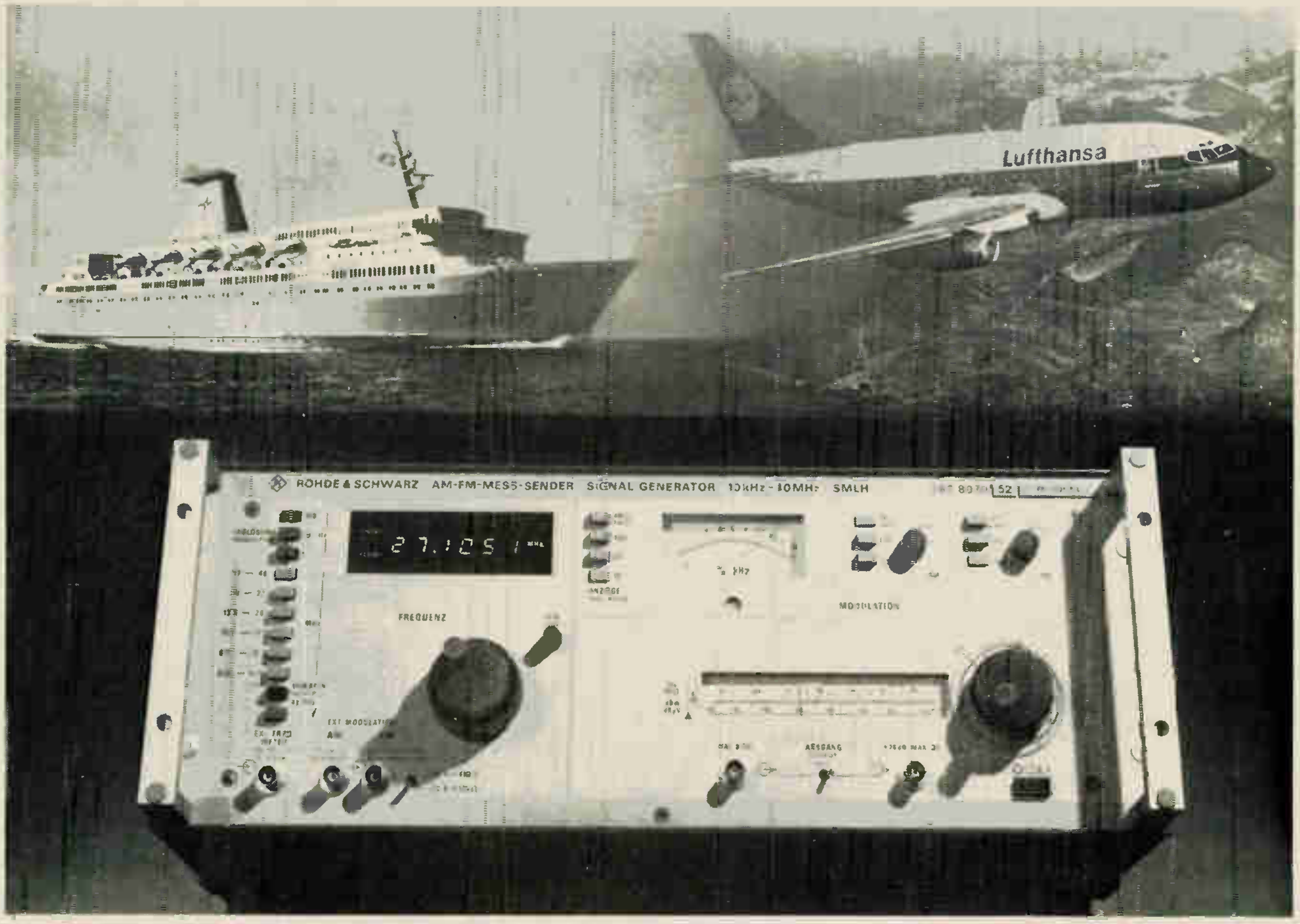
New AM/FM signal generator for long - medium - shortwave



1978 will see SSB introduced on a wide scale for international maritime and aeronautical radio, meaning high demands on the purity and stability of the signals used in testing the equipment – and making the SMLH the ideal signal source for producers of and workshops servicing marine and aero radio sets, HF direction finders, antennas and amplifiers.

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New products international

Noise meter GM-1 measures both noise level and the repetition rate of noise pulses on data lines. For noise levels, the measuring range is –90 to –19 dBm; the threshold for noise pulses can be set from –49 to 0 dBm. Wandel u. Goltermann, 7410 Reutlingen, P. O. Box 259, West Germany [473]

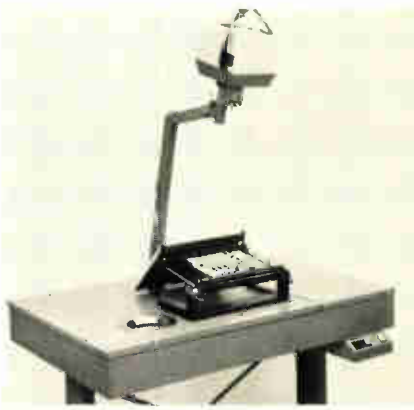
Capable of operation up to 5,000 V, the model NSG509 insulation tester has both automatic and manual modes. It can supply continuous testing currents as high as 100 mA even at 5 kV. Leakage current is indicated directly. Schaffner, CH-4708 Luterbach, Switzerland [474]

The E6 family of high-frequency chokes is available with inductance values from 10 to 2,200 μH. Housed in Noryl packages, the units can operate from –40°C to +100°C. Each choke takes up only 64 mm^2 of board area. Neumueller GmbH, Eschenstr. 2, 8021 Taufkirchen, West Germany [475]

New products international

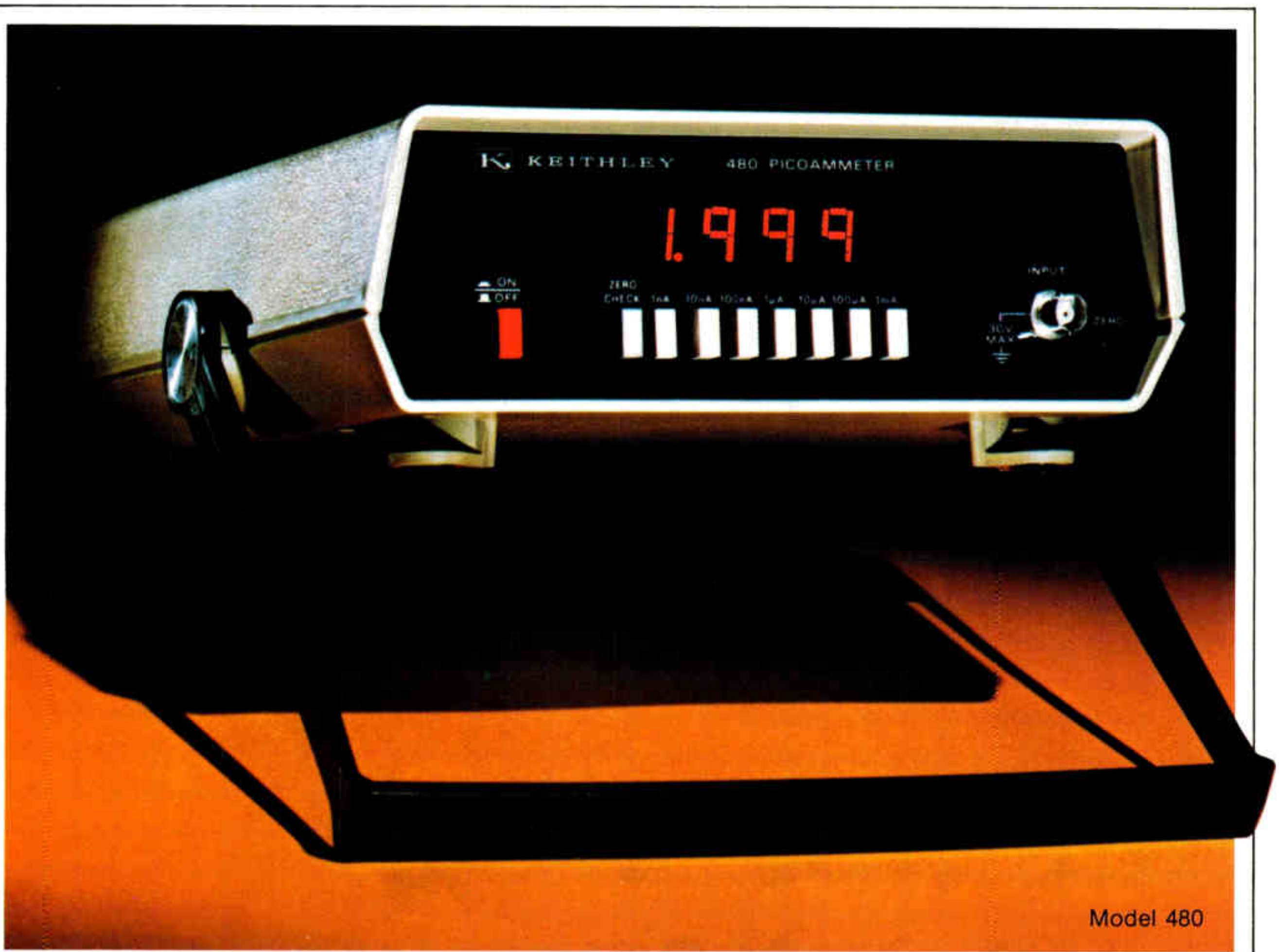
A 1-in. silicon-target vidicon, TH 9847, is designed for military-environment applications. Its integral deflection and focusing coils make it easy to align. Thomson-CSF, Division Tubes Electroniques, 38 rue Vauthier, 92100 Boulogne-Billancourt, France [443]

A four-channel multiplexer uses full solid-state circuitry making it highly reliable and lightweight. Its maximum input frequency is 62.5 Hz, and it supplies an output of 30 V dc at 50 mA. Takenaka Electronic Industrial Co., 20-1 Naranocho, Shinomiya, Yamashina-ku Kyoto 607, Japan [444]



A pc-board-assembly station automatically dispenses components held in up to 80 cups to an operator one at a time while an image is projected showing where the part is to be placed. John Parfitt Ltd., Blandford Heights, Blandford, Dorset, DT11 7TE, England [445]

NEW . . . Simple, economical picoampere measurement!



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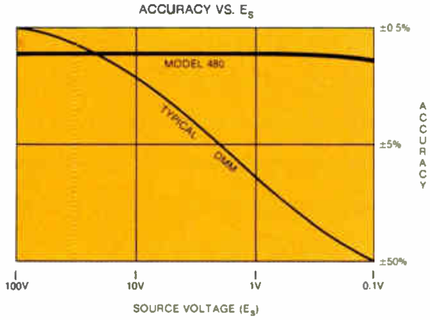

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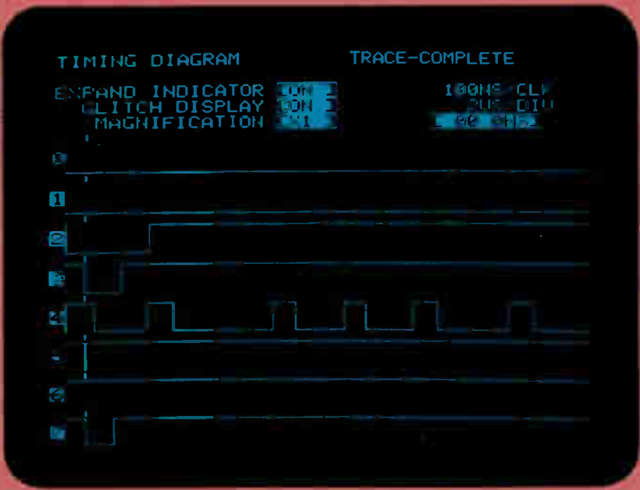
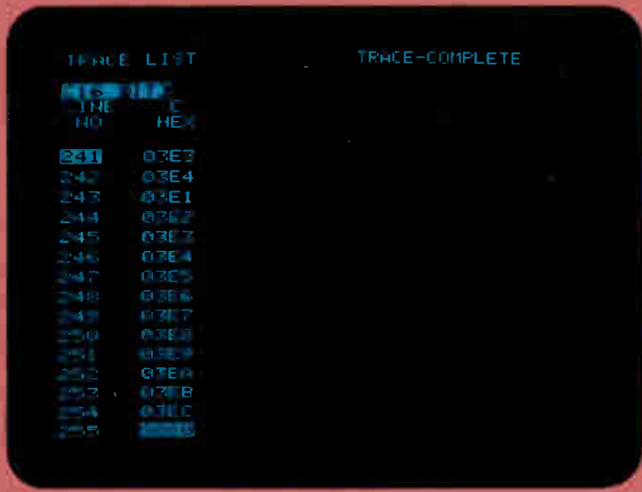
KEITHLEY

Circle 81 on reader service card

Timing Analysis—The hardware approach

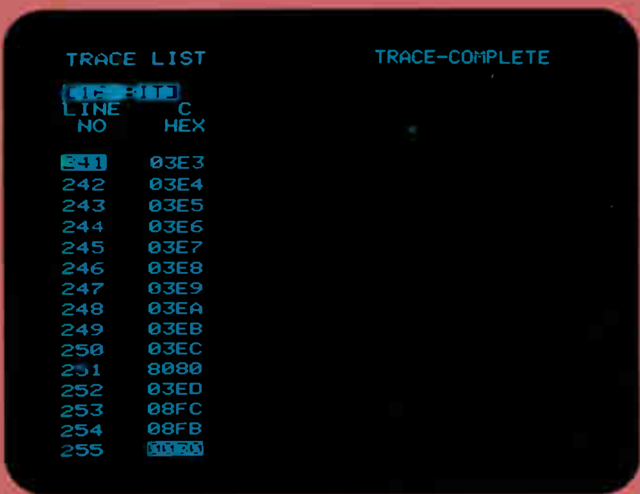


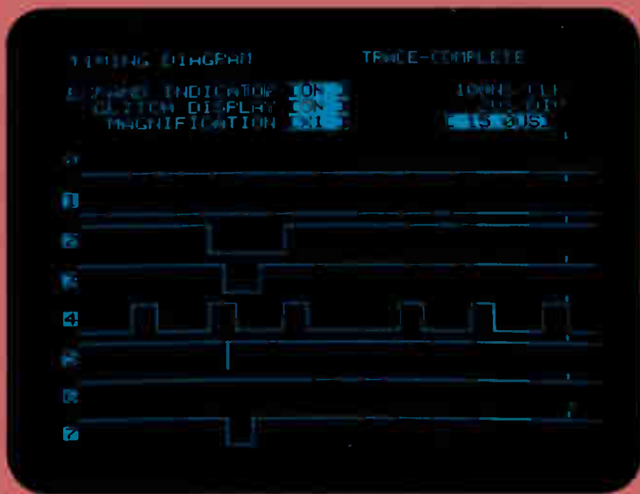


Trigger on glitches. A glitch on an input to a one shot (channel 5) is causing a false interrupt (channel 7). This glitch (which is intensified to distinguish it from data) can be used to trigger state as well as time displays.

Observing state display shows address flow at the moment the glitch occurs and reveals that the I/O port address 8080 always occurs at the same time. This would lead you to observe I/O related signals for transitions occurring simultaneously with the glitch.

State Analysis—The "Software" approach





Trigger on state. The interrupt vector (0030) can be used as the trigger point to observe address flow prior to the false interrupt. Evaluation shows that the I/O port address 8080 always appears four machine cycles prior to the interrupt vector.

Observing timing display of signals on I/O and one-shot shows that the glitch on the input to the one shot (channel 5) occurs four machine cycles before the trigger point and is coincident with the transition on I/O read (line 3) indicating possible capacitive coupling.

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For Technical Data circle 86 on Reader Service Card
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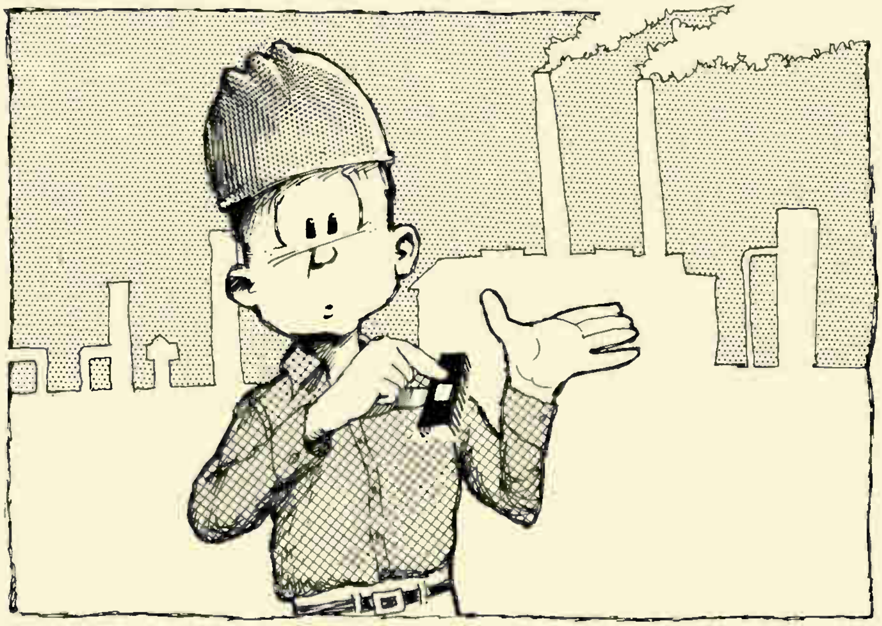
TEKTRONIX LOGIC ANALYZERS THE VERSATILE ONES

Switch to micros has them sweating

Makers of industrial-control gear are confused by hordes of devices, irritated by spec changes, and stymied by inadequate test data

by Bruce LeBoss, New York bureau manager

Manufacturers of industrial-control equipment are apparently foundering in attempts to switch to microprocessors in electromechanical or analog control machinery. That picture is painted by several major original-equipment manufacturers that find their industry buffeted by hardware- and software-related problems.



From the outset, OEMs trying to use microprocessors can find the experience a trying and traumatic one, states Bill Crawford, manager of micromodule products at Motorola Inc.'s Integrated Circuits division in Phoenix. His group builds microprocessor-based modules that go into process-control systems, among other things, so Crawford understands the dilemma.

To a greater degree than digital-systems manufacturers that are familiar with microprocessors and software, industrial OEMs face a difficult decision regarding what microprocessors to use and why. "Often it is a choice between unproven microprocessors and unproven interfaces that are to be sandwiched around unproven software. The result is a disastrous sandwich," says Crawford. Some microprocessor manufacturers, such as Motorola and Intel Corp., try to help by making microprocessor modules available, he adds, but "modules are not a panacea, just an open-faced disaster sandwich."

Inundated. Compounding the OEMs' dilemma is the plethora of microprocessor parts flowing from vendors, indicates Walt Luciw, a senior advanced-circuits design engineer at Sperry Univac in Blue Bell, Pa. Luciw, who applies microprocessors to Univac products and finds himself in continuing dialogue with other OEMs, says the proliferation of microprocessors is not bad in itself, since they offer the user a degree of flexibility, but does impose the need to make a large number of decisions about each type of microprocessor, such as how one feels about a particular vendor, its production capability and past performance.

Luciw also observes that the constant output of new microprocessors often leads to delays in product programs. He notes an apparent hesitancy in the industrial market, mostly due to manufacturers' reluctance to commit themselves to an intermediate-state microprocessor while new ones are coming down the pike. What's more, adds Robert D. Jurenko, an engineering specialist at process controls manufacturer Leeds & Northrup Co. in North Wales, Pa., "it is quite perplexing for us to know that after we've designed or shipped a microprocessor-based instrument it is obsolete within weeks."

Specs shift. One of several problems, not uncommon with semiconductors but even worse with microprocessors, Jurenko says, centers around device specifications. "A lot of the time, vendors come out with a preliminary spec sheet and get you to design your equipment around their part. Then, when the part comes out, they have changed the specs."

Sometimes, the microprocessors tailored for industrial controls just do not have enough horsepower, notes Jack V. Landau, staff engineer at the Singer Co.'s R&D Laboratory in Fairfield, N. J. For example, says

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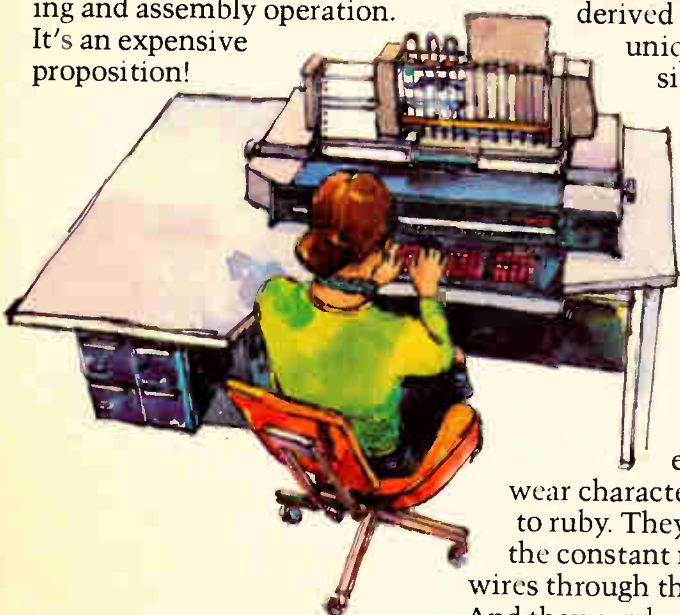

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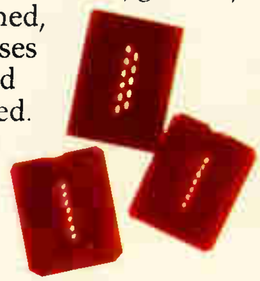

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CORNING

Computers

Taking a new route to IBM country

Magnuson Systems' M80 is a CPU series that also can be made to emulate machines from Burroughs, Univac, and Honeywell

by Rob Brownstein, San Francisco bureau

With International Business Machines Corp. clearly an increasingly inviting target for producers of new computer systems, it is difficult to imagine yet another way of attacking the giant corporation. But not only has the deed been done, its doer is a brand-new company: Magnuson Systems Inc.

Magnuson's entry is the M80 series of IBM-compatible central processing units. Unlike National Semiconductor's System 400 and Two Pi's V/32 [*Electronics*, May 11, p. 81], the M80 is not a minicomputer. Rather, it is a general-purpose CPU built with a standard medium-scale integrated Schottky transistor-transistor logic. But it is microprocessor-like in that it has control sequencing stored in read-only memory. While the components used to build the M80 are not as state-of-the-art as those used for either of the other two systems, which use bit-slice microprocessors, the architecture "makes the M80 series virtually obsolescence-proof," says Paul H. Magnuson, president and chairman of the year-old Santa Clara, Calif., company.

Employing what Magnuson calls "strategic architecture," the designers made the M80 so that system and technology may be upgraded. "For example, as charge-coupled-device or magnetic-bubble memories become cost-effective, they can be easily incorporated into our system without any system redesign having to be done," explains Joseph L. Hitt, marketing vice president.

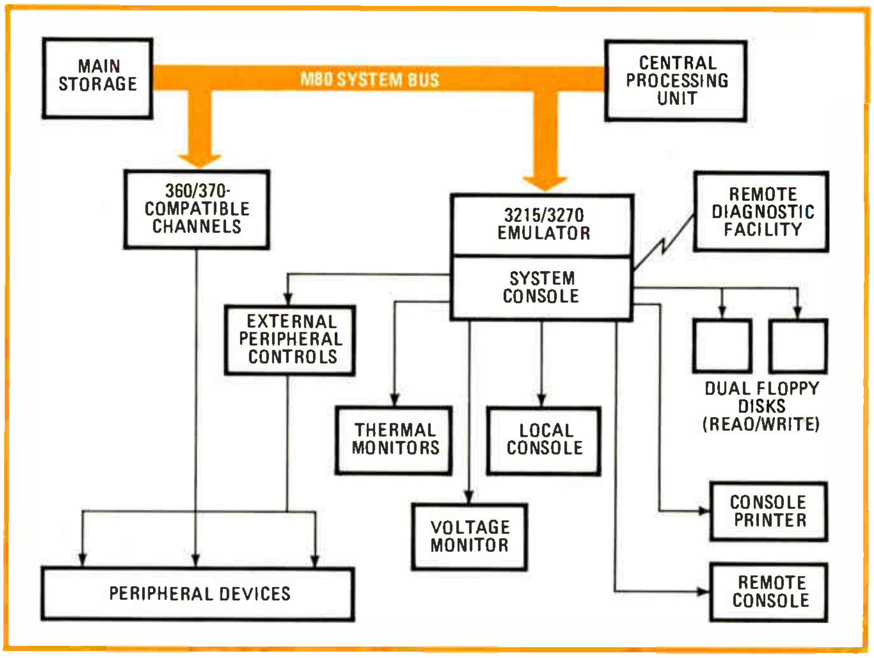
Moreover, according to Hitt, performance of a low-end M80/3, lying between that of an IBM 370/138 and 370/148, can be upgraded to meet the specs of the M80/4, which exceed those of the 148.

Although Magnuson is playing up the IBM compatibility, as are Two Pi and National, the firm is quick to point out that the M80 need not emulate only IBM systems. "By making some changes in microcode and input/output compatibility, for example, the M80 can emulate other systems, such as those of Burroughs, Honeywell, and Univac," Hitt says. But since the I/O is currently hard-wired, emulation is limited to IBM machines until alternative circuit boards can be designed.

Such versatility would be highly unnecessary if the goal were to sell only to original-equipment manufacturers, but it points up another difference between Magnuson and its rival companies: marketing plans.

For end users. Unlike both National and Two Pi, which are casting their wares exclusively into the OEM pool, Magnuson Systems is aiming for a mixed OEM and end-user market, with more of the latter. Paul Magnuson, drawing on his 10 years of experience with Cincinnati Milacron Inc., Amdahl Corp., RCA Corp., and IBM, sees a market waiting for intermediate-range computer systems that have greater flexibility than IBM's intermediate models.

He says that the general-purpose computer market has been growing at a rate of over $1 billion per year. On the basis of industry surveys, Magnuson Systems expects that rate to continue right into the 1980s. Of the $13 billion in U. S. shipments



New system on the block. Magnuson Systems, a new company aiming to take a chunk of IBM's market share, has designed a system that is a central processor rather than a mini.

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ROCKLAND

sion manager for broadcasting satellites and future communications satellites at ESA's Paris headquarters, there are some good reasons for putting aloft a preoperational satellite whose costs are shared by many nations. It is particularly the users that would benefit, he says.

Reliability requirements of national TV networks would require any nation lofting a satellite into space to put up a spare. And the service has to be financed until viewers are wooed into paying in sufficient numbers to make it economic. Important, too, will be the high cost of preparing TV programs to fill the new channels that a satellite would make available.

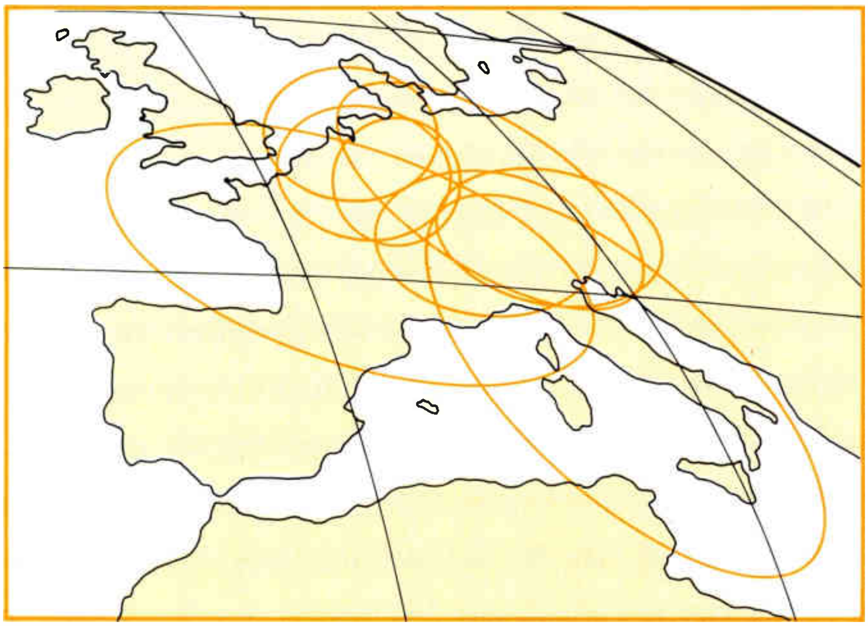
However, the member nations of ESA are looking at their own cooperative projects, and not only in Scandinavia. According to industry sources in Paris, the Germans have asked "almost everybody" to cooperate with them on launching a satellite. The French envisage at least a bilateral project for a possible H-SAT follow-up in the mid-1980s with even more distant plans for a national satellite to be launched after 1995.

Apart from the wrangling over how it should be done and who should do what, there are other political problems. These include spillover—broadcasting over national boundaries. This is likely to be widespread even when the guidelines set by last year's Geneva plan are followed. Feelings on spillover run high, with some nations talking darkly of cultural invasion.

Violence. For example, Swedish television is strictly nonviolent. What would be the Swedish reaction to no-holds-barred West German TV? Observers say that were Bonn to launch a satellite capable of covering large parts of Scandinavia, the Scandinavians could then be obliged to launch their own satellite in cultural self-defense.

Apart from the political problems, there are also the economic and technical aspects. Technically, most sources agree that the problems are almost solved. The crucial part is producing a system that allows low-cost reception at individual household level. This means a powerful traveling-wave tube in the satellite to reach a small ground terminal.

Among European suppliers working on the 150-watt and 450-W TWTs slated for launch in H-SAT are, respectively, Thomson CSF of France and AEG-Telefunken of West Germany. Though neither of these tubes has yet been flight-tested, the firms believe that they have mastered the technology. At AEG-Telefunken, the development teams are working on a whole range of TWTs from 100 to 800 W. At Thomson, the next stage beginning to be looked at is the 200-W TWT. H-SAT may carry two 200-W TWTs for experimental and standby purposes.



Dividing the job. With Western European nations clamoring for television satellites, a meeting last year in Geneva arrived at this compromise regarding service areas.

Economically, the problem may be split into two parts: can the satellite approach compete with a conventional ground network or cable TV? Secondly, can it be made cheap enough to attract the viewer as a paying customer? The French space agency estimates that the development of a five-channel operational satellite would cost around $43 million while five would cost four times that sum. Launch costs for four satellites (one in reserve) would be about $130 million. Including ground control and transmitting stations and just over $1 million a year running costs, the total cost would top $300 million over 10 years. Annual running costs, figures a space agency expert, work out to a third of a new conventional network.

That private estimate is considered a little exaggerated in some quarters, but it is much closer to reality if the cost of the rooftop antennas is ignored. Four-channel coverage could be achieved at a rental price of around $40 million a year, estimates Eurospace, a Paris-based consultant organization that represents European satellite manufacturers. Eurospace was due to propose a satellite rental service at the Lima international satellite communications seminar earlier this month.

Antenna cost. But it is not only the transmitting part of the hardware that boosts the cost. A satellite system also requires individual household antennas that cost significantly more than those for conventional TV. From the point of view of European industry, it is those antennas that are the big potential money earners. As Rosetti of ESA puts it: "At a rough estimate there will be 100 million sets in Europe by the end of 1980. Assuming just 10% of those viewers decide to spend $300 on a ground antenna, that makes a $3 billion market. Even spread over 10 years, that is a sizable sum." So far, European industry seems a long way from the $200 antenna. Philips talks of a price below $400, according to Eurospace experts. □

Packaging & production

Mass molding a boon to fast logic

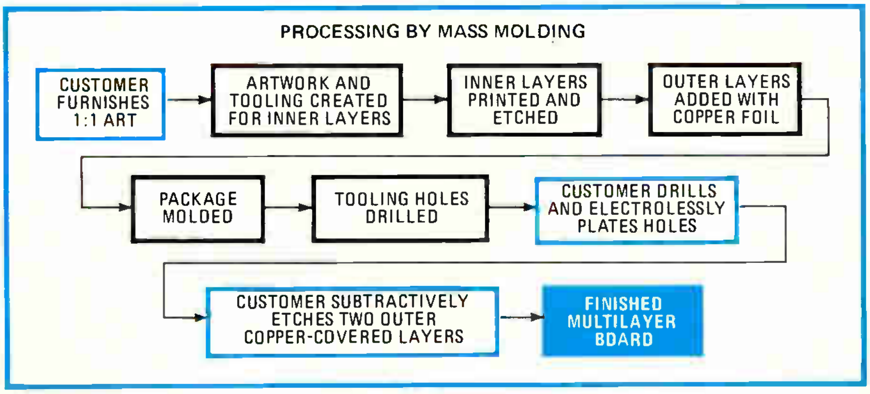
Makers of computers and peripherals are using newly popular method of making multilayer boards that is faster, simpler, and cheaper

by Jerry Lyman, Packaging & Production Editor

A nine-year-old technique that offers a simpler, low-cost, fast-turnaround alternative to the standard multilayer board has suddenly hit the big time. And what has propelled mass molding to its new heights of popularity is the growing interest being shown by makers of computers and peripheral devices in multilayer printed-circuit boards.

The usual multilayer board, with up to 30 conductive layers, is pretty much a high-density packaging approach suitable only for military and space applications. But with the advent of high-speed logic, a simplified four-layer form has begun to find its way into computers and peripherals because it is so much denser than single-layer printed-circuit boards. Moreover, mass molding, a method developed by Fortin Laminating Co. of San Fernando, Calif., can turn out these simpler boards almost on an assembly-line basis.

Comparison. conventional multilayer-board making amounts in effect to a custom process, providing the user with a ready-to-go pc board. The mass molding process provides semi-complete boards, made by stepping and repeating circuit patterns on the inner layers, each for a different board, on laminate sheets that are up to 48 by 24 inches in size. The first method turns out a board at a time, manufactured layer by layer



With mass molding, the system manufacturer receives a multilayered laminate from pc-board firms like Fortin, Lamination Technology Inc. of Santa Ana, Calif., and the Mica Corp. of Culver City, Calif. It has two conductive layers—usually a ground plane and a power plane—and two outer layers covered with copper foil. The customer then need only subtractively etch the patterns he needs from the two outer copper surfaces (see diagram).

Mass molding uses much the same materials as those found in conventional board manufacturing—cores, or epoxy-glass layers with copper foil on both sides, and prepregs, or thin sheets of partially polymerized epoxy resin. For the two internal layers, circuit details are first subtractively etched on the core material. Then several insulating prepregs are placed over the top and bottom, and standard copper-covered pc epoxy-glass material make up the final two outer layers. Lastly, the entire sandwich is laminated together in a molding press.

That contrasts strikingly with the conventional method of making multilayer boards. Most standard multilayer presses can handle only material that is 18 by 24 in., which limits the number of similar boards that can be turned out simultaneously. A conventional four-layer board is put together from a top circuit core with copper foil on both sides (layers 1 and 2) followed by prepregs and a bottom circuit core (layers 3 and 4).

Distortion a threat. In the manufacturing process, layers 2 and 3 are etched, then pins are used to ensure exact registration of the cores and prepregs, and the assembled layers are laminated together in a press. After this step, layers 1 and 4 have their circuit patterns subtractively etched onto them. The whole process uses much more labor than mass molding and requires many additional steps. What's more, any distortion of the laminates or pins due to the heat and pressure of the laminating press can knock the layers out of registration.

On the other hand, mass molding requires fewer steps and there are fewer opportunities for error. Registration of the outer to inner layers is simpler: pilot holes are drilled into the outer layers through which registration targets on the etched inner layers are found. Layers 1 and 4 are matched to these targets. This method virtually eliminates the registration defects that can crop up in the standard way of manufacturing multilayer boards.

Ordinarily, the

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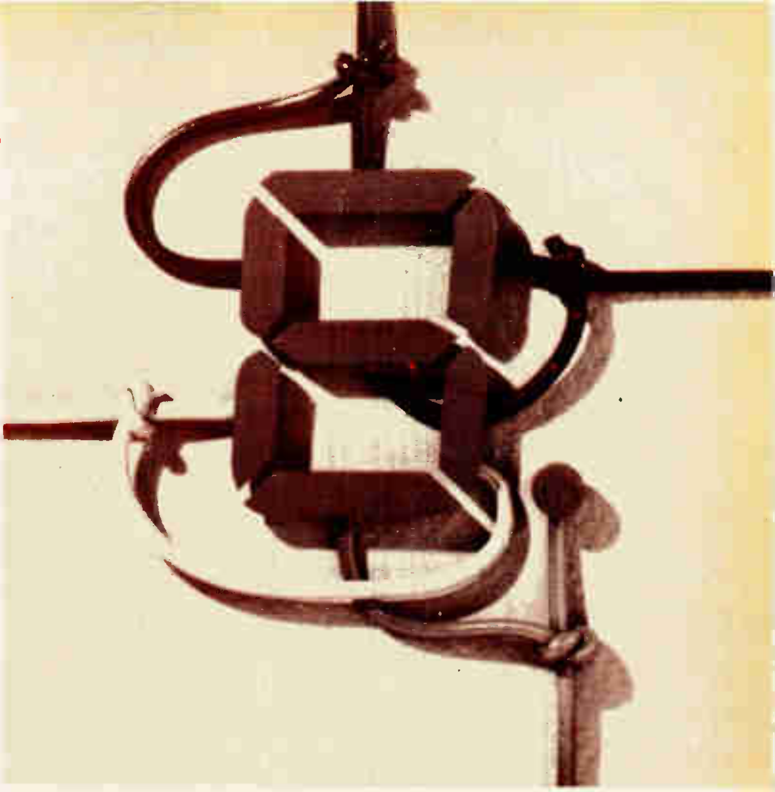


Suitable LCDs can be found, and addressing them as a matrix works

by Paul Smith
Beckman Instruments Inc., Helipot Division, Fullerton, Calif.

☐ They use so little power and stay so visible even in bright sunlight that liquid-crystal displays would seem a natural choice for large-area, multiple-character applications. But there is one big obstacle: the prohibitive cost of driving and terminating LCDs made up of six or more characters.

Multiplexing, of course, could halve the number of leads required, simplify the drive electronics, and permit direct interfacing to microprocessors. But few LCDs are good candidates for multiplexing, and although more suitable ones are becoming available, the complex characteristics of their electrooptic response still have to be taken into account. Nevertheless, determining which LCDs are the right ones and then multiplexing them together is by no means an impossible task, even if more difficult than for other display technologies.

In any multiplexed display, the various segments of different symbols are not independent but are interconnected. The method of interconnection commonly used with light-emitting-diode displays is to tie together all those segments that have the same location in each symbol (Fig. 1a) and then address the symbols sequentially. But this method of time-division multiplexing is not widely used with LCDs at present because limitations in their electrooptic response make it impossible to address more than three or four digits sequentially.

Alternatively, though, each digit could be configured as a matrix, and if that is done, any number of digits may be addressed at the same time. In this approach, the displays are wired so that interconnected segments do not share the same symbol backplane. Figure 1b shows how pairs of segments of different digits may be interconnected even though each member of a given pair belongs to a different half of the digit's backplane. Generally, alphanumeric characters may be configured as matrixes of three by four, four by four, or three by six segments or the familiar five by seven dots.

With a matrix-addressed LCD, each segment plus its associated backplane is electrically equivalent to a lossy, nonlinear, voltage-dependent capacitor (see "Examining liquid-crystal displays inside and out," p. 114). In fact, the entire array may be represented schematically as rows and columns interconnected by capacitors at each intersection (Fig. 2a). A series of select pulses ($\pm V_s$) drives each row, while a series of data pulses ($\pm V_d$), which are either in phase or out of phase with the select pulses, drives each column. In this example, there are four segment lines (N = 4), which are sequentially addressed (Fig. 2b), so the duty cycle (η) is one fourth and the display is said to be one-fourth multiplexed.

How matrix-addressed multiplexing works

In such a matrix-addressed multiplexed display, simultaneously applying a select signal and a data signal determines the select or nonselect status of any particular segment. For a ¼-multiplexed LCD, the frame period (T_f) of the select waveform is divided into four equally spaced intervals corresponding to the time segments in which each row is addressed. Essentially, the matrix is addressed by multiplexing N rows with a voltage of $\pm V_s$ and presenting data information with a voltage of $\pm V_d$. At the intersection of a row and column, the voltage that appears across an LCD segment is the difference between the select and data signals. On the average, for a period T_f, a segment will be on if the voltage during the interval of ηT_f is $V_s - (-V_d)$ and off if the voltage is $V_s - V_d$. For the rest of the frame period $(1 - \eta T_f)$, the segment sees only $\pm V_d$.

Since LCDs are sensitive to the root-mean-square voltage between their segments and backplane, they are similar to incandescent lamps, in that their brightness is independent of the waveshape so long as the rms value of applied voltage remains constant. If the off-segment (nonselect) rms voltage is $V_{\cdot}$, and the on-segment

Examining liquid-crystal displays inside and out

Liquid-crystal displays excel other display technologies in several respects. Their voltage and current needs are so low that they may be driven directly from complementary-MOS circuitry. They become not less but more legible in direct sunlight, and the brighter the sun, the better. They can reproduce graphics, symbols, and designs just as readily as the more usual alphanumeric characters. In portable equipment, yet another benefit is long battery life, which in watch applications extends out to two and sometimes even three years.

Their future looks even more promising. Their ruggedness is improving as their operating temperature range broadens and the resistance of plastic-sealed units to humidity increases. The development of dyes compatible with liquid-crystal materials will soon mean the availability of LCDs in a whole range of colors. Then, if polarizers can be eliminated also, legibility and appearance will really improve.

Device construction. The LCDs going into watches and instruments today are twisted-nematic, field-effect devices. They sandwich liquid crystals between front and back planes of thin glass, which are sealed together with plastic or glass. On the inner sides of both glass planes are transparent conductor patterns that are coated with a special chemical film that aligns liquid-crystal molecules. To the outside of both pieces of glass are laminated polarizers, each of which passes only those components of light that are parallel to its polarizing axis. As shown in (a), these axes are perpendicular to each other, so that light is blocked.

Liquid crystals, as their name implies, are materials that are neither fully liquid nor fully solid. Within a finite temperature range, they have properties intermediate between the liquid and solid states. Their cylinder-like molecules can exist in any of three mesophases—smectic, cholesteric, or nematic, of which the last is most useful for display purposes. In it, the long axes of the molecules are parallel to each other but not arranged in planes, rather like the raindrops in a shower of rain.

However, the twisted-nematic LCD literally imparts a 90° twist to those axes. The orientation of the long axes of its liquid-crystal molecules varies all the way from parallel with the axis of the front polarizer to parallel with the axis of the rear polarizer, so that the display now passes light. Causing this twist are the surface characteristics of the alignment film on the conductor patterns. This film yanks the molecules nearest it into the fully twisted position and in so doing exerts a similar but decreasing influence on those molecules more and more remote from it.

Natural phenomena like temperature, pressure, or an electrical or magnetic field can modify this twist. With field-effect LCDs, for instance, an electric field impressed via the conductor patterns aligns the long molecules parallel to itself, making those under its influence perpendicular to the rear polarizer's axis. These energized molecules now block light, causing dark images in the shape of the conductor patterns to appear on a light background.

However, the display could be constructed to produce light images on a dark background instead. Depending on the orientation of the polarizers, the unenergized LCD either transmits all incident light or blocks (absorbs) it. If the back polarizer is oriented to absorb light, application of the electric field will produce light images on a dark background. Conversely, with the back polarizer oriented to transmit light, the display has dark images on a light background, which is most often the case.

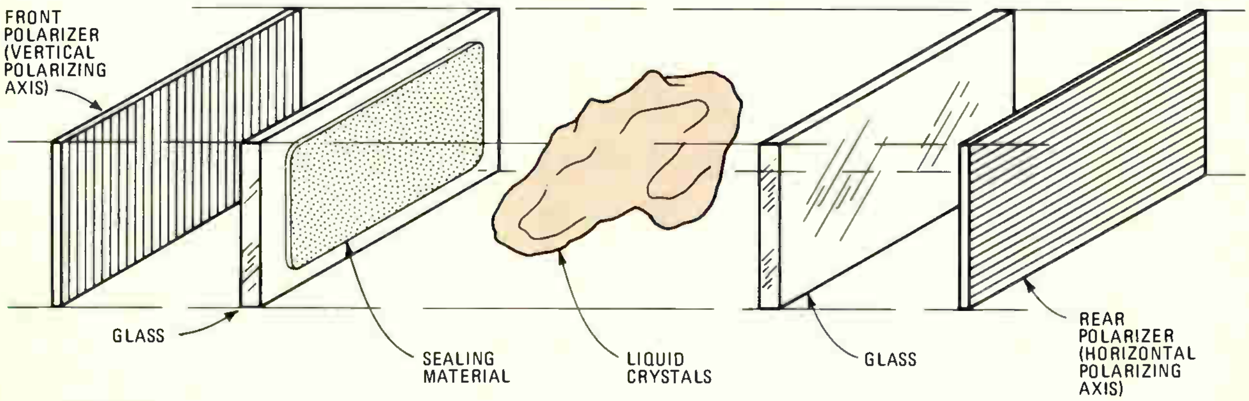
Conductors on the glass frontpiece shape the images, while others on the glass backplane complete the circuit. These conductors are applied by means of screening or, for finer resolution, photolithography.

Weakest link. The polarizers are the LCD's weakest link, because they are very susceptible to temperature and moisture degradation. Under extended high-temperature and high-humidity conditions, polarizer material fades and peels. Recent developments are beginning to improve matters, however.

Liquid-crystal displays may be purchased with or without polarizers, which are readily available as plastic sheets. If the sheet is cemented to the display, bubbles may form in the adhesive. So some users prefer to clamp it on instead, despite the resultant small loss in light transmission due to reflection at the glass-polarizer interfaces. Adhesives, as it happens, reduce this reflection.

Polarizers come in different colors and afford varying degrees of light transmission. Three of the most common grades provide 42%, 48%, or 55% light transmission. Combining different grades permits the contrast and to some extent the color of the dark areas to be altered. For example, with 42%/42% polarizers (42% front and 42% back), the dark portions of the display are black. With 42%/55% or 48%/48% polarizers instead, the appearance is blue to dark blue but the light portions of the display are brighter.

Most LCDs have a reflector attached to the rear polar-



(a) CONSTRUCTION

izer. This may be either reflective or transflective in type. Reflective material, of course, simply reflects all light, whereas transflective material is partially reflective and partially transmissive and is helpful in backlighting LCDs intended for use in low ambient light. A transflective back coating permits light from a source behind the display to pass through it in low ambient light while permitting the display to operate as usual under normal ambient light. On the other hand, such a coating reflects less well than a reflective material because it lets some of the light entering the cell from the front leak through it, dimming the display and yielding less of a contrast than the reflective types.

All but one of the many schemes currently in use for back-lighting LCDs require an external power source to light a lamp. The fairly recent technique that eliminates this need utilizes tritium, a radioactive material, to activate a phosphor coating. Unlike other radioactive materials, tritium need not be encapsulated and shielded to prevent radiation hazards. The beta rays emitted by the tritium impinge on the phosphor, causing it to light up, much as in a television picture tube. Light from the phosphor passes through the LCD's transflective back coating, thus illuminating the display.

Drive considerations. Basically, LCDs are low-voltage ac devices, typically operating at 3 to 6 volts root mean square. Much higher drive voltages are possible, but it is the rms value that is of interest. Even with ac, the dc component of the drive signal must be kept in the low millivolt range, because dc tends to degrade the liquid-crystal material and thus shorten display life.

Also, since the device is constructed as two conductors separated by a dielectric, it functions electrically like a capacitor, requiring very little drive current at low frequencies. In fact, its equivalent circuit is a capacitor, shunted by a very high resistance that accounts for some small current leakage. The frequency of the ac drive signal, while not critical, does have a preferable operating range. For any capacitive device, the higher the frequency, the lower the reactance and the greater the current drain. Alternatively, at the low end of the spectrum, flicker will develop as the display turns on and off with each cycle of the drive signal. As a rule, flicker becomes discernible at frequencies below 25 hertz.

To drive a display requires applying the appropriate ac voltages to on segments, off segments, and the backplane. As shown in (b), the drive signals to on segments and their associated backplane should be 180° out of phase. At the same time, off segments should be connected to the backplane to ensure that they are not partially turned on because of capacitive coupling between adjacent leads and segments.

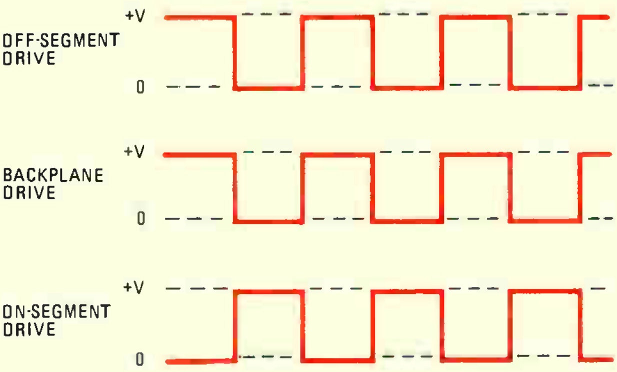
When an electric field energizes a portion of a display, the molecules of the liquid-crystal material must move physically before the effect becomes visible. The time required for this reorientation depends on the temperature of the material and the strength of the field. In turn, the voltage applied and the spacing between conductors determines the field strength—the higher the voltage and the smaller the spacing, the stronger the field and the faster the switching time.

Contrast values. Because LCDs do not appear to turn on and off instantly, image contrast values of 90% and 10% generally serve as the on and off points for measurement purposes. These points are much easier to recognize than contrasts of 100% and 0%, which for a typical display are approached asymptotically, as depicted in (c). In this case, the device is over 95% turned on at a drive voltage of 3 V rms.

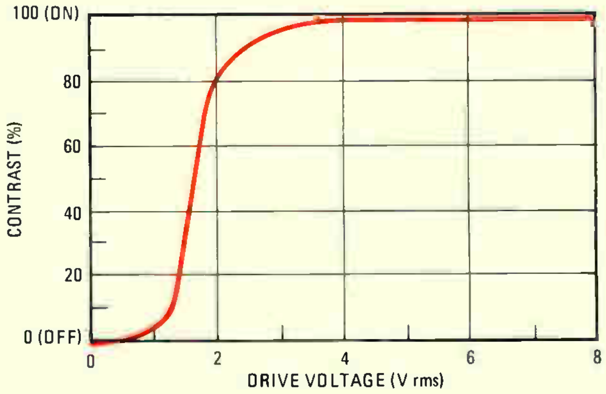
Temperature and humidity are the two greatest enemies of LCDs. Some liquid-crystal materials remain in a nematic state from −10°C to 75°C. Above and below these temperatures, the material undergoes a phase change, to either an isotropic liquid or a semi-solid crystal. A display raised to temperatures above its upper limit, or nematic-isotropic point, turns completely dark or completely clear, depending on the orientation of the polarizers. One approaching its lower temperature limit responds more and more sluggishly till it ceases to function at all. Displays usually recover from having exceeded the upper limit when returned to their normal operating range. Similarly, no damage is done if the lower limit is exceeded for only short periods of time. Research continues to extend the operating and storage temperature ranges of liquid-crystal materials, with some recent advances pushing the upper limit to over 80°C.

High temperature combined with high humidity is more of a problem for plastic-sealed LCDs than for glass-sealed units, which are truly hermetic. High temperatures increase the rate of moisture permeation through the plastic, although these seals are better than they used to be and getting even better all the time.

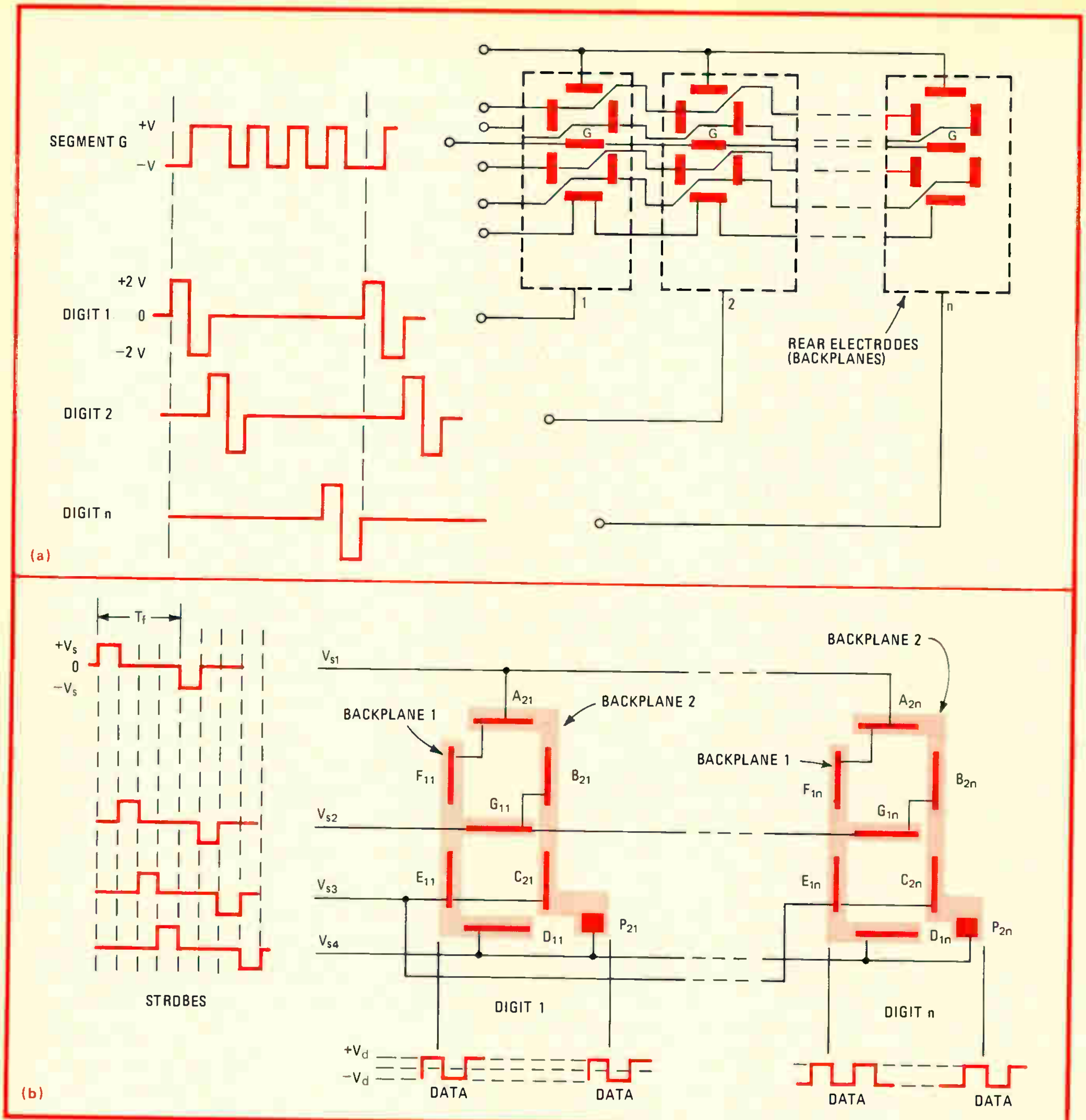
John Daniels
Beckman Instruments Inc.
Helipot Division



(b) DRIVE SIGNALS



(c) CONTRAST-VOLTAGE CURVE



1. Multiplexing schemes. Light-emitting-diode displays may be multiplexed by tying together all the segments that have the same location in each symbol (a). But this method permits multiplexing only three or four liquid-crystal displays, because of limitations in their electrooptic response. A better way (b) is to configure each LCD digit as a matrix so that interconnected segments belong to different backplanes.

(select) rms voltage is V_2, then the mean-squared on and off voltages are:

$$V_1^2 = \eta(V_s - V_d)^2 + V_d^2(1-\eta)$$
$$V_2^2 = \eta(V_s + V_d)^2 + V_d^2(1-\eta)$$

When the ratio of V_2/V_1 is maximum, the contrast between an on and off segment will be optimum. For a three-level select waveform ($\pm V_s$, 0), this optimum contrast will always occur when:

$$V_d = V_s\eta^{1/2}$$

For a ¼-multiplexed LCD, eight complete time segments constitute one scan period (T_s), or two frames. Each frame contains the same information and only the polarities of the strobe (select) and data pulses are reversed. This polarity reversal causes the average value of the select and nonselect voltages to be zero during a scan—an absolute must with LCDs. A nonzero average voltage across the display shortens its life through irreversible electrochemical action.

The first step in considering LCD suitability for multiplexing is to evaluate the display's optical response as a function of applied voltage. Since LCDs are light modifiers—as opposed to light emitters—the appropriate measure of optical response is either contrast or contrast ratio. Briefly, contrast is a measure of the amount of light that is reflected or transmitted by the symbol, whereas contrast ratio is the ratio of the unenergized to the energized image brightness. (See "Almost all about contrast and contrast ratio," p. 120.)

Figure 3 depicts the contrast characteristics of a typical symbol segment as a function of applied rms voltage for various viewing angles (θ). (This display has the best readability when viewed along the 225° direction—a typical wristwatch application.) The ideal electrooptic response curve for multiplexing purposes would exhibit an abrupt change in contrast from zero to some high value, followed by a plateau at that high level. However, in practice, as the viewing angle gets larger, the contrast reaches a maximum, and this maximum is then followed by a minimum value.

Moreover, while the off-segment condition can be determined with some degree of precision, the on-segment condition is not so easily defined. The operating points described by the intersections of lines $N = 2$ and $N = 8$ show that as more segments are multiplexed, the difference between the select and nonselect voltages becomes smaller. Also, the viewing angle required to obtain an acceptable level of contrast becomes smaller.

A practical definition of contrast

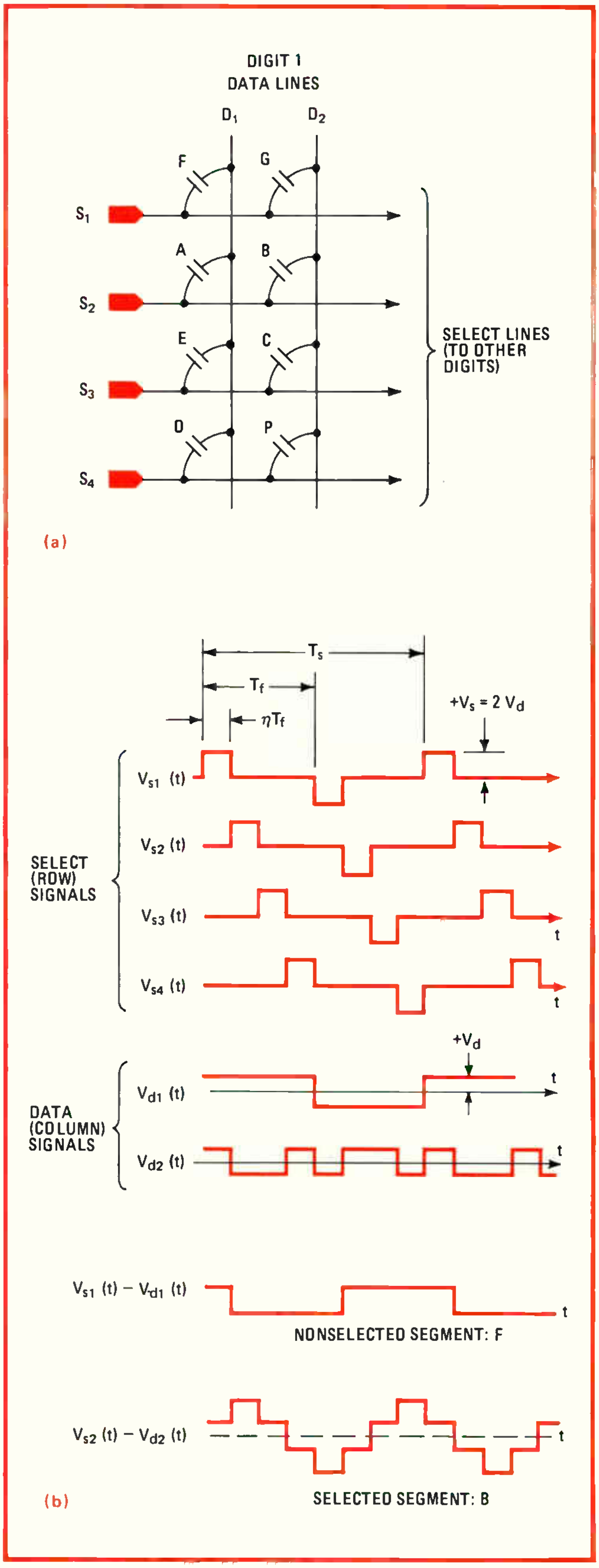
A useful parameter for describing the sharpness of the contrast-voltage curve is the threshold ratio (ρ), which may be expressed as:

$$\rho = E_{select}/E_{nonselect} \qquad (1)$$

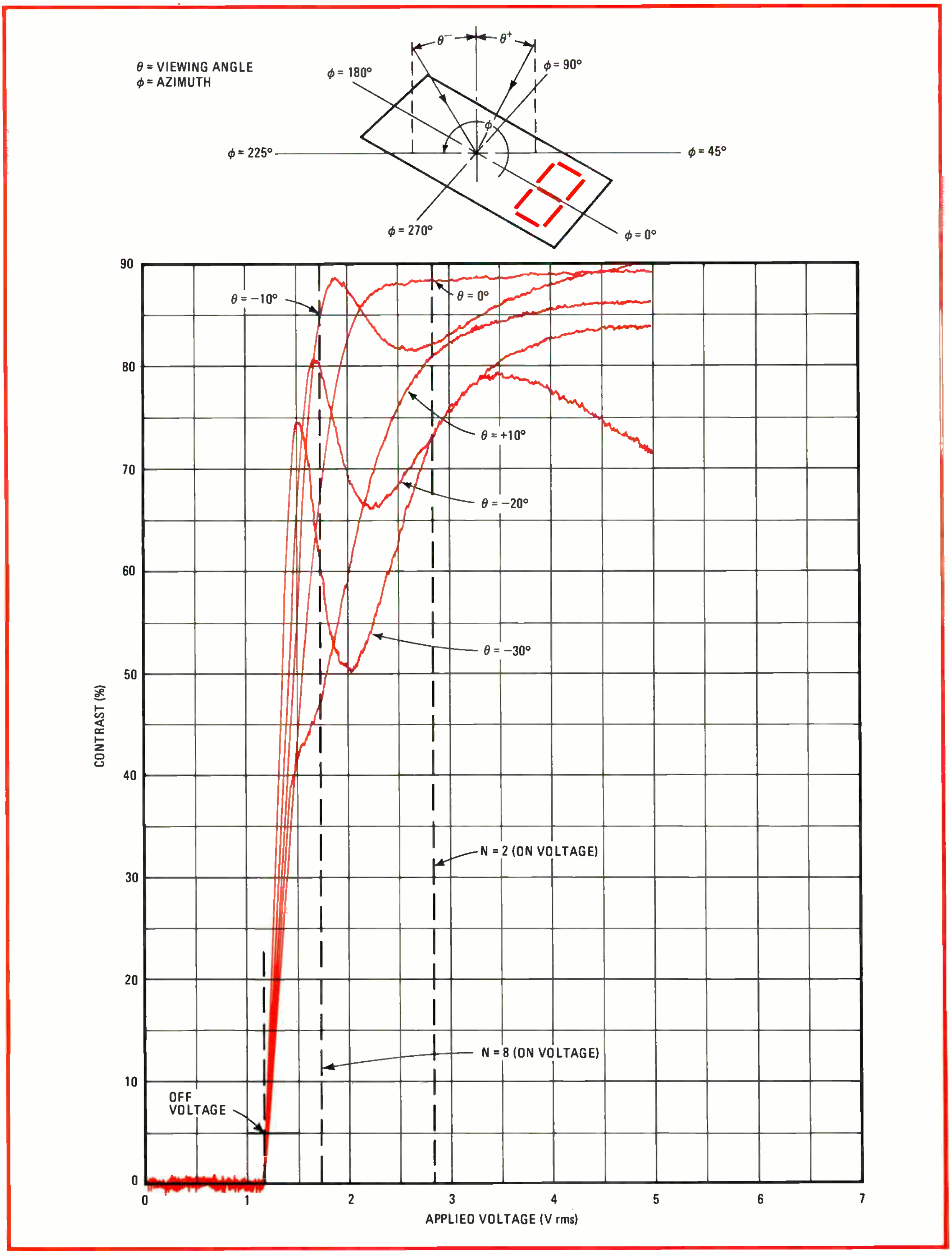
where E_{select} is the applied rms voltage that produces the on contrast and $E_{nonselect}$ is the rms voltage that results in the off contrast. Ideally, the threshold ratio should be unity, but it usually ranges between 1.1 and 2.4 for LCDs currently available for multiplexing. In practice, this parameter depends on various constants of the liquid-crystal materials, device construction, and viewing angle.

To minimize the connections to the display requires sequentially addressing a maximum number of select lines, but the LCD's electrooptic response limits this maximum number. Even if the threshold ratio were ideal ($\rho = 1$), the number of segments that could be sequentially addressed would be limited by other considerations, such as power-supply variations and the temperature coefficient of threshold voltage. Indeed, different liquid-crystal materials have different threshold-voltage temperature coefficients, typically ranging from −7 to −13 millivolts/°C. Moreover, if the number of multiplexed lines is large, the select and nonselect voltages will usually require temperature compensation, particularly if the power source is a battery, which has a positive temperature coefficient.

When the viewing angle increases in the 225° direction, the contrast-voltage curves shift to the left. This means that the nonselect voltage must be less than E_5 (the rms voltage that produces 5% of the maximum contrast) for the largest negative viewing angle expected, and the select voltage must be high enough to produce an



2. Driving the matrix. LCD segments and their associated backplanes behave electrically like lossy nonlinear capacitors, which interconnect the matrix' rows and columns (a). A series of select pulses drives each row, a series of data pulses each column (b).



3. Electrooptic response. For a typical LCD symbol segment, contrast will appear to vary with applied voltage, as well as with viewing angle. Also, as the number of multiplexed lines increases, the difference between the select and nonselect voltages becomes smaller.

acceptable value of contrast for the most positive viewing angle anticipated. Similarly, changing the azimuth of the viewing angle generates a different set of contrast-voltage curves. Just as the number of multiplexed lines will determine the operating points on these curves, a minimum contrast of 0.5 will define the viewing space. As the number of multiplexed lines increases, the viewing cone corresponding to a minimum contrast of 0.5 becomes smaller.

How many lines may be multiplexed?

The ratio of select to nonselect voltages (V_2/V_1) can be maximized for a specific duty cycle. This ratio, which depends on the number (N) of multiplexed lines, can be used to determine whether a particular electrooptic transfer characteristic is satisfactory for a given multiplexing application. If $\rho = V_2/V_1$ and ρ_{max} must be equal to or greater than E_{50}/E_5, then:

$$\left[\frac{(N_{max})^{1/2}+1}{(N_{max})^{1/2}-1}\right]^{1/2} > \rho_{max} > 1$$

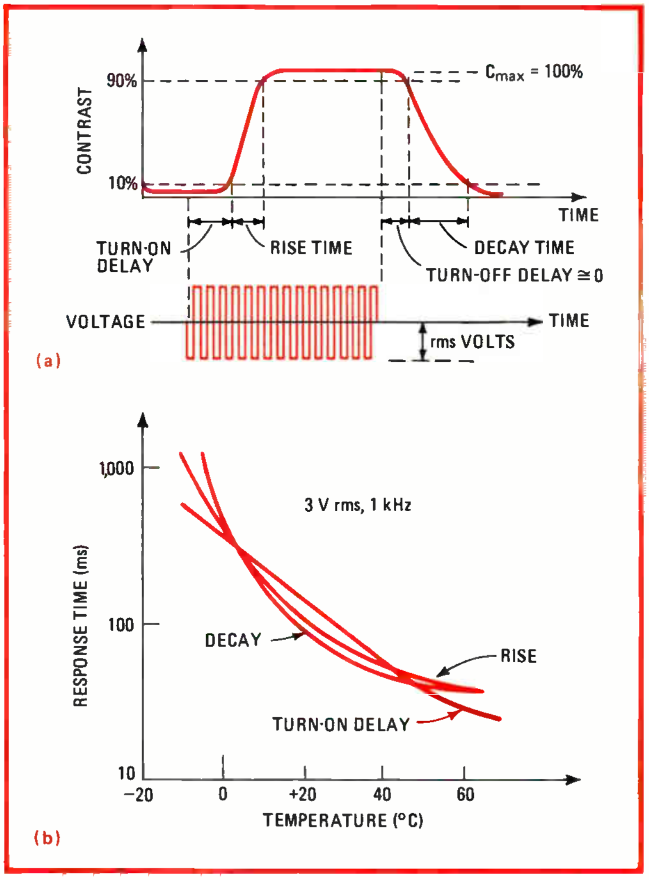
where N_{max} is the maximum number of multiplexed lines. Solving this equation for N_{max} yields:

$$N_{max} \leq \left[\frac{(\rho_{max})^2+1}{(\rho_{max})^2-1}\right]^2 \qquad (2)$$

Now determining the maximum number of multiplexed lines becomes a matter of simple arithmetic. From the contrast-voltage curves of Fig. 3 for a −30° viewing angle, the applied (select) voltage for 50% contrast, or E_{50}, is 2 v rms, and the (nonselect) voltage for 5% contrast, or E_5, is 1.2 v rms. With a select voltage of 2 v, the symbol segment would appear to be black ($C = 0.83$) at a viewing angle ($\theta = 0°$) normal to the plane of the display and would appear to turn gray gradually as the display is tilted away from normal towards −30°. Using these values of select and nonselect voltages in Eq. 1 to find the threshold ratio gives $\rho = \rho_{max} = 1.67$, and substituting this result into Eq. 2 yields a value of 4.5 for N_{max}. Therefore, if the display is ¼-multiplexed, it will be readable over a 30° viewing angle. Note that acceptable contrast can still be obtained for larger values of N (i.e. $N = 8$) if some contrast is sacrificed at viewing angles greater than −10°.

The effect of temperature on multiplexing may also be evaluated. Suppose the display is to operate over a temperature range of 0°C to 40°C and that the temperature coefficients of E_5 and E_{50} are −8 and −12 mv/°C, respectively. The negative temperature coefficients imply that the entire family of contrast-voltage curves shifts left as temperature rises and right as temperature drops. As the display is heated, then, nonselected segments will tend to turn on when biased with a nonselect voltage equal to E_5. The effect of temperature on selected segments is more complex, but in general, the contrast of a selected segment tends to decrease as the display is cooled.

Since the effect of nonselected segments turning on is more critical to an application than the decrease in contrast of selected segments, the design strategy should be to make nonselect voltage V_1 equal to E_5 at the highest operating temperature expected. In the example,



4. Speed of response. Turn-on and turn-off times (a) vary from 50 to 500 ms (b) between 0°C and 50°C. With multiplexing, because the nonselect voltage is greater than zero, turn-on delay—and thus turn-on time—is shorter than for nonmultiplexed operation.

the nonselect voltage may be computed as:

$$\begin{aligned} V_1 &= E_5 + (-8\,\text{mV/°C})(40°\text{C} - 20°\text{C}) \\ &= 1.2 - 0.16 \\ &= 1 \text{ v rms} \end{aligned}$$

The select voltage can remain the same at $V_2 = E_{50} =$ 2 v rms, so the threshold ratio becomes $\rho = \rho_{max} = 2/1 = 2$. Again using Eq. 2 to calculate N_{max} yields a value of 2.8, which suggests that without temperature compensation the display's multiplex potential is limited to ½- or ⅓-duty-cycle operation.

This example illustrates the effect of temperature on multiplexing capability in a general case where power-supply variations, manufacturing tolerances, and the like exist. Tolerances having an equal effect on both V_1 and V_2 may be expressed as:

$$(V_1)_t \geq V_1/(1+p)$$
$$(V_2)_t \leq V_2/(1-p)$$

where $(V_1)t$ and $(V_2)t$ are the new nonselect and select voltages, respectively, and p is the percent tolerance divided by 100. Also, the threshold ratio becomes:

$$(\rho_{max})_t = \frac{(V_2)t}{(V_1)t} = \frac{1+p}{1-p}\frac{V_1}{V_2}$$

Computing the value of N_{max} from Eq. 2 and setting the value of V_2/V_1 equal to 1 yields:

Almost all about contrast and contrast ratio

A good measure of the optical response of a liquid-crystal display is the device's contrast or contrast ratio. In effect, these parameters provide a yardstick for rating an LCD's readability. How they are defined depends on whether the LCD is reflective, displaying dark symbols against a light background, or transmissive, showing light symbols on a dark background.

In brief, contrast ratio (C_r) is the ratio of the off-voltage to on-voltage image brightness. For practical displays, contrast ratio generally ranges from 0 to 20, although it seldom exceeds 10 for reflective devices under diffused lighting conditions. When the LCD is reflective, which is usually the case for watch and instrument displays:

$$C_r = B_o/B_s$$

where B_o, the background brightness, is greater than or equal to B_s, the symbol brightness. For a transmissive display, contrast ratio becomes:

$$C_r = B_s/B_o$$

where B_s is greater than or equal to B_o.

Similarly, contrast (C) may be defined as the ratio of the difference between the symbol and background luminances to the luminance of the symbol or background, or:

$$C = |\Delta B|/B$$

where ΔB is the brightness difference between symbol and background, and B is either the background brightness (B_o) or the symbol brightness (B_s).

If the display is reflective:

$$C = (B_o - B_s)/B_o$$

where B_o is greater than or equal to B_s. For a transmissive display:

$$C = (B_s - B_o)/B_s$$

where B_s is greater than or equal to B_o. Contrast seldom exceeds 0.9 for reflective or 0.95 for transmissive displays.

Both contrast and contrast ratio are dimensionless quantities that depend on the applied voltage and the viewing angle. The two parameters are related by:

$$C = 1 - 1/C_r$$

The use of contrast offers some measure of convenience, because the output of a photometer, which may be used to measure display brightness, can be directly calibrated in units of contrast. On the other hand, contrast ratio is often the preferred definition in display system design. The table shows some accepted values of contrast for common hard-copy symbols.

Display specialists may disagree on what minimum value of contrast is an acceptable one for LCDs, but generally a contrast of 0.5 is readable and easily verified. In some cases, a symbol that is supposed to be off can have a brightness just slightly greater than, or slightly less than, the surrounding background. Therefore, there is also the problem of defining an acceptable off contrast. As a rule, a value of 0.05 is both practical for design purposes and useful for evaluating LCD systems in operation.

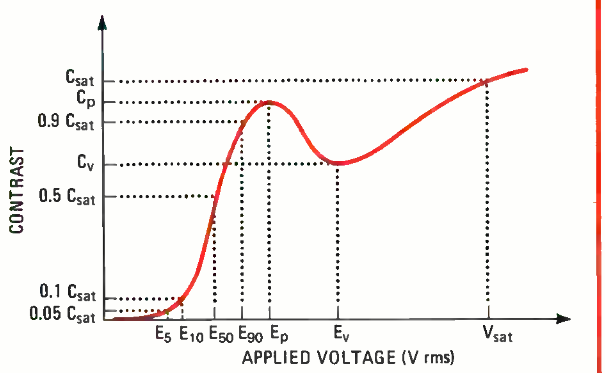
The figure shows the electrooptic response of a typical LCD at a specified azimuth and viewing angle. Some of the key contrast-voltage parameters along the curve are:

- V_{sat}, a reference voltage in the saturation region that defines a reference value of saturation contrast (C_{sat}).
- E_{90}, E_{50}, E_{10}, and E_5, the lowest applied root-mean-square voltages that, respectively, produce 90%, 50%, 10%, and 5% of the C_{sat} contrast.
- C_p, the relative maximum value of contrast occurring at E_p between an applied voltage of 0 and V_{sat}.
- C_v, the relative minimum value of contrast occurring at E_v between an applied voltage of E_p and V_{sat}.

In measurements of contrast, it is usually assumed that the illumination is constant over the area of the display, so that for a reflective display:

$$C = (R_b - R_s)/R_b$$

where R_b and R_s are the reflectivities of the display background and symbol, respectively. This equation is the basis for making practical measurements with either a photometric microscope or a reflectometer.



HARD-COPY CONTRAST

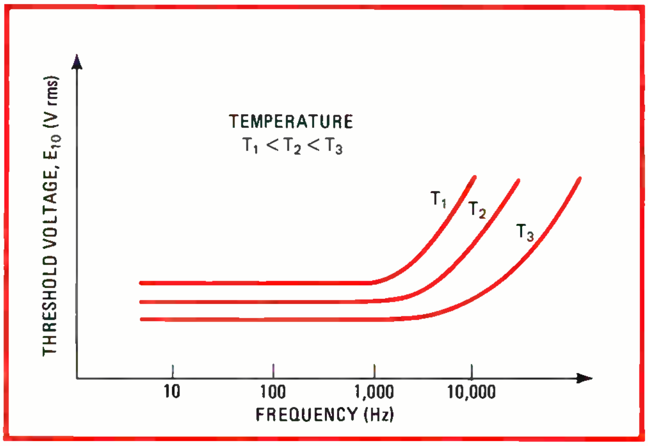
Type of hard copy	Contrast
Typewriter	0.79 – 0.87
Office copying machine	0.6 – 0.81
Handwritten copy	
Pencil	0.6 – 0.73
Ballpoint pen	0.76
Newspaper	0.85

$$N_{max} = \left[\frac{(1 + p^2)}{2p}\right]^2$$

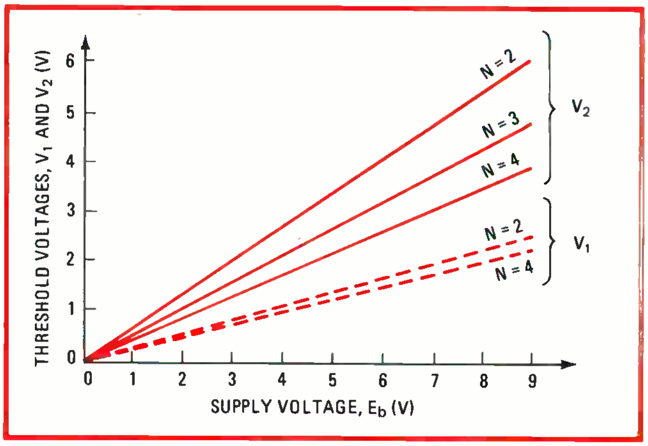
Even if the threshold ratio is ideal, therefore, tolerances on operating points V_1 and V_2 will ultimately determine the LCD's multiplex potential.

Besides the static parameters just discussed, dynamic parameters, like speed of response and operating frequency, must also be taken into account. Speed of response, for instance, is a function of turn-on delay, rise time, and decay time. As shown in Fig. 4a, LCD rise and decay times are measured between 10% and 90% of maximum reflective contrast. Turn-on time is the sum of the turn-on delay and the rise time.

Between temperatures of 0°C and 50°C, LCDs have turn-on and turn-off times that vary from 50 to 500



5. Operating frequency. Threshold voltage varies with both operating frequency and temperature. To minimize this variation, as well as flicker, LCDs should be operated at 25 to 250 Hz. Moreover, the higher the frequency, the greater the drive power required.



6. Selecting the right drive voltages. The thresholds for the select and nonselect voltages depend on both the available supply voltage and the number of multiplexed lines. The lower the supply and the larger the number of multiplexed lines, the smaller the select voltage will be. In contrast, the higher the supply voltage and the fewer the multiplexed lines, the greater will be the nonselect voltage required.

milliseconds (Fig. 4b). In multiplexing, then, to avoid the perception of a visual flicker, the scan time should be set for 25 ms or less. (Since the turn-off time is much greater than 25 ms, the segments do not turn off between frames.) On the other hand, the turn-on time is smaller for multiplexed operation than for nonmultiplexed operation, because the turn-on delay is less. For multiplexed LCDs, the off voltage is greater than zero, which causes a shortening of the turn-on delay. There is no equivalent effect for the on voltage, so the turn-off time remains the same for multiplexed and nonmultiplexed operation.

What about operating frequency?

Surprisingly, the highest operating frequency is not a function of the response time, but depends rather on device construction and the properties of the liquid-crystal material. Although some field-effect displays may be operated at multiplexing frequencies of up to tens of kilohertz, this is usually avoided for two reasons. First, the power required to drive the display increases with multiplexing frequency, and second, the cutoff characteristic of the liquid-crystal materials varies with both frequency and temperature (Fig. 5). For most field-effect materials, the operating frequency that minimizes both flicker and threshold voltage variation lies between 25 and 250 Hz.

As the number of multiplexed lines increases, the peak voltage on both the select and data lines must also increase to establish the correct on and off voltages. In some applications, especially those relying on a battery, the display must be selected to have a threshold voltage that matches the available supply voltage. Figure 6 shows the relationship between supply voltage (E_b) and the required LCD threshold voltages (V_1, V_2) for several segment drive conditions.

Calculating the threshold voltages

V_1 and V_2 may be expressed as a function of the number (N) of multiplexed lines, given the battery voltage available and assuming a unipolar select signal so that $V_s = E_b/2$. Under these conditions, the ratio of select to nonselect voltage is maximum, making the contrast ratio optimum. The thresholds become:

$$V_1 = E_b \left(\frac{N^{0.5} - 1}{2N^{1.5}} \right)^{0.5}$$

$$V_2 = V_1 \rho_{max}$$

With these equations, the required threshold voltages are easy to compute. For example, suppose a battery voltage between 4 and 5 V will power a ⅓-multiplexed (N = 3) display. The worst-case requirement on V_1 occurs when the supply is on the high side, because the higher the supply, the higher the nonselect voltage will be. Therefore, let E_b = 5 V and solve for V_1 = 1.3 V. Conversely, the lower the supply, the smaller will be the select voltage. So, threshold voltage V_2 may be found by letting E_b = 4 V, and thus V_2 = 2.1 V.

Most of the multiplexing considerations thus far have been limited to an examination of measurable parameters based on the electrooptic response curves of LCDs. But is there any correlation between these measurable parameters and what the viewer actually sees? The answer is yes. However, as with any art form, beauty is in the eye of the beholder. Contrast-voltage curves at a multiplicity of viewing angles and an iso-contrast map of the viewing space will help, but there is no substitute for actual tests by human observers. Only user judgment can take into account such factors as viewing distance and angle, character height and font, viewing background, and the effect of ambient light conditions.

Although multiplexing is more complex with LCDs than with other display technologies, the benefits are worthy of consideration. Multiplexing can greatly reduce the number of interconnects, while giving up very little in display contrast. Moreover, multiplexing permits direct interfacing to microprocessors—a practical alternative to expensive peripheral circuits. With improved liquid-crystal materials under development, multiplexing will become easier. Indeed, large dot-matrix arrays for video games and portable data terminals are just some examples of the possibilities open to LCD technology. □

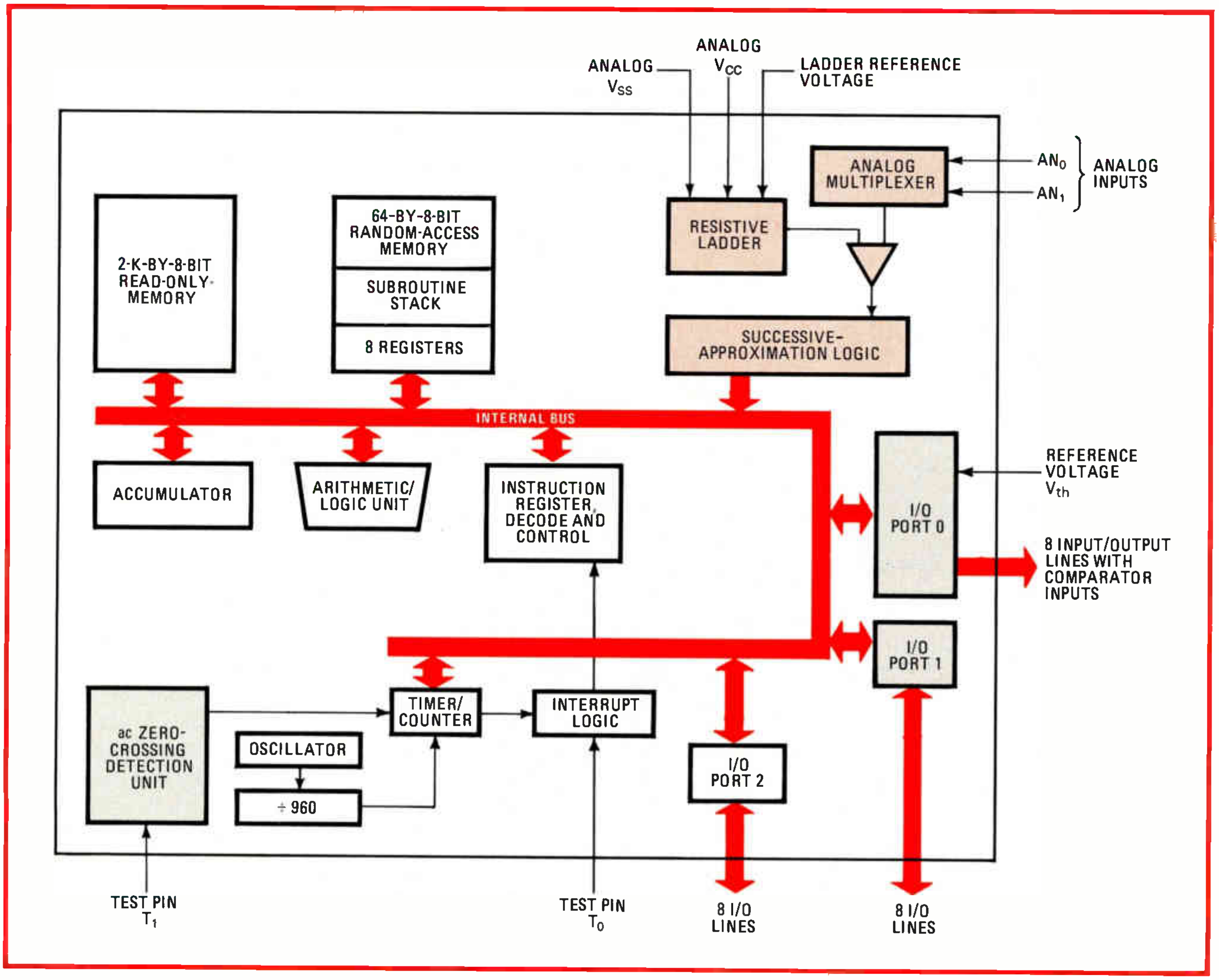
Microcontroller includes a-d converter for lowest-cost analog interfacing

Adding hardware for analog-to-digital conversion to a single-chip microcomputer cuts interface software and component count for high-volume control applications

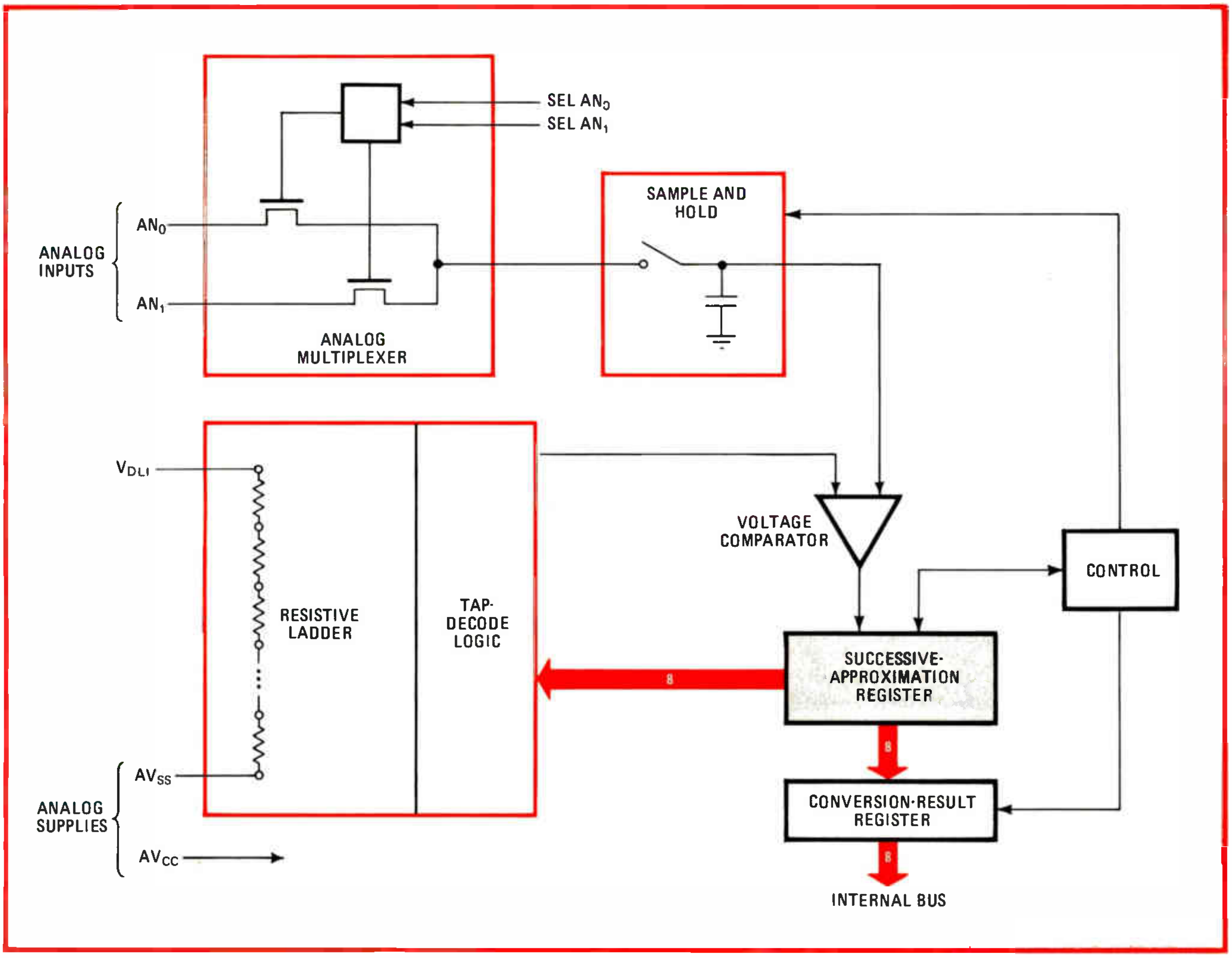
by W. Check, E. Cheng, G. Hill, M. Hollen, and J. Miller, *Intel Corp., Santa Clara, Calif.*

☐ Microcomputers' plunging size and cost are creating a rising new market: low-cost controllers that end up in automobiles, appliances, and consumer products. Now that the technology is available to integrate a high-performance 8-bit analog-to-digital converter and a microcomputer on a single chip, the tremendous need for low-cost analog interfacing has hastened the development of just such a device: the 8022. By integrating the a-d converter and other useful features, the chip achieves the minimum system cost possible for high-volume controller applications involving analog signals.

The heart of the 8022 is the 8021 general-purpose



1. All aboard. The first single-chip microcomputer with a built-in 8-bit analog-to-digital converter is Intel's 8022. Around a foundation of the 8021, the chip packs several features that suit it to control applications: two multiplexed analog inputs, a zero-crossing detector, two 7-mA digital outputs that are part of Port 1, and a total of 26 digital input/output lines, eight of which have voltage-comparator inputs.



2. The converter. The 8022's a-d converter uses successive approximation. A multiplexer selects either of two inputs, which is sampled and held. The successive-approximation register holds a byte that taps off a voltage from a 256-resistor divider through decoding logic. Input is compared with tapped voltage; when the two are equal, the held byte is sent to the conversion-result register.

microcomputer with built-in read-only and random-access memories, which go a long way since many functions are carried out in hardware or require minimal software. The 8021's modular design facilitates its use as a cornerstone for more highly integrated designs like the 8022. This new design, like the 8021, is a member of the MCS-48 family of single-chip microcomputers, and its on-chip a-d converter makes the family even more useful in such high-volume, cost-sensitive application areas as household appliances.

A microcomputer plus

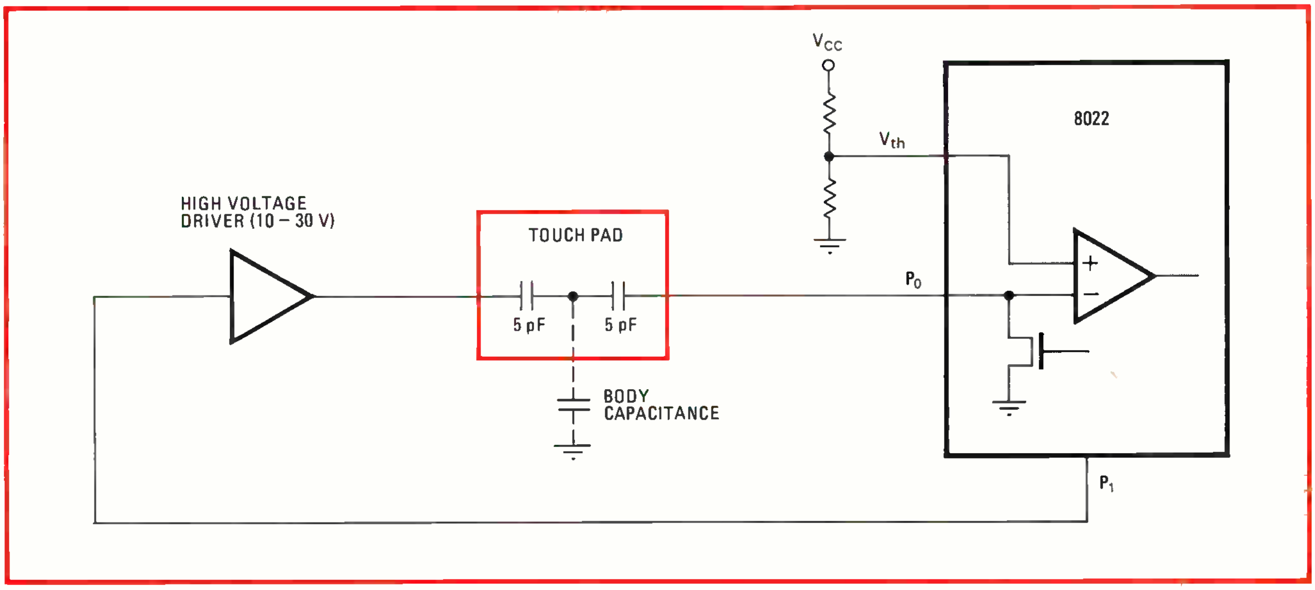
Operating on a single +5-volt power supply, the 8022 contains all the functions necessary for digital processing, plus digital or analog control. On the chip, as diagrammed in Fig. 1, are 2 kilobytes of ROM, 64 bytes of RAM, an 8-bit central processor with more than 70 instructions (a subset of the higher-performance 8048), an internal timer/event counter, a clock and oscillator, the 8-bit a-d converter with two analog inputs, and 26 digital input/output lines.

All parts of the a-d converter are integrated onto the chip—no external components are required. Conversion is performed entirely with hardware by a successive-approximation technique and takes 40 microseconds to complete. The only software is three single-byte instructions: select analog-input 0 (SEL AN0), select analog-input 1 (SEL AN1), and read the analog-to-digital conversion result (RAD).

Flexible I/O lines

The 26 digital input/output lines are organized into three 8-bit general-purpose ports and two test pins, T_0 and T_1. The three ports are quasi-bidirectional—each line can be programmed for input or output. Adding to the flexibility is an optional mask operation that eliminates the pull-up resistor for the metal-oxide-semiconductor drive transistor on each line, creating an open-drain output. The open drains are useful in driving analog circuits and for certain loads such as keyboards.

Port 0 also has variable-threshold voltage-comparator inputs with a common reference pin (V_{th}). This setup can accommodate such input situations as high noise margins, low-voltage (10-to-15-v) touch switching, and expansion of the analog inputs. Two input/output pins ($P1_0$ and $P1_1$) provide for high-current drive; each sinks



3. Low-voltage touch. Because port 0 has variable-threshold comparator inputs on each of its eight lines, new input configurations are possible, such as this low-voltage touch switch. Touching the panel momentarily pulls down the comparator input. The high-voltage driver, which may be a single transistor or part of a hex driver, then recharges the panel. The port is read by the microcomputer as is any other.

7 milliamperes, more than four times the 1.6-mA load of standard transistor-transistor-logic outputs. In many applications of the 8022, 7 mA can eliminate the need for discrete drive transistors.

The lower half of port 2, in addition to serving as general input/output, may be hooked up as a bus for attaching I/O expander units, such as the 8243, or discrete TTL parts for low-cost I/O expansion. Operations of the 8243 are synchronized by the port-expander strobe pin, a feature that is especially useful for input/output expansions designed with standard transistor-transistor logic gates.

The two test-pin inputs can be tested directly with two conditional-branch instructions. T_0 can interrupt the system, while T_1 also can detect the zero crossing of ac signals—a plus when it comes to firing triacs for phase control of motors.

The a-d converter

The 8022's a-d converter has two multiplexed input channels. Channel selection by either the SEL AN0 or SEL AN1 restarts the conversion sequence. A valid digital value can be read with the RAD instruction during the fourth instruction cycle after a select instruction. Conversions occur continuously, and RAD may be executed at any time with confidence that the sample is no more than 40 µs old. Typical software for reading two sequential a-d conversions would be:

```
SEL AN0       Starts conversion
MOV R0,#24    Setup memory pointer
RAD           First conversion to accumulator
MOV @R0,A     Store first value
INC R0        Ready for next conversion
RAD           Second conversion to accumulator
MOV @R0,A     Store second value
```

As shown in Fig. 2, the conversion hardware itself has three parts: a series string of resistors, a voltage comparator, and successive-approximation logic. The string of 256 resistors divides the voltage between V_{ss} and V_{DLI} (the reference pin) into 256 voltage steps. This configuration gives the converter inherent monotonicity. Decode logic selects the appropriate tap and transfers that voltage to the comparator block.

The conversion logic

The comparator amplifies the difference between the analog input and the voltage tap. This difference is presented to the successive-approximation logic. Eight comparisons result in a fully converted byte being transferred to the conversion-result register. All comparisons are performed automatically by on-chip hardware; executing the RAD instruction moves the contents of the CRR to the accumulator.

Novel circuit design (see "The a-d converter: how it was done," p. 27) gives the converter 8-bit accuracy over the full input range of V_{ss} to V_{cc}. This capability simplifies direct connection to sensors, reduces software, and provides fast, 40-microsecond conversions. The separate power-supply pins complete the analog block and keep the converter isolated from digital-noise sources.

The instruction set

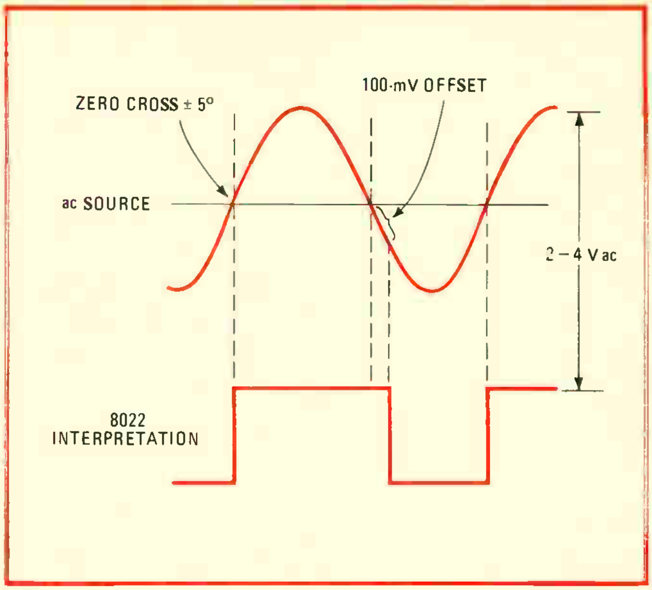
To conserve memory and maximize throughput, most instructions in the 8022 are single-byte and single-cycle; no instructions are longer than 2-byte, two-cycle. The cycle time is 10 µs.

The overall efficiency of the instruction set is enhanced for control applications by the extensive conditional-branch logic that has been built into the microprocessor. For example, the instruction to decrement a register and jump if not zero (DJNZ) allows loops to be formed in one 2-byte instruction. Similarly, the instruction to move to the accumulator from the current page (MOVP A, @ A) allows table look-up for constants or display formatting with just a single 2-byte instruction.

The 64-byte RAM integrates the hardware stack and data memory. The first eight memory locations are designated as working registers and are addressable by any of the 11 direct-register instructions. Besides increasing the variety of operations that can be performed on data in memory, this approach further reduces the number of instruction bytes required for processing. Working registers 0 and 1 also may be used as pointers to indirectly address all locations in memory, using the indirect-register instructions.

The next 16 bytes of RAM may be used as the address stack to enable the processor to keep track of the return addresses generated from call instructions and to handle interrupts. Since each address is 11 bits long, 2 bytes are needed to store each address. Thus, the 16 bytes of address stack allow a total of altogether eight levels of subroutine nesting.

A 3-bit stack pointer supplies the locations that are loaded with the next return address generated. This stack pointer is incremented when a return address is stored and decremented when an address is fetched during a return. If an application does not require all eight levels of subroutine nesting, the free portion of the address stack may be used as standard RAM.



4. Zero-crossing detector. Useful in timing the firing of triacs for ac phase control of appliances or getting a real-time clock, the 8022's T_1 test pin detects the crossing of a waveform's dc level by its rising edge. One hundred millivolts of hysteresis prevents chattering, and the ac frequency is limited to 1 kilohertz.

Other on-chip features

The 8022 contains its own clock and oscillator circuitry and requires only an external timing control element to generate all internal timing signals. For highly cost-sensitive applications, a single resistor or inductor may be used as this element. If a more precise clock is required, the designer may specify a crystal or external clock for the application.

To further reduce the user's system cost and to permit use of the chip in noisy environments, the power-supply tolerance has been increased, permitting a range from 4.5 to 6.5 v. Less filtering and regulation is necessary, therefore, and the microcomputer's immunity to noisy power supplies is greater, as well.

The programmable 8-bit timer/event counter accurately monitors elapsed time, avoiding the software overhead of timing loops. Once it has been loaded with the contents of the accumulator, its divide-by-32 prescaler is incremented for each system clock cycle and at prescaler overflow. A timer flag is set at overflow. Once activated, it can be tested by a conditional-branch instruction to generate an interrupt. Total count capacity is 8,192 instruction cycles or 81.9 milliseconds, for the 10-μs cycle time.

The timer may also be used as an event counter where the test pin T_1 serves as a counter input. Upon command, the chip will respond to a low-to-high transition on the pin by incrementing its timer.

Comparator inputs

The input/output port 0 of the 8022 has several properties that ease analog interfacing problems. Two of these features are moderate-gain voltage comparators and pull-up resistors on each line that either may serve as standard TTL outputs or may be masked out to give open-drain outputs.

The comparators are especially handy for troublesome inputs. The comparator at each pin accurately compares that line to the threshold-voltage reference pin, V_{th}, within about 100 millivolts in the range from V_{ss} to $V_{cc}/2$. Allowed to float, V_{th} will bias itself to the digital switch point of the other ports, and port 0 then behaves as a set of conventional digital inputs.

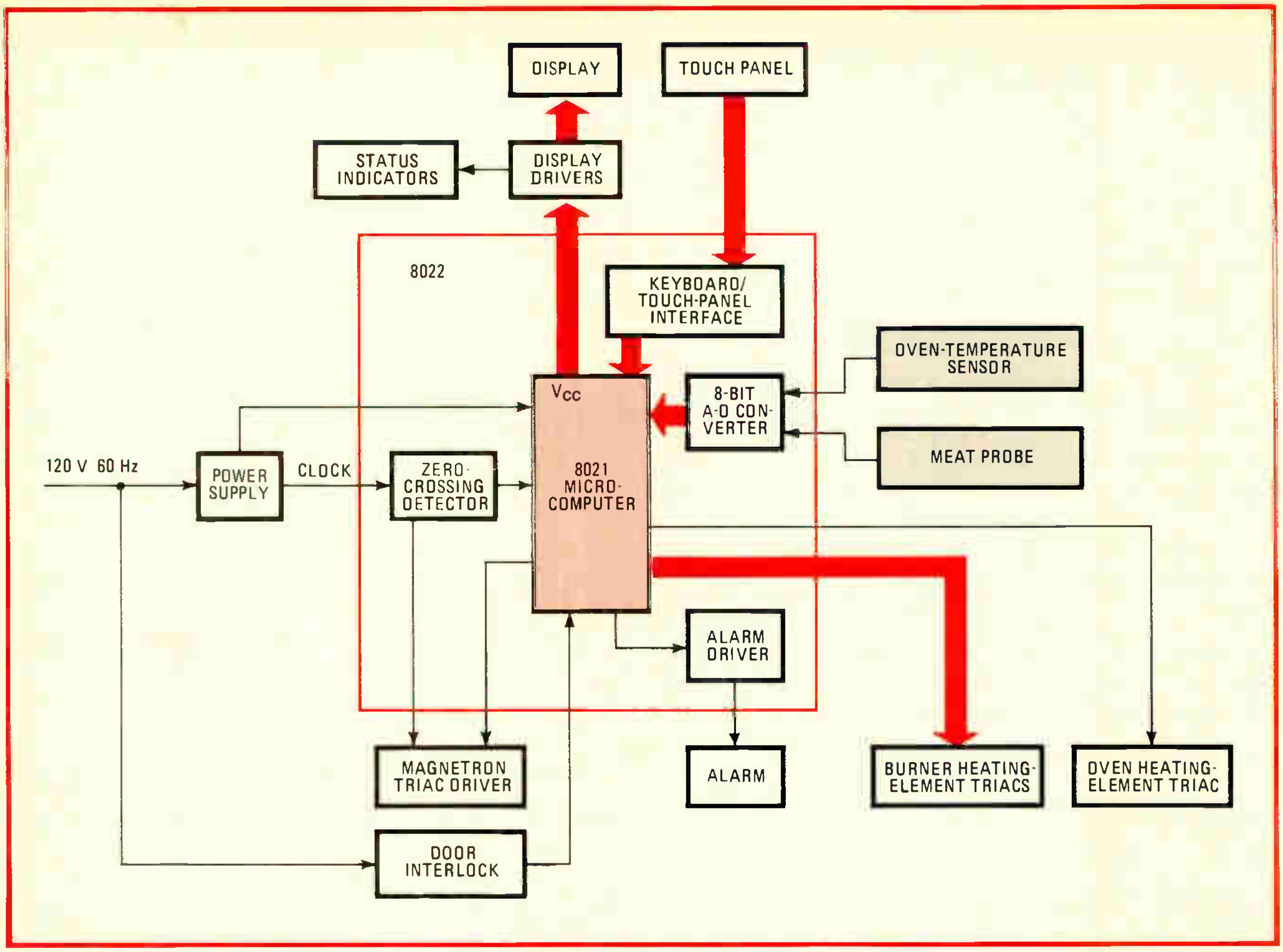
However, the switch point can be both tightly controlled and adjusted by specially biasing V_{th}. Uses for this would include high-noise-margin inputs (up to $V_{cc}/2$), unusual logic-level inputs as from a diode-isolated keyboard, analog-channel extension, and direct interfacing of capacitive touch panels. The comparator action is automatic, and the port is read just as is any other port.

Three advantages

Since the on-chip comparators allow small voltage changes to be detected, a cost-effective and safe touch panel can be built. Many appliances using touch panels have as much as 100 volts at the panel, albeit with extremely low power. The comparators in the 8022, however, permit appliance touch panels to be operated in the 10-to-15-v range.

The advantages of a low-voltage touch panel are three. First, it costs less to generate and switch the lower voltage. Then, since the keyboard operates at below 30 v, it is an Underwriters Laboratories' class II system, which can sharply cut the time required for approval. Finally, the possible product-liability problems associated with high-voltage operation disappear.

Simplified capacitive touch-panel operation is shown in Fig. 3. Contact with the panel drives both the voltage buffer and input to ground. When port 0 is read, a 0 on any line indicates a touched switch. The microcomputer drives the voltage buffer to recharge the panel. Matrix



5. Oven controller. The use of the 8022 is demonstrated in this controller for a combination microwave and conventional oven. The chip needs no assistance in figuring temperatures from thermistors connected to its analog inputs, reading inputs from a touch panel, detecting zero-crossing of ac for firing triacs and gating clocks and timers, direct-driving an alarm, and storing cooking-time instructions.

switch panels may also be sensed by the comparators.

Each pin on port 0 may or may not have an internal pull-up resistor: the option is chosen during selection of the ROM program code. If a resistor is left out for a given pin, the output appears as a true open drain for the range V_{ss} to V_{cc}. There is no temporary low-impedance drive to V_{cc}, as is the case with the remaining quasi-bidirectional ports. With open drains, accurate output waveforms can be generated, and operational amplifiers can be driven directly, for example.

The zero-crossing detector

Although the T_1 test pin on the 8022 may be driven directly by a digital input, it has special circuitry to detect an ac signal crossing its average direct-current level. The signal required for the zero-cross detection mode must be 2 to 4 v peak to peak and have a maximum frequency of 1 kilohertz. It couples to T_1 through an external capacitor.

Figure 4 shows the waveforms for zero-crossing detection. The internal digital state of T_1 is sensed as a 0, until the wave's rising edge crosses the average dc level, when it becomes a 1. The digital transition takes place within a 5° phase from the zero point. The digital level then remains at 1 until the input goes approximately 100 mv below the zero point on the falling edge. The 100-mv hysteresis keeps noise from causing chattering of the internal signal.

The zero-crossing detection capability allows the applications designer to make the 60-hertz power signal the basis for system timing. All timing routines, including time of day, can be implemented with the signal and just a few conditional jump instructions.

Moreover, since T_1 is also an input to the external event counter, the detection feature may be combined with this counter to interrupt processing at the critical zero-crossing point. Thus the user can trigger phase-sensitive devices, such as triacs and silicon-controlled rectifiers, and use the 8022 in such applications as shaft-angle measurement and speed control of motors—anywhere that the zero crossing of a waveform provides timing information.

An oven controller

The 8022's high level of functional integration provides a single-chip solution to sophisticated, high-volume controller applications that have required relatively expensive multichip designs. An example is a controller (Fig. 5) for a stove with a combined microwave and conventional oven and range-top burners.

The a-d converter: how it was done

The drive to increase the density of large-scale integration leads to continually improving control of small geometries. In fact, self-aligned silicon-gate processes now allow arrays of identical resistors and access transistors to be almost as densely packed as memory arrays.

The resistive ladder on the 8022 is a string of 256 matched diffusion resistors with access gates to each tap. Process geometry and resistivity control matches these within 8-bit accuracy without trimming or special processing. Any mismatched resistors simply expand or contract the voltage between taps. Even shorted resistors cannot cause nonmonotonic voltage outputs.

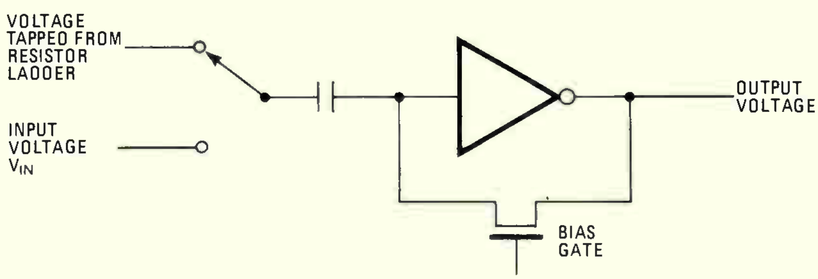
Design of the voltage comparator requires offset voltages smaller than could be expected from the standard memory/microprocessor process. So a chopper-stabilized design is used to compensate for offset inherently. Similarly, the low supply voltage of 4.5 to 6.5 volts does not allow sufficient gain or operating range from a differential stage. Thus a single-ended approach is used to increase gain. Carefully devised circuit tricks are enough to convert this stage into a differential comparator.

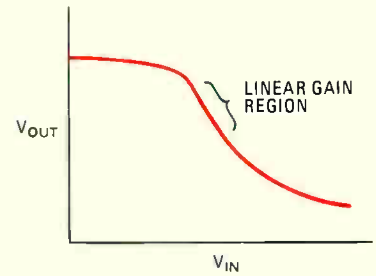
As shown, the basic gain stage is a logic element biased into its linear-gain region. Biasing is done while the input voltage is forced to the other side of the sample capacitor. When the bias gate is turned off and the ladder voltage is selected, the stage essentially amplifies the difference between the two voltage levels.

A string of these stages forms the comparator block. The input voltage has no effect on the amplifier bias point and therefore will not affect gain. This allows comparison down to voltages as low as V_{ss}.

Comparison with V_{cc} was made possible by judicious use of bootstrap circuitry. To limit bootstrap drivers, the voltage comparison actually occurs at half this external level. This allows all ladder select voltages to be simply V_{ss} or V_{cc}. Both resistive and capacitive dividers are used to drop the two comparison voltages to their internal level.

Finally, the capacitors inherent in the amplifier become the sample-and-hold mechanism that allows only one voltage sample to be taken per conversion.





Twenty keys enter timing and cooking instructions, and a four-digit display shows cooking time, temperature, and the time of day. Two temperature-sensing thermistors are employed, one for standard use and the other for microwave use.

While such a system could be controlled by a conventional 4-bit or 8-bit microcomputer, external circuitry would be required to interface the keyboard, convert the analog signals to digital data, drive an audio alarm, and determine the zero-crossing point of the 60-Hz power wave for timing functions and magnetron control. The 8022 reduces this multichip system to a single chip. The computer-plus-converter chip can save the oven maker upwards of several dollars in parts costs.

In this application, the 8022 program memory stores all control programs, cooking and power-cycling algorithms, and timing routines. Its 2-kilobyte ROM is large enough to provide for easy expansion of oven features and product differentiation. The on-chip RAM stores temperatures, power-level and timing settings, and all intermediate computational results.

The analog signals from the conventional temperature sensor and the microwave meat probe feed directly into the two analog inputs on the 8022 without any additional circuitry. What's more, the chip's 8-bit a-d converter gives more accurate temperature sensing than most existing discrete configurations.

The keyboard interfaces directly to the device through port 0. The keyboard in this application can be either a capacitive touch panel or a conventional switch type, since the 8022 directly interfaces either.

The T_1 pin in the zero-crossing detection mode establishes an accurate time base for all timing routines, including cooking cycles, presetting functions, and time of day. To accomplish this, the chip detects a zero crossing using the two conditional-jump instructions associated with T_1: JT1 and JNT1. Then it increments a register in data memory, effectively keeping track of elapsed time. Using this technique, a time-of-day routine can be written for most applications in less than 30 bytes of code.

Control of the magnetron

The zero-crossing detection capability also efficiently controls the microwave's magnetron. To minimize current surges through the system, the magnetron should be fired at the peak of the ac wave (90°). To achieve this performance, the 8022 detects the zero crossing point with its T_1 pin and delays the 90° phase shift with the internal timer.

The high-current drive pins, PI_0 and PI_1, are tied together to directly drive a piezoelectric alarm, which requires 10 to 15 mA of current. The remaining I/O lines are used to drive the display and status indicators, to monitor the door interlock, and to control the triacs that switch the burner and oven heating elements. The internal timer controls the refreshing of the displays and the scanning of the keyboard. □

PROM converts push-button command to binary number

by Marco A. Brandestrini
University of Washington, Center for Bioengineering, Seattle, Wash.

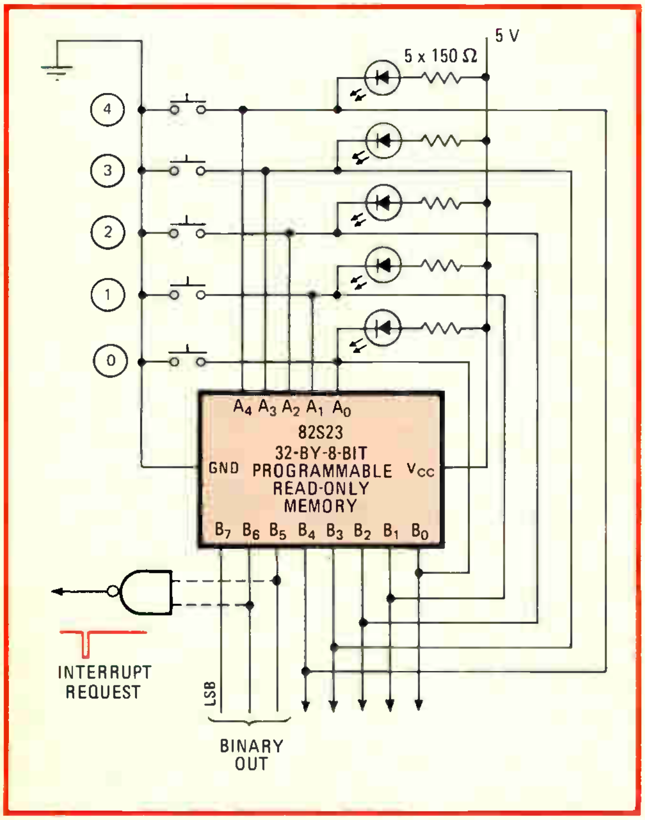
A programmable read-only memory can be used to convert a decimal-input command from a one-of-five momentary-contact-switch array to its equivalent binary number, thus forming a circuit with countless uses in logic- and microprocessor-control applications. The circuit is superior to systems using a thumbwheel switch to digitally set the binary number and is more reliable than single-switch arrays using an all-mechanical arrangement. Variations and extensions of this idea are limited only by the size of PROMS available.

The basic idea is to connect the PROM's output lines, B_0–B_4, to their respective address inputs, A_0–A_4 so that any input signal may be latched and the resulting signal at the output will remain active after a given key is released (see figure).

The PROM, here the Signetics 82S23, should be programmed as shown in the table if the output code is to be the binary equivalent number of the decimal input signal. In order to force the output to a given state after the circuit has been turned on (power up), inputs A_0–A_4, usually all high, can be programmed to actuate any of the five output combinations. The truth table shows how the PROM is programmed for state 0 after power up. Of course, any input-output relation may be programmed into the PROM as desired.

Circuit operation is simple. If, for example, the 0 key is depressed, a logic 0 appears at address A_0 (all input and output ports are active low). The resulting output at

Key-stroke commands. Circuit converts decimal-input command to its equivalent binary number. Momentarily depressed key is sensed by PROM and displayed by light-emitting diode. Outputs of PROM are wired to inputs and actuate latching. Interrupt generation is provided for microprocessor applications.



PROGRAMMING OF THE PROM

DECIMAL INPUT NUMBER	INPUTS A_4	A_3	A_2	A_1	A_0	OUTPUTS B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0
	0	0	0	0	0	1	1	1	1	1	1	1	1
	0	0	0	0	1								
	0	0	0	1	0								
	0	0	0	1	1								
	0	0	1	0	0								
	0	0	1	0	1								
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	0	1	1	0	0								
	0	1	1	0	1								
	0	1	1	1	0								
4	0	1	1	1	1	0	0	1	0	1	1	1	1
	1	0	0	0	0	1	1	1	1	1	1	1	1
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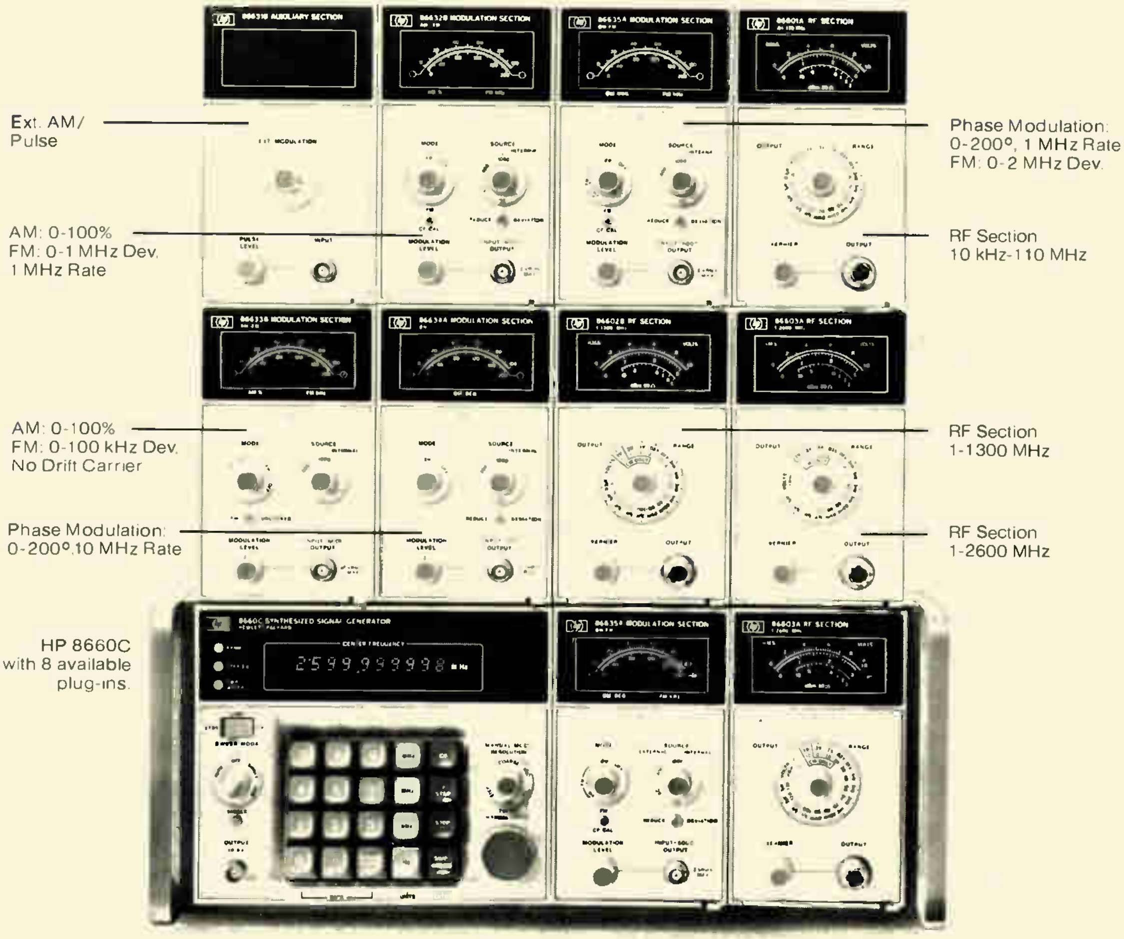
3	1	0	1	1	1	1	1	0	1	0	1	1	1
	1	1	0	0	0	1	1	1	1	1	1	1	1
	1	1	0	0	1								
	1	1	0	1	0								
2	1	1	0	1	1	0	1	0	1	1	0	1	1
	1	1	1	0	0	1	1	1	1	1	1	1	1
1	1	1	1	0	1	1	0	0	1	1	1	0	1
0	1	1	1	1	0	0	0	0	1	1	1	1	0
POWER UP	1	1	1	1	1	0	0	0	1	1	1	1	0

OUTPUT PORTS

PRECISION SIGNALS



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B_0 moves low, and this signal is fed back to its corresponding input, keeping A_0 low after key 0 has been released. A light-emitting diode monitoring the A_0 port glows, indicating that the line has been activated.

If a second key is depressed, all of the PROM's open-collector output lines move high temporarily, clearing the output (see table), and the new key position is latched. The temporary logic 1 state is sensed by the NAND gate shown and produces an interrupt request—which is useful in microprocessor applications. □

RC-discharge clock makes a-d encoder logarithmic

by V. Ramprakash
Electronic Systems Research, Madurai, India

This analog-to-digital converter produces a 12-bit digital output that represents the natural logarithm of an input audio signal in the 1-to-1,000-millivolt (60-decibel) range. It is useful for monitoring slow changes in many natural processes. The circuit also may be adapted for use as a combination voice compander and encoder in a digital communications system.

Operation is based on the principle that the discharge rate of a voltage stored across a resistance-capacitance network is proportional to the logarithm of the ratio of the instantaneous to the initially applied voltage. When the voltage across the RC network is used to control the gating time of a counter, the counter's output is a binary-coded decimal number equal to ln V_i, where V_i is the input voltage.

The voltage across a discharging capacitor, V_c, in an RC network is given by:

$$V_c = V_r e^{-t/RC}$$

where V_r is the initial voltage. This equation, when transposed, becomes:

$$t = -RC \ln(V_c/V_r)$$

Let t_i represent the time it takes the capacitor to discharge from V_r to the input voltage V_i. If during this time a down counter is gated while being clocked at frequency f_c, the number of counts reached will be:

$$n_d = f_c t_i = -f_c RC \ln(V_i/V_r)$$

More generally, if the down counter is initially at a count of n_i, then the net count n_n after time t_i will be:

$$n_n = n_i - n_d = n_i + f_c RC \ln(V_i/V_r)$$

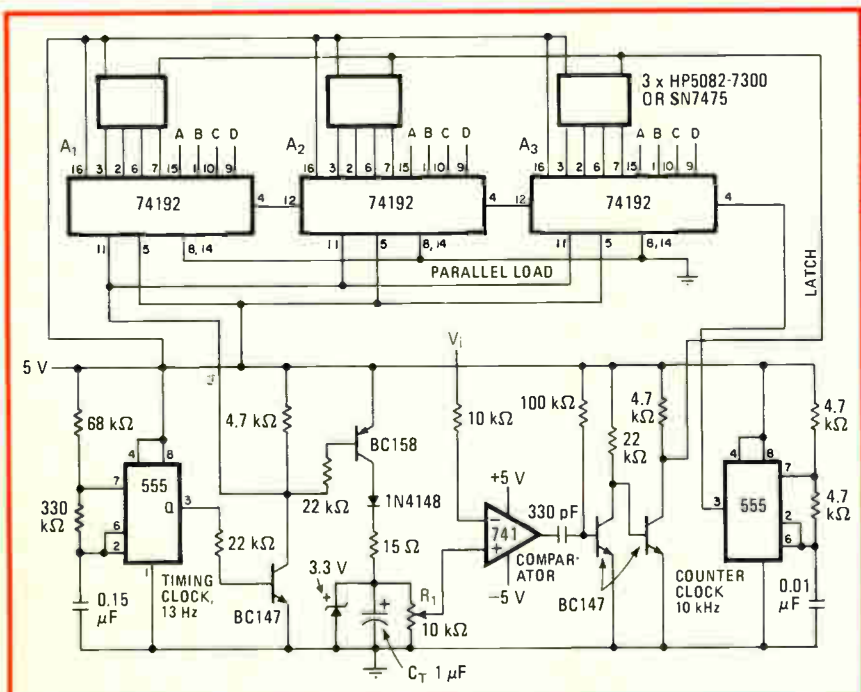
Letting V_r = 1,000 mv and n_i = 690, we arrive at:

$$n_n = 690 - 100 \ln 1000 + 100 \ln V_i = 100 \ln V_i$$

which can be reduced to $n_n = \ln V_i$ with appropriate scaling in a practical circuit.

The circuit shown in the figure implements the derived equation. When the output of the 555 timing clock is high, the 74192 up-down counter is loaded with the number 690 as shown in the table. At the same time, capacitor C_T is charged to 3.3 volts. R_1 facilitates the scaling of this voltage so that the potential as seen at the noninverting input of the comparator is 1 v.

When the output of the timing clock moves low, the 74192 begins to count down at a 10-kilohertz rate and C_T begins to discharge. As the voltage at the noninverting input drops below the sample voltage, V_i, the



LOADING OF 74192 UP-DOWN COUNTER

COUNTER	NUMBER	CODING A	B	C	D
A_1	6	1	1	0	0
A_2	9	1	0	0	1
A_3	0	0	0	0	0

Natural processing. Circuit is logarithmic a-d converter and digital encoder in one. Voltage across C_T, which decays exponentially at start of each sampling cycle, controls gating time of 74192 counters, ensuring logarithmic response. Counters are preset to 690 before each encoding to eliminate constant-coefficient terms inherent in circuit's transfer function, so that output from counter is n = ln V_i.


EAROM

comparator output moves low and generates a latch pulse for the BCD-to-seven-segment displays, or 4-bit latches, as required. Thus the contents of the counter are stored in either the display or the latches. The sequence is then repeated. Note that a decimal point is located in the most significant display (corresponding to counter A_1) so that the natural logarithm of a 1,000-mv input signal will be correctly displayed as 6.90.

The low-frequency clock limits the input signal sampling rate to 13 hertz. However if the clock frequency is increased to 5 kHz or so, and the clock counter is replaced by one that can run at a few megahertz, the circuit will serve as an excellent speech encoder. □

Switching-mode controller boosts dc motor efficiency

by Jay C. Sinnett
U. S. Environmental Research Laboratory, Narragansett, R. I.

On-site monitoring equipment that makes use of a variable-speed dc motor places a special premium on the efficient use of the instrument's battery supply, because current drain is often high. This motor-speed controller circuit, which works on the principle of the highly efficient switching-mode power supply, saves energy and thus reduces circuit losses associated with the motor.

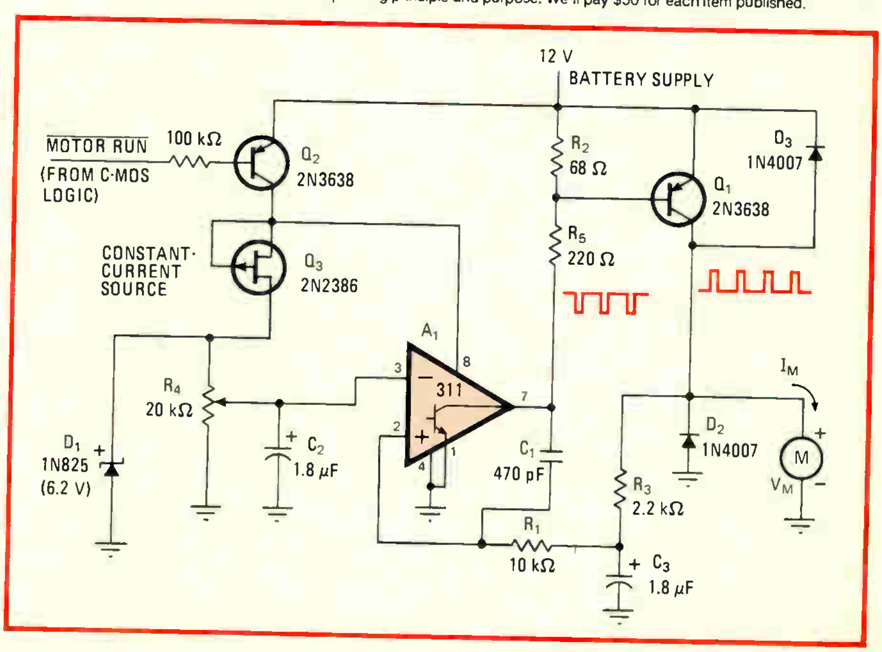
In this circuit, large, low-duty cycle pulses of supply current set up continuous currents in a small (0.01-horsepower) motor that are almost equal in magnitude to the peak current drawn by the supply, thereby contributing to circuit efficiency. As a typical example, almost 200 milliamperes of continuous motor current can flow when the average battery current drain is 100 mA, for an output voltage of 3.5 volts.

A_1, a voltage comparator, serves as both an oscillator and a duty cycle element in the controller, as shown in the figure. C_1 and R_1 provide positive feedback to A_1, enabling it to oscillate at about 20 kilohertz. The duty cycle, which can be from 10% to 70% of one 20-kHz period, is controlled by the negative feedback loop formed by Q_1, R_1, C_3, and R_3.

When the system's control signal, $\overline{\text{MOTOR RUN}}$, is asserted low, Q_2 turns on and applies power to the entire circuit. Pulses emanating from A_1 are amplified and inverted through Q_1 and pass through the motor, M. R_4 and D_1 set the average voltage supplied to the motor and thus largely determine the motor speed.

Note the absence of a capacitor at the output, which would normally be required to filter the pulsed signals and enable the motor to run smoothly. If a capacitor were used, it would have to be large in value and therefore large in size and costly as well. Instead, diode D_2 is placed in the circuit for filtering, enabling the pulsed energy to be stored by the motor's inductance in the field surrounding the windings. Between pulses, when Q_1 is off, little battery current is drawn, but the motor current is relatively large, since the amplitude of the current decays slowly through D_2.

Note also that although D_1 provides a stable, accurate reference, the average voltage fed back from the motor's terminals is affected by the forward-voltage drop of D_2. The drop varies with temperature and the current drawn through it and so reduces the absolute accuracy with which the output voltage can be set. However, resettability and stability are both very good with respect to battery voltage variations, and in applications where the temperature variations are minimal, the drawback will be unimportant. For example, the current variations due to even a 4-v supply-voltage change will be less than 2%. □



Less drain. Dc motor-speed control, which works on principle of switching-mode power supply, ensures minimum circuit losses. Duty cycle of pulsed output, 10% to 70% of one cycle at 20 kHz, drives motor, keeping battery current to minimum. Motor's inductance stores and filters pulses, essentially replacing filter capacitor normally used.

Techniques of automatic wiring multiply

Wire-Wrap remains the most popular, but others offer helpful options

by Jerry Lyman, *Packaging and Production Editor*

☐ Automatic wiring originated with the large backplane. This metal or plastic panel, with its thousands of wiring pins on one side and its crowd of printed-circuit-board or cable connectors on the other, turned up first in telephone exchanges and soon spread to computers. But almost immediately, it proved impossible to manually wire one of any size at a cost-effective rate and without excessive errors. Only an automated form of wiring could handle a large backplane.

Automatic wiring today takes many forms, from the well-known Wire-Wrap and Termi-Point through Multiwire, Stitch Wiring, and all the others listed in the table. While still used for backplane wiring, it has also become very popular for wiring panels of integrated-circuit sockets, which have wiring tails that lend themselves to some form of the process.

The techniques in the table, more or less without

SUMMARY OF DISCRETE WIRING TECHNIQUES

Type	Description	Kind of connection	Wire	Applications
Wire-Wrap	Mechanically wraps stripped insulated wire in helical coil about a rectangular post	Redundant gas-tight pressure connection to a copper- or gold-plated rectangular pin typically 0.025 in.^{2} with No. 30 AWG wire; 0.045 in.^{2} posts are used with No. 24 and 26 AWG wire	Teflon, polysulfone-and-polyester-insulated silver-plated copper, No. 24 through 30 AWG (most commonly No. 30 AWG)	Daughterboards, backplanes, and packaging panels
Termi-Point	Connects a solid or stranded wire to a rectangular post by means of a metal clip; 0.031-by-0.062-in. post used with No. 22 through 28 AWG; 0.022-by-0.036-in. post used with No. 28 through 30 AWG	Gas-tight connection at the wire-post interface by means of a spring-loaded clip	T or TE type Teflon-insulated solid or seven-strand wire, No. 22 to 30 AWG	Backplanes and packaging panels
Multiwire	Bonds continuous wire to an adhesive substrate and terminates it to a plated-through hole	Electroless copper-plated connection	Polyamide-insulated, solid No. 34 AWG, 6.3-mil overall diameter	Packaging panels, daughterboards, and backplanes
Stitch Wiring	Bonds continuous wire with insulation displacement	Resistance-weld (diffusion-bond) connection to a stainless-steel surface	FEP and TFE, Teflon-insulated nickel, typically No. 30 AWG solid	Low-profile daughterboards and backplanes
Tiers	Reflow-solders wire through insulation to a solder-coated pad on a printed-wiring board	Solder connection	Low-temperature, heat-strippable copper wire, No. 28 through 36 AWG	Packaging panels and backplanes
Solder-Wrap	Employs a three-stage routing, soldering, and cutting process	Solder connection to component lead	Polyurethane-coated, No. 38 AWG solid copper wire	Packaging panels, daughterboards, and backplanes
Quick Connect	Uses continuous wire with insulation displacement	Gas-tight pressure connection	Typically No. 30 AWG solid copper wire with any nonbonded insulation	Backplanes and packaging panels
U-Contact	Continuous run, insulation displacement between eight contact strips soldered to plated-through holes	Gas-tight, press-fit connection to beryllium-copper contacts with gold-over-nickel plating	Polyvinylidene-fluoride-insulated No. 30 AWG solid wire	Prototype and short-run production

exception, are low-cost, fast, and dense, and facilitate prototyping. Perhaps more important, they all share two big advantages over their main competitor, the multilayer printed-circuit board. First, the computer base used to produce the wiring software can also be made to produce the software needed for automatic continuity testing and for automatic component insertion. Second, changes in a wiring program are easy to put into effect, whereas a modified multilayer pc board can take weeks to deliver.

All wrapped up

Wire-Wrap, the firstcomer in the automatic wiring field, was invented in the 1950s by the Gardner-Denver Co., Grand Haven, Mich. According to Gnostic Concepts Inc. of Menlo Park, Calif., it accounted for over 90% of all automatic wiring in 1976, though the figure could shrink to 70% by 1983. In this process, a special automated (or manual) wiring tool wraps the stripped end of a solid wire five to seven times around a square post forming a gas-tight bond.

Tooling	Wiring rates (connections per hour)
Manual	50 – 80
Semiautomatic: numerically controlled terminal locating; manual wire terminating	175
Automatic: automatic terminal locating, wire feeding, stripping, and wrapping	900 – 1,000
Automatic: numerically controlled terminal locating; automatic cutting, stripping and terminating	850
Manual: manual termination tool	180
Computerized automatic wire routing, employing conventional printed-wiring technology for power and ground-plane circuit formation	800 from/to wires/panel; runs four panels simultaneously
Semiautomatic: numerically controlled terminal locating; manual wire routing and bonding	450 – 500
Manual systems: manual terminal locating; manual welding	75 – 125
Automatic: numerically controlled routing, soldering, and cutting	375
Semiautomatic: manual routing; automated soldering and cutting	150
Automatic: numerically controlled terminal locating; automated wrapping, soldering, and cutting.	300/panel; runs four panels simultaneously
Manual tooling	100
Semiautomatic: numerically controlled terminal locating; automatic wire feeding; manual terminating	300 – 400
Manual tooling	100

Source: Gnostic Concepts Inc.

Wire-Wrap is the most complete wiring technique at present available. Machines and wiring software, backplanes and IC socket panels, sockets, pins, and test fixtures are all available to convert logic diagrams or wiring lists into finished boards.

The process is heavily used in the telecommunications, instrumentation, computer, military, and industrial fields. It is also popular for prototyping digital circuitry. Its advantages over the multilayer board are high packaging density, easy repairability, a high wiring rate, and low manufacturing costs. Its chief disadvantages are a relatively high profile due to the length of its pins and poor high-frequency performance unless specially designed panels are used.

In 1961, AMP Inc. of Harrisburg, Pa., came out with a competitor to Wire-Wrap. Called Termi-Point, it also employs a gas-tight connection, but one made by sliding a tiny spring-metal clip over the end of a post to press the stripped end of a piece of wire against the post. The spring clip maintains a high-pressure, gas-tight area of contact between the conductor and the post. Up to three connections may be applied to the post either semiautomatically or fully automatically, or even manually.

Termi-Point, which is available only from AMP, is strong in aircraft and avionics because of its three main advantages over Wire-Wrap: it is relatively easy to repair, can handle stranded as well as solid wire, and can accept a twisted pair. But unfortunately, it suffers from the same deficiencies as Wire-Wrap—a high profile and poor high-frequency performance. This situation encouraged the entry of other wiring technologies seeking to supply the missing requirements.

Close to the board

One of the most heavily used of the new low-profile wiring methods is Multiwire. Multiwire was developed during 1970–1971 by the Photocircuits division of Kollmorgen Corp., Glen Cove, N. Y.

The first step in Multiwire is to etch power and ground planes from a copper-clad glass-epoxy board. The next is to coat the board with adhesive. Then a numerically controlled machine lays down a customized pattern of insulated wires in the adhesive, and the board is heat-treated to cure the adhesive. Finally, holes are drilled through wire and board and plated with electroless copper to connect the two.

Unlike Wire-Wrap with its multiple sources, Multiwire is really available only through Photocircuits and one other source, Diva Inc. of Eatontown, N. J. The latter firm multiwires its own disk-storage units but will supply custom boards made on its Multiwire machines. Photocircuits now has three design centers at various loca-

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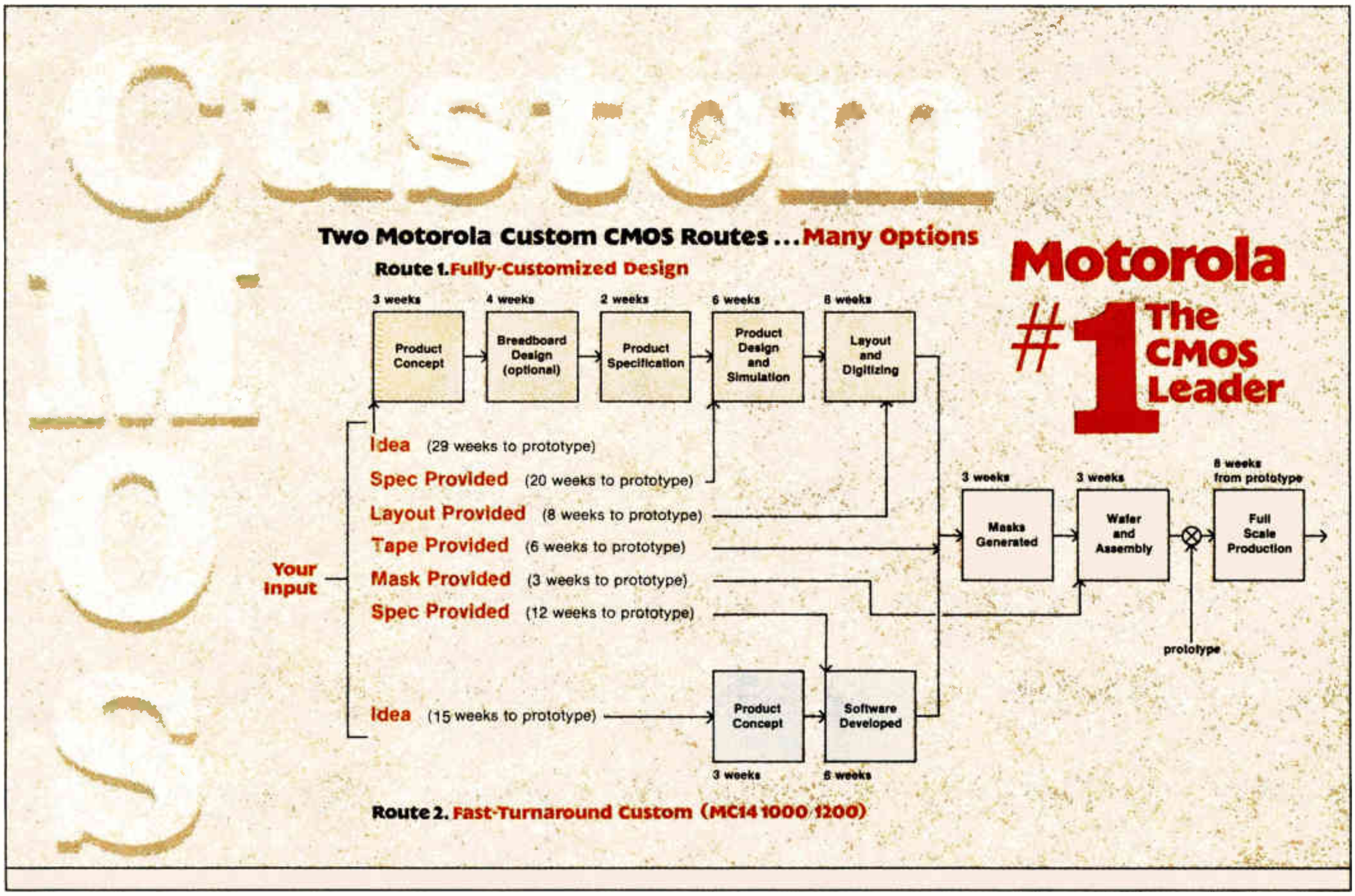

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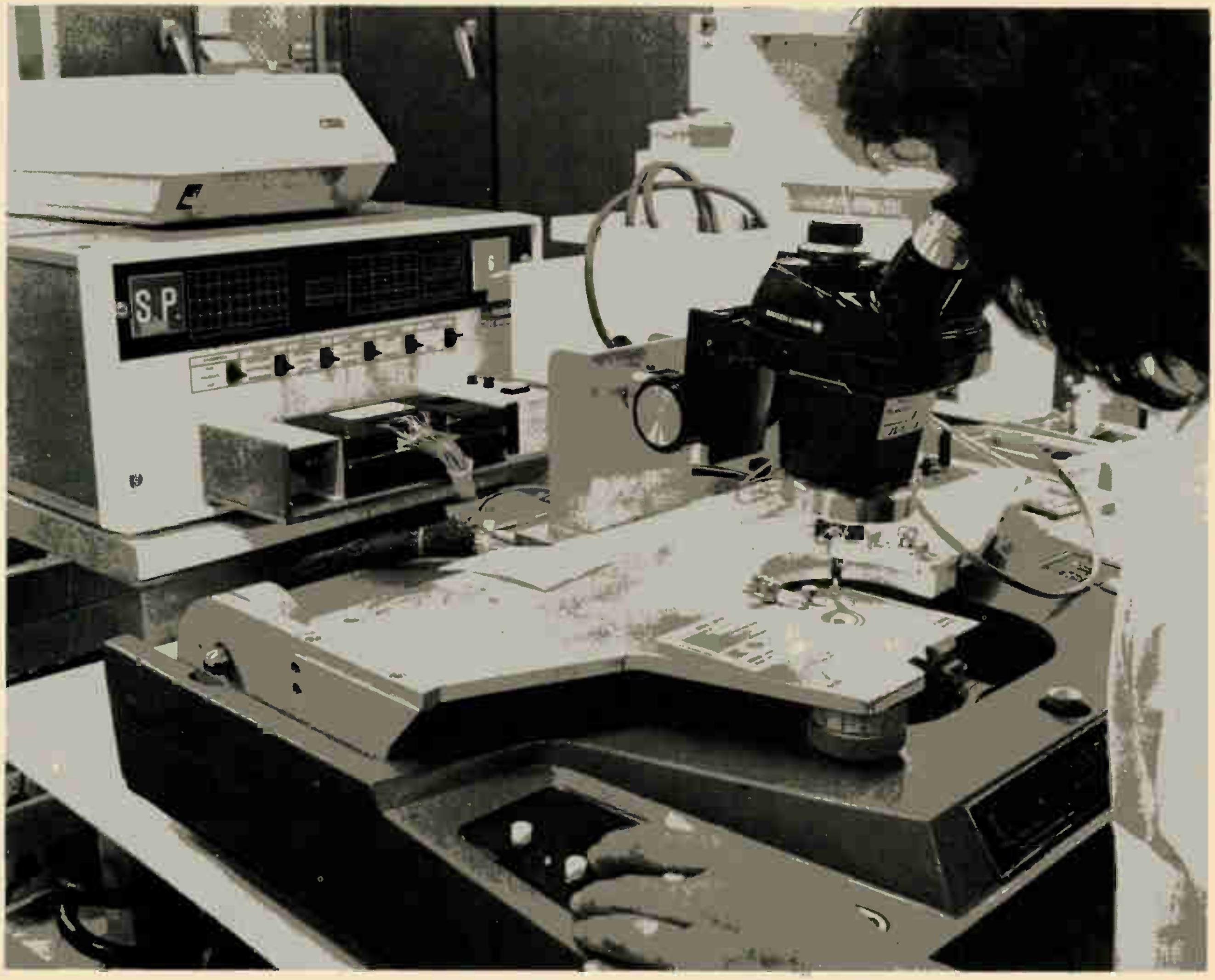
LSI tester gets microprocessors to generate their own test patterns

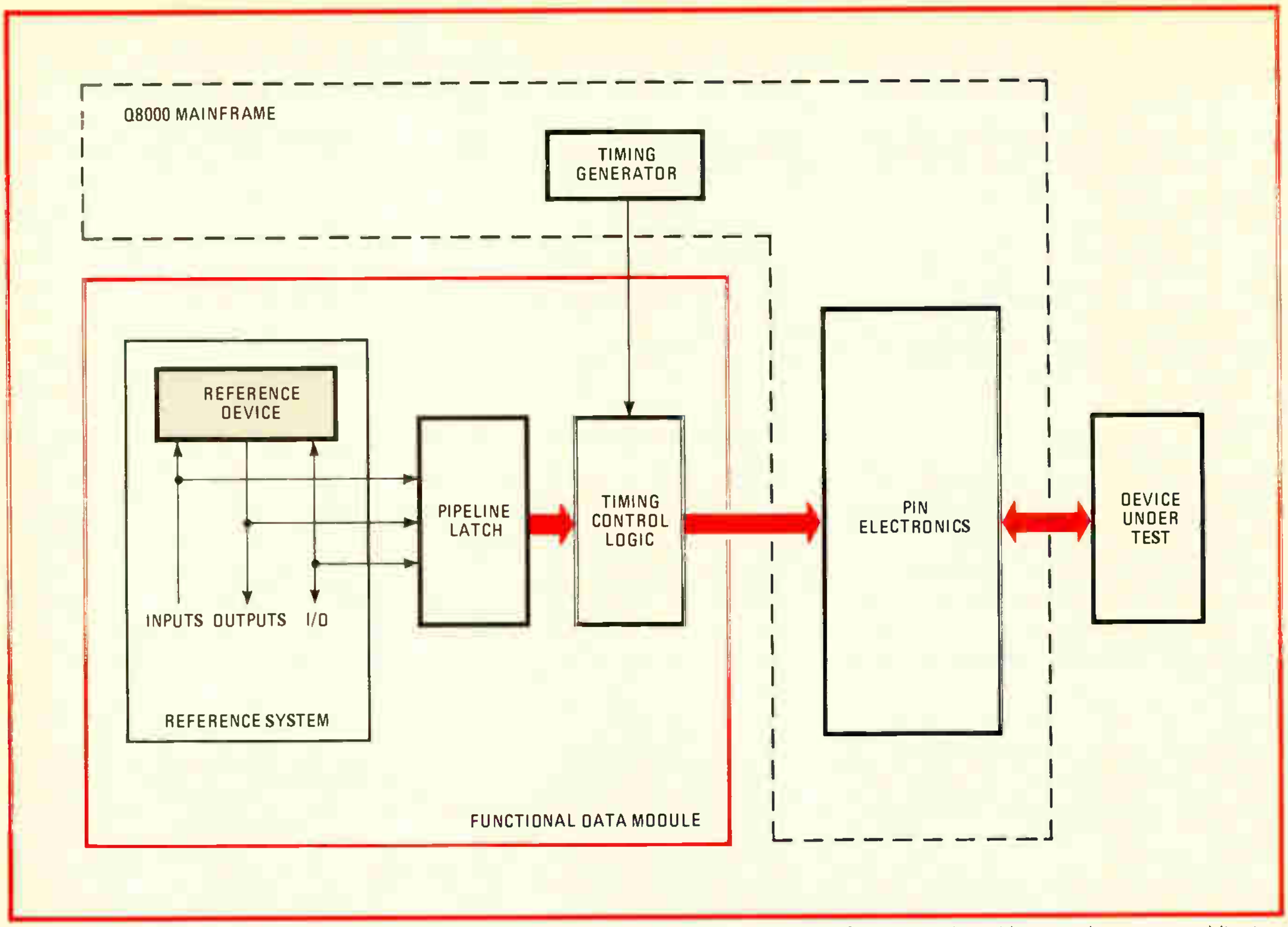
By deriving the test pattern from a device identical to the one under test, a general-purpose benchtop unit can handle different types of microprocessors and peripheral chips at actual system speeds

by Stephen Bisset, *Megatest Corp., Sunnyvale, Calif.*

☐ Integrated circuits are already evolving from large-scale to very-large-scale, yet problems of testing the first generation of LSI chips still remain. In addition, programming costs for functionally testing LSI circuits generally increase exponentially with device complexity, and if this continues to be true, testing will soon become the major cost involved in the manufacture and use of these devices.

There is, however, a way to break the back of this cost inflation that also solves many of the major testing problems. The low-cost Megatest Q8000 greatly simplifies test programming and keeps costs under control by drastically reducing both hardware costs and testing time as compared with buffer-memory or stored-response testers. In fact, the new tester, based on the use of a reference device identical to the one under test to generate test patterns, will do for microprocessors what algorithmic pattern generation did for memories—





1. General-purpose plus. Megatest Q8000 tester achieves high level of flexibility and ease of programming with general-purpose architecture and modular approach. Functional data module provides real-time data for generating functional test patterns.

greatly reduce the amount of storage required for test patterns, as well as speed up testing.

In this approach, an LSI device essentially emulates itself in real time. However, since stimulating most such devices with pseudorandom input sequences—which is done in older comparison techniques for less complex devices—will not reveal whether they will work in a specific application, the Q8000 allows the reference device to function as it would in its intended use. A central-processing-unit chip, for example, can then actually execute a program stored within the reference system. Functional testing is performed in real time at actual device clock rates with a consequent tenfold improvement in throughput as compared with any available stored-response method.

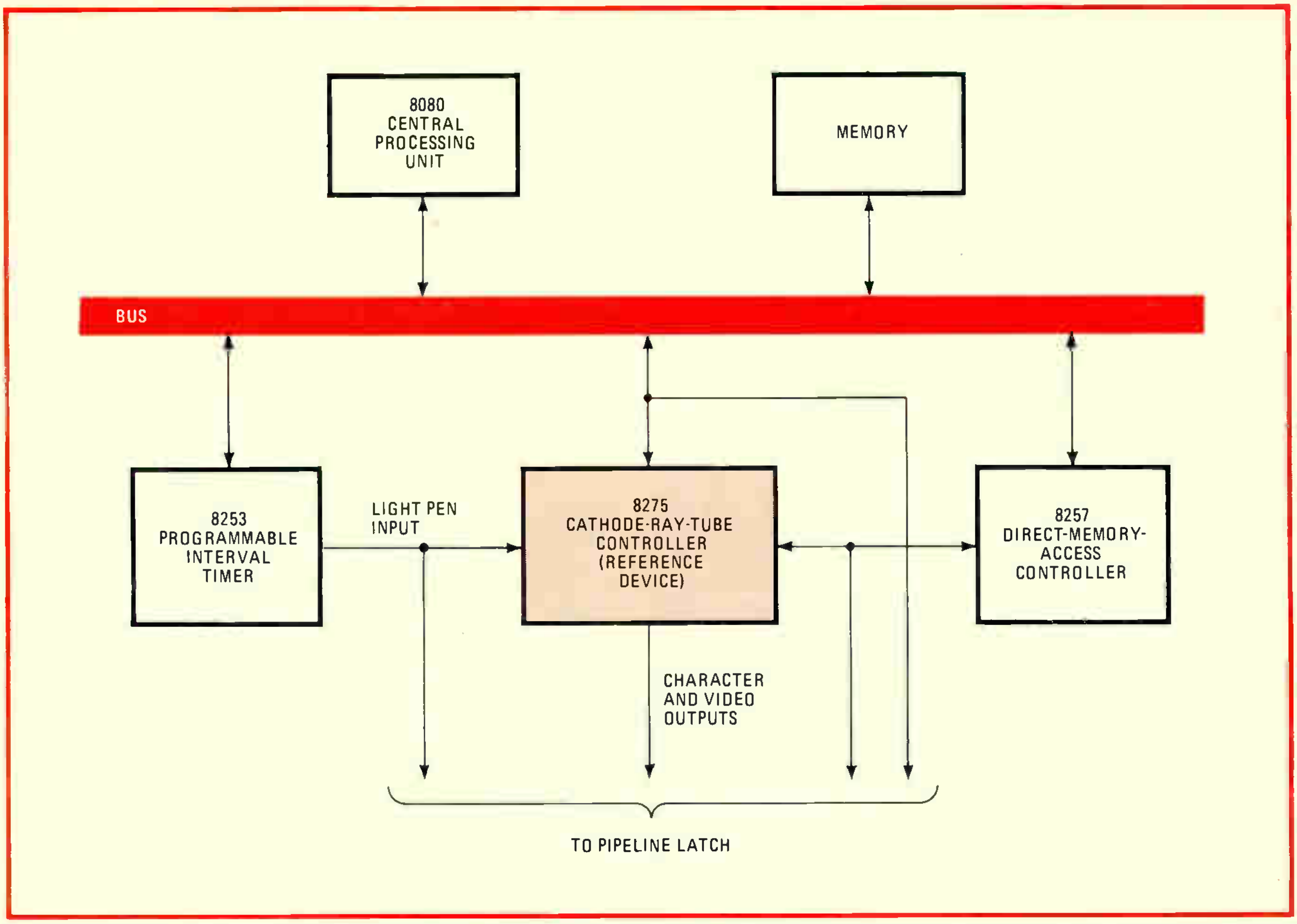
Dedicated vs general-purpose testers

Flexibility in a tester is more important to the low- and medium-volume end user than to the high-volume user because the former's costs will be extremely high if he has to buy different test systems for microprocessors, peripherals, memories, and transistor-transistor logic. Flexibility also matters to the device manufacturer because of the substantial investments in education and maintenance required for each type of test system.

A completely software-controlled test system may be desirable in a laboratory, but it has two drawbacks for production use. First, it will be unavoidably expensive, while most of its capability may be unused in testing any given device. Second, because of its generality, it may be poorly suited to a particular, isolated task—sooner or later, the attempt at universality through software control creates an inadequacy in some essential testing requirements.

On the other hand, a highly dedicated tester has an obvious drawback—each new device requires a new tester. To handle a variety of device types, a tester can have certain constant hardware, but it also must have some variable features. The hardware required generally is the same for many device types, provided the tester can handle the number of pins. Essentially, all devices require a tester that includes interfaces, controls, high-speed drivers and comparators, a dc parametric unit, programmable power supplies. and time-delay generation. The method of pattern generation, however, varies for each type of device. For example, pattern generation for memory chips is substantially different from that required for microprocessors.

A general-purpose LSI tester architecture, such as that used in the Q8000, needs a module to provide real-time data for functional test patterns for the device to be tested (Fig. 1). This modular approach gives the best of both worlds: most of the tester is standard and therefore general-purpose, while the pattern generator can be



2. Self-emulation. Typical reference system for an LSI peripheral (Intel 8275 cathode-ray-tube controller) contains reference device, central processing unit, program memory, and other logic. CPU is needed to drive reference device, additional logic to exercise it fully.

customized for the particular application.

There are three basic types of modules, called functional data modules, or FDMs:

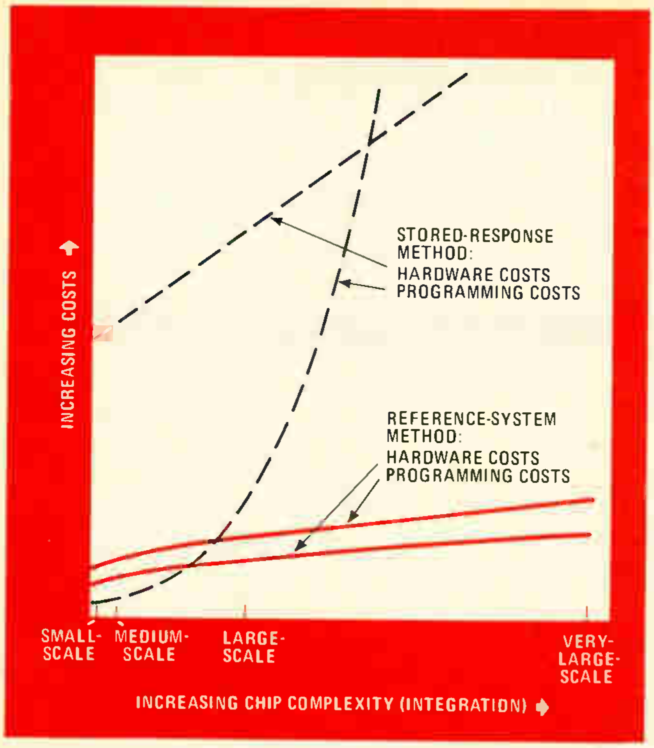
- Buffer-memory modules for simple devices requiring a few hundred, or at most a few thousand, clock cycles of functional test patterns. These include, for example, small- and medium-scale ICs and perhaps some bit-slice microprocessors.
- Algorithmic-pattern-generation FDMs for devices of regular structure such as read-only and random-access memories and shift registers. One such module, for instance, includes a microprogrammable address and data-pattern generator and may be software-programmed to test any RAM.
- Reference-system FDMs for emulating in real time highly complex devices such as microprocessors and peripherals.

The reference system takes a snapshot of each pin of the reference device at a point in each clock cycle when the data is stable. This is done by latching the data at each pin in a pipeline latch. Thus, the output of the pipeline latch appears as a truth table that is being sequenced in real time. The method of handling the truth table, or output test pattern, is the same as the way the outputs from a buffer memory in a stored-response tester are handled. Because of the latching, the truth table is independent of the timing and voltage characteristics (except for the cycle time) of the reference system.

Note that the pipeline latch and timing control logic are part of the module. The latches and gates control such operations as inversion of input data for worst-case testing of setup and hold times. The FDM may also include strobe-masking logic. Thus, flexibility is retained. In contrast, building this logic into the mainframe would require an extensive system of high-speed multiplexers to retain flexibility, and their use would inevitably make certain special timing requirements difficult or impossible. In other words, a huge system of buffer memory and timing control (which is obviously expensive and difficult to calibrate and maintain) is replaced by a single wire-wrapped card.

Functional programs for testing CPUs are straightforward, since the program is written directly in the assembly language of the device being tested. Peripherals, however, are slave devices and thus must be driven by a CPU. A reference system for testing peripherals therefore includes a reference peripheral device, a CPU, program memory, and other logic required to exercise the reference device. The functional sequence is generated by the CPU, which sets the various modes of the peripheral and causes it to execute its functions. Functional test data for the device under test is latched from the pins of the reference peripheral.

To test, say, the Intel 8275, a complex, programmable



3. Trends. Hardware and programming costs of reference-system approach rise gradually as degree of integration increases, and programming/hardware cost ratio actually decreases with increasing volume. Costs of stored-responses method rise sharply.

cathode-ray-tube controller, an 8080 CPU would execute the program (Fig. 2), but the tests can be defined in terms of the functions of the 8275. For example, a peripheral instruction might be: set characters per row = n_1, set retrace interval = n_2, scan n_3 pages. A complete peripheral instruction set can thus be defined with certain instructions having arguments (n_1, n_2, n_3, in the example).

These instructions have mnemonic equivalents that are assembled into operating codes. The 8080 program includes a supervisor that uses the op code to look up in a table the address of a corresponding procedure. Each procedure consists of several 8080 instructions that cause the peripheral to execute the function given by the peripheral instruction. The result is a concisely documented program that is not only easy to understand and modify but also costs far less to write and debug than tens or hundreds of thousands of 1s and 0s would.

Programming costs

By using the ability of LSI devices to generate their own test programs, the Q8000 cashes in on the huge investment made in chip development, instead of being penalized by it. Whereas the cost of stored-response test hardware goes up linearly with complexity (largely because of increased storage and test-time requirements), programming costs go up exponentially (because the cost of generating and modifying a truth table reflects the exponentially more complex interactions between different parts of a chip). On the other hand, as a chip becomes more complex, the ratio between chip complexity and test programming costs may actually improve when a reference system is used (Fig. 3).

First, observe the trend in system chip count. The whole thrust of LSI will continue to be replacing many chips with a few. Thus, the physical complexity of the reference system stays fairly constant. Second, the real hardware costs in systems are for interconnects, and the number of pins per device will not radically increase. The emphasis is on greater on-chip complexity to reduce exchanges between chips. Hence the number of drivers and receivers required for the bulk of LSI devices remains fairly constant (40 pins will cover most of them).

Third and most important, the greatest effort in microcomputer development is toward simpler programming. Therefore, although chips perform more and more complex functions, it remains relatively easy to command them to do so. This evolution in software efficiency is reflected in the simple programming required for the functional data modules.

The programming costs include, of course, the expense of designing an FDM. Experience has shown that the economic crossover on programming costs between the stored-response and the self-emulation, or reference-system, method lies somewhere between that for a bit-slice microprocessor, for which the reference-system approach would be more expensive, and that for an 8-bit CPU of the complexity of, say, an 8080, for which adequate stored-response testing is more expensive.

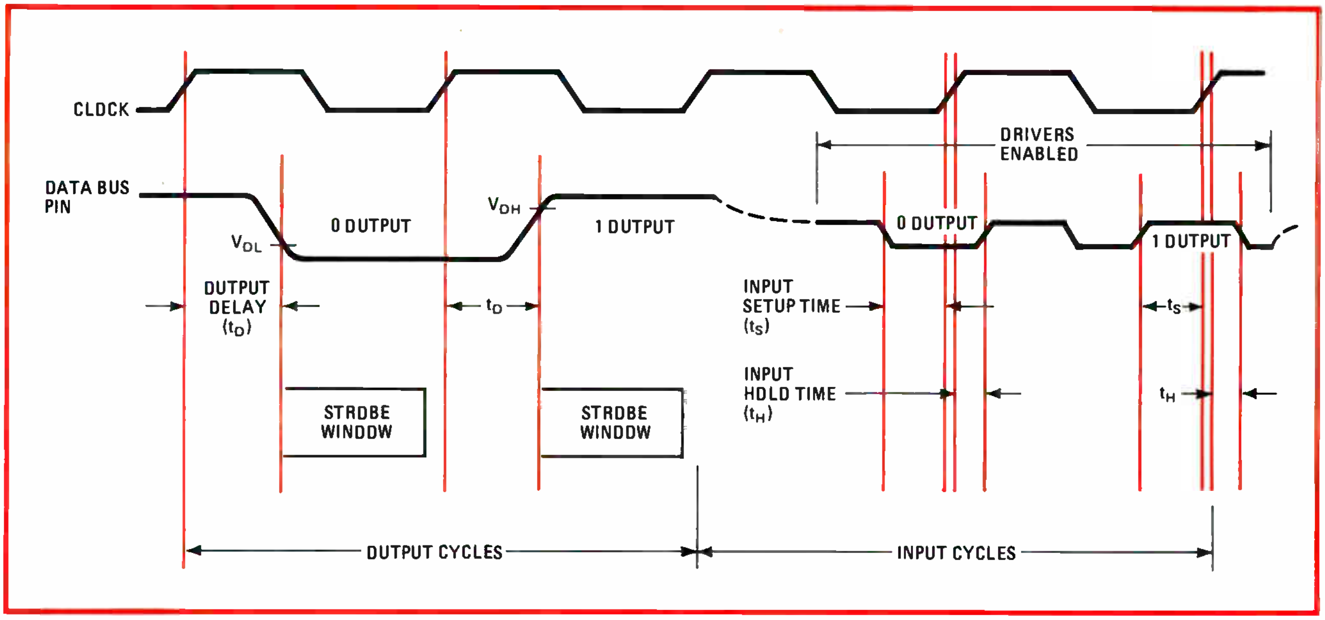
But what about the cost of all those hundreds of FDMs? Since LSI devices are programmable, a few satisfy many functions. In other words, users are not faced with hundreds of device types as they are with SSI and MSI. The typical user will need to test less than 10 kinds of device. In any event, as complexity goes up, the modules cost less than their fully software counterparts.

The FDM approach ensures that devices with unusual testing requirements can be accommodated. A recent example is single-chip microcomputers (actually, their test needs are far from unusual). With on-chip oscillators, output timing is often specified in relation to other outputs. This could have required a time-consuming characterization of each part in order to test it. But with the 8748, for example, the FDM designer simply generates time delays for output directly from the appropriate outputs of the device being tested. This is simple, but fast and effective. The tester does not lock the test engineer in with an unalterable set of "universal" capabilities.

Testing confidence—the ultimate judgment

Much of the literature on microprocessor testing has assumed (and lamented) that lower-cost testers automatically mean lower testing confidence. If this principle were always true, computers using integrated circuits would be inferior to those using vacuum tubes, since they are less expensive. Instead, technological changes often put a kink in the usually linear relationship between cost and quality.

Test quality for LSI devices depends on two things. First, all ac and dc parameters must be properly measured. For ac parameters, that means that every parameter must be measured during every clock cycle of an exhaustive functional test sequence. Since the Q8000 is of recent design, it is able to use both linear and digital



4. Ac parameters. Microprocessors and other large-scale integrated devices must be tested for ac and dc, as well as functional, parameters. Shown here is the basic set of ac parameter measurements made using a bidirectional bus pin as an example.

LSI, as well as innovative circuit design, to make possible economical measurement of all ac parameters (Fig. 4), plus all dc parameters.

The second and equally important criterion for testing confidence is the adequacy of the functional test sequence. Determining such adequacy is a large subject in itself. In brief, a test sequence can be evaluated by stimulating stuck-node conditions and seeing whether the test sequence detects them (a very expensive procedure), by correlating test results with other test sequences, and by statistical maturity—that is, a manufacturer ceases to receive returns from the field that passed his test sequence.

The latter two are more practical in the real world of LSI. The method of functional-sequence generation has no direct relationship to the adequacy of the sequence, providing there is no limitation on the types of sequences generated. But as a tool, the method used affects the practical likelihood of achieving good test quality. The reference-system approach encourages exhaustive functional testing. Once the reference system exists, generating and modifying functional sequences is very efficient. Because testing takes place in real time, and because there are no practical limits on program storage, there is much less pressure to reduce test length. Thus, for a given level of testing confidence, longer test sequences actually reduce programming costs, because it is cheaper to methodically test all functions of a device than it is to begin individually justifying each omission from thorough test coverage.

What if the reference device fails? There are two possible causes: the device may be defective, or the basic logic of the part may be in error. Experience has proved the first problem to be a nonproblem. If the reference device is defective, the test pattern becomes incorrect and yield drops to zero. It is no different from any other device in the pattern-generating system.

If, on the other hand, the basic logic of the device is incorrect, there is a problem, since a defect-free device under test will have the same logical error as the reference device and will therefore pass. However, it is not really the function of a test system to verify the device designer's logic. Although a truth table generated independently of an actual device is of value in finding logic errors, there is no guarantee that a part that matches a test sequence will work in a system. New designs must be thoroughly evaluated for functional correctness within the intended system. Once a design has been corrected and verified this way, an unlimited supply of valid reference-device candidates is immediately available.

Even though the manufacturer is forced to test less by economic pressures, he is also forced to test adequately by competitive pressures. And since he must test, he must make the investment in test programming. With microprocessor-related parts, this investment is not small, no matter what the approach.

Should each user have to duplicate the investment in test programming? While some independent generation of test procedures is healthy, the general availability of standard test programs and FDMs would provide the best possible testing credibility for the user at the lowest cost.

The device manufacturer is the best source of FDM designs and functional sequences, and a tester company is the logical vehicle for distributing and supporting them. While a user may wish to test using more combinations of voltage levels and timing than the manufacturer, programming of these parameters is trivial, the real cost being in the functional sequence. Because of the programming efficiency of the reference-system approach, and because the manufacturer is the target for all returned devices, he is highly likely to develop a good functional sequence (even if he does not test under enough different operating conditions). Besides, once the user has acquired a functional data module, he now has the most efficient possible pattern generator for implementing his own sequences, if desired. □

Biaxial modulators double data-system transfer rate

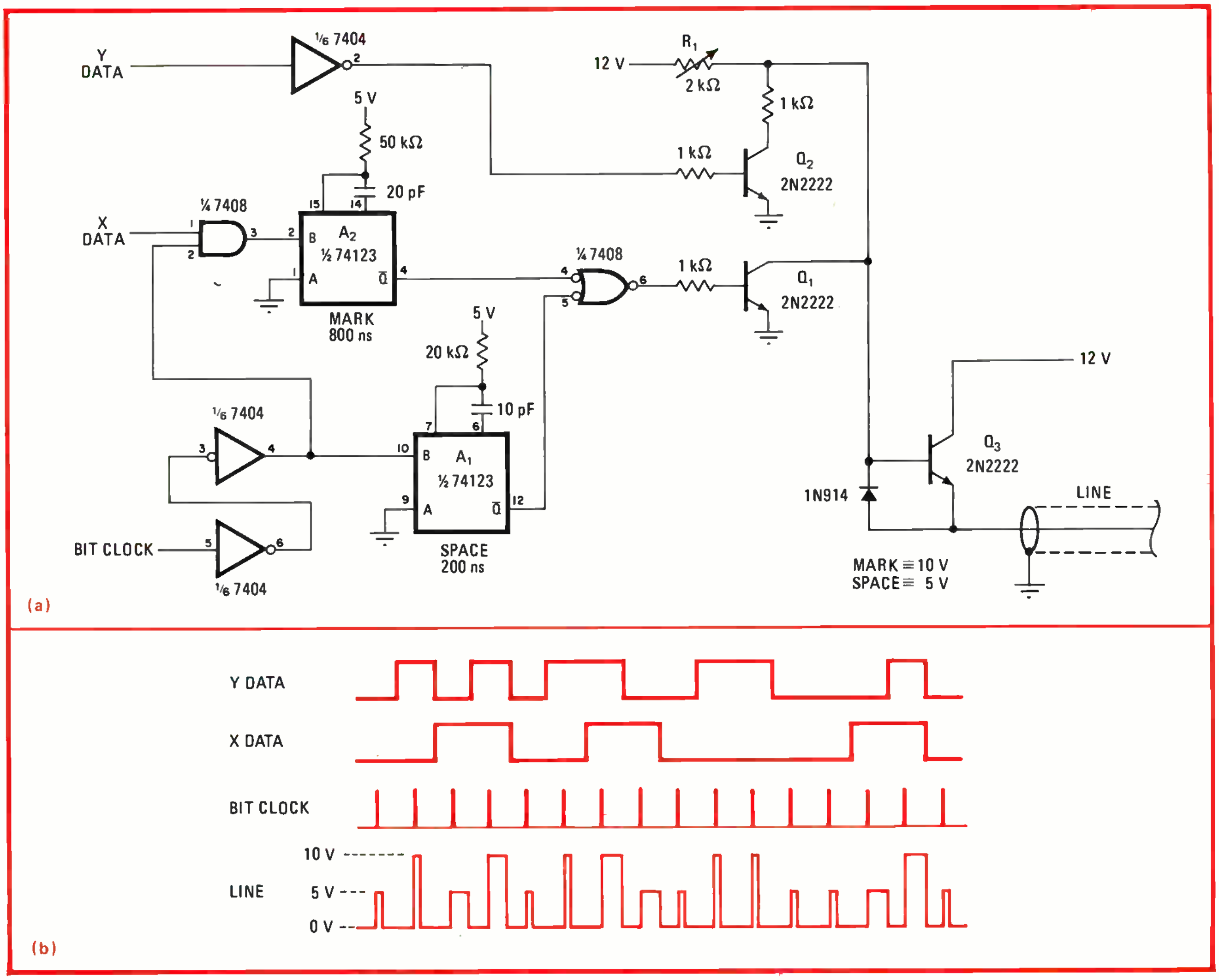
by Robert J. Stetson
Storage Technology Corp., Aurora, Ill.

The information-handling capacity of simple data systems will be doubled if a scheme employing both pulse-width and pulse-amplitude modulation is used to multiplex data through the transmission line. More specifically, a one-cable, single-channel system can be expanded to two channels, enabling data to be sent at twice the original bit rate. Such a biaxial modulation circuit is far more economical than those using separate cables and transmitter-receivers for each channel and is less complex and costly on a per-channel basis than those using synchronous eight-channel digital multiplexers. The biaxial transmitter and receiver are simple to build.

Figure 1a shows a transmitter suitable for transferring data through a line at 4,800 bauds per channel, or 9,600 bits of data per second for two channels. The X- and Y-input data, which are non-return-to-zero (NRZ) pulse trains, operate at the same baud rate and are synchronized with the bit clock. The latter is framed at the midpoint of the data, as shown in the timing diagram (Fig. 1b).

The width of the pulse emanating from transistor Q_1 and therefore from the output line is a function of the X-input data. Q_1 normally conducts with no input signal. Generally, the bit clock periodically fires A_1, a one-shot with an on time of 200 nanoseconds, and thus a 5-volt, 200-ns pulse appears at Q_1 if X and Y are at logic 0.

When the X data is high, however, a bit clock pulse



1. Modulation multiplexing. Two-mode modulation permits low-cost data multiplexing. Pulse-width modulation of X data combined with pulse-amplitude modulation of Y data doubles the capacity of one-cable systems (a). Timing diagram (b) details modulation processes.

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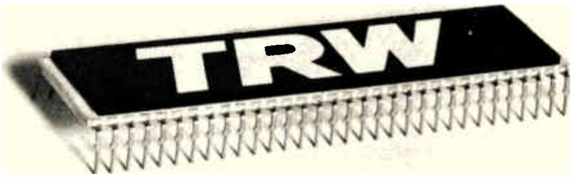

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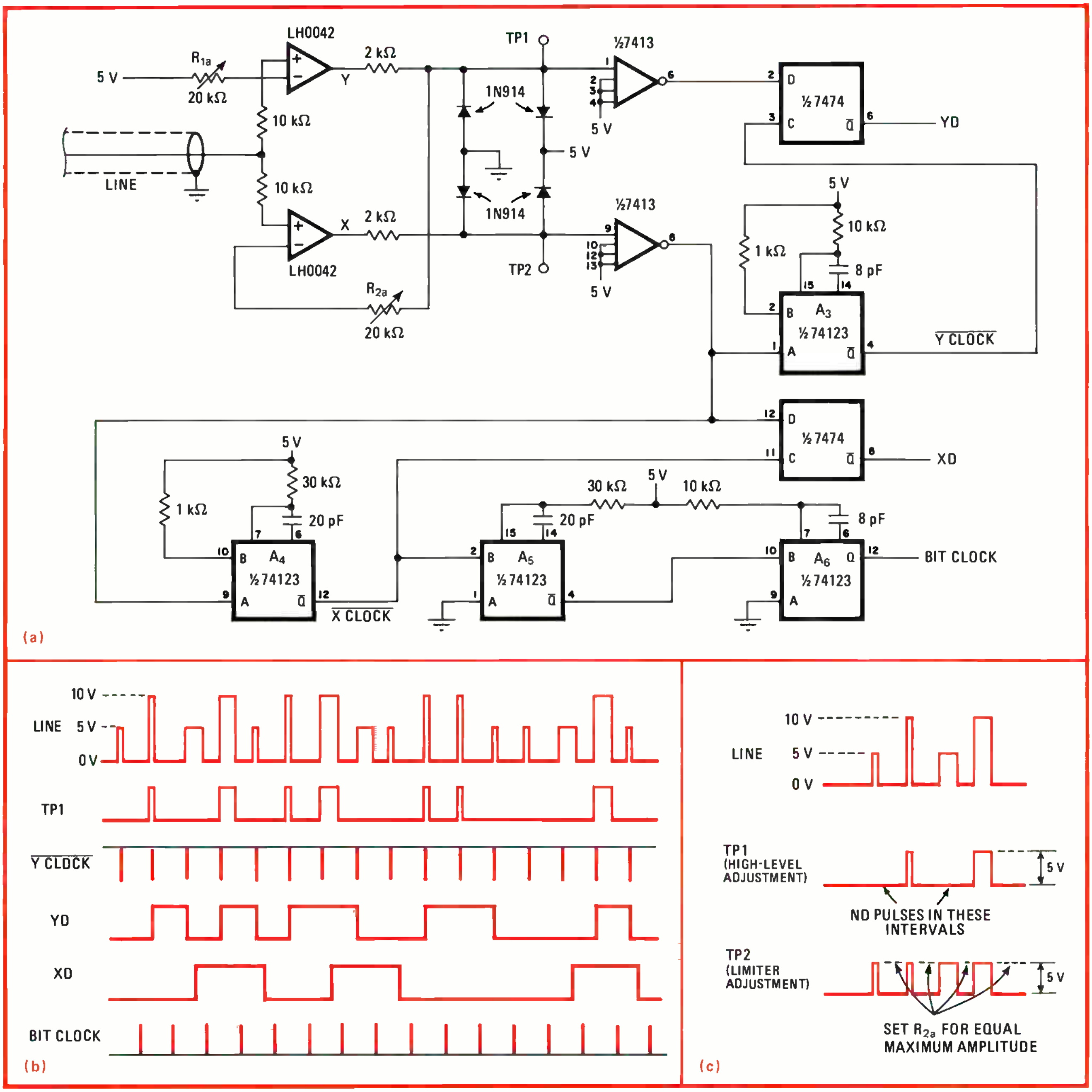
The output of Q_2 and the line, on the other hand, is pulse-amplitude-modulated by data on the Y port. When the Y input is high, and X = 0, the output of the signal line will be 10 v for a period of 200 ns after the arrival of the bit clock signal. If both X and Y are high, the line output will be at 10 v for 800 ns. The four possible X-Y input combinations are summarized in the timing diagram. The PWM-PAM signal that is to be sent over cable to the receiver appears at the line output, as shown.

The line signal is first introduced to the receiver end of the system through two LH0042 precision comparators (Fig. 2a). The 10-kilohm resistors limit the input current to well below the comparators' rated maximum of 200 microamperes. The Y comparator clips the signal, so that only the 5-to-10-v portion is seen at test point 1 (TP1). Note that the Y data is demodulated but not yet in the form it was originally at the transmitter, that is, reconstructed. The diode bridge at the input of the 7413s serves as a combination limiter and zero-crossover network to aid in signal recovery. The output of one 7413 fires the 74123 one-shot, A_3, producing the $\overline{Y}$



2. Recovery. Demodulation process is largely inverse to operation performed at transmitter. X and Y comparators separate pulse-width- and pulse-amplitude-modulated signals, generate XD and YD with aid of several one-shots and flip-flops (a). Timing diagram (b) aids in understanding the circuit's reconstruction operation. Two circuit adjustments optimize receiver performance (c).

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$\overline{\text{CLOCK}}$ signal to regenerate the Y data (YD).

The PWM portion of the receiver derives its signal from the X-data input component. The line signal is applied to the D input of the 7474 to generate the XD signal. The 7474 is also clocked by the same input signal through the 74123 one-shot, A_4, on the positive edge of each output pulse of the $\overline{\text{X CLOCK}}$.

The positive-going edge of the $\overline{\text{X CLOCK}}$ signal occurs 400 to 600 ns after A_4 fires. If the line-input signal is a logic 0 (200 ns wide), a space will be clocked in at the D input of the 7474 storing the XD data. If, on the other hand, the X input is at a logic 1 (800 ns wide), a mark will be clocked through, since the X pulse will still be present on the arrival of the $\overline{\text{X CLOCK}}$ signal. The trailing edge of $\overline{\text{X CLOCK}}$ also fires A_5 and A_6, two monostable multivibrators, for 400 to 600 ns. This enables the bit clock signal, which originated at the transmitter, to be recovered also, as shown in the timing diagram (Fig. 2b).

To set up the most efficient circuit, a scope is required. Also, the X and Y data inputs should be initially tied to ground at the transmitter. The scope should then be connected to the signal line cable and R_1 adjusted for a peak amplitude of 5 v. After a logic 1 is applied to the Y input, the signal line pulses should rise to at least 10 v.

At the receiver end, the scope should be connected to TP1 and R_{1a} adjusted as seen in Fig. 2c. Next, the scope should be connected to TP2 and R_{2a} adjusted as shown. A slight shift between the X and Y data output will occur, basically because of the internal-timing method used to recover the data. The output data will otherwise be a replica of the original information transmitted. □

Engineer's notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.

Go/no-go tester checks optocoupler's transfer ratio

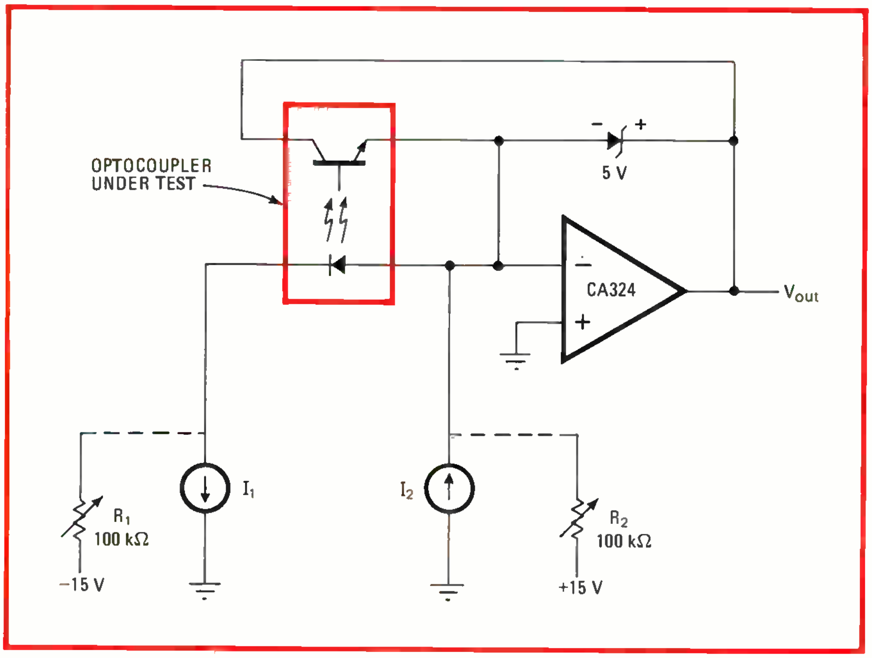
by S. Ashok
Rensselaer Polytechnic Institute, Troy, N. Y.

This extremely simple circuit performs a go/no-go test on the quality of an optocoupler. Here, an operational amplifier and a zener diode are used to determine if the most fundamental parameter of the optocoupler, its forward current-transfer ratio, α (which is the ratio of the phototransistor's output current to the photodiode input current), is greater or less than a preset value.

The operation of the circuit is based on the principle that the phototransistor tends to saturate if the current forced into its collector lead is less than αi, where i is the photodiode current, and that it tends toward avalanche breakdown if the current is higher than that amount. The forced current is (I_1-I_2), where I_1 and I_2 are current sources. The preset value of α corresponding to these currents will thus be $(I_1-I_2)/I_1$. Adequate current sources for I_1 and I_2 can be implemented by using variable resistors returned to +15- and −15-volt supplies as shown in the figure.

Typically, the phototransistor breakdown voltage is greater than 5 v, so that if the value of α is lower than the preset figure (bad optocoupler), the current into the zener-transistor combination will be greater than αi, the 5-v zener will break down, and V_{out} will then go to 5 v (logic 1). If on the other hand, α is higher than the preset value (good optocoupler), the phototransistor will saturate and there will be a logic 0 at the output.

Note that the polarity of I_2 should be reversed if optocouplers with Darlington outputs are tested, because Darlington circuits have an α that is greater than unity.



Light test. Op amp and zener diode check optocoupler quality by determining if its forward current-transfer ratio, α, is above or below preset value. If α is above value set by current sources I_1 and I_2, phototransistor saturates and $V_{out}=0$, indicating good element. Otherwise, the zener breaks down, and $V_{out}=5$, indicating bad device.

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$50,000 prize for TV engineers: apply now

A substantial but little-known prize—nearly $50,000 at present exchange rates—has been created to reward an outstanding contribution to television technology. It is the 1978 Eduard Rhein prize of DM100,000, nominations for which are now being received. Eduard Rhein, physicist, author, and publisher, founded the award in his name in the autumn of 1976 with a grant of DM2,000,000. His original goal was to encourage television research internationally, but when the executive board of his Rhein foundation found none of the work nominated in 1977 to be outstanding enough, it enlarged acceptable nominations to include **persons who have significantly improved the total TV system's performance in a major way the general viewer can appreciate.** Such a contribution may be a major improvement or development in either present or future TV systems.

Anyone interested should write either to the Eduard Rhein Foundation, Klopperstieg 3, 2000 Hamburg 67, Federal Republic of Germany, or to the U. S. member of the foundation, James Hiller of Arreton Road, Princeton, N. J. 08540.

Transformer circuit indicates presence of 60 or 400 Hz on bus

In many avionics test systems and uninterruptible power sources, high-voltage alternating current may be present at frequencies other than the usual 50 to 60 Hz of the standby mode and 400 Hz of the operational mode. To directly verify the presence of those frequencies (and no others) on a bus, David Newton of Abbot Transistor Laoratories in Los Angeles has designed a simple, reliable circuit consisting of a low-cost transformer, a resistor, and two neon bulbs. Key to its operation is **the frequency-sensitive saturation characteristic of the transformer's core.** In series with the transformer's primary winding is one bulb in parallel with the resistor. In parallel with the secondary winding is the other bulb.

The primary winding is designed to saturate the core at 60 Hz, yielding a low impedance that allows its bulb to light up. The secondary winding, meanwhile, in effect stays decoupled from the line until at 400 Hz the core operates linearly, energizing this winding and lighting up its bulb. The ratio of secondary to primary turns ensures that the primary bulb is kept well below its turn-on voltage while the resistor in parallel with it passes enough primary current to magnetize the core and power the secondary bulb. **The absence of semiconductors makes the circuit's operation in the power-line environment highly reliable.**

LEDs outlast bulbs on minicomputer consoles

The incandescent lamps in Digital Equipment Corp.'s PDP minicomputers fail often enough to create a really nagging replacement problem, says T. J. Rohrer, a senior engineer with Lockheed Electronics Co.'s Aerospace Systems division in Houston. His solution: replace them with National Semiconductor's NSL-7944 light-emitting diodes.

The NSL-7944 LED fits almost directly into the lamp assembly area on the programmer's console panel. The only modification necessary affects the lamp driver circuitry—the keep-alive resistor normally connected between each lamp's driver transistor and ground must be clipped out. Once installed, each LED runs at maximum intensity over its entire 3-to-18-v range and so far, of those retrofitted to Lockheed's PDP computers, **none has failed, though some have been in place for three years.**

Jerry Lyman

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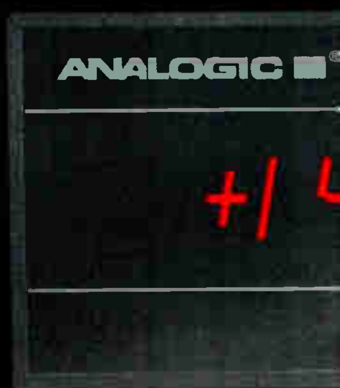

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ANALOGIC®

NCC eyes new roles for computer with emphasis on energy problem

Effects of growth form second theme at National Computer Conference

by Raymond P. Capece, *Computers Editor*

☐ Not only is it back to the land of fun, sun, and Disneyland for the National Computer Conference, but it's also Miller time again. From June 5 to 8, the computer people will again be at Anaheim Convention Center in southern California under the chairmanship of Stephen W. Miller. In 1975 the NCC was also held in Anaheim with Miller as chairman. This year, he is promising a bigger and better conference than ever.

Miller, who manages research program development at SRI International in Menlo Park, Calif., is espousing a dual theme: the role of computers and the growth of computing. The primary theme, the role of computers, focuses on the world's energy problem. "The NCC is traditionally a very big and broad show—a good conference to tackle a big issue like energy," he declares. "Besides, a national conference should address national and even international issues."

Miller feels the secondary theme of growth is important because of the problems it raises. "The computer industry is the most rapidly growing industry in the country," he says, "and such expansion breeds problems in everything from education and training to its impact on society—how computers affect our daily lives."

The primary theme is brought out in several ways. Energy issues start as the focus of the keynote addresses, which will be delivered by an impressive collection of scientists, industry leaders, and politicians. Next, a dozen or more of the technical sessions relate to the role of computers in energy either directly, as in modeling and econometric forecasting, or indirectly, as in the conservation and energy efficiency that computers contribute to manufacturing and production.

The growth leitmotiv is best evidenced by the Personal Computing Festival, an exciting addition that made its debut at last year's NCC in Dallas. The festival will complement the main conference with special sessions and exhibits in the Disneyland Hotel and Convention Center. Featured will be a microprocessor design contest offering several prizes of digital equipment and a special program that includes tutorials. And unlike last year, the festival will have no minimum age requirement—so the kids can divide their time between personal computing and looking for Mickey Mouse.

It all adds up to a meeting with more technical programs, exhibits, and, conference officials predict, greater attendance than ever before. The technical sessions will cover 26 topics. Among them are a number of trends and recent developments: new architectures that are taking advantage of advances in large-scale integrated circuits; the new hardware available; the swiftly expanding use of computer modeling; data-base management and the distributed systems with which its interest grows; and some theoretical subjects, like artificial intelligence and voice input to computers, that have migrated from the fringes into developments. Moreover, for the first time, several of the sessions will be devoted to the recent progress made in Japan, both in systems and in technology.

The record-setting number of exhibits, pegged at 1,401 booths filled by 353 organizations, is guaranteed to wear thin both patience and soles: the two main exhibit halls and the arena in the Convention Center total a quarter million square feet. The list of companies showing their wares is awesome. What's more, two firms will be appearing after a four- or five-year absence from the NCC: Digital Equipment Corp. will make the 3,000-mile trek from Maynard, Mass., with tons of equipment, including its recently announced 32-bit minicomputer and some surprises. Also rejoining the flock is NCR Corp., Dayton, Ohio, which will occupy a sizable piece of floor space. These large companies contribute to a trend for the traditional companies to show again at the NCC: two years ago, Sperry Univac division of Sperry Rand came back, and last year it was Honeywell Inc.

Hot topics at the show

More than 300 papers will be delivered at 107 sessions spread over the show's four days. But since as many as nine talks may be given concurrently, be sure to check the timetable. The preview below is broken down by to proceed any further with the energy program.

Another session devoted to energy is "Computer Modeling in Energy Technology," led by Julius Chang of Lawrence Livermore Laboratory, Livermore, Calif. This session deals with oil and how the computer can help in its conservation and recovery.

Data-base management

Interest in data-base management systems is growing for those involved in systems of all sizes, from mainframes down to microcomputers. Consequently, altogether four sessions are devoted exclusively to the subject. The first gives a synopsis of the report on data bases in a distributed environment that is being prepared by the Codasyl Systems Committee, followed by a commentary on the report.

The second session considers data-base design methodology, addressing some of the elusive problems in physical designs. The third discusses the headaches of software conversion, both for applications and for data, when new computer systems are installed. It will include a panel on the process of converting an application-oriented system to a DBMS environment.

Finally, the fourth session, "Programming Language Interfaces to DBMS," headed by Sham Navathe of New York University in New York City will take up changing DBMSs with statements embedded in high-level language programs. Navathe notes that with the proliferation of both hardware and software, "it becomes increasingly important to deal with program changes when going from one to another." Papers will delve into new areas like relational data bases and improved programming environments to support them and will also discuss a semiautomatic process to handle the effects of translating data when high-level queries are made.

Networks link the world

Four sessions come under the topic of "Data Networks," a subject with truly international appeal. The kickoff event is a panel on "International Data Networks," the chairman of which is Barry Wessler of Telenet Corp., Washington, D. C. With so many organizations in telecommunications interconnecting so many types of dissimilar equipment, there is indeed a problem,

<table>
<tr><th colspan="4">WEDNESDAY</th><th colspan="4">THURSDAY</th></tr>
<tr><th>8:15 A.M. – 9:55 A.M.</th><th>10:05 A.M. – 11:45 A.M.</th><th>2:00 P.M. – 3:40 P.M.</th><th>3:50 P.M. – 5:30 P.M.</th><th>8:15 A.M. – 9:55 A.M.</th><th>10:05 A.M. – 11:45 A.M.</th><th>2:00 P.M. – 3:40 P.M.</th><th>3:50 P.M. – 5:30 P.M.</th></tr>
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<tr><td colspan="4">DATA-BASE MANAGEMENT SYSTEMS</td><td colspan="4">SPECIAL-PURPOSE TERMINALS (VOICE INTERFACING)</td></tr>
<tr><td colspan="4">COMPUTER ARCHITECTURE</td><td colspan="3">ELECTRONIC FUNDS TRANSFER SYSTEMS</td><td>NEW APPLICATIONS</td></tr>
<tr><td colspan="4">EVOLUTION OF NEW HARDWARE TECHNOLOGY</td><td colspan="4">SOFTWARE DEVELOPMENT METHODOLOGY</td></tr>
<tr><td>PERF. MEAS. AND EVAL.</td><td colspan="3">AUTOMATIC PROGRAMMING</td><td colspan="4">ARTIFICIAL INTELLIGENCE</td></tr>
<tr><td colspan="2">OFFICE AUTOMATION</td><td colspan="5">DISTRIBUTED SYSTEMS</td><td></td></tr>
<tr><td colspan="2">LEGISLATION AND ITS IMPACT</td><td colspan="2">DATA-PROCESSING MANAGEMENT AND ADMINISTRATION</td><td colspan="3">FORMAL METHODS IN PROGRAMMING AND MICROPROGRAMMING</td><td></td></tr>
<tr><td colspan="7">COMPUTER CAREERS AND EDUCATION</td><td></td></tr>
<tr><td>SOFTWARE METHODOLOGY</td><td colspan="2"></td><td>PIONEER DAY</td><td colspan="4"></td></tr>
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and panel members from Japan, England, and Canada will dissect various of its aspects.

A second session, "Nationwide Packet-Switching Networks," compares the architectures of several types of packet-switched networks, including the Arpanet, Telenet's Public Packet Network, and IBM's System Network Architecture. The participants' goal theoretically will be to find the best architecture for serving the future data-communications needs of the public.

A third session is devoted to international computer communications regulations. Once the satellite joins the ranks of common carriers, regulations and standardization will be needed; and the difficulties that might arise are examined by the participants from their various viewpoints: that of a national satellite common carrier, a gateway state common carrier, a manufacturer of data-processing equipment, and an international service bureau company.

The fourth session is "Satellite Data Communications for the Public-Service Sector." It is the belief of session chairman John P. Witherspoon, president of the Public Service Satellite Consortium, San Diego, Calif., that in the developing market in the 1980s for satellite data communications, public-service groups will be bigger users than anyone previously thought. "With only a modest channel capacity projected for 1982—a bandwidth of about 90 megahertz—we estimate public-service revenues to exceed $100 million a year. That's a lot more than the private lines will do."

So Witherspoon assembled participants to present their views of what is needed to bring together an organization of such magnitude in such short time. Problems will be many. For one, Witherspoon says, the projections assume that present satellite communications plans will proceed without a hitch, "in particular that an appropriate network will be available and that numerous inexpensive earth stations will be located at the point of use." Another pitfall is that the National Aeronautics and Space Administration's experimental satellites ATS-6 and CTS, among others, might fail and not be replaced because of budget considerations.

Architectures old and new

Not to be missed are the discussions of computer architecture, which start off with a panel and follow up with a double session. The participants are noteworthy. Head of the panel, titled "Impact of Semiconductor Technology on Computer Architecture," is the president of Intel Corp. of Santa Clara, Calif., Gordon Moore. Represented on the panel, which will review the history of semiconductor technology in relation to computer architecture and offer some glances into the future, will be Fairchild Camera & Instrument Corp., Motorola Inc., and Texas Instruments Inc.

The two-part session—"Architecture Evolution"—boasts some of the most highly respected names in the computer business. The session has three chairmen: Samuel H. Fuller, formerly with the computer science department of Carnegie-Mellon University, Pittsburgh, and now with Digital Equipment Corp.; DEC's C. Gordon Bell; and Daniel E. Siewiorek of Carnegie-Mellon. It is based on the January 1978 special issue of the journal Communications of the ACM [Association for Computing Machinery], which was devoted to computer architecture, and the papers to be delivered in the session were originally published in that issue.

The session relates the histories of machines that have earned respect for their architectures. Each of the machines has contributed to the progress of computer architecture. The early machines out of Manchester University in England, like the Mark I and the Atlas, pioneered such concepts as paging and virtual memory; while the state-of-the-art MU-5, also from Manchester University, applies concepts of array processing and content-addressable memories to real life in a smart random-access memory that is capable of processing the elements it stores. Sperry Univac's 1100 series is perhaps the best study of a long-term, continuous architectural evolution, and Digital Equipment Corp.'s DECsystem 10 family has earned the major minicomputer maker respect in the mainframe business with a machine that originally aimed at artificial intelligence and academic timesharing. The IBM System 370, the world's most successful computer family, lived through the radical increase in memory size and the advent of timesharing (the speakers will discuss fully the machine's strong and weak areas). Finally, Cray Research Inc.'s CRAY-1 supercomputer is a marvel from the standpoints of both vector processing power and product development.

A look back at languages

"Programming and Operating Systems" reflects on the current state of applications and operating-system software. Sessions cover data protection in operating systems, which is a growing concern in data-processing centers, and the status of Cobol. Another is devoted to data encryption, which, though struggling through legislation, will surely be central to data communications and electronic funds transfer in the 1980s.

"A History of Programming Languages" will be led by Jean E. Sammet of IBM Corp. Apropros of programming, it is advisable to attend the Sigplan Conference on "The History of Programming Languages," which is being held June 3–5, just before the NCC, also at the Anaheim Convention Center. Sammet says that her NCC session is intended to provide some valuable insights into the early history of computer-programming languages, regardless of whether or not the persons attending it also attended the earlier conference.

Sammet is programming language technology man-computers. Remote data processing is also discussed, and a special application, a control system for Japan's Shinkansen high-speed railway, is detailed.

New hardware on the scene

While everyone appreciates the growing problem of software development for tomorrow's computers, it is much easier to get excited about the new hardware. That is why a big turnout is expected for the four sessions making up "Evolution of New Hardware Technology." Kicking off consideration of the topic is a session called "VLSI: The New Semiconductor Revolution," which is led by Federico Faggin, president of Zilog Inc., Cupertino, Calif.

Faggin promises to give attendees a knowledgeable look into upcoming developments. He himself believes that the industry is entering a transition period between LSI chips of 1,000 or more gates and VLSI chips with 10,000 to 20,000 gates. "The generation after the Z8000 [Zilog's upcoming 16-bit single-chip microcomputer] and Intel's 8086 will be in VLSI territory," he declares.

Faggin foresees by 1985 a single-chip microcomputer containing 32,768 by 16 bits of random-access memory, 8,192 by 16 bits of erasable programmable read-only memory, and 18,000 gates to perform the logic functions—all on a chip that measures 400 mils on a side. But with a device so powerful costing, as he expects, the same as present chips—less than $10 in quantity—the technology will be "outstripping our ability to use it," he says. A microcomputer superchip may sound fine, but Faggin wonders whether the market is big enough for it, alluding to the fact that worldwide minicomputer sales probably total less than 100,000 units so far. "We can make that many in a month," he says. "Then what?" Both Faggin and Intel's Ron Whittier will try to provide some answers to these questions in this session.

"What's Ahead in Computer Memory and Storage Technology" will cover RAMs, charge-coupled devices, and bubbles and other magnetic technologies. Keeping up with each technology becomes more difficult as progress is made, and in this session, chairman Lewis M. Terman of IBM's Thomas J. Watson Research Center in Yorktown Heights, N. Y., hopes to sort out some of the more recent changes.

"The Future of Peripheral Devices" is session three on new hardware technology. Chairman Gil Gates from Control Data Corp., Minneapolis, will focus on two major peripherals, printers and disks. Discussing the former will be Donald S. Swatik from CDC's Computer Peripherals Inc. subsidiary in Rochester, Mich. CPI is working in all areas of impact and nonimpact printing and will perhaps reveal some of its recent developments in the areas of ink-jet and electrophotographic printing.

The future of disks is presented by another CDC subsidiary, Magnetic Peripherals Inc. in Bloomington, Minn. David L. Conway and Thomas L. Muran will discuss the ever increasing growth of mass storage and the coincidental evolution of disk technology.

Finally, in the panel "Opportunity for New-Technology Companies" the chairman Vir A. Dhaka of Xerox Corp. in El Segundo, Calif., has brought together four representatives of firms that have successfully brought new technologies to the marketplace. Dhaka contends that technological innovations create unique opportunities for developing new markets and that the entrepreneurial force has in fact become the incentive for developing new technologies.

Computers that listen

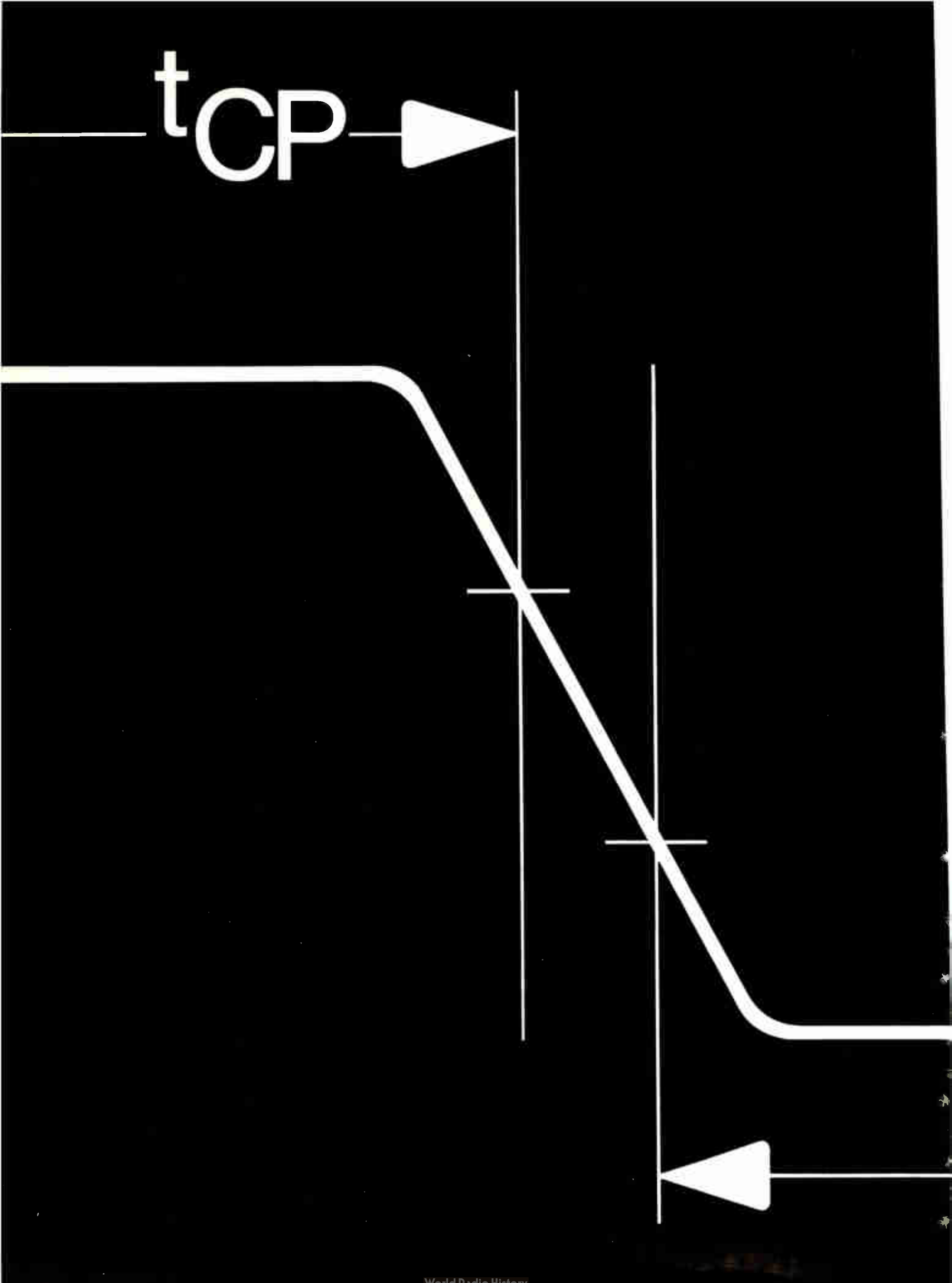
A double session entitled "Voice Interface to Computer Systems," should be well attended. The session, half of what the NCC is devoting to special-purpose terminals, will bring together leading experts in the field, including some from the military, which has probably done more research and development than all those in industry combined. In the second part of the session, speakers from both the technology and application areas—including representatives from IBM; Threshold Technology Inc., Delran, N. J.; Carnegie-Mellon University; the Speech Research Communication Laboratory; the U. S. Naval Air Development Center; and TI—will be open for questions.

Artificial intelligence

Probing the further reaches of man's understanding is "Artificial Intelligence as a Scientific Field." The first of three sessions considering this topic offers two papers from the academic world. One chronicles the activities of Stanford University's heuristic programs; the other, which was the 1977 MIT Computers and Thought lecture by Doug Lenat of Carnegie-Mellon, describes a system for discovering new mathematical concepts.

The second session, called "Question the Experts," is devoted entirely to audience inquiries. The panel will include such notables as Saul Amarel from Rutgers University, New Brunswick, N. J.; Ed Feigenbaum, Stanford University, Palo Alto, Calif.; and Raj Reddy and Doug Lenat from Carnegie-Mellon.

Finally, the double session "Artificial Intelligence in Science and Medicine" brings together 10 researchers from several disciplines. The first half of the session is devoted to artificial intelligence in medicine and covers diagnostic problem solving, treatment planning, and consultation systems. The second half concentrates on problems of artificial-intelligence systems designed to support scientific inquiry. One paper discusses design of experiments, a second takes up theory formation, and a third examines a mineral-exploration task. □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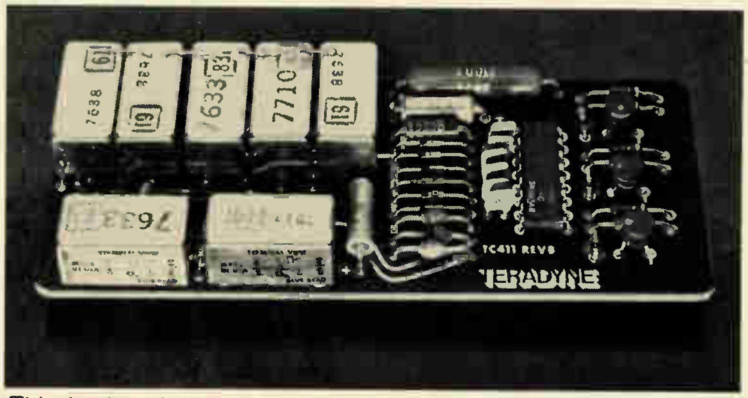

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Our new μA7307 is, modesty aside, simply the best low-cost amp for battery operation available today. Particularly at low voltage.

It's constructed on a single silicon chip using Fairchild's patented Planar process. And to save space, it's packaged in a plastic 8-pin mini-DIP with copper frame.

Power supply voltages range from 3.5 to 12 V. Power output from 0.22 to 1.6 W. Speaker impedance is 4 Ω. And minimum working voltage is 3 V.

The low-down on high.

Our new μA783 is a high voltage monolithic integrated circuit in a 12-pin power package.

It's designed for use as an audio frequency Class B power amplifier and for 8 and 16 Ω applications.

With 24 V of power supply voltage, you get 9 W of power output using an 8 Ω speaker.

The μA783 also has a wide supply voltage range from 4-30 V.

Applications are primarily line operated TV and audio.

A powerful performer.

Our new TDA2002/2002A's are 10 W audio power amps in 5-pin TO-220 power type packages.

The specs are powerful, too: Power supply voltage 16 V. Power output 10 W. Speaker impedance 2 Ω.

Features include thermal shutdown, overvoltage protection (on the TDA2002 only) and short-circuit protection.

TDA2002/2002A's are perfect for auto and mobile radios and CB's.

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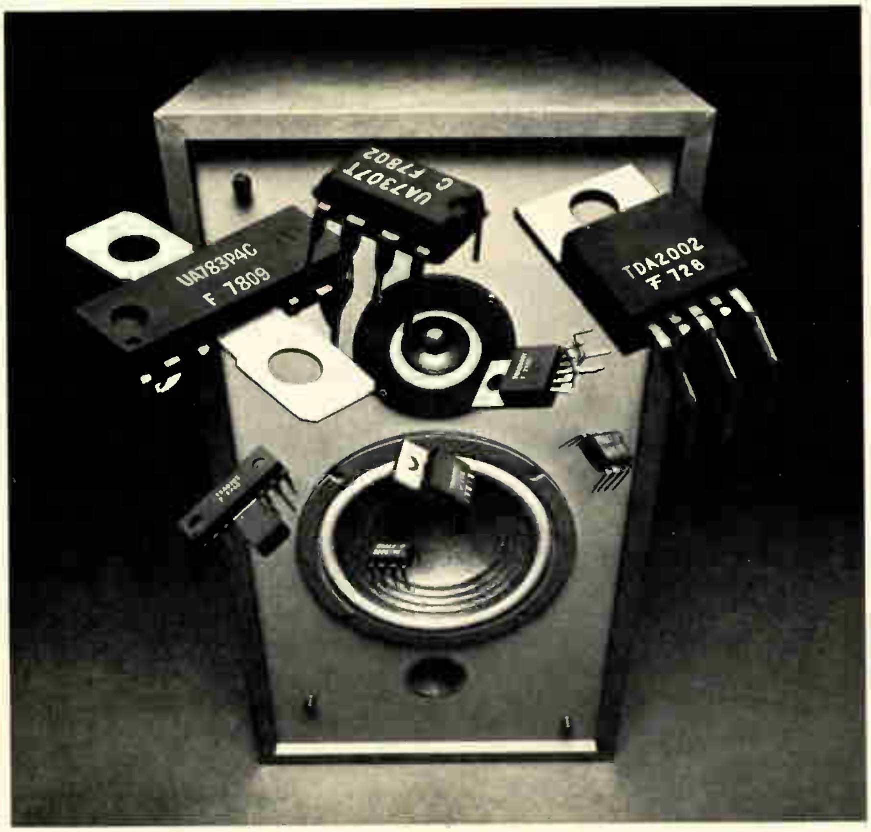

AUDIO POWER AMPLIFIERS			
Device	Power Supply Voltage Speaker Impedance Power Output	Package	Features/Mkt. Area
TDA2002 TDA2002A	16 V, 2 Ω, 10 W 14.4 V, 2 Ω, 8 W 14.4 V, 4 Ω, 5 W	5-pin TO-220 type Power package	2-4 Ω loads Thermal shutdown Overvoltage protection Short-circuit protection Auto radio, CB, Mobile Radio
μA783P3 μA783P4	24 V, 8 Ω, 9 W	12-pin Batwing	Thermal shutdown Operation 4-30 V Line operated TV & Audio
TBA810DS TBA810DAS	14.4 V, 4 Ω, 6 W	12-pin Batwing	Thermal shutdown Overvoltage protection Auto radio, CB, Mobile Radio
TBA810S TBA810AS	14.4 V, 4 Ω, 6 W	12-pin Batwing	Thermal shutdown General purpose audio
μA706BPC	14 V, 4 Ω, 5.5 W	14-pin dual in-line power pkg. w/bracket	Not recommended for new designs
TBA800 TBA800A	24 V, 16 Ω, 5 W	12-pin Batwing	Suitable for 24 V supply operation, e.g., TV and line operated radio
TBA641B11	14 V, 4 Ω, 4.5 W	14-pin quad in-line power pkg. w/bracket	Not recommended for new designs
μA706APC	9 V, 4 Ω, 2.2 W	14-pin dual in-line power package	Not recommended for new designs
TBA641A12	9 V, 4 Ω, 2.2 W	14-pin dual in-line power package	Not recommended for new designs
TBA820 TBA820L	12 V, 8 Ω, 2 W 9 V, 8 Ω, 1.2 W 6 V, 4 Ω, 0.75 W 3.5 V, 4 Ω, 0.22 W	14-pin DIP	Low power supply operation Suitable for battery operation
μA7307TC	9 V, 4 Ω, 1.6 W 9 V, 8 Ω, 1.2 W 6 V, 4 Ω, 0.75 W 3.5 V, 4 Ω, 0.22 W	8-pin mini-DIP	Low cost low voltage-battery operation

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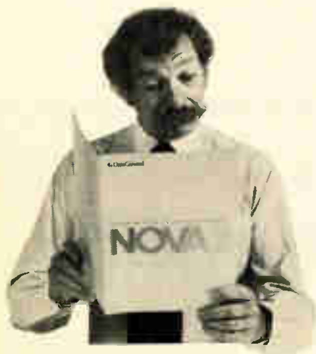

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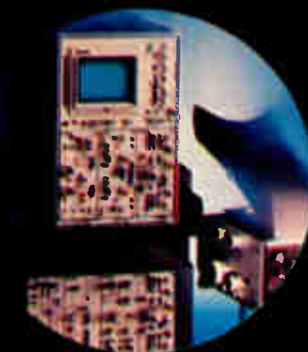
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C-size plotter is fast and smart, thanks to dual microprocessor

By combining a dual-microprocessor design with a dual-motor X-axis drive system, Tektronix Inc. comes up with a flatbed plotter that is fast, simple to operate, and easy to interface. The new 4663 will appear first at the 1978 National Computer Conference in Anaheim, Calif.

"We noticed a lack of plotters for C-size media," Byron E. Fisher, product marketing manager for the Information Display group says. "A plotter for that size [17 by 22 in. or 420 by 594 mm] that uses the latest technology to make it smart and versatile appeared to be a good choice for a new product," he adds. Fisher explains that, for an initial purchase, many companies have elected to buy a larger E-size plotter to accommodate larger drawings, "but 60% to 80% of the time they're using it for smaller plots."

To enhance the plotter's appeal, Tektronix designed a special X-axis drive system to outspeed similar plotters: with a maximum pen speed of 16.5 inches/second, the 4663 moves faster than the ink can flow out of some pens, according to Fisher. Fast vector drawing is aided by the system's programmable acceleration/deceleration rate of up to three times that of gravity at nearly 100 feet/second/second.

"The key in getting the speed up is minimizing reactive elements in the system," says Gunther Wimmer, hardware project engineer. Wimmer says that the dual-motor system cuts drive cable lengths in half, thus halving reactance as well. The motors are phase-locked electrically each time the system is powered up. "We've also minimized the system mass with lightweight parts, such as a magnesium Y-axis arm," the Tektronix project engineer explains.

The two microprocessors work in Mutt-and-Jeff fashion: all communications, interfacing, and local commands are implemented with a Motorola 6800 chip, while a Signetics 8X300 bipolar processor does the number crunching—vector generation and other high-speed housekeeping—and communicates with the 6800 through direct-memory-access channels. This parallel processing further enhances the throughput of the 4663. Moreover, the distributed internal processing can accept simple external commands with an expandable buffer memory (up to 6.5 kilobytes), thus alleviating any possible drag on a host computer.

Communicating baud rate, interface type, pen speed and pressure, and other operating parameters may be selected one at a time by the operator using a simple parameter-entry device. What's more, three complete parametric configurations can be stored in a battery-backed memory, and an operator can select any one of the three with a single keystroke. The parameter data stored in random-access memories lasts for up to 90 days with the power off, Fisher says.

Special firmware options include keyboard entry of vector instructions for graphic figures, circular arc generation, and down-loadable character sets. Optional interfaces are half- and full-duplex RS-232-C, GPIB (IEEE-488), 20- or 60-mA current loop, teletypewriter, and Tektronix-type 4081.

Fisher expects the market for the 4663 to be printed-circuit-board manufacturers as well as civil engineering and drafting firms, and he believes the plotter, at approximately $9,000, is the cost-performance design they will be after.

Deliveries of the 4663 are scheduled for late September or early October, according to the company.

Tektronix Inc., P. O. Box 500, Beaverton, Ore. 97077. Phone Byron Fisher at (503) 644-0161 [372]

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Documation fills out printer line

Part of the engineering philosophy at Documation Inc. is to introduce the more difficult-to-design, high-performance entries in a product line first, and then to add the more economical units later [*Electronics*, Jan 5, p. 14]. In line with that approach, the Melbourne, Fla., manufacturer of computer peripheral equipment is now introducing the slower, cheaper models in its latest family of impact line printers. A total of six printers will be unveiled at the National Computer Conference—three that run at 1,000 lines per minute and three with a speed of 1,200 lines/min.

The three models of both the DOC 1000 and DOC 1200 will consist of units compatible with the IBM 3211, units compatible with the IBM 1403, and versions for original-equipment manufacturers. All six employ 48-character print bands that can be replaced in less than two minutes, according to Joseph Cattorini, vice president for engineering.

In addition, both have some of the features of the recently introduced Impact 3000 [*Electronics*, Feb. 2, p. 34]. Cattorini says those features include the same paper-moving tractors and hammer, which are very similar, though not identical. The print bands offer most of the same character sets available with the higher-speed units, including ASCII, optical-character-recognition, text, and script bands.

Besides the Impact 3000, other models in the Documation Impact printer line operate at 1,500, 1,800, and 2,250 lines/min. Cattorini points out that the 1000 and 1200 will be especially important for the OEM market. "Before, if a customer bought his high-speed printers from us, he had to go to someone else for the lower-speed models." He expects the new printers to compete favorably with the IBM 3203, which he says is being used in many of that company's newer systems.

Two Intel 8080 microprocessors control channel communications, housekeeping, and all printer functions, such as paper stacking and feeding and hammer firing and servo controls, in the DOC 1000 and 2000. Both printers have a 50-inch-per-second slew rate and vertical spacings of 6 or 8 lines/inch. Both can handle up to six-part forms in lengths varying from 3 to 24 in. and widths from 4 to 18¾ in. Cattorini says that the slew rate, while slower than that of the Impact 3000, still offers efficient enough throughput for forms printing, even when there are only a few lines per page.

Prices, beginning June 1, are $42,500 for the DOC 1000, and $47,500 for the DOC 1200; prices for OEM models are available from the factory.

Documation Inc., P. O. Box 1240, Melbourne, Fla. 32901. Phone (305) 724-1111 [371]

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Floppies store twice as much

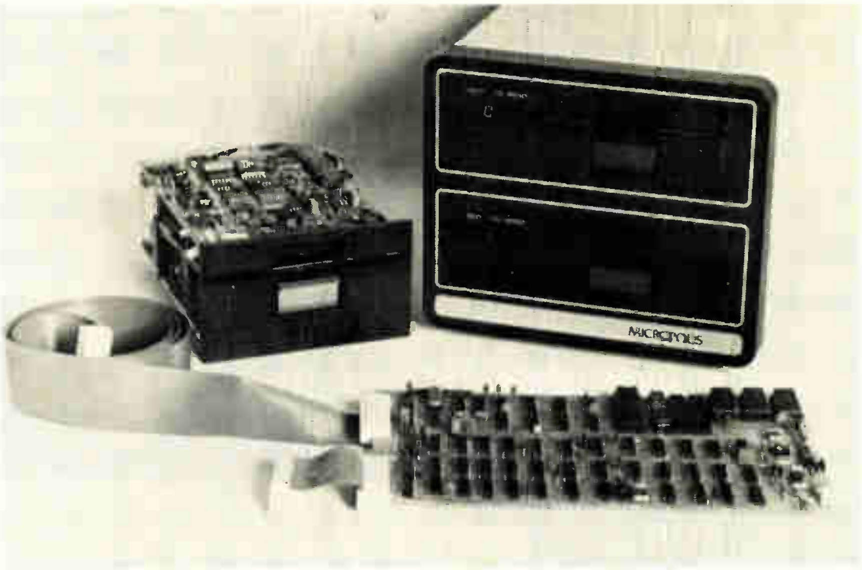
For the fourth time in two years, Micropolis Corp. has extended the capacity of its 5¼-inch floppy disk subsystems, adding double-sided models with formatted file storage of nearly 2 million bytes. Part of the firm's megaFloppy series, to be introduced at the National Computer Conference, they also feature an intelligent controller for interconnecton of four subsystems to a common interface. Total on-line storage capacity is more than 15 megabytes.

Double-sided versions of Micropolis' product line will be implemented initially on two existing models, the company says—the 1015 and the 1055. For large-volume original-equipment manufacturers, the 1015 is an unpackaged drive for integrating floppy-disk storage into system enclosures. Previously sold in single-sided, one-drive versions with 35 or 77 tracks per surface, it is expanded into four products with double-sided options. A range of storage capacity from 143,000 to 630,000 bytes per drive is available. With optional intelligent controller and group code recording method, file space may be expanded to 946,000 bytes.

For lower-volume OEMs who want a packaged subsystem, the model 1055 came out in March as a single-sided, dual drive. It now can have a doubled capacity, useful to systems integrators who buy all hardware and add value through software development and services. For a double-sided version, the 1055 has a maximum capacity of nearly 1.9 million bytes of file space for 77 tracks, each with four soft-sectored formats. Even greater capacity may be added through a module that has two read/write heads and two drives that share a common controller. Subsystem capacity of the module is nearly 3.5 million bytes, according to Micropolis. Further, up to four 1055s with add-ons can be daisy-chained to a common host for 15-megabyte storage.

"The differences between the 1015 and 1055 reflect the two-tier nature of our OEM marketplace," says Robert Chisum, Micropolis marketing manager. The single-drive 1015 is an unbundled subsystem that permits the high-volume buyer to buy drives, controllers, and selectable features in high volumes as if they were components.

"For the lower-volume system integrator, the 1055 series packages the hardware, allowing the customer to focus total attention on software for specific applications," he continues. "With its substantial upward growth capacity, the 1055 can handle virtually any application now



being programmed for the larger, more expensive 8-inch floppies."

The 35-track configuration single-drive, double-sided 1015 mod III, with 287 kilobytes of formatted capacity, is priced at $330 in 500 quantities. A quad-density version, with 77 tracks per surface, a density of 100 tracks per inch, and up to 946 kilobytes formatted capacity, the 1015 mod IV is $396. As an option on the quad-density model the Micropolis intelligent controller is $369 in 500 quantities.

The dual-drive, double-sided model 1055 mod IV is priced at $1,795 in 50 quantities. It includes controller, power supply, bidirectional interface, enclosure and nearly 2 megabytes of on-line capacity.

Micropolis Corp., 7959 Deering Ave., Canoga Park, Calif. 91304 [377]

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Low-cost band printer does 600 lines

The people at Dataproducts Corp. have been busy in the year since the last NCC. They have taken the B-300 band printer, introduced at that show, doubled its speed to 600 lines a minute, and will introduce the newly christened B-600 at Anaheim. Building on the 300's technological foundation, Dataproduct's designers used the same patented Mark V hammer technology, swapping the 66-double-column hammer set for a 132-single-column set to double the 600's throughput.

The B-600 is intended to fit into small- to medium-size business systems and batch terminals, according to Robert J. Pieper, vice president of marketing at the Woodland Hills, Calif., firm. It will compete in the same market as Control Data Corp.'s model 9386, Dataprinter's model 3600, Data 100's model 5560, Centronics' model 6600, and similar equipment.

The heart of the B-600's design is the Mark V hammer technology. By using rare-earth metals for the magnetics of the voice-coil–actuated hammers and cutting the hammers' mass, the designers are able to drive its circuitry directly from low-power integrated circuits.

Based on standard 2901 bit-slice microprocessor architecture, the B-600's electronics not only control the communications interface and decoding, but provide a set of valuable operator diagnostics. If the system should fail, the internal diagnostics indicates which mode the printer was last in, and by way of a two-digit numerical display, what the problem is "right down to the 5-volt supply," boasts James R. Christie, the firm's product manager

for medium-speed products.

The operator, simply by comparing the displayed two-digit number to a list of problems in an operator's manual, can tell immediately if the difficulty can be corrected by the operator—such as "needs paper"—or if it requires the attention of a field technician. The field technician, informed in advance of the two-digit code, need carry only the tools and parts required to correct the problem.

The steel-band font carrier is the same as that of the B-300. It is flexible yet durable and easily changed by the operator—no tedious alignment procedures are necessary. Another convenient feature is the B-600's self-test, which runs the printer independently of the system, so that the operator can see immediately if the malfunction is in the printer or the system.

Deliveries of the B-600 are scheduled for early 1979. The price will be $6,500 singly down to $4,700 in 100-piece quantity. Options for the B-600 include either direct-access or tape-controlled 12-channel vertical format units, a forms-length select switch, parity check, an elapsed-time meter, automatic line feed, long-line drivers, and receivers and ground isolation.

Dataproducts Corp., 6219 De Soto Ave., Woodland Hills, Calif. 91365. [374]

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Arrivals crowd Zilog MCZ-1 clan

To reinforce the point that Zilog Corp. makes more than just Z80 microprocessors, the Cupertino, Calif., subsidiary of Exxon Corp. will take the wraps off three new members of its modular MCZ-1 microcomputer family at the NCC. Expanding the current four-member family will be two at the low end and a new high-end system.

"Like the other family members [MCZ-1/20, 25, 30, and 60], the new MCZ-1/05, 10, and 90 are based on the Z80, and the whole family will now operate at 4-megahertz clock rates," says David West,

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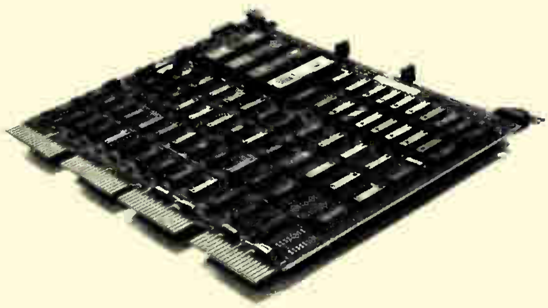

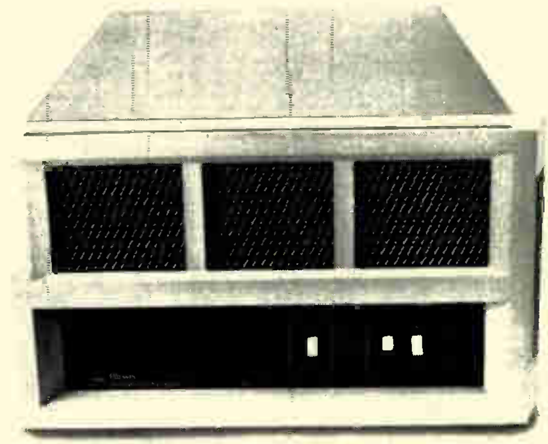

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Circle 177 on reader service card

manager of systems product marketing. The former maximum clock rate of 2.5 MHz has been increased by a combination of faster central processors and peripherals, according to West.

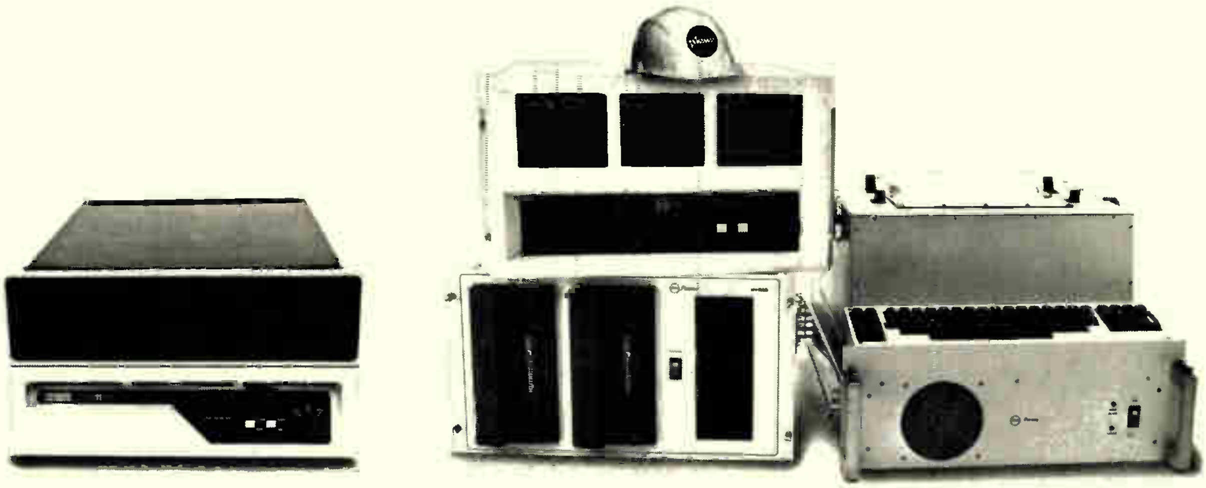
The low-end MCZ-1/05 and 10 are housed in a four-slot, modularly expandable card cage and have 32 kilobytes of random-access memory, 3 kilobytes of read-only memory, and 600-kilobytes of dual floppy-disk storage. The lowest-cost member, MCZ-1/05, is designed to communicate with a system console via its RS-232 or teletypewriter serial interface. Its main memory can be expanded to 64 kilobytes, and the user can choose from a selection of options for parallel and serial input/output plus a printer interface.

One step up from the 1/05, the 1/10 has an integral parallel keyboard and video drive interface for its 90-key ASCII II keyboard and 12-inch CRT monitor. Like the 1/05, it has undedicated RS-232 or teletypewriter interface provisions.

Both low-end systems are supported by Zilog's general-purpose RIO operating system, which has relocatable software modules and efficient I/O management, according to West. What's more, RIO can support a Cobol (ANSI 74) compiler, a Fortran IV compiler, a Basic interpreter, or a PL/Z interpreter and compiler, offering a host of high-level language programming choices. The 1/10's main memory can be expanded to 64 kilobytes and both low-end systems have room for an extra kilobyte of ROM.

At the high end, the 1/90 (see photo) offers the OEM a combination

We're getting tough with DEC®



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of a programmable intelligent terminal and general-purpose microcomputer system, West says. The list of features includes an integral 9-in. CRT display and a 12-megabyte moving-head disk drive. Main memory is expandable to 64 kilobytes, video memory to 52 kilobytes.

This high-end machine uses three Z80s. One microprocessor serves as the video processor, giving the unit intelligent terminal qualities and making it fully programmable by programs downloaded from the main processor. The second Z80, coupled with 16-K high-speed static RAM and the Z80 direct-memory-access board forms a powerful moving-head disk-drive controller. The last CPU is the basis for the general-purpose microcomputer board that is common to all family members.

The MCZ-1/90, like the others, is supported by RIO for a selection of high-level-language program capability and has optional serial, parallel, and printer interfaces plus the necessary software to implement them. Prices for the new family members are: MCZ-1/05, $4,750; MCZ-1/10, $5,750; and MCZ-1/90, $16,800. Delivery is in 30 days.

Zilog Corp., 10460 Bubb Road, Cupertino, Calif. 95014. Phone (408) 446-4666 [373]

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Four heads beat two in disk drive

Take a four-headed flexible-disk drive that stores up to 3.2 megabytes of data in the space required by a standard size of floppy drive, and you have the basis for a lower-cost independent data-management system, says its developer, PerSci Inc. of Los Angeles. The model 299 diskette drive interfaces to 8080, 6800, and Z80 type microprocessors, as well as minicomputers.

Model 299 is a dual-headed dual drive that reads and writes both sides of two 8-inch diskettes. Data may be encoded in either single or double density in IBM-compatible soft-sectored formats or in expanded hard- and soft-sectored formats on IBM's Diskette I, II, IID, or equiva-

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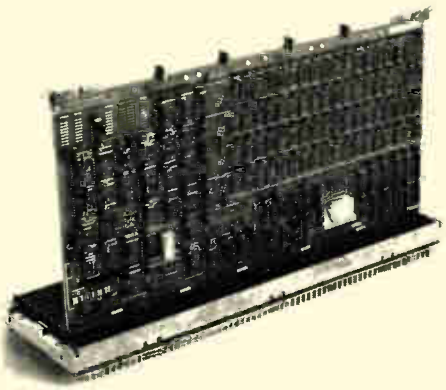

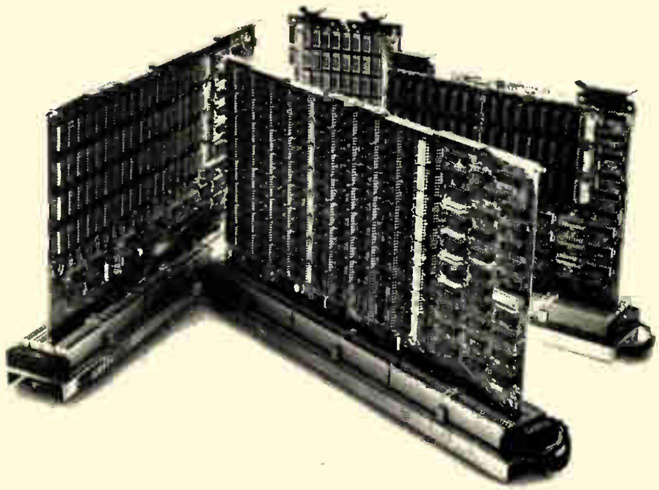

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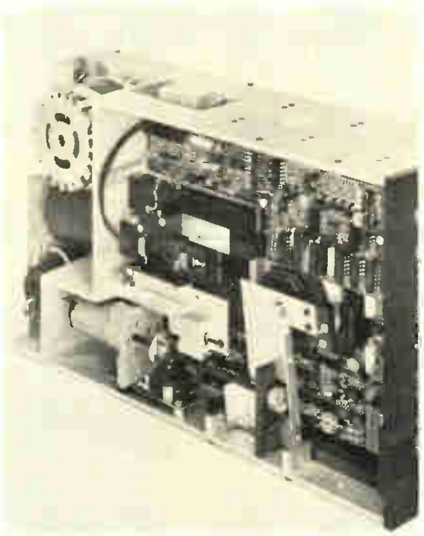

lent media. The drive will store up to 1 megabyte of data in IBM format, 1.6 megabytes of unformatted single-density data, and up to 3.2 megabytes in unformatted double-density form.

Operational tolerances required for dual-head data handling and storing double-density data are supplied by PerSci's voice-coil positioning system, a miniaturization of the positioner used for large disks, the company says. It gives the new drives an average seek time of 33 microseconds, which includes zero settle time and is claimed to be five to seven times faster than stepper-motor–positioned drives. A full-stroke 76-track seek, for instance, is performed in 100 μs. Speed and capacity are maintained with industry standard data reliability of 1 in 10^9 soft errors and 1 in 10^{12} hard errors.

For convenience in media handling, the 299 has electric autoload and can be unloaded by remote, host-software control. An optical-write protect feature secures the file.

The four-headed drive is 4.38 in. wide by 8.72 in. high by 15.4 in. deep so that two drives can be mounted horizontally or four vertically in a 19-in. rack. Price is $1,595 in single units, with large volume discounts available. Delivery starts in June.

PerSci Inc., 12210 Nebraska Ave., Los Angeles, Calif. 90025. Phone (213) 820-3764 [378]

PLUS EVERYTHING THEY WANT IT IN.

The new RL01 5Mb disk.

Introducing a top-load, rack mountable, low priced 5.2Mb disk with state-of-the-art performance and solid OEM reliability.

The RL01 features 512Kb per second transfer rate.

Plus an incredibly simple design. There's no back plane. And just 5 electronic modules. So it's super reliable and easy to spare.

The RL01 is simple to service, too. All maintenance is done from the top of the unit. The heads can be changed in minutes, not hours. There's even a universal power supply with a frequency range of 47.5-63 Hz that can be quickly (but not accidentally) switched between 100-127V and 200-254V. And it can be replaced with just four screws without disturbing heads or logic.

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The new RL01 disk and new PDP-11/RL01 packaged systems.

They're the systems you've always wanted.

Which is just what you'd expect from the OEM Group at Digital.

Call or write: Digital Equipment Corporation, PK3/M-86, Maynard, MA 01754. (617) 493-4237. In Europe: 12 av. des Morgines, 1213 Petit-Lancy/Geneva. Tel. 93 33 11. In Canada: Digital Equipment of Canada, Ltd.

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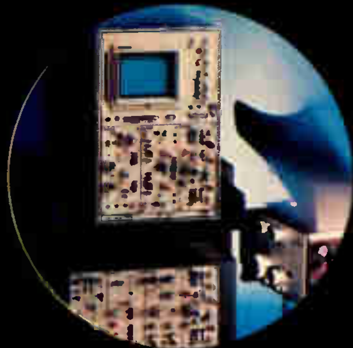

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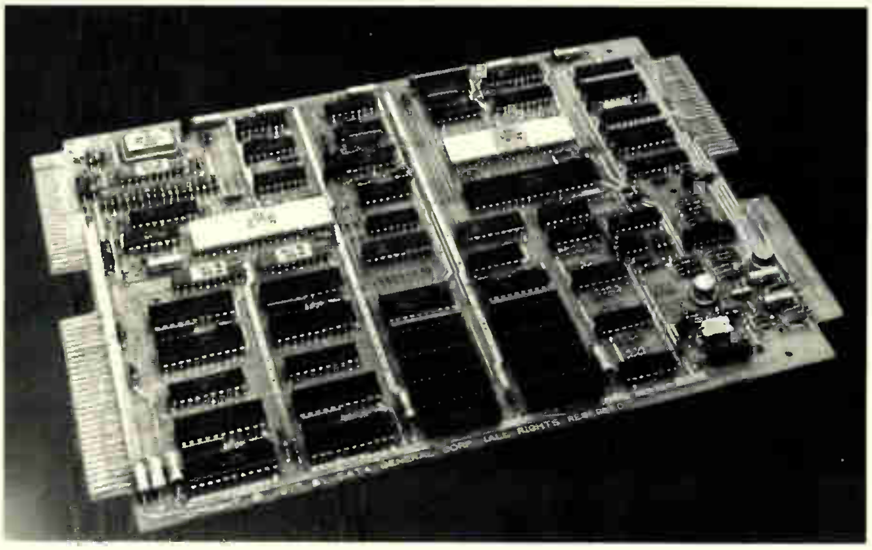
See Products newsletter, p. 241

Action in one-board computers

Data General's latest is a full 16-bit machine built around the MN601 chip; it includes 2 kilobytes of RAM and sockets for 4 kilobytes of ROM

by Lawrence Curran, Boston bureau manager



The single-board-computer business is heating up again with the introduction of a microNOVA computer system on one board by Data General Corp., Westboro, Mass. [*Electronics*, May 11, p. 33]. The 16-bit MBC/1 is one of the few such fully 16-bit machines to have reached the market, the first having been the TM990/100M from Texas Instruments Inc.

The MBC/1 is a full system in that it incorporates on one board what has required four or five circuit boards from most other microcomputer manufacturers, says Edward Zander, Data General's marketing manager for microproducts. It is built around the company's MN601 microNOVA microprocessor chip [*Electronics*, March 4, 1976, p. 133], which features 16-bit hardware multiply and divide capability, a real-time clock, direct-memory-access capability, hardware stack and frame pointers, and a 16-level priority-interrupt structure.

Besides those inherent features of the microprocessor, the MBC/1 also includes on the single 7.5-by-9.5-inch board 2,048 bytes of static random-access memory, sockets for 4,096 bytes of programmable read-only memory, an asynchronous communications interface, and a 32-line digital input/output port. A small operating system called MBC/M, available with the computer, allows users to develop software on larger Data General minicomputers—up to and including the largest in the Eclipse line. "That's a big plus for the user compared with most other single-board computers," says Edward Belove, manager of microprocessor development.

He points out that with most 8-bit microcomputers, software development is done on a simulator that communicates with the larger computer. "Here we can run on native hardware," Belove notes, by means of an emulator for program development under all Data General operating systems and a monitor for program execution on the MBC/1.

The price for a single MBC/1 is $725, but Zander says that will drop to $500 in quantities of 50, and below that in 100s. Zander foresees the system being used "by people who are just learning that they can computerize an instrument, such as a blood-gas analyzer, or in factory data automation. But we want more and more to reach people with packaging constraints and cost problems. This is a class of users that complements our existing microNOVA business." He expects the MBC/1 also to be used in communications systems where there is a need to put intelligence into remote terminals at the data source.

The 32-line digital I/O interface provides 16 input lines, an external interrupt line, 16 output lines, a data strobe, and a system reset line. The asynchronous interface offers full-duplex communication with an asynchronous terminal or modem at speeds from 110 to 9,600 bauds.

The memory and I/O buses are expandable to drive peripherals as far as 100 feet away, and the MBC/1 is compatible with the company's full line of microNOVA interfaces and peripherals. It is also compatible with the NOVA 3 minicomputer line, providing a variety of growth options. Delivery time is 90 days, and the MBC/1 will also be available from distributors Schweber Electronics Inc. and the Wyle Distribution Group.

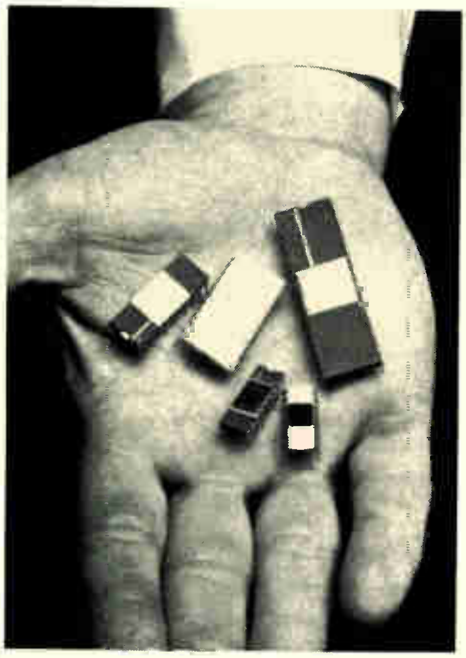
Data General Corp., Route 9, Westboro, Mass. 01581. Phone Dick Pleau at (617) 366-8911 [338]

ough the µP maze.

Everywhere you turn your µP choice has impact: system costs, parts count, power supplies, programming even future developments. The wrong choice could be expensive. That's why you should consider the RCA 1800 — it's CMOS and it has COSMAC architecture and it's a package put together to minimize your total system cost. Here's why.

CMOS means lower power requirements.

The RCA 1800 uses typically one fiftieth the power and that may mean you can reduce supply size. And CMOS also means better noise immunity and greater tolerance to supply voltage variations.



Built in I/O capability keeps parts count down.

The CPU has interrupt, DMA, flags in and bit control out, all of which means you need less I/O. And you get greater flexibility and power because of the wide range of low-cost I/O devices, including the unique 2-mode UART and programmable I/O.

COSMAC architecture gives you more efficient instructions.

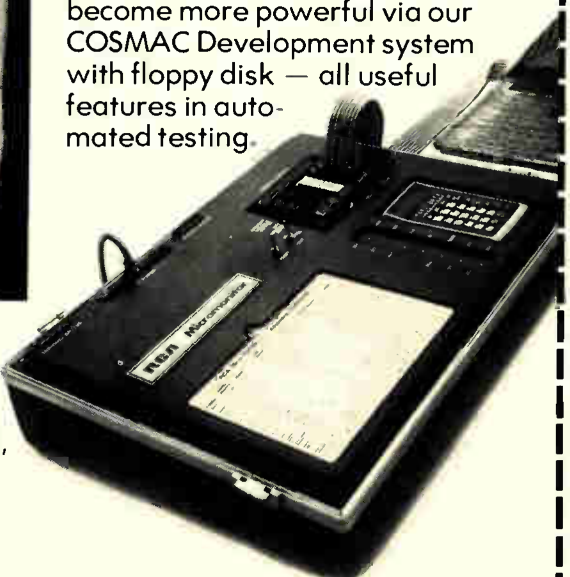
Since the CPU accepts compact 1-byte instructions, you need less memory. Registers store data with 1-byte access. And they act as pointers, so individual instructions don't need addresses.

Easily expandable memory.

Build up to 64K without adding any address management parts. RCA offers the ROMs you'll need and CMOS RAMs.

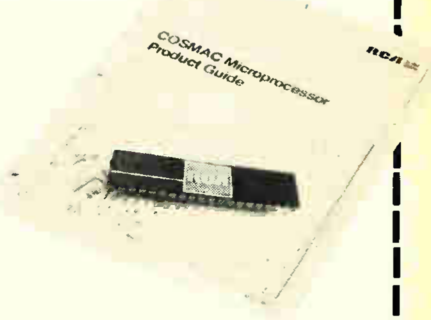
The new COSMAC Micromonitor reduces debugging time.

Our new COSMAC Micromonitor CDP 18S030 is the most complete portable µP system diagnostic tool available. The best tool, in fact, to perform breadboard debugging and factory checkouts and field tests without additional diagnostic equipment. The only one that can take instructions electronically, supply hardcopy or CRT display through your terminal and become more powerful via our COSMAC Development system with floppy disk — all useful features in automated testing.



And all the support you could ask for.

RCA provides everything you need in hardware and software from the basic Microtutor learning tool to a complete COSMAC Development System with floppy disk.
To get you through the µP maze, fill in the coupon and we'll send the RCA COSMAC Microprocessor Product Guide.



Name: ______________________

Company: ______________________

Address: ______________________

____

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2085 Quickborn b. Hamburg
Germany tel.: 04106/2001
Munchen tel.: 089/52 79/28
Stuttgart tel.: 0711/7363 57-59

RCA Ltd., Solid State-Europe
Sunbury-on-Thames
Middlesex TW17 7HW
England tel.: 093 27 85511

In France, Italy, Spain, and Sweden, call:
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RCA S.A., Madrid 250 6955
RCA Int'l Ltd., Solna 08 83 42 25

HP 1000 computers are refurbished

Improvements include faster processors, a graphics package, faster main memories, and a new operating system

by Raymond P. Capece, Computers Editor

In the face of competition that's as strong as ever in low-end minicomputers, Hewlett-Packard Co. has just revamped its HP 1000 computer line with a speedier processor, a new operating system, special scientific instructions, a hotter floating-point processor, a graphics package, and faster main memories.

The new F-series processor goes the previous E-series one better with floating-point hardware, which is exploited in special scientific instructions that execute transcendental functions quickly. Calculating the sine of a number, for example, takes only 47.6 μs using the special instructions, as compared with 300 to 500 μs for a software routine.

"Basically, we're using more microcode to get the speed up," says Bob Puette, marketing manager in HP's Data Systems division. The company is taking advantage of the flexibility of microprogramming, as evidenced in the set of microcoded routines it offers as standard to accelerate Fortran performance.

Underlying the refurbishing of HP's 1000 line is the quest to handle more data. That is why the 1000s get a new operating system, the RTE-IV. Now available, the fourth version of HP's real-time executive operating system (downward-compatible with the earlier three) can handle as much as 2 million bytes of data. Further, its ability to manipulate enormous matrixes makes it well suited for many scientific applications. A user can specify a 1-million-element matrix—he simply declares A(1000,1000)—and the memory management is carried out completely transparently.

A second emphasis in the 1000 systems is on greater graphics capability. HP has unified its graphics software to maintain compatibility throughout its many display peripherals. A high-level graphics language, called AGL, has been defined. "Since we have several divisions working on graphics products, we've moved to standardize on 40 graphics macrocommands," explains Puette. For the 1000s, AGL is available in a plotting package that takes care of all conversions between different display peripherals. If a user has described his plot on one of the company's raster-scan terminals, for example, the graphics software can configure that same plot automatically for any other HP display peripheral.

In all, HP is offering three new systems with different standard combinations of new and old software and hardware. The low-end model 25, for example, has the F-series processor, a 2645 terminal, the simplest RTE-M operating system and starts at $27,500 for 64 kilobytes of main memory expandable to 2 megabytes. The model 40 features the RTE-IV operating system, a 7906 20-megabyte disk, a 2645 terminal, the E-series processor, and is priced as low as $40,000 with 128 kilobytes of memory.

At the top of the line is the model 45, with both the F-series processor and the RTE-IV operating system. It comes with the 20-megabyte disk and the 2648 graphics terminal and plotting software and starts at $46,500 for 128 kilobytes of fast (350-nanosecond) memory. With 1 megabyte of high-performance, fault-controlled memory, the model 45 costs $85,000.

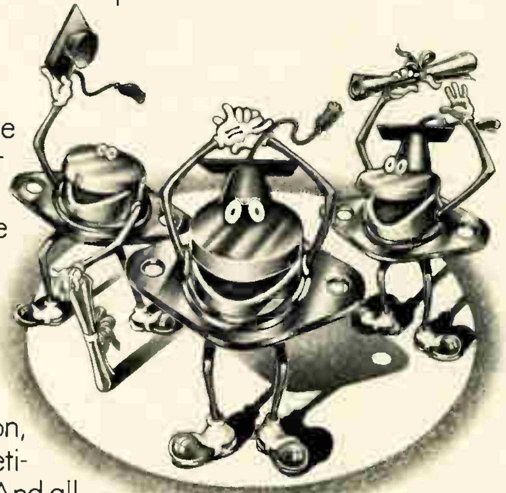
HP is also renaming its 21MX computers for original-equipment manufacturers to the 2111F and 2117F. These differ only in the number of memory and input/output boards they can house. The 2111F holds a ½ megabyte of fast fault-controlled memory and 9 I/O boards, while the 2117F can accommodate 1 megabyte of memory and 14 I/O boards. Delivery time for all models is estimated at 16 weeks.
Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304 [339]

HYBRID

IN A MARKET FULL OF DROPOUTS, OUR NEW REGULATORS ARE PHI BETA KAPPA.

Fairchild is introducing two new Linear regulators that are a study in efficiency. Our μA78HO5ASC 5-amp positive voltage regulator. And our μA78PO5SC 10-amp positive voltage regulator.

They're designed to provide extremely low dropout voltage — typically 2 volts at 5 amps on the μA78HO5ASC and 2.2 volts at 10 amps on the μA78PO5SC. And as any student of regulators knows, dropout like this just isn't available with monolithic designs.



STRAIGHT "A" PERFORMANCE.

Since lower dropout voltage provides more efficient power supply designs, these regulators, like all Fairchild voltage regulators, require fewer components than traditional designs. And that reduces design time considerably.

Features include short-circuit and safe-area protection, thermal shutdown and hermetically sealed TO-3 packages. And all this at the same price you'd expect to be paying for regulators that graduate at the bottom of their class. In fact, you can start designing in our new regulators for as little as $5.00 in quantities of 100 (μA78HO5ASC).

IF YOU HAVE QUESTIONS, PLEASE RAISE YOUR HAND.

For more details on our new enhanced voltage regulators, or information on our other Hybrid products, contact your Fairchild distributor or representative. Or, for immediate results, call your nearest Fairchild sales office.

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Subassemblies

Supply packs 1.6 W/in.³

600-W half-bridge uses only two power transistors, measures 3.5 by 7 by 13 in.

RO Associates, Menlo Park, Calif., finished designing the model 712 switching power supply two years ago, but the 600-W unit needed two 400-V, 15-A power transistors for its half-bridge drive circuit. At that time, no one made the necessary transistors. But now that they are available, the firm will introduce the new switcher at the current IEEE Electro/78 show.

"While half-bridge design is common in low-power switchers, using it in high-wattage supplies required paralleling existing power transistors," explains Richard Okada, marketing vice president. Early designs using parallel power transistors often failed. Although it was routinely possible to match the transistors at room temperature, variations in storage time with increased temperature caused a high component mortality rate, he says.

Instead of trying to parallel transistors or adopt an inherently less reliable full-bridge approach, the RO designers waited till International Rectifier and Fairchild came up with sufficiently high-power transistors. Then they snatched them up, and the 712 prototype was finally completed.

Okada believes it was worth the wait. A 3.5-by-8-by-13-inch unit, the 712 is not only a small supply, but also contains 50% fewer components in the failure-prone drive circuitry than previous supplies. Fan-cooled, the 712 is rated 1.6 W/in.³ Now fan-cooled switchers rarely exceed 1.3 W/in.³, Okada claims.

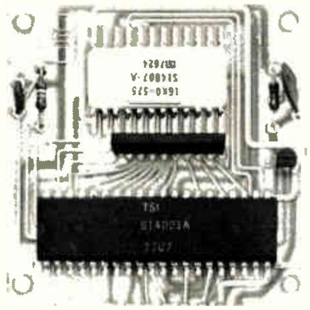
The 20-kHz supply delivers 5 V at up to 120 A, features current limiting, short-circuit and overvoltage protection, and a thermostat that will allow full output until the case temperature reaches approximately 80°C. It is available from stock at $650 apiece in quantities of less than 100. All model 712 power supplies are warranted for five years, according to the manufacturer.

RO Associates, 3705 Haven Ave., Menlo Park, Calif. Phone (415) 322-5321 [381]

Synthesizer is fluent in four languages

Using a 16-K read-only memory, a custom ROM controller, a digital-to-analog converter, and various other discrete components, the manufacturer of the model S2 series speech synthesizer has been able to generate a 24-word calculator vocabulary in English, German, Arabic, and French. Originally developed for use in a talking calculator for the blind, the module, programmed for any one of the four languages, is now available for small computer and OEM applications. Also being offered is a module with an additional 16-K ROM that can be manufacturer-programmed for either of two 64-word general-purpose vocabularies: an ASCII vocabulary or a vocabulary with standard numbers and measurement terms, including volts, ohms, amperes, hertz, dc, and ac.

The vocabulary stored in a ROM is fetched by the custom ROM controller when the latter receives a 6-bit parallel binary address code and a start signal. It then determines the speech characteristics of the word and provides a digital signal to an a-d converter. The resultant analog signal can produce a clear, intelligible male voice. The module requires power supplies of −5 and −15 V dc, an audio filter circuit, an audio amplifier, and a speaker. The manufacturer can supply these optional items.



The module alone, with a 24-word vocabulary, is priced at $95 and is available for immediate delivery. With associated circuitry, the price is $150 and delivery is also immediate. Prices for larger-vocabulary modules are higher, and custom vocabularies can be programmed.

Telesensory Systems Inc., 3408 Hillview Ave., P. O. Box 10099, Palo Alto, Calif. 94304. Phone (415) 493-2626 [383]

5-to-28-V power supplies reduce operating costs

The LGS-G series of switching power supplies consists of seven models that provide output voltages in the 5-to-28-V range and output currents of up to 200 mA. Rather than use fans or blowers to provide necessary supply cooling, the devices have been designed so that they can operate with convection cooling alone, thus reducing power consumption and operating costs. At a power cost rate of $0.04 per kilowatt, the units will pay for themselves in less than 18 months.

A feature of the LGS-G series is a digital front-panel meter that can be switch-set to read either voltage or current. Voltage is adjustable to within 5% of rated output. Standard, fixed-over-voltage protection has been built in to shut down the inverter and crowbar the output voltage. The supply also features a power hold-up time of 16 ms for line power failures.

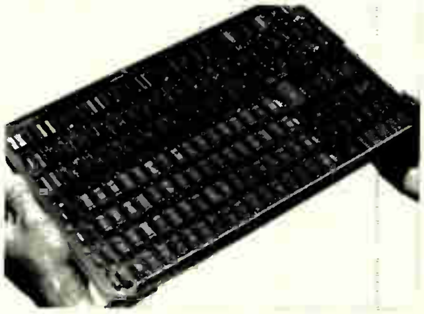
Designed for listing in the UL Recognized Component Index, units

are priced at $1,300 and are available for immediate delivery.
Lamda Electronics, 515 Broadhollow Rd., Melville, N. Y. 11746 [387]

CRT refresher displays images in up to 16 tones

The in-5770 refresh memory system, with a total capacity of 256-K 4-bit words, provides 4-bit resolution of the picture elements of video images projected onto raster-scan cathode-ray-tube display terminals. Use of a 256-kiloword memory produces a one-to-one relationship with the elements of the 512-by-512 graphic matrix commonly used in such terminals.

Designed specifically for use with computer-driven medical, scientific, and laboratory displays, the in-5770 can act to refresh displayed data or to store data for later viewing. With 4-bit resolution, the memory can produce 16 different tones; two units linked in parallel give 8-bit data storage that can be used to generate 256 different colors.



The 11.25-by-16-inch board-mounted memory accepts computer output on a 16-bit bidirectional data bus. Serial output to the CRT comes from the memory's four 16-bit shift registers; the memory also contains all the timing and control logic needed to operate the required random-access-memory address multiplexing and clock pulses. Maximum read or write cycle time is 450 ns. Typically, a read/write segment of an operational cycle will occupy 690 ns and data modification will take a maximum of 90 ns.

Power requirements for the circuit are +12, +5, and −5 V. The in-5770 is priced at $3,400, and a similar memory with half the line resolution is available for $2,400. Delivery is in 30 days after receipt of the order.
Intel Memory Systems, 1302 N. Mathilda Ave., Sunnyvale, Calif. 94086. Phone Connie Magne at (415) 745-7120 [388]

Crystal clock oscillator has timely price

The LOCO II is a thick-film crystal clock oscillator that is designed to sell for under $5.00. Three discrete frequencies are available: 19.6608, 18.432, and 16.000 megahertz. Taking into account the effects of temperature variation and of input voltage, load, and normal environmental changes, frequency instability is 0.05%.

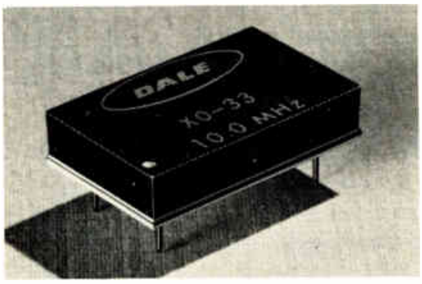
New products

The oscillator's output frequencies can be divided into universal-asynchronous-receiver/transmitter frequencies for various baud rates or into multiple outputs to drive combinations of baud-rate generators, microprocessors, and large-scale integrated circuits in the same system.

Motorola Inc., Communications Division, Motorola Component Products, 2553 North Edington, Franklin Park, Ill. 60131. Phone Barney Ill at (312) 451-1000 [386]

Crystal clock oscillators are short and stable

Packaged in low-profile ceramic enclosures, the XO-33 series of hybrid crystal clock oscillators provide output frequencies between 4 and 25 MHz with a frequency instability range from 0.005% to 0.1%. The devices have a maximum seated height of only 0.2 inch, are transistor-transistor-logic-compatible,



and drive up to 10 TTL gates each. The input supply requirement is 5 v dc both at 30 mA from 4 to 15.9 MHz and at 50 mA from 16 to 25 MHz.

Price for the device in quantities of 100 and above is typically $7.49 each. Delivery is from stock to eight weeks.

Dale Electronics Inc., Frequency Control Group, 930 W. 23 St., Tempe, Ariz. 85282. Phone John Elliot at (602) 967-7874 [385]

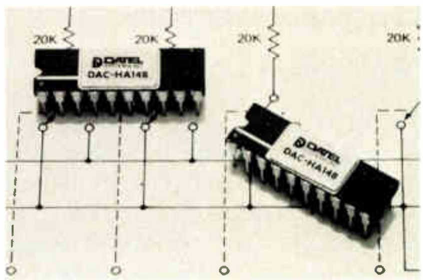
C-MOS a-d converter multiplies on little power

Combining complementary-metal-oxide-semiconductor switches with a laser-trimmed 10-kΩ–20-kΩ ladder network, the designers of the model DAC-HA14B 14-bit multiplying digital-to-analog converter have produced a device that is not only low in cost, but consumes very little power, too. The circuit requires a +5-v power supply, and the maximum quiescent current is 10 μA. And active-laser trimming of the ladder-network resistors gives 14-bit resolution with a maximum linearity error of ±1 least significant bit.

The device can be operated as a one-, two-, or four-quadrant multiplier for such applications as digitally controlled attenuators, automatic gain control, signal correlators, and digitally controlled voltage sources. The reference input voltage of the device can vary from −10 to +10 v, thus producing a true multiplying capability. The output current range is ±1 mA and settling time for the output is 500 ns. Inputs must be transistor-transistor-log–compatible. The reference input bandwidth extends to 200 kHz.

The DAC-HA14B comes in a 20-pin dual in-line package and is available in three temperature ranges, from standard commercial to military. In quantities of 1 to 24, a device with a range of 0 to +70°C is priced at $69; with a range of −25 to +85°C, $99; with a range of −55 to +125°C, $139. Availability for the devices is given by the manufacturer as four weeks.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone Eugene Murphy at (617) 828-8000, ext. 141 [384]



Whose whose in LSI-11 memories?

Strand Century, Inc.
Los Angeles, California

The company:
The leading manufacturer of memory light control systems for theatrical productions and TV shows.

Notable application:
Lighting controls for the Broadway hit "Annie." (Photo 1, courtesy Martha Swope.)

Whose CPU:
Digital Equipment Corporation LSI-11

Whose memory:
Monolithic Systems Corporation MSC 4601 Dual Height

Whose decision:
David Cunningham, Director Research and Development

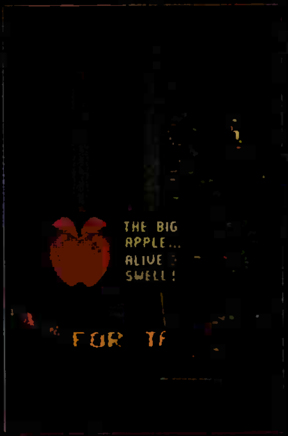
Comment:
"We've been buying both quad and dual height memories from Monolithic Systems for several years. The outstanding cooperation of their people and their on-time deliveries were major factors in selecting them."

American Sign & Indicator Corporation
Spokane, Washington

The company:
The world's largest supplier of computer directed lighted signs, scoreboards and color displays.

Notable application:
Mark 400 Spectacolor Display on Times Square (Photo 2, courtesy American Sign & Indicator Corporation.)

Whose CPU:
Digital Equipment Corporation LSI-11



2.

3.

Whose memory:
Monolithic Systems Corporation MSC 4601 Dual Height

Whose decision:
David Cole, Director of Materials

Comment:
"Our displays have used Monolithic Systems' LSI-11 memories exclusively since 1976. Cost and delivery were the primary reasons for changing vendors and Monolithic's new dual height version has kept us convinced we made the right choice."

EG & G Princeton Applied Research Corporation
Princeton, New Jersey

The company:
The leading manufacturer of signal recovery instrumentation and pioneer in multichannel electro-optical detection techniques.

Notable application:
The OMA-2 Optical Multichannel Analyzer (Photo 3) permits real-time spectral analysis from below 200 nanometers to nearly 2.0 micrometers. RAM memory is used for storage of the scan format.

Whose CPU:
Digital Equipment Corporation LSI-11

Whose memory:
Monolithic Systems Corporation MSC 4501 Quad Board

Whose decision:
John Zipper, Project Manager

Comment:
"We've standardized on Monolithic Systems' LSI-11 quad memories for two reasons...price and they work."

Your company

Whether your LSI-11 based system is a leader in the industry or heading in that direction, head in our direction for LSI-11 compatible memories. For price, delivery and reliability.

DEC compatible memories... from the first.

Monolithic Systems corp

14 Inverness Drive East
Englewood, Colorado 80110
303/770-7400

1. (Right) A scene from "Annie." Presented by Mike Nichols. Winner of 7 Tony Awards-1977 –including Best Musical. Best Musical Award 1976-77. N.Y. Drama Critics' Circle. Produced by Irwin Meyer, Stephen R. Friedman and Lewis Allen.

2. (Left top) World's largest computer controlled Spectacolor display at the nation's number one sign location, Times Square in New York City. Eighty-two hundred lamps enable the extraordinary system to perform cartoon like animation in up to 17 different colors.

3. (Left bottom) Just as the human eye detects the variations in the visible light spectrum, the OMA-2 provides a real-time readout of wavelengths and intensities of this spectrum. Suitable detectors allow OMA-2 to "see" into the ultraviolet and infrared regions as well.

ENLIGHTENMENT

How To Give Your Displays a Lot More Character:

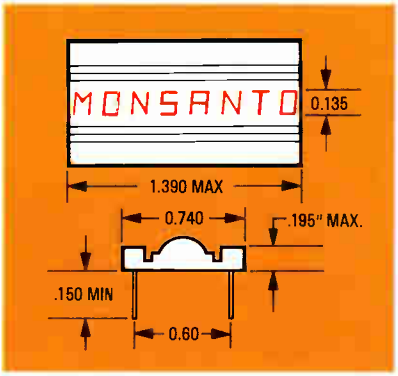
Put more LED alphanumerics in less space with Monsanto's new MAN2815. Save panel space with the "More Character Display" from Monsanto. Advanced engineering gives you more character density (character/inch of panel space) than competitive displays. Monsanto's unique lens and font design takes advantage of human engineering experience. More pleasant viewing with a height/width ratio that is optimized, not squatty and square.

MAN2815 gives you wider viewing angles with less distortion. Our new lens design lets you view the characters from several angles. Where other displays distort at off-axis viewing angles, the MAN2815 shows you the real message . . . clearly, brightly, undistorted. Less chance of error. More convenience.

Displays can be precisely aligned from character to character with MAN2815. The MAN2815 is precision manufactured to allow end-to-end stacking for any number of units. And you can maintain the alignment of the characters from module to module so a full line of words looks even and professional.

Reliability is high . . . the power requirement is a cool low. An average current of 0.5 mA is more than adequate for viewing in ambient conditions of 100 ft.-candles of illumination. That's only 60 mW, yet the MAN2815 is rated for 1200 mW. And competitive units can't match the MAN2815 for operating temperature range (0–85°C.). Not only do you get power savings . . . but cooler, longer, and more reliable operation.

Left: More characters—MAN2815 (top) and competitive unit character density in same panel space. **Right:** Less distortion—MAN2815 (top) and competitive unit when viewed 25° off of normal.



Send now for the MAN2815 Design Kit—limited time offer.
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Circle 211 on reader service card

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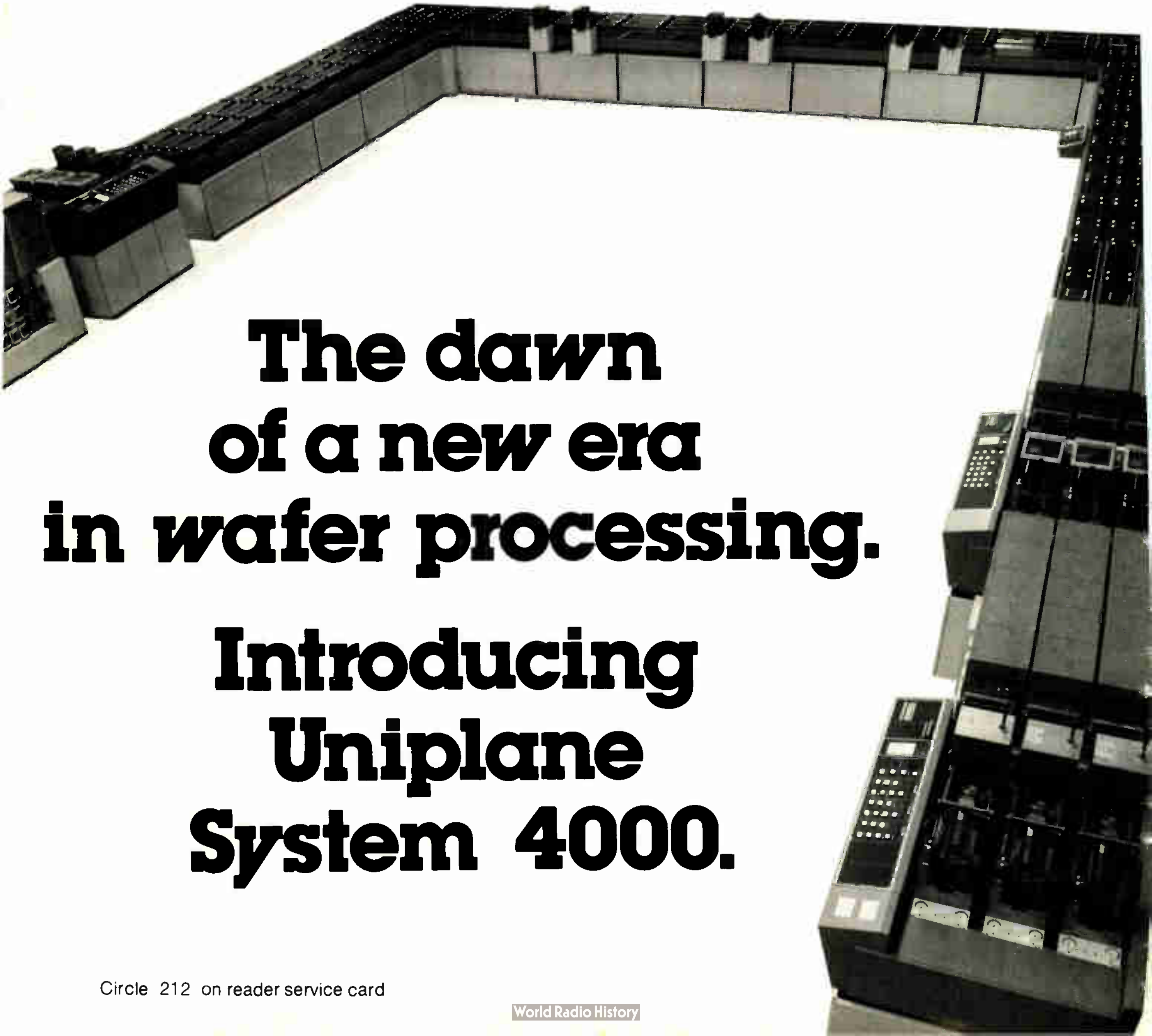

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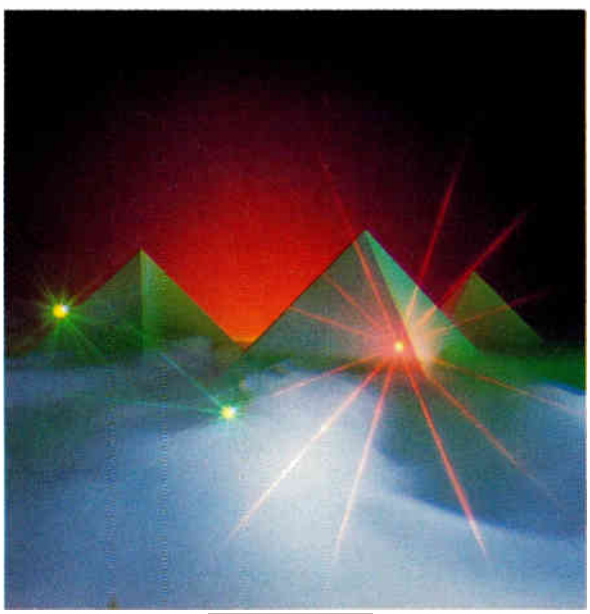


Circle 213 on reader service card

Data handling

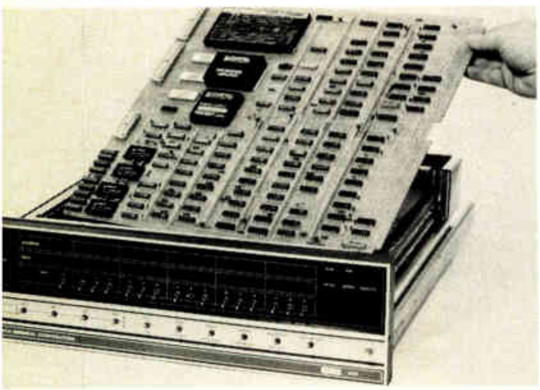
An analog I/O board for minis?

Yes, says Datel, for users who want to move up from microcomputers

With the rush to supply analog input/output boards for single-board microcomputers, it might seem surprising that Datel Systems would come up with an analog-to-digital/digital-to-analog interface subsystem for Data General's NOVA minicomputer line at this stage of the game. But Lawrence Copeland, Datel's product marketing manager for computer peripherals, argues persuasively for the strategy behind the ST-NOVA.

The ST-NOVA board slides directly into the NOVA series minicomputer housings, and offers 64 a-d channels and an optional four d-a output channels. Copeland believes that users of microcomputers who have to digitize analog data often find that after they have some experience with a microcomputer, they want more data channels or more speed or more performance than most 8-bit microcomputers provide. "In process control," Copeland maintains, "anything analytical needing higher-math Fortran, floppy disks, CRT peripherals, or many channels at high speed will make a microcomputer choke."

For that kind of user, the ST-NOVA



offers a speed of 45,000 a-d samples per second with a choice of program control, interrupts, or direct memory accessing. It is directly compatible with NOVA series assembly language programs, as well as with NOVA Basic, and Fortran. It can also be expanded to 256 or more a-d channels and 32 or more d-a channels if the customer separately purchases Datel's System 256 remote a-d/d-a housing.

The basic ST-NOVA, with 64 single-ended or 32 differential non-isolated channels, sells for $1,445 in single units; another $350 buys the four d-a output channels. Prices for the remote System 256 expander unit start at about $2,000. The latter has been on the market for some time, and deliveries of the ST-NOVA are in six to eight weeks after receipt of order. Its jumper-selected full-scale input ranges are: 0 to +5 v, 0 to +10 v, −5 to +5 v, and −10 to +10 v. The unit is accurate to within 0.025% of full-scale range at 25°C.

Resolution is 12 bits, and nonlinearity and differential nonlinearity are both within ½ least significant bit. The d-a output sections can include 12 latched digital bits per d-a converter, which, under program control, can be used as up/down controls for a chart pen, intensify/blank Z-axis controls for an oscilloscope, cathode-ray-tube color controls, or controls for external logic.

Copeland expects the ST-NOVA applications to include high-speed automatic test systems, intelligent analytical instruments, and signal processors. He says users who especially need hundreds of data channels include those testing such things as jet engines and nuclear reactors.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone Roland Petrelli at (617) 828-8000 [361]

System allows remote entry by master's voice

With intelligent terminals now getting heavy play for distributing processing throughout a network,

Interstate Electronics Corp. is acquainting potential buyers with its version of the next step: a user-programmable voice-operated intelligent terminal. The Interstate device aims at meshing with any system in which remote data must be entered into a central computer.

The system is built around its software and proprietary high-level language, Voice (Voice-Oriented In-Core Executive). This software lets a user configure a programming format to any requirement, much as with a microprogrammable computer. The Interstate terminal is controlled by a NOVA minicomputer, with the basic package capable of supporting four voice-input stations at the same time.

The package permits the choice of up to 900 words, or 250 per station in a four-input cluster. It offers such refinements as what the company calls an action structure, which can be triggered to carry out other programs with the appropriate voice command. Any experienced computer software person can learn how to program the terminal in several hours, and unskilled workers can operate it after only one run-through, says a company spokesman.

Another feature is the unit's sensitivity to variations in individual speech patterns. After each word has been placed in the vocabulary, the user repeats it slowly for storage in the terminal memory. The unit can even be programmed to respond only to one individual's speech. Also, words spoken into the microphone are displayed on a cathode-ray tube as a double check on accuracy and may be changed by voice command.

The basic $18,750 Interstate package comprises voice-recognition unit, user station, microphone, and a

The HP 2649A is what you make it.

A controller. It's a natural. Just program the built-in 8080 microprocessor to do your thing, and get it into your system. The HP 2649A has a variety of synchronous, asynchronous, serial and parallel interfaces (including HP-IB, our IEEE Interface Standard 488). This makes it easy to hook up with instruments and peripherals. In short, it's a complete controller system in a single package.

A terminal. Terrific! Great editing ability, a choice of keyboards, flexible data communications, and a variety of baud rates make it an excellent fit in an RJE situation. Preprogrammed firmware is available to get you off to a head start.

A microcomputer. Why not? The microprocessor gives you a lot of power. Then you can add ROM memory, interface with a disc, control peripherals, and access other systems via a modem. So the HP 2649A acts like a small computer, even if it doesn't look like one.

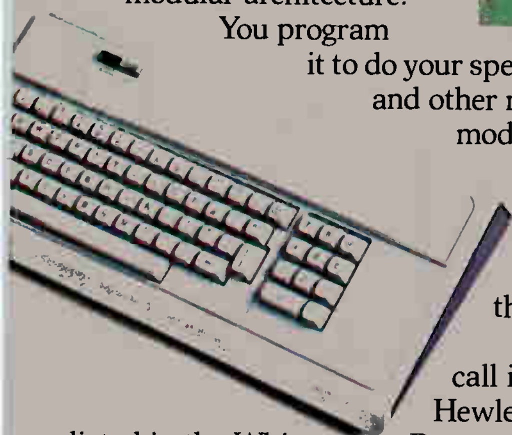
A graphics display station. Sure. You can put a window in your system and see exactly what's going on. Alphanumerics, auto-plot, and full graphics, including Area Shading, Pattern Definition and Rubber-band line, give you the whole picture.

You can really make a lot with the HP 2649A.

You start with the basics — a CRT, power supply, backplane, I/O cards, MPU, and versatile, modular architecture.

You program it to do your specific job, and pick only the memory, keyboard, I/O, breadboard, and other modules you need. These include RAM (up to 32K bytes on one module), ROM, and PROM boards, which all simply slip into the chassis. (There are slots for your own boards as well.) You can also add 220K bytes of mass storage on dual plug-in cartridges.

To top it off, we have documentation, development tools, and a one week training course in programming and customizing the HP 2649A.



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Circle 215 on reader service card

HOW COULD THE INDUSTRY STANDARD 5½-DIGIT DMM BE IMPROVED?

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Combine all this with autoranging, extensive overload protection, and a cost effective price, and it's no wonder the 8800A is the industry's most popular bench/portable 5½-digit DMM.

Now look at the 8810A.

It's modular! You can buy the lab-performance DC mainframe for only $695.* Add the six-range ohms converter for $175* any time you wish.

It's got true rms ac! Actually you can choose either the true RMS converter module for accurate measurements of most waveforms at $275,* or the average-responding AC converter module at $150.* Both are spec'd to 100 kHz.

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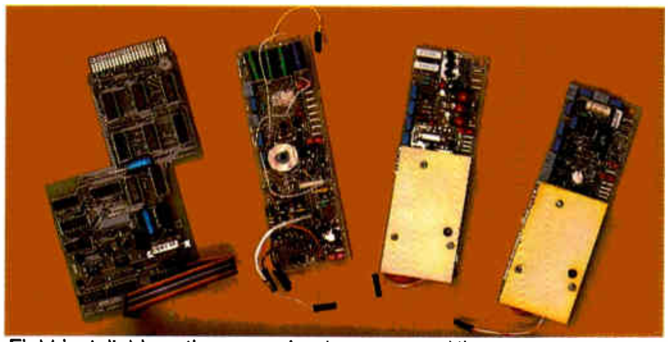
So now, in addition to the industry standard 8800A, you have your choice of application-oriented and cost-saving configurations of the new 8810A, choices you'd expect only from Fluke.



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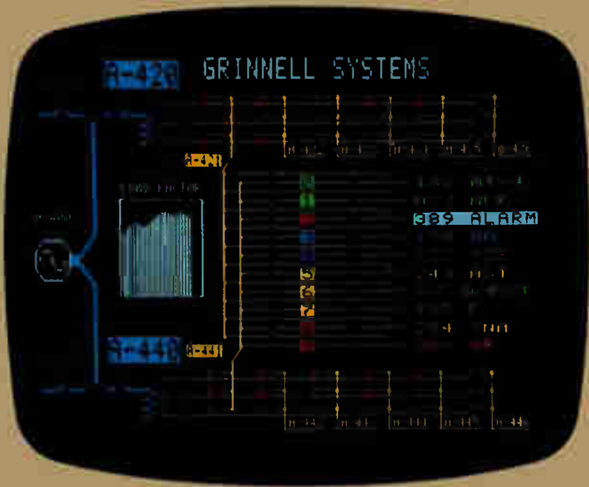

$5100 **256 x 512 resolution**
4 memory planes
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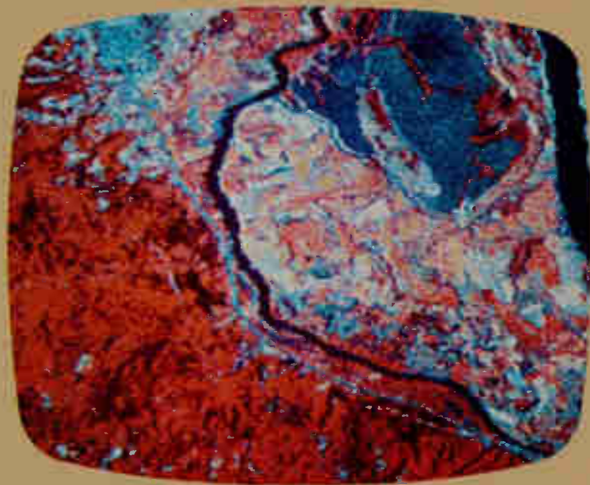

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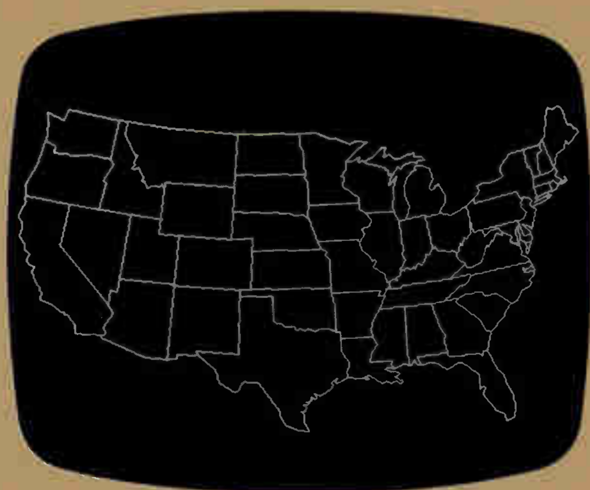

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These are just a few of the ways you can tailor the all solid state GMR-37 to fit your needs.

You don't give up performance either. Every GMR-37 has, as standard, the generation of vectors, characters, plots, graphic data and high speed images. Plus 4K MOS random access memories, memory readback, full alphanumerics and a standard RS-232 computer interface.

In addition, a powerful instruction set minimizes software overhead and simplifies programming. You don't need complex macro instructions and high order programming languages.

Available options include video lookup tables, independent cursors, trackball or joystick control units and many more. Plug-compatible parallel interfaces are available for most minis.

Further, if you ever want to move up, Grinnell has a complete line of larger systems—all software compatible with the GMR-37—to do things like animation, image processing and real-time frame grabbing.

GMR-37 systems start at **$3900,** and quantity discounts are available. (Domestic U.S.A. prices.)

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Circle 227 on reader service card

New products

Packaging & production

Wafer tester keeps hands off

Proprietary sonic testing and single-whisker sensing prevent wafer damage

Keeping tight controls on silicon-wafer thickness and resistivity is crucial to high integrated-circuit yields. But up to now, IC manufacturers have had to use either contact-type instruments, which damage portions of the wafer, or noncontacting types, which can only measure one parameter. Now Tencor Instruments' new Sonogage RT^2, employing a proprietary sonic technique, measures both parameters without contact and at the same point on the wafer surface.

"We expect to see the sonic technique being used in other instruments," Tencor vice president John R. Schwabacher predicts, because the technique, for which the company has a patent application, does not depend upon the measured material's physical properties and could therefore be used to measure the thicknesses of metals, paper, and other thin-sheet substances.

The bulk resistivity is determined automatically by calculation after the wafer's thickness and sheet conductance have been measured. Accuracy is maximized if both parameters are measured at the same point on the wafer; the RT^2's special head arrangement allows the user to do this.

The wafer is suspended on a track between two identical measurement-head housings: one above the wafer and one below it. In each housing are two heads—one to measure thickness and another to measure surface sheet conductance. The loading track, which is adjustable for wafers between 2 and 5 inches in diameter, can be internally programmed to move the wafer in linear increments and to rotate it so that several measurements can be made at different points on the wafer.

After each measurement, the results are displayed on the RT^2 light-emitting-diode display panel. Thickness can be read in micrometers or mils; the user simply selects which units he wants with a panel switch. Resistivity, in ohm-centimeters, is displayed once the thickness and conductance measurements have been fed into and operated upon by the internal National Semiconductor LH0094-based analog multiplier circuitry.

Most instruments use a four-point probe to determine whether a material is p- or n-type. Unfortunately, the probe comes in contact with the wafer's upper surface, thereby destroying a portion of it. The RT^2 is able to make the determination with a thin-wire whisker sensor that lightly brushes the underside of the wafer without damaging it.

An option provides for linking up the RT^2 with the new Hewlett-Packard HP 97S programmable printing calculator. This combination performs a five- or nine-point test pattern sequence on each wafer, with the calculator capable of recording all test values or just the final statistics.

The HP 97S controls the RT^2, which makes measurements at three or five positions along a wafer diameter, then rotates the wafer 90° and measures two or four more, skipping over the center, which has already been tested. The calculator, which has received all data via the binary-coded-decimal interface, can then perform whatever calculations the user requires.

The RT^2, which stands for resistivity, thickness, and typing, is Tencor's second product in its 15-month history. Schwabacher expects it to be used by both IC manufacturers and wafer fabricators to perform various types of inspection. It will sell for $8,000 without the calculator and $9,7000 with the HP 97S and software. Shipments are expected to start next month.

Tencor Instruments, 2426 Charleston Rd., Mountain View, Calif. 94043. Phone (415) 969-6767 [391]

Stacking connector gives close fit for pc boards

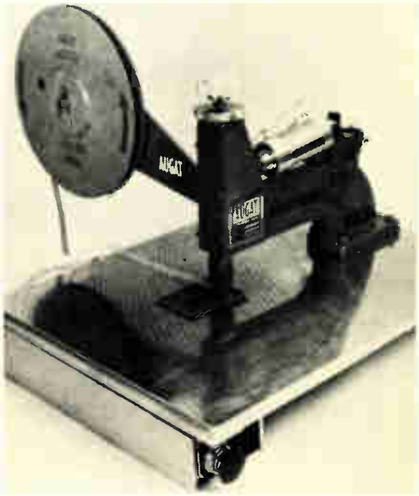
With the Conmet stacking connector, printed-circuit boards can be connected with as little as 0.025 inch between them. The device consists of a plastic holder into which the user can insert a red, blue, or green strip of silicone rubber containing a laminate of copper-alloy wires. The rubber strips provide electrical contact between pc boards while isolating the connection from the operating environment. For contact spacings of 0.025 to 0.050 in. center to center, red strips are used; for 0.050 to 0.100 in., the strips are green; and for 0.100 in. and above, blue are required.

In quantities of 10 to 24, the connectors are priced from $4.78 to $2.61, with substantial discounts available for large quantities. Delivery is in two to three weeks.

Technical Wire Products Inc., 129 Dermody St., Cranford, N. J. 07016. Phone (201) 272-5500 [394]

Press inserts DIP contacts from preloaded Mylar strips

Those who custom-make moderate quantities of printed-circuit boards for use with devices in dual in-line packages will be interested in the model 736-M001 Holtite socket-insertion machine. The unit, which may be operated manually or provided with an optional pneumatic activator, can stamp sets of Holtite contacts into pc boards that are 1/32 to 1/4 inch thick. The only other dimensional limitation on the boards is that their Y axis be no more than



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18 inches long, says the company.

Key to the machine's operation is the use of reels loaded with Mylar strips carrying prearranged configurations of connectors. Strips contain up to 5,000 tin- or gold-plated contacts each and are available in all standard 8- to 40-pin DIP socket patterns. Universal patterns with pins spaced on 0.100-in. centers in rows 0.300, 0.400, or 0.600 in. apart can also be obtained, and custom patterns are provided upon special request. On the average, 5,000 contacts can be pneumatically inserted per hour.

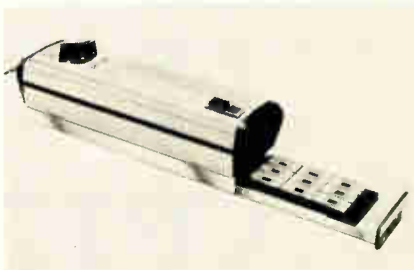
In its manual version, 736-M0015M, the machine costs $475 without seating tools. The pneumatic unit, 736-M0015A, is priced at $695. Users who purchase manual machines can later upgrade their systems to pneumatic use by purchasing a conversion kit, 736-HK-003, for $239.50. On reels, contacts are priced between 1.8 and 3 cents each, depending on the quantity ordered.

Interconnection Products Division, Augat Inc., 33 Perry Ave., Attleboro, Mass. 02703. Phone R. Holt at (617) 222-2202 [393]

High-intensity UV lamps erase up to 9 EPROMS in 12 minutes

The PT-24T is a specially designed unit that will erase a maximum of nine erasable programmable read-only memories in as little as 12 minutes using an ultraviolet lamp. The unit operates from a 115-v, 60-Hz source and contains a timer that can be set for any duration up to 60 minutes, after which it automatically shuts the lamp off.

The PT-24T weighs approximately 5 pounds and is priced at



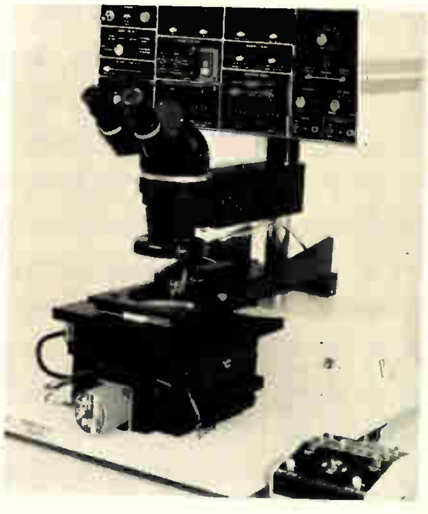
New products

$104.50. Smaller versions of the unit weighing about 4 lb and handling six erasable PROMs at the maximum are available for $84.50 with timer and $59.50 without.

Spectronics Corp., 956 Brush Hollow Rd., Westbury, N.Y. 11590. Phone B. William Cooper at (516) 333-4840 [395]

Wafer prober handles lab or line tasks

The PS50 wafer prober incorporates an 8085 microprocessor chip, giving it the ability to operate in any of four modes. Though not intended solely for production use, the machine can perform standard production probing using an X and Y die-size indexing system. It can also perform matrix probing using front-panel switches, random pattern probing employing the on-board programmable read-only memory, and probing controlled by an external computer and the internal microprocessor. These capabilities allow the prober to accummulate substantial data, both on the production line and in the laboratory, for process evaluation.



The PS50 standard format includes a 4-inch-wafer chuck. The unit also has a patented inking control with front-panel delay, an edge-sensing system under microprocessor control, a wafer location and orientation system, and controls that

Now, the first data logger with get-up-and-go.

Take EMR's suitcase-sized COMPACT 3430 Data Logger away to those "difficult" sites where bulky equipment or hardwiring would be too inconvenient or costly. Just take it and leave it — anywhere, any time, for as long as a month. COMPACT's built-in battery and power source make it easy.

You can even take your pick of three models: one with a built-in line printer; one with a built-in cassette tape recorder; and one with a universal peripheral interface usable with a line printer, paper punch tape, teleprinter or modem. All three are microprocessor-controlled, providing keyboard programmability for up to 30 analog inputs and 20 (optional) digital status inputs, with any mix of voltage or thermocouple inputs.

As simple to use as a pocket calculator, COMPACT's pushbutton control eliminates plug-in modules, and lets you set individual high and low limits, specify channel input type, skip channels and select scan intervals. A choice of three modes lets you record *all* input data, out-of-limit conditions only, or inputs as they pass through the set limits. You can even print out alarm conditions.

For more details or a demonstration, call or write today.

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Circle 235 on reader service card

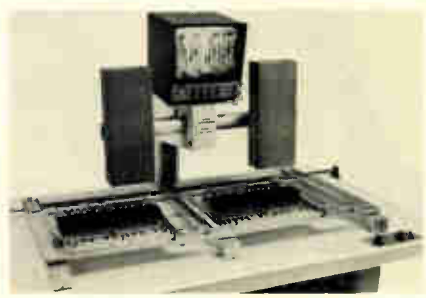
can be easily used by either left- or right-handed operators.

Equipped for all four operational modes, the unit may be purchased for $16,000. For only the standard production mode, it is priced at $7,000. Delivery is currently in 10 weeks.

Probe-Rite Inc., 2725 Lafayette St., Santa Clara, Calif. 95050. Phone (408) 249-1255 [396]

Unit compares pc boards with video overlay or split screen

Using two specially modified vidicon cameras, the Video Comparator System can compare a printed-circuit board under inspection with a preselected master board. The operator can chose to display either superimposed, split-screen, or individual video images, depending on the type of inspection he wishes to make. Boards up to 12 by 16 inches may be placed



in a ball-slide–mounted frame that is manually positioned by the operator during comparison. It takes an hour or less to learn how to operate the unit properly.

The VC system is 54 in. high, 54 in. wide, and 36 in. deep. It is available in three models: the VC1000A, which has a 9-in. monitor and provides a 3.8× magnification; the VC2000A, which offers a 12-in. monitor and 4.3× magnification; and the VC2000A-H, a 12-in. monitor unit with 5.2× magnification. All magnification figures are approximate. Prices for individual units begin at $4,400.

Ham Industries Inc., 853 Highland Rd., Macedonia, Ohio 44056. Phone (216) 467-4256 [397]

OUR OS4000 TAKES OVER WHERE TUBE STORAGE LEAVES OFF.

The Gould OS4000 digital memory oscilloscope extends your capabilities beyond the limits of conventional storage tube technology.

With the OS4000, stored transients do not deteriorate and are clearly displayed at will indefinitely — as long as you choose to keep the data. Stored trigger points allow you to display pretrigger signals as well as the signal itself. You see what actually caused the signal.

Digital storage also offers you four useful options: 1) Fully automatic operation, 2) analog and digital output for hardcopy, 3) higher resolution through expansion of stored traces, 4) the ability to generate complex wave forms.

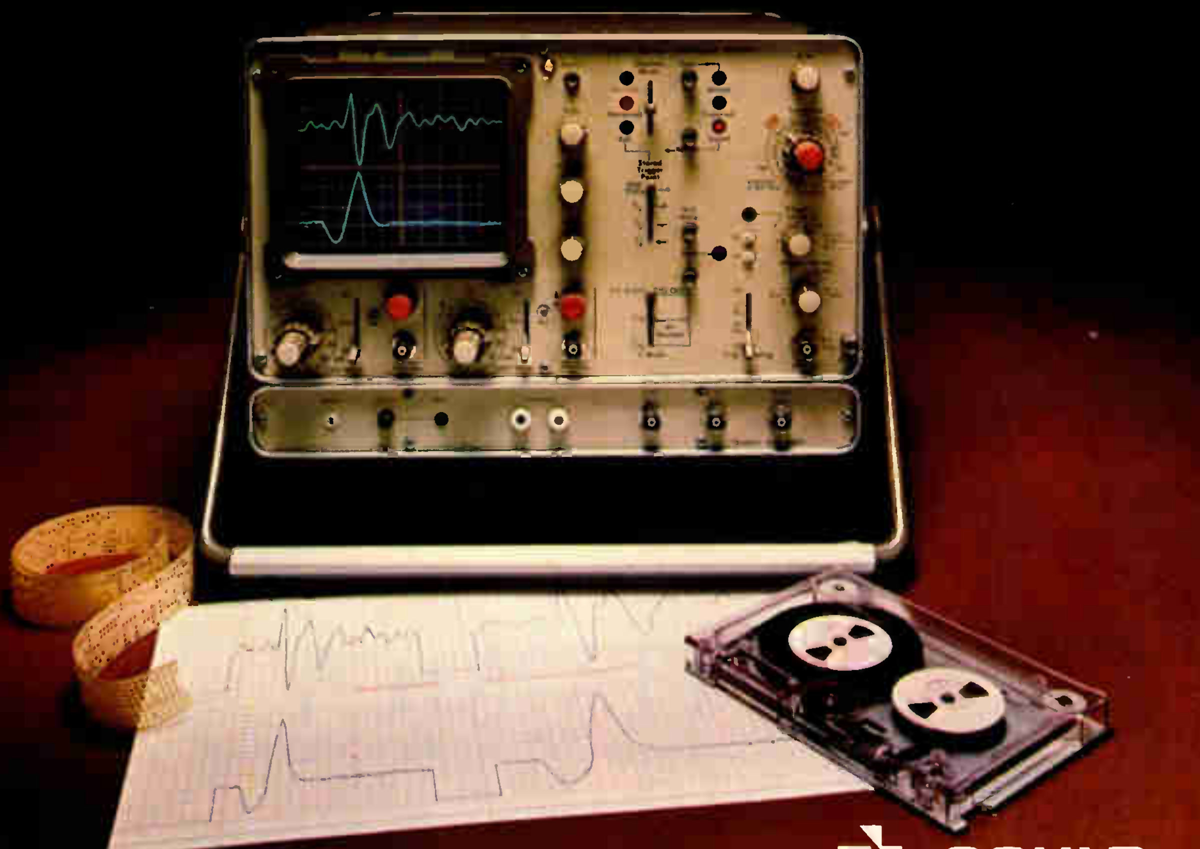
The OS4000 can enhance the effectiveness of traditional dual trace displays by simultaneously displaying real time and stored traces without the amplitude restrictions of a split beam storage tube. Both signals have optimum brightness to help you draw the critical inferences from close comparisons. At low frequencies there is no irritating flicker or C.R.T. glow.

Rated at 10 MHz for conventional operation the OS4000 utilizes an 8 bit x 1024 word RAM, with a sampling frequency of 1.8 MHz. Normal/refreshed/roll modes are standard.

With a multitude of new applications in general electronics, medical electronics, research laboratories and transducer related measurement situations, Gould's OS4000 simply outclasses every tube storage scope on the market. But even though the OS4000 represents a step forward in storage scope technology, it is both easy to use and extremely affordable.

For more information contact Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, OH 44114. In Europe contact Gould Advance LTD., Roebuck Rd., Hainault, Essex, CB10 1EJ, England.

For brochure call toll free (800) 325-6400. Ext. 77. In Missouri: (800) 324-6600.

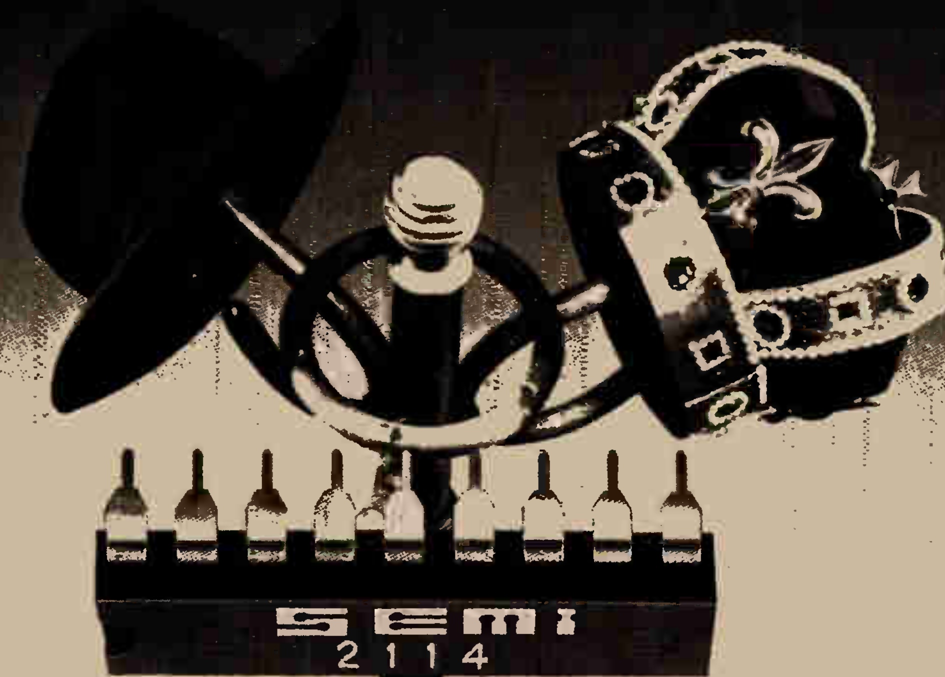


Example of expanded output (1:2)

GOULD

Circle 237 on reader service card

The 2114. It's old hat to us



Most 2114s are new products with new product problems. Not ours. The SEMI 2114 is a member of the Royal Family of Static RAMs. It is, in fact, a new pin-out of an 18-pin, 5V, 1Kx4 static RAM that we've been delivering in production quantities for a year and a half.

The SEMI 2114 features low power (only 300 mw), TTL compatible I/O, and all the speed you need for microprocessor applications.

If you'd like complete information on the SEMI 2114, or any other members of the Royal Family of static RAMS, see your local EMM/SEMI distributor, or contact us directly.

EMM SEMI, INC.

A subsidiary of Electronic Memories & Magnetics Corp., 3883 N. 28th Ave., Phoenix, Arizona 85107 (602) 263-0202

ENGLAND: EMM, Ltd. Tel: (01) 751-1213. **WEST GERMANY:** EMM, GmbH Tel: 6172-6629. **BELGIUM:** EMMSA Tel: (03) 76.69.75. **FRANCE:** EMM c/o Clip. Tel: (01) 754-2319

See us at Booth 1327 at the NCC Show, Anaheim, Ca. June 5-8.

Circle 251 on reader service card

Products newsletter

Signetics opens big push on RAMs for 8X300 family

Users of Signetics Corp.'s 8X300 will appreciate the midsummer arrival of a family of 2,048-bit random-access memories supporting the fast bipolar microprocessor. First will be a pair each of 256-by-8-bit and 256-by-9-bit devices. **The RAMs will mark the beginning of a big push by the Sunnyvale, Calif., company for the 8X300,** its flagship microcontroller, which has generated interest from those designers who are frustrated by the limitations of bit-slice units.

More personality modules due for HP 1611

Look for Hewlett-Packard to almost double the capabilities of its model 1611A logic-state analyzer by adding three new personality modules to the present list of four. The 1611A can now be used with the 6800, 8080, F8, and Z80. **New personality modules for the 1802A, 6502A, and 8085 are soon to be announced.** A 1161A with one module costs $5,200; users can add any of the remaining six modules for an additional $1,250 each. Modules can be exchanged in about 15 minutes and consist of two printed-circuit boards, a replacement section of front panel, and a dedicated microprocessor probe.

Honeywell adds digital programmer to industrial line

Planning to expand its family of microprocessor-based instruments and systems, Honeywell Inc.'s Process Control division in Fort Washington, Pa., has slated a mid-June unveiling of a new digital control programmer, the DCP 7700. It will offer users improved repeatability, resolution, and control accuracy in processes requiring generation of setpoint versus time profiles. **Applications include heat treating and furnace control, environmental or test-chamber control, metallurgy, and weld stress relieving.** The DCP 7700 is designed around an Intel 8080 microprocessor.

Two options offered for logic analyzers

BP Instruments of Cupertino, Calif., is about to announce two new options for its 50D and 50D16 logic analyzers. The first is a transitional clocking option for compacting data. It uses the incoming data for generating the clock. **The second new option is the Pro-Pod, an umbilical add-on with 12 inputs that attach to the 8 inputs of the 50D** to permit the use of four extra probes for additional qualifiers. By combining two Pro-Pods for the 50D16, for example, the user has 16 data inputs, plus extra qualifier lines. The transitional clock option will cost approximately $500, the Pro-Pod $435. BP will begin shipping the options in July.

Price changes

Recent price changes have been announced for semiconductor products by two companies:

- **EMM Semi Inc.,** Encino, Calif., which has dropped the price on its 3539 2,048 bit static random-access memories. In 500 quantities the cut was from $7.80 each to $4.05.
- **Standard Reference Labs. Inc.,** Fair Lawn, N. J., which has reduced the tags on four of its precision reference diodes. For quantities of one to nine, the reductions are as follows: type PRD 2005 from $170 to $140, PRD 2010 from $115 to $105, PRD 2020 from $70 to $65, and PRD 2030 from $47 to $45.

A single-component plastic adhesive with a temperature resistance of up to 400°F will bond ceramic to metal as well as adhere to glass, mica, and many plastics. Aremco-Bond 515 requires no weighing, mixing, or activating and can be cured at temperatures as low as 330°F in 45 minutes. It has a dielectric strength

of 400 v/mil and has a life of one year when refrigerated. Aremco-Bond 515 is available from stock at $27.50 per pint, $35 per quart, or $90 per gallon in 10-gallon lots.

Aremco Products Inc., 23 Snowden Ave., Ossining, N. Y. 10562 [476]

Infrared Solderflux 840, a biodegradable compound, efficiently fuses solder to circuit boards while they are being conveyed through an oven. The material wets and levels well on ground planes and provides a bright and essentially uncontaminated plated surface. It rinses well, is completely smoke-free, and is nearly odorless. It costs $40 for a 4-gallon pack, $47.50 for a 5-gallon pail, and $495 for a 55-gallon drum.

J&S Laboratories Inc., 1352 Coil Ave., Wilmington, Calif. 90744 [477]

A transparent epoxy resin called Eccogel 1265 can be used to protect components from shock or pressure or to provide a window when it is needed to inspect a device. Once cured, the resin becomes transparent and can be cut with a knife for access to a protected component and later repaired. The material has a low viscosity so that it will easily impregnate components. It can also be used as a laminating resin

between glass plates for safety purposes. Eccogel 1265 is available from stock in 16-pound quantities. It is priced at $2.95 per pound.

Emerson & Cuming Inc., Canton, Mass. 02021 [479]

A base-metal conductive coating designated X-coat 205 has a bright, reflective appearance similar to that of silver coatings, yet costs less than 50 cents per square foot. A one-part application that may be air-dried, it exhibits excellent environmental resistance and adheres well to engineering thermoplastics such as Valox, Noryl, and Lexan. Production quantities are available at $95 per gallon; a 1-pint evaluation sample costs $25. Delivery is from stock to two weeks.

Electro-Kinetics Systems Inc., 2500 E. Ridley Ave., Chester, Pa. 19013 [480]

Bubble-wrap bags use a 1-inch lip coated with pressure-sensitive adhesive to provide users with resealable protective bags. The bags are available in five sizes: 3 by 4 inches, 4 by 5½ in., 4 by 7½ in., 6 by 8½ in., and

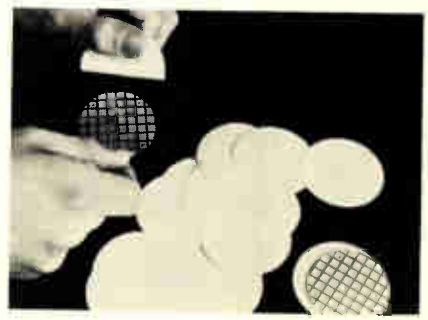
8 by 11½ in., says the company.

Sealed Air Corp., Park 80 Plaza East, Saddle Brook, N. J. 07662 [356]

A thick Kapton polyimide film is under evaluation by Du Pont. It is intended for applications that require insulations with thickness and stiffness in addition to an ability to retain their physical and electrical properties in hostile environments. The film has a dielectric strength of 1,440 v/mil and a dielectric constant of 3.33 at a frequency of 100 Hz and 25°C. Limited quantities of the 11- and 17-mil-thick experimental films are available.

Du Pont Co., Plastic Products and Resins Dept., D-6119, Wilmington, Del. 19898 [357]

An adhesive-backed plastic film can be used to hold silicon wafers, alumina and glass substrates, or other semiconductor materials for dicing or scribing. Wafer-Mount 559 has a paper backing that when peeled away exposes the soluble adhesive layer. Once the paper backing is removed, the substrate is positioned on the film and pressed down so that it adheres to the film; no heating is required during the process. Dicing or scribing of the material is accomplished mechanically or



with a vacuum manifold. The parts can be separated from the film by using an appropriate solvent. Wafer-Mount comes in 10-by-10-in. sheets at $50 for 10 sheets and $2.75 per sheet in lots of 1,000 and up. Disks that accommodate 2-, 3-, or 4-in. silicon wafers sell for $0.51, $0.71, and $1.05 each, respectively, in lots of 1,000 or more disks.

Aremco Products, P. O. Box 429, Ossining, N. Y. 10562 [478]

DDC has developed the world's fastest hybrid 12 bit and 8 bit data acquisition components. The 12 bit has a throughput rate of 450 kHz and the 8 bit has a throughput of 900 kHz. Each consists of two compatible stand-alone 24 pin DDIP modules: an A/D converter and a track/hold or sample/hold amplifier.

The 12 bit ADH-8516 Analog-To-Digital Converter has a conversion time of 1.8μs and 0.012% linearity. It is the smallest Hi-Rel A/D available that also includes 3-State outputs for microcomputer interfacing. With the matching ADH-050 Video Track and Hold Amplifier a super-fast acquisition time of 120ns is achieved. Aperture time uncertainty is a low 500ps. Buffering and pin programming allow many differential and single-ended input options.

The 8 bit data acquisition components include the ADH-8512 A/D Converter which features a 950ns conversion time. The matching SH-8518 Sample and Hold Amplifier has a 25ns acquisition time and a 60ps aperture uncertainty.

Both data acquisition component sets are well suited for military, aerospace and telecommunication applications. All DDC hybrids are processed to MIL-STD-883 requirements to perform under the most extreme environments. DDC also designs custom card mounted multiplexed data acquisition systems. Call your nearest DDC representative listed in EEM, or call Mike Andrews at (516) 567-5600.

DDC

ILC DATA DEVICE CORPORATION

A Wholly Owned Subsidiary of ILC Industries, Inc.

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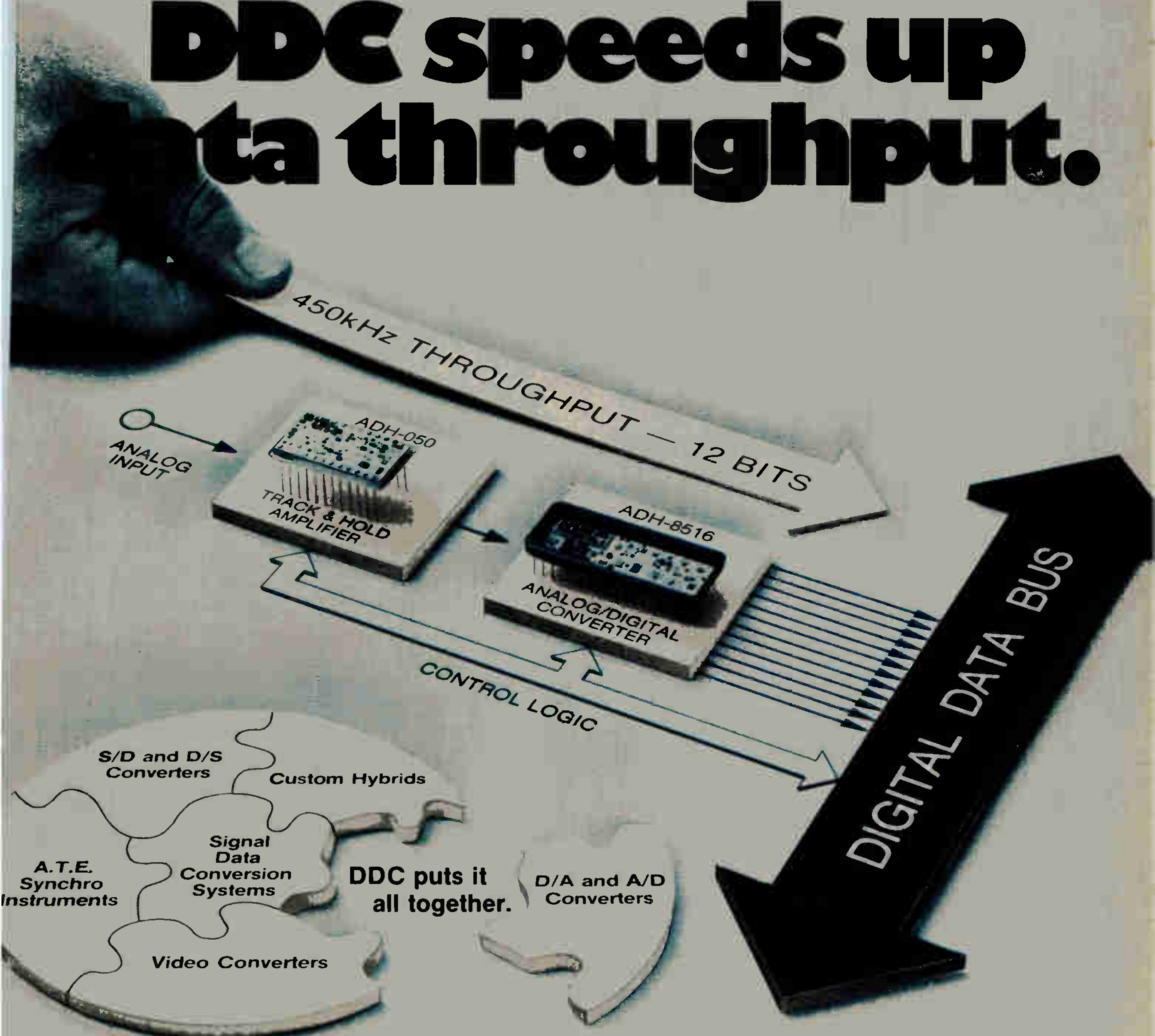
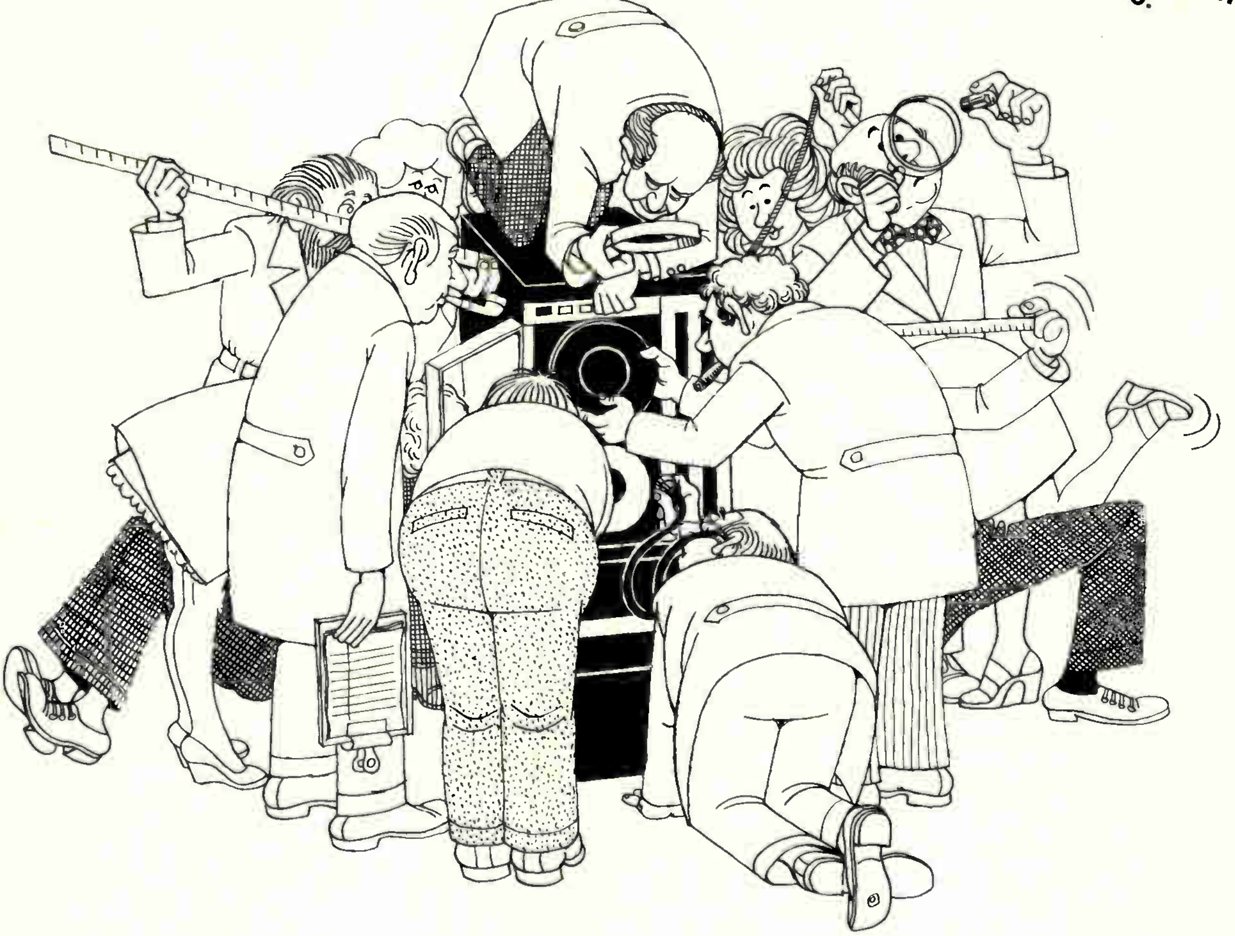
DDC speeds up data throughput.



Circle 243 on reader service card

See the STC 1900 at the N.C.C. Convention in Anaheim Booth Number 1619.



Twenty minicomputer makers are testing the 6250 bpi capability of the STC 1900...

What about the high-performance capability of your minis?

Can you offer your customers the high performance read-write capability of the GCR format?

- **Increased throughout using GCR's 6250 bpi.**
- **Improved error correction for fewer reruns.**
- **Three to one file compaction on multi-reel files.**

Can you remain competitive without a 6250 bpi tape subsystem for your minicomputer?

You can, with the STC 1900 high density magnetic tape subsystem. It includes 1600 and 6250 bpi as a standard feature, so you have library interchangeability with other systems operating at these densities.

and they're buying it.

You can offer the storage capability formerly available only with big mainframes.

Computer output microfilm (COM), and seismic exploration equipment makers have tested and approved the 1900. Minicomputer manufacturers have tested the 1900 and found it fits their needs for a rack mountable high density tape subsystem.

You can afford this high density subsystem because it's designed specifically for the OEM market by the world leader in high density tape subsystems.

To arrange for an evaluation, call Ron Brown direct, toll free. 800-525-2940.

STORAGE TECHNOLOGY CORPORATION
P.O. Box 6, Louisville, Colorado 80027 8-3878

plating information, are discussed in a 12-page catalog from Sealectro Corp., Mamaroneck, N.Y. 10543 [429]

Standards. A new release, RS-448, entitled "Standard Test Methods for Electromechanical Switches," will help engineers who need reference material on the mechanical, electrical, and environmental testing of switches. Fourteen test methods are given and the relationship of the RS-448 tests to those found in International Electromechanical Commission Standards is discussed. The index of Electronic Industries Association and the Joint Electron Device Engineering Council standards and engineering publications distributed by the EIA is available free of charge. Standard RS-448 sells for $8.25 a copy. Standards Sales Office, Electronic Industries Association, 2001 Eye St. N.W., Washington, D.C.

Data-conversion products. "Microcircuits for Data Conversion," a 48-page catalog, describes a broad line of high-performance monolithic and hybrid data converters. Features and specifications are given for: analog-to-digital, digital-to-analog, and voltage-to-frequency converters; multiplexers; operational amplifiers;

and active filters. Ordering information is included. Also, a short history of the hybrid and monolithic data-conversion circuits is provided, along with a discussion of some techniques for fabricating monolithic circuits. Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [430]

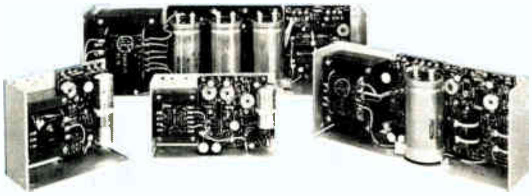
Lamps. A 24-page catalog offers information on a line of solid-state, neon and incandescent indicator lights. Important products covered are Omni-Glow, Glo-Dot, Line-O-Lite, Tiny-Glow and the Mini-Dot series of indicator lights. The available housings, lenses, and colors, and the types of bezels, plus mounting details, complete dimensions, leads

and terminations, are given for each series. A section on design considerations and on specifying indicator lights is included. A self-addressed request form makes it easy for designers to obtain free samples of any of the company's indicator lights for prototypes and new designs. ILG-378, Industrial Devices Inc., Edgewater, N.J. 07020 [431]

Microprocessor training. For those engineers who wish to increase their knowledge of microprocessors, National Semiconductor is offering training courses on such topics as microprocessor fundamentals, 8060 applications, 8900 applications, and peripherals, listed in an eight-page brochure. Registration is June 1, 1978. National Semiconductor Corp., Training M/S 470, 2900 Semiconductor Dr., Santa Clara, Calif. 95150 [432]

"Talk about

OPEN FRAMES



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SINGLE OUTPUT — STANDARD

±.02% REGULATION • REMOTE SENSING

VOLTS	AMPS	MODEL	PRICE 1-9
5	3.0	B5-3	$24.95
	6.0	C5-6	44.95
	12.0	D5-12	74.95
	18.0	E5-18	104.95
6	3.0	B5-3	$24.95
	5.0	C5-6	44.95
	12.0	D5-12	74.95
	18.0	E5-18	104.95

VOLTS	AMPS	MODEL	PRICE 1-9
12	1.7	B15-1.5	$24.95
	3.4	C15-3	44.95
	6.8	D15-6	74.95
	10.2	E15-9	104.95
15	1.5	B15-1.5	$24.95
	3.0	C15-3	44.95
	6.0	D15-6	74.95
	9.0	E15-9	104.95

VOLTS	AMPS	MODEL	PRICE 1-9
18	1.3	B24-1.2	$24.95
	2.6	C24-2.4	44.95
	5.2	D24-4.8	74.95
	7.8	E24-7.2	104.95
20	1.3	B24-1.2	$24.95
	2.6	C24-2.4	44.95
	5.2	D24-4.8	74.95
	7.8	E24-7.2	104.95

VOLTS	AMPS	MODEL	PRICE 1-9
24	1.2	B24-1.2	$24.95
	2.4	C24-2.4	44.95
	4.8	D24-4.8	74.95
	7.2	E24-7.2	104.95
—	—	—	—

SINGLE OUTPUT — HI-VOL

115/230 VAC INPUT • OVP ON 5V MODELS

VOLTS	AMPS	MODEL	PRICE 1-9
2	3.0	HB2-3	$29.95
	6.0	HC2-6	49.95
	12.0	HD2-12	79.95
	18.0	HE2-18	109.95
5	1.2	HA5-1.2/OVP*	$22.95
	3.0	HB5-3/OVP*	24.95
	6.0	HC5-6/OVP*	49.95
	9.0	HN5-9/OVP*	69.95
	12.0	HD5-12/OVP*	79.95
	18.0	HE5-18/OVP*	114.95

VOLTS	AMPS	MODEL	PRICE 1-9
12	0.5	HA15-0.5	$22.95
	1.7	HB12-1.7	24.95
	3.4	HC12-3.4	44.95
	5.1	HN12-5.1	64.95
	6.8	HD12-6.8	74.95
	10.2	HE12-10.2	104.95
15	0.5	HA15-0.5	$22.95
	1.5	HB15-1.5	24.95
	3.0	HC15-3	44.95
	4.5	HN15-4.5	64.95
	6.0	HD15-6	74.95
	9.0	HE15-9	104.95

VOLTS	AMPS	MODEL	PRICE 1-9
24	1.2	HB24-1.2	$24.95
	2.4	HC24-2.4	44.95
	3.6	HN24-3.6	64.95
	4.8	HD24-4.8	74.95
	7.2	HE24-7.2	104.95
28	1.0	HB24-1.2	$24.95
	2.0	HC28-2	44.95
	3.0	HN28-3.0	64.95
	4.0	HD28-4	74.95
	6.0	HE28-6	104.95

VOLTS	AMPS	MODEL	PRICE 1-9
48	0.5	HB48-0.5	$29.95
	1.0	HC48-1	49.95
	3.0	HD48-3	79.95
	4.0	HE48-4	109.95
180, 200	0.12	HB200-0.12	$34.95
250	0.1	HB250-0.1	$34.95

SINGLE OUTPUT — HIGH POWER

115/230 VAC INPUT • OVP ON 5V MODELS

VOLTS	AMPS	MODEL	PRICE 1-9
5	25.0	F5-25/OVP*	$149.00
	35.0	G5-35/OVP*	185.00
12	16.0	F15-15	$149.00
15	15.0	F15-15	$149.00
24	12.0	F24-12	$149.00
28	10.0	F24-12	$149.00

SINGLE OUTPUT — HIGH EFFICIENCY

EFFICIENCY UP TO 66% • RELIABLE LINEAR DESIGN

VOLTS	AMPS	EFFICIENCY @ NOMINAL LINE	MODEL	PRICE 1-9
5	9	66%	RD5-15/OVP*	$ 99.95
	12	63%		
	15	60%		
5	14	63%	RE5-23/OVP*	$130.00
	18	60%		
	23	57%		
5	25	63%	RG5-40/OVP*	$220.00
	32	60%		
	40	57%		

DUAL OUTPUT — STANDARD

TRACKING REGULATORS • ±.02% REGULATION

MODEL	OUTPUT #1	OUTPUT #2	PRICE 1-9
AA15-0.8	12V @ 1.0A or 15V @ 0.8A	−12V @ 1.0A or −15V @ 0.8A	$42.95
BB15-1.5	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A	$53.95
CC15-3.0	12V @ 3.4A or 15V @ 3.0A	−12V @ 3.4A or −15V @ 3.0A	$84.95

DUAL OUTPUT — HI-VOL

115/230 VAC INPUT • OVP ON 5V MODELS

MODEL	OUTPUT #1	OUTPUT #2	PRICE 1-9
±12 to 15V			
HAA15-0.8	12V @ 1.0A or 15V @ 0.8A	−12V @ 1.0A or −15V @ 0.8A or −5V @ 0.4A	$39.95
HBB15-1.5	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A or −5V @ 0.7A	49.95
HCC15-3.0	12V @ 3.4A or 15V @ 3.0A	−12V @ 3.4A or −15V @ 3.0A	79.95
±18 to 24V			
HAA24-0.6	18-20V @ 0.4A or 24V @ 0.6A	(−)18-20V @ 0.4A or −24V @ 0.6A	$39.95
±5V			
HBB5-3/OVP	5V @ 3.0A*	−5V @ 3.0A*	$61.95
HCC5-6/OVP	5V @ 6.0A*	−5V @ 6.0A*	92.95
5V and 9-15V (Isolated Outputs)			
HAA512	5V @ 2.0A*	9-15V @ 0.5A	$44.95
HBB512	5V @ 3.0A*	9-15V @ 1.25A	54.95
HCC512	5V @ 6.0A*	9-15V @ 2.5A	86.95

TRIPLE OUTPUT — STANDARD

TRACKING REGULATORS • ±.02% REGULATION

MODEL	OUTPUT #1	OUTPUT #2	OUTPUT #3	PRICE 1-9
BAA-40W	5V @ 3.0A	12V @ 1.0A or 15V @ 0.8A	−12V @ 1.0A or −15V @ 0.8A	$ 69.95
CBB-75W	5V @ 6.0A	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A	$ 91.95
DBB-105W	5V @ 12.0A	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A	$126.95

TRIPLE OUTPUT — HI-VOL

115/230 VAC INPUT • OVP ON 5V MODELS

MODEL	OUTPUT #1	OUTPUT #2	OUTPUT #3	PRICE 1-9
HTAA-16W	5V @ 2.0A*	9-15V @ 0.4A	(−)9-15V @ 0.4A or −5V @ 0.2A	$ 49.95
HBAA-40W	5V @ 3.0A*	12V @ 1.0A or 15V @ 0.8A	−12V @ 1.0A or −15V @ 0.8A or −5V @ 0.4A	$ 69.95
HCBB-75W	5V @ 6.0A*	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A or −5V @ 0.7A	$ 91.95
CP-131	5V @ 8.0A*	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A or −5V @ 0.7A	$110.00
HDBB-105W	5V @ 12A*	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A or −5V @ 0.7A	$126.95
HDCC-150W	5V @ 12A*	12V @ 3.4A or 15V @ 3.0A	−12V @ 3.4A or −15V @ 3.0A	$149.00

FLOPPY-DISK SERIES

SINGLE/DUAL DRIVE MODELS • FOR 5.25" & 8.0" MEDIA DRIVES

DISK-DRIVE MODEL	OUTPUT RATINGS				PRICE 1-9
	+5V*	−5V*	+12V AVG./PK	+24V AVG./PK	
+5V and +12V					
CP-249	0.7A		1.1A/1.7A		$ 39.95
+24V and ±5V					
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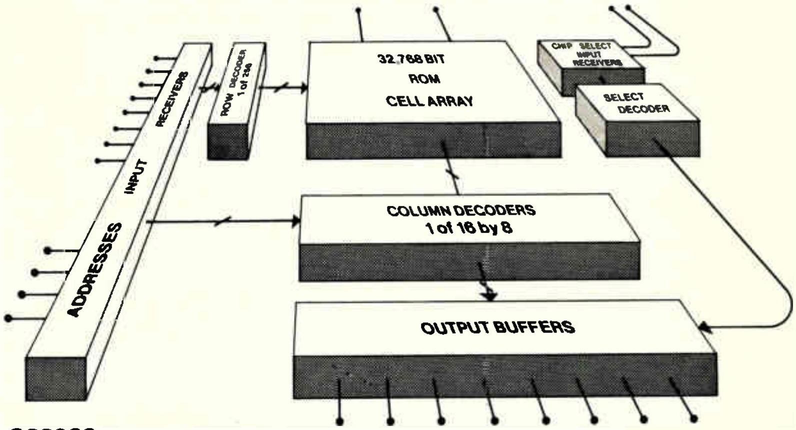

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